Westinghouse UK
AP1000 GENERIC DESIGN ASSESSMENT
Resolution Plan for GI-AP1000-CC-03
Consider and Action Plans to Address the Lessons Learnt from the Fukushima Event

MAIN ASSESSMENT AREA	RELATED ASSESSMENT AREA(S)	RESOLUTION PLAN REVISION	GDA ISSUE REVISION
Cross Cutting	All	2	2

GDA ISSUE:	Westinghouse are required to demonstrate how they will be taking account of the lessons learnt from the unprecedented events at Fukushima including those lessons and recommendations that are identified in the HM Chief Inspectors interim and final reports.
ACTION: GI-AP1000-CC-03.A1	Westinghouse to address the lessons learnt from their internal review following the Fukushima event relevant to GDA for the **AP1000®** plant. Evidence we expect to see provided to address this action includes: 1. Internal review summary report 2. A plan for the necessary actions arising from the internal review report 3. Modification of the following, as appropriate: a. Design Reference and SSERs b. Master Submission List documentation (Levels 1-3), including amendments to submission level 2 design information such as SDMs in accordance with GDA Issue GI-**AP1000**-CC-02 c. Resolution Plans in response to other relevant GDA Issues 4. Confirmation that any design changes resulting from these reviews for inclusion into GDA will be managed in accordance with the Westinghouse Level III Procedure Design Reference Point Change for GDA. UKP-GW-GAP-026 Revision 0. With agreement from the Regulators this action may be completed by alternative means.
ACTION: GI-AP1000-CC-03.A2	Westinghouse to address the lessons learnt that are relevant to GDA for the **AP1000** plant from HM Chief

	Inspector Nuclear Installations' interim and final reports. Evidence we expect to see provided to address this action includes: 1. A plan to address the relevant actions arising from HM Chief Inspector's interim and final report. 2. Modification of the following, as appropriate: a. Design Reference and SSERs b. Master Submission List documentation (Levels 1-3), including amendments to submission level 2 design information such as SDMs in accordance with GDA Issue GI-**AP1000**-CC-02 c. Resolution Plans in response to other relevant GDA Issues 3. Confirmation that any design changes resulting from these reviews for inclusion into GDA will be managed in accordance with the Westinghouse Level III Procedure Design Reference Point Change for GDA. UKP-GWGAP-026 Revision 0. With agreement from the Regulators this action may be completed by alternative means.
RELEVANT REFERENCE DOCUMENTATION RELATED TO GDA ISSUE	
Technical Queries	None
Regulatory Observations	None
Other Documentation	None

Scope of work :
Action 1 The **AP1000** plant design and its passive safety concepts have been developed considering catastrophic events which may lead to a complete and extended loss of power and infrastructure damage which could limit site accessibility. As a result, the **AP1000** plant design is very robust against these types of events. However, reviewing lessons learnt is a hallmark of the nuclear industry and inherent to the Westinghouse safety culture. Westinghouse, therefore, established an internal expert team to perform a comprehensive review of the **AP1000** plant design in light of the events at the Fukushima Daiichi nuclear power plant. The expert team was comprised of technical leaders from multi-disciplined Westinghouse engineering organisations including subject matter experts in safety system design, design for external hazards, plant layout, plant operations, probabilistic safety assessment, deterministic safety analyses, and design for severe accidents. The intent of the initial Westinghouse review was to challenge the plant's design and further

evaluate the performance of the **AP1000** plant design when subjected to extreme hazards such as those experienced at the Fukushima Dai-ichi site. The initial review was conducted with the best preliminary information available to Westinghouse at the time. The review team challenged the plant's design for combinations of scenarios involving extreme external hazards and loss of station power sources. Information from the initial reviews was utilised to generate summary assessments of **AP1000** plant design's ability to cope with station blackout events, arrangements for spent fuel pool cooling, and protection against external hazards. The review team also identified tasks, as described below, which required further assessment.

As more formalised information and recommendations have become available, the results of the initial internal evaluations have been reviewed, refined, and formalised to be able to respond to government and regulatory requests such as the recommendations presented in HM Chief Inspector Weightman's report and the requests from the European Commission. Based on the internal evaluations and review of industry and government recommendations, Westinghouse will identify if there are any reasonably practical enhancements that should be studied to determine if the enhancement should be incorporated into the design of the **AP1000** plant for the UK to further increase the plant's design margin against extreme events.

Following the events at Fukushima, the European Commission declared that "the safety of EU nuclear power plants should be reviewed on the basis of a comprehensive and transparent risk assessment" in the form of a "stress test". Driven by this recommendation, the European Nuclear Safety Regulators Group (ENSREG) developed the EU "Stress Test" specifications (Reference 1). While the stress test is mainly designed for applications to an operating plant, it does provide a framework under which a new plant design such as the **AP1000** plant can be 'stressed' to evaluate the robustness of the design. The stress test is defined as a targeted reassessment of the safety margins of nuclear power plants in light of the events which occurred at Fukushima: extreme natural events that challenge the plant safety functions and could lead to a severe accident.

Within the context of this resolution plan, Westinghouse believes the European Stress test provides an appropriate tool by which to present the results of the **AP1000** evaluation and inform the response to Chief Inspector Weightman's recommendations.

The **AP1000** plant assessment will consist of the following:

- An evaluation of the response of the **AP1000** nuclear power plant when facing a set of extreme situations as defined below in the description of work section.
- Verification of the preventative and mitigating measures chosen following a defence-in-depth logic: initiating events, consequential loss of safety functions, and severe accident management.

