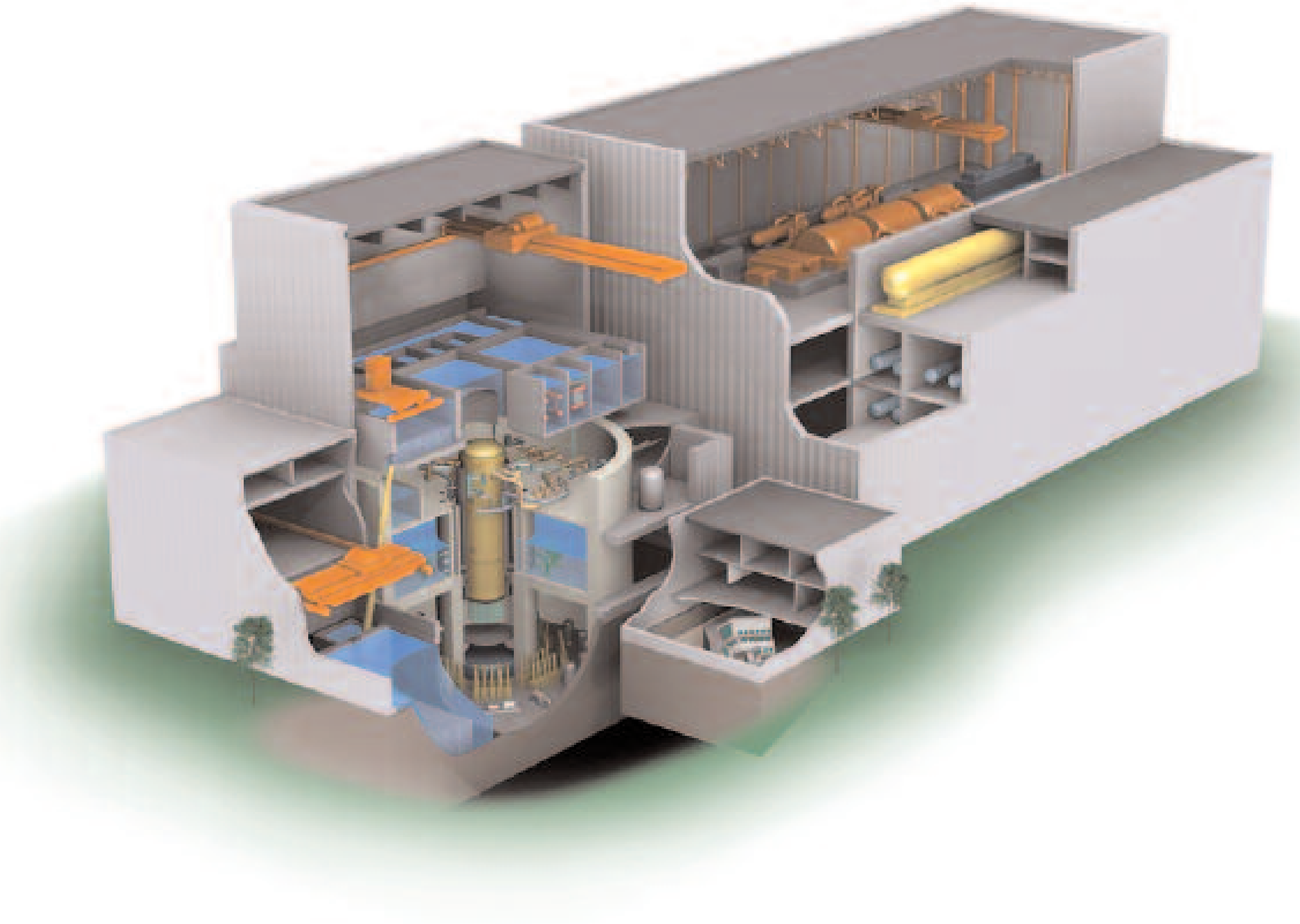
HSE

Health and Safety Executive

Public Report on the Generic Design Assessment of New Nuclear Reactor Designs

GE-Hitachi Nuclear Energy International LLC ESBWR Nuclear Reactor

Conclusions of the Fundamental Safety Overview of the ESBWR Nuclear Reactor (Step 2 of the Generic Design Assessment Process)



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Foreword

Our job is about protecting people and society from the hazards presented by the nuclear industry. As new nuclear power stations are now being considered for the UK, it is right for us as regulators to start our work to examine the safety and security aspects associated with those power stations' design.

We are looking at the reactors within a new process called Generic Design Assessment (GDA), which seeks to get the nuclear regulators involved at an early stage in development of proposals for new nuclear power stations. GDA allows the technical assessments of the reactors to be conducted before any specific nuclear site licence assessments are undertaken, thus identifying and resolving any potential regulatory issues before commitments are made to construct the reactors. The assessment is in several steps and includes initial and then more detailed examinations of the safety and security of the proposed reactors.

I am really pleased to be able to publish this report today and to set out the conclusions of our initial assessment of the ESBWR reactor. In summary, at this stage, we have found no safety shortfalls that would rule out its eventual construction on licensed sites in the UK.

The GDA process is new both for us and for the industry and we have set out very clear guidance on how it will be conducted. This report provides real proof that we are moving forwards in our assessment work, with the rigour, quality, and openness expected by the public.

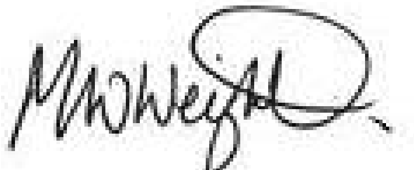
In doing this work we are setting new standards in efficiency. For example we have set up a Joint Programme Office with our colleagues at the Environment Agency so that the industry has a one-stop shop for nuclear regulatory issues.

We are also undertaking our assessment work in a more open manner than seen in the UK before. We have set up new reactor assessment information websites, put leaflets in libraries and set up an e-bulletin system. The industry has supported this open approach by putting GDA announcements in the press, making their safety documentation available on their websites, and inviting comments from the public. By acting in such an open manner, we aim to earn public confidence in our work.

We have also put ourselves up for independent scrutiny. In 2006 we underwent a review by the International Atomic Energy Agency (IAEA), and in the past few weeks, we have had an independent team look at how we have applied our GDA process. These reviews highlight that our regulation is effective and efficient, but they also help us identify areas for improvement and we will strive to learn from what they tell us.

There are challenges ahead. For example, we need more staff and we are actively recruiting to help us continue our assessment of new reactors and to ensure that people will continue to be properly protected if these reactors are eventually constructed.

If you have any comments on this report I will be pleased to hear from you, especially if you can help us in our drive for continuous improvement.



Mike Weightman
HM Chief Inspector of Nuclear Installations and
Head of HSE's Nuclear Directorate

Executive summary

The role of the Health and Safety Executive's (HSE's) Nuclear Directorate (ND) is to protect people and society from the hazards of the nuclear industry. To achieve this aim in the light of proposals for construction of new nuclear power stations in the United Kingdom, we have been assessing the nuclear safety and security aspects of four reactor* designs. We are examining these particular designs as they have been identified by the Department for Business, Enterprise and Regulatory Reform (BERR) as those most likely to be built in the UK, and which would thus be those that are most likely to present a hazard to the public.

