



Office for
Nuclear Regulation

Japanese Earthquake and Tsunami: Update on UK 'National Action Plan'

UK response to ENSREG National Action Plan

A Statement on ONR's Actions Extracted From the UK Post Japanese
Earthquake and Tsunami Implementation Plan:

2nd Updated Progress Report

December 2017

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Foreword

This second update report has been produced to describe the United Kingdom's progress against the European Nuclear Safety Regulators Group (ENSREG) National Action Plan that followed up the peer review of the stress tests performed on European Nuclear Power Plants. Specifically this statement answers the request to regulators for an updated national action plan associated with post-Fukushima lessons learnt and stress test peer review recommendations and suggestions, to be presented by the end of 2017 to ENSREG in a form suitable for peer review by a common discussion.

This report draws from, and builds upon, the work already done by the Office for Nuclear Regulation (ONR) and others within the UK following the Fukushima accident, which occurred on 11 March 2011 in Japan. It is especially reliant on ONR's most recent report "Progress in implementing the lessons learnt from the Fukushima accident" which provided an update on how the UK nuclear industry is implementing the lessons from Fukushima.

I am satisfied that this is a comprehensive response that not only meets the requirements specified by ENSREG but also presents a statement of how ONR has ensured that the lessons from the Fukushima accident have been implemented in the UK. I am also satisfied that the small amount of remaining work is being addressed satisfactorily as part of ONR's normal regulatory business.



A handwritten signature in black ink, appearing to read 'M. Foy' with a stylized flourish at the end.

Mark Foy
Chief Nuclear Inspector
December 2017

Contents

| | |
|--|----|
| Foreword | 3 |
| Executive Summary | 6 |
| Introduction | 10 |
| Updated UK National Action Plan Structure | 11 |
| Section 1 | 13 |
| 1.1 – External Events | 14 |
| National Stress Test Report..... | 14 |
| ENSREG and Country-Specific Peer Review for UK Stress Test Report | 15 |
| ENSREG Compilation of Recommendations | 15 |
| 1.2 – Loss of Safety Systems..... | 18 |
| National Stress Test Report..... | 18 |
| ENSREG and Country Specific Peer Review for UK Stress Test Report | 19 |
| ENSREG Compilation of Recommendations | 19 |
| 1.3 – Severe Accident Management | 26 |
| National Stress Test Report..... | 26 |
| ENSREG and Country Specific Peer Review for UK Stress Test Report | 27 |
| ENSREG Compilation of Recommendations | 28 |
| Section 2..... | 34 |
| 2.1 National Organisations | 34 |
| 2.2 - Emergency Response and Post Accident Management (off-site)..... | 39 |
| National emergency response arrangements | 40 |
| Planning Controls | 40 |
| Off-site Infrastructure Resilience | 40 |
| 2.3 – International Cooperation | 43 |
| International Recommendations for Response and Global Nuclear Safety | 43 |
| Section 3 - Additional Topics (Not in ENSREG or CNS consideration)..... | 45 |
| 3.1 Additional Topics | 45 |
| Openness and Transparency | 46 |
| Research..... | 48 |
| Section 4 – Timescales and Milestones | 48 |
| Conclusions | 49 |
| References | 73 |
| Annex 1 – ONR Recommendations and Findings | 78 |

Annex 2 - Information Requested in the NACP Template..... 84

Contacts 88

Executive Summary

This 2nd update report sets out the progress against the UK's 'National Action Plan' (NAcP) for implementation of lessons learned following the Fukushima accident in Japan in March 2011. This has been produced in response to the European Nuclear Safety Regulators Group (ENSREG) statement, issued in 2015 following the last update (Ref. 17) which sought a further update on progress during 2017.

The UK will continue to use ENSREG as the appropriate route for advising the European Commission on matters of nuclear safety and radioactive waste management, with a goal of using existing resources effectively to promote enhancing standards for global nuclear safety through continuous improvement, showing a clear commitment to openness and transparency.

This updated report has been developed from a number of UK ONR reports produced in response to Fukushima (Ref 1, 2, 3, 5 and 6), and is especially reliant on the ONR's subsequent and most recent reports; on implementing the lessons from Fukushima for the UK nuclear industry (Ref. 16), the first update of the 2012 NAcP in 2014 (Ref. 18), an ONR Project Assessment Report (PAR) specifically monitoring the activities performed by the UK's NPP licensee EDF Energy Nuclear Generation Limited (EDF NGL) (Ref. 19), the progress report on implementing lessons learnt from Fukushima (Ref. 20) and the 7th National Report on the Convention on Nuclear Safety (Ref. 21). These reports are highlighted in the table below. The NAcP is therefore not a stand-alone report; rather it is a summary of the current status of implementation of the lessons learnt and future planned activities.

The table below shows the reports in date order. Following the Fukushima event, the Secretary of State for Energy and Climate Change requested that ONR examine the circumstances of the Fukushima accident to see what lessons could be learnt to enhance the safety of the UK nuclear industry. References 1 and 2 are the responses to this, which produced a number of interim recommendations and a number of final recommendations, sent to all UK nuclear site licensees to consider and respond to.

Around the same time, the European Commission, supported by ENSREG, produced criteria and a plan for a review (known as the "stress tests") relating to operating nuclear power stations. The UK responded to this by producing Reference 3, which summarised the work programmes proposed by the UK licensees in response to the stress test review. References 6, 16 and 20 are an update to the UK government on the progress of work proposed in References 1-3, summarising interim recommendations, final recommendations and stress test findings. Reference 6 is the first UK National Action Plan with Reference 18 being the first update in 2014.

This current report is the 2nd update following on from the 2014 report, but takes into account all the reports in the table below as supporting information. It concentrates on the work of EDF NGL, the last remaining licensee of operating nuclear power plant in the UK. The UK's last Magnox reactor at Wylfa, operated by Magnox Ltd, has permanently shut down since the last update report. Information in the table below summarises the reports that have been produced and the numbers of recommendations or findings that resulted.

| Issue Date | Report | Description |
|------------|--|---|
| May 2011 | Interim Report by Chief Inspector to UK Govt ⁽¹⁾ | 26 Recommendations |
| Sept 2011 | Final Report by Chief Inspector to UK Govt ⁽²⁾ | 38 Recommendations (including those in Interim Report) |
| Dec 2011 | UK National stress test report. ⁽³⁾ (note in addition to this report an equivalent report for non-power generating facilities was published in May 2012) | 19 Findings (in addition to ~100 industry proposals) |
| Oct 2012 | Implementation Report on progress in implementing lessons learned ⁽⁵⁾ | Covers all UK nuclear installations and all findings, recommendations & stress test peer review outcomes |
| Dec 2012 | UK National Action Plan ⁽⁶⁾ | Covers ENSREG compilation of recommendations and ONR's recommendations and stress test findings |
| Sept 2014 | Progress in implementing the lessons learnt from the Fukushima accident ⁽¹⁶⁾ | Summary of implementation of recommendations from ONR's reports on Stress Test Findings |
| Dec 2014 | First update to the National Action Plan ⁽¹⁸⁾ | Covers progress on ENSREG compilation of recommendations and ONR's recommendations and stress test findings |
| May 2015 | Fukushima Recommendations and Stress Test Findings: Overall Review of EDF Energy Nuclear Generation Limited Responses ⁽¹⁹⁾ | Summary of implementation of recommendations from ONR's reports on Stress Test Findings |

| | | |
|----------|---|---|
| Feb 2016 | Progress in implementing the lessons learnt from the Fukushima accident ⁽²⁰⁾ | Summary of implementation of recommendations from ONR's reports on Stress Test Findings |
| Jan 2017 | UK 7 th National Report on the Convention on Nuclear Safety ⁽²¹⁾ | Information on current UK operating civil nuclear power stations and new build designs and licensing activities as well as information on post-Fukushima improvements |

The ENSREG action plan (Ref. 10) was published on 25th July 2012 with the objective of assisting in assuring that the conclusions from the stress tests and their peer review result in improvements in safety across European nuclear power plants. It also assisted, through further peer review, in ensuring that the recommendations and suggestions from the stress test peer review were addressed by national regulators and ENSREG in a consistent manner.

The UK supported the ENSREG Action Plan and, in addition to providing detailed information on progress in implementing lessons learned, volunteered nuclear sites for follow-up, fact-finding visits “for information exchange, and to promote further cooperation and confidence-building between European countries”.

As requested by ENSREG, the UK's NAcP provides an update on:

- a. national regulator conclusions from their national stress tests as documented in their national reports;
- b. recommendations in the ENSREG main and country peer review reports;
- c. additional recommendations arising from the Convention on Nuclear Safety (CNS); and,
- d. Additional activities derived from national reviews and related decisions.

In addition the UK NAcP also takes account of the ENSREG compilation of recommendations and suggestions produced in September 2012 (Ref 4), and will, in common with all of ONR's previous reports related to Fukushima, be made publicly available.

This updated report provides details of the current status in relation to all operating NPPs in respect of points a to d above and for each individual item from ENSREG's compilation of recommendations and suggestions. There was a degree of overlap between the various work streams that were addressing the Chief Nuclear Inspector's recommendations and the stress test outcomes; where this happened the updated NAcP clearly links these items to provide an auditable trail for all of the work.

Together with the supporting references, ONR's updated NAcP provides clear evidence that ONR and EDF NGL have incorporated the learning from the ENSREG peer review reports and the associated compilation of recommendations into the programme of work that has and continues to implement the lessons from Fukushima.

ONR has followed a process to embed the Fukushima work within its normal business to ensure that compliance is appropriately tracked and monitored, that any necessary regulatory intervention to progress issues is undertaken, and that the outcomes are reported in a transparent and open manner.

Overall ONR is satisfied that EDF NGL has addressed the learning from Fukushima. All the relevant findings and recommendations were considered closed at the time of the last update in 2015 (Ref. 19). Ten further recommendations were made at that time and these have since been progressed so that five remain to be fully addressed; with two of these expected to be closed in early 2018. Whilst this work remains on-going, it is regarded by ONR as normal business and is being monitored through normal ONR processes.

The updated NAcP, together with the supporting references, is expected to provide an adequate basis for peer review by common discussion within the ENSREG community.

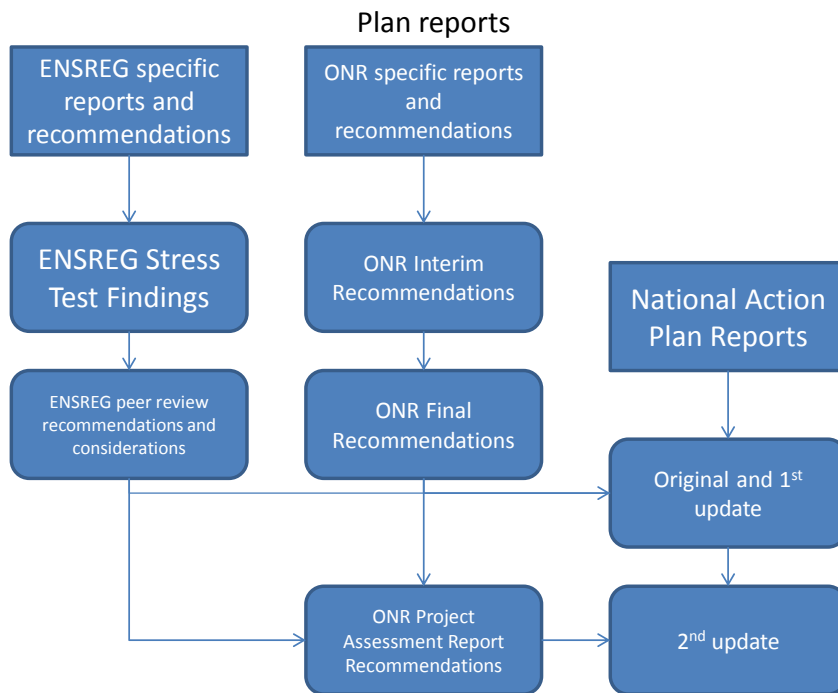
Introduction

1. On 11 March 2011, Japan suffered its worst recorded earthquake. The epicentre was 110 miles East North East from the site of Fukushima-1. Reactor Units 1, 2 and 3 on this site were operating at power before the event and on detection of the earthquake, shut down safely. Initially on-site power was used to provide essential post-trip cooling. About an hour after shutdown a massive tsunami from the earthquake swamped the site and took out the AC electrical power capability. Sometime later, alternative back-up cooling was lost. With the loss of cooling systems, Reactor Units 1 to 3 overheated as did a spent fuel pond in the building of Reactor Unit 4. This resulted in several disruptive explosions because overheated zirconium cladding reacted with water and steam and generated hydrogen. Major releases of radioactivity occurred, initially by air but later by leakage to the sea. This was a serious nuclear accident.
2. This report is the second update of the UK's 'Regulator's National Action Plan' (NAcP) for implementation of post Fukushima lessons learned. It has been produced in response to ENSREG's Action Plan (Ref. 10), which requested a consistent report from each European country on their progress against the national stress tests and recommendations in the ENSREG main and country-specific peer review reports. This updated NAcP draws heavily on the pre-existing UK-specific reports produced in response to Fukushima (Ref 1, 2, 3, 5 and 6), and is especially reliant on the ONR's most recent reports; on implementing the lessons from Fukushima for the UK nuclear industry (Ref. 16), the first update of the 2012 NAcP in 2014 (Ref. 18), an ONR Project Assessment Report (PAR) specifically monitoring the activities performed by the sole remaining operating reactor licensee EDF NGL (Ref. 19), the progress report on implementing lessons learnt from Fukushima (Ref. 20), and the 7th National Report on the Convention on Nuclear Safety (Ref. 21). This updated NAcP is therefore a summary of the current status and future activities that are planned for implementation of the lessons learnt.
3. The ENSREG action plan (Ref. 10) was published on 25th July 2012 with its objective to assist in assuring that the conclusions from the stress tests and their peer review result in improvements in safety across European NPP. It also assisted, through further peer review, in ensuring that the recommendations and suggestions from the stress test peer review were addressed by national regulators and ENSREG in a consistent manner.
4. The ENSREG Action Plan requested that national regulators produce a NAcP (Ref. 6) to provide an update on:
 - national regulator conclusions from their national stress tests as documented in their national reports (known as "stress test findings");
 - recommendations in the ENSREG main and country peer review reports (known as ENSREG considerations);
 - additional recommendations arising from the Convention on Nuclear Safety; and,
 - additional activities derived from national reviews and related decisions (interim recommendations and final recommendations).
5. In addition, the NAcP is expected to take account of the ENSREG compilation of recommendations and suggestions produced in September 2012 (Ref. 4), and to be made publicly available. An updated version of the NAcP was produced in accordance with guidance issued by ENSREG in 2014 and this further update has been made in response to a subsequent request made by ENSREG in 2015 and then again in January 2017.
6. A summary of the information requested by the NAcP guidance is included in Annex 2.

Updated UK National Action Plan Structure

7. The general approach to progressing the work described in this report has been the same for both types of the UK's NPP. These are Advanced Gas Cooled Reactors (AGR) and a single Pressurised Water Reactor (PWR). All responses covered in this report are relevant to the UK operating NPP licensee, EDF NGL. Since the previous update in December 2014, the one remaining Magnox station, Wylfa, has ceased operations and due to the substantially reduced risk is therefore no longer considered in this report. Reference to multiple licensees may still exist within the report to give context to the recommendations which originally included work performed by Magnox, the operator of the Wylfa site.
8. This report has been presented under specific topics as detailed in Ref. 10. The detailed structure of the original NAcPs varied between countries and therefore ENSREG judged it was not appropriate to propose a new detailed format for this updated NAcP. Hence this report will be an update of the existing reports, rather than a new document, with the emphasis on highlighting updates and changes to the NAcP. The 2014 NAcP report included a request to cover the recommendations arising from the Convention on Nuclear Safety (CNS) (Ref. 7), however the most recent Convention on Nuclear Safety review meeting did not make any specific recommendations for this report (Ref. 22). The request resulted in the definition of six topics (topics 1-3 from Ref. 10 and 4-6 from Ref. 7). The topics are as follows:
 - Topic 1 – External Events
 - Topic 2 – Design Issues
 - Topic 3 – Severe Accident Management and Recovery (On-site)
 - Topic 4 – National Organisations
 - Topic 5 – Emergency Preparedness and Response and Post-accident Management (Off-site)
 - Topic 6 – International Co-operation
9. Topics 1 to 3 are dealt with in Section 1, covering progress in terms of national stress test findings, country and overall peer review outcomes and the ENSREG compilation of recommendations and suggestions. The ENSREG compilation of recommendations and suggestions is covered in detail, whereas the national stress test and peer review outcomes have been considered in detail in the earlier Implementation Report (Ref. 5) and so only a summary is provided here. The status of Topics 4 to 6 in the UK are also summarised in Section 2 of this report. Additional activities derived from national reviews and related decisions are discussed in Section 3. Finally Section 4 provides an overview of the work programme in tabular format. Any text in italics has been taken directly from the referenced reports.
10. As noted, there are several types of recommendations discussed in this report. These can be split into two groups: ENSREG-specific and ONR-specific. The diagram below explains the relationship of these to this report. This includes ONR's Project Assessment Report (PAR) Recommendations introduced below which, when produced in 2015, took into consideration all recommendations placed on EDF NGL from all reports.

Recommendations and their relationship to the National Action



11. In this PAR, ONR concluded that all recommendations and stress test findings could be satisfactorily closed for NPP. An outcome of this assessment was that a small number (ten) of new, more specific recommendations were raised in order to progress further the learning from Fukushima. These new recommendations have been taken forward as normal regulatory business. Throughout the following sections, references will be made to this report and its recommendations, known as Project Assessment Report Recommendations PARR-1 to PARR-10 shown in the table below.

| PARR no. | Recommendation | Status |
|----------|--|---|
| 1 | EDF NGL should complete the work set out in its Summary of On-going Enhancements, to the stated timescales as part of their normal business work programme | On-going – considered under normal business |
| 2 | EDF NGL should provide a comprehensive summary of quantitative data on flood hazard (coastal and pluvial including uncertainty and confidence levels), Design Basis Flood levels, flood defence details, and the effects of flood hazard on the safety functions provided by bottom Line Systems, Structures and Components for each site. | Complete |
| 3 | EDF NGL should demonstrate the restoration of power supplies to the Continuous Emergency Monitoring System (CEMS), by on-site personnel using the site-based 180kVA diesel generators. Consideration should be given to the conditions that might be expected during a beyond design basis event when undertaking this demonstration. | Complete |
| 4 | Within the scope of its review of local to plant actions, EDF NGL should include a survey, including preparation arrangements, for alternative DBUE connection points. | Complete |
| 5 | EDF NGL should demonstrate the adequacy of the arrangements to ensure that the water treatment plant can be delivered, commissioned and made operational within a period of 48 hours. | Complete |
| 6 | EDF NGL should carry out structured plant walk-downs at each of the AGRs (except Hunterston B) to systematically crosscheck the level 2 PSA study | On-going – considered under normal business |

| PARR no. | Recommendation | Status |
|----------|--|---|
| | against the characteristics of the other AGRs. | |
| 7 | EDF NGL should consider the development of a level 2 PSA for Heysham 1 / Hartlepool, taking account of the evidence from the structured plant walk-downs and additional transient analysis. | On-going – considered under normal business |
| 8 | EDF NGL should review the output from STF-2 and if necessary develop a programme to fully account for uncertainty in seismic hazard evaluation and provide evidence that the design basis earthquake defined for each site incorporates sufficient conservatism. | On-going – considered under normal business |
| 9 | EDF NGL should provide further details of the beyond design basis margins available for seismic, flooding and meteorological hazards together with evidence to support any judgements made. EDF NGL should also demonstrate that the resultant risks are as low as reasonably practicable (ALARP). | On-going – considered under normal business |
| 10 | EDF NGL should provide a programme of work to address Recommendations 2-9 of this PAR by 30th September 2015. | Complete |

12. PARRs 1 and 10 are related to progress of the on-going Fukushima work monitored by ONR under normal business. PARR-1 is “EDF NGL should complete the work set out in its Summary of On-going Enhancements, to the stated timescales as part of their normal business work programme”. This is routinely monitored by ONR through the ONR issues database. PARR-10 is “EDF NGL should provide a programme of work to address Recommendations 2-8 of this PAR by 30th September 2015” which has been completed. The remainder will be discussed throughout section 1 of this report below.
13. PARRs 2, 3, 4, 5 and 10 are now considered to be closed. The remaining five PARRs are open but have made good progress and two are expected to be closed early 2018 as part of normal Regulatory business.

Section 1

National Stress test Findings

14. In the UK’s stress test report (Ref. 3), ONR identified 19 Stress Test Findings (STF) in addition to the work already underway within EDF NGL’s organisation. Table 1a in Section 4 provides an update to the work that remained at the time of the previous report. Table 1b in Section 4 summarises those findings considered closed in the previous report. Progress by EDF NGL in completing the work that they themselves had identified is summarised in ONR’s reports (Refs. 14 and 15). As noted above, ONR considers all of the STFs to be closed.

Peer Review Outcomes

15. The peer review outcomes from the ENSREG main and country peer review reports can be found on the ENSREG website (www.ensreg.eu) and have been incorporated within the wider UK learning from Fukushima, as shown in ONR’s Implementation Report. The items for follow up and peer review recommendations are linked to ONR’s STF’s, Recommendations and other work in Tables 2a and 2b of section 4.

16. In September 2012, ENSREG produced a compilation of recommendations and suggestions derived from consideration of all of the national stress test reports and associated peer reviews (Ref. 4). ONR and EDF NGL have reviewed this compilation, considering each in turn to see how they are, or can be addressed in the UK. The outcome of these reviews is summarised below. The timescales and milestones against the compilation of recommendations that were considered outstanding in the previous update are shown in Table 3a of Section 4 but are now all considered complete. The recommendations considered completed in the last update are shown in Table 3b.
17. The implementation status of ONR's national stress test findings along with the peer review outcomes are described at the beginning of all the relevant topics prior to the progress update on ENSREG's compilations of recommendations (Ref. 4).

1.1 – External Events

18. All UK NPP operators provided submissions against the ENSREG stress test specification (Ref. 4) as part of their responses to ONR's findings and recommendations. The ENSREG stress test specification required all European operators to demonstrate that:
 - the existing design basis definition of external hazards is well founded and is fit-for-purpose.
 - the existing safety cases are robust and adequate at the design basis level.
 - there is safety margin beyond the design basis either by virtue of conservatism in methodology or over-design.
19. EDF NGL has addressed these points through additional analysis, plant enhancements or improved arrangements.

National Stress Test Report

20. In addition to the wider programme of work driven by the Chief Nuclear Inspector's recommendations and findings, the UK national stress test report (Ref. 3) produced a total of 19 findings (STFs), which can be found in Table 1 of Section 4. Of these 19 findings, 8 relate to External Events. These are STFs 2, 3, 4, 5, 6, 7 and 13 and 14 respectively. All STFs are now considered closed by ONR, as reported in Ref. 19.

The peer review country report conclusions and recommendations (Ref. 13) stated -

“The review team noted that the UK regulator has raised a finding for additional review regarding the design basis approach and an adequate response regarding margins assessment beyond the design basis and identifies specific potential plant improvements”

21. Plant modifications were identified with respect to external hazards and outline specifications developed. Modifications such as the installation of dam boards to prevent flooding, fitted where practicable to doorways and entrances of buildings containing essential equipment, have been completed. A significant modification has been implemented at Dungeness B, improving the sea wall defences considerably.
22. Several STFs are discussed in this section of the report and have been used to support closure of some of the ENSREG considerations below. All STFs were considered closed by ONR in the PAR (Ref. 19). In some cases, further more specific recommendations were made by ONR to continue to monitor progress under normal business and therefore ONR issues were created to monitor progress to a suitable conclusion. In this section, three recommendations were made (PARR 2, 8 and 9). EDF NGL has made good progress towards closing these recommendations.

