From: [redacted]
To: SizewellC
Subject: Sizewell C
Date: 11 December 2019 15:17:23
Attachments: Sizewell C - a 2020 perspective 2019-12-5 11-25am.pdf

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Dear Planning Inspectorate,

It is difficult to see how the Sizewell C proposal due to be considered in the early part of 2020 can reach the standards necessary for nuclear infrastructure approval.

The enclosed document has been much researched and offers detail.

In summary:

Spent Fuel: The GDA (Generic Design Assessment) clearly states clearly that Spent Fuel is waste, and disposal of new build reactor waste will be in a Geological Repository.
In fact, Spent fuel is declared by Government as 'not being waste' thus separating Spent Fuel from a major range of safety, risk and environmental recommendations. We have neither a GDF nor even serious consideration of a GDF.
It is also the case that the Spent Fuel will be hotter and more radioactive than any legacy waste. We do not know the cooling period required in ponds and we do not know if EDF will try to use ponds for storage despite the proved liability of such an exercise.
(The Fukushima Spent Fuel Ponds were and remain an extreme liability).

The build programme: Despite multi-billion-pound EPR investment since 2005, not one watt of electrical power has been generated in Europe. The projects have been beset by endless delays. Given this lack of effective leadership or progress, the capability or capacity of EDF to undertake and monitor any agreed safety protocols or safeguards is questionable.
It is also surprising that there may be acceptance of 'Fault Preclusion' (a deterministic ruling out of failure) for critical and highly stressed components.

The Location: The claim to current stability of this coast is weak and based a highly selective interpretation of historical expert evidence. If climate change predictions are accepted (UKCP18, IPCC and IME) and a full risk analysis undertaken on this basis to define security, then it is reasonable to conclude that Sizewell is a highly unsuitable site. The excessive reliance on historical data (essentially no more than stating that because an event has not caused damage in the past it is unlikely to in the future) is of itself no basis for a decision, the consequences of which need to be measured in decades. Independent experts are clear that the lack of provision of risk modelling for extreme sea events occurring over the next 100 years represents a major weakness and significant danger.

Funding: RAB financing model is the riskiest model for the UK taxpayer as EDF would be paid, with full profit margins, regardless of performance and even if the plant is not completed (a likely outcome). Based on the evidential uncertainty of an EDF EPR build programme this is clearly not the correct approach.

Regards

Nick Scarr

Sizewell C – Safety, capability and capacity, environmental health and funding – a 2020 perspective.

The 1976 Royal Commission on Environmental Pollution concluded: 'There should be no commitment to a large program of nuclear fission power until it has been demonstrated beyond reasonable doubt that a method exists to ensure the safe containment of long lived, highly radioactive waste for the indefinite future.'

This paper will examine the proposed construction of Sizewell C with particular reference to spent fuel storage and how little has been achieved since 1976, construction history, site location and the method of financing.

1 – Safety: The handling of nuclear waste, with particular reference to Spent Fuel.

1.1 Background

New fuel rods are relatively safe and easy to handle. The main components are Uranium-238 and Uranium-235 that have very long half-lives and do not require complex, shielded containment. Once in the reactor, a neutron-induced, chain reaction fission is established in order to produce heat. After 1-3 years the fuel rods become 'Spent' in that they lose their efficiency and are removed from the reactor core. The spent fuel now contains fission products, some with short half-lives that are intensely radioactive and transuranic elements including plutonium that have much longer half-lives. It takes several hundred thousand years for the ingestion radiotoxicity of Spent Fuel to become that of the uranium ore (including its decay products) from which it was derived. It also generates high levels of heat. Although this decay heat falls rapidly in the Spent Fuel after reactor removal, it requires cooling for 140 years before reaching sufficiently low enough temperatures for geological storage requirements. It also requires effectively shielding indefinitely.

Technical note 1: For Spent Fuel heat information see Hinkley C documents (the PCSR). The reactor thermal power will be 4500MW of which 97.4% is developed in the fuel and the full weight of the reactor core is 127 tonnes of uranium giving a heat loading of 34.5 MW per tonne uranium.

Technical note 2: The toxicity of a radionuclide is dependent on its activity, and on what type of radiation its radioactive disintegration (decay) gives rise to. A distinction is made between two types of radiation: external and internal. External radiation is emitted by an external radiation source and penetrates the body from the outside, internal radiation comes from radioactive substances that enter the body, via ingestion or inhalation. Most radionuclides are more toxic if they are inhaled than if they are ingested. Ingestion radiotoxicity is a tangible measure of the difference in radioactivity between New Fuel and Spent Fuel. See, 'Spent nuclear fuel - how dangerous is it? A report from the project "Description of risk." Allan Hedin, Swedish Nuclear Fuel and Waste Management Co, Stockholm, Sweden March 1997' and IPFM, 'Spent Fuel from Nuclear Power Reactors, 2011', p.4. See Appendix 2 for a graph of ingestion radiotoxicity.

1.2 Proposed treatment of Spent Fuel at Sizewell C

It is proposed that the Spent Fuel produced over the full lifetime of operation of Sizewell C is to be stored onsite. This is despite clause 112 in the *Generic design Assessment UK EPR (Spent Fuel)*, which says: 'The ONR [Office Nuclear Regulation] have an assessment finding …to reduce the onsite storage period for the spent fuel produced by the reactor so that the fuel can be transported as soon as reasonably practical.' EDF has expressed no interest in reprocessing the Spent Fuel and we have no independent policy to do so. The construction of a new Geological Disposal Facility (GDF) was defined as a 'Base Case' requirement for new reactor build and ultimate disposal of Spent Fuel produced by new-build reactors: "we [The Environment Agency] note that the Government base case for new build is that a facility for long term storage of high-level waste and spent fuel will be available in time to receive the wastes from new reactor build." *'Generic design assessment UK EPR nuclear power plant design by AREVA NP SAS and Electricité de France SA, Final Assessment Report Spent Fuel,' clause 118.*

The paper continues: "EDF and AREVA take account of Government policy in their IWS [Integrated Waste Strategy], noting that spent fuel will be declared as waste and…then disposed of to the geological disposal facility" *op.cit., Clause 52.*

Also, according to the Government White Paper on Energy, *MAY 2007, MEETING THE ENERGY CHALLENGE, Clause 29 and Clause 99*: "Private sector developers would meet the full decommissioning costs and full share of waste management costs… [If they are to be] allowed to invest in new nuclear power stations…Government believes that new waste could technically be disposed of in a geological repository and that this would be the best solution for managing waste from any new nuclear power stations."

At present, however, Government, does '*not currently classify Spent Fuel as waste*', making a mockery of the Generic Design Assessment (GDA). Spent Fuel is not included in these waste commitments and will only be stored in a GDF 'at some future time if it becomes re-classified as waste'. See Government White Paper '*Implementing Geological Disposal, Dept Energy Climate Change July 2014, clause 2.11,2.17".*

In summary, Spent Fuel may be classified as waste when it becomes less radioactive at some unspecified future date. However, Spent Fuel is highly radioactive, especially in the first 200 years, and although it realistically serves no further purpose in power generation it is not considered to be waste, thus is separated from a major range of safety, risk and environmental recommendations.

1.3 Expert opinion on safety and technical issues of Spent Fuel for Sizewell C

In its *Initial Proposals and Options Consultation Stage1, para 2.2.16,* EDF declares that their new EPRs (The abbreviation generally expands to 'European Pressurised Reactor' and occasionally 'Evolutionary Power Reactor' and is the reactor type for Hinkley C and Sizewell C) will generate less spent fuel than existing reactors in the UK. This statement is a little misleading. Less Spent Fuel means 'High Burn-up' - the uranium fuel rods (with higher enrichment than legacy to 4.9% U-235) stay in the reactor longer than in earlier conventional reactors and can run up to 65,000 MWd/tU

(Megawatt days per tonne of Uranium). Advance Gas Cooled Reactors (AGRs) are 5000-30,000 MWd/tU for comparison.

While reactor coolant temperatures still have a maximum of 310 degrees C, the high power of the EPR is coming from a larger core and more fuel (hence the requirement for a million litres of fresh cooling water every day) rather than burning at higher temperatures, however the High Burn-up Spent Fuel, when removed from the reactor is more delicate, more radioactive and hotter than 'conventional' spent fuel. EDF has ONR (The Office for Nuclear Regulation) approval for high burn-up suggesting that safety systems are regarded as acceptable. (see appendix 3 for examples of the extent of the higher radioactivity of High Burn-up spent fuel). Also, *NDA Geological Disposal Report, March 2010 no. NDA/RWMD/013, page 11*; *See Generic Design assessment p.9 for water requirements.*

Incorporated into the EDF design are containment and core-catcher structures to ensure that there is no large-scale release of radioactivity to the environment in the event of a core meltdown (as happened at Chernobyl and Fukushima). However, outside the reactor containment zone with no 'core catcher' facility, the Spent Fuel ponds that will contain approximately a full reactor core's worth of 'spent' fuel rods every 3-4 years (there are 241 fuel assemblies per core). Because of the higher heat and radioactivity of the Spent Fuel, it is recognised that safety margins need to be more rigorous and will depend on the effective and continuous removal of significant thermal power. Failsafe technologies will need to be incorporated at every stage of this process to mitigate risk as all these systems are vulnerable to mechanical failure, deliberate disruption or flood yet must operate flawlessly for 'an extended cooling period' (decades) until the spent fuel has cooled sufficiently to be moved.

High Burnup is an exercise in reducing fuel cycle costs for the operator, however, High Burnup Spent Fuel is subject to a range of failures predominantly associated with increased cladding degradation: corrosion, hydrogen pickup and associated stresses, cladding and pellet interactions, internal fuel rod pressures and, perhaps most importantly, failure tendency of High Burnup Spent Fuel may increase in a LOCA (Loss of Cooling accident). It seems clear that a full risk analysis on all aspects of High Burnup fuel use is not yet fully established.
*IAEA - International Atomic Energy Agency: High Burnup Fuel: Implications and Operational Experience. Proceedings of a technical Conference Buenos Aires Nov 2013. IAEA-Techdoc -CD-1798, Page 119.*tttt

This uncertainty of cladding integrity is raised in clauses 109 and 110 of the *Generic design Assessment UK EPR (Spent Fuel): "*'The ONR commissioned the National Nuclear Laboratory (NNL) to carry out work to identify mechanisms that could lead to early failure of the fuel cladding or the fuel assembly during storage… There will be requirements for regular maintenance inspections on the fuel condition over the storage period, to maintain confidence that the fuel remains in a suitable condition". *'Generic design assessment UK EPR nuclear power plant design by AREVA NP SAS and Electricité de France SA, Final Assessment Report Spent Fuel'.*

1.4 The Cooling period and interim storage for Spent Fuel

According to the Environment Agency document, '*Generic design assessment UK EPR nuclear power plant design by AREVA NP SAS and Electricité de France SA. Final Assessment Report Spent Fuel, Clause 129:'* "NDA has published a generic Disposal Systems Safety Case (gDSSC) for a future Geological Disposal Facility (GDF), based on its understanding of the scientific and engineering principles supporting geological disposal (RWMD, 2010)…The review therefore confirms that there are no new issues arising from the generic DSSC that would challenge the fundamental disposability of the wastes and spent fuel expected to arise from operation of the AP1000 and EPR."

The expertise of the NDA's *Radioactive Waste Management Directorate (RWMD)* is acknowledged, however, it is essential to recognise that in the proposal for Sizewell C, there is no Geological Disposal Facility (GDF), no site for a GDF, and no design for a GDF.

There is also no consensus as to what the Cooling Period should be. Initial cooling must take place in in the Spent Fuel ponds for 'some years' followed by an 'extended period' of dry surface storage. According to the Nuclear Decommissioning Authority (NDA): "In order to ensure the performance of the bentonite buffer [the clay encasement in a GDF], a temperature limit [is required.] Based on a canister containing four EPR fuel assemblies, each with the maximum burn-up of 65 GWd/tU and adopting the canister spacing used in existing concept designs, it would require of order of **140 years** for the activity, and hence heat output, of the EPR fuel to decay sufficiently to meet this temperature criterion." *NDA Geological Disposal Generic Design Assessment: Summary of Disposability Assessment for Wastes and Spent Fuel arising from Operation of the UK EPR Jan 2014 section 6, page 6 (page 14).*

Directly relevant to this debate is the Fukushima disaster: "When the earthquake and tsunami knocked out the cooling systems …[s]everal spent-fuel-rod pools also lost electric power, shutting down pumps. Water in the cooling pools stopped circulating and began to boil off or leak out. As the water level fell, the spent fuel rods were exposed, and their temperatures soared. Several began to melt down, releasing extremely high levels of radiation into the air". *(The Week, 'Radioactive fuel rods – the silent threat. April 8th, 2011).*

In view of the Fukushima accident it is therefore a concern that EDF and AREVA can consider "long term wet storage of fuel as a solution that can be shown to be ALARP" - (risk as low as is reasonably practical). Their viewpoint, reported in the '*ONR Generic Design Assessment*' continues: "…spent fuel can be stored safely in a long-term storage pool for the following reasons: Due to low storage temperatures and satisfactory water chemistry, the preservation of cladding integrity is ensured which in turn guarantees the retrievability of stored assemblies at any time during storage. Monitoring of the assemblies is simple and inspection is performed regularly. Other systems such as ventilation, filters or make-up water add to the safety of the facility. The pool water inertia gives the operator a grace period sufficient to deal with incidents before the fuel integrity is compromised. The option also offers flexibility in the long-term management of spent fuel and in the retrieval of assemblies." *ONR - Generic Design Assessment – New Civil Reactor Build, Step 4 Radioactive Waste* *and Decommissioning Assessment of the EDF and AREVA UK EPR™ Reactor Assessment Report: ONR-GDA-AR-11-030 Revision 0 11 November 2011. Clause 192.*

Clearly, fuel pond storage makes inspection of Spent Fuel much simpler but is undoubtedly at the cost of overall plant security in event of a LOCA (loss of coolant accident) affecting the Spent fuel ponds.

The full analysis of the contribution of Spent Fuel in ponds to the radioactive debris and fallout from the Fukushima disaster will take time because of the ensuing chaos, however, it is clear that Spent Fuel storage ponds will suffer water evaporation in a LOCA (loss of cooling accident) followed by possible ignition of the Spent Fuel zirconium cladding and a release of volatile radioactive fission products. As stated earlier *(1.3)* there may be an increased failure tendency in High Burnup Spent Fuel over legacy Spent Fuel in this situation. This could prove to be a greater source of a radiation leak than from the reactor itself. If the reactor has a cooling problem, it is within a strong internal containment vessel surrounded by an external containment vessel and has the benefit of a core-catcher. This is not so for the Spent Fuel ponds, which after a mere 10 years reactor operation will contain the Spent Fuel of approximately three complete reactor cores.

Technical note 3: Article published by Mari Yamaguchi, Associated Press, Dec 1, 2019, 8:50pm. 'Fukushima melted fuel removal begins 2021, end state unknown', FUEL RODS:

"Together, the three melted reactors have more than 1,500 units of mostly used nuclear fuel rods still inside that must be kept cool in pools of water. They're among the highest risks at the plant because the pools are uncovered, and loss of water from structural damage or sloshing in the event of another major earthquake could cause fuel rods inside to melt and release massive radiation."

"TEPCO started removing the fuel rods from the Unit 3 pool in April 2019 and aims to get all 566 removed by March 2021. Removal of the rods from Units 1 and 2 is to begin in 2023. By 2031, TEPCO also plans to remove thousands at two other units that survived the tsunami to be stored in dry casks on the compound. More than 6,300 fuel rods were in six reactor cooling pools at the time of the accident, and only the Unit 4 pool has been emptied."

In Summary, Spent Fuel is a high risk to the environment in event of a LOCA when in onsite cooling ponds. High burnup Spent fuel being hotter and more radioactive than legacy can only increase the hazard. The Spent Fuel, therefore, needs to be transferred from ponds into the more secure containment of dry cask surface storage immediately thermal constraints permit. This should be possible if we take the GDA (Generic Design Assessment)'s claim at face value that 'no new issues arise that would challenge the fundamental disposability of the…[High Burnup] spent fuel expected to arise from operation of the EPR.'

2 – Capability and Capacity: Evidence and experience, 2005-2019.

2.1 Background

The following is a review of attempts at building the EPR pressurised water reactor - the design intended for Sizewell C. The EPR reactor was designed by Framatome and EDF. Over the period of construction, described below, the problems, both technical and financial, caused by the projects to the companies involved has variously resulted in joint operations, mergers, name changes, record losses, legal damages and interventions (bailout) by the French State. EDF is now a majority shareholder in Framatome.

2.2 Olkiluoto 3

The first EPR order was Olkiluoto 3, in Finland, started in 2005 and intended to be live in 2009. It is more than three times overbudget with a scheduled start date in 2020 (fuel loading is expected to take place in early 2020). This was a 'turn-key' fixed price project for €3bn and losses and damages to the supplier Framatome are so massive that its parent company Areva was effectively bankrupted with subsequent bailout transferred financial liability to the French State. The most recent cost calculation is €11bn for this 14-year project that is yet to generate any power.

2.3 Flamanville 3

Flamanville 3 EPR, in North West France, was an Areva NP/EDF project started in 2007 for completion in 2012 at a stated cost of Euros 3.3 billion. In 2012 EDF announced estimated cost escalation to Euros 8.5 billion and 2016 completion and in 2014 much the same story again. In July 2019 EDF announced a further delay of three years to 2022/2023 so Flamanville 3 will be at least 11 years late and 4 times over budget at €12.4bn. A further delay in this construction has occurred because more than 50 welds were found to be sub-standard. All will have to be repaired, however 8 of the welds are now inaccessible to human entry requiring as yet undeveloped robot technology. This brings to the fore EDF's 'Break Preclusion' concepts where, it is claimed, structures are built to such standards that they can 'never break'.

2.4 Taishan

Taishan's EPRs in China, supplied by Areva in which EDF has a minority stake and is involved in the construction has fared better but still 4-5 years late (this is far more delay than most other reactors in China). The conformity between Taishan's reactors and European versions may differ in some respects, but because costs and much other information are not in the public domain it is not possible to draw any further conclusions.

2.5 Hinkley C

As far as Hinkley C is concerned – a joint operation between EDF and China's CGN (China General Nuclear Power Group, a Chinese energy corporation under the SASAC - the State-owned Assets Supervision and Administration Commission of the State Council of China)- cost estimates so far have risen to £21.5 to 23.2 billion with a claimed online date of 2025-7 for the first unit. Based on experience we might reasonably assume this will change. (How CGN's US Government 'entity list' problem will affect the build at Hinkley is not yet known but can hardly be described as helpful.) The first cost overrun of £2.9 Billion has been announced on Sept 19 with unspecified delay.

