RADIOACTIVE WASTE MANAGEMENT AND NEW NUCLEAR POWER STATIONS

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NuLeAF
NUCLEAR LEGACY ADVISORY FORUM

Introduction

This Briefing Paper covers:

- the granting of interim acceptance by the regulators of the generic designs for two nuclear reactors proposed for construction in the UK;
- the application for approval to construct a new nuclear power station at Hinkley Point in Somerset;
- an initial review of the current position on proposals for managing radioactive wastes and spent fuel from new nuclear power stations; and
- the publication of Government guidance on the Funded Decommissioning Programme for new nuclear build.

The information in this paper was considered by the NuLeAF Steering Group at its meeting on 25 January 2012. As a result, it agreed to write to the Office for Nuclear Regulation (ONR) asking it to take account of the views of the Royal Society on methods of spent fuel storage when requiring future new build licensees to undertake actions to underpin their approach to such storage.

Interim Acceptance of Generic Designs

Generic designs for two nuclear reactors proposed for construction in the UK have been granted interim acceptance by the nuclear safety, security and environment regulators.

On 14 December, the Office for Nuclear Regulation (ONR) and the Environment Agency (EA) confirmed they are satisfied with how the designers of both EDF and Areva's UK EPR and Westinghouse's AP1000 reactors plan to resolve a number of remaining issues. Neither reactor can be built in the UK until these issues are resolved.

For both designs, the ONR has issued interim Design Acceptance Confirmations (iDAC) and the EA has issued interim Statements of Design Acceptability (iSoDA). When all GDA Issues have been addressed to the regulators' satisfaction the interim status will be reviewed and, if appropriate, final DACs and SoDAs will be provided, together with a report describing the basis of the GDA Issue resolution. Only when all GDA Issues have been addressed to the regulators' satisfaction will they confirm that that are content for safety related construction of the nuclear power station to start.

The GDA work will also be used by the regulators to help inform their decisions on any site-specific applications that they receive for new nuclear power stations.

The regulators have published reports for each design summarising the basis of their interim decisions, together with their technical assessment reports. They have also published documents explaining how the designers plan to resolve issues identified in a report written by the UK's Chief Inspector of Nuclear Installations, Mike Weightman, on the

Fukushima accident. The GDA decision documents are available at https://consult.environment-agency.gov.uk/portal/ho/nuclear/gda and http://www.hse.gov.uk/newreactors/index.htm.

Consultation on the EA's preliminary GDA views took place during 2010. In response, NuLeAF submitted comments questioning the extent to which a robust approach was being taken to the management of the uncertainties and risks inherent in the implementation of national policies and strategies for spent fuel and radioactive waste management. NuLeAF's comments are available on the NuLeAF website at Comments on EA GDA. The EA's responses to these comments are covered in Annex 1 below.

The Application for Construction of Hinkley Point C

The application from EdF to develop two EPRs at Hinkley Point C (HPC) has been accepted by the Infrastructure Planning Commission (IPC) and the application documents are available on the IPC website (see Hinkley Point C New Nuclear Power Station). The IPC has approximately three months to prepare for examination of the application. During this stage, interested parties are able to register to put a case on the application (registrations have to be received by the end of the day on 23 January).

A preliminary meeting will be organised by the IPC, at which the examining Commissioner(s) will decide which issues the examination will focus upon and the timetable for the examination. The details about the preliminary meeting will be sent to all who have registered a relevant representation and will be published on the IPC website.

Somerset County Council (SCC) is working on a topic paper on the impacts of radioactive waste management at HPC. This will inform the authority's written representations on the application, which in turn will inform the Local Impact Report, the Statement of Common Ground and requirements and obligations associated with the proposed development. Initial representations are being prepared and will be signed off during the coming few weeks.

The likely focus of the SCC topic paper is on the impact of long-term interim storage of ILW and spent fuel at HPC, including consideration of tangible and perceived impacts and consideration of mitigation and/or compensation measures.

In terms of timeline, SCC will make initial representations to the IPC by 23 January and seek to finalise the topic paper by the end of January, ensuring that it is acceptable to all three local authorities in the area (SCC, West Somerset and Sedgemoor).

Initial Review of the Proposals for Managing Radioactive Wastes and Spent Fuel

A considerable amount of material on proposals for managing radioactive wastes and spent fuel from new nuclear power stations is available, particularly in the GDA documentation and in EdF's proposals for HPC. This material is reviewed in the Annexes to this report.

The most significant points from this review are:

- There is considerable uncertainty over the *duration of interim storage of spent fuel* at new reactor sites. Ultimately, NDA assessment of whether there is scope to accelerate aspects of the GDF programme could bring forward disposal of new build spent fuel to 2080, which is close to when the proposed HPC station might cease operation. However, the Government's aspiration to find a single site for a GDF for legacy and new build wastes is subject to a range of risks and uncertainties, such that spent fuel disposal may not be possible until considerably after the current assumption of 2130. This means that the duration of interim storage of spent fuel at the proposed HPC could be comparable to the period of reactor operation, or extend for another 50 years or more.