23. PARR-2 is “EDF NGL should provide a comprehensive summary of quantitative data on flood hazard (coastal and pluvial including uncertainty and confidence levels), Design Basis Flood levels, flood defence details, and the effects of flood hazard on the safety functions provided by bottom line Structures, Systems and Components (SSCs) for each site.”. EDF NGL is undertaking significant flood modelling improvements and has submitted summary coastal flood information sufficient to close PARR-2. Any further work relating to flood assessment will be progressed under normal regulatory interface arrangements.
24. PARR-8 is “EDF NGL should review the output from STF-2 and if necessary develop a programme to fully account for uncertainty in seismic hazard evaluation and provide evidence that the design basis earthquake defined for each site incorporates sufficient conservatism.” PARR-8 is related to PARR-9 both of which are discussed below.
25. PARR-9 is “EDF NGL should provide further details of the beyond design basis margins available for seismic, flooding and meteorological hazards together with evidence to support any judgements made. EDF NGL should also demonstrate that the resultant risks are as low as reasonably practicable (ALARP)”. Similarly, based on a set of tables with flood information for all EDF NGL reactor sites, ONR is in a position to close this recommendation (in relation to flooding).
26. EDF NGL has undertaken a significant study of seismic hazard methodology and is planning to issue a detailed report in early 2018. ONR has held constructive discussions relating to the seismic work programme and subject to satisfactory delivery of the detailed seismic report, PARR-8 and 9 are expected to be closed early in 2018.

ENSREG and Country-Specific Peer Review for UK Stress Test Report

The UK stress test peer review (Ref. 13) also stated - *“For some specific external hazards, beyond design basis capability are inferred but not quantified and no specific evidence is provided that margins to cliff edge effects and potential specific improvements have been considered systematically for all NPP. In some cases there is no satisfactory evidence of capability of plant beyond design basis (e.g. tsunami, lightning)”*

27. ONR had already recognised this in its own stress test report (Ref. 3) and this is progressed by STF5 in the UK national report. The work is reflected in the main body of this report that gives updates on the ENSREG compilation of recommendations. ONR has maintained strong regulatory oversight in this area in line with both the ENSREG and country-specific peer review recommendations. For each site a report has been produced addressing coastal, fluvial (from rivers) and pluvial (from direct rainfall) flooding for the 10^{-4} pa flood event, using a consistent methodology for all stations.
28. These reports formed the basis for assessment of margins to cliff edge effects. Further studies provided information necessary to support decisions in respect of enhancing the existing resilience of the sites to cope with beyond design basis events from external hazards.
29. The UK Meteorological Office (MO) evaluated revised design basis parameters and investigated weather hazards at a return frequency of 10^{-5} per annum in order to facilitate the licensee's consideration of the potential effects on its plant's structures, systems and components (SSCs).

ENSREG Compilation of Recommendations

30. Progress in the following areas noted from Ref. 4 is described below along with a brief description of what Ref. 4 requires. For those recommendations identified as complete within the accompanying table 3b in the previous update, the text in the following sections has been

reproduced unaltered. For those recommendations listed in table 3a of the previous update, an update has been provided within the following sections, together with the basis for its completion. Where relevant, the accompanying recommendations or findings from Refs 1, 2 and/or 3 are also noted. The recommendations from Refs. 1-3 can be found in Tables 1 and 2 at the end of this document. To provide continuity, but to simplify an overview of the progress achieved, the tables have been split into those updated in this report (a) and those closed in the previous update (b).

Hazard Frequency

ENSREG consideration 3.1.1: "The use of a return frequency of 10-4 per annum (0.1g minimum peak ground acceleration for earthquakes) for plant reviews/back-fitting with respect to external hazards safety cases."

31. ONR's Safety Assessment Principles (SAPs) (Ref. 8) set standards for protection against natural external hazards based on a severity consistent with a 10^{-4} per annum frequency evaluated on a conservative basis. Minimum peak ground acceleration for earthquakes, when evaluated on this basis, varies from site to site but is in excess of 0.1g in all cases. This criterion was historically established in the UK prior to the Fukushima accident and therefore UK NPPs meet this protection requirement either by design or by virtue of review and upgrade via the Periodic Safety Review (PSR) process. Compliance against this criterion was further reviewed as part of the ENSREG stress test process. As a vehicle for continuous improvement, EDF NGL has reviewed and updated the hazard severity/occurrence data to confirm its adequacy and to ensure a consistent approach is applied across all facilities. ONR has also published revised SAPs following a review to ensure that the guidance contained therein is consistent with information gathered from post Fukushima reviews.

Secondary Effects of Earthquakes

ENSREG consideration 3.1.2: "The possible secondary effects of seismic events, such as flood or fire arising as a result of the event, in future assessments."

32. Seismically induced fire has been addressed by EDF NGL in response to STF4 of Ref. 3. ONR notes that the approach taken by EDF NGL involved site-based workshops and walk-downs by teams of Suitably Qualified and Experienced Personnel (SQEP) and was considered acceptable by ONR.
33. ONR has progressed flooding events with EDF NGL via IR 10 of Ref. 2. ONR has received an adequate description of the work that has been undertaken at all sites in the UK. The work involved an independent review of the current flood risk, in particular wave over topping events and a further assessment of plant items requiring additional flood protection. The reviews have led to a number of resilience enhancements across several sites, most notably the construction of the sea defence improvements at Dungeness B.
34. Table 3a refers to outstanding work related to STF-7 and IR-10 on flooding studies. As discussed above, these are now considered complete with residual work being monitored under ONR normal business processes.

Protected Volume Approach

ENSREG consideration 3.1.3: "The use of a protected volume approach to demonstrate flood protection for identified rooms or spaces."

35. ONR impressed upon the licensee the need to consider this approach together with other work on flood protection and margins. ONR supports the current position that the existing flooding hazards have been reviewed and follow-up work has been completed that includes the installation of dam boards and sealing of services penetrations to all essential buildings. The

program of work in this area ran in parallel with the other work described for hazards frequency and the secondary effects of earthquakes.

36. Table 3a refers to outstanding work related to STF-7 and IR-10 on flooding studies. As discussed above, these are now considered complete with residual work being monitored under ONR normal business processes.

Early Warning Notifications

ENSREG consideration 3.1.4: "The implementation of advanced warning systems for deteriorating weather, as well as the provision of appropriate procedures to be followed by operators when warnings are made."

37. EDF NGL already has local monitoring systems and operational response procedures. Furthermore UK national warning systems are in place. However, the approach was not consistent across the reactor fleet for all external hazards. ONR engaged with licensees to ensure that the relevant ONR Chief Inspector's recommendations and questions that ONR raised during the stress test evaluation process, which includes that of early warning systems were addressed. Additional severe weather forewarning systems are now provided to NPP sites (the Met Office's VisualEyes and Safesee systems) to ensure that station staff are aware of severe weather, such as that which could cause or exacerbate flooding hazards; this will aid staff's ability to ensure that suitable preparations are made, including placement of dam boards if appropriate. The two Met Office products are seen as good practice in terms of local forecasting technology.

Seismic monitoring

ENSREG consideration 3.1.5: "The installation of seismic monitoring systems with related procedures and training."

38. ONR has progressed this area via STF3 of Ref. 3. All NPPs are currently equipped with local seismic monitoring instrumentation that is directly accessible to control room staff. In addition to this, EDF NGL and ONR have access to a national monitoring system run by the British Geological Survey. The current arrangements are judged by ONR to be adequate. A review of operator actions following a seismic event, including the use of new deployable back up equipment has been undertaken by EDF NGL. ONR assessed this review and found it to be adequate and has closed STF-3 (Ref. 19 provides more details).

Qualified Walk downs

ENSREG consideration 3.1.6: "The development of standards to address qualified plant walk downs with regard to earthquake, flooding and extreme weather – to provide a more systematic search for non-conformities and correct them (e.g. appropriate storage of equipment, particularly for temporary and mobile plant and tools used to mitigate beyond design basis (BDB) external events)."

39. EDF NGL has conducted walk downs against all external hazards in response to the Chief Nuclear Inspector's (CNI) findings. The walk downs are consistent with approved processes and are undertaken to a set procedure, similar to that performed for PSR work. Plant walk-downs for seismic assessments are done in adherence to the Electric Power Research Institute (EPRI) standard, which ONR considers acceptable. More specific/targeted walk-downs addressed specific post Fukushima STFs, particularly in relation to beyond design basis events. ONR has also carried out site inspections to ensure that due attention is paid to the ability of operators to carry out remedial actions in response to beyond design basis events. ONR uses the standards set out in its SAPs (Ref. 8) for plant walk-downs but is currently not involved with the development of standards to address qualified plant walk-downs.

Flooding Margin Assessments

ENSREG consideration 3.1.7: “The analysis of incrementally increased flood levels beyond the design basis and identification of potential improvements, as required by the initial ENSREG specification for the stress tests.”

40. Flooding events were addressed via IR10 and STF5 of Refs. 2 and 3. A full flooding margin assessment as required by STF5 has been undertaken by EDF NGL that focussed on structures that protect the bottom line plant, the bottom line plant itself, and security of integrity of the pressure boundary.
41. Table 3a refers to outstanding work related to STF-7 and IR-10 on flooding studies. As discussed above, these are now considered complete with residual work being monitored under ONR normal business processes.

External Hazard Margins

ENSREG consideration 3.1.8: “In conjunction with recommendation 2.1 and 3.1.7, the formal assessment of margins for all external hazards including, seismic, flooding and severe weather, and identification of potential improvements.”

42. ONR has progressed this area via STF5 of Ref 3 which is considered to be closed. The work undertaken for external hazard margins has been described in the section above. Regarding recommendation 2.1, ONR led the development of guidance on natural hazards on behalf of the Western European Nuclear Regulators Association (WENRA) in addition to the work undertaken in the UK. The subject of extreme weather is discussed at regular meetings with EDF NGL, who has contracted the UK’s Met Office to carry out a significant review of extreme weather data. This review not yet complete but EDF NGL judges that the preliminary data from the review does not undermine the safety case. This is being monitored under normal business.

1.2 – Loss of Safety Systems

National Stress Test Report

43. The UK national stress test report (Ref. 3) produced a total of 19 findings (STFs), which can be found in Table 1 of Section 4. Of these 19 findings, 7 relate to Loss of Safety Systems. These are STFs 8-14 inclusive and are considered complete as reported in the ONR Project Assessment Report update (Ref. 19).

The UK stress test peer review (Ref. 13) states - *“Inject water into the reactor core as an ultimate means to provide residual heat removal from the core without use of the boilers and identify the means/equipment that would be used, including filtering”*

44. EDF NGL has installed connection points to allow the connection of portable generators with delivery of mobile 200kVA off-site generators. Mobile 150kVA on-site generators have also been procured.
45. The main focus for AGRs is to ensure water is provided to boilers via on site water stocks and reverse osmosis plant for extending on-site water stocks. Reverse osmosis plant has been procured as part of the suite of deployable back-up equipment together with the provision of compressed nitrogen gas. PARR-5 was made in the ONR PAR (Ref. 19) for EDF NGL to “demonstrate the adequacy of the arrangements that the water treatment plant can be delivered, commissioned and made operational within a period of 48 hours”. Subsequent to this, EDF NGL has performed studies and tests with conservative timescales that show that this equipment can be delivered within a 48 hour period and it has confirmed that all its stations have significantly in excess of 48 hours of protected water stocks already on site. ONR considers this to be sufficient to close PARR-5.

ENSREG and Country Specific Peer Review for UK Stress Test Report

The peer review country report conclusions and recommendations (Ref. 13) stated - *“Stocks of fuel etc. should be available for at least 72h”*

46. Wider arrangements for storage and deployment of equipment have been developed, which include the provision of fuel supplies. All sites currently have at least 72 hours of fuel and water supplies. After this, back-up equipment will be able to provide supplies via reverse osmosis and fuel delivery should this be required (e.g. beyond 48 hours in the case of water supplies, see para 45).

ENSREG Compilation of Recommendations

Alternate Cooling and Heat Sink

ENSREG consideration 3.2.1: “The provision of alternative means of cooling including alternate heat sinks. Examples include steam generator (SG) gravity alternative feeding, alternate tanks or wells on the site, air-cooled cooling towers or water sources in the vicinity (reservoir, lakes, etc.) as an additional way of enabling core cooling.”

47. ONR has progressed this work via IR19 and STFs 8 and 9 of Refs 2 and 3. Detailed reviews across NPP sites have been undertaken and the sites have confirmed sufficient capacity for at least 72 hours supply of feed water. Practical enhancements and modifications resulting from the reviews have been implemented. Reverse osmosis plant using seawater to extend on-site water stocks has been procured by EDF NGL.

AC Power Supplies

ENSREG consideration 3.2.2: “The enhancement of the on-site and off-site power supplies. Examples include adding layers of emergency power, adding independent and dedicated backup sources, the enhancement of the grid through agreements with the grid operator on rapid restoration of off-site power, additional and/or reinforced off-site power connections, arrangements for black start of co-located or nearby gas or hydro plants, replacing standard ceramic based items with plastic or other material that are more resistant to a seismic event. Another example is the possible utilisation of generator load shedding and house load operation for increased robustness, however, before introducing such arrangements the risks need to be properly understood.”

48. ONR has progressed this area via IRs17, 18 and STFs 8, 9, 10 and 11 of Refs 2 and 3. The licensees accepted the need to consider enhancements in these areas. In respect of off-site power supplies, the licensees engaged the UK transmission system operator, National Grid, to co-ordinate a review of grid reliability and possible enhancements for coordination and restoration. The review produced a number of recommendations and these are being progressed via “normal business”. These are in addition to the subjects described in this report to provide back-up supplies for cooling and power. An industry group was established and has explored the ability to restore the network following a physical failure. National Grid has emergency arrangements in place for restoring non-nuclear generators and it is working with industry to ensure reliability remains robust as the generation mix continues to change. ONR considers all relevant Recommendations and STFs to be closed in this area. As part of our normal regulatory business, further consideration is however being given to increasing resilience in the event of an extended loss of grid supplies.

49. EDF NGL has reviewed the on-site diesel generator or gas turbine power supplies and confirmed that all are capable of a minimum of 72 hours operation. EDF NGL has now demonstrated the deployment of backup generators should an event result in all on-site and off-site power supplies becoming unavailable. Suitable electrical connection points are installed at each site.

DC Power Supplies

ENSREG consideration 3.2.3: “The enhancement of the DC power supply. Examples include improving the battery discharge time by upgrading the existing battery, changing/diversifying battery type (increasing resistance to common-mode failures), providing spare/replacement batteries, implementing well-prepared load shedding/staggering strategies, performing real load testing and on-line monitoring of the status of the batteries and preparing dedicated recharging options (e. g. using portable generators).”

50. ONR considers that all the points in the consideration above have been progressed via STF9 of Ref. 3. Licensees were required to review response times and consider opportunities to enhance these times. ONR considers that operator action to reduce battery load is likely to be incompatible (in the short post trip period) with the operator's priority to establish adequate post-trip cooling. Importantly though, establishing adequate post trip cooling at the AGRs does not rely on battery systems that are likely to become drained and so, as a result of the review, the licensees did not conclude that it was appropriate to increase battery capacity at the AGR sites. ONR supports this view.
51. Replacement of the battery-charging diesel generators at the UK PWR has been completed. Modifications to the design have also been undertaken to increase robustness to flooding and seismic hazards. This includes seismic qualification and the flood protection of the building that houses the generators.

Operational and Preparatory Actions

ENSREG consideration 3.2.4: “Implementation of operational or preparatory actions with respect to the availability of operational consumables. Examples include, ensuring the supply of consumables such as fuel, lubrication oil, and water and ensuring adequate equipment, procedures, surveillance, drills and arrangements for the resupply from off-site are in place.”

52. ONR has progressed this area via IR9 and STFs 9 and 15 of Refs. 2 and 3. ONR considers the plans for on-site electrical and water supplies and consumables such as gas stocks (for AGRs) and fuel to be adequate, both in terms of on-site capacity and resupply from off-site. The reviews produced a programme of work for enhancements as part of continuous improvement that were completed during 2014.

Instrumentation and Monitoring

ENSREG consideration 3.2.5: “The enhancement of instrumentation and monitoring. Examples include separate instrumentation and/or power sources to enable monitoring of essential parameters under any circumstances for accident management and the ability to measure specific important parameters based on passive and simple principles.”

53. ONR has progressed this area with EDF NGL via IRs 22 and 23 and STFs 14 and 15 of Refs. 2 and 3. An ONR review of EDF NGL's response that has taken into account these IRs and STFs is complete and EDF NGL has completed the following work:
- Strategies have been developed to re-energise existing systems and, as necessary to use pre-determined cable routes/connection points to utilise this equipment. Provision of direct feeds into control rooms from devices, such as data loggers or cubicle mounted apparatus, and cameras that can be deployed post-event have been completed.
 - Reasonably practicable resilience enhancements to existing Control & Instrumentation (C&I) systems and equipment have been made to ensure that plant status information can be made available to plant control rooms and/or emergency management facilities (e.g. Emergency Control Centres (ECCs), Alternative Indication Centres (AICs) and Emergency Indication Centres (EICs)). This capability now exists as part of the suite of back-up equipment that is deployed to the sites. Work is now complete to have an equivalent capability in the time between the initiation of an event and the arrival of back-up equipment to site. Further enhancements are planned with the last station expected to complete handover of Continuous Emergency Monitoring System (CEMS) by the end of the first

quarter in 2018. This capability includes alternative means of transmitting information to plant control rooms and/or severe accident management facilities.

- Other related considerations arising from completion of the licensee's stress tests included the provision of additional evidence in relation to, for example, the specification for the aerial lighting and grab torches, including details of any relevant battery management regime. Extra equipment has been procured and arrangements are in place to utilise existing sensors that may be energised via mobile 415V generators or batteries as part of the back-up equipment.

54. In ONR's PAR (Ref. 19), PARR-3 recommended that EDF NGL should demonstrate the restoration of power supplies to Continuous Emergency Monitoring System (CEMS), by on-site personnel using the site based 180kVA diesel generators and that consideration should be given to the conditions that might be expected during a beyond design basis event when undertaking this demonstration. CEMS has now been rolled out at all stations and is available. Only minor work is required at Heysham 2 and Torness and this will be completed during the next outages. This recommendation is thus considered closed, with the remaining minor work regulated to completion under normal ONR business (and monitored using ONR's issues database).

Shutdown Improvements

ENSREG consideration 3.2.6: "The enhancement of safety in shutdown states and mid-loop operation. Examples of improvements include, reducing or prohibiting mid-loop operation, adding dedicated hardware, procedures and drills, the use of other available water sources (e. g. from hydro-accumulators), requiring the availability of steam generators during shutdown operations and the availability of feedwater in all modes."

55. In accordance with ONR SAPs (Ref. 8) EDF NGL safety cases look at all operating modes for a given plant and this includes mid-loop operation where applicable. The UK specific reports on Fukushima and the stress tests were carried out in this light. In the UK, mid-loop operation is only relevant to the PWR at Sizewell B and was already recognised as a potentially higher-risk state when Sizewell B was designed. Existing Technical Specifications contain requirements for redundancy in both instrumentation and heat sinks. The heat sink arrangements include significant diversity in the form of a diverse air-cooled reserve ultimate heat sink, qualified against natural hazards. The provision of adequate electrical supplies to these systems has been considered elsewhere in this document as have battery-charging diesel generators. Upgrading the resistance of the associated buildings to natural hazards and connection of portable generators and pumps for diverse cooling was completed during 2014.

Reactor Coolant Pump Seals

"ENSREG consideration 3.2.7: "The use of temperature-resistant (leak-proof) primary pump seals."

56. In the UK this consideration is only relevant to Sizewell B. EDF NGL examined the equipment available to allow improvements to the integrity of the main coolant pump seals. Replacement seal units were identified but EDF NGL considers that this equipment is novel and the safety benefit of such seals is not yet proven. EDF NGL will review operational experience from any plants that do adopt these seals, and may fit them at some future date. ONR considers this approach acceptable.

57. Seal injection flow at Sizewell B is available from diverse sources (electrical and steam turbine equipment). The conservative approach to the plant change proposed is consistent with the practice generally adopted by Sizewell B. Since it is the only PWR in the UK, its policy is to be conservative in its adoption of technical changes. This is consistent with ONR guidance.

Ventilation

ENSREG consideration 3.2.8: “The enhancement of ventilation capacity during station black-out (SBO) to ensure equipment operability.”

58. ONR has progressed this area via IR 21 and STFs 18 of Refs. 2 and 3. ONR has seen good progress in this area with installation of Passive Autocatalytic Recombiners at Sizewell B. A feasibility study for the installation of Filtered Containment Venting (FCV) has been completed and a decision on installation at Sizewell B is under review and subject to discussions between ONR and EDF NGL. A review of the risk of combustible gas production on the AGR fleet has been completed and concludes that hydrogen generation is not possible in the way that occurred at Fukushima, therefore EDF NGL has not fitted Passive Autocatalytic Recombiners at any of the AGR stations. ONR agrees with this position.

Main and Emergency Control Rooms

ENSREG consideration 3.2.9: “The enhancement of the main control room (MCR), the emergency control room (ECR) and emergency control centre (ECC) to ensure continued operability and adequate habitability conditions in the event of a station black-out (SBO) and in the event of the loss of DC.”

59. ONR has progressed this area via IR22, FR2 and FR3 of Ref. 2. Appropriate programmes to implement reasonably practicable resilience enhancements to existing ECCs have been completed. This includes provision of diesel generators to ensure continued operability. The necessary functions of communications, management of personnel in potentially hazardous areas and plant indications have been replicated by the provision of back-up equipment which, if required, can be deployed and operational within the required timescales. The changes made to infrastructure, equipment and procedures have been integrated into emergency arrangements, and aspects such as on-going maintenance and training will be dealt with under normal regulatory business.

60. The section on the spent fuel pool below describes the quicker response time required for PWR's. Due to this, construction of a hardened emergency response centre at Sizewell B has been completed, which differs from the capability to supply back-up emergency equipment from regional stores for the AGRs. The AGRs will utilise mobile pods to be brought to site as a source of back-up emergency equipment, rather than the construction of a response centre as is the case at Sizewell B.

Spent Fuel Pool

ENSREG consideration 3.2.10: “The improvement of the robustness of the spent fuel pool (SFP). Examples include reassessment/upgrading SFP structural integrity, installation of qualified and power-independent monitoring, provisions for redundant and diverse sources of additional coolant resistant to external hazards (with procedures and drills), design of pools that prevents drainage, the use of racks made of borated steel to enable cooling with fresh (unborated) water without having to worry about possible recriticality, redundant and independent SFP cooling systems, provision for additional heat exchangers (e. g. submerged in the SFP), an external connection for refilling of the SFP (to reduce the need for an approach linked to high doses in the event of the water falling to a very low level) and the possibility of venting steam in a case of boiling in the SFP.”

61. ONR considers that all of the above points have been progressed via the work done in response to IRs 13, 14, 15 and 20 of Ref. 2. Reviews have been carried out across all NPPs with regard to reassessment/upgrading of SFP structural integrity. Full site walk downs have been undertaken along with on-going work looking at earthquake responses of concrete structures. This work included considering pond thermal performance and cracking. Installation of power-independent monitoring has focussed on post-event emergency equipment rather than on looking at how monitoring could be continued via installed equipment in the event of power failure.

62. EDF NGL has completed a review of site contingency plans for pond water make-up under severe accident conditions. Various additional options have been identified which allow

operators to deliver pond water make-up if required in a severe event if normal water supplies and pumps were not available. These include provision of additional emergency back-up equipment which can be deployed following a severe accident and emergency pond water/buffer store make-up and cooling module provision with hoses and appropriate connections laid as necessary.

63. Reviews have been carried out across all NPPs with regard to siphoning faults and anti-siphoning features currently installed. The results were received by ONR and judged to be adequate. C&I equipment and systems that can be used to monitor pond water level and temperature have been procured as part of the suite of deployable back up equipment.
64. In AGR cooling ponds, borated steel is present in the skips. In addition, the fixed fuel geometry in the skips ensures sub-criticality. Although the AGR fuel storage ponds are doped with boron, this is not required to guarantee reactivity remains sub-critical in normal operation. Therefore, provided the fuel geometry in the skips does not alter in the accident and the boronated stainless steel remains in place, then re-filling the pond with unborated water should not pose a criticality safety hazard. At Sizewell B the pond water is borated but this neutron poison is required to control the criticality hazard should an element be misplaced in the storage racks or should an element in transit be dropped. The main criticality controls in normal operations are the presence of solid absorber assemblies in one out of four rack storage positions and boral inserts in the fuel storage racks.
65. Most pond fault sequences have significant time periods before irradiated fuel temperatures can lead to nuclear safety hazards. Hence the off-site back-up equipment includes a pond cooling system that provides an indication of pond water temperature and it is not considered necessary to have this equipment in place on site.
66. ONR has recognised that calculations show that for AGR plants, the earliest time for the onset of boiling is significantly in excess of 72 hours, even at the most onerous heat loadings. This time is significantly less for the PWR at Sizewell B though, so different strategies were needed (e.g. the construction of the Sizewell B emergency response centre). ONR considers the approach adopted by EDF NGL to SFPs to be reasonable.