Professor Steve Thomas, Emeritus Professor of Energy Policy, Public Services International Research Unit (PSIRU), Business School, University of Greenwich, an acknowledged expert on EPR build programs, has raised the following concerns over the Hinkley Point C design which, as of December 2019, remains unfinished:

The Hinkley deal was agreed in Oct 2013 giving EDF plenty of time to complete the 'Balance of Plant'. The term, Balance of Plant, refers to all the supporting components and auxiliary systems of a power plant needed to deliver the energy other than the generating unit itself and is a process that is relatively short and simple. EDF claimed that they would not pour concrete until design completion, yet design has slipped to 2022 and first concrete was poured in December 2018. Why has EDF not completed the design?

The EPR underwent a Generic Design Assessment (GDA), that relates to the whole design in detail except for non-safety critical, site-specific details such as taking account of local geology. However, the incomplete design also involves the Instrumentation & Control system which is clearly safety critical. The French, Finnish and US regulators (the design was planned for USA and went into their equivalent of the GDA) differed over the redundancy in the back-up system. The UK claims it will look at experience in these projects and decide later.

The ONR (Office of Nuclear Regulation) has a 'traffic light' system to show the status of design issues. If the light is grey, the design issue is resolved, if green, it is on target to be resolved in the required time, if amber, there will be problems completing the review by the scheduled date and if red there is next to no chance it can be resolved in time. For the Hinkley EPR, by Aug 2012, red lights remained but, surprisingly, by December, they had all gone to grey and the GDA was given. The ONR had seemingly agreed that these remaining design issues would be resolved in the construction phase, effectively making a mockery of the GDA process. *Steve Thomas Emeritus Professor of Energy Policy Public Services International Research Unit (PSIRU) Business School University of Greenwich 30 Park Row London SE10 9LS UK*

2.6 Expert assessment of EPR construction.

All the evidence proves beyond reasonable doubt that EDF's construction record for EPR is extremely poor with not a single European EPR yet operational from a 2005 start. Given this lack of effective leadership or progress, the capability or capacity of EDF to undertake and monitor any agreed safety protocols or safeguards is questionable.

The design of the Hinkley plant remains incomplete and the GDA process rendered debatable by deferring significant design criteria 'to the construction phase'.

It is important to recognise that commitment to these projects has resulted in major disruption for the nuclear industries of France. The EPR design was an attempt at better safety after the Chernobyl and Three Mile Island disasters but the evidence shows it is clearly beyond reasonable complexity and cost with not one project completed, and not a single Watt of energy delivered in Europe after 15 years of multi-billion pound investment.

The complexity, redundancy and space limitations have become too challenging – access is limited or impossible for some structures resulting in 'break preclusion' being forced upon constructor and regulators alike.

An investigation ordered by the French Government in 2009, long before the extent of the problems at Olkiluoto, Flamanville and Taishan had become apparent, and chaired by a former CEO of EDF, Francois Roussely found much the same in stating that build 'complexity' was the fundamental difficulty: '[t]he complexity of the EPR comes from design choices, notably of the power level, containment, core catcher and redundancy of systems. It is certainly a handicap for its construction, and its cost. These elements can partly explain the difficulties encountered in Finland [and] Flamanville.' see: *'The EPR in Crisis, Prof. Steve Thomas, PSIRU University of Greenwich, London'*

EPRs, being so complex to construct must equally be complex to maintain. What will be the 'outage' time for Hinkley C and Sizewell C when inevitable anomalies are found during planned maintenance? EDF's EPR has critical components that are inaccessible: as a consequence of this Flamanville, a reactor yet to be completed is facing extraordinary delays to repair some welds. How then will EDF be able to effectively test core components for regular in-service inspection using technologies such as ultrasound, dye penetrants and spark optical emission spectrometry (OES)? Carbon flaws have been a major bugbear of the industry and these tests are imperative to the safety of any nuclear installation. EDF is relying on 'break preclusion' to void these tests in some areas.

3 – Environment

3.1 Background

RSPB Minsmere nature reserve is adjacent to the proposed development site on the Suffolk Coast and has been a nature reserve since 1947. It is a flagship site for both wildlife and visitors. Minsmere forms part of a wider area of the Suffolk Coast widely recognised for its value for wildlife.
The Suffolk Coast is an outstanding location for wildlife and people alike, with a rich and varied mosaic of habitats providing a landscape of wild beauty. It is a safe haven for an amazing variety of wildlife including iconic species such as the bittern, marsh harrier and otter. (Ref, RSPB website Minsmere) Besides being in an Area of Outstanding Natural beauty it is protected by a number of national and international nature conservation designations. These include:

- SSSI (a type of protected area with special or exceptional wildlife features)
- SPA (European designation for rare and vulnerable birds)
- SAC (European designation designed to protect habitats and wildlife species)
- Ramsar site (for wetlands of international importance)

3.2 Coastal morphology, stability and changes in sea level.

Dunwich, which was 5km from the proposed site for Sizewell C, has already been lost to coastal erosion. This erosion occurred before any of the expected rising median sea levels as defined in UKCP 18 (the government's accepted reference document for same) and in the 2019 IPCC (Intergovernmental Panel on Climate Change) report.

EDF claims that the site benefits from a 'micro-stability' which is related to the ridges of sub-sea coralline crag.

Technical note 1: According to the '*Thorpeness Coastal Erosion Appraisal Final Report December 2014, Mott Macdonald',* the geological feature of greatest significance to Thorpeness, (Thorpeness is located at the southern end of the Greater Sizewell Bay) is the ridge of Coralline Crag composed of cemented iron-stained Pliocene shelly sand that extends north-eastwards from Thorpeness beneath the modern beach sediments. This offers resistance to erosion compared with the other deposits. It has been suggested that the position of the Ness to the north of Thorpeness is comparatively fixed by this geological unit which also serves to anchor the SDBC (Sizewell Dunwich Bank Complex) –The Coralline Crag ridge under Thorpeness is also recognised as being important in protecting the Sizewell coast (EDF, 2002). A slight 'headland' at Thorpeness occurs because these relatively more resistant rocks occur at the base of the cliff, and they extend out to form the offshore seabed. The geomorphological erosion dynamic of the shoreline is approximately 30 years and is subjected to periods of erosion lasting several years. '*Thorpeness Coastal Erosion Appraisal, Final Report, December 2014, Mott Macdonald.'*

Technical note 4: Crag is an East Anglian term for the sedimentary rocks of shelly sand characteristic of the area.

Technical note 5: The largest waves recorded by a Waverider buoy deployed offshore from the Sizewell-Dunwich Bank complex (SDBC) in 18m of water from 11 February 2008 to 24 February 2011 had a mean direction, ⍰, of 155° (the direction of travel), a significant wave height, Hm0, of 4.71m (15.45 ft) and peak period, Tp, of 9.1s (wave power, Pw, 1.54 x 105J/m/s) see: Thorpeness Coastal Erosion Appraisal Final Report December 2014, Mott Macdonald, p.15. This is interesting to consider with regard to future climate change predictions for wave height and frequency.

EDF's proposed cooling water outfall pipes for Sizewell C are designed to avoid the erosion of these offshore banks. EDF is here admitting that they must consider their stability critical.

A historical hydrographical survey chart in Appendix 1, however, shows that offshore banks are not stable over the longer term. The map outlines changes in the position and shape of the Sizewell-Dunwich Banks between 1868 and 1992. *See Appendix 1 or PYE, K. and BLOTT, S.J., 2006. Coastal processes and morphological change in the Dunwich-Sizewell area, Suffolk, p466.*

It is also the case that "…the area north of Sizewell Power Station is still experiencing periodic storm erosion. This may be related to changes in the nearshore and offshore morphology, including the development of a gap between the crests of the Sizewell and Dunwich Banks through which waves are able to penetrate". Op. cit., PYE, K. and BLOTT, p464.

3.3 Sea level changes, storm surges and flooding: expert opinion

UKCP18, the Met Office document for climate projection confirms the accepted science of significant median sea level rises into the next century. Historical coastal erosion and flooding already experienced by this coast will reach new heights and intensities. The IPCC (Intergovernmental Panel on Climate Change) reported on 24th Sept 2019 stated that extreme sea level events that are rare (once per century) are projected to occur at least once per year by 2050 in many places. (IPCC The Ocean and Cryosphere in a changing climate 24th Sept 2019, page spm-22)

The IPCC report continues: 'Under the same assumptions, annual coastal flood damages are projected to increase by 2–3 orders of magnitude by 2100 compared to today *(high confidence*)'. *(spm-32).*

'In the absence of adaptation, more intense and frequent extreme sea level events, together with trends in coastal development will increase expected annual flood damages by 2-3 orders of magnitude by 2100 (*high confidence*). However, [the report suggests], well-designed coastal protection is very effective in reducing expected damages and cost efficient for urban and densely populated regions, but generally unaffordable for rural and poorer areas (*high confidence*).' *IPCC, Page 516 of 1170.*

It is not possible to construct 'well-designed' coastal protection around the low-lying Sizewell and Minsmere levels that surround the proposed Sizewell C. East Anglia is flatland: much of the Sizewell Belts (1-2 Km to the East of Sizewell) are 2-4 m above sea level, the Minsmere levels (1-2Km North of Sizewell) are 1-2m above sea level on average.

The floods of 1953 that submerged huge areas of this part of Suffolk - a typical once per century event - were caused by a 2m surge. Consider, then the flooding possibilities when a 1-2m median sea level rise represents the baseline and these major floods become 'at least once per year' as the IPCC report states. This is presumably why many suggest that Sizewell B and C will, at best, be islands within the near future on their 6.4m and 7.3m plinths above sea level respectively.

According to the Institution of Mechanical Engineers (IME) "…in the UK, nuclear sites such as Sizewell, which is based on the coastline, may need considerable investment to protect it against rising sea levels, or even abandonment/relocation" IME (Institution of Mechanical Engineers) (2009): Climate Change: Adapting to the inevitable, Institution of Mechanical Engineers, Westminster, London.

Therefore, UKCP18, the IPCC, and the Institute of Mechanical Engineers are all of the same opinion, independently stating that a coastal location is vulnerable: 'abandonment and relocation' of Sizewell power stations are strong terms to come from the IME, a professional organisation not noted for hyperbole.

The case for acceptability of the site location, EDF's claim to 'micro-stability,' is largely predicated up on the so-far safety of Sizewell A and B which have been subjected to, and survived, tidal surges.

This approach raises an important question in relation to the analysis of information and interpretation of evidence: the site for Sizewell C is arguably only suitable if we restrict analysis to recent historical data and we ignore evidence-based climate science predictions. Climate science is the justification for building Sizewell C in the first place, climate science is used to justify the need for the project but has been interpreted in a highly selective manner when it comes to the choice of location. EDF owns Sizewell so it wants to build there.

In summary, the claim to current stability of this coast is weak and based a highly selective interpretation of historical expert evidence. If climate change predictions are accepted and a full risk analysis undertaken on this basis to define security, then it is reasonable to conclude that both Sizewell (and Hinkley Point) are highly unsuitable sites. The excessive reliance on historical data (essentially no more than stating that because an event has not caused damage in the past it is unlikely to in the future) is of itself no basis for a decision, the consequences of which need to be measured in decades. Independent experts are clear that the lack of provision of risk modelling for extreme sea events occurring over the next 100 years represents a major weakness and significant danger.

4 Funding models for Sizewell C

4.1 Background

The original funding for Hinkley C and Sizewell C was based on a 'Contract for Difference' (CfD)– a government guaranteed base price for delivered power.

This method has been used successfully in the renewable energy sector and awarded by auction, a method that they can be seen to serve public interest with offshore wind prices falling: Triton Knoll at £74.50 per MWh for completion 2021/2 and Moray Offshore East with Hornsea Project Two (completion in 2022/23) at £57.50 per MWh. (BEIS figures). The latest 2019 CfD offshore wind round was awarded at £39.65- £41.61 per MWhr for the Dogger bank 3.6GW development reverting to straight wholesale prices after 15 years. (Prices quoted are set at 2012 by Government convention but are all comparable) The Contract for Difference for Hinkley C, however, has been awarded directly by government at **£92.50** per MWh (for 35 years minimum).

4.2 Regulated Asset Base (RAB) funding

EDF is now looking at RAB, 'Regulated Asset Base' for financing Sizewell C. Although many important details are not made explicit in the Consultation document, EDF would not be expected to own any of the plant. However, EDF owns the site and will be the contractor supplying the reactor and, presumably, managing the civil works. It is uncertain whether EDF be contracted to build or whether this will be subjected to the rigors of competitive tender. There is a perception that these contracts will be awarded to EDF without any external review, peer assessment or competition.

In view of EDF's construction history, (see section 2 above) the likely complexity of maintenance and dealing with the spent fuel for the plant's lifetime, the use of RAB as a new funding model might prove to be an extremely poor decision with many years of funding with no returns on investment. It is not clear if risk modelling and a failure regime are incorporated in the RAB proposals, an unproven method of funding in this situation. Arguably, the only saving grace of Hinkley's CfD, from the perspective of HM Treasury and the electricity billpayer, is that EDF receives no income until the plant is running (and the price paid for power appears to be capped). Investors in RAB, however, are unlikely to be interested unless liability (cost overruns, accident, higher running costs, high downtime, the plant is not completed or produces less electricity than expected) rests with electricity consumers and/or taxpayers (with no risk sharing proposed).

Under RAB, the 'owners', either EDF, financiers or other, would be paid during construction, unlike Hinkley C. This advance payment mechanism has been tried in the USA where two new nuclear projects, the only new nuclear since 1974, has resulted in one complete abandonment (Virgil C. Summer Nuclear Generating Station Units 2 and 3 began on March 9, 2013 but was abandoned on July 31, 2017) and the other likely to be cancelled at any time (Vogtle Generating plant). Both were way over budget and late. Under RAB, this is what we would offer EDF.

The National Infrastructure Commission has recognised some aspects of this and have publicly expressed the following: "This makes projects appear cheaper as consumers are effectively financing the projects at zero interest. At least some of the risk associated with construction costs also sit with consumers, a further hidden cost, since consumers are not paid to hold these risks in the way investors would be."

Their report, *National Infrastructure Assessment*, continues: "…it is taxpayers [more likely electricity consumers], rather than the holders of debt, who bear the risk. But this does not mean the risk, and its associated costs, have been avoided. The apparently lower financing costs represent a transfer, rather than a reduction, in risk".

Abandonment of Sizewell C at some stage is highly likely but for the builders and financiers this may only represent a reduction in profits under RAB financing. Like the Public Finance Initiative (PFI) RAB financing promises to burden the Treasury and taxpayer with an unproven and costly means of financing a project that all evidence shows has a high probability of cost overrun and an appreciable risk of abandonment.

4.3 Cost of disposal for the Spent Fuel

The following statements show that there is no understanding or shared view with regard to the cost of disposal of Spent Fuel, the most problematic and expensive item to deal with. This is not included in the 'share of waste management costs' (arising from confusion caused by Spent Fuel not being classified as waste, see 1.2)

"Government [we are told], is developing specific proposals to protect the taxpayer. Under these proposals, private sector developers would meet the full decommissioning costs and full share of waste management costs… [If they are to be] allowed to invest in new nuclear power stations. They would need to be in place before proposals for new power stations could go ahead." It continues: "The Government believes that new waste could technically be disposed of in a geological repository and that this would be the best solution for managing waste from any new nuclear power stations." *White Paper on Energy MAY 2007, MEETING THE ENERGY CHALLENGE*, clause 29 and 99.

However, Government continues: "In addition to existing wastes, there are some radioactive materials that are not currently classified as waste, but would, if it were decided at some point that they had no further use, need to be managed as wastes through geological disposal. These include spent fuel (including spent fuel from new nuclear power stations), plutonium and uranium." *BEIS*

National Policy Statement for Geological Disposal Infrastructure. A framework document for planning decisions on nationally significant infrastructure, 2008. Para.2.3.4

This position is in direct contradiction with the Environment Agency Document, "*Generic design assessment for the UK EPR*", which clearly expresses: Clause 52: "…*spent fuel will be declared as waste*…"

Despite the Environment Agency's statement, Spent Fuel, the most problematic and expensive item to deal with, is not included in the 'share of waste management costs': it is 'not waste' and can be left onsite. Private Sector Developers who were to be held so manfully to financial account for the benefit of taxpayers appear to be freed from the full responsibility of dealing with Spent Fuel.

What are the projected costs of handling UK's nuclear waste? According to the *World Nuclear Waste Report 2019*, quoting *NDA 2018, Annual Report and Accounts 2017*: "The total costs of managing all of the UK's nuclear waste is very high…As of 2006, the NDA estimated the undiscounted future costs of its task to amount to £53 billion… By 2018 this had escalated to an estimate of £121 billion... The NDA now puts an uncertainty range on its central estimate of £99–£225 billion". *The World Nuclear Waste Report. Focus Europe. 2019. Berlin & Brussels. Page 134. www.worldnuclearwastereport.org*

4.4 Future governance

There is an informed opinion that, to overcome current and future financial challenges, EDF will be restructured at some point in the future. Codenamed 'Hercule or Hercules,' EDF would be split into two entirely separate companies, EDF Bleu containing nuclear and EDF Vert for renewables. EDF Bleu is expected to become a 100% state owned company (16% of EDF's shares are currently owned by private investors). EDF Vert will be part-floated to raise funds because it has value. EDF Bleu is 'bad bank' because the liabilities are too high for it to survive without. An extraordinary corollary of this is that Hinkley C and Sizewell C may have to be placed in the 'bad bank' before they are built. *Reference: Le Figaro, Cyrille Pluyette, 4 Oct 2019 and Financial Times June 20th, 2019.*

NNBG, the builder of Hinkley C, which is 66.5% EDF and 33.5% CGN has the added problem of CGN being added to the US 'entity list' (a US blacklist) which could severely limit its operation.

The imperative to build Sizewell C would appear to be vested in ideas of private financial gain, EDF's reputational capital in their 'third generation' EPR design and an exploitable UK government eager to be seen to be resolving carbon emissions – certainly, however, it is all at the general expense of consumers, national policy advantage and the environment.

We need low-carbon power but there remains a requirement to due process.

Summary and recommendations

1. New evidence about sea-level predictions and coastal morphology and stability, including information and lessons from the Fukushima Daiichi disaster, need to be incorporated into the design and new risk modelling with particular reference to how Spent Fuel is classified and stored.