The assessment being undertaken by HSE, along with the Environment Agency, is part of a new process called Generic Design Assessment (GDA). This report is an interim report on our GDA assessment and it summarises our findings to date. In parallel, the Environment Agency is publishing a separate report on its assessment of environmental aspects.

Progress through GDA does not guarantee that any of these designs will eventually be constructed in the UK. What it does do is allow us to examine the safety and security aspects at an early stage when we can have significant influence, and to make public reports about our opinions so that:

- the public can be informed about our independent review of the designs; and
- industry can have clarity on our opinions and thus take due account of them in developing new construction projects.

This new GDA process is being conducted with a high degree of openness. We have made information about our process and the reactor designs available to the public via our website www.hse.gov.uk/newreactors. Furthermore, the public have been encouraged to comment on the reactor designs and we are considering these comments, along with the responses from the designers, within our assessment.

A further advantage of the GDA process is that it has been designed to allow the nuclear regulators (HSE and the Environment Agency) to work closely together. In support of this we have set up a Joint Programme Office, which administers the GDA process on behalf of both Regulators, providing a 'one-stop shop' for this phase of the assessment of potential new nuclear power stations. We believe this is improving efficiency both for the Regulators and the Industry, and it will help to provide more effective regulation of potential hazards.

There are four steps to the GDA process. Step 1 of the GDA was devoted to preparatory work and we made a statement on our website in August 2007 that this was complete and that Step 2 was commencing.

This report is the first of our public statements for the ESBWR design by GE-Hitachi (GEH) and it comes at the end of GDA Step 2. The aim of Step 2 was to provide an overview of the fundamental acceptability of ESBWR within the UK regulatory regime. It was also intended that Step 2 would allow HSE inspectors to familiarise themselves with the design and provide a basis for planning subsequent assessment work.

* In this report, the word 'reactor' can be taken to cover all nuclear safety and security related areas of the proposed nuclear power station design.

To achieve these aims, HSE has undertaken a high-level review of GEH's claims for a number of different safety aspects of the ESBWR reactor, and we have considered the security aspects of the design.

In summary, we have not found any safety or security shortfalls that are so serious as to rule out at this stage eventual construction of the ESBWR on licensed sites in the UK.

As anticipated, our assessment has identified a number of topics that will need to be addressed in more detail during GDA Step 3 and Step 4, should the ESBWR proceed through to the next steps of the GDA process. In this event, we will summarise our progress on these topics in a public report at the end of Step 3 and in a final GDA report at the end of Step 4.

Background

In response to growing interest in nuclear power and in anticipation of possible applications for new build in the UK, HSE began development in 2005 of a progressive generic design assessment approach for new nuclear power stations. HSE outlined the proposed assessment process in its Expert Report on new energy technologies, which was submitted to DTI* in June 2006 to inform the Government's Energy Review. The Government subsequently asked HSE to fully develop its assessment proposals and this led to the production of guidance on HSE's Generic Design Assessment (GDA) process for new nuclear power stations, which was published in January 2007 and updated in July 2007.

HSE considers that the GDA approach not only offers benefits to an expanding nuclear industry, but also strengthens HSE's position as an independent regulator with a focus on protecting workers, the public and society, by ensuring that it has sufficient time to address regulatory and technical issues relating to a design for a new nuclear power station, in advance of and separate from any public planning inquiries based on a site-specific proposal.

Following on from its Energy Review, the Government published an Energy White Paper in May 2007, alongside which DTI launched a public consultation on the future of nuclear power. At the same time, DTI invited interested parties to submit proposals to the Regulators for reactor designs to be subject to GDA. In the event, four designs were proposed which DTI (BERR) confirmed were suitable for the regulators to start GDA assessment. The four designs were:

- ACR-1000 (Atomic Energy of Canada Limited)
- AP1000 (Westinghouse)
- ESBWR (GE-Hitachi)
- UK EPR (EDF and AREVA)

Based on DTI's advice that there was potential support from industry for building these four reactors, HSE formally started a dialogue with each 'Requesting Party' in July 2007. In parallel, the Environment Agency also began its regulatory assessment work. HSE and the Environment Agency's work on GDA has been co-ordinated by a Joint Programme Office, which has been set up specifically for this project and is based in HSE's Merseyside headquarters.

* At the time, the Department of Trade and Industry (DTI) was the lead department for UK Government energy policy. This role now falls to the Department for Business, Enterprise and Regulatory Reform (BERR).

Having considered the views expressed during its nuclear public consultation, the Government published a further White Paper on the future of nuclear power* on 10 January 2008. This concluded that it would be in the public interest to allow energy companies to invest in new nuclear power stations. To ensure that people and society are properly protected, HSE will continue to apply the GDA process to the designs which are most likely to be chosen for construction in the UK. In allocating resources to this ongoing GDA process, HSE will therefore take due account of advice from the Government and others about the designs that are considered most likely to be progressed for construction.

Introduction

The safety of nuclear installations is achieved by good design and operation, but it is assured by a system of regulatory control at the heart of which is the nuclear site licensing process. This requires a licence to be granted before any construction work can start. The licence is granted, after assessment of the application, to a corporate body (eg an operator) to use a site for specified activities. In doing this we look at the siting and organisation factors. Licensing and the licence conditions apply throughout the lifetime of an installation from manufacture, through construction, commissioning, operation, modification and on to eventual decommissioning.

Following renewed interest in nuclear power in the UK, HSE introduced a new procedure for assessing the safety of new nuclear power stations. The updated arrangements are based on a two-phase process which separates the design assessment from the site and again from specific licensing assessment (Phase 2).

Phase 1, termed Generic Design Assessment (GDA), is a review of the safety features and ultimate acceptability of nuclear reactor designs. It is undertaken independently from any specific site. The process will allow a rigorous and structured examination of detailed safety and security aspects of the reactor designs, and is likely to take around 3.5 years to complete.

If successful, we will issue a 'Design Acceptance Confirmation' – a statement that the design is acceptable for nuclear safety and security. Guidance on the GDA process is provided in *Nuclear power station generic design assessment – guidance to requesting parties*[1] and *Guidance document for generic design assessment activities.*[2]

Phase 2 will involve an applicant seeking a nuclear site licence to construct and operate such a reactor at a specific site (or sites). Phase 2 will take approximately one year and will enable HSE to carry out a site licence assessment, in which we will examine the proposed design, the site and the management organisation of the operating company. If the application is judged to be acceptable we will grant a Nuclear Site Licence. More information on the licensing process can be found in *The licensing of nuclear installations*.[3]

Phase 1 (the GDA process) consists of four steps:

- Step 1, which was completed for ESBWR in late August 2007, was for the preparatory part of the design assessment process. The majority of the work was undertaken by GE-Hitachi (GEH), as the Requesting Party, in assembling the safety submissions for Step 2. It involved discussions between the Requesting

* *Meeting the Energy Challenge: A White Paper on Nuclear Power* CM 7296 The Stationery Office January 2008

Party and HSE to ensure a full understanding of the requirements and processes that would be applied, and to arrive at formal agreements to allow HSE to recover its costs associated with the assessment from the Requesting Party.