- Whether the Fukushima accident and subsequent UK reviews mean there is now a clearer case for preferring *dry storage of spent fuel* in the longer-term, rather than pond storage as proposed by EdF for HPC. The Royal Society has concluded that there is, but the ONR have been more circumspect in their conclusions (see Annex 2). In the light of this, NuLeAF has written to the ONR asking it to take account of the views of the Royal Society on methods of spent fuel storage when requiring future new build licensees to undertake actions to underpin their approaches to such storage.

Annex 1 also considers: the location of the interim storage and encapsulation of spent fuel; the disposability of new build spent fuel; ILW management and LLW management proposals.

Publication of Government Guidance on the Funded Decommissioning Programme

The Government legislated in the Energy Act 2008 (the Energy Act) to ensure that operators of new nuclear power stations will have secure financing arrangements in place to meet the full costs of decommissioning and their full share of waste management and disposal costs. Under the Energy Act, operators of new nuclear power stations are required to have a Funded Decommissioning Programme (FDP) approved by the Secretary of State for Energy and Climate Change (Secretary of State) in place before construction of a new nuclear power station begins, and to comply with this FDP thereafter. Failure by the operator or an associated company which has obligations under the FDP, to comply with the FDP will be a criminal offence under section 57 of the Energy Act.

The Energy Act makes provision for the Secretary of State to publish guidance about the preparation, content, modification and implementation of an FDP. The Energy Act also requires the Secretary of State to publish guidance about the factors which it may be appropriate to consider in deciding whether or not to: a) approve a programme; b) approve a programme with modifications or subject to conditions, or; c) make a proposed modification to a programme or the conditions subject to which it is approved.

In December 2010 the Government published for consultation draft Guidance on what an approvable FDP should contain, together with specific questions for consultation. The final version of that Guidance was published in December 2011 and is available on the DECC website at fdp-guidance-new-nuclear.

In its comments on the draft guidance, NuLeAF drew attention to the need for robust approval processes for operator FDP proposals, independent verification, and adequate risk premiums and measures to ensure protection against insufficient funds. The comments noted that Government intended to allow a combination of measures to protect against insufficient funds, including front loading of payments in early years, use of insurance or financial instruments and parent company guarantees. In order to secure public confidence in the adequacy of these arrangements, NuLeAF pointed out that it will be important that their operation is made as visible and transparent as possible, including publication of annual and quinquennial reports and the Government's response.

In its response to comments, the Government seeks to provide reassurance on these points, including:

- A commitment to publish decisions on FDP approvals, the advice from Nuclear Liabilities Financing Assurance Board (NLFAB) (except where issues are commercially confidential or have security sensitivities), and Annual Reports and Quinquennial Reports (taking into account, as appropriate, commercial confidentiality and security considerations).

- The Government would expect that any Verifier should be clearly and demonstrably independent. If the Verifier's independence could not be established, then the Secretary of State would not be able to rely on the Verifier's report. Instead the Secretary of State would commission further advice and recover the cost of that advice from the operator.

- The FDP should contain effective mechanisms to ensure that major project risks are identified and that the calculations of the costs take due account of risk and uncertainty. The FDP will be reviewed at each quinquennial review of the FDP in order that the assessment of risk remains up to date.

- The Government acknowledges that the long lifetime of an FDP increases the importance of ensuring robust arrangements and notes that one of the Guiding Factors is that the FDP must be a durable arrangement. It will be for an operator to demonstrate in its FDP that its proposals guarantee the security of the Fund Assets in the event of operator insolvency.

- The Government agrees that there are substantial risks regarding the sufficiency of the Fund that the operator needs to address in its plans. An operator will also be required to set out its analysis of risk and uncertainty. This analysis will be an important input into the determination of the prudent risk-based contingency element of the Target Value for the Fund. These cost estimates will be subject to independent verification and regular review.

- The Guidance requires there to be mechanisms in the FDP to address shortfall in the Fund. There will be flexibility as to how protection against an insufficient Fund can be provided with a case-by-case analysis by the Secretary of State, drawing on advice from the NLFAB. With regard to the various types of security that might be acceptable, the Government continues to encourage potential operators, the financial industry and insurance bodies to explore potential packages and stimulate interest in developing suitable insurance products. It is the Government's view that parent company guarantees may be able to provide sufficient security as part of a combination of security measures, but maintains that such guarantees on their own are unlikely to provide sufficient taxpayer protection.

NuLeAF also requested that Government clarify what mechanisms Government will put in place to ensure that new build operators will make a proportionate contribution to the community benefits that may be associated with development and use of regional or national radioactive waste management facilities. The Government's response to comments does not address this point.

ANNEX 1: REVIEW OF PROPOSALS FOR MANAGING RADIOACTIVE WASTES AND SPENT FUEL

EdF explain that strategic planning of waste management would be implemented at HPC through the development of an Integrated Waste Strategy (IWS) which will be reviewed and updated throughout the lifecycle of the HPC development. The principle objective of the IWS is to ensure that waste management throughout the lifecycle of HPC is robust, consistent with UK policy and protects people and the environment.

Through the GDA process, the EA has concluded that:

a) EdF and AREVA have provided a reasonable radioactive waste and spent fuel strategy for all waste streams that a UK EPR will typically produce.
b) The radioactive waste and spent fuel strategy is consistent with recent government statements.
c) The UK EPR design facilitates decommissioning, and uses Best Available Techniques (BAT) to minimise decommissioning waste and the impacts on people and the environment of decommissioning operations (EA EPR Decision Document, para 242).