2. The latest IPCC and UN reports predict that extreme sea level events that are currently once per century are projected to occur once per year by 2050 in many places. In view of these independent and evidence based predictions it is imperative to question the decision to build Sizewell C on the beach of a vulnerable coastline and Hinkley C on the flat, low Somerset coastline that experiences some of the highest tides in the world (including a tsunami in 1607). The claim to current stability of the Sizewell C site is extremely weak and based on recent historical datasets that are of no value in assuring future site integrity and safety. It is also not possible to construct 'well-designed' coastal protection around the low-lying Sizewell and Minsmere levels that surround the proposed Sizewell C. East Anglia is flatland: much of the Sizewell Belts (1-2 Km to the East of Sizewell) are 2-4 m above sea level, the Minsmere levels (1-2Km North of Sizewell) are 1-2m above sea level on average. If the authoritative reports by the IPCC and others are accepted, then on the basis of current climate and sea level predictions both Sizewell (and Hinkley Point) can only be regarded as highly unsuitable sites.

3. Climate science is cited as the justification for nuclear power generation, it follows that climate science should inform the choice of location for new nuclear power generation. As the Institution of Mechanical Engineers tells us: "…in the UK, nuclear sites such as Sizewell, which is based on the coastline, may need… abandonment or relocation". On this basis, taken with revised predictions on sea level and new information about costal stability, we should be reviewing the assumptions made 20 years ago about the locations for new nuclear infrastructure and spent fuel storage. This review should also address actively decommissioning existing nuclear infrastructure located in vulnerable locations.

4. No new nuclear power generation should be built until there is clear and consistent policy (and investment) regarding nuclear waste disposal. Currently the Generic Design Assessment (GDA) for the EPR is in a state of absurd contradiction over Spent Fuel: Spent Fuel must be removed from site 'as soon as reasonably practical' according to the ONR (see 1.2) yet will remain onsite; the GDA confirms that It is a government 'base case condition' that a deep repository (GDF) would be constructed in time for new build EPR waste and both government and the Environment Agency declare that 'Spent Fuel is waste', meanwhile, government is saying Spent Fuel is not waste and little or no progress is made on a GDF. Government must also consider the interim period before geological disposal is possible and impose dry cask, surface storage as another base-case condition in order to deal with most of the critical 140 year highly radioactive period when the fuel is cooling. Spent fuel should be moved to dry storage within 10-20 years after reactor removal, as soon as thermal constraint allows, and Spent Fuel ponds must only be used for cooling and not as a storage facility. Much of the Sizewell C Spent Fuel will be notably hotter and more radioactive than its legacy counterpart and will contain high activity fission products as well as in the region of 27 tonnes of plutonium by the end of life of each of the two reactors. It will take several hundred thousand years

for the ingestion radiotoxicity of this Spent Fuel to become that of the uranium ore (including its decay products) from which it was derived. It needs safeguarding and removal from coastal vulnerability. (ref: *Disposal System Safety Case document NDA Report DSSC/422/0.. See:* NDA *Geological Disposal Generic Design Assessment: Summary of Disposability Assessment for Wastes and Spent Fuel arising from Operation of the UK EPR Jan 2014* page 30/32, pdf pages 38-40.

5. The proposed EPR is demonstrably far too big, powerful, complex and costly to build (and probably maintain). Some of the Flamanville EPR welds that need repairing are inaccessible to human entry and require as yet undeveloped robot technology. It also seems clear that 'break preclusion' concepts where catastrophic failure is 'deterministically ruled out' as a design assumption for structures and surrounding components, may need scrutiny. The Generic Design Assessment (GDA) for the EPR in the UK is, again, absurd in allowing significant design criteria to be delayed and established during the construction phase. We have been building reactors that are too large, complex and expensive for 30 years as pointed out by Cantor and Hewlett, with evidence, in 1986. EDF's EPRs are larger and more expensive yet: £21.5 to 23.2 billion; 245 football fields, 3 million tons of concrete, 50,000 tons of structural steel and a million litres of fresh cooling water per day. All this for 3.2GW of electricity. (The 3.6GW Dogger Bank windfarm will cost £9 billion to build - and they have the technical challenges of construction 130Km off the coast of Yorkshire).

6. Large scale nuclear power generation has never previously operated in a private market setting. All large-scale nuclear infrastructure is a liability and any non-nationalised financing model will always have the same objective of offloading the risk to the public sector, for instance the cost and problems of the long-term disposal of the spent fuel.

The imperative to build Sizewell C is not in the interests of consumers and national policy advantage. Under the CfD proposals, and possibly the RAB, private profits appear prodigious but EDF's construction history and EPR complexity reveal another side to this. Overall it will be the losses that are prodigious, almost certainly however, these losses will be for the public sector. Under RAB financing the constructors and financiers will have all the build costs covered including cost escalations and profit margins with regular payments even if the plant is abandoned.
RAB, therefore, appears completely unsuitable as a financing model for a project with the evidential uncertainty of an EDF EPR build.

Nick Scarr - [redacted]
Special thanks to Prof.Stephen Thomas, Emeritus Professor of Energy Policy, Public Services international Research Unit (PSIRU)
Special thanks to Dr Robert Winter for general advice in the editing process..
All CfD prices quoted are '2012 prices' but are comparable.
For a detailed account of the construction history of the EPR see 'EPR in Crisis', Professor Steve Thomas, 2010: https://gala.gre.ac.uk/id/eprint/4699/3/(ITEM_4699)_THOMAS_2010-11-E-EPR.pdf

Appendix 1

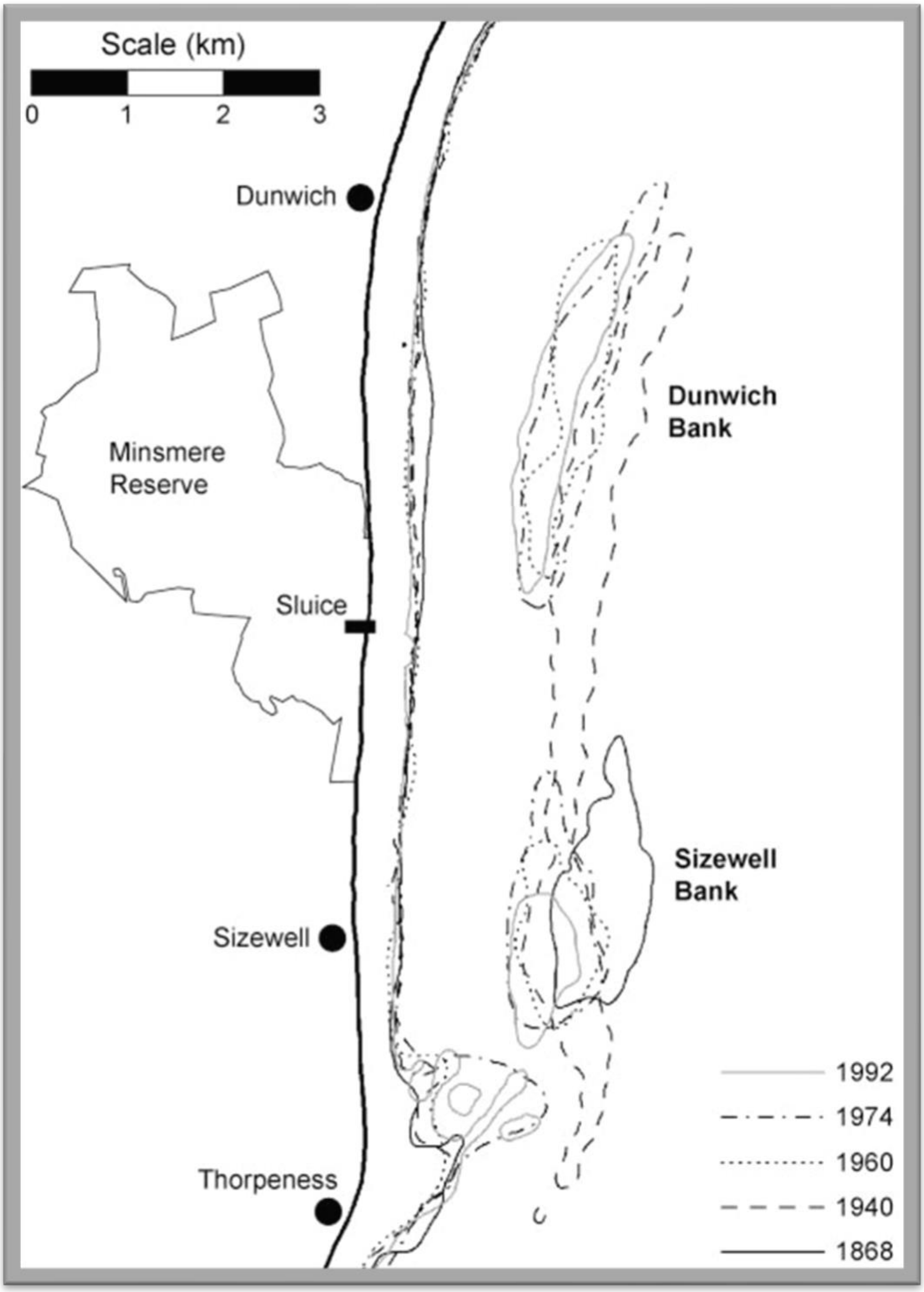
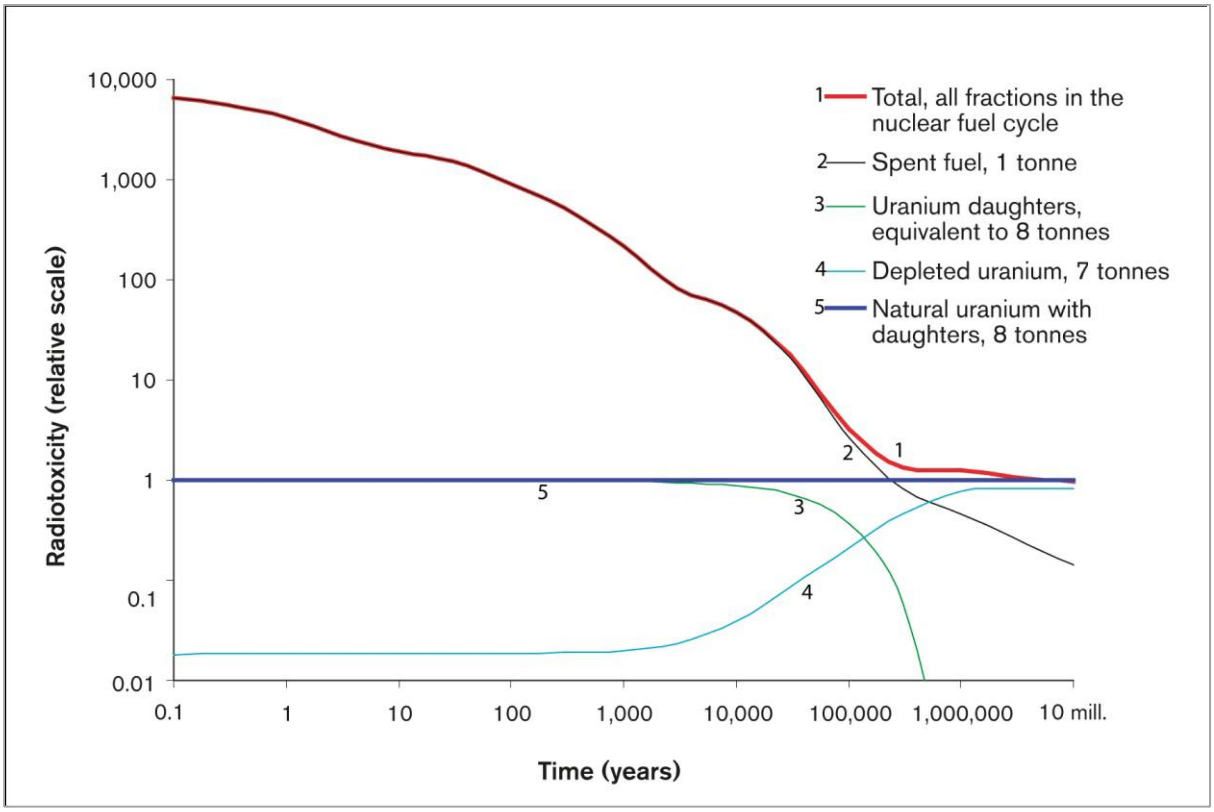


Figure 1: Historical hydrographical surveys detailed in the following chart show that the banks referred to by EDF are not stable but volatile over the longer term: The map outlines changes in the position and shape of the Sizewell-Dunwich Banks between 1868 and 1992, based on Admiralty surveys. PYE, K. and BLOTT, S.J., 2006. Coastal processes and morphological change in the Dunwich-Sizewell area, Suffolk, p46

Appendix 2



Note logarithmic scale of Time axis.

Figure 4. Graph of Ingestion Radiotoxicity comparing the ingestion radiotoxicity of Spent Fuel with that of the uranium ore (including its decay products) from which it was derived.

Relative ingestion radiotoxicity of uranium ore (line 5) and of the spent LWR fuel that could be derived from it (line 2). Line 3 describes the toxicity of the uranium decay products that are separated in the uranium mill and line 4 that of the depleted uranium that is stored at the enrichment plant. Approximately eight tons of natural uranium are used to produce one ton of enriched uranium fuel (and seven tons of depleted uranium). Source: *A. Hedin, "Spent Nuclear Fuel - How Dangerous Is It?" SKB Technical Report 97-13, Swedish Nuclear Fuel and Waste Management Co., 1997*.

Appendix 3 - Information regarding nuclear fission and EPR (Hinkley C, Sizewell C) High burnup spent fuel.

A3.1 Background – how fission works

A nuclear reactor's purpose is to create heat. This is to produce steam that will then drive a turbine and produce electricity.

In order to do this the reactor establishes nuclear fission chain reactions. Radiation is a by-product of fission and a property of the elements created by the fission process. The energy comes from 'missing mass' (a variance in the mass of nucleons depending on their existence in an independent state or the binding energy of the nucleus they are contained within).

A3.1.1 The nature of Uranium fuel and its properties.

Natural Uranium is U-238 containing a very small percentage of U-235 (0.7%) and U-234 (0.005%). The Uranium 238 must be enriched up to around 5% U-235 for EPRs, higher than PWRs and BWRs, however Magnox and CANDU reactors use natural uranium.

The new fuel rods are relatively safe and easy to handle, U-238 and U-235 having very long half-lives so not very radioactive, and do not require complex, shielded containers.

U-235 is fissile, the only naturally occurring isotope with this quality.

U-238 is not fissile, but fissionable and fertile in that it can *make* a fissile element.

These unusual characteristics are the key to heat generation.

A3.1.2 Fission, the Chain Reaction and its regulation.

U-235 will respond to thermal neutrons (slow, low energy neutrons) and break down into fission products (for example Xenon-140 and Strontium-93 plus 3 neutrons). The bulk of the released energy is in the kinetic energy of the fission products which quickly changes to heat.

This is the start of the self-sustaining chain reaction. U-235 will fission in different ways producing a range of products, the relative amounts being known from measurement. The resulting fission products are always highly radioactive.

The energy release in this fission is some 50 million times more than an equivalent burning of hydrocarbon molecules. The energy release is so large because the nucleons in the fission products are more tightly bound than the parent nucleus, this is an 'effective weight loss' and energy conversion relates to $E = mc^2$

The neutrons emitted are high velocity and need to be slowed to be effective in fissioning more U-235. This is done by a moderator. Magnox and AGR reactors use graphite; EPRs, PWRs, BWRs use light water. (Light water is H_2O, heavy water is D_2O which is used in the CANDU reactor). The moderator affects the required enrichment of the fuel (light water absorbs some neutrons).

So, the chain reaction in U-235 is established, heat builds, and radioactive fission products develop.

However, this is not the complete cycle. The Uranium 238 will also absorb some neutrons. Plutonium 239 (24,000 years half-life) is the effective result and is fissile in the same way as U-235 (which is why U-238 is regarded as fertile).

The plutonium Pu-239 created by the U-238 can now act as fission fuel and produce chain reactions in the same way as the U-235. Pu-239 fission produces approximately the same energy per fission as U-235 fission and leaves around 1- 1.3% isotopes in the Spent Fuel.

These critical chains of fissile U-235 and Pu-239 are the heat engine of the reactor; the radioactive fission products and actinides including plutonium forming the Spent Fuel.

A3.2 Efficiency of fission in nuclear reactors

It can be argued that for a given thermal energy produced in a reactor you need a fixed number of fissions of uranium or plutonium, (with an energy of 200-210MeV per fission), and hence produce a fixed amount of fission products and actinides. In theory, then we only depend upon the thermal efficiency of the reactor, rather than the burnup of the fuel, as regards the amount of fission products and long-life actinides produced per GWyear. In this respect the EPR appears to be marginally better than Sizewell B and most other PWRs around the world, marginally worse than the AGRs, and considerably better than the old Magnox reactors.

A3.3 High Burn-up fuel

High Burnup Spent Fuel of the type to be used in the new EPR reactors has been quantified for radioactivity by *Radioactive Waste Management Ltd* and the *Nuclear Decommissioning Authority*. Their datasets for high burn up Spent Fuel activity appear to show some marked nuances and particularities in the development of fission products and actinides by comparison with legacy Spent Fuel, something that EDF appears to describe as a benefit:

In clause 70 of the 'Generic design Assessment': "*EDF and AREVA claim the improvements in environmental performance of the UK EPR project with regard to waste and fuel include:*
a) a more efficient use of natural uranium resources;

b) a significant reduction in the quantity (volume, mass) of long-lived radioactive waste resulting from the fuel and its cladding owing to its: neutronic design (large core, neutron reflector) and the fuel management performance (high burn up)."

A3.4 High Burn-up Spent Fuel analysis using RWM (Radioactive Waste Management) data:

Data supplied by RWM (*Radioactive Waste Management Limited (RWM) is a wholly owned subsidiary of the NDA and is responsible for implementing Government policy on geological disposal)* suggest that by the year 2200 Sizewell C's Spent fuel will be generating 2,056,908 Tbq (Terrabecquerels) of radiation (20% of 10,284,544). By comparison, our Legacy Spent Fuel combined will be generating less radiation of 1,702,423 Tbq. This dataset is supplied by RWM is for communities to make a 'fully informed decision' about Spent Fuel. *Radioactive Waste Management Ltd, Geological Disposal, Disposal System Safety Case: Data Report December 2016,* see pages 32-34. Also, Government White paper on implementing Geological disposal, Dept Energy Climate Change, July 2014, clause 7.41.

RWM offers below a comparison of quantified descriptions of inventory extrapolated to 2200 for the radioactivity of two waste groups: legacy spent fuel waste to be managed and High Burn-up spent fuel (such as Hinkley C and Sizewell C) to be managed.