- Step 2, which is completed with the publication of this report, was an overview of the fundamental acceptability of the proposed reactor design concept within the UK regulatory regime. The aim was to identify any fundamental design aspects or safety shortfalls that could prevent the proposed design from being licensed in the UK. It also introduced HSE inspectors to the design and provided a basis for planning subsequent assessment. This report provides HSE's findings and the conclusions of the fundamental overview.
- Step 3 will be a system design safety and security review of the proposed reactor. The general intention will be to move from considering the fundamental safety claims of the previous step to an analysis of the design, primarily by examination at the system level and by analysing the Requesting Party's supporting arguments. From a security perspective, the foundations for developing the conceptual security plan will be laid through dialogue with the Requesting Party.
- Step 4 is designed to move from the system-level assessment of Step 3 to a detailed examination of the evidence given by the safety analyses, on a sampling basis. We will also seek to examine the proposed conceptual security plan for ESBWR. If the design is considered acceptable, we will issue a 'Design Acceptance Confirmation' at the end of Step 4. There may be certain exceptions or exclusions attached to the Design Acceptance Confirmation, eg on any issues that are not fully resolved, or where the design is not sufficiently complete.

The Design Acceptance Confirmation could then be carried forward to support a site-specific nuclear site licence application. It is the intention that there will be no reassessment of aspects included in the Design Acceptance Confirmation except, of course, to address any of the exceptions or exclusions. The assessment of ESBWR during Phase 2 should therefore be limited to any site-specific aspects and any proposed design changes.

HSE expectations for modern reactors

HSE expects that any nuclear reactor that is built in the UK in the near future will be of a robust design that provides adequate protection against potential accidents to a degree that meets modern international good practice. In other words, reactors built in the UK should be at least as safe as modern reactors anywhere else in the world.

Potential accidents in a reactor could arise from failures of equipment, for example pipe leaks or pump breakdowns, or from hazards such as fires, floods, extreme winds, earthquakes, or aircraft crash. HSE expects the reactor to be designed to withstand all these scenarios. We expect to see a robust demonstration of three key features: the ability to shut down the reactor and stop the nuclear chain reaction; the ability to cool the shutdown reactor; and thirdly the ability to contain radioactivity.

The adequacy of protection provided should be demonstrated by a comprehensive safety analysis that examines all the faults and hazards that can threaten the reactor. This should show that the reactor design is sufficiently robust to withstand these faults and hazards and that it operates with large margins of safety. HSE expects an approach of defence-in-depth to be adopted. This means that if one part of the plant fails then another part is available to fulfil the same safety duty. To maximise protection, different backup systems and other safety features can be provided. This multi-barrier protection concept should be repeated until the risk of an accident is acceptably low.

In modern reactor design, these concepts are well understood and HSE therefore expects to see a comprehensive demonstration that an acceptably low level of risk has been achieved. The principles used by HSE in assessing whether the safety demonstration is adequate are set out in the document *Safety assessment principles for nuclear facilities*[4] (SAPs). To help ensure HSE applies good international practice in its assessment, the SAPs have recently been revised and updated and this included benchmarking against the IAEA Safety Standards.

HSE expectations from the GDA process

Details of HSE's expectations for Step 2 of the GDA process can be found in the GDA guidance.[1] For the completeness of this report a key section of that document, which describes what HSE expects from a Requesting Party, is repeated in Annex 1.

Some of the items listed in Annex 1 (specifically items 1, 3, 4, 7 and 16) are generic and have been considered as an integral part of all the assessments described in this report. In the other cases, the items relate to the specific topic areas assessed and reported below.

Details of the expectations of the Office for Civil Nuclear Security (OCNS) for Step 2 can be found in the OCNS guidance.[2] In summary, the expectation was that a Requesting Party would provide sufficient information to allow an initial review of design submissions to enable OCNS to become familiar with the technology, and to form a view of the measures required to deliver appropriate security.

A key aim of this report is to provide a summary of the information HSE has gathered from GEH during Step 2 to address the points listed in Annex 1.

The safety standards and criteria used and links to WENRA reference levels and IAEA Standards

The main document used for the Step 2 assessment was the 2006 edition of HSE's *Safety assessment principles for nuclear facilities*[4] (SAPs). We also benchmarked the relevant SAPs against the Western European Regulators' Association (WENRA) reference levels[5] and the IAEA document *Safety of Nuclear Power Plants: Design – Requirements*.[6]

Assessment strategy

The aim of Step 2 was a high-level review of the fundamental safety issues. In particular we focused on the claims made by the Requesting Party in the safety documentation.

Throughout this report the words 'claims, arguments and evidence' are used. The concept behind these words is explained below by using a simple everyday analogy:

> Many people purchase cars and one criterion for the purchase is often the claimed fuel economy, one important part of which is the urban cycle. So if the manufacturer states in the brochure that the urban cycle is 55 mpg, that is a **claim**. Responsible manufacturers do not leave it at that and often they give **arguments**, within the car's brochure, why the car can meet its urban cycle claim. Valid arguments might be the development of advanced engine

management systems, use of advanced lightweight construction materials, development of low rolling resistance tyres and many more. In addition, **evidence** can be provided by the manufacturer by publishing the results of independent tests on the car's performance under urban cycle conditions.

So, for the Step 2 assessment, we have focused on the claims. Our objective was to make sure that the claims were complete and that they were reasonable in the light of our current understanding of reactor technology. Examination of the detailed arguments and evidence will come in our assessment during Step 3 and Step 4 of GDA.

In our Step 2 assessment, we have made a judgement on the claims in GEH's preliminary safety report (PSR)[7] when compared against the relevant parts of HSE's SAPs. To help us in this task, we developed a strategy to define both the technical areas to be covered and those SAPs most relevant for Step 2 of the GDA process.

Main features of the design and safety systems

The ESBWR, as proposed to us by GEH, is described in Chapter 1 of the ESBWR Design Control Document (DCD).[8]

GEH describes the ESBWR as a boiling water reactor in which the steam is generated within the reactor pressure vessel (RPV) and transferred directly to the turbine to generate electricity. The ESBWR has a claimed design life of 60 years and is expected to have an electrical output of 1600 MWe. GEH describes that the design is the result of evolution of the boiling water reactor concept over a number of years, with significant developments from its forerunner, the advanced boiling water reactor (ABWR) which operates in Japan. The claimed developments include natural circulation of coolant within the pressure vessel over the full range of operating power and the inclusion of passive safety systems.

The reactor core is situated in the bottom section of the 27.5 m high, 7.1 m diameter pressure vessel and it houses 1132 standard GE14E fuel assemblies using enriched uranium dioxide (UO_2) fuel. Coolant is fed to the reactor and flows down an annular space to the bottom of the vessel and up into the core where it is heated. Near the top of the core boiling begins and the two-phase mixture of steam and water passes up through a vertical chimney section to the steam separator and steam dryer from where the dry steam flows from the reactor vessel to the turbine.