For the assessment of these extreme situations, sequential loss of the lines of defence will be assumed using a deterministic approach, irrespective of the probability of this loss. This approach allows for the evaluation of the levels of defence available following different external hazards, both within and beyond the design basis. The assessment will report on the response of the plant and on the effectiveness of the preventative measures. The assessment will aim to identify if there are any potential vulnerabilities for the considered extreme events in order to verify the robustness of the plant's defence-in-depth design and identify if there are any reasonably practical enhancements that could provide potential margin improvements.

The assessment will focus on the impact of such extreme events relative to maintaining the key plant safety functions of core cooling, containment integrity, and spent fuel pool cooling.

The focus of the technical scope of the **AP1000** plant stress test assessment will be placed on the following issues:

a. Initiating events
   - Earthquake
   - Flooding (not limited to a tsunami)
   - Combination of both
   - Other potential limiting external hazards

b. Consequences of loss of safety functions from initiating events considered in the standard plant design
   - Loss of electrical power, including station blackout (SBO)
   - Loss of ultimate heat sink (UHS)
   - Combination of both

c. Severe accident management issues
   - Means to protect from and to manage loss of core cooling functions
   - Means to protect from and to manage loss of cooling functions in the spent fuel pool
   - Means to protect containment integrity

The assessment will be performed for the UK **AP1000** design including the spent fuel pool. Unlike an operating nuclear facility, site and operator specific design aspects cannot be completely addressed in the stress test evaluation for the **AP1000** design, but generic considerations will be provided. These aspects include such items as site location, geography and topology, return period considered in the design basis for extreme events, site specific emergency responses facilities, and site specific flooding protection measures.

The evaluation will be performed assuming a single unit site while also describing the potential impacts of multiple units on the site. Westinghouse will formulate specific recommendations for the operation of multi-unit sites as appropriate; however, the presence of multiple **AP1000** units on the site should have limited impact on the evaluation since no equipment important to nuclear safety is shared between units on a multi-unit site. Potential impacts relate to items such as the evacuation of the site which cannot be fully evaluated until the site specific licensing phase. During site licensing, Westinghouse will work with the licensee to address potential site specific issues. Within GDA, Westinghouse demonstrated that there were a number of potential options for a future licensee to safely store spent fuel in the event that the spent fuel pool capacity is reached before a permanent national repository or storage facility is available.

This evaluation is documented in UKP-GW-GL-085 (Reference 2). The evaluation considers several potential options a licensee may choose to implement once removal of spent fuel from the spent fuel pool is necessary. The evaluation considers best available technology that currently exists and provides an overview of the technology. Detailed safety cases for long term storage of high level waste will be generated prior to implementation of a specific technology.

Such storage equipment will not be required until a reactor has been operation for more than 10 years. Such storage technology is very likely to evolve and improve prior to that time, and the current dry storage technology is already very robust against extreme events since air

cooling of the spent fuel removed from the fuel pool is typically sufficient.

As such, Westinghouse has excluded this topic from the evaluation being conducted as part of the resolution of this GDA Issue.

An evaluation of the European stress tests for the **AP1000** standard plant design is documented in EPS-GW-GRR-201 (Reference 3). This evaluation has been performed by Westinghouse within the framework of the European Passive Plant (EPP) program in cooperation with Ansaldo and the member utilities (RWE, EON, EDF, GDF-SUEZ, Vattenfall).

However, there is additional information that is not included in Reference 3 that needs to be discussed in order to meet the ONR expectations:

- The report presents a post-Fukushima evaluation for the **AP1000** standard plant design and does not reflect the UK specific design changes.
- The report does not use the UK safety classification.
- The report does not use the UK metrication unit convention.
- The report does not provide ALARP assessments of potential design modifications that could enhance the plant margin against extreme external events and consequential loss of electrical power / loss of ultimate heat sinks events. For example, it does not consider potential additional features to protect structures, systems, and components needed to deliver fundamental safety functions from beyond design basis flooding. The report has several open items which need to be closed out.

A comprehensive, standalone post-Fukushima response for the UK context (UKP-GW-GRR-201) will therefore be prepared to address the additional information required. The UK specific report will also include a better quantification of the margin for beyond design basis external events and the cliff edge levels. Finally, Westinghouse will undertake a comprehensive review of the International lessons learnt, guidance documents and relevant good practice, establish criteria to define the scope of documents most relevant for the UK context and the **AP1000** plant design, and include a discussion of the relevant documents in the report. For example, this discussion will:

1. Address the findings of the most recent ONR reports that are applicable to the GDA and to the **AP1000** plant. For example:
    - ONR, European Council “Stress Tests” for UK nuclear power plants National Final Report (Reference 5, note that this report is already discussed in the EPP report, but the discussion will be expanded for the UK-specific report)
    - ONR, “Stress Tests” for UK non-Power Generating Nuclear Facilities Final Report (Reference 6)
2. Describe the work performed to address the lessons learned from the Fukushima event for the current **AP1000** plant projects, in China and in the United States. For example, the report will discuss the work performed for the Nuclear Regulatory Commission (NRC) orders for the **AP1000** plant licensees in the United States.

Note that the European stress tests report also discusses the IAEA report on the “International Fact Finding Expert Mission of the Fukushima Dai-ichi NPP Accident Following the Great East Japan Earthquake and Tsunami” (Reference 4). This discussion will be maintained in the UK specific report and reviewed in light of the information now available.

