Westinghouse UK
AP1000® GENERIC DESIGN ASSESSMENT
Resolution Plan for GI-AP1000-PSA-02
Fire PSA

MAIN ASSESSMENT AREA	RELATED ASSESSMENT AREA(S)	RESOLUTION PLAN REVISION	GDA ISSUE REVISION
PSA	Internal Hazards	1	0

GDA ISSUE:	From the GDA assessment of the **AP1000®** PSA it cannot be concluded that the current prediction of internal fire risk is representative for the **AP1000** design. This leaves ONR with a lack of understanding of the potential gap between the current estimated **AP1000** risk associated with internal fires, and the **AP1000** fire risk based on an up-to-date, realistic and complete evaluation. Since the current prediction of the fire Core Damage Frequency (CDF) is 5E-08/yr (approx 25% of the overall CDF) the uncertainty in the fire risk translates directly into uncertainty in the overall plant risk. Therefore a modern standards Fire PSA should be developed for the **AP1000** design to close this gap.
ACTION: GI-AP1000-PSA-02.A1	Westinghouse should provide the final approved procedure (Guidebook) established to guide the development of Fire PSA for the **AP1000** PSA. With agreement from the Regulator this action may be completed by alternative means.
ACTION: GI-AP1000-PSA-02.A2	Westinghouse should provide detailed information on the Database/s established / selected to be used to support the Fire PSA. The database/s should be populated with up-to-date design information. Example of information expected to be found in the database/s selected or developed to support the Fire PSA include: • List of fire PSA components and failure modes. • Circuit analysis, cable selection and routing process (with identification of uncertainties). • Physical characteristics of the fire compartments and their inventories, barriers and penetrations, ignition sources, transient combustibles, etc. • Equipment & power supplies location. Data on relevant fire events in other NPPs. A database of assumptions should also be developed. This should provide clarity on: • General assumptions of the fire PSA analysis. • The type of assumptions (related to design, operation, fire impact, etc).

	• Specific information on those assumptions that are not yet substantiated in specific design documentation. • Pointers to the area of the Fire PSA where the specific assumptions are used. It is expected that the assumptions database (updated as appropriate) should feature in most of the deliverables for relevant GDA Issue Actions. With agreement from the Regulator this action may be completed by alternative means.
ACTION: GI-AP1000-PSA-02.A3	Westinghouse should provide information (including a programme of work) of the modifications to the internal events PSA model required to support the development of the Fire PSA. This should address the following: • Updates to the internal events PSA model and data to comply with Westinghouse's PSA Guidebooks which are required to support the development of the Fire PSA. • Updates to the internal events PSA model and data to address relevant findings from ONR's review of the **AP1000** PSA during GDA, which are required to support the development of the Fire PSA. This should include completion of the list of Initiating Events and associated models as required. • Specific changes to the internal events PSA required by the Fire PSA itself. With agreement from the Regulator this action may be completed by alternative means.
ACTION: GI-AP1000-PSA-02.A4	Westinghouse should provide detailed documentation of any qualitative screening of fire compartments including the screening criteria used and assumptions made. With agreement from the Regulator this action may be completed by alternative means.
ACTION: GI-AP1000-PSA-02.A5	Westinghouse should undertake and document thoroughly an evaluation of Hot Shorts that could impact the risk associated to internal fires. ONR would expect Westinghouse to convene an expert panel to address single and multiple spurious actuation issues which may impact one or more safety functions (Note this would also be a requirement to support a modern deterministic safe shutdown analysis; albeit extended to address additional systems considered within the fire PSA). With agreement from the Regulator this action may be completed by alternative means.