Against this background, this Annex provides an initial review of the current position on proposals for managing the spent fuel, ILW and LLW from new nuclear power stations, with specific reference to the proposals for HPC.

Spent Fuel (SF)

This section covers the location, duration and method of the interim storage of spent fuel, the location for its packaging for disposal and on its disposability to a GDF.

Location of interim storage of SF

At the January 2011 Steering Group, Nuclear Industry Association (NIA) representatives presented the outcome of the industry study on options for new build spent fuel management and disposal. Much of the discussion focused on the potential process for moving from the base case (spent fuel storage at each new build site) to a centralised approach. NIA explained that currently EdF has to proceed with the base case. In their opinion, to do otherwise would require a Government policy change to the base case, and development of a demonstrable case for a centralised approach, which were matters for the MRWS process.

This issue was pursued with DECC at the NuLeAF Steering Group meeting in April 2011. In contrast to the NIA view, DECC stated that the nuclear industry is free to consider moving towards centralised or regional storage for spent fuel from new nuclear stations, but they would have to go through a process of discussion with relevant parties.

In its interim acceptance of generic reactor designs the EA describes the base case assumption of interim storage at each new build site as a "prudent assumption in the absence of any firm proposals for alternative arrangements" (para 1213, EA EPR Decision Document). The application for HPC includes proposals for the interim storage of spent fuel at HPC pending geological disposal.

Duration of interim storage of SF

NuLeAF's comments on the EA's initial GDA views focused on two types of uncertainties that could impact on the duration of interim storage: the cooling period needed for spent fuel before it could be disposed of; and the potential for delays to the development of a GDF that includes new build spent fuel in its inventory. Preliminary NDA Radioactive Waste Management Division (RWMD) assessment had indicated that a 100 year period of cooling might be necessary which, combined with a reactor lifetime of 60 years, had led to concerns about the long period of on-site interim storage that could arise.

Subsequently, in its response to consultation on the Nuclear NPS, Government stated that '…the duration of storage of spent fuel after the end of power station operation could in principle be reduced to the order of 50 years through combining in disposal canisters fuel from the earlier years of operation with fuel from the later years of operation'. On this basis, the EA has noted that the date at which spent fuel could be first disposed of, assuming 60 years operation beginning in 2018 and 50 years storage, is then close to the current 2130 date when it is projected access to the GDF will first become available for new build wastes after dealing with legacy wastes.

It should be noted, however, that the 2130 date could also be subject to change, as NDA is assessing whether there is scope to accelerate aspects of the GDF programme, which could involve potential to bring forward disposal of new build spent fuel by 50 years to 2080 (subject to meeting thermal requirements). This could shorten the duration of on-site interim storage to a timescale comparable with reactor operation.

In contrast to this potential 'best case', NuLeAF has previously commented that the Government's aspiration to find a single site for a GDF that would enable legacy and new build spent fuel to be disposed of in the same facility is subject to a range of risks and uncertainties. In particular, the capacity of suitable host rock at a preferred site may not be sufficient for new build spent fuel and legacy wastes, or the volunteer communities may not agree to the disposal of new build spent fuel. It is possible, therefore, that a second GDF will be required for new build spent fuel , which adds to the uncertainties around timescales and the risk that a disposal route for new build higher activity wastes will not be found.

NuLeAF suggested to the EA that the GDA process should explicitly address the implications of such scenarios for the interim management of spent fuel. In response, the EA has stated that this is not within the scope of the GDA (EA EPR Decision Document, para 818). It does state however that whatever the duration of interim storage the Regulators will collectively require operators to store waste safely and securely and with the environment properly protected (EA EPR Decision Document, para 1212). In addition, ONR requires action AF-UKEPR-RW-08, that the licensee shall produce a plan, with RWMD input, for the work necessary to reduce the on-site storage period for the spent fuel produced by the reactor so that the fuel can be transported as soon as reasonably practical. ONR require the action to be complete prior to the first fuel load (ONR Radioactive Waste and Decommissioning Assessment, para 312).

Method of Interim Storage of SF

During 2010, EdF expressed the view that there is no clearly superior technology for the interim storage of spent fuel from new nuclear power stations, with both wet and dry storage systems having strengths. In these circumstances, EdF suggested that decisions have to be based on judgement, taking into account detailed factors at a particular site.

The question arises of whether the Fukushima accident and the consequent UK review should cause any change to such a view. In particular, is there now a clearer case for preferring dry storage systems? The Royal Society has recently concluded that there is, but the Office for Nuclear Regulation has been more circumspect in its conclusions on the implications of the Fukushima accident. Annex 2 to this paper outlines: the approach to spent fuel storage in the UK; proposals for spent fuel storage at Hinkley Point C; the views of the Royal Society on best practice for spent fuel storage; the relevant findings of the UK Fukushima review (the "Weightman Report"); the relevant findings of post-Fukushima 'stress tests'; the relevant findings of the GDA process; and comments on proposals for spent fuel storage at Hinkley Point C.