GEH claims that the ESBWR safety systems are designed to mitigate the consequences of plant failures, ensuring reactor shutdown, removal of decay heat and prevention of radioactive releases. The key systems GEH identify are:

Reactor shutdown

- Control rods: these are inserted from the bottom of the reactor by either hydraulic pressure or the electrical fine-motion control drive rod mechanisms.
- Standby liquid control system: a solution of sodium pentaborate in water injected directly into the reactor vessel by pressurised accumulators.

Emergency core cooling

- The gravity-driven core cooling system injects water into the reactor in the event of a loss-of-coolant accident. For this to happen, the reactor is first depressurised by the automatic depressurisation system. Both systems employ fast-operating valves (pyrotechnic squib valves).
- Additional water is available from the suppression pool, which GEH claims has, together with the gravity driven cooling system, sufficient water to ensure core coverage even in the event of a large breach.

Containment

- The ESBWR containment is designed to be a low-leakage reinforced concrete structure with an internal steel liner in the drywell and suppression chamber to serve as a leak-tight membrane.
- The containment contains a passive cooling system which GEH claims has sufficient cooling water reserves for 72 hours without any outside assistance. Additional cooling water can be added from a variety of sources outside the containment building.

Basemat-internal melt arrest coolability

- In the unlikely event of a fault sequence that leads to gross melting of the core and reactor internals and damages the pressure vessel itself, GEH claims that additional protection is provided by the BiMAC (basemat-internal melt arrest coolability). This is in effect a core catcher that uses thick concrete and a passive cooling system to prevent escape of Corium (or molten core) from the containment.

Summary of HSE findings

This section summarises the findings of the fundamental safety overview which comprised Step 2 of the GDA process.

Quality management and safety case development arrangements

HSE considers that leadership and management for safety are key to achieving appropriate high levels of safety, and establishing and sustaining a positive safety culture.

HSE believes that good quality design and safety documentation is dependent on having in place an organised management system, effective procedures (especially for change control) and sufficient appropriately trained and qualified staff. As part of the examination of GEH's claims in this area, HSE and the Environment Agency jointly inspected GEH's USA offices. To assist us, we were joined by an inspector from the US nuclear regulatory body, the Nuclear Regulatory Commission (US NRC).

GE's nuclear engineering business recently merged with Hitachi's nuclear engineering business to become GE-Hitachi Nuclear Energy (GEH), and it operates as three business units, New Plants, Fuel, and Nuclear Services. GE and Hitachi co-operated on the Advanced Boiling Water Reactor and together they have built around 40 nuclear power plants. The merger has expanded the manufacturing and construction capability significantly for ESBWR.

The inspection found that GEH's Quality Management System satisfies the US requirements, Appendix B of Title 10 of the US Code of Federal Regulations, Section 50, *Domestic licensing of production and utilization facilities*. This has also been developed to meet the requirements of the American Society of Mechanical Engineers standard NQA-1 and more recently ISO 9001, the scope of which includes design activities. We noted that a UK project-specific quality plan is under development that will identify the organisational and procedural arrangements applicable to the project.

The inspection found that the GEH Quality Management System includes Level 1 procedures that are applied across the company, supported by Level 2 Engineering Operational Procedures. The procedures provide the basis of sound arrangements for the control of design activities during the GDA process. The procedures are managed by identified owners who ensure that they remain current and relevant to the business objectives and that changes are properly controlled. The procedures cover aspects such as document control, design changes, auditing and corrective actions. These provide confidence in the quality of the safety documentation at this stage of the project. There are sufficient and appropriate reviews of changes to the safety documentation and there are dedicated staff allocated to document control.

We noted that GEH has significant technical personnel resources. Many of these individuals are experienced within the nuclear industry and in boiling water reactor technology specifically. The company is continuing to recruit to meet the significant demand of an industry that is experiencing renewed worldwide interest in nuclear power. Significant additional resources are available in the GEH Nuclear Services and Fuel business units. Strategies are in place to attract, train and retain technical resources, particularly those identified as key.

We believe that GEH can provide a history of the development of the ESBWR that includes elements of optioneering and considerations for plant simplification and more reliance on passive systems. This information is not formalised at this stage, but we consider it would provide a good basis for the demonstration of the application of 'best available techniques' and 'as low as reasonably practicable' (ALARP) principles. In addition, GEH uses close working relationships with operators, suppliers and customers to obtain operational experience feedback pertinent to the operation of boiling water reactors. This helps provide and promote consideration of modifications where necessary.

We found that the selection and use of contractors is carried out to established procedures. Procurement includes the use of an approved suppliers list which has been compiled based on document reviews, audit and surveillance activities carried out by GEH. The ownership of technical information required to enable contractors to carry out their function is retained within GEH. The specification and the subsequent monitoring and acceptance of contracted work is controlled by GEH personnel.

Overall, we conclude that GEH's quality management arrangements provide a sound basis for this stage of the UK GDA process.

Standards

As noted above, HSE works on the basis of linking its SAPs to international standards, such as those of IAEA and WENRA. To evaluate detailed design information, we also use more detailed international standards such as International Electrotechnical Commission (IEC) standards, implemented by the British Standards Institution (BSI).

Our examination of GEH's documentation shows that it has used US standards, some from the 1980s and 1990s. HSE has therefore asked GEH to produce, as part of the future safety documentation submissions, a document demonstrating that the standards used are consistent with modern international good practice.

The approach to ALARP

In respect of 'as low as reasonably practicable' (ALARP), Step 2 of the GDA guidance[1] requires the Requesting Party to provide a description of the process being adopted by the applicant to demonstrate compliance with the UK legal duty to reduce risks to workers and the public 'so far as is reasonably practicable' (SFAIRP). The GDA guidance goes on to say that HSE will undertake 'an assessment directed at reviewing the design concepts and claims' and specifically 'the approach to ALARP'. Hence whether or not ALARP has yet been demonstrated is not being assessed in Step 2; rather we have looked at high-level claims on how ALARP will be shown to be met by GEH during Step 3 and 4.

GEH's case is outlined in its PSR[7] and the major supporting document is the design control document (DCD)[8] compiled to meet US NRC requirements. Section 2.2 of the PSR addresses ALARP, describing a process of progressive safety improvement both through the evolution of GEH's boiling water reactors in general and the specific evolution of the ESBWR. This process has, for example, led to safety improvements to reduce the likelihood and impact of severe accidents, such as the passively cooled core catcher (the BiMAC), and further measures to reduce operational dose, such as materials selection and equipment design to minimise radiation levels. As a result, GEH is able to claim a significant reduction in risk for the ESBWR from the baseline plant, the Advanced Boiling Water Reactor. GEH goes on to report cost–benefit analysis which indicates that only relatively small amounts of money would be worth spending on further risk reduction measures given the already low risks for both accidents and operational doses.

Overall we conclude that GEH has provided an adequate description of the approach to ALARP for Step 2. Our assessment for Step 3 and beyond will consider whether or not the approach described by GEH actually delivers a design for which the risks have been reduced ALARP.