Separation and Independence

ENSREG consideration 3.2.11: "The enhancement of the functional separation and independence of safety systems. Examples include the elimination of full dependence of important safety functions on auxiliary systems such as service water and the introduction of an alternate source of cooling."

67. ONR has progressed this area via STF14 of Ref. 3. EDF NGL has completed the work from the initial scoping exercises through to the installation and implementation of various measures. This includes interactions with off-site backup equipment, its storage at diverse locations, compatibility with existing equipment and its use by operators. Modifications, such as the use of alternative cooling supplies, backup equipment provisions and hardened on-site stock supplies have been completed and are described in other relevant sections of this report.

Flow Path and Access Availability

ENSREG consideration 3.2.12: "The verification of assured flow paths and access under Station Black Out (SBO) conditions. Ensure that the state in which isolation valves fail and remain, when motive and control power is lost, is carefully considered to maximise safety. Enhance and extend the availability of DC power and instrument air (e. g. by installing additional or larger accumulators on the valves). Ensure access to critical equipment in all circumstances, specifically when electrically operated turnstiles are interlocked."

68. ONR has progressed this area via IR25 and STF14 and 15 of Refs 2 and 3. The licensee carried out analysis and established that adequate post-trip cooling does not rely on battery systems that are likely to become drained. As a result of the review EDF NGL concluded that it was not necessary to increase battery capacity at the AGR sites. ONR accepted this position.
69. In respect of on-site personnel access under SBO conditions, EDF NGL assessed the feasibility of operator recovery actions following extreme weather (flooding and high winds) and seismic events. These assessments considered aspects such as visibility, which may be impaired following such extreme events. The scope of these assessments is considered to adequately address the potential access concerns. The scope covers both internal and external critical plant associated with SBO. ONR has witnessed proof of concept demonstrations and whilst with all exercises there are opportunities for learning, ONR found the demonstrations to be adequate.
70. For gas cooled reactors in the event of a SBO, either on its own or accompanied by a severe external hazard, there are few isolation valves which are required to close in order to support nuclear safety. Such valves are qualified for hazard conditions and operate immediately following a reactor trip supported by battery-backed control and motive power (some motive power is also hydraulically actuated.) Such valves are not required to change state (i.e. open) in any SBO condition that may subsequently develop. The establishment of core cooling via the boilers requires the introduction of feed water. In a SBO situation, feed water flow to the boilers may be established either via manual operation of valves normally in the closed position, or via manual operation of bypass valves. The long timescales available on AGRs (many hours) for such operations to be undertaken before core damage would occur, together with the high number of redundant feed water routes, are considered to provide high confidence that manual recovery actions would be successful in a SBO.
71. Similarly, at Sizewell B, in the event of a SBO, either on its own or accompanied by a severe external hazard, there are few isolation valves which are required to close in order to support nuclear safety. All such valves are configured to fail to a 'safe-state' in the event of a loss of motive power. The valves are qualified (where required) for hazard conditions. A small number of valves are required to operate following a reactor trip in a SBO condition. These are either battery-backed or have dedicated motive air supplies. Key examples include flow control valves in the auxiliary feed water lines and variable set point power-operated relief valves in the main steam lines. In addition, steam-driven feed water pumps, feed water bypass lines and statutory steam relief valves enable continued safe shutdown of the plant even if supplies to these key valves are unavailable.

Mobile Devices

ENSREG consideration 3.2.13: "The provision of mobile pumps, power supplies and air compressors with prepared quick connections, procedures, and staff training with drills. Mobile devices are intended to enable the use of existing safety equipment, enable direct feeding of the primary or secondary side, allow extended use of instrumentation and operation of controls, allow effective fire fighting, and ensure continued emergency lighting. The equipment should be stored in locations that are safe and secure even in the event of general devastation caused by events significantly beyond the design basis."

72. ONR has progressed this area via STF8, 10 and 15 of Ref. 3. Work, involving mobile devices has been described elsewhere in this report in terms of both demonstrating mobilisation of people and equipment (from both on and off-site) and the provision of on-site connections to allow use of mobile equipment. Such equipment includes back-up generators, off road vehicles, cooling and fuel supplies with compatible connections and welfare facilities. Aside from Sizewell B, where this equipment is held close to site in the hardened Emergency Response Centre (ERC), the AGRs have such provisions available from pods that are stored at strategic locations within the UK in order to provide a response on suitably short timescales.

Bunkered/Hardened Systems

ENSREG consideration 3.2.14: "The provision for a bunkered or "hardened" system to provide an additional level of protection with trained staff and procedures designed to cope with a wide variety of extreme events including those beyond the design basis."

73. UK licensees considered implementing hardened systems as part of a holistic approach to accident prevention, management and mitigation. This included consideration of the requirement for, and degree of resilience of facilities such as Emergency Control Centres and main/central control rooms. Due to the different age and design of UK NPPs, different levels of inherent/designed resilience, redundancy and practicability of improvement were required. The appropriate levels of resilience are site-specific and enhancements against hazards were implemented as appropriate.
74. As part of this holistic approach, licensees also developed enhancements to hardened site facilities wherever appropriate. This is in addition to the design basis considerations that were accounted for during construction. Off-site storage locations for mobile emergency equipment at locations such that equipment can be transported to site in timescales required for emergency response also provide a degree of separation and independence from on-site facilities that reside in hardened structures. The focus for the off-site emergency equipment includes the ability to mitigate against Beyond Design Basis Accident (BDBA) scenarios.

Multiple Accidents

ENSREG consideration 3.2.15: "The enhancement of the capability for addressing accidents occurring simultaneously on all plants of the site. Examples include assuring preparedness and sufficient supplies, adding mobile devices and fire trucks and increasing the number of trained and qualified staff."

75. ONR has progressed this area via IR11 and 24 of Ref. 2. The licensee's work here includes enhancement of information management systems and command and control processes such that multi-plant events can be managed simultaneously. Sufficient quantities of back-up equipment, located in regional stores, which is provided in association with training of staff from other sites to ensure an adequate number of trained and qualified staff to deploy and operate back-up equipment. A multi-plant exercise took place during the first quarter of 2014. ONR witnessed the exercise and found the arrangements to be adequate. Continuous improvement is covered as part of normal business.

Equipment Inspection and Training Programs

ENSREG consideration 3.2.16: "The establishment of regular programs for inspections to ensure that a variety of additional equipment and mobile devices are properly installed and maintained, particularly for temporary and mobile equipment and tools used for mitigation of BDB external events. Development of relevant staff training programmes for deployment of such devices"

76. ONR has progressed this area via STF15 of Ref. 3. ONR had adequate visibility of the licensee's procurement of mobile back-up equipment intended to mitigate beyond design basis events. A corresponding programme of in-service support and staff training is also in place and is subject to appropriate regulatory oversight by ONR. This area of work is closely related to the other work streams described above.

Further Studies to Address Uncertainties

ENSREG consideration 3.2.17: "The performance of further studies in areas where there are uncertainties."

Uncertainties may exist in the following areas:

- *The integrity of the spent fuel pond (SFP) and its liner in the event of boiling or external impact.*
- *The functionality of control equipment (feedwater control valves and SG relief valves, main steam safety valves, isolation condenser flow path, containment isolation valves as well as depressurisation valves) during the SBO to ensure that cooling using natural circulation would not be interrupted in a SBO.*
- *The performance of additional studies to assess operation in the event of widespread damage, for example, the need for different equipment (e.g. bulldozers) to clear the route to the most critical locations or equipment. This includes the logistics of the external support and related arrangements (storage of equipment, use of national defence resources, etc.).”*

77. The progress of work surrounding boiling in the SFP is described in the relevant section above and ONR is satisfied with the licensee’s response. Functionality of equipment under SBO conditions is also discussed in topics such as those that deal with electrical supplies and backup equipment. A fleet of off-road vehicles has also been procured, noting the problems experienced at Fukushima regarding the movement of vehicles around the site due to debris.

78. The licensees have also conducted further studies surrounding issues such as managing the traumatic, psychological, stress and family effects that staff and other responders may encounter during a severe and prolonged nuclear emergency.

1.3 – Severe Accident Management

National Stress Test Report

79. The UK national stress test report (Ref. 3) produced a total of 19 findings (STFs), which can be found in Table 1 of Section 4. Of these 19 findings, 4 relate to severe accident management. These are STFs 15-18 inclusive. ONR now considers that these are complete as reported in the ONR PAR (Ref. 19).

80. EDF NGL has produced a human aspects key findings report. The report summarises key findings from a desktop review of documentation, lessons learnt reports and a review of arrangements. Areas that have been highlighted in the report include staff willingness to respond, staff availability during emergency response, enhancing responders’ resilience and stress management, managing traumatic events, addressing the human aspects of radiation incidents and recovery issues, including family and community support.

The peer review country report conclusions and recommendations (Ref. 13) stated - *“The SBERGs and SAGs should be further developed to cover fully all spectrums of accident scenarios, including plant shutdown conditions. Training and exercises for implementation of the procedures should be improved”*

81. EDF NGL has completed a review and revision of their reactor System Based Emergency Response Guidelines (SBERGs). The main areas for review for reactor SBERGs included, safety case developments and plant modifications, structural integrity values, recent transient analysis development. A review of the existing SBERG was performed by station operations staff, simulator tutors and nuclear safety engineers. Items relating to SBERGs that were identified from the PSR process were also included.

82. New fuel route SBERGs have also been produced. Analyses of spent fuel storage areas, buffer store thermal analysis, pond thermal analysis and pond cracking analysis have also taken place. The reports provided from these analyses were used as the technical basis for the development of fuel route SBERGs.

83. Review and revision of Severe Accident Guidelines (SAGs) has also taken place. The revisions separated out the parts of the existing SAGs which deal with recovery actions and took account of new Back-up Equipment (BUE), including the fuel route plant. The first

document provides accident management guidance to emergency controllers under circumstances in which the accident management strategy can be centred on deployment of the BUE. A second document is an amended version of the existing SAGs with the advice having a greater level of detail. The intention is to make the advice more useful in the event of a potential severe accident, so that less development would be needed in real time. It should be noted that Sizewell B does not have SBERGs and SAGs, instead it has prescriptive Station Operating Instructions (SOIs, series 8 for emergency operations) and separate Severe Accident Management Guidelines (SAMGs) respectively. These are being reviewed separately as part of the PSR process following the plant modifications.

ENSREG and Country Specific Peer Review for UK Stress Test Report

Necessary implementation of measures allowing prevention of accidents and limitation of their consequences in case of extreme natural hazards is a finding of the peer review that national regulators should consider (Ref. 12).

“Urgent implementation of the recognised measures to protect containment integrity is a finding of the peer review that national regulators should consider” (Ref. 12).

84. For AGRs the primary circuit pressure boundary is provided by a steel-lined, reinforced concrete pressure vessel. A seismic event is the only credible external hazard considered to cause direct damage to the primary circuit pressure boundary. A re-evaluation of the seismic robustness of the primary circuit pressure boundary was carried out to provide assurance that sufficient margins are in place. At newer plants the seismic hazard has been integrated into the plant design – there are judged to be significant margins against the 10^{-4} pa seismic criterion at these plants. The position at the older plants is less robust, but nevertheless acceptable in terms of risk. ALARP arguments, presented in the seismic safety cases for the older sites are considered to remain valid.

85. For the PWR at Sizewell B, Passive Autocatalytic Recombiners have been installed which oxidize hydrogen via catalysis in the event of severe fuel damage. A feasibility study for the installation of Filtered Containment Venting (FCV) has been completed and a decision on installation at Sizewell B is under review and subject to on-going discussions between ONR and EDF NGL. A decision on the installation of FCV at Sizewell B will be made early in 2018.

The peer review country report conclusions and recommendations (Ref. 13) stated - *“In accordance with the existing plans, the on-site emergency facilities should be strengthened in order to be resistant against external hazards and provide for working conditions in case of severe accident”*

86. EDF NGL has built the new Sizewell B Emergency Response Centre (ERC) and the AGRs are provided with portable ultimate backup Emergency Control Centres (ECC). The latter have the advantage of flexibility of location and therefore are less prone to the hazard compromising their effectiveness. EDF NGL has also reviewed the capability of their current emergency facilities. In the recent PAR (Ref. 19), PARR-4 was made “Within the scope of its review of local to plant actions, EDF NGL should include a survey, including preparation arrangements, for alternative DBUE (Deployable Back-Up Equipment) connection points”. EDF NGL has now included in its arrangements, suitable and sufficient advice for use of alternative DBUE connection points. In September 2017, ONR witnessed the site emergency arrangements for use of the DBUE at Sizewell B. The site was able to demonstrate better ownership and use of this equipment. ONR now considers PARR-4 to be closed.

The peer review country report conclusions and recommendations (Ref. 13) stated - *“Radiation conditions, which may potentially develop on-site in case of severe accident, possibly at several units, should be more comprehensively analysed and appropriate measures to address them implemented”*

87. ONR's work to regulate improvements in the radiation protection of emergency responders has focussed on having consistent arrangements for emergency responses. This work is on-going and ONR forms part of a multi-agency group, which involves the emergency services who are reviewing and revising their guidance in this area.

“The peer review Board recommends that WENRA, involving the best available expertise from Europe, develop guidance on natural hazards assessments, including earthquake, flooding and extreme weather conditions, as well as corresponding guidance on the assessment of margins beyond the design basis and cliff-edge effects” (Ref. 12).

88. WENRA has since developed such guidance. An experienced ONR inspector led the development of Issue T of the WENRA Safety Reference Levels and associated guidance on behalf of WENRA within the working group (T1) on natural hazards.

ENSREG Compilation of Recommendations

WENRA Reference Levels

“ENSREG consideration 3.3.1: “The incorporation of the WENRA reference levels related to severe accident management (SAM) into their national legal frameworks, and ensure their implementation in the installations as soon as possible. This would include:

- Hydrogen mitigation in the containment - Demonstration of the feasibility and implementation of mitigation measures to prevent massive explosions in case of severe accidents.*
- Hydrogen monitoring system - Installation of qualified monitoring of the hydrogen concentration in order to avoid dangerous actions when concentrations that allow an explosion exist.*
- Reliable depressurization of the reactor coolant system – Hardware provisions with sufficient capacity and reliability to allow reactor coolant system depressurization to prevent high-pressure melt ejection and early containment failure, as well as to allow injection of coolant from low pressure sources.*
- Containment overpressure protection - Containment venting via the filters designed for severe accident conditions.*
- Molten corium stabilization - Analysis and selection of feasible strategies and implementation of provisions against containment degradation by molten corium.”*

89. The UK has an established process for adoption of WENRA Reference Levels (including those related to severe accident management) into our national legal framework. In response to WENRA's updates to its Reference Levels in light of the Fukushima accident, the UK has updated ONR's technical assessment guide (TAG) 005 (Ref. 11). TAG 005 details how the Health and Safety at Work Act 1974 sections 2 and 3 (which are the key legal requirements in UK law) are applied to the UK nuclear industry. The TAG is explicit in making the WENRA Reference Levels “relevant good practice” for nuclear power plants, and as such they need to be considered by licensees in their safety cases in order to meet their legal obligations. In addition ONR's procedure for the revision of its TAGs includes the requirement for authors to identify all WENRA Reference Levels relevant to the technical area. The revised TAGs will be published on ONR's website.

90. The SAM measures noted in the bullets above have been considered already in this report, and will be further reviewed upon formal adoption of new WENRA Reference Levels to consider if any revisions need to be made.

SAM Hardware Provisions

ENSREG consideration 3.3.2: “Adequate hardware provisions that will survive external hazards (e.g. by means of qualification against extreme external hazards, storage in a safe location) and

the severe accident environment (e.g. engineering substantiation and/or qualification against high pressures, temperatures, radiation levels, etc.), in place, to perform the selected strategies.”

91. The long term durability of EDF NGL's emergency response capability has been assessed against the potential effects of severe accidents, and improvements have been implemented to address the long term requirements, including taking account of staff welfare. The necessary functions of communications, the management of personnel in potentially hazardous areas and plant indications can be replicated by the use and demonstration of the deployable back up equipment, which if required can be deployed and operational within the required timescales.
92. Work has also been undertaken regarding the development of long-term severe accident exercises along with reviews of source terms and dose uptakes. A flexible approach has been adopted by EDF NGL that includes provision of mobile back-up equipment in combination with hardened on-site structures to provide a degree of separation and independence.
93. In Table 3a, 3.3.2 to 3.3.8 were all considered on-going in the 2014 report due to two aspects relating to beyond design basis task analysis and weather and seismic human factors. EDF NGL considers that all actions relating to IR-24 and STF-16 are now complete. ONR has reviewed this position and considers (in Ref.19) that IR-24 and STF-16 can be closed with some aspects (such as training) monitored under normal regulatory business. It is worth noting that ONR will continue to monitor the implementation of the arrangements around SBERGs and SAMs through their use in emergency exercises and demonstrations. One such example is the use of DBUE at Sizewell B in a recent exercise (September 2017). In regards to the sections below where no update is required, this is in light of the information provided here explaining why ONR considers IR-24 and STF-16 are complete.

Review of SAM Provisions Following Severe External Events

ENSREG consideration 3.3.3: “The systematic review of SAM provisions focusing on the availability and appropriate operation of plant equipment in the relevant circumstances, taking account of accident initiating events, in particular extreme external hazards and the potential harsh working environment.”

94. ONR has progressed this area via IR24 and STF16 of Refs. 2 and 3. The provision of plant and equipment has already been discussed. EDF NGL has conducted reviews of its SAM provisions and has completed work as described in the previous paragraph. In addition, ONR has a programme of exercises to test these provisions, which includes sustainability of a capable response and appropriate operation of plant equipment. This programme of emergency exercises is an on-going part of ONR normal regulatory business.

Enhancement of Severe Accident Management Guidelines (SAMG)

ENSREG consideration 3.3.4: “The enhancement of SAMGs taking into account additional scenarios, including, a significantly damaged infrastructure, including the disruption of plant level, corporate-level and national-level communication, long-duration accidents (several days) and accidents affecting multiple units and nearby industrial facilities at the same time.”

95. ONR has progressed this area via IR24 and STF 16 of Refs. 2 and 3. EDF NGL has revised and made enhancements to its SBERGs, including updates for consistency, better presentation, wider scope (e.g. fuel route SBERGs) and enhanced roll-out, training and exercising EDF NGL has also redefined the scope of its AGR SAGs to take account of enhanced SAG guidance, deployable and other backup equipment, improved usability and enhanced roll-out, training and exercising.
96. For Sizewell B the relevant SOIs are being reviewed as part of normal regulatory business.
97. The nuclear emergency exercise programme for fixed nuclear installations within the UK is continuing as planned. There are secured opportunities to test the on-site and off-site response. Such exercises may involve the testing of the prolonged delivery and sustainability

of the on-site, off-site and central government responses. The exercises have also highlighted areas for further improvements, which will inform reviews of on-site and off-site emergency plans and feed into future work programmes. These findings will inform reviews of the duration of the future nuclear emergency exercises. Government involvement is now exercised in off-site emergency exercises.

SAMG Validation

ENSREG consideration 3.3.5: "The validation of the enhanced SAMGs."

98. ONR has progressed this area via IRs 24 and 25 and STF16 of Refs. 1 and 3. EDF NGL has reviewed, updated and enhanced the guidance contained in its existing SBERGs, SAGs and SAMGs and these updated guidelines will be used as part of an on-going exercise programme. The planned training and exercising programme will allow independent validation from ONR and forms part of normal regulatory business, as well as providing training for licensee and other staff involved in the emergency response.

SAM Exercises

ENSREG consideration 3.3.6: "Exercises aimed at checking the adequacy of SAM procedures and organisational measures, including extended aspects such as the need for corporate and nation level coordinated arrangements and long-duration events."

99. ONR has progressed this area via IR6 and 7 of Ref. 2. The Fukushima accident identified scope for lessons to be learnt, particularly in ONR's own capability to respond to a prolonged emergency. A review has since resulted in a proposal for improved arrangements for ONR's response to initial notifications of all nuclear emergencies, including severe accidents, and for ensuring the prompt deployment of trained staff to remote locations and to ONR's central emergency response centre, the Redgrave Court Incident Suite (RCIS). During deployment, a senior nuclear inspector will be available to discuss and advise upon the developing situation with the affected duty holder, ONR colleagues, central government and other agencies.

100. ONR is working with nuclear operators and a range of government agencies to develop arrangements for early plotting of radioactive plumes and potential off-site doses using real-time weather information. In addition, ONR is participating in the Joint Agency Modelling (JAM) working group, which is a government-led project. JAM will provide advice to the Scientific Advisory Group for Emergencies on the potential scale and impact scenarios of accidental releases. A programme to review and update the site and plant information held in ONR's RCIS for all the licensed sites has already led to significant improvements in this area and will facilitate ONR's response, including the transmission of timely, authoritative data to the International Atomic Energy Agency (IAEA) in accordance with international obligations.

101. Work is continuing in the area of exercise and response arrangements across ONR, licensee organisations and government departments. Planning for Fukushima type scenarios is expected and will integrate with the current exercise programme that is required under the site licence conditions.

SAM Training

ENSREG consideration 3.3.7: "Regular and realistic SAM training exercises aimed at training staff. Training exercises should include the use of equipment and the consideration of multi-unit accidents and long-duration events. The use of the existing NPP simulators is considered as being a useful tool but needs to be enhanced to cover all possible accident scenarios."

102. ONR has progressed this area via IR24 of Ref. 2. Part of the scope of work that reviewed and updated the SBERGs, SAG and SOIs involved the training of EDF NGL staff. Part of this training involves the use of newly procured, backup equipment. In addition to the normal exercise programme, a multi-site exercise at Heysham 1 and 2 power stations has taken place. The new SBERGs and SAGs were successfully used in the exercise. Further assessment of SAM training will form part of normal ONR regulatory business.

Extension of SAMGs to All Plant States

ENSREG consideration 3.3.8: "The extension of existing SAMGs to all plant states (full and low-power, shutdown), including accidents initiated in SFPs."

103. ONR has progressed this area via IR 24 and 25 of Ref. 2. The extension of existing SAMG to all plant states has been addressed as part of the wider review of severe accident contingency arrangements.

104. In particular, as part of the response to these recommendations EDF NGL has revised its AGR fuel route SBERGs and SAGs. Other key aspects of this work included the revision of the SBERGs/SAGs to take into account the provision of improved backup equipment.

Improved Communications

ENSREG consideration 3.3.9: "The improvement of communication systems, both internal and external, including transfer of severe accident related plant parameters and radiological data to all emergency and technical support centres and regulatory premises."

105. ONR has progressed this area via IR23 of Ref. 2. Work is presented in Section 2 of this report concerning the information exchange between ONR and the affected site, EDF NGL's Central Emergency Support Centre (CESC) and wider national/international organisations. EDF NGL has procured satellite phones and implemented their use as part of its exercise programmes.

Presence of Hydrogen in Unexpected Places

ENSREG consideration 3.3.10: "The preparation for the potential for migration of hydrogen, with adequate countermeasures, into spaces beyond where it is produced in the primary containment, as well as hydrogen production in SFPs."

106. ONR has progressed this area via IR21 and STF18 of Refs. 2 and 3. Reviews have taken place across EDF NGL reactors and ONR has assessed the outputs of the work. Although it is recognised that the gas cooled reactors cannot generate hydrogen in the same way as that which occurred at Fukushima, the formation of carbon monoxide is credible and the fire/explosion risk has been assessed as part of the reports with the conclusion that this does not pose a fire/explosion risk. Installation of Passive Autocatalytic Recombiners at Sizewell B was completed during 2014.

Large Volumes of Contaminated Water

ENSREG consideration 3.3.11: "The conceptual preparations of solutions for post-accident contamination and the treatment of potentially large volumes of contaminated water."

107. ONR has progressed this area via IR25 of Ref. 2. The initial approach has centrally located storage facilities (bags) that are deployed as necessary. These bags have been used in military applications and the current capacity in storage is around 10,000 m³. Appropriate pumping equipment is also available. Longer term water treatment has been considered and suitable water treatment chemicals have been sourced. The shelf life of such chemicals means that procurement will be as-required rather than having centrally held stocks. Small scale storage will be available on site. The approach will be to leave water where it accumulates if secure, and only pump to bags if necessary.