Location for encapsulation plant for SF

The Government's current base case is that an encapsulation plant would be built at each new nuclear power station site, but NDA acknowledge the possibility of a centralised encapsulation facility at a GDF site. Because of the complexity and expense of such a facility, in their application for Hinkley Point C, EdF say that a "more realistic assumption would be for a single UK facility to be developed to encapsulate both legacy and new build spent fuel and HLW." They add that "such a facility could be co-located with the eventual repository site" (HPC Application, Environmental Statement, Vol 2, para 7.7.12).

In their GDA decision document, the EA note that there is considerable experience internationally to show that packaging could be done safely at the reactor site, the GDF site or a third site if appropriate facilities and operations are put in place (para 836). EA adds that they recognise that EdF and Areva need to know other organisations' plans in order to take a considered view of the best option (para 837). Similarly, ONR conclude that the information provided by EdF and AREVA on the encapsulation of spent fuel is sufficient to show that packaging for disposal should be feasible. ONR adds that "as this facility would not be required for several tens of years I do not believe that there is any benefit in pursuing this issue further within GDA (ONR Radioactive Waste and Decommissioning Assessment, para 282).

Disposability of new build SF

EdF reports that the NDA RWMD has undertaken an assessment of the disposability of EPR spent fuel to a GDF and concludes that no new issues arise, compared with existing spent fuel, that challenge its fundamental disposability. They add that "Given a disposal site with suitable characteristics, the spent fuel from the UK EPR is expected to be disposable (HPC Application, Environmental Statement, Vol 2, para 7.7.15).

The EA concurs that the spent fuel is likely to be suitable for disposal in a geological repository but, through the GDA process, requested EdF/AREVA to develop and submit a plan for addressing disposability issues and seeking endorsements to support the case for disposability of spent fuel following storage. In general, the EA concludes, "we consider the plans proposed by EDF and AREVA, outlining how and when they and future licensees will address the outstanding disposability issues, to be adequate at this stage" (EA EPR Decision Document, para 832).

The EA also identified the following assessment finding: "The future operator should provide confidence at the site-specific stage that adequate Radioactive Waste Management Cases (RWMCs), supported by appropriate stage LoCs[1] and taking due account of necessary

[1] The LoC (letter of compliance) process is the mechanism that RWMD use to provide confidence that a waste

storage periods, can be developed for spent fuel on the timescales identified in EDF and AREVA's plan for disposability of spent fuel. (UK EPR AF17)" (EA EPR Decision Document, para 832).

ILW

On ILW, EdF provide an overview of the categories of ILW likely to arise from normal operation and maintenance of two UK EPRs at HPC (HPC Application, Environmental Statement, Vol 2, para 7.4.3). They explain that the strategy is for ILW to be retrieved, conditioned and packaged on site throughout the operational phase and that waste processing would result in a passively safe package ready for interim storage. Conditioning would take place in an Effluent Treatment Building (ETB) built on the HPC site. The packages would then be stored in an ILW Interim Storage Facility (ILWISF) for the duration of operations. Stored ILW packages would be removed when a GDF is available to accept new build waste for disposal.

EdF state that there are no plans to receive, process or store radioactive wastes from other nuclear sites and that the facilities proposed for HPC have been designed and sized to manage and store the waste from the HPC site only (Vol 2, para 7.2.5). It is not clear whether EdF has given any consideration to the scope for the use of shared radioactive waste management facilities between the A, B and C sites at HP and, if so, what the reasons are for not pursuing such shared use. Note by way of context that NDA is currently examining the scope for consolidating ILW treatment and storage across its estate.

In their GDA report, ONR recognise that EDF and AREVA have demonstrated credible options for short term storage and conditioning of ILW, but will require the licensee to go through a process to optimise the process for conditioning wastes: "**AF-UKEPR-RW-06**: *the licensee shall produce a safety report for the processing and long-term storage of the ILW. The report will contain information equivalent to that of a Preliminary Safety Case as defined in Guidance on the Purpose, Scope and Content of Nuclear Safety Cases, (Ref. 60) and be complete prior to the pouring of nuclear island safety related concrete"* (para 289).

EdF explain that some ILW will be suitable for 'decay storage' after which time the radioactivity would have reduced to such levels that waste could be removed from the ILWISF and be managed as LLW (para 7.4.7). The EA confirms that decay storage could enable some of the ILW to be reclassified as LLW (para 686).

On disposability, EdF explain that RWMD has indicated that, in principle, any of its proposed ILW waste packages would be acceptable for disposal (para 7.4.11). The EA states that, in general, it considers the plans proposed by EDF and AREVA, outlining how and when they and future licensees will address outstanding disposability issues, to be adequate at this stage (para 696). The EA has also identified the following assessment finding: the future operator shall provide confidence that adequate RWMCs, supported by appropriate stage LoCs, can be developed for all ILW on the timescales identified in EDF and AREVA's plan for disposability of ILW (UK EPR-AF10).

EdF also provide a 'baseline processing strategy' which sets out a waste description, annual arisings, lifetime arisings, type of processing and number of anticipated packages for each ILW stream (Table 7.5).

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package can be accepted at a future GDF.