The design basis analysis/fault study approach

For Step 2 of the GDA process, Section 2.5 of the GDA guidance[1] requires the Requesting Party to provide 'an overview statement of the approach, scope, criteria and output of the deterministic safety analysis'. The GDA guidance goes on to say that HSE will undertake 'an assessment directed at reviewing the design concepts and claims' to include, among other things 'the design basis analysis/fault study approach'. Hence the detail of the deterministic safety case itself was not assessed in Step 2; rather the aim was to see that claims have been made in respect of the relevant SAPs, for example on the reactor core, design basis analysis and severe accidents. The arguments and evidence supporting these claims will be assessed in Step 3 and beyond.

The ESBWR design has evolved making extensive use of the operating experience of existing generations of boiling water reactors (BWRs). Novel features include: the use of natural circulation for providing the means of coolant flow through the core at power, thereby eliminating initiating events associated with reactor coolant pump failures; and extensive use of passive systems for heat removal and emergency cooling to cope with design basis accidents.

As part of the safety and fault analysis in support of the design of the ESBWR, GEH has presented information on the following:

- Core stability – DCD[8] Section 4.3
- Design basis analysis – PSR[7] Section 2.5, DCD[8] Chapter 15
- Severe accident evaluation – DCD[8] Section 19.2

GEH claims that the core will be stable under normal operation and fault conditions, such that there will be no uncontrollably large or rapid increases in reactivity due to any changes in temperature, power, xenon distribution or coolant voiding.

In the design basis analysis, GEH claims to have carried out a comprehensive study to identify a complete set of faults (ie those things that could go 'wrong' on the reactor). The core transients resulting from these faults have been modelled using validated codes embodying appropriate assumptions and data. This includes, for example, assuming the worst combination of plant temperature, pressure and power distribution that could exist just before a fault occurred, and the worst possible performance by the safety systems after the fault occurs. Even with such pessimistic assumptions, GEH claims that the plant has appropriate protection against these faults and that consequences such as, for example, melting of the fuel, are avoided. The methods used by GEH to arrive at these conclusions will form an important part of our assessment in future steps.

GEH claims that severe accidents have been addressed to identify necessary actions and provisions to contain large-scale fuel melting and prevent a large release from the containment building. Should the Corium melt through the vessel, a device (the BiMAC) has been added directly below it to cool the molten Corium, preventing it from damaging the containment structural concrete.

Overall, we conclude that GEH has carried out what appears to be an extensive study identifying significant faults and analysing the effects on the core and where necessary making provision for the mitigation of severe accidents. In doing this they claim to meet the Fault Analysis SAPs covering Design Basis Analysis and Severe Accidents, identifying the relevant sections in the PSR[7] and DCD.[8] The quality of the submission leads us to be confident that they will be able to substantiate their claims in the later Step 3 and Step 4.

The probabilistic safety analysis (PSA) approach

For Step 2 of the GDA process, Section 2.6 of the GDA guidance[1] requires the Requesting Party to provide 'An overview statement of the approach, scope, criteria and output of the probabilistic safety analysis'. The GDA guidance goes on to say that HSE will undertake 'an assessment directed at reviewing the design concepts and claims' and specifically in point 2.22 'the PSA approach'. Hence the PSA itself is not being assessed in Step 2; rather the aim is to see that appropriate claims have been made in respect of PSA SAPs FA.10-14 and that there is a reasonable prospect of meeting the SAPs Basic Safety Objective numerical targets. The arguments and evidence supporting these claims will be assessed in Step 3 and beyond.

GEH addresses PSA in Section 2.6 of the PSR.[7] It claims to have carried out a comprehensive study (Section 2.6.1 of the PSR) and to have systematically analysed the complete range of anticipated initiating faults, internal and external initiators, and this includes all modes of operation (Section 2.6.2 of the PSR). The PSR goes on to discuss the various elements of the PSA. Section 2.6.5 of the PSR covers PSA methodology and Section 2.6.6 gives an overview of the results. The methodology section covers initiating faults, accident sequence analysis, systems analysis, human reliability analysis, data analysis (initiating fault frequencies, component reliability and common cause failure), quantification, containment performance (level 2 PSA) and consequence analysis (level 3 PSA).

All of the subsections in Section 2.6 of the PSR have copious references to GEH's DCD[8] and sampling these links indicates that the stated support is there.

GEH's preliminary estimate of the ESBWR total core damage frequency is 6.16×10^{-8}/yr, which, in conjunction with the arguments presented, gives HSE a strong indication that the Basic Safety Objective numerical targets set out in our SAPs will be met.

HSE recognise that PSA provides estimates of the risks, not a precise measure of them, and that these cannot be readily compared between designs. The way in which uncertainty over input parameters and sensitivity to assumptions affects the results will feature in the more detailed assessment in Step 3 and beyond.

Overall, we conclude that GEH has provided an adequate overview of the approach, scope, criteria and output of the PSA. In addition to the PSA information, GEH has identified and given commitments to address gaps in the PSA, notably non-core sources of radioactivity (such as resin tanks and the spent fuel pool), and to re-analyse the PSA consequences to demonstrate that they meet SAPs numerical targets.

Structural integrity

For Step 2 of the GDA process, HSE's review of design concepts and claims for the integrity of metal components and structures includes aspects of:

- the safety philosophy, standards and criteria used;
- the design basis analysis/fault study approach;
- the overall safety case scope and extent;
- an overview of the claims in a wide range of areas of the safety analysis.

A fundamental aspect of the SAPs for integrity of significant safety-related metal components and structures (pressure vessels and piping, their supports and vessel internals), is the identification of those components where the claim is that gross failure is so unlikely that the consequences can be discounted from consideration in the design of the station and its safety case. For such components, the SAPs require an in-depth explanation of the measures over and above normal practice that support and justify the claim. In these circumstances, the emphasis falls on the arguments and evidence to support the claim that gross failure is so unlikely that it can be discounted. Similar claims have featured in safety cases for operating nuclear stations in the UK and the supporting arguments and evidence have been considered by HSE.

For the ESBWR, GEH does not consider gross failure of the RPV in the design basis analysis, although such failures are considered in the PSA. Gross failure of certain piping is explicitly claimed to be discounted on the basis of a set of arguments and evidence referred to as 'break exclusion zone' (piping in the vicinity of the containment wall).

HSE's Step 2 review has not examined in detail the arguments and evidence to support claims on structural integrity of metal components and structures. Some of the items in question are long-lead time components and, to reduce their regulatory risk, GEH may wish to ask HSE to assess such items at an early stage.

Relevant general matters likely to arise in the Step 3 and Step 4 assessments are:

- material specification for ferritic forgings and welds to be used in the RPV;
- location of circumferential welds in the RPV body;
- nature of the arguments and evidence to support integrity claims for some piping.

The ESBWR RPV is large (27.5 m high, 7.1 m diameter) and represents an increment in height compared with earlier BWR designs, but this is not a fundamental issue.