Radiation Protection

ENSREG consideration 3.3.12: "The provision for radiation protection of operators and all other staff involved in the SAM and emergency arrangements."

108. ONR has progressed this area via STF16 of Ref. 3. ONR is working closely with government and other agencies to address capability gaps in radiological protection arrangements in response to severe radiation accidents. An example of ONR's work to

improve the radiation protection of responders is the adoption of consistent arrangements for emergency exposure limits. ONR is working with emergency responders and local authorities to ensure a consistent overall approach to nuclear emergencies. Work has been undertaken with the emergency services in the UK to review and revise their guidance in this area. In addition, the police service has published guidance which has been adopted throughout the UK, and training is being delivered in support of these new arrangements. The fire and rescue service has reviewed its arrangements and published guidance. The ambulance service has also reviewed its arrangements.

109. ENSREG's recommendation is considered to be complete with ongoing developments considered as normal ONR regulatory business.

On-site Emergency Centre

ENSREG consideration 3.3.13: "The provision of an on-site emergency centre protected against severe natural hazards and radioactive releases, allowing operators to stay onsite to manage a severe accident."

110. ONR has progressed this area via IR22 of Ref. 2. Licensee programmes have implemented reasonably practicable resilience enhancements to ECCs. This includes provision of battery-charging diesel generators to ensure continued operability, improvements to ventilation systems, increased flood protection and the removal of glazing in the ECCs. At Sizewell B the ERC, located just outside the site boundary, is operational and is now the designated backup ECC. The AGRs are provided with portable ultimate back-up ERCs which have the advantage of flexibility of location and continued mobility and are therefore less prone to the hazard or radiological conditions affecting their tenability. The AGR sites may utilise some existing facilities where appropriate but stores backup equipment and vehicles at regional support centres.

Support to Local Operators

ENSREG consideration 3.3.14: "Rescue teams and adequate equipment to be quickly brought on-site in order to provide support to local operators in case of a severe situation."

111. ONR has progressed this area via IR25 of Ref. 2. The licensee has adopted a strategy of storing back-up equipment in a number of regional stores. Optimum locations were selected to ensure back-up equipment can be deployed to sites within the timescales required to mitigate progression of identified severe accidents. A separate exercise programme ensures additional licensee resource can be quickly deployed from identified sites in order to provide support to local operators on affected sites. The work here relies on the use of mobile devices and further detail is noted under that topic.

Level 2 Probabilistic Safety Assessments (PSAs)

"ENSREG consideration 3.3.15: "A comprehensive Level 2 Probabilistic Safety Analysis (PSA) as a tool for the identification of plant vulnerabilities, quantification of potential releases, determination of candidate high-level actions and their effects and prioritizing the order of proposed safety improvements. Although PSA is an essential tool for screening and prioritising improvements and for assessing the completeness of SAM implementation, low numerical risk estimates should not be used as the basis for excluding scenarios from consideration of SAM especially if the consequences are very high."

112. ONR has progressed this area via FR4 of Ref. 2. ONR has been engaging with EDF NGL to ensure the development of an adequate level 2 PSA for its NPPs. Most of the AGR severe accident phenomena and mitigating actions are insensitive to the design of the individual AGRs. Therefore, EDF NGL has developed a generic level 2 PSA for the AGRs (based on Hunterston B), which is considered by the licensee to be representative of the AGR fleet.

113. One of the mitigating features for the AGRs is the long timescales over which severe accident scenarios could develop, which enables significant recovery attempts to be made. The insights from the level 2 PSA have been used to inform the site-specific Symptom Based Emergency Guidelines (SBERGs), which identify actions that should be attempted to restore

the reactors to a safe shutdown state following a beyond design basis scenario and additional recovery actions set down in the Severe Accident Guidelines (SAGs), which are generic for the AGRs.

114. The insights from the Hunterston B level 2 PSA have been read-across to three other AGR stations (Heysham 2, Torness and Hinkley Point B) and used to update their site-specific SBERGs. Work is ongoing at the remaining AGR stations. Engagement continues between ONR and EDF NGL as part of normal regulatory business.
115. No further work has been done for Sizewell B as it already has an adequate full scope level 2 PSA.
116. In addition, two recommendations (PARR-6 and 7) were made in the ONR PAR (Ref. 19). PARR-6 is that "EDF NGL should carry out structured plant walk-downs at each of the AGRs (except Hunterston B) to systematically crosscheck the level 2 PSA study against the characteristics of the other AGRs". EDF NGL has completed desk-top exercises to crosscheck the characteristics of the Hunterston B level 2 PSA against other stations to inform the updates to its SBERGS and SAGs; a structured plant walk-down has not however yet been undertaken.
117. ONR plans to undertake site-specific inspections to gain confidence that the process used and information collected is adequate to confirm that the characteristics of the Hunterston B level 2 PSA are sufficiently similar and can be used to inform the updates to the SBERGs and SAGs at other AGR stations.
118. PARR-7 is that "EDF NGL should consider the development of a level 2 PSA for Heysham 1/Hartlepool, taking account of the evidence from structured plant walk-downs and additional transient analysis". Currently, EDF NGL does not intend to develop a site-specific level 2 PSA for Heysham 1 / Hartlepool. A review of the benefits from undertaking further transient analysis is ongoing to determine if further insights can be obtained to further inform the updates to the SBERGs and SAGs.
119. PARR-6 and 7 remain open actions on EDF NGL until considered complete by ONR. This is being progressed as normal regulatory business.

Severe Accident Studies

ENSREG consideration 3.3.16: "The performance of further studies to improve SAMGs. Examples of areas that could be improved with further studies include:

- *The availability of safety functions required for SAM under different circumstances.*
- *Accident timing, including core melt, reactor pressure vessel (RPV) failure, basemat melt-through, SFP fuel uncover, etc.*
- *PSA analysis, including all plant states and external events for PSA levels 1 and 2.*
- *Radiological conditions on the site and associated provisions necessary to ensure MCR and ECR habitability as well as the feasibility of accident mitigation measures in severe accident conditions, multi-unit accidents, containment venting, etc.*
- *Core cooling modes prior to RPV failure and of re-criticality issues for partly damaged cores, with un-borated water supply.*
- *Phenomena associated with cavity flooding and related steam explosion risks.*
- *Engineered solutions regarding molten corium cooling and prevention of basemat melt-through.*

- *Severe accident simulators appropriate for NPP staff training.*

120. ONR has progressed this area via IRs 24 and 25, FR 4 and STFs 3, 5, 6 and 17 of Refs 2 and 3. This is a broad area of work and many of its aspects are covered under the topics listed above. These recommendations and findings are now all considered to be complete. An update on STF-5 and 7 is provided in table 1a, which are now considered complete. In addressing IR-24, EDF NGL has undertaken an extensive work programme that addresses all significant Human Factors issues including leadership, prolonged response and staff welfare. The roll out of training and enhanced exercise arrangements is a continuous process and ONR considers that this can be best monitored through routine regulatory business. ONR therefore now considers that IR-24 can be closed. ONR has reviewed the ENSREG UK country peer review report and considers that the areas raised for consideration have been covered in the above sections.

Section 2

121. ENSREG's Action Plan also called for a discussion on additional recommendations arising from the CNS meeting (Ref. 7) and these are discussed under topics 2.1, 2.2 and 2.3 below. These are topics 4, 5, 6 which are "National Organisations", "Emergency Preparedness and Response and Post-accident Management (Off-site)" and "International Co-operation" respectively. These are outlined in the introduction to this report.

2.1 National Organisations

122. ONR has progressed this area via IR3, 8 and 25, FR6 and FR7 and STF 15 of Refs. 2 and 3. This topic has been addressed by obtaining additional information from UK government, regulators, operators and nuclear accident response organisations. Further, national organisations were considered within the Chief Nuclear Inspector (CNI) reports on the Fukushima accident (Refs. 1 and 2).

123. To date there have been no organisational changes within EDF NGL as a result of the events at Fukushima, other than to establish teams to co-ordinate and manage the response to an event. Based on its own reviews, EDF NGL considers that it already had robust mechanisms in place to deal with severe events. These mechanisms have however been further reviewed and enhanced as a result of the events at Fukushima. So far, as a result of these reviews, EDF NGL has not identified any particular benefits in making organisational changes though, as a learning organisation, it is open to making such changes if further information or operational experience comes to light that challenges this position. ONR does not consider there are any significant changes required to the organisation of EDF NGL. Where changes are considered necessary, they are managed through normal regulatory business.

Government organisations

124. Prior to the accident at Fukushima, the UK government had already begun a process of establishing the ONR as a statutory corporation and this took place on 1st April 2014. The aim of establishing the statutory corporation is to enable ONR to respond more quickly and effectively to civil nuclear issues by, for instance, ensuring we have the capability and resource necessary to meet the challenges of a rapidly developing nuclear industry. However, the creation of ONR as a statutory body does not alter the regulatory standards that the nuclear industry is subject to.

125. In July 2011 the UK transposed the Council Directive 2009/71/EURATOM establishing a Community framework for the nuclear safety of nuclear installations. While transposition did not require any changes to UK legislation, it did further commit the UK to periodic peer reviews,

the establishment of national plans and programmes to manage and improve safety and the reporting of progress against those programmes. These plans include the roles of all stakeholders.

126. The work that created a statutory ONR has, at its heart, the transparency of the regulatory process and ONR's relationship with government (including bodies concerned with the promotion or utilisation of nuclear energy) as an independent regulator.

Nuclear emergency planning preparedness and response

127. The UK has enacted the Radiation (Emergency Preparedness and Public Information) Regulations 2001 (REPPIR) which implements in the UK the Articles of Council Directive 96/29/Euratom on intervention in cases of radiation (radiological) emergency. The Directive lays down the basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation (the BSS96 Directive). In addition, REPPIR Regulation 17 (Duty of local authority to supply information to the public in the event of a radiation emergency) is made under the European Communities Act 1972 and is applicable to all Local Authorities (LAs). Currently the Government is transposing the Euratom Basic Safety Standards Directive (BSSD) (2013/59/Euratom); this will result in a revised REPPIR which will further enhance the UK's emergency arrangements.

128. REPPIR enabled the UK government to meet a recommendation made by the inspectors at the public inquiries at Sizewell B and Hinkley Point C, in that REPPIR brings on-site and off-site emergency planning together in a coordinated manner. This ensures that the UK has a fully joined up multi-agency response plan with appropriate capability.

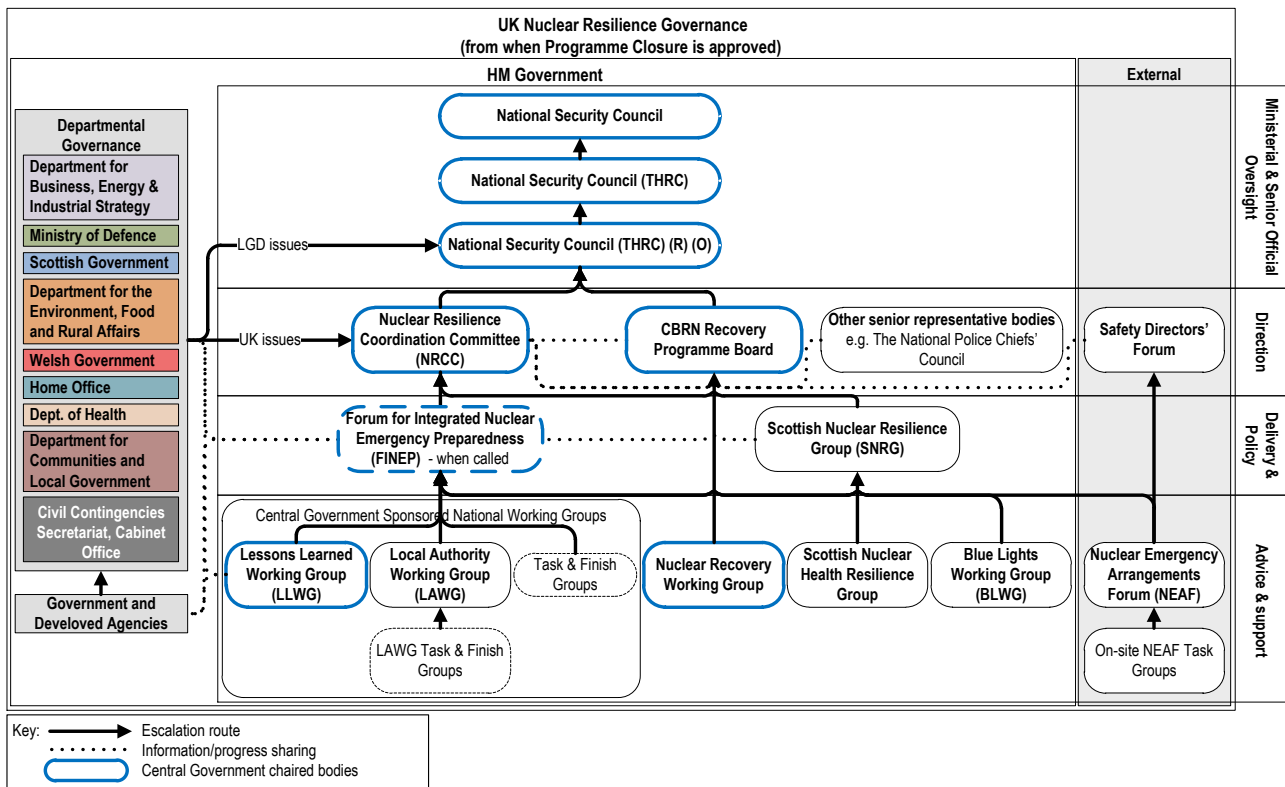
129. A government department (the Department of Business, Energy and Industrial Strategy (BEIS) formerly Department of Energy and Climate Change (DECC)) co-ordinates emergency preparedness policy at national level, as the lead government department on arrangements for response to any emergency with off-site consequences from a licensed civil nuclear site in England and Wales. In the event of an emergency resulting from an accident at a civil nuclear site in Scotland, the governmental lead for coordinating the main national response would fall to the Scottish Government. BEIS would still be responsible however, for briefing the Westminster Parliament and the UK's international partners. There are no nuclear facilities in Northern Ireland.

130. The UK's national arrangements are based on generic civil contingency arrangements as far as possible with the approach being to ensure that the response is seamless at each level and across the UK.

131. BEIS has issued National Nuclear Emergency Planning and Response Guidance (Ref. 9), to all organisations that may be involved in planning for a civil nuclear emergency. The guidance describes the arrangements that have been developed for responding to an emergency in the UK over a number of years and aims to harmonise the UK response to a nuclear emergency.

132. The Nuclear Resilience Coordination Committee (NRCC) is the national programme set up to direct the UK's approach to responding to a nuclear emergency. The NRCC aims to ensure that the UK's planning for response to a nuclear emergency at home or overseas is effective, proportionate and sustainable.

133. Reporting to the NRCC, there are a number of key working groups that provide advice and support in setting the national direction. The structure of the UK Nuclear Resilience Governance, including the NRCC and working groups, can be seen below.



134. Consolidated guidance (Ref. 9) is published on the Gov.uk website, bringing together general reference information for emergency response planners and practitioners at UK Nuclear sites. The guidance describes the underlying arrangements that have been developed for responding to an emergency in the UK over a number of years. The IAEA Integrated Regulatory Review Service (IRRS) mission to the UK in October 2009 considered the creation of the consolidated guidance to be 'good practice' in supporting a multi-agency response. In line with the principle of continuous improvement, the guidance is currently being updated by BEIS, working closely with a wide range of organisations with interests in emergency planning at a civil or defence nuclear site. This guidance will be updated after the revised REPIR is enacted.

IR 3 - The Nuclear Emergency Planning Liaison Group should instigate a review of the UK's national nuclear emergency arrangements in light of the experience of dealing with the prolonged Japanese event.

This information should include the practicability and effectiveness of the arrangements for extending countermeasures beyond the Detailed Emergency Planning Zone (DEPZ) in the event of more serious accidents.

135. The UK government conducted a review of the UK's national nuclear emergency arrangements in light of the experience of dealing with the prolonged event at Fukushima.

136. As part of that review, the decisions and actions that were taken in Japan to protect the public were examined by groups consisting of BEIS, ONR, operators, local authorities and the multi-agency responders and lessons were identified for the UK. This work included a re-evaluation of radiation monitoring capacity/capability and a recommendation that central government clarify the requirements for delivering the data and information in the event of a prolonged incident in the UK and that these arrangements should be tested annually. To address this recommendation the Government has put in place two projects: the Joint Agency Modelling (JAM) project and the NERIMNET project. JAM (when complete) will provide a range of potential scenarios on how an incident might develop to be used at national and local level to inform medium/long term response. JAM will support strategic decision making at national level. JAM has completed phase 1 and is in phase 2 with a completion date of March 2019. NERIMNET, which will replace RIMNET, will deliver an improved radiological monitoring and information management service to government to assist in the effective management of the planning for, and response to, a nuclear emergency. Exercises of off-site emergency plans are

being reviewed so that they include aspects such as extendibility, dealing with prolonged events and the deployment of reassurance monitoring units. The response arrangements for central government and, in particular, the provision of scientific and technical advice in the event of a nuclear emergency in the UK or overseas were assessed and reviewed. This was to ensure that the Cabinet Office Briefing Room (COBR) has one authoritative source of advice and included a recommendation that the overseas nuclear emergency response plan should be tested fully through the Nuclear Energy Agency's international exercise programme. BEIS participated in an international ConvEx ECUREX 3 exercise, through RIMNET in June 2017 and plans on reviewing the findings and reporting them back to UK stakeholders in due course.

137. The report also recommended that ONR should enforce a stronger testing regime which includes extendibility arrangements and an overseas nuclear accident response. A range of options for taking forward extendibility have been debated and discussed via the Local Authority (LA) Working Group. BEIS has funded pilot studies for four local authorities to examine their arrangements in regard to extendibility. Outcomes of these studies are being incorporated into the revised REPPiR and its associated guidance. The current position with respect to radiation protection of the emergency services is given in paragraph 108 and Section 4 of this report. ONR's responsibilities under such a testing regime would be to assess the licensees' arrangements under the conditions of their site licences rather than assessment of any other participating agency. This would be done in line under arrangements described in paragraph 155. ONR is encouraging the incorporation of greater challenge to the off-site testing regime which is being adopted by local authority emergency planning staff. ONR has also instigated an inspection programme of Local Authorities arrangements for producing off-site plans. Three successful pilot inspections have been conducted and we are now embedding these inspections into our forward inspection plan.

138. The opportunities and recommendations identified above form part of a wider programme of work being taken forward by the working groups that sit under the NRCC. The NRCC has significantly strengthened the governance arrangements for further development of UK national emergency arrangements and, in particular, provides clear lines of tasking, communication and decision making between operational delivery and ministerial involvement. In addition the revised REPPiR will provide a regulatory framework to further develop the UK's capacity to plan for and respond to the full range of nuclear emergencies.

139. Some of this work has still to be developed. With regard to enhanced arrangements for extendibility, ONR will work with BEIS, Ministry of Defence (MoD) and other interested parties to ensure we are able to provide the necessary regulatory oversight.

FR-6: *The nuclear industry with others should review available techniques for estimating radioactive source terms and undertake research to test the practicability of providing real-time information on the basic characteristics of radioactive releases to the environment to the responsible off-site authorities, taking account of the range of conditions that may exist on and off the site.*

140. The Nuclear Emergency Arrangements Forum (NEAF) is coordinating the Nuclear Industry review of the available techniques for estimating radioactive source terms and collaborative research on the practicability of providing real time information during accidents. The intention is that UK operators will have the capability in place to advise on the plant status and potential source terms in the event of a nuclear emergency as required for the purposes of the Joint Agency Modelling (JAM) work.

FR-7: *The Government should review the adequacy of arrangements for environmental dose measurements and for predicting dispersion and public doses and environmental impacts, and to ensure that adequate up to date information is available to support decisions on emergency countermeasures.*

141. BEIS continues to coordinate JAM, which involves the Met Office, Public Health England (PHE), Radioactive Incident Monitoring Network (RIMNET), ONR and Nuclear Industry operators in working together to further develop the capability to be able to respond quickly to any incident at a nuclear site anywhere in the world. The objective of this capability is for the UK to be able to draw upon the collective resources and expertise of the nuclear industry operators, regulators and others, as necessary. The Met Office has the capability to provide atmospheric dispersion information in real time following any incident in the UK and worldwide. The Met Office is part of a collaboration, co-ordinated by BEIS, with contributions from the operators, PHE and ONR to develop a tool for estimating the spatial distribution of radiation doses in real time following a radiation release in the UK or elsewhere, the most appropriate pathways and other dose factors required to estimate doses to individuals. The work has been building upon existing arrangements in place for incidents in the UK, whilst developing an appropriate basis and supporting procedures for overseas responses.
142. In the event of a radioactive release from a UK nuclear site, the operators are responsible for carrying out monitoring in the immediate vicinity with PHE co-ordinating monitoring further afield; this information, together with emergency plans is used for the immediate emergency response. There are a number of other initiatives in this area, including the replacement of RIMNET as noted above.
143. In addition, Public Health England, the Environment Agency, the Scottish Environment Protection Agency (SEPA), Natural Resources Wales (NRW) and the Northern Ireland Environment Agency (NIEA) all carry out or co-ordinate routine environmental monitoring for radionuclides. In the event of a radiological emergency, this routine monitoring would be enhanced as necessary and used to provide information that would support later decisions on emergency countermeasures.
144. In the event of a nuclear emergency, mobile monitoring teams from PHE EA, SEPA, NRW and NIEA, and other government organisations, alongside volunteered industry and commercial personnel would be mobilised, and the teams coordinated by PHE to ensure their most effective use.

IR-8: *The UK nuclear industry should review the dependency of nuclear safety on off-site infrastructure in extreme conditions, and consider whether enhancements are necessary to sites' self-sufficiency given for the reliability of the grid under such extreme circumstances.*

This should include:

a) essential supplies such as food, water, conventional fuels, compressed gases and staff, as well as the safe off-site storage of any equipment that may be needed to support the site response to an accident; and

b) timescales required to transfer supplies or equipment to site.

IR-25: *The UK nuclear industry should review, and if necessary extend, analysis of accident sequences for long-term severe accidents. This should identify appropriate repair and recovery strategies to the point at which a stable state is achieved, identifying any enhanced requirements for central stocks of equipment and logistical support.*

STF-15: *Licensees should complete the various reviews that they have highlighted so that ONR can assess their proposals and associated timescales. These reviews should look in detail at on-site emergency facilities and arrangements, off-site facilities, facilities for remote indication of plant status, communication systems, contents and location of beyond design basis containers and the adequacy of any arrangements necessary to get people and equipment on to and around site under severe accident conditions. Any changes to arrangements and equipment will require appropriate training and exercising.*

145. As part of the response to a number of recommendations and findings, EDF NGL has identified and procured a range of back-up emergency equipment. As noted already, this

equipment is stored in three regional depots (serving the AGR fleet) and in the new Sizewell B ERC. The locations of the regional depots allow deployment of the equipment to sites on timescales that meet the claims made by EDF NGL in its safety arguments for the provision of backup equipment.

146. These depots contain equipment to enhance resilience including the following:
- Off-road vehicles
 - Debris moving vehicles (route clearance for example)
 - Personal protective equipment
 - Diesel-driven electricity generators
 - Diesel-driven water pumps – for reactor and fuel cooling
 - Reverse osmosis equipment to supply clean water
 - Damage repair equipment
 - Diesel-driven dewatering pumps
 - Waste water treatment facilities
 - Temporary structures for response coordination and staff welfare
 - Mobile communications equipment, including deployable instrumentation facilities
 - Inert gas supplies
 - All necessary ancillary equipment required to use these facilities, including fuel stocks
147. ONR considers that the provision of such equipment and the associated storage locations provide a significant improvement in EDF NGL's ability to provide resilience to cope with a wide range of events.
148. Deployment of such equipment to the sites and other remote locations has formed part of demonstrations undertaken by EDF NGL during 2014. These activities will continue to form part of the on-going emergency exercise programme.
149. Whilst the AGR back-up equipment storage locations are at strategic locations around the UK it is noted that the Sizewell B ERC is located within a few kilometres of Sizewell B. This is because the time available to provide protection for a PWR in the event of an extreme beyond design basis event is more limited than that for an AGR. It is noted that in addition to providing storage for back-up equipment, the Sizewell ERC also includes a back-up ECC. ONR considers this strategy to be appropriate.
150. Overall, in the context of providing off-site back-up equipment, ONR considers that good progress has been made, which now provides EDF NGL with a significant improvement in its ability to provide resilience against a wide range of events.