Nuclide Half Life (years)	Legacy Spent Fuel TBq	High Burn-up Spent Fuel TBq (New Build Spent Fuel NB-SF)
I- 129 5730	6.64	31.3
Cl-36 300,000	3.09	71.7
Cs-135 2,400,000	130	515
Tc-99 2.1 x 10(5)	1780	12900
Pd-107 6.5 x 10(6)	22	135
U-234 2.4 x 10(5)	393	1730
U-235 7.0 x 10(8)	3.25	6.24
Pu-239 2.4 x 10(4)	4.81 x 10(4)	2.08 x 10(5)
Am-243 7.4 x 10(3)	3660	45100
Totals for 49 Nuclides	*1,702,423*	*10,284,544*
		(2,056,908 for Sizewell C)

Columns 2 and 3 are in TBq (Terabecquerels).

This table is a small sample of 49 nuclides listed. For the full list refer to: *Radioactive Waste Management Ltd, Geological Disposal, Disposal System Safety Case: Data Report December 2016,* see pages 32-34 (16-18).

The quantified radioactivities in columns 2 and 3 are calculated for the year 2200 when it is assumed that the (not yet designed or commissioned) geological repository (GDF) will be closed. Calculation is based on half-life of the elements quoted.
The 'Waste Group' for High Burn-up is drawn from the assumption of a 16GW new build and on that basis Hinkley C and Sizewell C would represent 40% of the total new build nuclear at 6.4 GW. (clause 3.4.3 and White Paper '*Implementing Geological Disposal, Dept Energy Climate Change July 2014* where it confirms: '*The current stated industry ambition for new nuclear development is 16 gigawatt electrical',* (clause 7.41))

It could be claimed, however, in refutation of this position, that legacy Spent Fuel might only represent approximately 8GW for 20 years as much legacy spent fuel has been reprocessed and is no longer classified as Spent fuel.

It is therefore interesting to take a different approach and look at a direct comparison of Spent fuel from Sizewell B and what will be produced by Sizewell C or Hinkley C:

A3.5 High Burn-up Spent Fuel analysis using NDA (Nuclear Decommissioning Authority) data.

Below is a direct comparison of a canister of Spent Fuel from Sizewell B and what would be expected from Sizewell C:

Radionuclide	Sizewell B Spent Fuel	EPR (Sizewell C) Spent Fuel	Ratio of EPR/SZB	Half life
	TBq per canister	TBq per canister		Years
C-14	0.0645	0.311	4.8	5700 years
C-36	0.000831	0.0157	19	300,000 years
Ni59	0.000908	0.0363	40	76,000 years
Se79	0.0318	0.0101	0.32	650,000 years
Sr-90	675	1270	1.9	28.0
Tc-99	1.03	1.89	1.8	211,000 years
Sn-126	0.0567	0.0859	1.5	230,000 years
I-129	0.00239	0.00481	2	1.5million
Cs-135	0.0302	0.0722	2.4	2.3 million
Cs-137	1020	2060	2	30.0
U-233	0.0000123	0.0000291	2.4	160,000 years
U-234	0.133	0.231	1.7	245,000 years
U-235	0.00153	0.00105	0.69	700 million years
U-236	0.0215	0.0367	1.7	23 million years
U-238	0.0246	0.0236	1	4.4 billion years
Np-237	0.0328	0.0694	2.1	2.14M
Pu-238	90.9	391	4.3	87 years
Pu-239	25	31	1.2	24,000 years
Pu240	36.1	60.3	1.7	6500 years
Pu-241	123	215	1.7	14 years
Pu-242	0.124	0.39	3.2	373,000 years
Am-241	283	497	1.8	432 years
Am-242	0.732	0.821	1.1	432 years
Am243	1.14	6.26	5.5	7300 years
Sum	2256.43	4534.56		

Table: Comparison of Radionuclide activities for one spent fuel canister from Sizewell B and one spent fuel canister from an EPR such as Sizewell C at 90 years cooling. *NDA, Geological Disposal Generic Design Assessment: Summary of Disposability Assessment for Wastes and Spent Fuel arising from Operation of the UK EPR. Jan 2014*. Pages 30-32 (pdf pages 38-40).

Notes from the above chart of Sizewell B and Sizewell C data:

1) Actinides are the elements between Uranium and Americium.

2) The comparison assumes an average fuel burn rate for Sizewell B and a maximum rate of 65GWd/Ut for Sizewell C.

3) For much of the first 100 years, the radioactivity is dominated by the fission products: mainly Strontium 90 and Caesium 137 (Sr-90, Cs-137). After a few hundred years radioactivity is dominated by the transuranics: Plutonium, Americium and Neptunium (Pu,Am,Np).

4) It takes several hundred thousand years for the ingestion radiotoxicity of Spent Fuel to become that of the uranium ore (including its decay products) from which it was derived.

5) An EPR such as Sizewell C operating for 60 years at 1.6 GW(e) would produce 3,600 spent fuel assemblies which is equivalent to 37.5 spent fuel assemblies for every GW(e) year(ref, NDA, ibid.p.29). This compares with Sizewell B which would produce 46.9 spent fuel assemblies for every GW(e) year. This is clearly a volume efficiency. (ref, NDA, ibid.) The volume efficiency, however, is of debatable value in as much as greater spacing will be required around EPR (Sizewell C) Spent Fuel canisters in a GDF due to greater heat and radiation.

6) The Plutonium builds up from zero in new fuel to reach a concentration of about 1%, with a rough equilibrium being achieved between Pu being produced from neutron absorption by U238, and Pu239 being fissioned (Pu-239 becomes fuel along with the U-235). However, because the EPR is high burn-up, the Pu will have a higher percentage of Pu240 so the PU present in the spent fuel is considered lower "weapons grade". This may be significant for the national/international regulations for storage and movement.

7) The bare critical mass of weapons grade U235 is approximately 50kg and Plutonium less than 10kg.

8) This dataset appears to compare canisters at the same half-life age of 90 years.

9) The interdependency and daughter products of actinides are convoluted by creating 'build-up chains', for example: Pu-239 will decay to U-235; U-236 and U238 produce NP-237 which in turn produces Pu-238.

A3.6 – Brief note on Spent Fuel storage

The GDA (see section 1.3) makes clear that cladding degradation and stress requires that High Burnup Spent Fuel is inspected 'to maintain confidence that the fuel remains in a in a suitable condition'. It is difficult to see how this assists earlier dry surface storage or potential geological storage. We do not have a plan, design or location for a GDF (Geological storage) however, non-retrievability of the stored waste is assumed. We therefore urgently need to establish whether a GDF that meets the standards required for our High burnup new reactor Spent Fuel and our legacy material is feasible. (Legacy waste in temporary store in Sellafield comprises 65 years' worth of High Level Waste, including spent fuel from the AGRs, Sizewell B and including 146 tonnes of separated plutonium).

From:	Mignano, Kate
To:	SizewellC
Subject:	FW: EN-6 Review
Date:	13 December 2019 16:21:40

From: Nick Scarr [redacted]
Sent: 13 December 2019 13:51
To: NI Enquiries <NIEnquiries@planninginspectorate.gov.uk>
Subject: EN-6 Review

For the attention of the Planning Inspectorate

Re: Potentially suitable sites for new nuclear.

EN-6 declared that Sizewell was a 'Potentially suitable site'. This was before major reports on Climate change were published.

A non-selective analysis of data and climate science shows Sizewell to be a highly unsuitable site. I hope the new EN-6 will reflect this.

The following brief analysis validates the claim:

Background

-
The Department of Energy and Climate Change in its *National Policy Statement for Nuclear Power Generation (EN-6) July 2011,* declared Sizewell to be a 'potentially suitable site'. EDF claims on their wesbite that this confers approval for the site and makes the choice of location 'outside the scope for ongoing consultation'.
https://www.edfenergy.com/energy/nuclear-new-build-projects/sizewell-c/proposals.

This decision, however, was taken before the main Climate Science reports were published. (The IPCC report was published in 2019, (*IPCC The Ocean and Cryosphere in a changing climate 24th Sept 2019*) and *UKCP18* was published in 2018.)

The National Policy Statement clause 1.6.1 states: 'This NPS will remain in force in its entirety unless withdrawn or suspended in whole or in part by the Secretary of State. It will be subject to review by the Secretary of State to ensure that it remains appropriate.'

This review of site suitability is active as of today's date (13/12/2019) and should result in a BEIS consultation.

-

Minsmere and protected areas.

-
RSPB Minsmere nature reserve is adjacent to the proposed development site on the Suffolk Coast and has been a nature reserve since 1947. It is a flagship site for both wildlife and visitors. Minsmere forms part of a wider area of the Suffolk Coast widely recognised for its value for

wildlife.
The Suffolk Coast is an outstanding location for wildlife and people alike, with a rich and varied mosaic of habitats providing a landscape of wild beauty. It is a safe haven for an amazing variety of wildlife including iconic species such as the bittern, marsh harrier and otter. (Ref, RSPB website Minsmere) Besides being in an Area of Outstanding Natural beauty it is protected by a number of national and international nature conservation designations. These include:

- SSSI (a type of protected area with special or exceptional wildlife features)
- SPA (European designation for rare and vulnerable birds)
- SAC (European designation designed to protect habitats and wildlife species)
    - Ramsar site (for wetlands of international importance)

Coastal morphology, stability and changes in sea level.

-
Dunwich, which was 5km from the proposed site for Sizewell C, has already been lost to coastal erosion. This erosion occurred before any of the expected rising median sea levels as defined in UKCP 18 (the government's accepted reference document for same) and in the 2019 IPCC (Intergovernmental Panel on Climate Change) report.

EDF claims that the site benefits from a 'micro-stability' which is related to the ridges of sub-sea coralline crag.

Technical note : According to the '*Thorpeness Coastal Erosion Appraisal Final Report December 2014, Mott Macdonald',* the geological feature of greatest significance to Thorpeness, (Thorpeness is located at the southern end of the Greater Sizewell Bay) is the ridge of Coralline Crag composed of cemented iron-stained Pliocene shelly sand that extends north-eastwards from Thorpeness beneath the modern beach sediments. This offers resistance to erosion compared with the other deposits. It has been suggested that the position of the Ness to the north of Thorpeness is comparatively fixed by this geological unit which also serves to anchor the SDBC (Sizewell Dunwich Bank Complex) –The Coralline Crag ridge under Thorpeness is also recognised as being important in protecting the Sizewell coast (EDF, 2002). A slight 'headland' at Thorpeness occurs because these relatively more resistant rocks occur at the base of the cliff, and they extend out to form the offshore seabed. The geomorphological erosion dynamic of the shoreline is approximately 30 years and is subjected to periods of erosion lasting several years. '*Thorpeness Coastal Erosion Appraisal, Final Report, December 2014, Mott Macdonald.'*

Technical note : Crag is an East Anglian term for the sedimentary rocks of shelly sand characteristic of the area.

Technical note : The largest waves recorded by a Waverider buoy deployed offshore from the Sizewell-Dunwich Bank complex (SDBC) in 18m of water from 11 February 2008 to 24 February 2011 had a mean direction, q, of 155° (the direction of travel), a significant wave height, Hm0, of 4.71m (15.45 ft) and peak period, Tp, of 9.1s (wave power, Pw, 1.54 x 105J/m/s) see: Thorpeness Coastal Erosion Appraisal Final Report December 2014, Mott Macdonald, p.15. This is interesting to consider with regard to future climate change predictions for wave height and frequency.

EDF's proposed cooling water outfall pipes for Sizewell C are designed to avoid the erosion of these offshore banks. EDF is here admitting that they must consider their stability critical.

A historical hydrographical survey chart in Appendix 1, however, shows that offshore banks are not stable over the longer term. The map outlines changes in the position and shape of the Sizewell-Dunwich Banks between 1868 and 1992. *See Appendix 1 or PYE, K. and BLOTT, S.J., 2006. Coastal processes and morphological change in the Dunwich-Sizewell area, Suffolk, p466.*

It is also the case that "…the area north of Sizewell Power Station is still experiencing periodic storm erosion. This may be related to changes in the nearshore and offshore morphology, including the development of a gap between the crests of the Sizewell and Dunwich Banks through which waves are able to penetrate". Op. cit., PYE, K. and BLOTT, p464.

Sea level changes, storm surges and flooding: expert opinion

UKCP18, the Met Office document for climate projection confirms the accepted science of significant median sea level rises into the next century. Historical coastal erosion and flooding already experienced by this coast will reach new heights and intensities. The IPCC (Intergovernmental Panel on Climate Change) reported on 24th Sept 2019 stated that extreme sea level events that are rare (once per century) are projected to occur at least once per year by 2050 in many places. (IPCC The Ocean and Cryosphere in a changing climate 24th Sept 2019, page spm-22)

The IPCC report continues: 'Under the same assumptions, annual coastal flood damages are projected to increase by 2–3 orders of magnitude by 2100 compared to today *(high confidence*)'. *(spm-32).*

'In the absence of adaptation, more intense and frequent extreme sea level events, together with trends in coastal development will increase expected annual flood damages by 2-3 orders of magnitude by 2100 (*high confidence*). However, [the report suggests], well-designed coastal protection is very effective in reducing expected damages and cost efficient for urban and densely populated regions, but generally unaffordable for rural and poorer areas (*high confidence*).' *IPCC, Page 516 of 1170.*

It is not possible to construct 'well-designed' coastal protection around the low-lying Sizewell and Minsmere levels that surround the proposed Sizewell C. East Anglia is flatland: much of the Sizewell Belts (1-2 Km to the East of Sizewell) are 2-4 m above sea level, the Minsmere levels (1-2Km North of Sizewell) are 1-2m above sea level on average.

The floods of 1953 that submerged huge areas of this part of Suffolk - a typical once per century event - were caused by a 2m surge. Consider, then the flooding possibilities when a 1-2m median sea level rise represents the baseline and these major floods become 'at least once per year' as the IPCC report states. This is presumably why many suggest that Sizewell B and C will, at best, be islands within the near future on their 6.4m and 7.3m plinths above sea level respectively.

According to the Institution of Mechanical Engineers (IME) "…in the UK, nuclear sites such as Sizewell, which is based on the coastline, may need considerable investment to protect it against rising sea levels, or even abandonment/relocation" IME (Institution of Mechanical Engineers) (2009): Climate Change: Adapting to the inevitable, Institution of Mechanical Engineers, Westminster, London.

Therefore, UKCP18, the IPCC, and the Institute of Mechanical Engineers are all of the same opinion, independently stating that a coastal location is vulnerable: 'abandonment and relocation' of Sizewell power stations are strong terms to come from the IME, a professional organisation not noted for hyperbole.

The case for acceptability of the site location, EDF's claim to 'micro-stability,' is largely predicated up on the so-far safety of Sizewell A and B which have been subjected to, and survived, tidal surges.

This approach raises an important question in relation to the analysis of information and interpretation of evidence: the site for Sizewell C is arguably only suitable if we restrict analysis to recent historical data and we ignore evidence-based climate science predictions. Climate science is the justification for building Sizewell C in the first place, climate science is used to justify the need for the project but has been interpreted in a highly selective manner when it comes to the choice of location. EDF owns Sizewell so it wants to build there.

In summary, the NPS (National Policy Statement) that declared Sizewell to be a 'potentially suitable site' for newbuild reactors is outdated by UKCP18 and IPCC reports that it was unable to consider. The claim to current stability of this coast is weak and based a highly selective interpretation of historical expert evidence. If climate change predictions are accepted and a full risk analysis undertaken on this basis to define security, then it is reasonable to conclude that both Sizewell (and Hinkley Point) are highly unsuitable sites. The excessive reliance on historical data (essentially no more than stating that because an event has not caused damage in the past it is unlikely to in the future) is of itself no basis for a decision, the consequences of which need to be measured in decades. Independent experts are clear that the lack of provision of risk modelling for extreme sea events occurring over the next 100 years represents a major weakness and significant danger.

Regards
Nick Scarr

From: [redacted]
To: SizewellC
Subject: Sizewell C - proposed
Date: 05 January 2020 11:22:09
Attachments: Summary document - Sizewell C - Safety, capability and capacity, environmental health and funding - a 2020 perspective, Jan 20.pdf
Sizewell C - Safety, capability and capacity, environmental health and funding - a 2020 perspective, Jan 20.pdf

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Dear Planning Inspectorate,

I understand the proposed application to planning will be made for Sizewell C in Quarter 1 of this year.

EDF has not met its obligations to clarity on this proposal and an application for a DCO appears defacto improper and should be rejected at first sight.

Please find enclosed my finalised paper on Sizewell C (including a brief Summary Document).

The paper is supported and approved by acknowledged experts in the field - Prof. Stephen Thomas and Dr Paul Dorfman to name two.

The paper covers the following areas:

1) Safety including the contradictory classification of Spent Fuel, its indeterminate storage onsite and undisclosed nature, undisclosed cooling requirements, management, storage and handling.
2) Environment and location - how climate science must inform choice of location for new nuclear build.
3) The build programme - the capability and capacity of EDF.
4) The unsuitability of RAB finance.

Regards

Nick Scarr

Sizewell C – Safety, capability and capacity, environmental health and funding – a 2020 perspective.

The 1976 Royal Commission on Environmental Pollution concluded: 'There should be no commitment to a large program of nuclear fission power until it has been demonstrated beyond reasonable doubt that a method exists to ensure the safe containment of long lived, highly radioactive waste for the indefinite future.'

This paper, a response to Electricité de France SA's (EDF)'s public consultation, will examine the proposed construction of Sizewell C with particular reference to spent fuel storage and how little has been achieved since 1976, construction history, site location and the method of financing.

1 – Safety: The handling of nuclear waste, with particular reference to Spent Fuel.

1.1 Background

New fuel rods are relatively safe and easy to handle. The main components are Uranium-238 and Uranium-235 that have very long half-lives and do not require complex, shielded containment. Once in the reactor, a neutron-induced, chain reaction fission is established in order to produce heat. After 1-3 years the fuel rods become 'Spent' in that they lose their efficiency and are removed from the reactor core. The Spent Fuel now contains fission products, some with short half-lives that are intensely radioactive and transuranic elements including plutonium that have much longer half-lives. It takes several hundred thousand years for the ingestion radiotoxicity of Spent Fuel to become that of the uranium ore (including its decay products) from which it was derived. It also generates high levels of heat. Although this decay heat falls rapidly in the Spent Fuel after reactor removal, it requires cooling for 140 years before reaching sufficiently low enough temperatures for geological storage requirements. It also requires effectively shielding indefinitely.

Technical note 1: For Spent Fuel heat information see Hinkley C documents (the Pre-Construction Safety Reports, PCSR). The reactor thermal power will be 4500MW of which 97.4% is developed in the fuel and the full weight of the reactor core is 127 tonnes of uranium giving a heat loading of 34.5 MW per tonne uranium. For the cooling period of 140 years, see: NDA Geological Disposal Generic Design Assessment: Summary of Disposability Assessment for Wastes and Spent Fuel arising from Operation of the UK EPR Jan 2014 section 6, page 6.