EdF anticipates that the ILWISF would be emptied of waste and decommissioned within 20 years of end of generation, although its lifespan is capable of extension if necessary through refurbishment or replacement of equipment and structures (para 7.4.32). It explains that a reactor that begins generation in 2018, with a 60 year generating life, could have all ILW packaged and ready for transfer to a GDF by around 2100 (which is significantly earlier than the currently anticipated date for disposal of new build wastes, 2130).

EdF states that the current scheduling for transfer of ILW to the GDF has not been optimised for new build waste, but that optimisation should allow earlier disposal of new build ILW (para 7.5.8). For the purposes of decommissioning planning, EdF assumes that GDF scheduling can be optimised to allow transfer of ILW during the main site decommissioning phase, but that if optimisation requires a further period of interim storage at the HPC site, it is possible that the ILWISF may need refurbishment.

In their GDA report, ONR state that they are satisfied that EDF and AREVA have made sound arguments showing their plans for long term storage of ILW should be safe to implement (para 294).

LLW

For each type of LLW that would arise at HPC, EdF provide an estimate of annual raw LLW arisings, the preferred waste management approach, and alternative arrangements (HPC Application, Environmental Statement, Vol 2, Table 7.2). The preferred waste management approaches include conditioning and packaging for disposal to the LLWR near Drigg, the off-site disposal of VLLW to landfill, transfer for incineration and transfer for metals treatment.

EdF states that direct disposal to LLWR is seen as the least desirable option so where a reasonably practicable alternative disposal route exists (eg incineration or metal recycling) this has been chosen as the preferred option (para 7.3.16). It explains that disposability in principle has been confirmed by LLWR Ltd for the volume and activity of LLW in its application for HPC (para 7.3.18).

The EA notes that the LLWR agreement in principle is on the basis that LLW waste streams would be suitable for treatment/disposal against their current arrangements, but that LLWR Ltd cannot guarantee future capacity today (para 654).

EdF acknowledge that the LLWR has a current estimated lifetime shorter than the operation of HPC, but assumes that, as stated in Government policy, that new disposal facilities will ultimately be provided by the NDA (para 7.3.21).

Although consistent with national policy and strategy, it is uncertain how far into the future LLWR and off-site landfill will be available. There will be a need for further permissions (including for site life extensions) if a significant landfill disposal capacity is to be available beyond the next few years. To an extent EdF acknowledges the uncertainties by reference to alternative arrangements in the final column of Table 7.2.

EA notes that such concerns are outside the scope of the GDA because under the Energy Act 2004, the NDA has the responsibility for developing a UK-wide strategy for managing the UK nuclear industry's LLW (EA Final Assessment Report on Solid radioactive waste, para 74).

As with ILW, LLW would be transferred to the ETB. It would then be categorised, segregated, treated and packaged as appropriate to the chosen disposal route.

The EA note that the storage capacity of the reference ETB is enough to ensure buffer storage of LLW for more than one year of operating, including maintenance operations, even in the case that two UK EPR units share the ETB (para 649).

Overall, EA comment that: "We do not expect the information on solid radioactive waste treatment to have the same level of detail as that of an existing plant or one that is undergoing decommissioning. We agree that EDF and AREVA have only provided basic evidence of how they will minimise the quantities of LLW and ILW needing disposal. Hence, we require evidence during the detailed design phase that the proposed specific techniques for preventing and, where that is not possible, minimising the creation of LLW and ILW are BAT (UK EPR-AF11). We also require evidence during the detailed design phase that the proposed specific techniques for treating and conditioning of LLW and ILW before disposal are BAT (UK EPR-AF12). We also have assessment findings that if smelting or incineration of LLW is pursued, the future operator shall demonstrate that the conditions of acceptance of the selected smelting / incineration facility can be met (UK EPR-AF13 and UK EPR-14)". (EA Final Assessment Report on Solid Radioactive Waste, para 73)

ANNEX 2: METHOD OF INTERIM STORAGE OF SPENT FUEL FOR NEW NUCLEAR POWER STATIONS

During 2010, EdF expressed the view that there is no clearly superior technology for the interim storage of spent fuel from new nuclear power stations, with both wet and dry storage systems having strengths. In these circumstances, EdF suggested that decisions have to be based on judgement, taking into account detailed factors at a particular site[2].

The question arises of whether the Fukushima accident and the consequent UK review should cause any change to such a view. In particular, is there now a clearer case for preferring dry storage systems?

The Royal Society has recently concluded that there is, but the Office for Nuclear Regulation has been more circumspect in its conclusions on the implications of the Fukushima accident.

This note outlines:

- the approach to spent fuel storage in the UK
- proposals for spent fuel storage at Hinkley Point C
- the views of the Royal Society on best practice for spent fuel storage
- the relevant findings of the UK Fukushima review (the "Weightman Report")
- the relevant findings of the post-Fukushima stress tests
- the relevant findings of the GDA process
- comments on proposals for spent fuel storage at Hinkley Point C.