References

1. European Nuclear Safety Regulation Group (ENSREG), "EU Stress Tests Specification," May 2011
2. UKP-GW-GL-085 Revision 0, "Long Term Storage of **AP1000** NPP ILW and Spent Fuel in the UK"
3. EPS-GW-GRR-201, Revision 2, "European Passive Plant Program - **AP1000** Plant Post-Fukushima Assessment"
4. International Atomic Energy Agency (IAEA), "International Fact Finding Expert Mission of the Fukushima Dai-ichi NPP Accident Following the Great East Japan Earthquake and Tsunami," May 24 June 2, 2011. *http://www-pub.iaea.org/MTCD/Meetings/PDFplus/2011/cn200/documentation/cn200_Final-Fukushima-Mission_Report.pdf*
5. ONR, "European Council 'Stress Tests' for UK Nuclear Power Plants, National Final Report," December 2011. *http://www.hse.gov.uk/nuclear/fukushima/stress-tests-301211.pdf*
6. ONR, "Stress Tests" for UK non-Power Generating Nuclear Facilities Final Report, May 2012 *http://www.onr.org.uk/fukushima/ngpf-report.pdf*

Action 2

Based on the conclusions drawn from the **AP1000** plant stress test evaluation and its supporting assessments, Westinghouse will generate a response for each of the applicable recommendations contained in HM Chief Inspector Nuclear Installations' interim and final reports. This response will be included in the UK specific report (UKP-GW-GRR-201) that will be transmitted in response to Action 1. Note that Reference 3 includes a high level discussion of the recommendations contained in HM Chief Inspector Nuclear Installations' interim and final reports. The extent of the Westinghouse response to the individual recommendations will vary based on the nature of the recommendations. Certain site specific or utility specific recommendations cannot be fully responded to within the context of the review being conducted as part of GDA.

Interim recommendations 8, 9, 13, 14, 16, 18, 20, and 21 relate to specific design aspects of a nuclear power plant. As such Westinghouse intends to be able to fully respond to these recommendations as part of this resolution plan. Interim recommendation 4 and final recommendations 6, 9, and 11 relate to organisational aspects of the nuclear industry in the UK. As such, Westinghouse will provide a response to these recommendations to indicate how Westinghouse actively supports such initiatives.

Interim recommendation numbers 10, 11, 12, 17, 19, 22, 24, and 25 and final recommendations 2 and 3 relate to both nuclear power plant design and site specific and operational aspects of a nuclear power plant. Within the context of this resolution plan, Westinghouse will provide a response for the recommendation as it relates to the UK **AP1000** plant design. The site specific and operational aspects, such as emergency planning, of these recommendations will be required to be responded to by a site licensee once a final site is selected. During site licensing, Westinghouse will interface closely with the site licensee to

assist in addressing these items to align their operational responses with the **AP1000** plant design.

Final recommendation 3 relating to the adequacy of the structures, systems and components needed for managing and controlling actions in response to an accident will only be partially addressed within GDA. The scope of work for GDA is limited to the general design control structures, systems and components.

Final recommendation 4 relating to ensuring that adequate Level 2 Probabilistic Safety Analysis (PSA) are provided will be addressed as part of the PSA review to address the existing PSA GDA issues and the development of the site specific PSA during site licensing and commissioning. A summary of the latest **AP1000** plant PSA (including the Level 2 PSA) will be included in the report, with references to the work performed to address the PSA GDA issues (GI-AP1000-PSA-01 and GI-AP1000-PSA-02). It should however be noted that external hazards PSA depends on site-specific characteristics. The discussions of external hazards PSA in the UK-specific Fukushima Response report will therefore be limited. A commitment already exists as a result of the Step 4 assessment for a future **AP1000** plant licensee to perform a full scope PSA.For the purpose of the **AP1000** standard plant review, interim recommendation 23 is not applicable. Recommendation 23 requires a review of the necessary off-site communications for severe accidents involving widespread disruption. This is an activity that requires a site licensee to develop and review offsite communication plans as part of their site emergency plans. The site emergency planning and communication facilities will be site specific and developed during the site licensing phase. During site licensing, Westinghouse will interface closely with the licensee to assist in addressing these items to align their operational responses with the **AP1000** plant design.

For interim recommendation 15 the specific lessons learned relative to the performance of concrete or other structures and equipment cannot be fully assessed until more specific information is made available for review by the industry. In general, the events at Fukushima demonstrate that the seismically designed structures performed their safety function when subjected to the initial earthquake and the follow on aftershocks even though the initial earthquake had higher peak ground acceleration than that included in the plants' design basis. Generically this lesson will be incorporated as part of the **AP1000** plant stress test evaluation. However, specific implications relevant to design and analysis of seismic structures and equipment will not be known for some time. Westinghouse will continue to follow these activities and assess the applicability of any future modifications to industry codes and standards which may occur as more information is gathered related to the performance of the seismically designed structures and equipment at Fukushima.

The table below summarises the applicability of both the interim and final recommendations as they relate to inclusion in the Westinghouse resolution plan and as described above.