Overall, we conclude that GEH has provided an adequate overview of the claims made for structural integrity of metal components and structures. However, for Step 3 and Step 4 there will need to be an explicit listing of those components where gross failure is claimed to be so unlikely that it can be discounted. GEH has also provided some coverage of the type of arguments and evidence to support the claims.

Waste and decommissioning

The objective of HSE's Step 2 GDA radioactive waste and decommissioning assessment was to identify any fundamental aspects or safety shortfalls that could prevent the proposed design from being constructed on licensed sites in the UK. The Environment Agency have also assessed radioactive waste and decommissioning proposals and their findings are reported separately.

For Step 2 of the GDA process, Section 2.18 of the GDA guidance[1] requires the Requesting Party to provide 'Information on radioactive waste and decommissioning'. The GDA guidance goes on to say that HSE will undertake 'an assessment directed at reviewing the design concepts and claims', to include 'any matters that might be in conflict with UK Government policy'. The aim of the Step 2 assessment is to identify whether the strategies put forward for radioactive waste and decommissioning are likely to comply with Government policy, SAPs and existing HSE guidance on waste and decommissioning matters. The arguments and evidence supporting these claims will be assessed in Step 3 and beyond. It should be noted that the UK Government recently announced its intention to make it a legal requirement for funded decommissioning plans to be approved by the Government before construction of new reactors commences.

GEH addresses radioactive waste, spent fuel and decommissioning in Section 2.18 of the PSR.[7] It gives an overview of the wastes arising from operation and Steps taken to minimise their arising and/or their impact. GEH also indicates the options considered for managing the waste and spent fuel arisings. Further information is provided in Section 12.6 of the DCD,[8] which explains how the ESBWR design procedures minimise contamination and facilitate decommissioning (eg by judicious selection of materials).

GEH's waste management expectations are predicated on the current or future availability of national disposal facilities. It is proposed that low level waste (LLW) will be disposed of into the existing LLW disposal facility near Drigg in Cumbria and future such facilities. Intermediate level waste (ILW) and spent fuel is intended to be stored on site until a national repository is available. The proposed use of dry casks for interim spent fuel storage would be a new method for the UK, although one that is employed internationally. We will examine these proposals further during GDA Step 3 and Step 4. Examples of design features that would facilitate decommissioning are presented, the techniques and timing broadly being left to the operator to determine.

There are no indications of any waste streams which would present particular difficulties, and this is sufficient for HSE for Step 2. However, there is no attempt to demonstrate that the waste streams would meet the appropriate criteria for disposal in a LLW facility or an ILW/spent fuel repository. HSE will therefore be seeking further detail of the acceptability for disposal of waste arisings during subsequent steps of the GDA process.

Civil engineering and external hazards

As noted above, for Step 2 of the GDA process, the Requesting Parties were required to provide a preliminary safety report (PSR) that included sufficient information for the HSE fundamental safety overview assessment, in particular:

- design philosophy and a description of the resultant conceptual design;
- overview of the approach, scope, criteria and output of the deterministic safety analyses;
- specification of the site characteristics used as the basis for the safety analysis (the 'generic siting envelope');
- reference to and justification of standards and design codes used.

A review of these aspects has been undertaken in the light of civil engineering, external hazards and siting. External hazards include potential challenges to the plant that arise from outside the site, such as extreme winds or earthquakes. Our assessment has found that GEH has clearly identified the design classification for structures and plant in what appears to be a systematic manner. This has been linked to design codes and standards. These standards for the most part are specifically intended for application to nuclear facilities and are primarily American in origin. The standard design incorporates a foundation which is primarily designed for siting on rock or firm strata. For some UK coastal sites, with deep soil profiles, including some existing nuclear sites, this standard design would not be applicable. Therefore, if the ESBWR is not to be limited to only certain UK sites, GEH will need to amend its design or carry out site remediation work. We will progress this issue through Step 3 and Step 4 of GDA.

We note that GEH has not undertaken a review of the design against other HSE requirements, such as the requirements of the Construction (Design and Management) Regulations 2007. These Regulations apply during the design phase and so we expect them to be addressed later in the GDA process.

The design basis external hazards applied to the structures and plant have been clearly identified by GEH, as have the limitations on the standard design. It is recognised by GEH that there are a number of hazards, such as external flooding, the magnitude of which cannot readily be determined until a site(s) has been identified. There has not been an attempt to put the design basis hazards into a UK context at this stage. The standard design is currently being assessed by GEH against the effects of aircraft impact of a non-accidental nature, with the specific intention that the design will be modified if necessary to accommodate this hazard. We will review the completeness of the external hazards considered by GEH in more detail in the next steps of the GDA process.

Overall, we conclude that the submission is sufficient at this stage to allow progression to Step 3 of the assessment process. GEH has acknowledged the need to place the design into a UK context, and to consider other UK-specific regulations which apply to the design of installations such as this.

Internal hazards

For Step 2 of the GDA process Section 2.5 of the GDA guidance[1] requires the Requesting Party to provide 'an overview statement of the approach, scope, criteria and output of the deterministic safety analyses'. Deterministic analysis includes, among others, consideration of internal hazards. The GDA guidance goes on to say that HSE will undertake 'an assessment directed at reviewing the design concepts and claims'. Hence the analysis of internal hazards itself is not being assessed in Step 2; rather the aim is to see if appropriate claims have been made against the internal hazard-related SAPs. The arguments and evidence supporting these claims will be assessed in Step 3 and beyond.

The overall objective of the hazard principles is to minimise the effects of internal hazards such as, for example, fires. In particular, we want to ensure that internal hazards do not adversely affect the reliability of safety systems. One of the threats posed by hazards such as fires is that they can, if not properly addressed, affect a range of different plant at the same time. This is called a 'common cause' effect and it is important to ensure that this is avoided. Safety systems and safety-related systems should therefore be qualified to withstand the effects of internal hazards or they should make appropriate use of redundancy, diversity, separation or segregation. The SAPs therefore require that a comprehensive and systematic approach be used to identify the internal hazards and protection provided. This should include combining the hazards with other potential simultaneous hazards and/or faults, and taking into account plant out for maintenance.

GEH addressed their compliance with the internal hazard SAPs in their response to a regulatory technical query. The response to the query contained cross references to the GEH PSR[7] and the ESBWR design control document (DCD),[8] which both contained additional information supporting compliance with the SAPs.

GEH has identified a range of potential internal hazards. Separation of redundant divisions or trains of safety-related equipment is principally achieved, outside primary containment, with three-hour fire-rated hazard barriers and within containment with a combination of structural walls, local fire barriers, distance and equipment qualification. The passive approach to ensuring segregation outside containment is the preferred approach and is consistent with IAEA recommendations.[9]

Overall we note that GEH claims compliance with the internal hazard SAPs. We conclude that GEH has provided an adequate overview of the concept and approach being adopted to address internal hazards within the deterministic safety analyses. This approach provides reasonable confidence that GEH will be able to substantiate its claim in Step 3 and Step 4.

Reactor protection and control

The objective of the Step 2 GDA Control and Instrumentation (C&I) assessment was to identify any fundamental design aspects or safety shortfalls that could prevent the proposed design from being constructed on licensed sites in the UK. In particular, to determine whether an adequate claim of compliance exists for those C&I SAPs which address fundamental design aspects.