Approach to Spent Fuel Storage in the UK

Spent fuel is intensely hot and radioactive due to the natural decay processes of the fission products and minor actinides it contains. It is initially cooled under wet conditions in storage ponds located in the immediate proximity of the reactor. Water provides an effective coolant and radiation shielding. With more than 50 years of experience, wet storage is considered to be a mature technology. However, it requires relatively high maintenance, especially tight control of the water's chemistry to prevent the fuel or its cladding from degrading. In addition, the pond is actively cooled. Pumps circulate water from the pool to heat exchanges so that the heat generated by the assemblies is continuously removed. The environment above the pond in the storage facility is carefully monitored and treated, including the detection of hydrogen gas, created by radiolysis of pond water by high levels of radiation adjacent to the spent fuel.

The period of initial cooling varies with types of spent fuel. Active cooling demands for gas-cooled reactor (Magnox and AGRs) spent fuel are relatively light. PWR spent fuel requires longer (several years) before alternative management options can be considered. Alternative options can depend on a number of factors, including the length of time spent fuel is to be stored on site and the choice of fuel cycle.

Most of the spent fuel generated in the UK has been stored wet at the site of arising, prior to transport to Sellafield for reprocessing. Exceptions to this include: Magnox spent fuel at Wylfa which is stored dry prior to transport to Sellafield for reprocessing; a proportion of AGR spent fuel which is stored in ponds at Sellafield pending direct disposal to a GDF; and

[2] These factors could include: burn-up of the fuel, the time the spent fuel has been in a reactor pond before transfer, fuel quantity and scope for modifying existing plant.

spent fuel from Sizewell B which is currently stored wet at Sizewell, pending transfer to dry storage on the site and eventual direct disposal to a GDF.

Proposals for Spent Fuel Storage at Hinkley C

EdF's proposals for a new nuclear power station at Hinkley C include:

- initial cooling of spent fuel in the reactor pool within the Fuel Buildings associated with each reactor unit for up to 10 years (Vol 2 Hinkley application, para 7.6.8);
- transfer to a separate on-site interim wet store (the 'ISFS') pending disposal to a GDF in around 2130 (para 7.6.9-10).

EdF explain that the ISFS would be designed so as to be capable of operating independently of other parts of the site in recognition of the need, under current assumptions, for its lifetime to extend beyond the decommissioning of other facilities on site (para 7.6.11).

The choice of wet storage for the ISFS was made following a Multi-Attribute Decision Analysis (MADA). EdF explain that the MADA placed a high level of importance on safety and environmental performance, but because all storage options (including dry storage) can meet regulatory requirements, the selection of wet storage was linked to performance against the following 4 attributes:

- protecting long term flexibility with respect to possible development in fuel technology;
- ease of inspection of spent fuel thus enabling review of fuel condition against GDF waste acceptance criteria;
- reducing financial risks; and
- maximising the benefits from retaining consistency in design with other EdF reactors.

The Royal Society on Spent Fuel Storage

The Royal Society (RS) has recently published a report entitled, 'Fuel Cycle Stewardship in a Nuclear Renaissance' (October 2011). This considers the potential of new technologies and governance best practices to make the nuclear fuel cycle more secure and proliferation resistant, with a particular focus on the management of spent fuel. The report is available on the RS's website at Fuel cycle stewardship in a nuclear renaissance,

The RS report says the following on the "resilience of dry storage":

> If spent fuel is to be stored pending reprocessing, then it would be less complicated to continue to wet store it. Robust arrangements for continuous and back up cooling and onsite power are essential to guarantee safety and security over the long term. If there is no intention of reprocessing, then the high degree of passive safety and security provided by dry storage should be exploited.
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> Dry storage involves surrounding spent fuel assemblies with inert gas inside a large cask, typically a steel cylinder that is welded or bolted closed. This inner canister is surrounded by an outer cask made of steel, concrete or other material to provide extra radiation shielding. Cooling channels in the outer cask allow air to circulate naturally around the inner canister so that heat is removed by natural convection processes. In some cases, the casks are stacked vertically or horizontally in concrete vaults to provide further radiation shielding.

Although wet storage allows greater heat dissipation, dry storage is considered to be a safer long term management option due to its simpler, passive cooling systems. Unlike wet storage, dry storage does not necessarily rely on the intervention of an operator or mechanical control. Casks are considered to be highly robust to various attack scenarios. Casks may be easier to access than spent fuel in wet stores but their sheer size and bulk makes handling and movement of them highly difficult. Dry storage may be more expensive than wet storage, requiring extra space to store the same amount of spent fuel. Several casks are needed for each reactor discharge, thereby dividing up the inventory of spent fuel into a large number of discrete containers.

One R&D priority is to design casks that allow spent fuel to be removed from ponds after one to two years following initial cooling rather than the standard five years, although this may require active cooling. Further R&D may be necessary in the drying process, especially for damaged spent fuel.

Casks can be either single or dual use depending on whether they are to serve as the storage container only or also as the transport container. Other options are being explored, including multipurpose designs that can function as the storage, transport and waste container for disposal deep underground. This practice should be encouraged since it builds in contingency should spent fuel need to be moved or alternative management options pursued. Continued R&D can help provide confidence that spent fuel can be storable, transportable and disposable in the long term (CoRWM 2009b).