2.2 - Emergency Response and Post Accident Management (off-site)

151. ONR has progressed this area via IRs 2, 6 and 7 and FR 5 of Ref. 2. The progress described in Section 2.1 – National Organisations is also relevant to this topic but is not described here in order to avoid duplication. In addressing this topic, the UK has sought to describe and review the appropriateness of our current emergency preparedness and response arrangements.

152. Within the UK, any off-site emergency will be met by a multi-agency response consisting of the relevant UK government department, local authorities, emergency services, nuclear operator/licensees and the regulatory authorities. Therefore, this section has been split into analysis performed by the UK government, who would lead the response of local bodies and emergency services; and nuclear operating organisations. The response of ONR is considered throughout this topic.

National emergency response arrangements

153. The circumstances of the events at Fukushima were particularly demanding in that the threat of significant radiological release continued for weeks before some degree of reliable control was established, and it was in the context of massive infrastructure disruption. Such circumstances have the potential to stretch resources at all levels, both in the country affected and in other countries seeking to provide advice to their citizens at home and abroad.

IR-2: *The Government should consider carrying out a review of the Japanese response to the emergency to identify any lessons for UK public contingency planning for widespread emergencies, taking account of any social, cultural and organisational differences.*

154. ONR and the UK government consulted with, and gained valuable evidence from, the Japanese government and the Foreign and Commonwealth Office, as well as a range of publically available reports that were written about the emergency. In order to complete its review in a timely way, the UK government used the evidence available at the time to inform its response. However, as further evidence has emerged, ONR and the UK government have continued to review and update the position with regard to emergency response and preparedness. A good example of this ongoing work was ONR's review of the IAEA's comprehensive report on Fukushima, published in 2015 (Ref. 23). ONR's review of the IAEA work did not however identify any additional matters to those already addressed or under consideration.

Planning Controls

FR-5: *The relevant government departments in England, Wales and Scotland should examine the adequacy of the existing system of planning controls for commercial and residential developments off the nuclear licensed site.*

155. The practicability of implementing off-site countermeasures is inextricably linked to the density and distribution of people around the nuclear site. A site that was acceptable for emergency planning purposes when it was first established may not necessarily continue to be acceptable if planning controls fail to suitably limit population growth in the site's locality, or if off-site emergency countermeasures can no longer cope effectively with the changed demographic. In making decisions on planning consent for developments near to nuclear sites, ONR will continue to provide high quality advice to the planning authorities. In light of the events at Fukushima, it was timely for the relevant government department(s) in the UK to examine the existing system of planning controls for developments in the vicinity of nuclear sites and consider the need for improvements.

156. This review has confirmed the validity of existing extendibility planning principles to protect the public against the unlikely event of a severe nuclear emergency. Nevertheless, there is a need to learn from the experiences of all actual incidents to ensure that the supporting details required to provide outline planning for extendibility are still appropriate.

Off-site Infrastructure Resilience

157. ONR's role here is defined in legislation by the Nuclear Installations Act 1965 (NIA65) and REPPiR. In consequence, it needs to ensure that the on-site and off-site emergency plans are joined up and fully integrate the multi-agency response for any given site. Thus, ONR has followed up the lessons learnt from Fukushima with all duty holders that make up the multi-

agency response under REPPiR, in particular the Nuclear Resilience Coordination Committee (NRCC) working groups and BEIS (the lead Government Department).

158. ONR has reviewed the government / BEIS and licensees' planned actions and schedules. ONR is of the opinion that appropriate lessons have been learnt from Fukushima and that completion of the planned activities have strengthened the multi-agency preparedness and response capability.
159. On being notified of an emergency affecting a licensed nuclear site, ONR would send inspectors, both to site and to the appropriate off-site facility, who would monitor the situation and review the activities of the operators. This is to ensure that they are taking all reasonable steps both to restore the plant to a safe state that minimises the risk to the general public and to gather evidence for any subsequent investigation or inquiry.
160. ONR would set up its RCIS to provide a technical assessment capability and to support the CNI or his representative and the ONR inspectors on the site, at the off-site facility or at the Central Emergency Support Centre (CESC). This would allow ONR to make independent assessments of the likely course of the accident and its consequences, and to consider any implications for other nuclear installations.
161. ONR's previous Government Technical Advisor (GTA) role ceased in April 2016 as BEIS decided at the time that this was inconsistent with the Government's other emergency response arrangements. Instead a "Lead Inspector" will give advice based on ONR's assessments to government departments, devolved administrations, and the operators as appropriate.
162. The CNI's Final Report (Ref. 2) noted that the extensive and extended nature of the Fukushima accident indicated that there is a need to consider extending some emergency exercises in the UK to include severe (large-scale) accident scenarios. ONR's RCIS is at our headquarters in Bootle, Liverpool and was staffed and operational for over two weeks immediately following the accident at Fukushima. ONR is proposing a specific project for 2018 to determine improvements for dealing with large-scale accident scenarios. Similarly, the UK nuclear power industry set up and ran its own crisis centre. The use of these centres for such a long period has identified some areas where improvements may be made through exercising in real time; these include: hand-over arrangements, sustainability of resourcing, the provision of technical advice in short timescales (tailored to the needs of different recipients), the vital role of communications and the acquisition of reliable data. For an effective response to any UK incident there may also be benefits in the regulator having direct access to real time independent information of key parameters from the affected site. This is already the case in some other countries. Additionally, there are clear advantages in having available for each site a more extensive suite of radiological release calculations, release categories and associated dose rate predictions as discussed previously in this section.
163. In light of the extended Japanese emergency, CNI Interim Report made the following recommendation:

IR-6: *ONR should consider to what extent long-term severe accidents can and should be covered by the programme of emergency exercises overseen by the regulator.*

This should include:

- *evaluation of how changes to exercise scenarios supported by longer exercise duration will permit exercising in real time such matters as hand-over arrangements, etc.;*
- *how automatic decisions taken to protect the public can be confirmed and supported by plant damage control data; and*

- *recommendations on what should be included in an appropriate UK exercise programme for testing nuclear emergency plans, with relevant guidance provided to REPPiR duty holders.*

164. Recommendation IR6 was made on the basis that ONR considers to what extent long-term severe accidents can and should be covered by the programme of emergency exercises overseen by the regulator. The emergency exercise programme for fixed nuclear installations within the UK has provided opportunities to test the on-site and off-site response for prolonged periods. Such exercises are intended to test the prolonged delivery and sustainability of the on-site, the off-site and central government responses. The exercises also highlighted areas for further improvements which will inform reviews of onsite and off-site emergency plans and feed into future work programmes. The findings will inform reviews of the duration of the future nuclear emergency exercises.

165. ONR has completed a review of the existing programme of exercises to evaluate how increased challenge to the testing regime including longer exercise duration will permit exercising in real time such matters as hand-over arrangements etc. It will also look closely at how automatic decisions taken to protect the public can be confirmed and supported by plant damage control data. It will then make recommendations on what should be included in an appropriate UK exercise programme for testing nuclear emergency plans. Off-site guidance is available through the NEPRG guidance (Ref. 9 is the overall guidance but Part 2 on this website provides more detail on testing emergency plans). New relevant guidance in the form of a Code of Practice by ONR will be provided to REPPiR duty holders.

166. To fully capture the learning from the Fukushima event, CNI's Final Report (Ref. 2) made the following recommendation:

IR-7: ONR should review the arrangements for regulatory response to potential severe accidents in the UK to see whether more should be done to prepare for such very remote events.

This should include:

- *enhancing access during an accident to relevant, current plant data on the status of critical safety functions, i.e. the control of criticality, cooling and containment, and releases of radioactivity to the environment, as it would greatly improve ONR's capability to provide independent advice to the authorities in the event of a severe accident; and*
- *review of the basic plant data needed by ONR – this has much in common with what we suggest should be held by an international organisation under Recommendation IR1.*

167. Although stakeholders have fed-back positively regarding ONR's response to the Fukushima accident, such as its provision of authoritative advice to government, the organisation is always striving to continuously improve. As such, improvement work-streams relevant to ONR's emergency arrangements function have been established as part of normal business:

- Proactively continuing to improve through its existing links and engagement with NRCC committees and working groups and other emergency arrangements stakeholders, and through working with our emergency arrangements training provider.

One of ONR's Deputy Chief Inspectors was given the lead to conduct a lessons learnt exercise specifically regarding our response during Fukushima (and other times when the ONR RCIS has been operational, for example, during exercises) and our arrangements for responding to emergencies. This work was completed at the end of 2011. ONR's improved emergency response capability is now supported by "command and control" training supplemented by new role-specific training modules. A significant number of individuals have been trained in more than one role (for example, a command role in addition to a technical role) to help provide the flexibility needed in ONR's response to a severe accident or other prolonged emergency. Refresher training is provided as a matter of course. ONR has worked with a specialist command and control consultancy to develop improved supporting documentation.

2.3 – International Cooperation

168. International co-operation required in the interest of nuclear safety was considered by the CNI's reports on the Fukushima accident (Refs. 1 and 2). ONR has progressed work in this area via IRs 1 and 3 and FR9 from Refs 1 and 2 and these are quoted where appropriate. This section considers operating organisations, regulatory organisations and UK government.

International Recommendations for Response and Global Nuclear Safety

IR-1 - *The Government should approach IAEA, in co-operation with others, to ensure that improved arrangements are in place for the dissemination of timely authoritative information relevant to a nuclear event anywhere in the world.*

This information should include:

a) basic data about the reactor design including reactor type, containment, thermal power, protection systems, operating history and condition of any nuclear materials such as spent fuel stored on the site should be held permanently in a central library maintained on behalf of the international community; and

b) data on accident progression and the prognosis for future accident development. The operator would provide such information as is available to its national authorities. International mechanisms for communicating this information between national governments should be strengthened. To ensure that priority is given to relevant information, international agreement should be sought on the type of information that needs to be provided.

FR-9 - *The UK Government, nuclear industry and ONR should support international efforts to improve the process of review and implementation of IAEA and other relevant nuclear safety standards and initiatives in the light of the Fukushima-1 (Fukushima Dai-ichi) accident.*

169. The UK government has stated (Ref. 2) that the UK is committed to working with our international partners to consider how dissemination of information under the Convention on Early Notification of a Nuclear Accident can be further improved in terms of both efficiency and substance.

170. There is existing good co-operation between ONR and nuclear regulators worldwide, including through various international nuclear bodies. This latter grouping includes:

- the IAEA;
- the Organisation for Economic Co-operation and Development's (OECD) Nuclear Energy Agency (NEA);
- ENSREG;
- the Western European Nuclear Regulators' Association (WENRA).

171. All have had meetings since the Fukushima accident at which lessons to be learnt were discussed. Additionally, at the triennial Review Meetings of the CNS (April 2011, 2014 and 2017) and the Review Meeting of the Joint Convention (May 2012 and May 2015) special attention was paid to the Fukushima accident and lessons learnt. ONR staff continue to play an active part in all these meetings, the outcomes of which include:

- IAEA - A ministerial conference convened by IAEA in June 2011 followed by the development of an action plan where ONR provided independent and objective advice to the UK government in support of its participation;

- NEA - A special conference under the auspices of NEA in Paris of nuclear regulators and stakeholders in June 2011;
- ENSREG - The development of European Council "Stress Tests", the submission of national reports and the subsequent peer review process. Participation in both ENSREG 2013 meetings.
- WENRA – The development of the technical content of the ENSREG stress tests and the process for peer review. A subsequent programme of further work including a review of safety reference levels;
- CNS - An Extraordinary Review Meeting of the Convention on Nuclear Safety to review contracting parties' responses to the Fukushima accident in August 2012. The UK National Report was delivered in May 2012 and ONR participated fully in the meeting.

172. In addition, ONR has close bilateral links with other nuclear regulators, in particular the French Autorité de Sûreté Nucléaire (ASN) and the United States Nuclear Regulatory Commission (US NRC). These links have been very useful in the immediate and longer term response to the accident and in co-ordinating work.

173. ONR's previous CNI has had bilateral discussions with several other chief nuclear regulators from around the world and with the director generals and senior staff of IAEA and NEA, and similarly with the Director General for Energy of the European Council.

174. ONR has led the UK's participation in the European stress test process. All UK licensees produced a submission against the ENSREG stress test specification. Subsequently, ONR published a national stress test report (Ref. 3). This report has undergone European peer review, the results of which are reported in an ENSREG country report and published on the ENSREG website.

175. Additionally, ONR's previous CNI led an IAEA high-level team of international nuclear experts to conduct a fact-finding mission to the Fukushima plant in Japan, initially to inform the IAEA Ministerial Conference. Subsequently under bilateral arrangements CNI has had meetings with the Japanese regulator, members of both sides of the Japanese Parliament and the Japanese Parliament's independent investigation team. Such co-operation has greatly enhanced ONR's ability to respond to the Fukushima accident. Such co-operation will continue.

176. Overall, ONR considers that the responses from the UK government, UK operating organisations and from within the regulatory body (ONR) are sufficient to demonstrate that support for international efforts to improve the process of review and implementation of IAEA and other relevant nuclear safety standards and initiatives in the light of the Fukushima-1 accident have effectively become normal business.

177. In response to these recommendations the UK government has continued to work with its partners in the G7 governments and in other international fora to ensure better compliance with international conventions and push forward work on enhancing nuclear safety standards established under the auspices of the IAEA.

178. The UK has participated in the IAEA activities that led to the development of the Director General's action plan and will continue to work with the IAEA to help ensure the delivery mechanism for the action plan is both robust and realistic - especially bearing in mind the significance of the work it proposes.

179. In meeting the actions proposed by the plan the UK have already committed, through the UK's statement at the IAEA Ministerial Conference, to participate in further IRRS peer review missions and has met this commitment since 2011 with the next planned IRRS mission for the UK anticipated to be in 2019.

180. The UK government is also committed to working with our international partners to consider how the dissemination of information under the Convention on Early Notification of a Nuclear Accident can be further improved in terms of both efficiency and substance.
181. The UK has not proposed any changes to the existing suite of international conventions. In general the UK believes that the existing Conventions provide an adequate framework in which continuous improvement can be achieved.
182. The UK continues to be an active member of a range of international organisations including the IAEA, the NEA, WENRA, and ENSREG. In addition the UK has established bilateral links at government level with our closest neighbours – primarily France – to ensure the maximum benefits are gained through cooperation and sharing of information and expertise in ensuring nuclear safety.
183. The UK continues to welcome periodic peer review of our regulatory approach to ensuring nuclear safety, and has hosted an IRRS follow up mission in 2014. Also the UK has fully participated in the European stress test initiative which includes a peer review process – i.e. UK involved in the peer review of other states as well as subjecting UK regime to peer review.
184. In addition, as part of addressing IR3 (Ref. 1), BEIS, under the new strategic framework, is also taking forward a number of international projects in order to better understand the risks the UK faces and strengthen our ability to respond. This work includes for example, a new joint UK-France framework on emergency planning and the international benchmarking of UK emergency arrangements. BEIS is also working on the guidance for responding to malicious incidents and events overseas.
185. It is of note that within the IAEA action plan that, in response to member state prompting in this area (including UK), the IAEA Secretariat have committed to work to provide member states, international organizations and the general public with timely, clear, factually correct, objective and easily understandable information during a nuclear emergency on its potential consequences, including analysis of available information and prognosis of possible scenarios based on evidence, scientific knowledge and the capabilities of member states.

Section 3 - Additional Topics (Not in ENSREG or CNS consideration)

3.1 Additional Topics

186. This section deals with topics that aren't specifically covered elsewhere in the document but still play an important part in the UK's National Action Plan in response to the events at Fukushima.
187. Following the events at Fukushima, the UK's CNI produced two substantial reports which contained 38 recommendations. These placed actions on the UK nuclear industry, ONR and the UK government. A number of these recommendations have been discussed throughout this report; however, the Chief Inspector's reports took a holistic approach to consider the whole nuclear sector and produced a number of Recommendations which have not been considered within the ENSREG specification. The table below provides information on the additional topic areas that have been considered in the Chief Inspector's reports and a summary of the relevant Recommendations.

| Topic Area | Chief Inspector's Recommendation |
|-----------------------------------|--|
| Planning Controls | <p>Recommendation FR-5: The relevant Government departments in England, Wales and Scotland should examine the adequacy of the existing system of planning controls for commercial and residential developments off the nuclear licensed site.</p> |
| Safety Assessment Approach | <p>Recommendation IR-5: Once further detailed information is available and studies are completed, ONR should undertake a formal review of the Safety Assessment Principles to determine whether any additional guidance is necessary in the light of the Fukushima accident, particularly for “cliff-edge” effects.</p> <p><i>The review of ONR's Safety Assessment Principles (SAP should also cover ONR's Technical Assessment Guides (TAG), including external hazards.</i></p> |
| Research | <p>Recommendation FR-10: ONR should expand its oversight of nuclear safety-related research to provide a strategic oversight of its availability in the UK as well as the availability of national expertise, in particular that needed to take forward lessons from Fukushima. Part of this will be to ensure that ONR has access to sufficient relevant expertise to fulfil its duties in relation to a major incident anywhere in the world.</p> |
| Spent Fuel Strategies | <p>Recommendation IR-12: The UK nuclear industry should ensure the adequacy of any new spent fuel strategies compared with the expectations in the Safety Assessment Principles of passive safety and good engineering practice.</p> <p><i>Existing licensees are expected to review their current spent fuel strategies as part of their periodic review processes and make any reasonably practicable improvements, noting that any intended changes need to take account of wider strategic factors including the implications for the nuclear fuel cycle.</i></p> |
| Human Capabilities and Capacities | <p>Recommendation FR-11: The UK nuclear industry should continue to promote sustained high levels of safety culture amongst all its employees, making use of the National Skills Academy for Nuclear and other schemes that promote “nuclear professionalism”.</p> |

188. The reasoning behind these additional recommendations is provided in the two Chief Inspector's Reports (Refs. 1 & 2). For a more complete picture on the work done to address these recommendations please refer to the ONR's Fukushima close out reports (Refs. 14 and 15).

Openness and Transparency

Recommendation IR-4: *Both the UK nuclear industry and ONR should consider ways of enhancing the drive to ensure more open, transparent and trusted communications, and relationships, with the public and other stakeholders.*

189. The UK nuclear regulator has been developing its openness and transparency agenda for over a decade. This was seen from the outset for the Generic Design Assessment (GDA) for potential new reactors with the publication of requesting parties' safety submissions and periodic reports from the regulator as the project proceeded. In addition, all of the GDA assessment reports produced so far have been placed in the public domain.

190. ONR has stated that openness and transparency means adopting a presumption of disclosure, and a specific work stream is in place to ensure more work is made publicly available. An example of improvements made include the online publication of Project Assessment Reports (PAR) which explain the rationale for regulatory decisions on nuclear

safety issues and demonstrate that decisions are balanced, consistent and evidence based. These provide a brief overview of the regulatory decision, and can be readily understood.

191. Originally, only executive summaries of PARs were published but ONR has now moved towards publishing full PARs on its website (www.onr.org.uk). These contain significant technical details that are necessary to inform the regulatory decision. Details remain in the document, unless it is necessary to redact them under normal Freedom of Information (FoI) exemptions (e.g. for security reasons). For example, to date, full PARs have been published for many of our regulatory decisions and this is now a well embedded process as part of ONR's regulatory activity. ONR is continuing to build on this work and is striving to publish more of its output, covering aspects of all its regulatory activities.
192. Although ONR is intending to publish much more of its work, it is by no means the only way ONR communicates with its stakeholders. CNI and other senior managers in ONR meet on a twice-yearly basis with non-governmental organisations (NGO) to share information and listen to their concerns. The groups understand that they will not always agree but recognise that this has created an environment for sharing and engagement. The minutes of these meetings are published on ONR's website. At NGO meetings, and at the annual forum with leaders of the nuclear sector, openness and transparency has been on the agenda.
193. ONR has both attended, and held, events for members of the public interested in CNI's report on events at Fukushima and what it means for the UK. There has also been a general forum for communities living near to the Sizewell and Hinkley nuclear sites to hear from inspectors responsible for regulating safety and security at the plants. There are, in addition to the many presentations at conferences and other meetings, routine site inspection reports to local communities, which are also published on ONR's website.
194. The website is a key channel for ONR with regards to its commitment to being open and transparent. Openness and transparency feature as key success criteria in the four year ONR strategy (2016-2020) and 2017/2018 corporate plan. As such the work from this recommendation is now considered to take place within normal business.
195. ONR encourages licensees to be as open and transparent as possible within the bounds of security and commercial sensitivities. The licensees have been receptive to this and have published reports including those relating to Fukushima on their respective websites.

Recommendation FR-8: The Government should consider ensuring that the legislation for the new statutory body requires ONR to be open and transparent about its decision-making, so that it may clearly demonstrate to stakeholders its effective independence from bodies or organisations concerned with the promotion or utilisation of nuclear energy.

196. The work that took place to create a statutory ONR had at its heart the transparency of the regulator and its relationship with government (including bodies concerned with the promotion or utilisation of nuclear energy). The Secretary of State reports to Parliament on any directions that he gives to the statutory ONR, as well as the use of his powers such as making appointments to the statutory ONR Board. In addition, the statutory ONR will report every five years to Parliament on the functioning of the nuclear regulatory regime. All of these measures, the creation of the statutory ONR's Board and giving the statutory ONR powers and duties over nuclear regulation in its own right, will lead to greater transparency. This will help to clearly demonstrate the statutory ONR's effective independence from anybody concerned with the promotion or utilisation of nuclear energy. The Energy Act 2013 contains provisions that created the ONR as an independent statutory corporation.
197. As a statutory body, ONR retains the best of previous practice whilst creating a modern independent regulator based on the better regulation principles of transparency, accountability, proportionality and consistency. ONR has built on its existing strengths as an effective regulator and is better placed to respond quickly and flexibly to current and future regulatory challenges while retaining its core focus on securing the protection of people and society from

the hazards of nuclear generation. As a result, there is a more transparent statutory arrangement under which ONR has legal responsibility for this, and other, functions. Additionally, transparency and independence has been enhanced by creating the role of Chief Nuclear Inspector in statute for the first time and, in practice, delegating all of the regulatory functions to the Chief Nuclear Inspector.

Research

FR-10: *ONR should expand its oversight of nuclear safety-related research to provide a strategic oversight of its availability in the UK as well as the availability of national expertise, in particular that needed to take forward lessons from Fukushima. Part of this will be to ensure that ONR has access to sufficient relevant expertise to fulfil its duties in relation to a major incident anywhere in the world.*

198. The Government has established an Nuclear Innovation and Research Office (NIRO) to advise on the development of a national research and development strategy. As the research board includes representatives from a broad range of interested parties, including CNI, it is able to provide high-level strategic review of UK nuclear research activities. To support the research board, and to provide additional oversight of relevant research activities, to identify opportunities for collaboration and to share good practice, the nuclear regulators have established a cross-cutting Research Working Group. The working group includes representatives from the Environment Agency, SEPA, Health and Safety Laboratory, PHE, the Nuclear Decommissioning Authority (NDA) and BEIS.

199. Since the nuclear accident at Fukushima, ONR has undertaken a review of its strategic oversight of nuclear safety and security related research, and its arrangements for commissioning and managing research and specialist technical support. An updated research strategy was produced in 2015 and is available on the ONR website. This strategy set out the important role research and technical support plays in underpinning our regulatory decisions, the challenges we face going forward and how we plan to overcome these. ONR recognises the benefit of effective internal and external challenge and values, seeking advice from those with alternative points of view. In accordance with these values, ONR has established an advisory panel to obtain credible and authoritative advice from external technical experts on a broad range of nuclear safety and security matters. Membership of the Independent Advisory Panel comprises eminent scientists, engineers and security professionals with a broad range of experience gained both inside and outside the nuclear sector. Advice from the panel will inform ONR's proposals for development of regulatory policies and guidance and ONR's nuclear safety research activities. The panel is chaired by ONR's Chief Nuclear Inspector.

200. The main vehicle used by ONR to take forward its research priorities is the Regulatory Research Register (which supersedes the Nuclear Research Needs (NRN)), which represents ONR's view of what research is needed to support existing nuclear facilities. This is used by the nuclear site licensees to inform the development of their own research strategies. ONR will commission any research areas not taken forward by the nuclear site licensees and then recover the costs from the licensees via levy.