GEH provided a number of submissions relevant to C&I assessment including a specific response against those C&I SAPs that address fundamental design aspects. The main submissions[7,8] describe the C&I. The C&I provisions claimed include those that would be expected of a modern nuclear reactor such as:

- safety systems (eg reactor shutdown systems such as the reactor protection system that initiates insertion of neutron absorbing rods and the standby liquid control system that injects a neutron-absorbing sodium pentaborate solution);
- plant control and monitoring systems (eg the non-safety-related distributed control and information system, and the rod control and information system that controls reactor power);
- main control room with backup via the remote shutdown system panels; and
- communications systems allowing information transfer both within and external to the plant.

An important aspect of the safety demonstration is the classification of systems important to safety and the application of appropriate design standards. The accepted practice is that the standards are more onerous for those systems that are more important to safety. In the UK the importance to safety is typically judged by a combination of deterministic and probabilistic criteria. The deterministic analysis considers the functions performed by the system, such as to shut down the reactor, and the probabilistic analysis considers the reliability required of the system. The GEH ESBWR C&I design concept reflects US custom and practice, and is largely based on US C&I standards (eg Institute of Electrical and Electronics Engineers (IEEE) standards) and US NRC requirements. Two system classifications are used (ie safety related and non-safety related).

During Step 3 and Step 4, GEH will address the issue of the use of international standards (IEC and IAEA), grading of the importance to safety through the use of three system classifications (ie safety system, safety-related system and non-classified), and use of probabilistic criteria in the design of C&I systems important to safety.

GEH's submissions provide a satisfactory overview of the C&I provisions and adequate claims of compliance for all of the fundamental C&I Step 2 SAPs. In addition, the Step 2 C&I assessment has not identified any fundamental issues that would prevent the ESBWR from proceeding to Step 3.

Novel features

The ESBWR reactor concept contains a number of advanced passive features. 'Passive' features are those that operate independently from facility power sources, such as electrical supplies. For example, these might include cooling systems that operate by natural circulation, or water injection systems that operate through differential pressures. On the other hand, 'active' features are those that rely on external power sources. Safety systems on existing reactors are often active and require electric supplies to power pumps and valves.

In safety terms, passive systems are often simpler than active ones and so can be considered more reliable. HSE's own SAPs rate passive systems higher in the preference hierarchy of responses to hazards than active safety systems.

No nuclear power plant that has a significant dependence on passive safety systems has received a licence to operate anywhere in the world and therefore many aspects of the ESBWR's cooling system are considered to be novel. This does not mean that there is no experience in the world of passive systems, as many existing reactors do use elements of passive safety in their designs, but their use on ESBWR is more widespread.

The robust design of the ESBWR should avoid accidents that could damage the reactor core. Although such accidents would be extremely unlikely, we still require them to be considered in the safety analyses. Part of the protection designed-in to the ESBWR concept is the novel system known as the BiMAC. This is claimed to arrest and, together with the containment systems, contain the hazard of a molten core that has melted through the pressure vessel. There are significant merits to this claim. However, the arguments and evidence to support it will, in our view, be challenging to demonstrate with an appropriate degree of confidence. We will look at this further in Step 3 and Step 4.

Long-lead items

Large plant items such as the reactor pressure vessel and steam generators take a long time to manufacture and they are typically among the first items to be ordered.

Section 2.17 of the PSR provides a typical list of long-lead items. If there is a possibility that some of these orders will be placed while the GDA assessment is still ongoing then, to reduce their regulatory risk, GEH may wish to ask HSE to assess such items at an early stage.

International Atomic Energy Agency technical review

As part of the Step 2 assessment, HSE requested that IAEA undertake a technical review of all four Requesting Parties' designs from the IAEA. The reason for this is that IAEA has ready access to considerable expertise on a wide range of reactor types in operation and under construction throughout the world.

The findings from the IAEA technical review have been taken into account by HSE during our own assessment. IAEA did not reveal any fundamental safety problems with the ESBWR. All of the findings in the report are recommendations for further assessment work, particularly in areas that are novel or technically complex, and we will take these into account in Step 3 and Step 4 as appropriate.

Any matters that might be in conflict with UK Government policy

HSE has found no matters in the GEH submission that are in conflict with UK Government policy.

Security

OCNS has begun familiarisation with the ESBWR design during Step 2. Initial discussions have been held with GEH and review of the documentation provided to date has been carried out. It is concluded that the design appears to be sufficiently developed to give confidence that during Step 3 and Step 4 of the GDA process a conceptual security plan can be developed which will provide the appropriate resistance to postulated threats. This outcome will of course depend on the detailed review of the design during Step 3 and Step 4 and adoption of any UK-specific design changes deemed necessary (eg UK-specific security furniture).

Discussions with the relevant US authorities are progressing to allow the transfer of sensitive nuclear information between countries to support the GDA process. A procedure is in place to allow vetting clearances to be granted by the Director of OCNS to facilitate the exchange of such information.

Public involvement process

HSE has emphasised the importance it attaches to openness in the GDA process, and the opportunity for public involvement at key stages is an important part of this. By this means, we aim to give the public confidence in the GDA process.

Members of the public have been able to view the design information provided by GEH for the GDA process. A comprehensive safety, security and environmental report for the ESBWR was made available on the company's website from 10 September 2007, www.gehgenericdesignassessment.co.uk. The same information was also made available upon request in CD-ROM format.

In addition, to help encourage public participation, GEH made announcements in the national press at that time to publicise the GDA openness arrangements. To supplement these, the Regulators (HSE and the Environment Agency) published a leaflet, *Designs for potential new nuclear power stations: Public involvement*, which was distributed to public libraries. We also set-up a new-build e-bulletin system and wrote to all UK Members of Parliament, Peers, Scottish Members of Parliament and Welsh Assembly Members to inform them of the public involvement opportunity.

Members of the public were invited to view the design information and comment on it – either electronically or in writing. Comments relevant to the published design information were forwarded to GEH, who were asked to respond to the person who made the comment within 30 days of receipt. The regulators monitored this process and where appropriate the issues raised have been considered as part of our assessment during Step 2. Only those comments made between 10 September and 4 January 2008 have been considered in Step 2; any issues raised in comments made after that date will be considered in our assessment during GDA Step 3.

The number of website hits recorded indicated a good level of awareness of and interest in the public involvement process. However, only a small number of comments were received during GDA Step 2. Issues raised on the ESBWR included accident scenarios (ability to manage and withstand accidents similar to those that have occurred elsewhere, eg Chernobyl), cancer risks (probability of radiation dose limits being exceeded, extent of long-term risks, appropriateness of dose limits referred to in design information), use of seawater in reactor cooling (protection from corrosion, safe handling of contaminated cooling water during decommissioning), aircraft impact (can it be demonstrated that reactors can withstand deliberate high-speed aircraft impact?), and on-site storage of radioactive waste and spent fuel (how many years storage does the design provide for low level and intermediate level waste and spent fuel?).