On best practice, the RS concludes that when planning interim spent fuel storage:

- The amount of spent fuel stored in ponds in the vicinity of reactors should be minimised by removing spent fuel as early as is feasible for interim storage elsewhere whether on-site (away from reactors) or off-site.
- Interim storage at centralised stores offsite may be more secure than distributed storage at numerous reactor sites.
- If wet storage is to continue in the interim, then sufficient storage capacity should be planned to reduce the need for high density packing and to guarantee continuous cooling.
- Whenever possible, interim storage under dry conditions should be adopted to enhance nuclear safety and security.

Weightman Report

On spent fuel management at Fukushima, the final report:

- Discusses the extent to which the spent fuel ponds at Fukushima were affected by, and contributed to, the accident (paras 211-224, p40). It suggests that the structures of the individual reactor ponds remained essentially intact and that it is unlikely that any hydrogen explosions were caused by the uncovering of spent fuel as a result of water loss in the ponds (although "no definitive mechanism has been established" for the explosions). It notes that the improvised ways of providing water to the ponds seems to have been effective in maintaining water levels. It also summarises information about the reactors' common pond and on dry cask storage, reporting no significant damage to the former and (despite water inundation) no effect on the casks (paras 230-231, p44).

- Concludes that "the ponds appear not to have been a significant contributor to the consequences of the accident" (para 324, p60).
- Points to the "ability to provide make-up water for a prolonged period of time (admittedly by unconventional means and with access enabled by damage to the buildings)" (para 324 p60), but says "it is worth noting that more urgent operator actions to provide make-up would have been required if the spent fuel ponds integrity had been breached and water lost by leakage. This would potentially have exacerbated the overall situation considerably." (para 382, p71)

On UK arrangements for spent fuel storage, the report notes that:

- the "response to the Interim Report recommendations and the European Council "Stress Tests" being carried out in the UK should demonstrate whether the UK spent fuel ponds are passively "safe" by design, and in some cases whether it is ALARP[3] to impose relatively straight forward minimum cooling times or racking configurations to ensure that with a total loss of active cooling (possibly even a catastrophic loss of water inventory) the fuel should remain substantially intact." (para 325, p60)
- EdF recognises that there will be a need to carefully assess and make appropriate changes in several key areas, including: enhancements to on-site resilience from the effects of major events; provision of off-site emergency back-up equipment that can readily be connected to the plant; and the potential impact of abnormal natural events on local and national infrastructure (para 602, p107). In addition, EdF has identified a number of specific potential enhancements to resilience, including a larger water reservoir for make-up under severe accident conditions that is seismically qualified (para 616, p110).
- Magnox has undertaken work on Oldbury and Wylfa that identifies a number of potential improvements which could enhance the resilience to various events, in particular extreme seismic or flooding events. Examples of the potential improvements highlighted by Magnox are: enhanced protection of existing facilities to reduce the potential for damage; and storage of existing on-site back-up equipment (e.g. spare pumps and pressure circuit sealing equipment) in diverse locations at various levels (para 624, p111).

Post-Fukushima Stress Tests

The ONR final report on the EC stress tests was published in early January 2012 and is available at Stress Tests Report. The report includes considerable discussion of current arrangements for the storage of spent fuel at existing reactor sites.

It contains two findings of direct relevance to spent fuel storage:

STF 5: Licensees should further review the margins for all safety-significant structures, systems and components (SSC), including cooling ponds, in a structured systematic and comprehensive manner to understand the beyond design basis sequence of failure and any cliff-edges that apply for all external hazards.

STF19: Reports on the progress made in addressing the conclusions of the licensees *Considerations* and the ONR findings should be made available to ONR on the same timescale as that for HM Chief Inspector's recommendations (June 2012). These should include the status of plans and details of improvements that have been implemented.

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[3] As Low As Reasonably Practicable

Background to STF5 is provided in para 1088 of the report: "EDF NGL has concluded that the robustness of the AGR and PWR pond against design basis accidents is appropriate; however, the review of robustness to beyond design basis accidents has identified several areas where enhancement could be considered. The consideration will relate to provision of additional emergency back-up equipment. This equipment could provide additional diverse means to ensure robust, long-term, independent supplies to the pond. It could be located at an appropriate off-site location close to the station to provide a range of capability to be deployed in line with initial post-event assessment. The equipment may include items to enable pond cooling, emergency command and control facilities, communications equipment, emergency response / recovery equipment, electrical supplies for lighting, C&I. It could also include water supplies for cooling and robust means for transportation of it all, and personnel, to the site post-event."

Interim Acceptance of Generic Designs

Both EA and ONR draw conclusions about the method of spent fuel management in their interim acceptance of generic designs.

The EA explains that during the GDA process EdF and AREVA considered three spent fuel storage technologies, based on available and proven technologies: a) wet interim pool storage- fuel assemblies stored in a pool; b) dry interim cask storage- fuel assemblies stored in metal casks; and c) dry interim storage in purpose designed stores- fuel assemblies stored in vault type storage. EA conclude that both wet and dry storage systems could be used and that it is for any future operator to make the choice of the interim spent fuel storage system, and to provide evidence that the chosen option represents BAT (EA EPR Decision Document, para 775).

The ONR draw a number of conclusions:

- The actual period that the fuel has to be cooled before it is placed into long-term interim storage will need to be derived on a site specific basis by the licensee (ONR Radioactive Waste and Decommissioning Assessment, para 282).