201. In addition to relying on our own technical specialists, there are occasions when we use external technical support, for example to validate risk data provided by industry. Due to the volume of confirmatory analysis needed for our GDA process, we have established a framework agreement with around 30 technical support contractors, across a range of 15 technical areas using the Official Journal of the European Union (OJEU) process. This framework ensures effective work across the range of ONR's activities, and in particular would provide any technical support we might need in the event of a nuclear accident overseas.

Section 4 – Timescales and Milestones

202. This section addresses the implementation of actions raised within Section 1 of this report. It demonstrates the progress ONR has made with the UK licensees in addressing the lessons

learnt from the events at Fukushima and the planned activities by both the licensees and the UK regulatory bodies in addressing these lessons.

203. The UK licensees have provided information about the progress they have made against the lessons learnt from the events at Fukushima. This information has included progress and plans to address the CNI recommendations, ONR stress test findings and the licensees own considerations.
204. These recommendations, findings and considerations form the basis of the UK's response to Fukushima. The Recommendations, Findings and Considerations have been linked to the ENSREG compilation of recommendations and suggestions (Ref. 4). This linking has been described within Sections 1 to 3 of this report. ENSREG's Action Plan called for an update on the implementation status on the national regulator's conclusions from the national stress tests. Table 1 (a and b) provides an update on the status of work carried out by EDF NGL to address the stress test findings. These are now all considered complete. Table 3 confirms that all tasks relating to the ENSREG compilation of recommendations and suggestions are complete with any ongoing work considered to be part of normal regulatory business.

Conclusions

205. This report has been prepared by the UK regulator (ONR) in response to ENSREG's Action Plan (Ref. 10) and as an update to the UK NAcP (Ref. 6) for NPP's. This second update to the NAcP draws on the pre-existing UK specific reports produced in response to Fukushima (Ref 1, 2, 3, 5 and 6), and is especially reliant on the most recent reports relating to the Fukushima event (Refs. 16,18,19 and 20).
206. Together with the supporting references, ONR's updated NAcP provides clear evidence that ONR and EDF NGL have incorporated the learning from the ENSREG peer review reports (individual UK report and the overall report) and compilation of recommendations into the existing programme of work being taken forward in the UK to learn lessons from Fukushima.
207. ONR has followed a formal process to embed the Fukushima work within ONR's normal regulatory business to ensure that compliance is appropriately tracked and monitored, that any necessary regulatory intervention to progress issues is undertaken, and that the outcomes are reported in a transparent and open manner.
208. Overall, ONR is satisfied that EDF NGL has addressed the learning from Fukushima. Whilst some work remains ongoing this is regarded by ONR as normal regulatory business and is being monitored through normal ONR processes.
209. The updated NAcP, together with the supporting references, is expected to provide an adequate basis for peer review by common discussion within the ENSREG community.

Table 1a: Update of Work Being Carried out by EDF NGL to Address UK National Stress Tests

| Ref. | Stress Test Finding | Status | Progress to date | Completion Date |
|-------|--|----------|--|---|
| STF-2 | The nuclear industry should establish a research programme to review the Seismic Hazard Working Party (SHWP) methodology against the latest approaches. This should include a gap analysis comparing the SHWP methodology with more recent approaches such as those developed by the Senior Seismic Hazard Analysis Committee (SSHAC). | Complete | ONR closed STF-2 in the PAR in 2015. Further work has continued under PARR-8 and a final report from EDF NG is due by the end of 2017 and it is expected that assessment of that report will enable PARR-8 to be closed and is being progressed as part of normal business. | Complete |
| STF-3 | Licensees should undertake a further review of the totality of the required actions from operators when they are claimed in mitigation within external hazards safety cases. This should also extend into beyond design basis events as appropriate. | Complete | ONR closed STF-3 in the PAR in 2015 on the basis of the evidence provided by EDF NGL. | Complete |
| STF-4 | Licensees should undertake a further systematic review of the potential for seismically-induced fire which may disrupt the availability of safety-significant structures, systems and components (SSC) in the seismic safety case and access to plant areas. | Complete | ONR closed STF-4 in the PAR in 2015 noting that EDF NGL had completed a seismic/fire pilot study at one of the stations and that subsequent studies had been completed that resulted in recommendations which have been taken forward through EDF NGL's Corrective Action Process. | Complete |
| 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. | Complete | <p>ONR closed STF-5 in the PAR in 2015.</p> <p>Flooding – EDF NGL has submitted a set of tables with flood information for all EDF NGL reactor sites.</p> <p>Seismic hazard – EDF NGL has completed a seismic hazard assessment.</p> <p>Extreme Weather - EDF NGL has addressed causally-linked weather events that may affect the hazard margins.</p> | <p>Complete</p> <p>Complete</p> <p>Complete</p> |

| Ref. | Stress Test Finding | Status | Progress to date | Completion Date |
|--------|---|----------|--|-----------------|
| STF-6 | Licensees should review further the margin to failure of the containment boundary and the point at which containment pressure boundary integrity is lost should be clearly established for the advanced gas-cooled reactors (AGR) and Magnox stations. | Complete | ONR closed STF-6 in the PAR in 2015 on the basis of a detailed seismic assessment undertaken by EDF NGL for Hinkley Point B. | Complete |
| STF-7 | Licensees should undertake a more structured and systematic study of the potential for floodwater entry to buildings containing safety-significant structures, systems and components (SSC) from extreme rainfall and / or overtopping of sea defences. | Complete | ONR closed STF-7 in the PAR in 2015 on the basis of modifications completed by EDF NGL including improvements to sea walls and installation of dam boards. Whilst some work continues in this area it is being progressed as part of normal business. | Complete |
| STF-10 | Licensees should identify safety-significant prime mover-driven generators and pumps that use shared support systems (including batteries, fuel, water and oil) and should consider modifying those prime movers systems to ensure they are capable of being self-sufficient. | Complete | ONR closed STF-10 in the PAR in 2015. EDF NGL carried out a detailed study at Heysham 1 which did not reveal any weaknesses in the capability of prime mover systems or their support systems. ONR has assessed this and considers the conclusion reasonable. EDF NGL used this study to assess the implications for the remaining stations and concluded no further reviews were necessary. | Complete |
| STF-16 | Licensees should review the symptom-based emergency response guidelines (SBERG) and severe accident guidelines (SAG) taking into account improvements to the understanding of severe accident progression, phenomena and the equipment available to mitigate severe accident. This review should also take into account the fuel route. Once completed, appropriate training and exercising should be arranged. | Complete | ONR closed STF-16 in the PAR in 2015 noting that EDF NGL has reviewed and revised the SBERGs and SAGs. | Complete |
| STF-17 | Licensees should further review the systems required to support long-term claims on the pre-stressed concrete pressure vessel containment capability in severe accident conditions. | Complete | ONR closed STF-17 in the PAR in 2015 noting that that provision of further defence in depth against vessel cooling failure via plant modifications is unlikely to be of significant benefit and that reasonably practicable improvements are more likely to be derived from procedural enhancements. | Complete. |

Table 1b: Findings considered closed in the 2014 update to address UK National Stress Tests

| Ref. | Stress Test Finding | Status | Progress to date | Completion Date |
|--------|--|----------|--|---|
| STF-1 | Licensees should provide ONR with the decision-making process to be applied to their <i>Considerations</i> along with a report which describes the sentencing of all their <i>Considerations</i> . The report will need to demonstrate to ONR that the conclusions reached are appropriate. | Complete | The decision making process and the update detailing all of its Considerations has been delivered to the ONR by EDF NGL as part of this June 2012 submission. EDF NGL will continue to provide information on the progress of the ONR recommendations and findings as well as its own Considerations as the JER Programme progresses. | June 2012 |
| STF-8 | Licensees should further investigate the provision of suitable event-qualified connection points to facilitate the reconnection of supplies to essential equipment for beyond design basis events. | Complete | A number of site walkdowns have been carried out to review the practicability of providing connection points to facilitate the reconnection of supplies to essential equipment for beyond design basis events. A number of connection points have been installed across the 9 UK reactor sites to provide the necessary points to connect power generating equipment and increase essential water stocks. | STF-8 – Provision of plant connection points Installation of connection points - Complete |
| STF-9 | Licensees should further investigate the enhancement of stocks of essential supplies (cooling water, fuel, carbon dioxide, etc.) and extending the autonomy time of support systems (e.g. battery systems) that either provide essential safety functions or support emergency arrangements. | Complete | EDF NGL has completed a fleet wide assessment of the supply and demand of essential stocks on-site and made enhancements with respect to beyond design basis events. | Modifications implemented - Complete |
| STF-11 | Licensees should further consider resilience improvements to equipment associated with the connection of the transmission system to the essential electrical systems (EES) for severe events. | Complete | After considering enhancements to this equipment combined with the likely condition of the national grid, EDF NGL have concluded that it is not appropriate to implement changes to the grid connection and therefore this does not form part of EDF NGL's strategy. The current strategy has therefore concentrated on getting on-site generation in place and appropriate plug in points identified and installed to support recovery efforts. | Further Physical Review and walk down of installation - Complete Review of current repair procedures - Complete Procurement of spare parts - Complete |
| STF-12 | Magnox Ltd should assess the progressive loss of electrical systems on all aspects of the fuel route and address any implications. | Complete | Magnox has completed an assessment of the effects of loss of power to fuel routes at all relevant sites. No Magnox site is reliant on off-site power sources and sufficient measures are in place to assure recovery of on-site power supplies. | Complete |

| Ref. | Stress Test Finding | Status | Progress to date | Completion Date |
|--------|--|----------|--|--|
| STF-13 | Magnox Ltd should demonstrate that all reasonably practical means have been taken to ensure integrity of the fuel within the dry fuel stores in the extremely unlikely event of the natural draft air ducting becoming blocked. | Complete | Magnox has reviewed the potential for, and effects of, blockage of the dry fuel store ventilation ducts. Reasonably practicable enhancements have been implemented, in particular pumps to enable removal of water accumulation from the ducts have been provided. | Complete |
| STF-14 | Licensees should confirm the extent to which resilience enhancements are to be made to existing equipment and systems that are currently installed at nuclear power plants. Information should be provided on the equipment and systems that may be affected and the nature of the resilience enhancements, including interconnectivity with mobile back-up equipment. | Complete | <p>The focus here is concerned with resilience enhancements to be made to existing equipment and systems.</p> <p>Modifications/ enhancements have been implemented to varying extents as considered necessary on a station by station basis.</p> <p>Identification of resilience measures for all stations covering hazard protection of back-up feed systems, electrical distribution and generator systems (to aid long term recovery of plant) have been completed.</p> | <p>Assessment of modifications - Complete</p> <p>Specifications written for Interfaces and Resilience modifications - Complete</p> <p>Modifications implemented - Complete</p> |

| Ref. | Stress Test Finding | Status | Progress to date | Completion Date |
|--------|---|----------|---|--|
| STF-15 | Licensees should complete the various reviews that they have highlighted so that ONR can assess their proposals and associated timescales. These reviews should look in detail at on-site emergency facilities and arrangements, off-site facilities, facilities for remote indication of plant status, communication systems, contents and location of beyond design basis containers and the adequacy of any arrangements necessary to get people and equipment on to and around site under severe accident conditions. Any changes to arrangements and equipment will require appropriate training and exercising. | Complete | <p>A review of structures, systems and components needed in the response to an accident have been completed.</p> <p>A review of station on-site and off-site communications resilience due to extreme conditions has been completed and resilience improvement plans made for any communications related enhancements and modifications</p> <p>A review has been carried out with regards to access to and around site as well as transporting mobile back-up modules to site in a severe event.</p> <p>Specifications to procure backup equipment to support stations for beyond design basis events is complete.</p> <p>Training and Exercising approach, principal components and delivery of training now underway.</p> | <p>Reviews completed</p> <p>Fixed communications resilience issues and whether enhancements are feasible. Complete</p> <p>Deployment strategy for each site. Complete</p> <p>Expected capability shown. Complete</p> <p>All back-up equipment delivered / full deployment capability - Complete.</p> |
| STF-18 | EDF NGL Energy Nuclear Generation Ltd should complete its feasibility study into the installation of filtered containment venting, installation of passive autocatalytic hydrogen recombiners and flexible means of injecting water into the Sizewell B containment. | Complete | <p>Passive Autocatalytic Recombiners now installed on plant. Feasibility review for FCV now complete.</p> <p>A method of introducing cooling water to containment has been undertaken. The penetration for water injection has been completed.</p> | <p>Containment modifications – Feasibility study complete</p> <p>Install PARs - Complete</p> <p>Modifications to allow for containment water injection - Complete</p> |

| Ref. | Stress Test Finding | Status | Progress to date | Completion Date |
|--------|--|----------|---|-----------------|
| STF-19 | Reports on the progress made in addressing the conclusions of the licensees <i>Considerations</i> and the ONR findings should be made available to ONR on the same timescale as that for Chief Inspector's recommendations (June 2012). These should include the status of plans and details of improvements that have been implemented. | Complete | EDF NGL responded to the ONR as expected in June 2012 where EDF NGL have provided updates on the Interim Recommendations, the Final Recommendations, the Stress Test Findings and EDF NGL's own Considerations. | N/A |

Table 2a: Work Addressing the Peer Review Outcomes

| Item for follow up | UK recommendation, STF or consideration that bounds or includes the item |
|--|--|
| Full scope L2 PSAs not yet performed for AGRs (see below) | FR4 |
| BDB capability – margins & cliff edges | IR 10, STF5 |
| Current assessments have not accounted for recent tsunami research | IR10 |
| No satisfactory evidence of capability of the plants beyond the design basis | STF5 |
| Inclusion of defence in depth principle as part of margin an cliff edge work | STF5 |
| Not all plants fully comply with WENRA Reference Levels yet (apart from the PSA issue, there were no other examples in this section of none or partial WRL compliance cited by the peer review team) | FR4 |
| Consider injection of water in to AGR core to provide heat removal when boilers not available | IR25, IR24, STF16 |
| Consider having 72 hr fuel and other stocks (eg CO2) | STF 9, IR8 |
| Consider improving battery capacity | STF9 |
| Consider increasing robustness of the operating environment of the SZB steam driven pumps | IR25, FR3 |
| Strengthen on-site emergency facilities against ext. Hazards and severe accidents | STF15 |
| Assessment of severe accident(s) at multiple facilities | IR11 |
| Consider need for backup control room | IR 22, STF 15 (in part) |

| Item for follow up | UK recommendation, STF or consideration that bounds or includes the item |
|---|--|
| Further development of SBERGs and SAGs – all accident types and operating modes. | STF16 |
| Improved training for “improved” SBERGs and SAGs | IR 24, IR 25, STF16 |
| Analysis of severe accident radiation conditions on-site & development of measure to address them | IR24, IR 25 |
| Consider operability issues for new SAM hardware in severe external hazard conditions & SBO | IR16, IR24, IR 25, FR2,FR3, STF8 |
| Consider strengthening SFP coolant inventory top up capability | IR 19, IR 20, STF 9 |

Table 2b: Work Addressing Overall Peer Review Report on European NPP

| ENSREG recommendation | ONR coverage |
|--|--|
| <p>The peer review Board recommends that WENRA, involving the best available expertise from Europe, develop guidance on natural hazards assessments, including earthquake, flooding and extreme weather conditions, as well as corresponding guidance on the assessment of margins beyond the design basis and cliff-edge effects.</p> | <p>ONR is leading the WENRA task group on this topic. IR 10, STF 5</p> |
| <p>The peer review Board recommends that ENSREG underline the importance of periodic safety review. In particular, ENSREG should highlight the necessity to re-evaluate natural hazards and relevant plant provisions as often as appropriate but at least every 10 years.</p> | <p>ONR is participating in the WENRA task group looking at revising the PSR WRLs.</p> <p>FR1</p> |
| <p>Urgent implementation of the recognised measures to protect containment integrity is a finding of the peer review that national regulators should consider. The measures to be taken can vary depending on the design of the plants. For water cooled reactors, they include equipment, procedures and accident management guidelines to:</p> <ul style="list-style-type: none"> • depressurise the primary circuit in order to prevent high pressure • core melt; • prevent hydrogen explosions; • prevent containment overpressure. | <p>STF 18</p> |
| <p>Necessary implementation of measures allowing prevention of accidents and limitation of their consequences in case of extreme natural hazards is a finding of the peer review that national regulators should consider.</p> | <p>IR 16, FR2, FR3</p> |

Table 3a: Update on the outstanding ENSREG Compilation of Recommendations in the previous update

| Ref. | Site | Activity | Status | Activity Key Milestones | Complete |
|----------------------------------|------------------|--|----------|--|----------------------------------|
| Topic 1 – Natural Hazards | | | | | |
| 3.1.2 | All UK NPP sites | Secondary Effects of Earthquakes The possible secondary effects of seismic events, such as flood or fire arising as a result of the event, in future assessments. | Complete | STF-4 - Systematic review of the potential for seismically induced fire: <ul style="list-style-type: none"> • Production of subsequent station reviews • Optioneering to identify any resolutions. | Complete Complete |
| | | | Complete | STF-7 & IR-10– Review of flooding studies: <ul style="list-style-type: none"> • Completion of flooding studies • Completion of the Safety Case comparison • Implementation of site resilience modifications | Complete Complete Complete |
| | | | Complete | (Magnox) STF-4 - Systematic review of the potential for seismically induced fire at Wylfa | Complete |
| 3.1.3 | All UK NPP sites | Protected Volume Approach The use a protected volume approach to demonstrate flood protection for identified rooms or spaces. | Complete | STF-7 & IR-10– Review of flooding studies: <ul style="list-style-type: none"> • Completion of flooding studies • Completion of the Safety Case comparison • Implementation of site resilience modifications | Complete Complete Complete |
| 3.1.5 | All UK NPP sites | Seismic Monitoring The installation of seismic monitoring systems with related procedures and training. | Complete | Seismic monitoring was considered within the assessment undertaken as part of the European Stress Tests. | Complete |
| | | | Complete | STF-3 - Actions from operators in mitigation external hazards: <ul style="list-style-type: none"> • Initial operator action review – seismic | Complete |
| | | | Complete | (Magnox) Seismic monitoring was considered within the assessment undertaken as part of the European Stress Tests and is already available at Wylfa together with appropriate procedures for post event operator actions. | Complete |

| Ref. | Site | Activity | Status | Activity Key Milestones | Complete |
|---|------------------|---|----------|--|----------------------------------|
| 3.1.7 | All UK NPP sites | Flooding Margin Assessments The analysis of incrementally increased flood levels beyond the design basis and identification of potential improvements, as required by the initial ENSREG specification for the stress tests. | Complete | STF-7 & IR-10 – Review of flooding studies: <ul style="list-style-type: none"> • Completion of flooding studies • Completion of the Safety Case comparison • Implementation of site resilience modifications | Complete Complete Complete |
| | | | Complete | (Magnox) STF-7 & IR-10– Review of flooding studies: <ul style="list-style-type: none"> • Review of flooding studies • Implementation of site resilience modifications | Complete Complete |
| 3.1.8 | All UK NPP sites | External Hazard Margins In conjunction with recommendation 2.1 and 3.1.7, the formal assessment of margins for all external hazards including, seismic, flooding and severe weather, and identification of potential improvements. | Complete | STF-5 - External Hazards margin assessment: <ul style="list-style-type: none"> • Seismic • Extreme Weather • Flooding | Complete Complete Complete |
| | | | Complete | (Magnox) STF-5 - External Hazards margin assessment: <ul style="list-style-type: none"> • Seismic margins study • Review of resilience against extreme hazards • Implementation of resilience enhancements | Complete Complete Complete |
| Topic 2 - Loss of Safety Systems | | | | | |

| Ref. | Site | Activity | Status | Activity Key Milestones | Complete |
|---|------------------|---|----------|---|----------|
| 3.2.2 | All UK NPP Sites | <p>AC Power Supplies The enhancement of the on-site and off-site power supplies. Examples include adding layers of emergency power, adding independent and dedicated backup sources, the enhancement of the grid through agreements with the grid operator on rapid restoration of off-site power, additional and/or reinforced off-site power connections, arrangements for black start of co-located or nearby gas or hydro plants, replacing standard ceramic based items with plastic or other material that are more resistant to a seismic event. Another example is the possible utilisation of generator load shedding and house load operation for increased robustness, however, before introducing such arrangements the risks need to be properly understood.</p> | Complete | IR-17 - Resilience of national grid - National Grid resilience assessment. | Complete |
| | | | Complete | STF-11 - Resilience improvements to equipment associated with the connection of the transmission grid. | Complete |
| | | | Complete | IR-18 - Long-term independent electrical supplies on-sites. | Complete |
| | | | Complete | STF-15 - All back-up equipment delivered / full deployment capability. | Complete |
| | | | Complete | STF-8 – Provision of plant connection points. | Complete |
| | | | Complete | STF-10 – Self sufficiency of generation equipment. | Complete |
| | | | Complete | (Magnox) IR-18 – Additional generators provided for emergency electrical on-site supplies (also for 3.2.3) | Complete |
| 3.2.5 | All UK NPP Sites | <p>Instrumentation and Monitoring The enhancement of instrumentation and monitoring. Examples include separate instrumentation and/or power sources to enable monitoring of essential parameters under any circumstances for accident management and the ability to measure specific important parameters based on passive and simple principles.</p> | Complete | IR-22 - Provision on-site of emergency control, instrumentation and communication | Complete |
| | | | Complete | STF-15 - Facilities for remote indication of plant status | Complete |
| Topic 3 - Severe Accident Management | | | | | |

| Ref. | Site | Activity | Status | Activity Key Milestones | Complete |
|-------|------------------|---|--|---|--|
| 3.3.2 | All UK NPP Sites | SAM Hardware Provisions Adequate hardware provisions that will survive external hazards (e.g. by means of qualification against extreme external hazards, storage in a safe location) and the severe accident environment (e.g. engineering substantiation and/or qualification against high pressures, temperatures, radiation levels, etc.), in place, to perform the selected strategies. | Complete Complete Complete Complete | IR-6 - Extend long-term severe accidents emergency exercises. FR-6 - Estimating radioactive source terms IR-24 & STF-16 - SBERGs and SAGs: <ul style="list-style-type: none"> SBERGs and SAGs Review and Revision Human Aspects Beyond Design Basis Task Analysis Weather and Seismic Human Factors Back-up Equipment – Equipment, training and exercising (Magnox) IR-24 & STF-16 - SBERGs and SAGs: <ul style="list-style-type: none"> SBERGs and SAGs Review and Revision Human Aspects Back-up equipment – equipment, training and exercising (Also applicable for 3.3.3-3.3.8) | Complete Complete Complete Complete Complete Complete Complete |
| 3.3.3 | All UK NPP Sites | Review of SAM Provisions Following Severe External Events The systematic review of SAM provisions focusing on the availability and appropriate operation of plant equipment in the relevant circumstances, taking account of accident initiating events, in particular extreme external hazards and the potential harsh working environment. | Complete | IR-24 & STF-16 - SBERGs and SAGs: <ul style="list-style-type: none"> SBERGs and SAGs Review and Revision Human Aspects Beyond Design Basis Task Analysis Weather and Seismic Human Factors Back-up Equipment – Equipment, training and exercising | Complete Complete Complete Complete Complete |