The issues raised from the comments and their responses have been considered in the judgements made by HSE on the ESBWR as part of Step 2. Where appropriate, these issues will be considered in more depth by assessors during Steps 3 and 4.

A number of the comments made by the public were not directly relevant to the ESBWR or the other designs being assessed; nevertheless these were considered by HSE and responded to as appropriate.

Overseas regulators' assessments

Design review in the US

The US NRC is the only other regulatory authority undertaking a formal review of the ESBWR design. The forerunner to the ESBWR was the Advanced Boiling Water Reactor which was the first plant to use the new licensing process in the US, Title 10 of the US Code of Federal Regulations, Section 52, Licenses, certifications, and approvals for nuclear power plants. The Advanced Boiling Water Reactor design was certified in 1997.

Following some initial US NRC pre-application review work, GEH submitted an application for standard design certification for the ESBWR in August 2005. The application was accepted for assessment in December 2005. Assessment is ongoing and, as of February 2008, US NRC had raised approximately 4000 requests for additional information and reported that around 75% had been resolved.

In November 2007 US NRC indicated that, contingent on timely submissions from GEH and satisfactory resolution of requests for additional information, they anticipate issuing the Final Design Approval in June 2009, approximately two years ahead of the completion date for GDA Step 4. The US NRC is re-evaluating that schedule, in the light of the current status of the review and timing of GEH deliverables to support its completion.

The DCD is a formal regulatory submission in the USA. For the GDA process it is a reference to the main safety report.[7] The version of the DCD referenced by GEH's Step 2 submission is Revision 3.[8] The current version that is being reviewed by US NRC is Revision 4. This will be supplied to HSE in April 2008, together with an indication of those areas of the DCD which are likely to change as a result of interaction with US NRC. Revision 5 of the DCD, which is to incorporate US NRC comments, is expected to be issued to HSE in June or July 2008.

HSE collaboration with other regulators

HSE has an information exchange agreement with US NRC and has had a number of bilateral meetings to discuss new-build assessment collaboration and transfer of information. This process is ongoing for the ESBWR and HSE intends to continue this through the GDA timeframe.

HSE sees great value in being able to share information with other regulators who have carried out relevant assessments, and we have published our views on how this information can be used in our GDA guidance.[1] However, because the UK legal and regulatory framework is UK-specific, design approval by other regulators cannot be transferred automatically to the UK. Furthermore, under international conventions etc, nuclear safety regulation is a national responsibility and HSE must perform its duty to the UK public and workers. This has not prevented HSE from making appropriate use of overseas regulators' assessments, and it is HSE's intention that this practice will continue in future GDA Steps.

Conclusions

This report is our GDA Step 2 public statement for the ESBWR reactor.

The aim of Step 2 was to provide an overview of the fundamental acceptability of ESBWR within the UK regulatory regime. It was also intended that Step 2 would allow HSE inspectors to become familiar with the design and provide a basis for planning subsequent assessment work.

HSE has undertaken a high-level review of GEH's claims for a number of different safety aspects of the ESBWR reactor, and we have considered the security aspects of the design.

In summary, we have not found any safety or security shortfalls that are so serious as to rule out at this stage eventual construction of the ESBWR on licensed sites in the UK. As a result of our assessment, we see no reason why ESBWR should not progress to GDA Step 3.

As intended, our assessment has identified a number of topics that will need to be addressed in more detail during the GDA Step 3 and Step 4 assessment, should the ESBWR proceed through the GDA process. In this event, we will summarise our progress on these topics in a public report at the end of Step 3 and in a final GDA report at the end of Step 4.

Abbreviations

ALARP	As low as reasonably practicable
BERR	Department for Business, Enterprise and Regulatory Reform
BiMAC	Basemat-internal melt arrest coolability
BSI	British Standards Institution
BWR	Boiling water reactor
C&I	Control and Instrumentation
DCD	Design control document
DTI	Department of Trade and Industry
GDA	Generic design assessment
GEH	GE-Hitachi Nuclear Energy International LLC
HSE	Health and Safety Executive
IAEA	International Atomic Energy Agency
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
ILW	Intermediate level waste
LLW	Low level waste
ND	Nuclear Directorate
PSA	Probabilistic safety analysis
PSR	Preliminary safety report
RPV	Reactor pressure vessel
SAPs	Safety assessment principles
SFAIRP	So far as is reasonably practicable
US NRC	Nuclear Regulatory Commission (United States of America)
WENRA	Western European Nuclear Regulators' Association

Annex 1: Summary of HSE's expectations for Step 2 of the GDA process

Details of HSE's expectations for Step 2 of the GDA process can be found in the GDA guidance.[1] From that document, the key expectations of Requesting Parties for Step 2 are:

Provide a Preliminary Safety Report that includes sufficient information for the Step 2 Fundamental Safety Overview, in particular:

1. A statement of the design philosophy and a description of the resultant conceptual design sufficient to allow identification of the main nuclear safety hazards, control measures and protection systems.

2. A description of the process being adopted by the applicant to demonstrate compliance with the UK legal duty to reduce risks to workers and the public so far as is reasonably practicable (SFAIRP).

3. Details of the safety principles and criteria that have been applied by the Requesting Party in its own assessment processes, including risks to workers and the public.

4. A broad demonstration that the principles and criteria are likely to be achieved.

5. An overview statement of the approach, scope, criteria and output of the deterministic safety analyses.

6. An overview statement of the approach, scope, criteria and output of the probabilistic safety analyses.

7. Specification of the site characteristics to be used as the basis for the safety analysis (the 'generic siting envelope').

8. Explicit references to standards and design codes used, justification of their applicability and a broad demonstration that they have been met (or exceptions justified).

9. Information on the quality management arrangements for the design, including design controls; control of standards; verification and validation; and interface between design and safety.

10. A statement giving details of the safety case development process, including peer review arrangements, and how this gives assurance that nuclear risks are identified and managed.

11. Information on the quality management system for the safety case production.

12. Identification and explanation of any novel features, including their importance to safety.

13. Identification and explanation of any deviations from modern international good practices.

14. Sufficient detail for HSE to satisfy itself that HSE's Safety Assessment Principles (SAPs) and that the Western European Nuclear Regulators' Association (WENRA) Reference Levels are likely to be satisfied.

15. Where appropriate, information about all the assessments completed by overseas regulators.

16. Identification of outstanding information that remains to be developed and its significance.

17. Information about any long lead items that may be manufactured in parallel with the Design Acceptance process.

18. Information on radioactive waste management and decommissioning.

The Requesting Party will also be required to respond to questions and points of clarification raised by HSE during its assessment, and to issues arising from public comments.

References

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6 *Safety of Nuclear Power Plants: Design – Requirements* IAEA Safety Standards Series No. NS-R-1 IAEA 2000

7 *ESBWR-UK preliminary safety report. Step 2 sections 1.0 – 2.18* (Revision 0) GE Nuclear Energy Document 26A7403AA August 2007 www.gehgenericdesignassessment.co.uk

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9 *Protection against internal fires and explosions in the design of nuclear power plants* IAEA Safety Standards Series No. NS-G-1.7 IAEA 2004

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