Table 1: Applicability of Interim and Final Report Recommendations

Recommendations		Applicability
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.	Not Applicable Government Action
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.	Not Applicable Government Action
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.	Not Applicable Government Action
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.	Applicable
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.	Not Applicable ONR Action
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.	Not Applicable ONR Action
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.	Not Applicable ONR Action
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.	Applicable
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.	Applicable
IR-10	The UK nuclear industry should initiate a review of flooding studies, including from tsunamis, in light	Applicable to GDA

	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.	Design Scope
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.	Applicable to GDA Design Scope
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.	Applicable to GDA Design Scope
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.	Applicable
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.	Applicable
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.	Applicable
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.	Applicable
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.	Applicable to GDA Design Scope
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.	Applicable
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.	Applicable to GDA Design Scope

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.	Applicable
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.	Applicable
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.	Applicable to GDA Design Scope
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.	Not Applicable Future Site Licensee's Scope
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 using contractors for some aspects on-site such as maintenance and their possible response.	Applicable to GDA Design Scope
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.	Applicable to GDA Design Scope
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.	Not Applicable Future Site Licensee's Scope
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 off-site emergency centres, are adequately protected against hazards that could affect several simultaneously.	Applicable to GDA Design Scope
FR-3	Structures, systems and components needed for managing and controlling actions in response to an	Partially Applicable to

	accident, including plant control rooms, on-site 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.	GDA Design Scope
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.	Partially Applicable to GDA Design Scope
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.	Not Applicable Government Action
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.	Applicable
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.	Not Applicable Government Action
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.	Not Applicable Government Action
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.	Applicable
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.	Not Applicable ONR Action

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”.	Applicable
FR-12	Reports on the progress that has been made in responding to the recommendations in this report should be made available to ONR by June 2012. These should include the status of the plans, together with details of improvements that have been implemented by that time.	Applicable

Description of work :

The description of work below provides the Westinghouse action plan to address the defined GDA Issue. Information relative to the **AP1000** plant design's ability to cope with station blackout events, arrangements for spent fuel pool cooling, and response to external hazards is available on the Westinghouse's **AP1000** plant UK application website at the following address: https://www.ukap1000application.com/. The information is summarised in three separate reports that were generated as a result of the initial Westinghouse internal review.

Action 1

The **AP1000** plant stress test report will be prepared to align with the guidance in the EU Stress Test Specification.

The **AP1000** plant stress test report will provide an overview of the main characteristics of the design. This will include an overview of design basis site parameters, a description of the **AP1000** standard plant design features, and a summary of the **AP1000** plant probabilistic risk assessment scope and results. The standard plant design description will describe the design's approach to safety and discuss key safety systems that enable the design to meet its safety requirements.

The report will then evaluate the plant's design basis for both seismic and flooding events and examine if there are other limiting external hazards. The assessment for each will describe the plant's design basis relative to the hazard, the provisions in place to protect against the defined design basis hazard, and the plant's margin against either a defined beyond design basis seismic event or a defined beyond design basis flooding event. The report will also evaluate the plant's margin against a beyond design basis seismic event coincident with a beyond design basis flooding event.

The comprehensive review of the **AP1000** plant's seismic design will include an overview of the plant design basis including the level of design basis earthquake expressed in terms of peak ground acceleration (PGA), methodology for seismic classification, and seismic analysis.

For the **AP1000** plant design, a detailed seismic margin assessment has already been performed to identify potential vulnerabilities and demonstrate seismic margin beyond the design level safe shutdown earthquake. The capacity of the components required to bring the plant to a safe stable condition has been assessed and High Confidence of Low Probability of Failures (HCLPF) values have been determined for these components. The goal of the seismic margin assessment is to demonstrate that the plant HCLPF is at least 0.5g PGA. The report will provide an overview of this assessment.

Additionally, the Westinghouse review team determined it was prudent to extend this assessment to the spent fuel area since the previous assessments focused on the systems, structures, and components (SSC) required to protect the fuel in the reactor. Therefore, the assessment provided in the report will include HCLPF values for the SFP and surrounding SSCs. This includes the spent fuel pool and surrounding pools that provide passive makeup to the spent fuel pool when AC power is lost.

The Westinghouse review team also identified that a review of the passive safety systems' performance should be completed to assess the effects of potential degraded performance as a result of an extreme seismic event. The SSCs in the passive safety systems required to protect the core are included in the seismic margin assessment to demonstrate their resilience to beyond design basis seismic events. However, it is reasonable to assume that such an event could impact the systems' performance even if the seismic margin assessment

demonstrated high confidence that the SSCs would survive the event. Therefore, best estimate sensitivity assessments are being evaluated to examine various effects on passive system performance under degraded conditions.

There is no analogous existing margin evaluation for a flooding event that exceeds the plant's design basis in a manner such as the seismic margin assessment. However, as part of the Westinghouse evaluation, the design will be stressed to determine the effect of a flooding event that exceeds the design basis. Westinghouse will review the effects of flooding events that exceed the plant's design basis. These events will be reviewed to determine what the level of flooding is required to impact the key safety functions of core cooling, spent fuel cooling, and containment integrity.

The report will evaluate the plant's response to the loss of electrical power and loss of the ultimate heat sink. For each event, the different lines of defence that can be credited to maintain safe conditions will be identified. A range of plant operating modes will be considered as part of the evaluation. The purpose of this evaluation is to assess the robustness of the relevant systems, structures, and components (SSCs) and the effectiveness of the **AP1000** plant defence-in-depth concept.