Technical note 2: The toxicity of a radionuclide is dependent on its activity, and on what type of radiation its radioactive disintegration (decay) gives rise to. A distinction is made between two types of radiation: external and internal. External radiation is emitted by an external radiation source and penetrates the body from the outside, internal radiation comes from radioactive substances that enter the body, via ingestion or inhalation. Most radionuclides are more toxic if they are inhaled than if they are ingested. Ingestion radiotoxicity is a tangible, quantifiable measure of the environmental and health risk associated with Spent Fuel. See, 'Spent nuclear fuel - how dangerous is it? A report from the project "Description of risk." Allan Hedin, Swedish Nuclear Fuel and Waste Management Co, Stockholm, Sweden March 1997' and IPFM, 'Spent Fuel from Nuclear Power Reactors, 2011', p.4. See Appendix 2 for a graph of ingestion radiotoxicity.

1.2 Proposed treatment of Spent Fuel at Sizewell C

It is proposed that the Spent Fuel produced over the full lifetime of operation of Sizewell C is to be stored onsite. This is despite clause 112 in the *Generic design Assessment UK EPR (Spent Fuel)*, which says: 'The ONR [Office Nuclear Regulation] have an assessment finding …to reduce the onsite storage period for the spent fuel produced by the reactor so that the fuel can be transported as soon as reasonably practical.' EDF has expressed no interest in reprocessing the Spent Fuel and we have no independent policy to do so. The construction of a new Geological Disposal Facility (GDF) was defined as a 'Base Case' requirement for new reactor build and ultimate disposal of Spent Fuel produced by new-build reactors: "we [The Environment Agency] note that the Government base case for new build is that a facility for long term storage of high-level waste and spent fuel will be available in time to receive the wastes from new reactor build." *'Generic design assessment UK EPR nuclear power plant design by AREVA NP SAS and Electricité de France SA, Final Assessment Report Spent Fuel,' clause 118.*

The paper continues: "EDF and AREVA take account of Government policy in their IWS [Integrated Waste Strategy], noting that spent fuel will be declared as waste and…then disposed of to the geological disposal facility" *op.cit., Clause 52.*

Also, according to the Government White Paper on Energy, *MAY 2007, MEETING THE ENERGY CHALLENGE, Clause 29 and Clause 99*: "Private sector developers would meet the full decommissioning costs and full share of waste management costs… [If they are to be] allowed to invest in new nuclear power stations…Government believes that new waste could technically be disposed of in a geological repository and that this would be the best solution for managing waste from any new nuclear power stations."

At present, however, Government, does '*not currently classify Spent Fuel as waste*', making a mockery of the Generic Design Assessment (GDA). Spent Fuel is not included in these waste commitments and will only be stored in a GDF 'at some future time if it becomes re-classified as waste'. See Government White Paper '*Implementing Geological Disposal, Dept Energy Climate Change July 2014, clause 2.11,2.17".*

In summary, Spent Fuel may be classified as waste when it becomes less radioactive at some unspecified future date. However, Spent Fuel is highly radioactive, especially in the first 200 years, and although it serves no further purpose in power generation it is not considered to be waste, thus is separated from a major range of safety, risk and environmental recommendations.

1.3 Expert opinion on safety and technical issues of Spent Fuel for Sizewell C

In its *Initial Proposals and Options Consultation Stage1, para 2.2.16,* EDF declares that their new EPRs (The abbreviation generally expands to 'European Pressurised Reactor' and occasionally 'Evolutionary Power Reactor' and is the reactor type for Hinkley C and Sizewell C) will generate less spent fuel than existing reactors in the UK. This statement is a little misleading. Less Spent Fuel means 'High Burn-up' - the uranium fuel rods (with higher enrichment than legacy to 4.9% U-235) stay in the reactor longer than in earlier conventional reactors and can run up to 65,000 MWd/tU (Megawatt days per tonne of Uranium). Advance Gas Cooled Reactors (AGRs) are 5000-30,000 MWd/tU for comparison.

While reactor coolant temperatures still have a maximum of 310 degrees C, the high power of the EPR is coming from a larger core and more fuel (hence the requirement for a million litres of fresh cooling water every day) rather than burning at higher temperatures, however the High Burn-up Spent Fuel, when removed from the reactor is more delicate, more radioactive and hotter than 'conventional' spent fuel. EDF has ONR (The Office for Nuclear Regulation) approval for high burn-up suggesting that safety systems are regarded as acceptable. (see appendix 3 for examples of the extent of the higher radioactivity of High Burn-up spent fuel). Also, *NDA Geological Disposal Report, March 2010 no. NDA/RWMD/013, page 11*; *See Generic Design assessment p.9 for water requirements.*

Incorporated into the EDF design are containment and core-catcher structures to ensure that there is no large-scale release of radioactivity to the environment in the event of a core meltdown (as happened at Chernobyl and Fukushima). However, outside the reactor containment zone with no 'core catcher' facility, are the Spent Fuel ponds that will contain approximately a full reactor core's worth of 'spent' fuel rods every 3-4 years (there are 241 fuel assemblies per core). Because of the higher heat and radioactivity of the high burnup Spent Fuel, it is recognised that safety margins need to be more rigorous and will depend on the effective and continuous removal of significant thermal power. Failsafe technologies will need to be incorporated at every stage of this process to mitigate risk as all these systems are vulnerable to mechanical failure, deliberate disruption or flood yet must operate flawlessly for 'an extended cooling period' (decades) until the spent fuel has cooled sufficiently to be moved.

High Burnup is an exercise in reducing fuel cycle costs for the operator, however, High Burnup Spent Fuel is subject to a range of failures predominantly associated with increased cladding degradation: corrosion, hydrogen pickup and associated stresses, cladding and pellet interactions, internal fuel rod pressures, hoop stresses and, perhaps most importantly, failure tendency of High Burnup Spent Fuel may increase in a LOCA (Loss of Cooling accident). It seems clear that a full risk analysis on all aspects of High Burnup fuel use is not yet fully established.
IAEA - International Atomic Energy Agency: High Burnup Fuel: Implications and Operational Experience. Proceedings of a technical Conference Buenos Aires Nov 2013. IAEA-Techdoc -CD-1798, Page 119.

This uncertainty of cladding integrity is raised in clauses 109 and 110 of the *Generic design Assessment UK EPR (Spent Fuel): "*'The ONR commissioned the National Nuclear Laboratory (NNL) to carry out work to identify mechanisms that could lead to early failure of the fuel cladding or the fuel assembly during storage… There will be requirements for regular maintenance inspections on the fuel condition over the storage period, to maintain confidence that the fuel remains in a suitable condition". *'Generic design assessment UK EPR nuclear power plant design by AREVA NP SAS and Electricité de France SA, Final Assessment Report Spent Fuel'.*

1.4 The Cooling period, interim and long-term storage for Spent Fuel

According to the Environment Agency document, '*Generic design assessment UK EPR nuclear power plant design by AREVA NP SAS and Electricité de France SA. Final Assessment Report Spent Fuel, Clause 129:'* "NDA has published a generic Disposal Systems Safety Case (gDSSC) for a future Geological Disposal Facility (GDF), based on its understanding of the scientific and engineering principles supporting geological disposal (RWMD, 2010)…The review therefore confirms that there are no new issues arising from the generic DSSC that would challenge the fundamental disposability of the wastes and spent fuel expected to arise from operation of the AP1000 and EPR."

The expertise of the NDA's *Radioactive Waste Management Directorate (RWMD)* is acknowledged, however, it is essential to recognise that in the proposal for Sizewell C, there is no Geological Disposal Facility (GDF), no site for a GDF, and no design for a GDF.

There is also no consensus as to what the Cooling Period should be. Initial cooling must take place in in the Spent Fuel ponds for 'some years' followed by an 'extended period' of dry surface storage. The Generic Design Assessment (ibid. clause 113), suggests an 'assumed period of 10 years… or up to 15 years in the Spent Fuel Pool' but that there is 'sufficient flexibility in the Spent Fuel Pool design to allow the Licensee (EDF) to meet any cooling constraints'. According to the Nuclear Decommissioning Authority (NDA): "In order to ensure the performance of the bentonite buffer [the clay encasement in a GDF], a temperature limit [is required.] Based on a canister containing four EPR fuel assemblies, each with the maximum burn-up of 65 GWd/tU and adopting the canister spacing used in existing concept designs, it would require of order of **140** years for the activity, and hence heat output, of the EPR fuel to decay sufficiently to meet this temperature criterion." *NDA Geological Disposal Generic Design Assessment: Summary of Disposability Assessment for Wastes and Spent Fuel arising from Operation of the UK EPR Jan 2014 section 6, page 6.*

Directly relevant to this debate is the Fukushima disaster: "When the earthquake and tsunami knocked out the cooling systems …several spent-fuel-rod pools also lost electric power, shutting down pumps. Water in the cooling pools stopped circulating and began to boil off or leak out. As the water level fell, the spent fuel rods were exposed, and their temperatures soared. Several began to melt down, releasing extremely high levels of radiation into the air". *(The Week, 'Radioactive fuel rods – the silent threat. April 8th, 2011).*

Technical Note 3: In view of the Fukushima accident it is therefore a concern that EDF and AREVA can consider "long term wet storage of fuel as a solution that can be shown to be ALARP" - (risk as low as is reasonably practical). Their viewpoint, reported in the 'ONR Generic Design Assessment' continues: "…spent fuel can be stored safely in a long-term storage pool for the following reasons: Due to low storage temperatures and satisfactory water chemistry, the preservation of cladding integrity is ensured which in turn guarantees the retrievability of stored assemblies at any time during storage. Monitoring of the assemblies is simple and inspection is performed regularly. Other systems such as ventilation, filters or make-up water add to the safety of the facility. The pool water inertia gives the operator a grace period sufficient to deal with incidents before the fuel integrity is compromised. The option also offers flexibility in the long-term management of spent fuel and in the retrieval of assemblies." ONR - Generic Design Assessment – New Civil Reactor Build, Step 4

Radioactive Waste and Decommissioning Assessment of the EDF and AREVA UK EPR™ Reactor Assessment Report: ONR-GDA-AR-11-030 Revision 0 11 November 2011. Clause 192.

Clearly, fuel pond storage makes inspection of Spent Fuel much simpler but is undoubtedly at the cost of overall plant security in event of a LOCA (loss of coolant accident) affecting the Spent fuel ponds.

The full analysis of the contribution of Spent Fuel in ponds to the radioactive debris and fallout from the Fukushima disaster will take time because of the ensuing chaos, however, it is clear that Spent Fuel storage ponds will suffer water evaporation in a LOCA (loss of cooling accident) followed by possible ignition of the Spent Fuel zirconium cladding and a release of volatile radioactive fission products. As stated earlier *(1.3)* there may be an increased failure tendency in High Burnup Spent Fuel over legacy Spent Fuel in this situation. This could prove to be a greater source of a radiation leak than from the reactor itself. If the reactor has a cooling problem, it is within a strong internal containment vessel surrounded by an external containment vessel and has the benefit of a core-catcher. This is not so for the Spent Fuel ponds, which after a mere 10 years reactor operation will contain the Spent Fuel of approximately three complete reactor cores.

Technical note 4: Article published by Mari Yamaguchi, Associated Press, Dec 1, 2019, 8:50pm. 'Fukushima melted fuel removal begins 2021, end state unknown', FUEL RODS:

"Together, the three melted reactors have more than 1,500 units of mostly used nuclear fuel rods still inside that must be kept cool in pools of water. They're among the highest risks at the plant because the pools are uncovered, and loss of water from structural damage or sloshing in the event of another major earthquake could cause fuel rods inside to melt and release massive radiation."

"TEPCO started removing the fuel rods from the Unit 3 pool in April 2019 and aims to get all 566 removed by March 2021. Removal of the rods from Units 1 and 2 is to begin in 2023. By 2031, TEPCO also plans to remove thousands at two other units that survived the tsunami to be stored in dry casks on the compound. More than 6,300 fuel rods were in six reactor cooling pools at the time of the accident, and only the Unit 4 pool has been emptied."

In Summary, Spent Fuel is a high risk to the environment in event of a LOCA when in onsite cooling ponds. High burnup Spent fuel being hotter and more radioactive than legacy will increase the hazard. The Generic Design Assessment's position that there will be an 'assumed period of 10 years… or up to 15 years in the Spent Fuel Pool... but there is sufficient flexibility in the design to meet any cooling constraints', shows a lack of concern for this danger. Post-Fukushima this is not a defensible stance: Spent Fuel must be transferred from ponds into the more secure containment of dry cask surface storage immediately thermal constraints permit.

For geological disposal Government has been clear that communities hosting nuclear waste and Spent Fuel should be 'fully informed' and provided with a 'detailed and complete picture of the possible inventory'. Communities should also be able to enter into 'formal discussions with, and have access to information from', the developer. Considering that East Suffolk is obliged to host all EDF's Spent Fuel produced over the 60-year lifetime of the plant plus 140 years beyond, it is essential that the local communities should be afforded the same guidelines offered to those hosting geological disposal. It is important to note that in the copious amount of documentation produced by EDF in the four stages of 'Public Consultation' on Sizewell C there is no meaningful information on

Spent Fuel, nor how EDF's Spent Fuel is to be cooled, packaged and stored. In addition, communities must be satisfied that high burn-up procedure, which provides fuel-cycle cost benefits for EDF but lacks full empirical data on the implications for the Spent Fuel in medium- and long-term storage, does not represent moral hazard. EDF is duty-bound to open a further public consultation on Spent Fuel in order to fully address their ambiguous omission.

For information on involvement of Communities see: Dept Energy Climate Change Implementing Geological Disposal, A Framework for the long-term management of higher activity radioactive waste, July 2014, section 2,3,7.

2 – Capability and Capacity: Evidence and experience, 2005-2019.

2.1 Background

The following is a review of attempts at building the EPR pressurised water reactor - the design intended for Sizewell C, designed by Framatome and EDF. Over the period of construction, described below, the problems, both technical and financial, caused by the projects to the companies involved have variously resulted in joint operations, mergers, name changes, record losses, legal damages and interventions (bailout) by the French State. EDF is now a majority shareholder in Framatome.

2.2 Olkiluoto 3

The first EPR order was Olkiluoto 3, in Finland, started in 2005 and intended to be live in 2009. It is more than three times overbudget with a scheduled start date in 2020 (fuel loading is expected to take place in early 2020). This was a 'turn-key' fixed price project for €3bn and losses and damages to the supplier Framatome are so massive that its parent company Areva was effectively bankrupted with subsequent bailout transferred financial liability to the French State. The most recent cost calculation is €11bn for this 14-year project that is yet to generate any power.

2.3 Flamanville 3

Flamanville 3 EPR, in North West France, was an Areva NP/EDF project started in 2007 for completion in 2012 at a stated cost of Euros 3.3 billion. In 2012 EDF announced estimated cost escalation to Euros 8.5 billion and 2016 completion and in 2014 much the same story again. In July 2019 EDF announced a further delay of three years to 2022/2023 so Flamanville 3 will be at least 11 years late and 4 times over budget at €12.4bn. A further delay in this construction has occurred because more than 50 welds were found to be sub-standard. All will have to be repaired, however 8 of the welds are now inaccessible requiring as yet undeveloped robot technology. This brings to the fore EDF's 'Break Preclusion' concepts where, it is claimed, certain highly stressed components such as main steam lines (VVP) are built to such standards that catastrophic failure is 'deterministically ruled out'.

Technical note 5: 'For the EPR, implicit in the submission is that gross failure of the Reactor Pressure Vessel is discounted, together with discounting gross failure of any of the four Steam Generators and the Pressuriser. By comparison, gross failure of certain piping is explicitly discounted (a claim) based on a set of arguments and *evidence referred to as 'Break Preclusion'. HEALTH AND SAFETY EXECUTIVE HM NUCLEAR INSTALLATIONS INSPECTORATE New Reactor Generic Design Assessment (GDA) - Step 2 Preliminary Review Assessment of: Structural Integrity Aspects of AREVA/EdF EPR. P. 2.24*

Technical note 6: The French Nuclear Regulator (ASN) Advisory committee for Nuclear Pressure Equipment held a Meeting in Montrouge on 09 and 10 April 2019 to examine the approach to the processing of deviations affecting the break preclusion category welds on the main steam lines (VVP lines) of the Flamanville EPR reactor: 'The Advisory Committee considers that unless EDF agrees to waive all or part of the break preclusion process, it must carry out conformity work on these penetrations…The Advisory Committee observes a particularly high number of deviations encountered in the technical choices, the production processes, the acceptance results and in the external monitoring…which come on top of inappropriate filler material choices, leading to a level of quality well below that which was required… These deviations are notably indicated by certain very low toughness values obtained on test specimens….These points represent major obstacles to application of a break preclusion approach… [however] The Advisory Committee also familiarised itself with the difficulties expressed by EDF regarding the abandonment of the break preclusion approach for the pipes concerned…' ASN (The French Nuclear Regulator) GROUPE PERMANENT D'EXPERTS POUR LES EQUIPEMENTS SOUS PRESSION NUCLEAIRES, 'Avis relatif à la démarche d'EDF de traitement des écarts affectant les soudures des lignes principales de vapeur en exclusion de rupture du réacteur EPR de Flamanville', Réunion tenue à Montrouge les 09 et 10/04/2019

Technical note 7: The unsatisfactory welds mentioned above are a consequence of, 'break preclusion requirements…not being transmitted by Framatome to its supplier in charge of the VVP pipe manufacturing operations. The supplier thus applied the provisions of the RCC-M code, which are not sufficient for the adoption of a break preclusion approach'. ASN, Montrouge 20 June 2019, Technical Notice, Flamanville EPR reactor, Deviations affecting the welds on the main steam lines at the Flamanville EPR reactor containment penetrations.

The capability and capacity, therefore, to undertake and monitor agreed safety protocols and safeguards appears to be uncertain.

2.4 Taishan

Taishan's EPRs in China, supplied by Areva in which EDF has a minority stake and is involved in the construction has fared better but still 4-5 years late (this is far more delay than most other reactors in China). The conformity between Taishan's reactors and European versions may differ in some respects, but because costs and much other information are not in the public domain it is not possible to draw any further conclusions.

2.5 Hinkley C

As far as Hinkley C is concerned – a joint operation between EDF and China's CGN (China General Nuclear Power Group, a Chinese energy corporation under the SASAC - the State-owned Assets Supervision and Administration Commission of the State Council of China)- cost estimates so far have risen to £21.5 to 23.2 billion with a claimed online date of 2025-7 for the first unit. Based on experience we might reasonably assume this will change. (How CGN's US Government 'entity list' problem will affect the build at Hinkley is not yet known but can hardly be described as helpful.) The first cost overrun of £2.9 Billion has been announced on Sept 19 with unspecified delay.