- Safety Assessment Principle (SAP) RW5 states that radioactive waste should be stored in accordance with good engineering practice and in a passively safe condition. For very long term storage, EdF and AREVA indicate that some fuel may have to be cooled for disposal for 100 years. ONR states that "it is challenging to meet the principles of SAP RW5 over this timescale" (ONR, para 298).

- The information provided by EdF and AREVA on the long term management of spent fuel is to a level of detail broadly in line with ONR's published expectations (Ref. 13). In addition, EdF and AREVA have provided alternative processes for storing these wastes.

- SAP RW 5 is supported by explanatory text. Much of the evidence this explanatory text would require is beyond the requirements of GDA. The arguments presented by EdF and AREVA show that the aspects required for GDA can be met and that fuel can be stored for the required periods (ONR paras 303-304).

- ONR acknowledge that there remains a small residual risk that after interim storage the fuel is not in a suitable state for transport. To alleviate this risk it will be an important aspect of the storage option selected that: "the transfer of the fuel from the at-reactor spent fuel pool to the long-term store does not adversely affect the long term performance of the fuel, cladding or support structure; the fuel can be monitored so that any detected changes can be acted upon; and there is sufficient space for maintenance, repair or replacement of the equipment and the fuel" (ONR para 305).

- To compliment the design of the storage facility it will also be important for the licensee to have programmes in place to: research the evolution of the fuel, cladding and support structure to build to maintain confidence that it is not undermining the ability to transport the fuel; learn from the international experience on the long term management of spent fuel so that any potential remediation can occur early; and work with RWMD to optimise the storage periods so that transport can occur as soon as reasonably practical.

- ONR is requiring the licensee to undertake a number of actions associated with the development of the long-term spent fuel interim storage facilities. These include: "**AF-UKEPR-RW-10**: the licensee shall produce a safety report for the long-term storage of spent fuel. The report will contain information at least equivalent to that of a Preliminary Safety Case as defined in Guidance on the Purpose, Scope and Content of Nuclear Safety Cases. It shall also detail the proactive inspection regime for the spent fuel in on-site storage that builds on existing knowledge and experience, allows the spent fuel to be retrieved and inspected within a reasonable time frame and limits the number of fuel assembly lifts. This will be complete prior to the first fuel load." "**AF-UKEPR-RW-07**: the licensee shall identify the evidence necessary to underpin their spent fuel storage, transport and disposal strategy, the activities needed to secure this evidence and the time needed for these activities. The provision of this evidence and associated activities will be detailed on a plan that will link the evidence needed with the construction activities for all on site facilities required to manage the spent fuel over its lifetime. This will be complete prior to the pouring of nuclear island safety related concrete" (ONR, para 312).

Comments on Proposals for Spent Fuel Storage at Hinkley Point C

Comments on EdF's proposals are as follows:

Initial cooling within the ponds in the reactor Fuel Buildings

EdF anticipates initial cooling of spent fuel over a period of up to 10 years in the ponds in the reactor Fuel Building. In contrast the Royal Society recommends that the amount of spent fuel stored in ponds in the vicinity of reactors should be minimised by removing spent fuel as early as is feasible for interim storage elsewhere on-site (away from reactors). As noted above, ONR concludes that the actual period that the fuel has to be cooled before it is placed into long-term interim storage will need to be derived on a site specific basis by the licensee.

The assessment of spent fuel storage options

EdF's assessment concludes that wet interim storage is the best approach for the reasons stated above. In contrast the Royal Society recommends that whenever possible, interim storage under dry conditions should be adopted to enhance nuclear safety and security. As noted above, ONR point out that SAP RW5 states that radioactive waste should be stored in accordance with good engineering practice and in a passively safe condition. For very long term storage, EDF and AREVA indicate that some fuel may have to be cooled for disposal for 100 years. ONR states that "it is challenging to meet the principles of SAP RW5 over this timescale".

This raises the question of whether ONR should ask EdF to review the robustness of the MADA undertaken to identify a preferred approach to interim storage of spent fuel in the light of thinking post-Fukushima. In particular, it might be appropriate to give more weight to the long-term safety advantage of passively cooled dry casks compared with actively cooled ponds (but see EdF claims below). It might also aid understanding and confidence if EdF were able to explain why the first three claimed advantages of wet storage (p2 above) would not also apply to spent fuel storage at Sizewell B (where spent fuel is to be transferred to dry storage).

Arrangements for wet storage within the ISFS

EdF explains that the ISFS design will be optimised to favour as much as possible passive operation of the facility. This will include use of a volume of water that is large in comparison with the amount of heat generated within the stored spent fuel and the design of cooling systems that can provide significant cooling even when operating in passive mode and hence safety over very long periods even if power supplies were lost (Vol 2, Hinkley application, para 7.6.17). However, water chemistry will have to be controlled to avoid corrosion of fuel assemblies.

As noted above, ONR is requiring licensees to undertake a number of actions associated with the development of long-term spent fuel interim storage facilities, including production of a safety report and the evidence necessary to underpin their spent fuel storage strategy.

In the light of this, it is recommended that the SG agree to write to the ONR asking it to take account of the views of the Royal Society on methods of spent fuel storage when requiring future new build licensees to undertake actions to underpin their approaches to such storage.