Relative to loss of electrical power, the following two scenarios will be evaluated:

1. Loss of Offsite Power (LOOP) + Loss of normal back-up source: For the **AP1000** plant design, this scenario translates into the loss of the offsite AC power and the loss of the standby diesel generators.
2. LOOP + Loss of all back-up sources: For the **AP1000** plant design, this scenario translates into the loss of offsite AC power, the loss of the standby diesel generators, and the loss of the ancillary diesel generators.

For each of these situations (loss of electrical power and loss of the ultimate heat sink), the following type of information will be provided:

- Battery capacity and duration
- Design provisions for coping with the defined condition
- Duration the site can withstand a SBO/loss of ultimate heat sink without external support
- Actions required to prevent fuel damage and timeframe within which the actions must be taken
- Provisions for providing alternative power supplies.

Additionally, scenarios will be considered where all station power, both AC and DC, is compromised.

In the **AP1000** plant design, decay heat is transferred to the environment by means of a passive ultimate heat sink. On the reactor side, the primary means to remove heat from the core and containment is by the passive core cooling system (PXS) and passive containment cooling system (PCS) neither of which relies on external connections for an extended period of time. For the spent fuel pool, the Class 1 means of decay heat removal is by heating up and boiling off spent fuel pool water, the resulting steam is released to the atmosphere through a filtered vent path. For the purpose of this evaluation, the report will examine the effects of the loss of the plant's normal heat sink and potential failure modes related to SSCs that support the plant's passive heat removal capabilities. As part of the robustness evaluations, the assessment will define actions required for prolongation of the safety

functions beyond the design coping time.

Additionally, best estimate evaluations will be completed examining the effects of air only cooling for PCS. The evaluations will review the consequences of loss of PCS water cooling at various defined stages following an extreme event to determine the effect on containment pressurisation.

Regardless of the outcome of the evaluations of the events described above, the plant's severe accident management and mitigation features will be reviewed. Accident Management in the context of the **AP1000** plant evaluation is understood as severe accident management, i.e. mitigation of severe accident consequences, when the reactor core is already in an overheated state or when there is partial core melt or in the spent fuel pool there is fuel uncovered or some fuel damage. This includes evaluations of scenarios with the potential for hydrogen generation. The report will describe the plant design features specifically provided to mitigate a severe accident. The report will also discuss the Severe Accident Management Guidelines (SAMG) that have been generated for the standard design.

Based on the stress test evaluation, Westinghouse will identify if there are any reasonably practical enhancements that should be studied to determine if the enhancement should be incorporated into the design of the **AP1000** plant for the UK to further increase the plant's design margin against extreme events. If such margin enhancements are identified to be further considered, they will be documented in a separate lessons learnt report. The lessons learnt report will evaluate the feasibility of the potential margin enhancements. If the enhancements are deemed feasible and reasonably practical to implement, they will be incorporated into the design for the UK according to the Westinghouse design change process and in line with ONR's 6 step process for inclusion within GDA.

An evaluation of the European stress tests for the **AP1000** standard plant design is documented in EPS-GW-GRR-201. This evaluation has been performed by Westinghouse within the framework of the European Passive Plant (EPP) program in cooperation with Ansaldo and the member utilities (RWE, EON, EDF, GDF-SUEZ, Vattenfall). The EPP report addresses many of the actions identified in this resolution plan.

However, there is additional information that is not included in the EPP report that needs to be discussed in order to meet the ONR expectations:

- The report presents a post-Fukushima evaluation for the **AP1000** standard plant design and does not reflect the UK specific design changes.
- The report does not use the UK safety classification.
- The report does not use the UK metrication unit convention.
- The report does not provide ALARP assessments of potential design modifications that could enhance the plant margin against extreme external events and consequential loss of electrical power / loss of ultimate heat sinks events. For example, it does not consider potential additional features to protect structures, systems, and components needed to deliver fundamental safety functions from beyond design basis flooding.
- The report has several open items which need to be closed out.

A comprehensive, standalone post-Fukushima response for the UK context (UKP-GW-GRR-201) will therefore be prepared to address the additional information required. The UK specific report will also include a better quantification of the margin for beyond design basis external events and the cliff edge levels. Finally, Westinghouse will undertake a review of the International lessons learnt, guidance documents and relevant good practice, establish criteria

to define the scope of documents most relevant for the UK context and the **AP1000** plant design, and include a discussion of the relevant documents in the report. For example, this discussion will:

1. Address the findings of the most recent ONR reports that are applicable to the GDA and to the **AP1000** plant. For example:
   - ONR, European Council "Stress Tests" for UK nuclear power plants National Final Report, December 2011 *http://www.onr.org.uk/fukushima/stress-tests-301211.pdf (*note that this report is already discussed in the EPP report, but the discussion will be expanded for the UK-specific report)
   - ONR, "Stress Tests" for UK non-Power Generating Nuclear Facilities Final Report, May 2012 *http://www.onr.org.uk/fukushima/ngpf-report.pdf*
2. Describe the work performed since the issuance of the EPP report to address the Nuclear Regulatory Commission (NRC) orders for the **AP1000** plant licensees in the United States.

Note that the European stress tests report also discusses the IAEA report on the "International Fact Finding Expert Mission of the Fukushima Dai-ichi NPP Accident Following the Great East Japan Earthquake and Tsunami" (Reference 4). This discussion will be maintained in the UK specific report and reviewed in light of the information now available.