| Ref. | Site | Activity | Status | Activity Key Milestones | Complete |
|-------|------------------------------------|--|----------|--|--|
| 3.3.4 | All UK NPP Sites except Sizewell B | Enhancement of Severe Accident Management Guidelines (SAMG) In conjunction with the recommendation 2.4, the enhancement of SAMGs taking into account additional scenarios, including, a significantly damaged infrastructure, including the disruption of plant level, corporate-level and national-level communication, long-duration accidents (several days) and accidents affecting multiple units and nearby industrial facilities at the same time. | Complete | IR-24 & STF-16 - SBERGs and SAGs: <ul style="list-style-type: none"> SBERGs and SAGs Review and Revision Human Aspects Beyond Design Basis Task Analysis Weather and Seismic Human Factors Back-up Equipment – Equipment, training and exercising | Complete Complete Complete Complete Complete |
| 3.3.5 | All UK NPP Sites | SAMG Validation The validation of the enhanced SAMGs. | Complete | IR-24 & STF-16 - SBERGs and SAGs: <ul style="list-style-type: none"> SBERGs and SAGs Review and Revision Human Aspects Beyond Design Basis Task Analysis Weather and Seismic Human Factors Back-up Equipment – Equipment, training and exercising | Complete Complete Complete Complete Complete |
| 3.3.6 | All UK NPP Sites | SAM Exercises Exercises aimed at checking the adequacy of SAM procedures and organisational measures, including extended aspects such as the need for corporate and nation level coordinated arrangements and long-duration events. | Complete | IR-24 & STF-16 - SBERGs and SAGs: <ul style="list-style-type: none"> SBERGs and SAGs Review and Revision Human Aspects Beyond Design Basis Task Analysis Weather and Seismic Human Factors Back-up Equipment – Equipment, training and exercising | Complete Complete Complete Complete Complete |
| 3.3.7 | All UK NPP Sites | SAM Training Regular and realistic SAM training exercises aimed at training staff. Training exercises should include the use of equipment and the consideration of multi-unit accidents and long-duration events. The use of the existing NPP simulators is considered as being a useful tool but needs to be enhanced to cover all possible accident scenarios. | Complete | IR-24 & STF-16 - SBERGs and SAGs: <ul style="list-style-type: none"> SBERGs and SAGs Review and Revision Human Aspects Beyond Design Basis Task Analysis Weather and Seismic Human Factors Back-up Equipment – Equipment, training and exercising | Complete Complete Complete Complete Complete |

| Ref. | Site | Activity | Status | Activity Key Milestones | Complete |
|--------|------------------|--|----------|--|--|
| 3.3.8 | All UK NPP Sites | Extension of SAMGs to All Plant States The extension of existing SAMGs to all plant states (full and low-power, shutdown), including accidents initiated in SFPs. | Complete | IR-24 & STF-16 - SBERGs and SAGs: <ul style="list-style-type: none"> SBERGs and SAGs Review and Revision Human Aspects Beyond Design Basis Task Analysis Weather and Seismic Human Factors Back-up Equipment – Equipment, training and exercising | Complete Complete Complete Complete |
| 3.3.10 | All UK NPP Sites | Presence of Hydrogen in Unexpected Places The preparation for the potential for migration of hydrogen, with adequate countermeasures, into spaces beyond where it is produced in the primary containment, as well as hydrogen production in SFPs. | Complete | IR-21 - Review the ventilation and venting routes for nuclear facilities - Review of AGR ventilation equipment and routes | Complete |
| | | | Complete | STF-18 – Installation of PARs | Complete |
| | | | Complete | (Magnox) IR-21 – Review of sources of combustible gases | Complete |
| 3.3.12 | All UK NPP Sites | Radiation Protection The provision for radiation protection of operators and all other staff involved in the SAM and emergency arrangements. | Complete | FR-6 - Estimating radioactive source terms | Complete |
| | | | Complete | STF-16 - Review of the SBERGs and SAGs taking into account improvements to the understanding of severe accident progression, phenomena and the equipment available to mitigate severe accident, including the use of backup equipment | Complete |
| | | | Complete | (Magnox) STF-15 – Additional Health Physics and Personal Protective Equipment provided | Complete |

| Ref. | Site | Activity | Status | Activity Key Milestones | Complete |
|--------|------------------|--|----------|--|--|
| 3.3.16 | All UK NPP Sites | <p>Severe Accident Studies</p> <p>The performance of further studies to improve SAMGs. Examples of areas that could be improved with further studies include:</p> <ul style="list-style-type: none"> The availability of safety functions required for SAM under different circumstances. Accident timing, including core melt, reactor pressure vessel (RPV) failure, basemat melt-through, SFP fuel uncover, etc. PSA analysis, including all plant states and external events for PSA levels 1 and 2. Radiological conditions on the site and associated provisions necessary to ensure MCR and ECR habitability as well as the feasibility of accident mitigation measures in severe accident conditions, multi-unit accidents, containment venting, etc. Core cooling modes prior to RPV failure and of re-criticality issues for partly damaged cores, with unborated water supply. Phenomena associated with cavity flooding and related steam explosion risks. Engineered solutions regarding molten corium cooling and prevention of basemat melt-through. Severe accident simulators appropriate for NPP staff training. | Complete | IR-25 - Review, and if necessary extend, analysis of accident sequences for long-term severe accidents. This is covered by the Recommendations and Findings below: | Complete |
| | | | Complete | STF-3 <ul style="list-style-type: none"> Initial operator action review – extreme weather Initial operator action review – seismic Development of detailed phase 2 scope | Complete Complete Complete |
| | | | Complete | STF-5 and STF-7 <ul style="list-style-type: none"> Flooding Review and Consolidation Flooding Margin Report Seismic Methods and Safety Case Extreme Weather Review | Complete Complete Complete Complete |
| | | | Complete | FR-4 <ul style="list-style-type: none"> Selected Station PSA Analysis | Complete |
| | | | Complete | IR-24 <ul style="list-style-type: none"> SBERGs and SAGs Review and Revision Human Aspects (Emergency Response) Beyond Design Basis Task Analysis Weather and Seismic Human Factors Back-up Equipment – Equipment, training and exercising. | Complete Complete Complete Complete Complete |
| | | | Complete | (Magnox) STF-5 and STF-7: <ul style="list-style-type: none"> Seismic margins study Review of resilience against extreme hazards Implementation of resilience enhancements | Complete Complete Complete |
| | | | Complete | FR-4 <ul style="list-style-type: none"> Limited scope Level PSA for Wylfa | Complete |
| | | | Complete | IR-24 & STF-16 - SBERGs and SAGs: <ul style="list-style-type: none"> SBERGs and SAGs Review and Revision Human Aspects Back-up equipment – equipment, training and exercising | Complete Complete Complete |

Table 3b: ENSREG Compilation of Recommendations considered completed in the previous update

| Ref. | Site | Activity | Status | Activity Key Milestones | Complete |
|---|------------------|---|----------|---|----------|
| Topic 1 – Natural Hazards | | | | | |
| 3.1.1 | All UK NPP sites | Hazard Frequency The use a return frequency of 10-4 per annum (0.1g minimum peak ground acceleration for earthquakes) for plant reviews/back-fitting with respect to external hazards safety cases. | Complete | Covered by the SAPs 2006, this is been further considered during the SAPs reassessment due for publication 2013. Criteria reassessed during the UK Stress Test to reconfirm the compliance of all UK nuclear sites. | N/A |
| 3.1.4 | All UK NPP sites | Early Warning Notifications The implementation of advanced warning systems for deteriorating weather, as well as the provision of appropriate procedures to be followed by operators when warnings are made. | Complete | CSA030 – Assessment of current station forecasting arrangements. | Complete |
| | | | Complete | (Magnox) Developing Company standard for early warning of extreme events | Complete |
| 3.1.6 | All UK NPP sites | Qualified Walkdowns The development of standards to address qualified plant walkdowns with regard to earthquake, flooding and extreme weather – to provide a more systematic search for non-conformities and correct them (e.g. appropriate storage of equipment, particularly for temporary and mobile plant and tools used to mitigate beyond design basis (BDB) external events). | Complete | Qualified Walkdowns of all NPP sites completed as part of the European stress tests. | Complete |
| Topic 2 - Loss of Safety Systems | | | | | |
| 3.2.1 | All UK NPP Sites | Alternate Cooling and Heat Sink The provision of alternative means of cooling including alternate heat sinks. Examples include steam generator (SG) gravity alternative feeding, alternate tanks or wells on the site, air-cooled cooling towers or water sources in the vicinity (reservoir, lakes, etc.) as an additional way of enabling core cooling. | Complete | IR-19 – Long term cooling supplies: Back-up equipment provisions | Complete |
| | | | Complete | STF-8 – Provision of plant connection points. Installation of connection points. | Complete |
| | | | Complete | STF-9 – Increasing hardened on-site stocks. | Complete |

| Ref. | Site | Activity | Status | Activity Key Milestones | Complete |
|-------|------------------|---|----------|--|----------------------------------|
| 3.2.3 | All UK NPP Sites | DC Power Supplies The enhancement of the DC power supply. Examples include improving the battery discharge time by upgrading the existing battery, changing/diversifying battery type (increasing resistance to common-mode failures), providing spare/replacement batteries, implementing well-prepared loadshedding/ staggering strategies, performing real load testing and on-line monitoring of the status of the batteries and preparing dedicated recharging options (e. g. using portable generators). | Complete | STF-9 - Autonomy time of support systems (e.g. battery systems): | Complete |
| | | | Complete | Review of battery autonomy times and identification of possible enhancements. | Complete |
| | | | Complete | Sizewell B - Battery charging diesel generators upgraded | Complete |
| 3.2.4 | All UK NPP Sites | Operational and Preparatory Actions Implementation of operational or preparatory actions with respect to the availability of operational consumables. Examples include, ensuring the supply of consumables such as fuel, lubrication oil, and water and ensuring adequate equipment, procedures, surveillance, drills and arrangements for the resupply from off-site are in place. | Complete | IR-19 - On-site supplies or greater off-site capability. | Complete |
| | | | Complete | STF-9 - Enhancement of stocks of essential supplies. | Complete |
| | | | Complete | STF-15 - Getting people and equipment on to and around site under severe accident conditions. | Complete |
| 3.2.6 | Sizewell B | Shutdown Improvements The enhancement of safety in shutdown states and mid-loop operation. Examples of improvements include, reducing or prohibiting mid-loop operation, adding dedicated hardware, procedures and drills, the use of other available water sources (e. g. from hydro-accumulators), requiring the availability of SGs during shutdown operations and the availability of feedwater in all modes. | Complete | STF-18 - Filtered Containment Venting (feasibility) and PARs | Complete |
| | | | Complete | STF-9 - Battery-charging diesel generators and upgrading the resistance of the associated buildings to natural hazards | Complete |
| | | | Complete | STF-8 - Connection points for Sizewell B | Complete |
| 3.2.7 | Sizewell B | Reactor Coolant Pump Seals The use of temperature-resistant (leak-proof) primary pump seals. | Complete | EDF NGL initial review complete | Complete |
| | | | Complete | EDF NGL plans to review Operational Experience from any plants that do adopt these seals, and may choose to fit them at some future date. | Complete |
| 3.2.8 | Sizewell B | Ventilation The enhancement of ventilation capacity during SBO to ensure equipment operability. | Complete | STF-18 – Installation of Filtered Containment Venting: <ul style="list-style-type: none"> • Containment modifications • Install PARs • Modifications to allow for containment water injection | Complete Complete Complete |
| | AGRs | | Complete | IR-21 - review the ventilation and venting routes for nuclear facilities - Review of AGR ventilation equipment and routes. | Complete |

| Ref. | Site | Activity | Status | Activity Key Milestones | Complete |
|--------|------------------------------------|---|----------|---|----------------------|
| 3.2.9 | All UK NPP Sites (excluding Wylfa) | Main and Emergency Control Rooms The enhancement of the main control room (MCR), the emergency control room (ECR) and emergency control centre (ECC) to ensure continued operability and adequate habitability conditions in the event of a station black-out (SBO) and in the event of the loss of DC (this also applies to Topic 3 recommendations). | Complete | IR-22 - review the provision on-site of emergency control, instrumentation and communications: <ul style="list-style-type: none"> Sizewell B ERC site work AGR site modifications | Complete Complete |
| | | | Complete | FR-2 & FR-3 - Protection of control rooms against hazards: <ul style="list-style-type: none"> On-site resilience enhancements to emergency control facilities | Complete |
| 3.2.10 | All UK NPP Sites (excluding Wylfa) | Spent Fuel Pool The improvement of the robustness of the spent fuel pool (SFP). Examples include reassessment/upgrading SFP structural integrity, installation of qualified and power-independent monitoring, provisions for redundant and diverse sources of additional coolant resistant to external hazards (with procedures and drills), design of pools that prevents drainage, the use of racks made of borated steel to enable cooling with fresh (unborated) water without having to worry about possible recriticality, redundant and independent SFP cooling systems, provision for additional heat exchangers (e. g. submerged in the SFP), an external connection for refilling of the SFP (to reduce the need for an approach linked to high doses in the event of the water falling to a very low level) and the possibility of venting steam in a case of boiling in the SFP. | Complete | IR-20 - Site contingency plans for pond water: <ul style="list-style-type: none"> Implementation of backup equipment | Complete |
| 3.2.11 | All UK NPP Sites | Separation and Independence The enhancement of the functional separation and independence of safety systems. Examples include the elimination of full dependence of important safety functions on auxiliary systems such as service water and the introduction of an alternate source of cooling. | Complete | Separation and Independence is covered by the SAPs 2006 (Ref. 8) Alternate source of cooling is discussed at 3.2.1 Diverse locations of back-up equipment is discussed at 3.2.13 | N/A |

| Ref. | Site | Activity | Status | Activity Key Milestones | Complete |
|--------|------------------|--|----------|---|----------|
| 3.2.12 | All UK NPP Sites | Flow Path and Access Availability The verification of assured flow paths and access under SBO conditions. Ensure that the state in which isolation valves fail and remain, when motive and control power is lost, is carefully considered to maximise safety. Enhance and extend the availability of DC power and instrument air (e. g. by installing additional or larger accumulators on the valves). Ensure access to critical equipment in all circumstances, specifically when electrically operated turnstiles are interlocked. | Complete | STF-15 - adequacy of any arrangements necessary to get people and equipment on to and around site under severe accident conditions. | Complete |
| | | | Complete | (Magnox) STF-15 – Resilience enhancements implemented to assist operator access | Complete |
| 3.2.13 | All UK NPP Sites | Mobile Devices The provision of mobile pumps, power supplies and air compressors with prepared quick connections, procedures, and staff training with drills. Mobile devices are intended to enable the use of existing safety equipment, enable direct feeding of the primary or secondary side, allow extended use of instrumentation and operation of controls, allow effective fire-fighting, and ensure continued emergency lighting. The equipment should be stored in locations that are safe and secure even in the event of general devastation caused by events significantly beyond the design basis (this also applies to Topic 3 recommendations). | Complete | STF-15 - adequacy of any arrangements necessary to get people and equipment on to and around site under severe accident conditions. | Complete |
| | | | Complete | SFT-8 – Provision of plant connection points. | Complete |
| | | | Complete | (Magnox) STF-15 – Additional pumps provided to support reactor boiler feed and general duties | Complete |
| 3.2.14 | All UK NPP Sites | Bunkered/Hardened Systems The provision for a bunkered or “hardened” system to provide an additional level of protection with trained staff and procedures designed to cope with a wide variety of extreme events including those beyond the design basis (this also applies to Topic 3 recommendations). | Complete | IR 22 – Review the provision on-site of emergency control, instrumentation and communications: <ul style="list-style-type: none"> • Sizewell B ERC site work complete • Completion of AGR site modifications | Complete |
| | | | Complete | IR-23 necessary off-site communications for severe accidents: <ul style="list-style-type: none"> • Provision of satellite phones as well a feasibility study regarding increasing the resilience of telephone exchanges. | Complete |
| | | | Complete | (Magnox) IR-22 – Resilience enhancements implemented | Complete |

| Ref. | Site | Activity | Status | Activity Key Milestones | Complete |
|---------|---------------------------------|--|--------------------------|---|---|
| 3.2.15 | All UK NPP Sites (except Wylfa) | Multiple Accidents The enhancement of the capability for addressing accidents occurring simultaneously on all plants of the site. Examples include assuring preparedness and sufficient supplies, adding mobile devices and fire trucks and increasing the number of trained and qualified staff (this also applies to Topic 3 recommendations). | Complete | IR-11 - Adequately demonstrate the capability for dealing with multiple serious concurrent events. Strategic depots, associated deployable equipment, proof of concept exercises. | Complete (exercise programme and training part of on-going normal business) |
| 3.2.16 | All UK NPP Sites | Equipment Inspection and Training Programs The establishment of regular programs for inspections to ensure that a variety of additional equipment and mobile devices are properly installed and maintained, particularly for temporary and mobile equipment and tools used for mitigation of BDB external events. Development of relevant staff training programmes for deployment of such devices. | Complete Complete | STF-15 - adequacy of any arrangements necessary to get people and equipment on to and around site under severe accident conditions. (Magnox) STF-15 – Programme of training and maintenance to be established | Complete |
| 3.2.17 | All UK NPP Sites | Further Studies to Address Uncertainties The performance of further studies in areas where there are uncertainties. Uncertainties may exist in the following areas: | Complete | Managing the traumatic, psychological, stress and family effects that staff and other responders may encounter during a severe and prolonged nuclear emergency. | Complete |
| 3.2.17a | All UK NPP Sites (except Wylfa) | The integrity of the SFP and its liner in the event of boiling or external impact. | Complete | IR-20 - Site contingency plans for pond water make up: Implementation of backup equipment. | Complete |
| 3.2.17b | | The functionality of control equipment (feed water control valves and SG relief valves, main steam safety valves, isolation condenser flow path, containment isolation valves as well as depressurisation valves) during the SBO to ensure that cooling using natural circulation would not be interrupted in a SBO (this is partially addressed in recommendation 3.2.10). | Complete | Assessment of SBO of all NPP sites completed as part of the European stress tests. | Complete |
| 3.2.17c | | The performance of additional studies to assess operation in the event of widespread damage, for example, the need for different equipment (e.g. bulldozers) to clear the route to the most critical locations or equipment. This includes the logistics of the external support and related arrangements (storage of equipment, use of national defence resources, etc.). | Complete Complete | STF-15 - Adequacy of any arrangements necessary to get people and equipment on to and around site under severe accident conditions. (Magnox) STF-15 Resilience enhancements implemented to assist operator access | Complete |

| Topic 3 - Severe Accident Management | | | | | |
|--------------------------------------|---------------------------------|--|----------|---|----------------------------------|
| 3.3.1 | All UK NPP Sites | WENRA Reference Levels The incorporation of the WENRA reference levels related to severe accident management (SAM) into their national legal frameworks, and ensure their implementation in the installations as soon as possible. | Complete | Current WENRA reference levels are incorporated into the UK's national requirements. There is an established mechanism for incorporation of any formal revision of reference levels. | Complete |
| | | | Complete | FR-1 - Completing Periodic Reviews (PSR) to the required standards and timescales, & to implementing identified reasonably practicable plant improvements. | Part of normal business |
| 3.3.9 | All UK NPP Sites | Improved Communications The improvement of communication systems, both internal and external, including transfer of severe accident related plant parameters and radiological data to all emergency and technical support centre and regulatory premises. | Complete | IR-23 - Necessary off-site communications for severe accidents: <ul style="list-style-type: none"> • Circulation of communication vulnerability report • Distribution of satellite phones to stations • Meeting with Paradigm for HITS service possibility | Complete Complete Complete |
| | | | Complete | (Magnox) IR-23 necessary off-site communications for severe accidents: <ul style="list-style-type: none"> • Distribution of satellite phones to stations | Complete |
| 3.3.11 | All UK NPP Sites (except Wylfa) | Large Volumes of Contaminated Water The conceptual preparations of solutions for post-accident contamination and the treatment of potentially large volumes of contaminated water. | Complete | IR-25 - Centrally located storage facilities (bags) that will be deployed as necessary. Small scale storage will be available on site. | Complete |
| 3.3.13 | All UK NPP Sites | On-site Emergency Centre The provision of an on-site emergency centre protected against severe natural hazards and radioactive releases, allowing operators to stay onsite to manage a severe accident. | Complete | IR-22 - Review the provision on-site of emergency control, instrumentation and communications: <ul style="list-style-type: none"> • Sizewell B ERC site work complete • Completion of AGR site modifications | Complete Complete |
| | | | Complete | (Magnox) IR-22 – Review of existing emergency facilities | Complete |
| 3.3.14 | All UK NPP Sites | Support to Local Operators Rescue teams and adequate equipment to be quickly brought on-site in order to provide support to local operators in case of a severe situation. | Complete | STF-15 - Adequacy of any arrangements necessary to get people and equipment on to and around site under severe accident conditions. | Complete |

| Ref. | Site | Activity | Status | Activity Key Milestones | Complete |
|--------|------------------|--|----------|---|----------|
| 3.3.15 | All UK NPP Sites | Level 2 Probabilistic Safety Assessments (PSAs) A comprehensive Level 2 PSA as a tool for the identification of plant vulnerabilities, quantification of potential releases, determination of candidate high-level actions and their effects and prioritizing the order of proposed safety improvements. Although PSA is an essential tool for screening and prioritising improvements and for assessing the completeness of SAM implementation, low numerical risk estimates should not be used as the basis for excluding scenarios from consideration of SAM especially if the consequences are very high. | Complete | FR-4 - Level 2 Probabilistic Safety Analyses (PSA): Pilot study on a single AGR Station. | Complete |
| | | | Complete | (Magnox) Limited scope Level PSA for Wylfa | Complete |

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Abbreviations

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| AC | Alternating Current |
| AGR | Advanced Gas-cooled Reactor |
| ASN | Autorité de Sûreté Nucléaire (French nuclear safety authority) |
| BDB | Beyond Design Basis |
| BDBA | Beyond Design Basis Accident |
| BEIS | Department for Business, Energy and Industrial Strategy (formerly DECC) |
| C&I | Control and Instrumentation |
| CESC | Central Emergency Support Centre |
| CNI | Chief Inspector of Nuclear Installations |
| COBR | Cabinet Office Briefing Room |
| DC | Direct Current |
| DECC | Department of Energy and Climate Change |
| DEPZ | Detailed Emergency Planning Zone |
| ECC | Emergency Control Centre |
| EDF NGL | Electricité de France Energy Nuclear Generation Limited |
| EIC | Emergency Indication Centre |
| ENSREG | European Nuclear Safety Regulators Group |
| EPRI | Electric Power Research Institute |
| ERC | Emergency Response Centre |
| FCV | Filtered Containment Venting |
| FR | Final Recommendation |
| GDA | Generic Design Assessment |

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| GTA | Government Technical Advisor |
| IAEA | International Atomic Energy Agency |
| IR | Interim Recommendation |
| IRRS | International Regulatory Review Service |
| JAM | Joint Agency Modelling |
| LA | Local Authority |
| MO | Meteorological Office |
| MoD | Ministry of Defence |
| NDA | Nuclear Decommissioning Authority |
| NEA | Nuclear Energy Agency (of the OECD) |
| NEAF | Nuclear Energy Arrangements Forum |
| NEPLG | Nuclear Emergency Planning Liaison Group |
| NGO | Non-Governmental Organisation |
| NIA | Nuclear Industrial Association |
| NIEA | Northern Ireland Environment Agency |
| NIRO | Nuclear Innovation and Research Office |
| NPP | Nuclear Power Plant |
| NRCC | Nuclear Resilience Coordination Committee |
| NRW | Natural Resources Wales |
| OECD | Organisation for Economic Co-operation and Development |
| OJEU | Official Journal of the European Union |
| ONR | Office for Nuclear Regulation (formerly the Nuclear Directorate of the HSE) |
| PAR (ONR) | Project Assessment Report |

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| PHE | Public Health England |
| PSA | Probabilistic Safety Analysis |
| PSR | Periodic Safety Review |
| PWR | Pressurised Water Reactor |
| RCIS (ONR) | Redgrave Court Incident Suite |
| REPPIR | Radiation (Emergency Preparedness and Public Information) Regulations 2001 |
| RIMNET | Radioactive Incident Monitoring Network |
| SAG | Severe Accident Guidelines |
| SAMG | Severe Accident Management Guidelines |
| SBERG | System Based Emergency Response Guidelines |
| SAP (ONR) | Safety Assessment Principle(s) (HSE) |
| SBO | Station Blackout |
| SEPA | Scottish Environment Protection Agency |
| STF | Stress Test Finding |
| TAG (ONR) | Technical Assessment Guide |
| US NRC | United States Nuclear Regulatory Commission |

Annex 1 – ONR Recommendations and Findings

Below is a list of the recommendations and findings from the CNI's Interim (Ref. 1), Final (Ref. 2) and stress test (Ref. 3) reports.