Professor Steve Thomas, Emeritus Professor of Energy Policy, Public Services International Research Unit (PSIRU), Business School, University of Greenwich, an acknowledged expert on EPR build programs, has raised the following concerns over the Hinkley Point C design which, as of December 2019, remains unfinished:

The Hinkley deal was agreed in Oct 2013 giving EDF plenty of time to complete the 'Balance of Plant'. The term, Balance of Plant, refers to all the supporting components and auxiliary systems of a power plant needed to deliver the energy other than the generating unit itself and is a process that is relatively short and simple. EDF claimed that they would not pour concrete until design completion, yet design has slipped to 2022 and first concrete was poured in December 2018. Why has EDF not completed the design?

The EPR underwent a Generic Design Assessment (GDA), that relates to the whole design in detail except for non-safety critical, site-specific details such as taking account of local geology. However, the incomplete design also involves the Instrumentation & Control system which is clearly safety critical. The French, Finnish and US regulators (the design was planned for USA and went into their equivalent of the GDA) differed over the redundancy in the back-up system. The UK claims it will look at experience in these projects and decide later.

The ONR (Office of Nuclear Regulation) has a 'traffic light' system to show the status of design issues. If the light is grey, the design issue is resolved, if green, it is on target to be resolved in the required time, if amber, there will be problems completing the review by the scheduled date and if red there is next to no chance it can be resolved in time. For the Hinkley EPR, by Aug 2012, red lights remained but, surprisingly, by December, they had all gone to grey and the GDA was given. The ONR had seemingly agreed that these remaining design issues would be resolved in the construction phase, effectively making a mockery of the GDA process. *Steve Thomas Emeritus Professor of Energy Policy Public Services International Research Unit (PSIRU) Business School University of Greenwich 30 Park Row London SE10 9LS UK*

2.6 Expert assessment of EPR construction.

All the evidence proves beyond reasonable doubt that EDF's construction record for EPR is extremely poor with not a single European EPR yet operational from a 2005 start. Given this lack of effective leadership or progress, the capability and capacity of EDF to undertake and monitor any agreed safety protocols or safeguards is questionable. The welding contractor at Flamanville was not informed that they should have been working to 'break preclusion' standards on the main VVP steam line pipe manufacturing operations. This is an indefensible omission as the consequences of subsequent failure would clearly be disastrous. *See Technical notes 5-7.*

The design of the Hinkley plant remains incomplete and the GDA process rendered debatable by deferring significant design criteria 'to the construction phase'.

It is important to recognise that commitment to these projects has resulted in major disruption for the nuclear industries of France. The EPR design was an attempt at better safety after the Chernobyl and Three Mile Island disasters but the evidence shows it is clearly beyond reasonable complexity and cost with not one project completed, and not a single Watt of energy delivered in Europe after 15 years of multi-billion pound investment.

An investigation ordered by the French Government in 2009, long before the extent of the problems at Olkiluoto, Flamanville and Taishan had become apparent, and chaired by a former CEO of EDF, Francois Roussely, found much the same in stating that build 'complexity' was the fundamental difficulty: '[t]he complexity of the EPR comes from design choices, notably of the power level, containment, core catcher and redundancy of systems. It is certainly a handicap for its construction, and its cost. These elements can partly explain the difficulties encountered in Finland [and] Flamanville.' see: *'The EPR in Crisis, Prof. Steve Thomas, PSIRU University of Greenwich, London'*

EPRs, being so complex to construct must equally be complex to maintain. Technologies such as ultrasound, dye penetrants and spark optical emission spectrometry (OES) have been critical in finding fractures and carbon flaws that have been a major bugbear of the industry and these tests are imperative to the safety of any nuclear installation. The complexity, redundancy and spatial limitations of the new EPR have become too challenging – access is limited or impossible for some structures resulting in EDF relying on 'break preclusion' to void these tests on some highly stressed components.

3 – Environment

3.1 Background

The Department of Energy and Climate Change in its *National Policy Statement for Nuclear Power Generation (EN-6) July 2011,* declared Sizewell to be a 'potentially suitable site'. EDF claims on their wesbite that this confers approval and makes the choice of location 'outside the scope for ongoing consultation'. https://www.edfenergy.com/energy/nuclear-new-build-projects/sizewell-c/proposals.

This decision, however, was taken before the main Climate Science reports were published. (The IPCC report was published in 2019, (*IPCC The Ocean and Cryosphere in a changing climate 24th Sept 2019*) and *UKCP18* was published in 2018.)

The National Policy Statement clause 1.6.1 states: 'This NPS will remain in force in its entirety unless withdrawn or suspended in whole or in part by the Secretary of State. It will be subject to review by the Secretary of State to ensure that it remains appropriate.'

This review of site suitability is active as of today's date (13/12/2019) and should result in a BEIS consultation.

3.2 Minsmere and protected areas.

RSPB Minsmere nature reserve is adjacent to the proposed development site on the Suffolk Coast and has been a nature reserve since 1947. It is a flagship site for both wildlife and visitors. Minsmere forms part of a wider area of the Suffolk Coast widely recognised for its value for wildlife.

The Suffolk Coast is an outstanding location for wildlife and people alike, with a rich and varied mosaic of habitats providing a landscape of wild beauty. It is a safe haven for an amazing variety of wildlife including iconic species such as the bittern, marsh harrier and otter. (Ref, RSPB website Minsmere) Besides being in an Area of Outstanding Natural beauty it is protected by a number of national and international nature conservation designations. These include:

- SSSI (a type of protected area with special or exceptional wildlife features)
- SPA (European designation for rare and vulnerable birds)
- SAC (European designation designed to protect habitats and wildlife species)
- Ramsar site (for wetlands of international importance)

3.3 Coastal morphology, stability and changes in sea level.

Dunwich, which was 5km from the proposed site for Sizewell C, has already been lost to coastal erosion. This erosion occurred before any of the expected rising median sea levels as defined in UKCP 18 (the government's accepted reference document for same) and in the 2019 IPCC (Intergovernmental Panel on Climate Change) report.

EDF claims that the site benefits from a 'micro-stability' which is related to the ridges of sub-sea coralline crag.

Technical note 8: According to the 'Thorpeness Coastal Erosion Appraisal Final Report December 2014, Mott Macdonald', the geological feature of greatest significance to Thorpeness, (Thorpeness is located at the southern end of the Greater Sizewell Bay) is the ridge of Coralline Crag composed of cemented iron-stained Pliocene shelly sand that extends north-eastwards from Thorpeness beneath the modern beach sediments. This offers resistance to erosion compared with the other deposits. It has been suggested that the position of the Ness to the north of Thorpeness is comparatively fixed by this geological unit which also serves to anchor the SDBC (Sizewell Dunwich Bank Complex) –The Coralline Crag ridge under Thorpeness is also recognised as being important in protecting the Sizewell coast (EDF, 2002). A slight 'headland' at Thorpeness occurs because these *relatively more resistant rocks occur at the base of the cliff, and they extend out to form the offshore seabed. The geomorphological erosion dynamic of the shoreline is approximately 30 years and is subjected to periods of erosion lasting several years. 'Thorpeness Coastal Erosion Appraisal, Final Report, December 2014, Mott Macdonald.'*

Technical note 9: Crag is an East Anglian term for the sedimentary rocks of shelly sand characteristic of the area.

Technical note 10: The largest waves recorded by a Waverider buoy deployed offshore from the Sizewell-Dunwich Bank complex (SDBC) in 18m of water from 11 February 2008 to 24 February 2011 had a mean direction, , of 155° (the direction of travel), a significant wave height, Hm0, of 4.71m (15.45 ft) and peak period, Tp, of 9.1s (wave power, Pw, 1.54 x 105J/m/s) see: Thorpeness Coastal Erosion Appraisal Final Report December 2014, Mott Macdonald, p.15. This is interesting to consider with regard to future climate change predictions for wave height and frequency.

EDF's proposed cooling water outfall pipes for Sizewell C are designed to avoid the erosion of these offshore banks. EDF is here admitting that they must consider their stability critical.

A historical hydrographical survey chart in Appendix 1, however, shows that offshore banks are not stable over the longer term. The map outlines changes in the position and shape of the Sizewell-Dunwich Banks between 1868 and 1992. *See Appendix 1 or PYE, K. and BLOTT, S.J., 2006. Coastal processes and morphological change in the Dunwich-Sizewell area, Suffolk, p466.*

It is also the case that "…the area north of Sizewell Power Station is still experiencing periodic storm erosion. This may be related to changes in the nearshore and offshore morphology, including the development of a gap between the crests of the Sizewell and Dunwich Banks through which waves are able to penetrate". Ibid., PYE, K. and BLOTT, p464.

3.4 Sea level changes, storm surges and flooding: expert opinion

UKCP18, the Met Office document for climate projection confirms the accepted science of significant median sea level rises into the next century. Historical coastal erosion and flooding already experienced by this coast will reach new heights and intensities. The IPCC (Intergovernmental Panel on Climate Change) reported on 24th Sept 2019 stated that extreme sea level events that are rare (once per century) are projected to occur at least once per year by 2050 in many places. (IPCC The Ocean and Cryosphere in a changing climate 24th Sept 2019, page spm-22)

The IPCC report continues: 'Under the same assumptions, annual coastal flood damages are projected to increase by 2–3 orders of magnitude by 2100 compared to today *(high confidence*)'. *(spm-32).*

'In the absence of adaptation, more intense and frequent extreme sea level events, together with trends in coastal development will increase expected annual flood damages by 2-3 orders of magnitude by 2100 (*high confidence*). However, [the report suggests], well-designed coastal protection is very effective in reducing expected damages and cost efficient for urban and densely populated regions, but generally unaffordable for rural and poorer areas (*high confidence*).' *IPCC, Page 516 of 1170.*

It is not possible to construct 'well-designed' coastal protection around the low-lying Sizewell and Minsmere levels that surround the proposed Sizewell C. East Anglia is flatland: much of the Sizewell Belts (1-2 Km to the west of Sizewell) are 2-4 m above sea level, the Minsmere levels (1-2Km North of Sizewell) are 1-2m above sea level on average.

The floods of 1953 that submerged huge areas of this part of Suffolk - a typical once per century event - were caused by a 2m surge. Consider, then the flooding possibilities when a 1-2m median sea level rise represents the baseline and these major floods become 'at least once per year' as the IPCC report states. This is presumably why many suggest that Sizewell B and C will, at best, be islands within the near future on their 6.4m and 7.3m plinths above sea level respectively.

According to the Institution of Mechanical Engineers (IME) "…in the UK, nuclear sites such as Sizewell, which is based on the coastline, may need considerable investment to protect it against rising sea levels, or even abandonment/relocation" IME (Institution of Mechanical Engineers) (2009): Climate Change: Adapting to the inevitable, Institution of Mechanical Engineers, Westminster, London.

Therefore, UKCP18, the IPCC, and the Institute of Mechanical Engineers are all of the same opinion, independently stating that a coastal location is vulnerable: 'abandonment and relocation' of Sizewell power stations are strong terms to come from the IME, a professional organisation not noted for hyperbole.

The Governor of the Bank of England, Mark Carney, on the 30th December 2019 'Today' program with presenter Mishal Hussain and guest edited by Greta Thunberg issued a 'climate change warning' to commerce. He said that leading pension fund analysis shows that if "…you add up the policies of all of companies out there, they are consistent with warming of 3.7-3.8 degrees C." This would represent a 6.9 to 10.8 metre sea rise according to the Climate Central. *(Climate Central, MAPPING CHOICES, CARBON, CLIMATE, AND RISING SEAS OUR GLOBAL LEGACY, November 2015, Page 10) See: https://www.bbc.co.uk/news/business-50868717*

The case for acceptability of the site location, EDF's claim to 'micro-stability,' is largely predicated up on the so-far safety of Sizewell A and B which have been subjected to, and survived, tidal surges.

This approach raises an important question in relation to the analysis of information and interpretation of evidence: the site for Sizewell C is arguably only suitable if we restrict analysis to recent historical data and we ignore evidence-based climate science predictions. Climate science is the justification for building Sizewell C in the first place, climate science is used to justify the need for the project but has been interpreted in a highly selective manner when it comes to the choice of location. EDF owns Sizewell so it wants to build there.

In summary, the NPS (National Policy Statement) that declared Sizewell to be a 'potentially suitable site' for newbuild reactors is outdated by UKCP18 and IPCC reports that it was unable to consider. The claim to current stability of this coast is weak and based a highly selective interpretation of historical expert evidence. If climate change predictions are accepted and a full risk analysis undertaken on this basis to define security, then it is reasonable to conclude that both Sizewell (and Hinkley Point) are highly unsuitable sites. The excessive reliance on historical data (essentially no more than stating that because an event has not caused damage in the past it is unlikely to in the future) is of itself no basis for a decision, the consequences of which need to be measured in decades. Independent experts are clear that the lack of provision of risk modelling for extreme sea events occurring over the next 100 years represents a major weakness and significant danger.

4 Funding models for Sizewell C

4.1 Background

The original funding for Hinkley C and Sizewell C was based on a 'Contract for Difference' (CfD)– a government guaranteed base price for delivered power.

This method has been used successfully in the renewable energy sector and awarded by auction, a method that they can be seen to serve public interest with offshore wind prices falling: Triton Knoll at £74.50 per MWh for completion 2021/2 and Moray Offshore East with Hornsea Project Two (completion in 2022/23) at £57.50 per MWh. (BEIS figures). The latest 2019 CfD offshore wind round was awarded at £39.65- £41.61 per MWhr for the Dogger bank 3.6GW development reverting to straight wholesale prices after 15 years. (Prices quoted are set at 2012 by Government convention but are all comparable) The Contract for Difference for Hinkley C, however, has been awarded directly by government at £92.50 per MWh (for 35 years minimum).

4.2 Regulated Asset Base (RAB) funding

EDF is now looking at RAB, 'Regulated Asset Base' for financing Sizewell C. Although many important details are not made explicit in the Consultation document, EDF would not be expected to own any of the plant. However, EDF owns the site and will be the contractor supplying the reactor and, presumably, managing the civil works. It is uncertain whether EDF be contracted to build or whether this will be subjected to the rigors of competitive tender. There is a perception that these contracts will be awarded to EDF without any external review, peer assessment or competition.

In view of EDF's construction history, the likely complexity of maintenance and dealing with the spent fuel for the plant's lifetime, *(see section 2 above)* the use of RAB as a new funding model might prove to be an extremely poor decision with many years of funding with no returns on investment. It is not clear if risk modelling and a failure regime are incorporated in the RAB proposals, an unproven method of funding in this situation. Arguably, the only saving grace of Hinkley's CfD, from the perspective of HM Treasury and the electricity billpayer, is that EDF receives no income until the plant is running (and the price paid for power appears to be capped). Investors in RAB, however, are unlikely to be interested unless liability (cost overruns, accident, higher running costs, high downtime, the plant is not completed or produces less electricity than expected) rests with electricity consumers and/or taxpayers (with no risk sharing proposed).

Under RAB, the 'owners', either EDF, financiers or other, would be paid during construction, unlike Hinkley C.

The National Infrastructure Commission has recognised some aspects of this and have publicly expressed the following: "This makes projects appear cheaper as consumers are effectively financing the projects at zero interest. At least some of the risk associated with construction costs also sit with consumers, a further hidden cost, since consumers are not paid to hold these risks in the way investors would be."

Their report, *National Infrastructure Assessment*, continues: "…it is taxpayers [more likely electricity consumers], rather than the holders of debt, who bear the risk. But this does not mean the risk, and its associated costs, have been avoided. The apparently lower financing costs represent a transfer, rather than a reduction, in risk".

Abandonment of Sizewell C at some stage is highly likely but for the builders and financiers this may only represent a reduction in profits under RAB financing. Like the Public Finance Initiative (PFI) RAB financing promises to burden the Treasury and taxpayer for decades, an unproven and costly means of financing a project that all evidence shows has a high probability of cost overrun and an appreciable risk of abandonment.

4.3 The USA experience of new nuclear and Early Cost Recovery financing

"New payment mechanisms, like RAB have been tried in the USA. At its 2009 peak, the "nuclear renaissance" consisted of applications to build 31 units pending at the Nuclear Regulatory Commission. Twenty nine of the thirty-one have been cancelled. Despite expenditures exceeding $20 billion, no new U.S. nuclear plants have gone into service.

In South Carolina the would-be builders of the two VC Summer units spent $9 billion before the bankruptcy of the lead contractor Westinghouse caused them to cancel the project. More than a billion dollars were spent on the Levy County units in Florida and several hundred million apiece on additional units in Florida, North and South Carolina.

Two of the original 31 "renaissance" reactors remain under construction. The Vogtle plant in Georgia has doubled its original cost estimate. The current estimate is $27.5 billion, with the reactors expected five years late in 2021 and 2022". *The Proposed RAB Financing Method, Professor Steve Thomas, Peter Bradford, Tom Burke CBE, Dr Paul Dorfman. Pages 5-6*

4.4 Cost of disposal for the Spent Fuel

The following statements show that there is no understanding or shared view with regard to the cost of disposal of Spent Fuel, the most problematic and expensive item to deal with. This is not included in the 'share of waste management costs' (arising from confusion caused by Spent Fuel not being classified as waste, see 1.2)

"Government [we are told], is developing specific proposals to protect the taxpayer. Under these proposals, private sector developers would meet the full decommissioning costs and full share of waste management costs… [If they are to be] allowed to invest in new nuclear power stations. They would need to be in place before proposals for new power stations could go ahead." It continues: "The Government believes that new waste could technically be disposed of in a geological repository and that this would be the best solution for managing waste from any new nuclear power stations." *White Paper on Energy MAY 2007, MEETING THE ENERGY CHALLENGE*, clause 29 and 99.

However, Government continues: "In addition to existing wastes, there are some radioactive materials that are not currently classified as waste, but would, if it were decided at some point that they had no further use, need to be managed as wastes through geological disposal. These include Spent Fuel (including Spent Fuel from new nuclear power stations), plutonium and uranium." *BEIS National Policy Statement for Geological Disposal Infrastructure. A framework document for planning decisions on nationally significant infrastructure, 2008. Para.2.3.4*

This position is in direct contradiction with the Environment Agency Document, "*Generic design assessment for the UK EPR*", which clearly expresses: Clause 52: "…*spent fuel will be declared as waste*…"

Despite the Environment Agency's statement, Spent Fuel, the most problematic and expensive of all industrial waste to deal with, is not included in the 'share of waste management costs': it is 'not waste' and can be left onsite. Private Sector Developers who were to be held so manfully to financial account for the benefit of taxpayers appear to be freed from the full responsibility of dealing with Spent Fuel.