Action Response Summary

In summary, Westinghouse will provide a comprehensive assessment of the **AP1000** plant design in light of the events at Fukushima to address Action A1.1. The assessment will be presented in the framework of the European Stress test as outlined by ENSREG. In response to Action A1.2, Westinghouse will examine the results of the assessment to determine if there are any reasonably practical enhancements that could be incorporated into the plant's design to further increase the plant's safety margin. In response to Actions A1.3 and A1.4, any potential enhancement would be incorporated into the design for GDA per the defined process and modifications would be made to the appropriate documentation.

Action 2

As part of the **AP1000** plant stress test evaluation, Westinghouse will provide responses to each of the applicable recommendations identified above. These responses will be included in the UK specific report (UKP-GW-GRR-201) that will be transmitted in response to Action 1. Note that EPP report includes a high level discussion of the recommendations contained in HM Chief Inspector Nuclear Installations' interim and final reports. Where appropriate, the responses to the recommendations will utilise the conclusions and details contained within the stress test evaluation. Along with the conclusions generated as part of the stress test evaluation, Westinghouse will take into consideration each of the applicable recommendations when identifying if there are any reasonably practical design enhancements that could be implemented in the design to further enhance the plant's margin against extreme events.

The responses to IR-4, FR-6, FR-9, and FR-11 are not directly dependent on the results of the detailed Westinghouse **AP1000** plant post Fukushima assessment. As noted above these recommendations relate to organisational aspects of the nuclear industry in the UK and

Westinghouse will provide a response to these recommendations to indicate how Westinghouse actively supports such initiatives.

IR-8 is primarily related to a review of the sites self sufficiency. The **AP1000** plant is designed to be self sufficient for a period of 72 hours with no operator action and for a period of at least 7 days with limited actions following an accident. These coping times and the design features that enable these coping times will be reviewed in detail in response to this recommendation. The response to this recommendation will be closely linked to the evaluations of SBO conditions, loss of UHS, and survivability of SSCs when challenged by extreme external events.

IR-9 requests the industry to review the lessons that can be learnt by comparing the events at Fukushima-1 and Fukushima-2. A review of these events has been undertaken by the internal Westinghouse review team. The review will be used to support the response to this recommendation and to inform the overall conclusions for the assessment.

IR-10, IR-13, IR-15, IR-16, FR-2, and FR-3 are similar in the fact that the response to each will be informed by the detailed external hazards review. Though the conclusions from the entirety of the assessment will be important in informing the responses to these recommendations, the response to each recommendation will be closely linked to various aspects of the external hazards review. There are limitations in the evaluation of external hazards for a generic design. Indeed many site-specific features and parameters cannot be discussed in detail. More precisely, these include:

- The site characteristics, including the site location, geography and topology
- The methodology to evaluate the design basis external events and the adequacy of the design basis for external events, including the return period and the past events
- The potential impact of structures outside the standard plant (dams, dikes, potential for external explosions, etc) on the plant safety
- The site-specific protection measures and associated surveillance programs

Chapter 12 of the **AP1000** plant PCSR describes the design basis external hazards for the **AP1000** plant and provides a description of how they were addressed for the generic design. Similarly, the external hazards review that will be undertaken to address the lessons learnt from the Fukushima accident will be limited to generic design considerations. The scope of the review will be the naturally induced external hazards, in line with the guidance provided in the ENSREG Stress Tests Specification. The detailed evaluations for external hazards that will be presented in the post-Fukushima response report will focus on the potential effects from seismic and flooding hazards. The potential exists for other external natural hazards to challenge the safety of the plant. As part of the Westinghouse evaluation for the **AP1000** plant design, other potential external hazards will be reviewed to confirm that there was not another credible external natural hazard that could potentially challenge the safety of the plant in a more limiting manner than either an extreme seismic or flooding event. These other external natural hazards will include:

- Extreme ambient temperatures
- Meteorology
- Extreme wind and wind-driven missiles

IR-11 is focused on the potential simultaneous events to be occurring at different reactors on a common site. The **AP1000** plant design's GDA assessment has primarily been focused on

the design of a stand alone unit since no equipment important to safety is shared between units on a multi-unit site. As part of the totality of the assessment, Westinghouse may formulate specific recommendations for the operation of multi-unit sites; however, the detailed design assessment will focus on the performance of an individual unit when subjected to extreme events. Considerations for multi-unit sites will be important in development of the site emergency plan.

IR-12 focuses on strategies for protection and cooling of spent fuel. This is a key safety feature that will be examined in detail through each phase of the assessment. In line with the overall **AP1000** plant approach to safety, the spent fuel pool is designed to be protected using passive makeup. The response to this recommendation will be informed by the overall conclusion of the assessment as it related to spent fuel pool cooling and specifically the conclusions for the evaluation of SBO conditions and loss of UHS.

IR-14 also relates to spent fuel pool design, but it is very specific to with respect to penetrations into the pool. In the **AP1000** plant design, penetrations into the pool or surrounding pools near or below the spent fuel are seismically designed. The number, location, and design of these penetrations will be reviewed in response to this recommendation to determine if any ALARP improvements are feasible.

IR-17 and IR-18 relate to electrical supplies for the plant. The responses to these recommendations will build on the conclusions from the evaluations of LOOP and SBO conditions. The response to IR-17 will review the designs sensitivity to the assumed frequency of loss of grid connection.

IR-19 and IR-20 relate to cooling supplies for core cooling, containment cooling, and spent fuel cooling. The responses to these recommendations will be informed by the overall conclusion of the assessment, and it will be specifically supported by the evaluation of SBO conditions and loss of UHS.