| Interim and Final recommendations | |
|--|--|
| International Arrangements for Response | <p>Recommendation IR-1: The Government should approach IAEA, in co-operation with others, to ensure that improved arrangements are in place for the dissemination of timely authoritative information relevant to a nuclear event anywhere in the world. <i>This information should include:</i></p> <p><i>a) basic data about the reactor design including reactor type, containment, thermal power, protection systems, operating history and condition of any nuclear materials such as spent fuel stored on the site should be held permanently in a central library maintained on behalf of the international community; and</i></p> <p><i>b) data on accident progression and the prognosis for future accident development. The operator would provide such information as is available to its national authorities. International mechanisms for communicating this information between national governments should be strengthened. To ensure that priority is given to relevant information, international agreement should be sought on the type of information that needs to be provided.</i></p> |
| Global Nuclear Safety | <p>Recommendation FR-9: The UK Government, nuclear industry and ONR should support international efforts to improve the process of review and implementation of IAEA and other relevant nuclear safety standards and initiatives in the light of the Fukushima-1 (Fukushima Dai-ichi) accident.</p> |
| National Emergency Response Arrangements | <p>Recommendation IR-2: The Government should consider carrying out a review of the Japanese response to the emergency to identify any lessons for UK public contingency planning for widespread emergencies, taking account of any social, cultural and organisational differences.</p> <p>Recommendation IR-3: The Nuclear Emergency Planning Liaison Group should instigate a review of the UK's national nuclear emergency arrangements in light of the experience of dealing with the prolonged Japanese event. <i>This information should include the practicability and effectiveness of the arrangements for extending countermeasures beyond the Detailed Emergency Planning Zone (DEPZ) in the event of more serious accidents.</i></p> <p>Recommendation FR-6: The nuclear industry with others should review available techniques for estimating radioactive source terms and undertake research to test the practicability of providing real-time information on the basic characteristics of radioactive releases to the environment to the responsible off-site authorities, taking account of the range of conditions that may exist on and off the site.</p> <p>Recommendation FR-7: The Government should review the adequacy of arrangements for environmental dose measurements and for predicting dispersion and public doses and environmental impacts, and to ensure that adequate up to date information is available to support decisions on emergency countermeasures.</p> |
| Planning Controls | <p>Recommendation FR-5: The relevant Government departments in England, Wales and Scotland should examine the adequacy of the existing system of planning controls for commercial and residential developments off the nuclear licensed site.</p> |
| Openness and Transparency | <p>Recommendation IR-4: Both the UK nuclear industry and ONR should consider ways of enhancing the drive to ensure more open, transparent and trusted communications, and relationships, with the public and other stakeholders.</p> <p>Recommendation FR-8: The Government should consider ensuring that the legislation for</p> |

Interim and Final recommendations

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| | <p>the new statutory body requires ONR to be open and transparent about its decision-making, so that it may clearly demonstrate to stakeholders its effective independence from bodies or organisations concerned with the promotion or utilisation of nuclear energy.</p> |
| Safety Assessment Approach | <p>Recommendation IR-5: Once further detailed information is available and studies are completed, ONR should undertake a formal review of the Safety Assessment Principles to determine whether any additional guidance is necessary in the light of the Fukushima accident, particularly for “cliff-edge” effects. <i>The review of ONR’s Safety Assessment Principles (SAP should also cover ONR’s Technical Assessment Guides (TAG), including external hazards.</i></p> |
| Emergency Response Arrangements and Exercises | <p>Recommendation IR-6: ONR should consider to what extent long-term severe accidents can and should be covered by the programme of emergency exercises overseen by the regulator.</p> <p><i>This should include:</i></p> <p><i>a) evaluation of how changes to exercise scenarios supported by longer exercise duration will permit exercising in real time such matters as hand-over arrangements, etc.;</i></p> <p><i>b) how automatic decisions taken to protect the public can be confirmed and supported by plant damage control data; and</i></p> <p><i>c) recommendations on what should be included in an appropriate UK exercise programme for testing nuclear emergency plans, with relevant guidance provided to Radiation (Emergency Preparedness and Public Information) Regulations 2001 (REPPiR) duty holders.</i></p> <p>Recommendation IR-7: ONR should review the arrangements for regulatory response to potential severe accidents in the UK to see whether more should be done to prepare for such very remote events.</p> <p><i>This should include:</i></p> <p><i>a) enhancing access during an accident to relevant, current plant data on the status of critical safety functions, i.e. the control of criticality, cooling and containment, and releases of radioactivity to the environment, as it would greatly improve ONR’s capability to provide independent advice to the authorities in the event of a severe accident; and</i></p> <p><i>b) review of the basic plant data needed by ONR – this has much in common with what we suggest should be held by an international organisation under Recommendation IR-1.</i></p> |
| Research | <p>Recommendation FR-10: ONR should expand its oversight of nuclear safety-related research to provide a strategic oversight of its availability in the UK as well as the availability of national expertise, in particular that needed to take forward lessons from Fukushima. Part of this will be to ensure that ONR has access to sufficient relevant expertise to fulfil its duties in relation to a major incident anywhere in the world.</p> |
| Off-site Infrastructure Resilience | <p>Recommendation IR-8: The UK nuclear industry should review the dependency of nuclear safety on off-site infrastructure in extreme conditions, and consider whether enhancements are necessary to sites’ self-sufficiency given for the reliability of the grid under such extreme circumstances.</p> <p><i>This should include:</i></p> <p><i>a) essential supplies such as food, water, conventional fuels, compressed gases and staff, as well as the safe off-site storage of any equipment that may be needed to support the site response to an accident; and</i></p> |

Interim and Final recommendations

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| | <p><i>b) timescales required to transfer supplies or equipment to site.</i></p> <p>Recommendation IR-9: Once further relevant information becomes available, the UK nuclear industry should review what lessons can be learnt from the comparison of the events at the Fukushima-1 (Fukushima Dai-ichi) and Fukushima-2 (Fukushima Dai-ni) sites.</p> |
| Impact of Natural Hazards | <p>Recommendation IR-10: The UK nuclear industry should initiate a review of flooding studies, including from tsunamis, in light of the Japanese experience, to confirm the design basis and margins for flooding at UK nuclear sites, and whether there is a need to improve further site-specific flood risk assessments as part of the periodic safety review programme, and for any new reactors. This should include sea-level protection.</p> |
| Multi-reactor Sites | <p>Recommendation IR-11: The UK nuclear industry should ensure that safety cases for new sites for multiple reactors adequately demonstrate the capability for dealing with multiple serious concurrent events induced by extreme off-site hazards.</p> |
| Spent Fuel Strategies | <p>Recommendation IR-12: The UK nuclear industry should ensure the adequacy of any new spent fuel strategies compared with the expectations in the Safety Assessment Principles of passive safety and good engineering practice.</p> <p><i>Existing licensees are expected to review their current spent fuel strategies as part of their periodic review processes and make any reasonably practicable improvements, noting that any intended changes need to take account of wider strategic factors including the implications for the nuclear fuel cycle.</i></p> |
| Site and Plant Layout | <p>Recommendation IR-13: The UK nuclear industry should review the plant and site layouts of existing plants and any proposed new designs to ensure that safety systems and their essential supplies and controls have adequate robustness against severe flooding and other extreme external events.</p> <p><i>This recommendation is related to Recommendation IR-25 and should be considered along with the provisions put in place under that recommendation. It should include, for example, the operator's capability to undertake repairs and the availability of spare parts and components.</i></p> |
| Fuel Pond Design | <p>Recommendation IR-14: The UK nuclear industry should ensure that the design of new spent fuel ponds close to reactors minimises the need for bottom penetrations and lines that are prone to siphoning faults. Any that are necessary should be as robust to faults as are the ponds themselves.</p> |
| Seismic Resilience | <p>Recommendation IR-15: Once detailed information becomes available on the performance of concrete, other structures and equipment, the UK nuclear industry should consider any implications for improved understanding of the relevant design and analyses.</p> <p><i>The industry focus on this recommendation should be on future studies regarding the continuing validation of methodologies for analysing the seismic performance of structures, systems and components important to safety. This should include concrete structures and those fabricated from other materials.</i></p> |
| Extreme External Events | <p>Recommendation IR-16: When considering the recommendations in this report the UK nuclear industry should consider them in the light of all extreme hazards, particularly for plant layout and design of safety-related plant.</p> <p>Recommendation FR-2: The UK nuclear industry should ensure that structures, systems and components needed for managing and controlling actions in response to an accident, including plant control rooms, on-site emergency control centres and offsite emergency centres, are adequately protected against hazards that could affect several</p> |

Interim and Final recommendations

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| | <p>simultaneously.</p> <p>Recommendation FR-3: Structures, systems and components needed for managing and controlling actions in response to an accident, including plant control rooms, onsite emergency control centres and off-site emergency centres, should be capable of operating adequately in the conditions, and for the duration, for which they could be needed, including possible severe accident conditions.</p> |
| Off-site Electricity Supplies | <p>Recommendation IR-17: The UK nuclear industry should undertake further work with the National Grid to establish the robustness and potential unavailability of off-site electrical supplies under severe hazard conditions.</p> |
| On-site Electricity Supplies | <p>Recommendation IR-18: The UK nuclear industry should review any need for the provision of additional, diverse means of providing robust sufficiently long-term independent electrical supplies on-sites, reflecting the loss of availability of off-site electrical supplies under severe conditions.</p> <p><i>This should be considered along with Recommendation IR-8 within the wider context of "on-site resilience".</i></p> |
| Cooling Supplies | <p>Recommendation IR-19: The UK nuclear industry should review the need for, and if required, the ability to provide longer term coolant supplies to nuclear sites in the UK in the event of a severe off-site disruption, considering whether further on-site supplies or greater off-site capability is needed. This relates to both carbon dioxide and fresh water supplies, and for existing and proposed new plants.</p> <p>Recommendation IR-20: The UK nuclear industry should review the site contingency plans for pond water make up under severe accident conditions to see whether they can and should be enhanced given the experience at Fukushima.</p> |
| Combustible Gases | <p>Recommendation IR-21: The UK nuclear industry should review the ventilation and venting routes for nuclear facilities where significant concentrations of combustible gases may be flowing or accumulating to determine whether more should be done to protect them.</p> |
| Emergency Control Centres, Instrumentation and Communications | <p>Recommendation IR-22: The UK nuclear industry should review the provision on-site of emergency control, instrumentation and communications in light of the circumstances of the Fukushima accident including long timescales, wide spread on and off-site disruption, and the environment on-site associated with a severe accident.</p> <p><i>In particular, the review should consider that the Fukushima-1 site was equipped with a seismically robust building housing the site emergency response centre which had: adequate provisions to ensure its habitability in the event of a radiological release; and communication facilities with on-site plant control rooms and external agencies, such as TEPCO headquarters in Tokyo.</i></p> <p>Recommendation IR-23: The UK nuclear industry, in conjunction with other organisations as necessary, should review the robustness of necessary off-site communications for severe accidents involving widespread disruption.</p> <p><i>In addition to impacting communications, it is possible that external events could also affect off-site centres used to support at site in an emergency. Alternative locations should be available and they should be capable of being commissioned in an appropriate timescale.</i></p> |
| Human Capabilities and Capacities | <p>Recommendation IR-24: The UK nuclear industry should review existing severe accident contingency arrangements and training, giving particular consideration to the physical, organisational, behavioural, emotional and cultural aspects for workers having to take actions on-site, especially over long periods. This should take account of the impact of</p> |

Interim and Final recommendations

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| | <p>using contractors for some aspects on-site such as maintenance and their possible response.</p> <p><i>This is a wide ranging recommendation and there are a number of aspects that need to be included:</i></p> <p><i>a) the reviews need to acknowledge design differences between individual nuclear facilities and consider whether corporate Severe Accident Guidelines need to be customised;</i></p> <p><i>b) adequacy of trained personnel numbers for long-term emergencies, particularly for multi-unit sites, and taking into account the potential impact of infrastructure damage and societal issues on the ability to mobilise large numbers of personnel;</i></p> <p><i>c) the time windows for availability of off-site support may be challenged hence the role of on-site personnel may change, which has implications for procedures and training;</i></p> <p><i>d) the review of Severe Accident Management Guidelines (SAMG) should consider not only critical safety functions prioritisation, but also whether and how SAMGs support any dynamic reprioritisation based on emerging information;</i></p> <p><i>e) consideration should also be given to operator support requirements relating to tactical and strategic decision making; and</i></p> <p><i>f) in addition to the acute phase of a severe accident, consideration also needs to be given to stabilisation, recovery and clean- up, and the personnel involved from the many organisations involved.</i></p> <p>Recommendation FR-11: The UK nuclear industry should continue to promote sustained high levels of safety culture amongst all its employees, making use of the National Skills Academy for Nuclear and other schemes that promote “nuclear professionalism”.</p> |
| <p>Safety Case</p> | <p>Recommendation IR-25: The UK nuclear industry should review, and if necessary extend, analysis of accident sequences for long-term severe accidents. This should identify appropriate repair and recovery strategies to the point at which a stable state is achieved, identifying any enhanced requirements for central stocks of equipment and logistical support.</p> <p><i>Recommendation IR-25 is linked with Recommendation IR-13. Combining these two recommendations means that we would expect industry to:</i></p> <p><i>a) identify potential strategies and contingency measures for dealing with situations in which the main lines of defence are lost. Considerations might include, for example, the operator's capability to undertake repairs and the availability of spares (capability includes the availability of personnel trained in the use of emergency equipment along with necessary supporting resources);</i></p> <p><i>b) consider the optimum location for emergency equipment, so as to limit the likelihood of it being damaged by any external event or the effects of a severe nuclear accident;</i></p> <p><i>c) consider the impact of potential initiating events on the utilisation of such equipment;</i></p> <p><i>d) consider the need for remotely controlled equipment including valves; and</i></p> <p><i>e) consider in the layout of the site effective segregation and bunding of areas where radioactive liquids from accident management may accumulate.</i></p> <p><i>Regarding other aspects of Recommendation IR-25, the industry needs to:</i></p> <p><i>f) ensure it has the capability to analyse severe accidents to properly inform and support</i></p> |

Interim and Final recommendations

on-site severe accident management actions and off-site emergency planning.

Further research and modelling development may be required;

g) ensure that sufficient severe accident analysis has been performed for all facilities with the potential for accidents with significant off-site consequences, in order to identify severe accident management and contingency measures. Such measures must be implemented where reasonably practicable and staff trained in their use; and

h) examine how the continued availability of sufficient on-site personnel can be ensured in severe accident situations, as well as considering how account can be taken of acute and chronic stress at both an individual and team level (this is linked to Recommendation IR-24).

Recommendation FR-1: All nuclear site licensees should give appropriate and consistent priority to completing Periodic Safety Reviews (PSR) to the required standards and timescales, and to implementing identified reasonably practicable plant improvements.

Recommendation FR-4: The nuclear industry should ensure that adequate Level 2 Probabilistic Safety Analyses (PSA) are provided for all nuclear facilities that could have accidents with significant off-site consequences and use the results to inform further consideration of severe accident management measures. The PSAs should consider a full range of external events including “beyond design basis” events and extended mission times

Annex 2 - Information Requested in the NACP Template

The UK is committed to ENSREG as the appropriate vehicle to advise the European Commission on matters of nuclear safety and radioactive waste management and with a goal of using existing resources effectively to promote enhancing standards for worldwide nuclear safety through continuous improvement, showing a clear commitment to openness and transparency.

Further activities from the updated ENSREG Action Plan for national regulators were:

- To consider the results of the peer review as they are published in the ENSREG main and updated country reports
- To develop and make public an updated national action plan associated with post-Fukushima lessons learned and stress test peer review recommendations and suggestions by the end of 2017.

Overview of UK National Action Plan

Clearly, the UK's Post Japanese Earthquake and Tsunami Implementation report (Ref. 5) covers this request and much more. As a consequence ONR considers that it would not be appropriate to present the full UK implementation report to ENSREG.

Instead, this report has been produced as a statement of UK Regulators Actions related to Post-Fukushima lessons learnt and stress test peer review recommendations and suggestions contained within the UK post Japanese earthquake and tsunami implementation plan. It has been prepared by abstracting relevant details from the UK implementation report which may be found via the ONR website (<http://www.onr.org.uk>) and represents progress made by ONR up to the end of November 2017.

The report has been prepared in accordance with the NAcP template issued by ENSREG in November 2012 (<http://www.ensreg.eu>) which requests that the National regulator considers presenting:

- Details of the process the regulator took to deliver the NAcP
- The national approach to monitoring and achieving compliance / resolution including regulatory structure and intervention
- State the proposed approach to transparency and public interaction

These requirements from ENSREG have been addressed and will be found in relevant sections within this report.

In addition to the work surrounding the ENSREG Stress Tests and the production of this report ONR is undertaking a wider programme of work that is based upon the UK Stress Tests and Chief Inspector's reports. ONR will continue to satisfy itself that these improvements are effectively implemented and will monitor and assess the adequacy of progress made by the industry over the longer term. On-going activity will be tracked and recorded until ONR is satisfied that the significant lessons learnt from the Fukushima event have been adequately discharged and will, if necessary, use its regulatory powers to ensure that reasonably practicable improvements are implemented. ONR will deliver and secure such oversight by embedding on-going "Fukushima learning" oversight activities into its operational regulatory programmes. This approach offers a number of distinct benefits in that it:

- Secures longer term oversight by ONR of improvements relating to the lessons learnt from the Fukushima event;
- Is both effective and efficient in terms of future use of regulatory resources;
- Ensures that, in the overall interests of nuclear safety, such improvements are delivered taking into account the relative significance of all activities on the site; and
- That such improvements are regulated, as appropriate, under the provisions of the licence conditions attached to each nuclear site licence.

Whilst ONR does not intend to produce further discrete Fukushima Implementation reports or Action Plans, it is committed to continuing to monitor and assess progress through normal business, to publish summary updates for stakeholders on our website and site stakeholder reports and to continue to advise government on the adequacy of progress made by the industry.

In the immediate aftermath of the Fukushima accident ONR and UK nuclear industry began work on identifying potential lessons that could be learned to enhance safety for UK nuclear power plants (and other nuclear installations). This work predated the European wide Stress Test process, with the CNI Interim Report (Ref. 1) being published mid-May 2011 and final report (Ref. 2) in September 2011. A strong focus of the work by licensees was to try and identify ways in which safety improvements could be implemented within a relatively short time, taking into account the longer timescales available at AGR sites which represent the majority of the UK NPPs. This strategy has been supported by ONR. As a result major efforts have been focussed on the provision, commissioning and demonstration of backup equipment and the means to deploy that backup equipment early in potential severe accident sequences or in the event of an extreme external hazard event. This remains a significant part of the planned Fukushima related enhancements but is by no means the totality.

The UK has taken a full and active role in the stress test process. Whilst many of the topics covered in the stress test work replicated those already contained in the UK specific reports (Refs 1 & 2, the stress test process has enabled further improvement measures to be considered in the UK and given confidence regarding the measures already identified.

This report has been presented under specific topics, and has been supplemented and updated where necessary to meet the guidance for the contents of this report. Many of the work items are inter-related and timescales for implementation are necessarily linked. The topics also have links to the wider recommendations and findings from the CNI Interim (Ref. 1) and Final (Ref. 2) Reports. Relevant interim recommendations (IRs) and final recommendations (FRs) are stated throughout the topic updates. The six topics are as follows:

Topic 1 – External Events (Section 1)

Topic 1 has been addressed by the licensees' submissions which provide their conclusions against the external hazard sections of the ENSREG stress test specification (Ref. 4). These were reported in ONR's National Report on stress tests (Ref. 3) which gave ONR's view on the adequacy of the licensees' submissions. Further progress to the end of November 2017 is reported here to reflect the steps made by ONR in ensuring that the findings from these reports are implemented.

Topic 2 – Design Issues (Section 1)

Topic 2 has been addressed by the licensees' submissions which provide their conclusions against progressive loss of electrical supplies and cooling capability irrespective of the initiating event and the severe accident progression sections of the ENSREG stress test specification (Ref. 4). These were reported in ONR's National Report on stress tests (Ref. 3), which gave

ONR's view on the adequacy of the licensees' submissions. Further progress to the end of November 2017 is reported here to reflect the steps made by ONR in ensuring that the findings from these reports are implemented.

Topic 3 – Severe Accident Management and Recovery (On-site) (Section 1)

Topic 3 has been addressed by the licensees' submissions which provide their conclusions against the severe accident management sections of the ENSREG stress test specification (Ref. 3). These were reported in ONR's National Report on stress tests (Ref. 4) which gave ONR's view on the adequacy of the licensees' submissions. This report systematically explored the organisational and management measures that are in place to deal with emergencies, including severe accidents, and identified areas where it may be beneficial to enhance current arrangements in order to mitigate consequences. The progress in enhancing the current arrangements to the end of November 2017 is described in this report.

Topic 4 – National Organisations (Section 2)

Topic 4 falls outside of the requirements of the ENSREG stress test specification but is specified in Ref 6. It has been addressed by obtaining additional information from UK government, regulators and licensees. Further, national organisations were considered within the CNI's reports on the Fukushima accident (Refs 1 and 2).

Topic 5 – Emergency Preparedness and Response and Post-accident Management (Off-site) (Section 2)

Topic 5 was addressed within the CNI's Final Report (Ref. 2) which considered the UK's response to a nuclear accident as well as the requirements of the responding organisations.

This topic has also been addressed by the licensees' submissions, which provide their conclusions against the severe accident management sections of the ENSREG stress test specification (Ref. 4). These were reported in ONR's National Report on stress tests (Ref. 3) which gave ONR's view on the adequacy of the licensees' submissions. This report systematically explored the organisational and management measures that are in place to deal with emergencies, including severe accidents, and identified areas where it may be beneficial to enhance current arrangements in order to mitigate consequences. The progress in enhancing the current arrangements to the end of November 2017 is described in this report.

Topic 6 – International Co-operation (Section 2)

This topic area falls outside of the requirements of the ENSREG stress test specification but is specified in Ref 6. It has been addressed by obtaining additional information from UK government, regulators and licensees. However, international co-operation required in the interest of nuclear safety was considered by the CNI's reports on the Fukushima accident (Refs 1 and 2).

These six topics cover the first two sections of this report with further sections on Additional Topics and Implementation of Activities. The first two sections and any additional topics cover aspects of design basis analysis, fault analysis, severe accident management, periodic safety review and continuous improvement. This aligns with both the ENSREG proposed document structure and with the recommendations and findings noted in Refs 1, 2 and 3.

Section 3 deals with topics that aren't specifically covered elsewhere in the document but still play an important part in the UK's National Action Plan in response to the events at Fukushima.

The Chief Inspector's reports (Refs 1 and 2) took a holistic approach to consider the whole nuclear sector and produced a number of Recommendations which have not been considered within the ENSREG specification and so are discussed in Section 3. These particular requests from ENSREG have been summarised below:

Process taken to deliver the NAcP. The NAcP has been produced by extracting information from key UK specific publications (Ref 1, 2, 3 & 5), updating this information where appropriate and presenting it in the order and manner requested by ENSREG. The NAcP report production has followed standard ONR processes for production and approval, as well as the established processes for the underlying technical assessment of licensee activities, and has been approved at the highest level by the Chief Inspector.

The National Approach to Monitoring Compliance. The national approach to monitoring compliance is described in the Implementation Report (Ref 5) and involves embedding the Fukushima related activities within ONR's operational programmes. This means that the required follow up work in monitoring compliance and ensuring on-site implementation effectively becomes part of normal business and dealings with the licensees. All on-going activity will be tracked and recorded until ONR is satisfied that that adequate implementation has been achieved. ONR is a goal setting, largely non-prescriptive regulator. This means that we expect the licensees to make proposals on how they intend to meet the required safety outcomes, and to justify why their proposal represents the safest reasonably practicable option for improvement. ONR may then challenge the basis for these proposals, and the associated timescales, to see if any more can be done that is reasonably practicable to reduce risks further. If we are not satisfied, ONR will require licensees to revisit the issue, undertake further work as appropriate, and provide further evidence to justify their proposals. In the event that ONR remains dissatisfied enforcement action will be taken to ensure an appropriate outcome.

Openness and Transparency The UK nuclear regulator has been developing its openness and transparency agenda for over a decade. ONR has stated that openness and transparency mean adopting a presumption of disclosure, and a specific work stream is in place to ensure more work is made publicly available. This report will be made publically available in addition to the Project Assessment Reports relating to this work that are available on the ONR website (<http://www.onr.org.uk>). The website is a key channel for ONR with regards to its commitment to being open and transparent. This report will form a part of these updates. Whilst ONR does not intend to produce further discrete Fukushima Implementation reports or Action Plans, it is committed to continuing to monitor and assess progress through normal business, to publish summary updates for stakeholders on our website and site stakeholder reports and to continue to advise government on the adequacy of progress made by the industry. There will be a published auditable trail on the resolution of all of the outstanding work items related to Fukushima lessons.

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