What are the projected costs of handling UK's nuclear waste? According to the *World Nuclear Waste Report 2019*, quoting *NDA 2018, Annual Report and Accounts 2017*: "The total costs of managing all of the UK's nuclear waste is very high…As of 2006, the NDA estimated the undiscounted future costs of its task to amount to £53 billion… By 2018 this had escalated to an estimate of £121 billion... The NDA now puts an uncertainty range on its central estimate of £99–£225 billion". *The World Nuclear Waste Report. Focus Europe. 2019. Berlin & Brussels. Page 134.* www.worldnuclearwastereport.org

4.4 Future governance

There is an informed opinion that, to overcome current and future financial challenges, EDF will be restructured at some point in the future. Codenamed 'Hercule or Hercules,' EDF would be split into two entirely separate companies, EDF Bleu containing nuclear and EDF Vert for renewables. EDF Bleu is expected to become a 100% state owned company (16% of EDF's shares are currently owned by private investors). EDF Vert will be part-floated to raise funds because it has value. EDF Bleu is 'bad bank' because the liabilities are too high for it to survive without. An extraordinary corollary of this is that Hinkley C and Sizewell C may have to be placed in the 'bad bank' before they are built. *Reference: Le Figaro, Cyrille Pluyette, 4 Oct 2019 and Financial Times June 20th, 2019.*

NNBG, the builder of Hinkley C, which is 66.5% EDF and 33.5% CGN has the added problem of CGN being added to the US 'entity list' (a US blacklist) which could severely limit its operation.

The imperative to build Sizewell C would appear to be vested in ideas of private financial gain, EDF's reputational capital in their 'third generation' EPR design and an exploitable UK government eager to be seen to be resolving carbon emissions. The available evidence, including powerful new information about climate change, coastal morphology and safety, now shows these proposals to be at high cost to consumers and the environment coupled with increased risk of catastrophic nuclear accident

Summary and recommendations

1. New evidence about sea-level predictions and coastal morphology and stability, including information and lessons from the Fukushima Daiichi disaster, need to be incorporated into the design and new risk modelling with particular reference to how Spent Fuel is classified and stored.

2. The latest IPCC and UN reports predict that extreme sea level events that are currently once per century are projected to occur once per year by 2050 in many places. In view of these independent and evidence-based predictions it is imperative to question the decision to build Sizewell C on the beach of a vulnerable coastline and Hinkley C on the flat, low Somerset coastline that experiences some of the highest tides in the world. The claim to current stability of the Sizewell C site is extremely weak and based on recent historical datasets that are of no value in assuring future site integrity and safety. It is also not possible to construct 'well-designed' coastal protection around the low-lying Sizewell and Minsmere levels that surround the proposed Sizewell C. East Anglia is flatland: much of the Sizewell Belts (1-2 Km to the west of Sizewell) are 2-4 m above sea level, the Minsmere levels (1-2Km North of Sizewell) are 1-2m above sea level on average. If the authoritative reports by the IPCC and others are accepted, then on the basis of current climate and sea level predictions both Sizewell (and Hinkley Point) can only be regarded as highly unsuitable sites.

3. Climate science, quite properly, cited as the justification for nuclear power generation should inform the choice of location for new nuclear power generation. The Institution of Mechanical Engineers has reviewed the available information and has concluded: "…in the UK, nuclear sites such as Sizewell, which is based on the coastline, may need… abandonment or relocation". On this basis, taken with revised predictions on sea level and new information about coastal stability, the assumptions made 20 years ago about the locations for new nuclear infrastructure and spent fuel storage should be reviewed. The NPS (National Policy Statement) that declared Sizewell to be a 'potentially suitable site' for newbuild reactors is outdated and invalidated by contemporaneous UKCP18 and IPCC reports.

4. The Governor of the Bank of England Mark Carney on the 30th December 2019 'Today' program with presenter Mishal Hussain and guest edited by Greta Thunberg issued a 'climate change warning' to commerce. He suggested that leading pension fund analysis shows that if "…you add up the policies of all of companies out there, they are consistent with warming of 3.7-3.8 degrees C." This could represent a 9-meter rise in sea levels. *(see Section 3.4)* Extreme sea events such as surges will obviously operate from new median levels. During a very brief period (11 February 2008 to 24 February 2011), a Waverider buoy deployed offshore from the Sizewell-Dunwich Bank complex in 18m of water recorded a significant wave height, Hm0, of 4.71m (15.45 ft). *(see Technical Note 10).*

5. No new nuclear power generation should be built until there is clear and consistent policy (and investment) regarding nuclear waste disposal. Currently, Government nuclear agencies are in a state of acute contradiction over Spent Fuel:

- Spent Fuel, according to the Office for Nuclear Regulation, must be removed from site 'as soon as reasonably practical', yet will remain onsite indefinitely.
- The Environment Agency has declared that 'Spent Fuel is waste', meanwhile, Government has declared Spent Fuel is 'not waste', thus separating Spent Fuel, the most problematic of all industrial material, from a major range of safety, risk and environmental recommendations.
- The GDA states that it is a 'base case condition' that a deep repository (GDF) would be constructed in time for new build EPR waste including Spent Fuel, however, we do not have a geological repository (GDF) nor even serious consideration for a GDF.
- For geological disposal, Government has been clear that communities hosting nuclear waste and Spent Fuel must be 'fully informed' and provided with a 'detailed and complete picture of the possible inventory' and 'have access to information from the developer'. East Suffolk, however, the host for all the Spent Fuel Sizewell C will produce, has not been afforded the same guidelines or respect. The copious documentation published by EDF in the four stages of 'Public Consultation' on Sizewell C omits specific information on the nature of the Spent Fuel or how it is to be cooled, packaged and stored. *For information on involvement of Communities see: Dept Energy Climate Change Implementing Geological Disposal, A Framework for the long-term management of higher activity radioactive waste, July 2014, section 2,3,7.*

6. Government must consider the interim period before geological disposal is possible and impose the safest form of dry cask, surface storage as another base-case condition in order to deal with most of the critical 140 year highly radioactive period when the fuel is cooling. Spent fuel should be moved to dry storage as soon as thermal constraint allows and Spent Fuel ponds must only be used for cooling and not as a storage facility. The Fukushima Spent Fuel Ponds were, and remain, an extreme liability. EDF must satisfy local communities of the design, safety and intended use of the Spent Fuel ponds.

7. Much of the Sizewell C Spent Fuel will be notably hotter and more radioactive than its legacy counterpart and will contain high activity fission products as well as in the region of 27 tonnes of plutonium by the end of life for each of the two reactors. It will take several hundred thousand years for the ingestion radiotoxicity of this Spent Fuel to become that of the uranium ore (including its decay products) from which it was derived. It needs safeguarding and removal from coastal vulnerability. (ref: *Disposal System Safety Case document NDA Report DSSC/422/0.. See:* NDA *Geological Disposal Generic Design Assessment: Summary of Disposability Assessment for Wastes and Spent Fuel arising from Operation of the UK EPR Jan 2014* page 30/32, pdf pages 38-40.

8. Local communities must be afforded a further public consultation on Spent Fuel in order to fully understand its nature, management and implications. This further consultation must inform on EDF's high burn-up procedure which provides fuel-cycle cost benefits for EDF but lacks full empirical data on the implications for the Spent Fuel in medium- and long-term storage (due to the greater heat, radioactivity and fragility of the Spent Fuel). It must be clear that the choice of high burn-up does not represent moral hazard.

9. The proposed EPR is demonstrably far too big, powerful, complex and costly to build (and probably maintain). Some of the Flamanville EPR welds that need repairing require as yet undeveloped robot technology. It also seems clear that 'break preclusion' concepts where catastrophic failure is 'deterministically ruled out' as a design assumption for structures and surrounding components, may need scrutiny. The Generic Design Assessment (GDA) for the EPR in the UK is surprising in allowing significant design criteria to be delayed and established during the construction phase. We have been building reactors that are too large, complex and expensive for 30 years as pointed out by Cantor and Hewlett, with evidence, in 1986. EDF's EPRs are larger and more expensive yet: £21.5 to 23.2 billion; 245 football fields, 3 million tons of concrete, 50,000 tons of structural steel and a million litres of fresh cooling water per day. All this for 3.2GW of electricity. (The 3.6GW Dogger Bank windfarm will cost £9 billion to build - and they have the technical challenges of construction 130Km off the coast of Yorkshire).

10. Large scale nuclear power generation has never previously operated in a private market setting. All large-scale nuclear infrastructure is a liability and any non-nationalised financing model will always have the same objective of offloading the risk to the public sector, for instance the cost and problems of the long-term disposal of the spent fuel.

The imperative to build Sizewell C is not in the interests of consumers and national policy advantage. EDF's construction history and EPR complexity adds to the evidence that large scale nuclear is hopelessly expensive and uncompetitive. Overall the costs to the public sector (taxpayers and /or bill payers) will be prodigious. Under RAB financing the constructors and financiers will have all the build costs covered including cost escalations and profit margins with regular payments even if the plant is abandoned.

RAB, therefore, appears completely unsuitable as a financing model for a project with the evidential uncertainty of an EDF EPR build.

Nick Scarr - [redacted]

Special thanks to Prof.Stephen Thomas, Emeritus Professor of Energy Policy, Public Services international Research Unit (PSIRU)

Special thanks to Dr Robert Winter for general advice in the editing process.

All CfD prices quoted are '2012 prices' but are comparable.

For a detailed account of the construction history of the EPR see 'EPR in Crisis', Professor Steve Thomas, 2010: https://gala.gre.ac.uk/id/eprint/4699/3/(ITEM_4699)_THOMAS_2010-11-E-EPR.pdf

Appendix 1

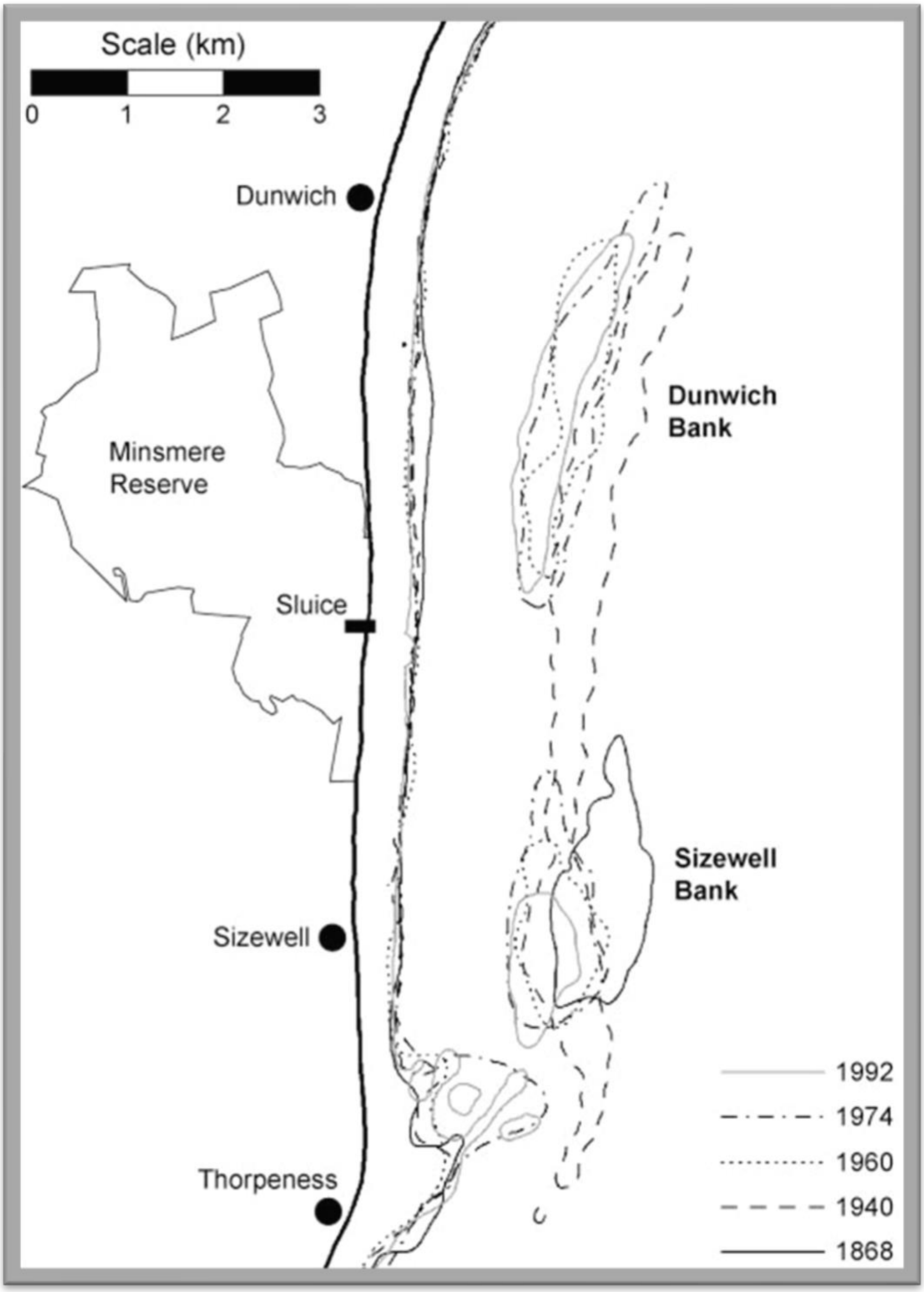
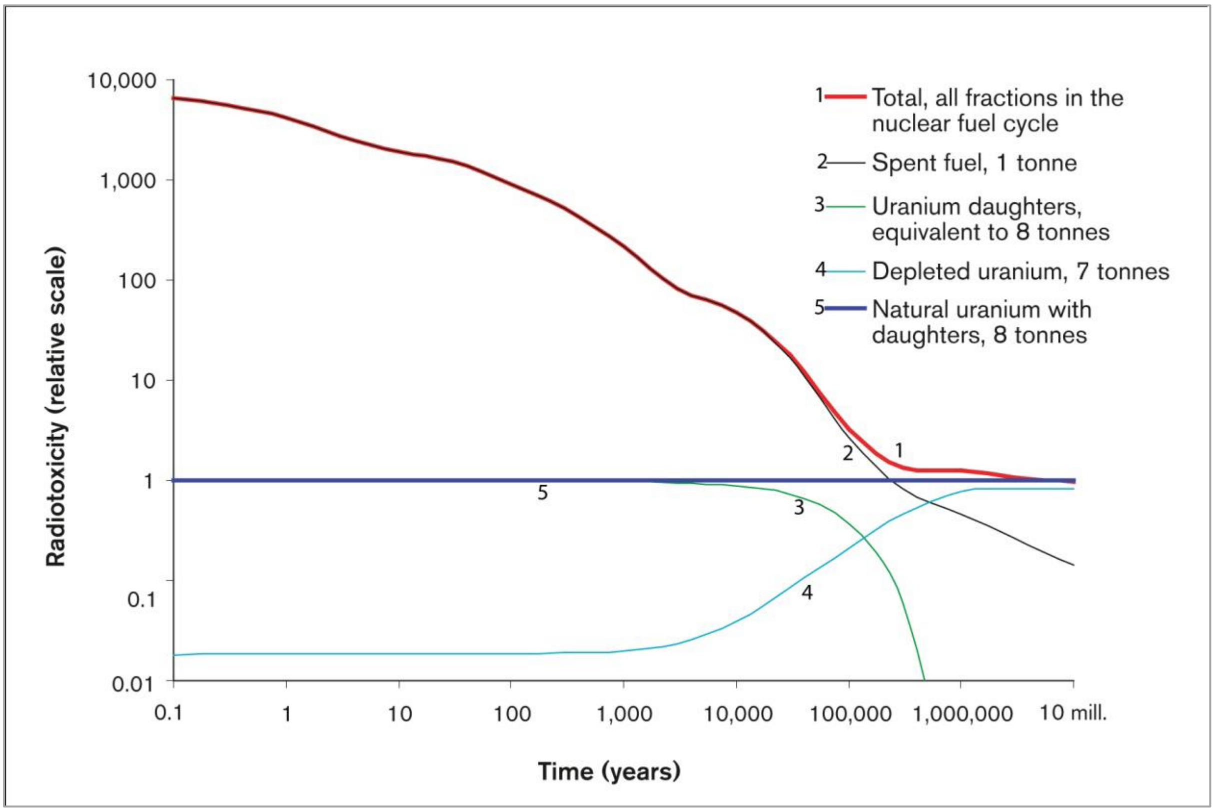


Figure 1: Historical hydrographical surveys detailed in the following chart show that the banks referred to by EDF are not stable but volatile over the longer term: The map outlines changes in the position and shape of the Sizewell-Dunwich Banks between 1868 and 1992, based on Admiralty surveys. PYE, K. and BLOTT, S.J., 2006. Coastal processes and morphological change in the Dunwich-Sizewell area, Suffolk, p46

Appendix 2



Note logarithmic scale of Time axis.

Figure 4. Graph of Ingestion Radiotoxicity comparing the ingestion radiotoxicity of Spent Fuel with that of the uranium ore (including its decay products) from which it was derived.

Relative ingestion radiotoxicity of uranium ore (line 5) and of the spent LWR fuel that could be

derived from it (line 2). Line 3 describes the toxicity of the uranium decay products that are separated in the uranium mill and line 4 that of the depleted uranium that is stored at the enrichment plant. Approximately eight tons of natural uranium are used to produce one ton of enriched uranium fuel (and seven tons of depleted uranium). Source: *A. Hedin, "Spent Nuclear Fuel - How Dangerous Is It?" SKB Technical Report 97-13, Swedish Nuclear Fuel and Waste Management Co., 1997*.

Appendix 3 - Information regarding nuclear fission and EPR (Hinkley C, Sizewell C) High burnup spent fuel.

A3.1 Background – how fission works

A nuclear reactor's purpose is to create heat. This is to produce steam that will then drive a turbine and produce electricity.

In order to do this the reactor establishes nuclear fission chain reactions. Radiation is a by-product of fission and a property of the elements created by the fission process. The energy comes from 'missing mass' (a variance in the mass of nucleons depending on their existence in an independent state or the binding energy of the nucleus they are contained within).

A3.1.1 The nature of Uranium fuel and its properties.

Natural Uranium is U-238 containing a very small percentage of U-235 (0.7%) and U-234 (0.005%). The Uranium 238 must be enriched up to around 5% U-235 for EPRs, higher than PWRs and BWRs, however Magnox and CANDU reactors use natural uranium.

The new fuel rods are relatively safe and easy to handle, U-238 and U-235 having very long half-lives so not very radioactive, and do not require complex, shielded containers.

U-235 is fissile, the only naturally occurring isotope with this quality.

U-238 is not fissile, but fissionable and fertile in that it can *make* a fissile element.