IR-21 relates to the venting of combustible gases. The **AP1000** plant design has design features to prevent the build up of combustible gases and defined vent routes for scenarios where these features fail. The response to this recommendation will review these features. The response to this recommendation will be informed by the overall conclusions of the assessment, and it will be specially supported by the evaluation of SBO conditions, loss of UHS, and severe accident review.

IR-22 relates to the design of emergency control facilities. The emergency control centre will be a site specific design for the UK. For the purpose of this resolution plan, the focus of this response will be on control and communication capabilities and instrumentation availability following an extreme event.

IR-24 and IR-25 relate to design and operation capabilities following extreme events and during severe accidents. The responses to these recommendations will be informed by the overall conclusions of the assessment, and they will be specially supported by the severe accident review.

FR-3 relating to the adequacy of the structures, systems and components needed for managing and controlling actions in response to an accident will only be partially addressed within GDA. The scope of work for GDA is limited to the generic design control structures, systems and components, as described in the GDA design reference point (UKP-GW-GL-060) and in the Chapter 19 of the PCSR.

FR-4 relating to ensuring that adequate Level 2 Probabilistic Safety Analysis (PSA) are provided will be addressed as part of the PSA review to address the existing PSA GDA Issues

and the development of the site specific PSA during site licensing and commissioning. A summary of the latest **AP1000** plant PSA (including the Level 2 PSA) will be included in the report, with references to the work performed to address the PSA GDA issues (GI-AP1000-PSA-01 and GI-AP1000-PSA-02). It should however be noted that external hazards PSA depends on site-specific characteristics. The discussions of external hazards PSA in the UK-specific Fukushima Response report will therefore be limited. A commitment already exists as a result of the Step 4 assessment for a future **AP1000** plant licensee to perform a full scope PSA.

In response to FR-12, Westinghouse will describe the progress that has been made in responding to the recommendations within the UK specific report.

Action Response Summary

In summary, Westinghouse will utilise the comprehensive assessment generated in response to Action 1 to inform the response to each applicable recommendation for HM Chief Inspector Weightman's reports as requested in response to Action A2.1. The recommendation responses will be documented as part of the assessment report (UKP-GW-GRR-201). In response to Action A2.2, Westinghouse will examine the responses to the recommendations to determine if there are any reasonably practical enhancements that could be incorporated into the plant's design to further increase the plant's safety margin. Per action A2.3, any potential enhancement would be incorporated into the design for GDA per the defined process and modifications would be made to the appropriate documentation.

The interdependcies of the Fukushima evaluation of the **AP1000** plant with the interdependent GDA Issues identified below will be assed per the defined process for incorporating design changes. The Westinghouse personnel that will lead the resolution of interdependent GDA Issues will be informed regularly of the progress and results of the Fukushima evaluation performed to address the CC-03 GDA Issue. Additionally, reviews of potential impacts have been incorporated into the integrated schedule for each interdependent GDA Issue listed below.

- GI-**AP1000-**CI-02 on DAS Adequacy of Architecture
- GI-**AP1000**-CI-03 on Diversity between PMS (CIM) and DAS
- GI-**AP1000**-CI-10 on Class 1 Displays and Controls
- GI-**AP1000**-CE-01 on Justification of Novel Form of Structure for the Steel/ Concrete Composite Walls and Floors known as CA Modules
- GI-**AP1000**-CE-02 on Further Justification of Novel Form of Structure for Steel / Concrete Composite Wall to the Enhanced Shield Building
- GI-**AP1000**-CE-03 on AP1000 Material Standards and Material Specifications
- GI-**AP1000**-CE-04 on Fuel Handling Area Secondary Containment Leak Detection and Collection System
- GI-**AP1000**-EE-01 on PCSR Presentation of Claims, Arguments and Evidence
- GI-**AP1000**-FS-01 on Spent Fuel Safety Case
- GI-**AP1000**-FS-03 on Diversity for Frequent Faults
- GI-**AP1000**-FS-06 on IRWST Cooling Function for the PRHR
- GI-**AP1000**-FS-07 on Safety Case for Shutdown Faults

- GI-**AP1000**-FS-08 on Fault Schedule for AP1000
- GI-**AP1000**-IH-01 on Internal fire Safety Case Substantiation
- GI-**AP1000**-IH-02 on Internal Flooding Safety Case
- GI-**AP1000**-IH-03 on Pressure Part Failure
- GI-**AP1000**-IH-04 on Internal Explosion Safety Case Substantiation
- GI-**AP1000**-IH-05 on Internal Missile Safety Case
- GI-**AP1000**-PSA-01 on Success Criteria
- GI-**AP1000**-PSA-02 on Fire PSA
- GI-**AP1000**-RP-01 on Spent Fuel Pool Criticality Safety Case

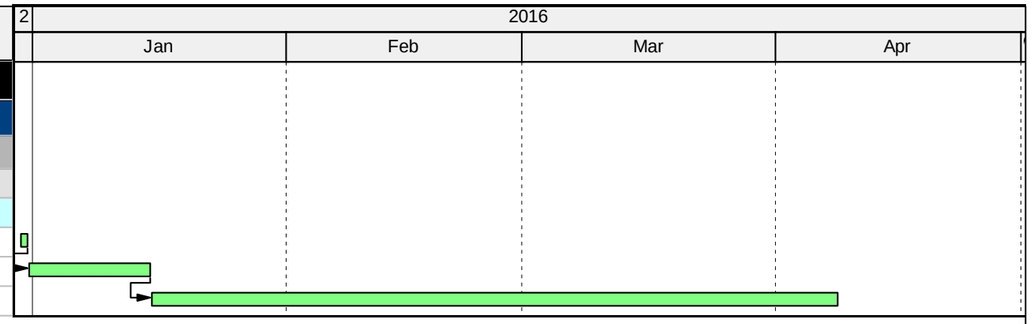
Summary of Deliverables

- UKP-GW-GGR-201: this report will document the comprehensive, standalone post-Fukushima response for the UK context, as described in the description of the work for Actions 1 & 2.
- Margin Enhancements Design Change Proposals: if ALARP margin enhancements design modifications are identified to be applicable to all plants, the design change proposals documenting these changes will be submitted.
- Safety Submission Documentation; a markup of the relevant sections of the Safety, Security and Environment reports (SSERs) will be provided that will document the proposed changes to the SSERs based on the conclusions of the post-Fukushima response.

Schedule/ programme milestones :

Please see the following page for the schedule.

#	Activity Name
1	**UK Generic Design Assessment (GDA) Resolution Plans (51)**
2	**CROSS CUTTING**
3	**CC.03 Fukushima Lessons Learnt**
4	**CC.03 UK Fukushima Assessment Report Finalization**
5	**CC.03 UK Fukushima Assessment Report**
6	Submit UK Specific Stress Test Report (UKP-GW-GGR-201) & Response to Reccommendations to ONR/EA
7	UK Specific Stress Test Report (UKP-GW-GGR-201)-Present to ONR/EA
8	UK Specific Stress Test Report (UKP-GW-GGR-201)-ONR & EA Review of Submittal



Methodology:

Action 1

As described above, the Westinghouse assessment of **AP1000** plant performance in light of the events at Fukushima Dai-ichi will be documented according to the specification provided by ENSREG and the EU Commission. The detailed evaluation of the extreme events will follow a step wise approach that examines the consequences of losses of defined levels of defence. Regardless of the probability of occurrence, each scenario will be evaluated to determine the multitude of safety features that must be defeated before core or spent fuel damage occurs. Assuming a severe accident has occurred, the report will describe the design features and guidance provided to mitigate the consequences of such an event.

Westinghouse will utilise the outcomes of the evaluation to determine if there are any reasonably practical enhancements that could be made to further enhance the plant design margin against extreme events.

If reasonably practical enhancements are identified as a result of the evaluation, Westinghouse will manage the incorporation of these enhancements into the design in accordance with the Westinghouse Level III Procedure Design Reference Point Change for GDA. This will include identification of the appropriate modifications, as applicable, to the design reference point, safety security and environmental reports, and master submission list documentation. Additionally, Westinghouse will review the results of this resolution plan to determine whether its conclusions have an effect on the resolution of other GDA Issues.

Action 2

The methodology for responding to the recommendations in HM Chief Inspector's final report is based on developing responses to the recommendations using the conclusions and insights gained from completing the stress test evaluation described in response to Action 1. To reiterate what is stated in response to Action 1, Westinghouse will manage the incorporation of any enhancements stemming from the response to these recommendations into the design in accordance with the Westinghouse Level III Procedure Design Reference Point Change for GDA. This will include identification of the appropriate modifications, as applicable, to the PCSR, Environmental Report and its supporting documents, design reference point, and master submission list documentation. Additionally, Westinghouse will review the results of this resolution plan to determine whether its conclusions have an effect on the resolution of other GDA Issues.

Justification of adequacy:

The description of work outlined above aligns with the scope of work contained in the GDA Issue action. The Westinghouse resolution of this action is based on following an accepted European industry guidance document, and the UK **AP1000** plant stress test report and response to HM Chief Inspectors final report will be generated and reviewed by a team of suitably qualified and experienced personnel.

The plan outlined to address Action 1 and Action 2 builds on the initial Westinghouse internal reviews and aligns with the guidance developed by the European regulators and utilities following the events at Fukushima. The Westinghouse response plan is consistent with the stress test reports being generated by other nuclear plant operators in Europe. The plan is

based on the specification provided by the European Nuclear Safety Regulators Group, which has been endorsed by the European Commission. This assessment will then be utilised to generate a response to the recommendations contained in HM Chief Inspectors final report.

The UK **AP1000** plant stress test report will be thoroughly reviewed by an array of Westinghouse subject matter experts. Contributions to the report will be provided from personnel with expertise in safety system design, design for external hazards, plant layout, plant operations, probabilistic safety assessment, deterministic safety analyses, and design for severe accidents.

The report will receive executive review from the Westinghouse Vice President and Chief Technologist of New Plant Technology. These levels of internal review provide confidence in the thoroughness of the report and assurance in the integration of the multiple disciplines required to generate such an evaluation.

The standard **AP1000** plant stress test evaluation (EPS-GW-GRR-201), which will serve as the basis for the UK specific evaluation, has been further independently reviewed with experts from European utilities involved in the Westinghouse European Passive Plant Program.

Impact assessment

The following documents will be updated as appropriate:

- Pre-Construction Safety Report and its supporting documents
- Environmental Report and its supporting documents
- Conceptual Security Arrangements
- Design Reference Point
- Master Submission List
- Roadmap

The impact on other GDA Issue Resolution Plans will also be reviewed and actioned as appropriate.