These unusual characteristics are the key to heat generation.

A3.1.2 Fission, the Chain Reaction and its regulation.

U-235 will respond to thermal neutrons (slow, low energy neutrons) and break down into fission products (for example Xenon-140 and Strontium-93 plus 3 neutrons). The bulk of the released energy is in the kinetic energy of the fission products which quickly changes to heat.

This is the start of the self-sustaining chain reaction. U-235 will fission in different ways producing a range of products, the relative amounts being known from measurement. The resulting fission products are always highly radioactive.

The energy release in this fission is some 50 million times more than an equivalent burning of hydrocarbon molecules. The energy release is so large because the nucleons in the fission products are more tightly bound than the parent nucleus, this is an 'effective weight loss' and energy conversion relates to $E = mc^2$

The neutrons emitted are high velocity and need to be slowed to be effective in fissioning more U-235. This is done by a moderator. Magnox and AGR reactors use graphite; EPRs, PWRs, BWRs use light water. (Light water is H_2O, heavy water is D_2O which is used in the CANDU reactor). The moderator affects the required enrichment of the fuel (light water absorbs some neutrons).

So, the chain reaction in U-235 is established, heat builds, and radioactive fission products develop.

However, this is not the complete cycle. The Uranium 238 will also absorb some neutrons. Plutonium 239 (24,000 years half-life) is the effective result and is fissile in the same way as U-235 (which is why U-238 is regarded as fertile).

The plutonium Pu-239 created by the U-238 can now act as fission fuel and produce chain reactions in the same way as the U-235. Pu-239 fission produces approximately the same energy per fission as U-235 fission and leaves around 1- 1.3% isotopes in the Spent Fuel.

These critical chains of fissile U-235 and Pu-239 are the heat engine of the reactor; the radioactive fission products and actinides including plutonium forming the Spent Fuel.

A3.2 Efficiency of fission in nuclear reactors

It can be argued that for a given thermal energy produced in a reactor you need a fixed number of fissions of uranium or plutonium, (with an energy of 200-210MeV per fission), and hence produce a fixed amount of fission products and actinides. In theory, then we only depend upon the thermal efficiency of the reactor, rather than the burnup of the fuel, as regards the amount of fission products and long-life actinides produced per GWyear. In this respect the EPR appears to be marginally better than Sizewell B and most other PWRs around the world, marginally worse than the AGRs, and considerably better than the old Magnox reactors.

A3.3 High Burn-up fuel

High Burnup Spent Fuel from the new EPR reactors has been quantified for radioactivity by *Radioactive Waste Management Ltd* and the *Nuclear Decommissioning Authority*. Their datasets for high burn up Spent Fuel activity appear to show some marked nuances and particularities in the development of fission products and actinides by comparison with legacy Spent Fuel, something that EDF appears to describe as a benefit:

In clause 70 of the 'Generic design Assessment': "*EDF and AREVA claim the improvements in environmental performance of the UK EPR project with regard to waste and fuel include:*
a) a more efficient use of natural uranium resources;

b) a significant reduction in the quantity (volume, mass) of long-lived radioactive waste resulting from the fuel and its cladding owing to its: neutronic design (large core, neutron reflector) and the fuel management performance (high burn up)."

A3.4 High Burn-up Spent Fuel analysis using RWM (Radioactive Waste Management) data:

Data supplied by RWM (*Radioactive Waste Management Limited (RWM) is a wholly owned subsidiary of the NDA and is responsible for implementing Government policy on geological disposal)* suggest that by the year 2200 Sizewell C's Spent fuel will be generating 2,056,908 Tbq (Terrabecquerels) of radiation (20% of 10,284,544). By comparison, our Legacy Spent Fuel combined will be generating less radiation of 1,702,423 Tbq. This dataset is supplied by RWM is for communities to make a 'fully informed decision' about Spent Fuel. *Radioactive Waste Management Ltd, Geological Disposal, Disposal System Safety Case: Data Report December 2016,* see pages 32-34. Also, Government White paper on implementing Geological disposal, Dept Energy Climate Change, July 2014, clause 7.41.

RWM offers below a comparison of quantified descriptions of inventory extrapolated to 2200 for the radioactivity of two waste groups: legacy spent fuel waste to be managed and High Burn-up spent fuel (such as Hinkley C and Sizewell C) to be managed.

Nuclide	Half Life (years)	Legacy Spent Fuel TBq	High Burn-up Spent Fuel TBq (New Build Spent Fuel NB-SF)
I- 129	5730	6.64	31.3
Cl-36	300,000	3.09	71.7
Cs-135	2,400,000	130	515
Tc-99	2.1 x 10(5)	1780	12900
Pd-107	6.5 x 10(6)	22	135
U-234	2.4 x 10(5)	393	1730
U-235	7.0 x 10(8)	3.25	6.24
Pu-239	2.4 x 10(4)	4.81 x 10(4)	2.08 x 10(5)
Am-243	7.4 x 10(3)	3660	45100
Totals for 49 Nuclides		*1,702,423*	*10,284,544*
			(2,056,908 for Sizewell C)

Columns 2 and 3 are in TBq (Terabecquerels).

This table is a small sample of 49 nuclides listed. For the full list refer to: *Radioactive Waste Management Ltd, Geological Disposal, Disposal System Safety Case: Data Report December 2016,* see pages 32-34 (16-18).

The quantified radioactivities in columns 2 and 3 are calculated for the year 2200 when it is assumed that the (not yet designed or commissioned) geological repository (GDF) will be closed. Calculation is based on half-life of the elements quoted.

The 'Waste Group' for High Burn-up is drawn from the assumption of a 16GW new build and on that basis Hinkley C and Sizewell C would represent 40% of the total new build nuclear at 6.4 GW. (clause 3.4.3 and White Paper '*Implementing Geological Disposal, Dept Energy Climate Change July 2014* where it confirms: '*The current stated industry ambition for new nuclear development is 16 gigawatt electrical',* (clause 7.41))

It could be claimed, however, in refutation of this position, that legacy Spent Fuel might only represent approximately 8GW for 20 years as much legacy spent fuel has been reprocessed and is no longer classified as Spent fuel.
It is therefore interesting to take a different approach and look at a direct comparison of Spent fuel from Sizewell B and what will be produced by Sizewell C or Hinkley C:

A3.5 High Burn-up Spent Fuel analysis using NDA (Nuclear Decommissioning Authority) data.

Below is a direct comparison of a canister of Spent Fuel from Sizewell B and what would be expected from Sizewell C:

Radionuclide	Sizewell B Spent Fuel	EPR (Sizewell C) Spent Fuel	Ratio of EPR/SZB	Half life
	TBq per canister	TBq per canister		Years
C-14	0.0645	0.311	4.8	5700 years
C-36	0.000831	0.0157	19	300,000 years
Ni59	0.000908	0.0363	40	76,000 years
Se79	0.0318	0.0101	0.32	650,000 years
Sr-90	675	1270	1.9	28.0
Tc-99	1.03	1.89	1.8	211,000 years
Sn-126	0.0567	0.0859	1.5	230,000 years
I-129	0.00239	0.00481	2	1.5million
Cs-135	0.0302	0.0722	2.4	2.3 million
Cs-137	1020	2060	2	30.0
U-233	0.0000123	0.0000291	2.4	160,000 years
U-234	0.133	0.231	1.7	245,000 years
U-235	0.00153	0.00105	0.69	700 million years
U-236	0.0215	0.0367	1.7	23 million years
U-238	0.0246	0.0236	1	4.4 billion years
Np-237	0.0328	0.0694	2.1	2.14M
Pu-238	90.9	391	4.3	87 years
Pu-239	25	31	1.2	24,000 years
Pu240	36.1	60.3	1.7	6500 years
Pu-241	123	215	1.7	14 years
Pu-242	0.124	0.39	3.2	373,000 years
Am-241	283	497	1.8	432 years
Am-242	0.732	0.821	1.1	432 years
Am243	1.14	6.26	5.5	7300 years
Sum	2256.43	4534.56		

Table: Comparison of Radionuclide activities for one spent fuel canister from Sizewell B and one spent fuel canister from an EPR such as Sizewell C at 90 years cooling. *NDA, Geological Disposal Generic Design Assessment: Summary of Disposability Assessment for Wastes and Spent Fuel arising from Operation of the UK EPR. Jan 2014*. Pages 30-32 (pdf pages 38-40).

Notes from the above chart of Sizewell B and Sizewell C data:

1) Actinides are the elements between Uranium and Americium.

2) The comparison assumes an average fuel burn rate for Sizewell B and a maximum rate of 65GWd/Ut for Sizewell C.

3) For much of the first 100 years, the radioactivity is dominated by the fission products: mainly Strontium 90 and Caesium 137 (Sr-90, Cs-137). After a few hundred years radioactivity is dominated by the transuranics: Plutonium, Americium and Neptunium (Pu,Am,Np).

4) It takes several hundred thousand years for the ingestion radiotoxicity of Spent Fuel to become that of the uranium ore (including its decay products) from which it was derived.

5) An EPR such as Sizewell C operating for 60 years at 1.6 GW(e) would produce 3,600 spent fuel assemblies which is equivalent to 37.5 spent fuel assemblies for every GW(e) year (ref, NDA, ibid.p.29). This compares with Sizewell B which would produce 46.9 spent fuel assemblies for every GW(e) year. This is clearly a volume efficiency. (ref, NDA, ibid.) The volume efficiency, however, is of debatable value in as much as greater spacing will be required around EPR (Sizewell C) Spent Fuel canisters in a GDF due to greater heat and radiation.

6) The Plutonium builds up from zero in new fuel to reach a concentration of about 1%, with a rough equilibrium being achieved between Pu being produced from neutron absorption by U238, and Pu239 being fissioned (Pu-239 becomes fuel along with the U-235). However, because the EPR is high burn-up, the Pu will have a higher percentage of Pu240 so the PU present in the spent fuel is considered lower "weapons grade". This may be significant for the national/international regulations for storage and movement.

7) The bare critical mass of weapons grade U235 is approximately 50kg and Plutonium less than 10kg.

8) This dataset appears to compare canisters at the same half-life age of 90 years.

9) The interdependency and daughter products of actinides are convoluted by creating 'build-up chains', for example: Pu-239 will decay to U-235; U-236 and U238 produce NP-237 which in turn produces Pu-238.

A3.6 – Brief note on Spent Fuel storage

The GDA (see section 1.3) makes clear that cladding degradation and stress requires that High Burnup Spent Fuel is inspected 'to maintain confidence that the fuel remains in a in a suitable condition'. It is difficult to see how this assists earlier dry surface storage or potential geological storage. We do not have a plan, design or location for a GDF (Geological storage) however, non-retrievability of the stored waste is assumed. We therefore urgently need to establish whether a GDF that meets the standards required for our High burnup new reactor Spent Fuel and our legacy material is feasible. (Legacy waste in temporary store in Sellafield comprises 65 years' worth of High-Level Waste, including spent fuel from the AGRs, Sizewell B and including 146 tonnes of separated plutonium).

Summary Document - Sizewell C – a 2020 perspective and a need to rethink

Since public consultation in 2012, vital new information and experience has accumulated. Safety, environmental change and capability now challenge the initial assumptions that have underpinned proposals for a large new nuclear EPR reactor at Sizewell C in coastal Suffolk. These assumptions, many now shown to be incorrect, have been central to the final proposals developed by Electricité de France SA's (EDF) that will be submitted to the Planning Inspectorate in 2020.

Environment: The Location.

1. Since 2012 new evidence about sea-level predictions and coastal morphology/stability have undermined and contradicted EDF's claim that site suitability has been afforded by National Policy Statement (NPS) EN-6.

2. The NPS EN-6 that stated Sizewell to be a 'potentially suitable site' for new build reactors has been invalidated and discredited by current evidence in the 2019 UKCP18 and Intergovernmental Panel on Climate Change (IPCC) reports, predicting that extreme sea level events that are currently once per century are projected to occur more frequently, perhaps once per year by 2050 in many places. In 2019, UKCP18, the Met Office document for climate projection, accepts that a body of evidence has shown that there will be progressive median sea level rises into the next century. Historical coastal erosion and flooding, already experienced to a high degree by this coast over the last 50 years, are projected to reach new heights and intensities. The 2019 IPCC report concurs with this 'Under the same assumptions, annual coastal flood damages are projected to increase by 2–3 orders of magnitude by 2100 compared to today'. (IPCC The Ocean and Cryosphere in a changing climate 24th Sept 2019).

3. Using these new climate change predictions to inform a full risk analysis, it is impossible not to conclude that Sizewell is a most unsuitable site. In view of these independent and evidence-based predictions it is essential to re-examine the decisions to build both a new Sizewell C on the beach of a vulnerable coastline and Hinkley C on the flat, low Somerset coastline that experiences some of the highest tides in the world.

4. The claims to current stability of the Sizewell C site are extremely weak and based on recent historical datasets that are of no value in assuring future site integrity and safety. EDFs excessive reliance on historical data (essentially little more than stating that because an event has not caused damage in the past it is unlikely to do so in the future) is not an adequate basis for the decision that needs to be taken in 2020, the consequences of which must be measured in decades. The EDF proposals are devoid of any serious attempt to model the risk of extreme sea events occurring over years and this represents but one of several major weaknesses and a concern of significant public danger. Climate science and environmental issues, which are quite properly given as the justification for nuclear power generation, should inform the choice of location for new nuclear power

generation. On the basis of the current evidence the Institution of Mechanical Engineers have already cautioned: "…in the UK, nuclear sites such as Sizewell, which is based on the coastline, may need… abandonment or relocation".

Safety: The handling of nuclear waste, with particular reference to Spent Fuel.

1. Government nuclear agencies are in a state of acute contradiction over the handling of Spent Fuel:

- Spent Fuel, according to the Office for Nuclear Regulation, must be removed from site 'as soon as reasonably practical', yet will remain onsite indefinitely.
- The Environment Agency has declared that 'Spent Fuel is waste', meanwhile, Government has declared Spent Fuel is 'not waste', thus separating Spent Fuel, the most problematic of all industrial material, from a major range of safety, risk and environmental recommendations.
- The GDA states that it is a 'base case condition' that a deep repository (GDF) would be constructed in time for new build EPR waste including Spent Fuel, however, we do not have a geological repository (GDF) nor even serious consideration for a GDF.
- For geological disposal, Government has been clear that communities hosting nuclear waste and Spent Fuel must be 'fully informed' and provided with a 'detailed and complete picture of the possible inventory' and 'have access to information from the developer'. East Suffolk, however, the host for all the Spent Fuel Sizewell C will produce, has not been afforded the same guidelines or respect. The copious documentation published by EDF in the four stages of 'Public Consultation' on Sizewell C omits specific information on the nature of the Spent Fuel and how it is to be cooled, packaged and stored.

2. East Suffolk, obliged as stated, to host all EDF's Spent Fuel produced over the 60-year lifetime of the plant plus the 140 year cooling period beyond, should be afforded a further public consultation on Spent Fuel in order to fully understand its nature, management and implications.

3. Local communities must also be satisfied that EDF's high burn-up procedure, which provides fuel-cycle cost benefits for EDF but lacks full empirical data on the implications for the Spent Fuel in medium- and long-term storage (due to the greater heat, fragility and radioactivity of the Spent Fuel), does not represent moral hazard.

4. Seven years of data, to 2018, from the 2011 Fukushima Daichi disaster in which three nuclear reactors were damaged by an extreme sea level event at a coastal nuclear power plant has shown the risk in relation to storage of Spent Fuel and nuclear waste on a coastal site. The Fukushima Spent Fuel Ponds were, and remain, an extreme liability. EDF must satisfy local communities of the design, safety and intended use of the Spent Fuel ponds.

Capability and Capacity: Evidence and experience, 2005-2019. The build programme.

Between 2000 and 2019 EDF have been engaged in a multi-billion-pound investment and commitment to EPR programme (the proposed reactor type for Sizewell C). This has resulted in major disruption for the nuclear industries of France, with not one project completed, and by the beginning of 2020 not a single Watt of energy delivered in Europe from the EDF programme since a 2005 construction start. Projects have been beset by endless delays and cost overruns.

The only European example in which full information is available is the construction of third nuclear reactor at the Flamanville Nuclear Power site in Normandy. EDF began construction of Flamanville 3 in 2007 with commercial introduction scheduled for 2012. As of 2019 the project is four times over budget and years behind schedule, pushing the commercial introduction date to the end of 2022, a delay of 10 years, as a result of seemingly insurmountable technical and safety issues. One example that has come to light is with steam line welding. The main steam pipes are highly stressed, critical components and welding to 'Break Preclusion' (where failure is deterministically ruled out) standards was mandatory. However, some of the Flamanville EPR welds now need repairing and require as yet undeveloped robot technology.

It is of particular concern that, despite full knowledge of these problems and the failure of EDF to complete a single EPR nuclear reactor build in Europe on agreed timescale or budget, the Generic Design Assessment (GDA) for the Sizewell C EPR in the UK is allowing significant design criteria to be delayed and established during the construction phase.

Funding models for Sizewell C:

Large scale nuclear power generation has never previously operated in a private market setting. All large-scale nuclear infrastructure is a liability and any non-nationalised financing model will always have the same objective of offloading the risk to the public sector, for instance the cost and problems of the long-term disposal of the spent fuel.

The proposed new method of funding Sizewell C, termed Regulated Asset Based (RAB) financing, presents a novel, high risk, untested model for the UK taxpayer. Under RAB, the ‘owners’ (EDF, financial institutions or other) would be paid during construction. Abandonment of Sizewell C at some stage is distinctly possible but for the builders and financiers this may only represent a reduction in profits under RAB financing. Like the discredited Public Finance Initiative (PFI), RAB financing promises to burden the Treasury and taxpayer for decades, an unproven and costly means of financing a project that all evidence shows has a high probability of cost overrun and an appreciable risk of abandonment.

Conclusion

All the evidence now shows that EDF's proposal to build Sizewell C has a number of important issues with regard to safety, the environment and governance not considered in previous public consultations or included in earlier formal assessments. EDF's record demonstrates the complexity of building the EPR nuclear reactor and has already shown that large scale nuclear power is expensive and uncompetitive with substantial but unknown lifetime cost to the public, possibly to be compounded by an untested financing model. The risks of a nuclear accident during the lifetime of the project, such as have already occurred elsewhere, are real and have not been adequately addressed. The proposals for disposal of nuclear waste and Spent Fuel are particularly weak, flawed by unresolved conflicts of strategy and about its classification. Furthermore, the governance record of EDF in building new EPR reactors to cost and to timescale is extremely poor.

A more detailed analysis and interpretation of the evidence and related issues is provided in the report: *Sizewell C – Safety, capability and capacity, environmental health and funding – a 2020 perspective, Nick Scarr, December 2019*