ACTION: GI-AP1000-PSA-02.A6	Westinghouse should provide detailed documentation on the Evaluation of Fire frequencies. With agreement from the Regulator this action may be completed by alternative means.
ACTION: GI-AP1000-PSA-02.A7	Westinghouse should provide detailed documentation of any quantitative screening of fire compartments including the screening criteria used. With agreement from the Regulator this action may be completed by alternative means.
ACTION: GI-AP1000-PSA-02.A8	Westinghouse should provide fire progression event trees (or equivalent) for all compartments screened in accompanied by detailed documentation of fire impact in each compartment and details of all the fire scenarios identified. • Details of any fire modelling undertaken to support this task should also be included. • The identification of the most onerous Initiating Event for each fire scenario should be clearly documented. With agreement from the Regulator this action may be completed by alternative means.
ACTION: GI-AP1000-PSA-02.A9	Westinghouse should provide documented evaluation of the reliability of the fire protection measures claimed (e.g. PSA models for fire protection systems claimed and human reliability analyses as appropriate). With agreement from the Regulator this action may be completed by alternative means.
ACTION: GI-AP1000-PSA-02.A10	Westinghouse should provide documented evaluation of the inter-compartment fire propagation. Fire progression event trees for all relevant multi-compartment fires and details of any fire modelling undertaken to support this task should also be included as per Action 08. With agreement from the Regulator this action may be completed by alternative means.
ACTION: GI-AP1000-PSA-02.A11	Westinghouse should provide documented re-evaluation of the Human Reliability Analysis for all the fire scenarios identified. The effects of the fire, both direct (e.g. the need to evacuate the control room) and indirect (e.g. confusing information resulting from spurious indications, impact of smoke), on operator actions have to be considered. With agreement from the Regulator this action may be completed by alternative means.
ACTION: GI-AP1000-PSA-02.A12	Westinghouse should provide a documented Fire PSA model in CAFTA together with the results of the CDF

	quantification and evaluation of the results. With agreement from the Regulator this action may be completed by alternative means.
ACTION: GI-AP1000-PSA-02.A13	Westinghouse should provide an estimation of the Large Release Frequency associated with internal fires. With agreement from the Regulator this action may be completed by alternative means.
ACTION: GI-AP1000-PSA-02.A14	Westinghouse should provide the complete fire PSA documentation and ALARP assessment. With agreement from the Regulator this action may be completed by alternative means.
ACTION: GI-AP1000-PSA-02.A15	Westinghouse should develop and provide a Living PSA procedure to allow the Fire PSA to be updated as further design information becomes available and when the Internal Events PSA evolves in a way that may impact the Fire PSA. With agreement from the Regulator this action may be completed by alternative means.
RELEVANT REFERENCE DOCUMENTATION RELATED TO GDA ISSUE	
Technical Queries	
Regulatory Observations	
Other Documentation	

Scope of work:
The current **AP1000** plant fire PSA was based on the EPRI FIVE methodology, which was published in 1992. In 2005, EPRI and the NRC published a much more rigorous and comprehensive fire PSA methodology, NUREG/CR-6850. Application of this new methodology at legacy plants has resulted in higher, often significantly higher, calculations of fire-induced CDF and LERF. As a result, the ONR is concerned that that the current **AP1000** plant fire PSA may not be an accurate representation of fire risk. This concern is especially acute since fire risk comprises about 25% of overall **AP1000** plant risk, so there is some potential to change the overall risk profile of the plant design when a modern fire PSA is developed. To resolve this issue, Westinghouse will develop a detailed fire PSA using the NUREG/CR-6850 methodology.

Description of work:
The fire PSA development will consist of the 16 tasks identified in NUREG/CR-6850. A high level description of each task is provided below. *Task 1 Plant Boundary Definition and Partitioning* – This task will first define the Global Plant Analysis Boundary (GPAB), which encompasses all areas on the site with the

potential to contribute visibly to fire risk. The GPAB is then subdivided into fire compartments, which will serve as the basic physical analysis units for the fire PSA.

Task 2 Component Selection – This task primarily identifies the initiators, sequences, components, and failure modes to be modeled by the fire PSA. Component selection starts with a review of the internal events PSA. It is followed by a series of additional reviews (e.g., reconciliation with fire safe shutdown analysis, multiple spurious operations review, etc.) aimed at identifying fire risk-relevant failures that may not have been captured by the internal events model.

Task 3 Cable Selection – This task identifies all cables, and their corresponding routing through the plant, whose fire-induced failure could affect equipment on the fire PSA component list.

Task 4 Qualitative Screening – This task screens fire compartments from further consideration based on the following criteria:

1) Fire originating within the compartment will not cause a reactor trip (either automatic, manual, or forced shutdown), and
2) Fire originating within the compartment will not affect fire PSA components or cables.

Task 5 Fire-Induced CCDP and CLRP Models - This task develops a model and quantification process for determining fire-induced Conditional Core Damage Probabilities (CCDPs) and Conditional Large Release Probabilities (CLRPs). The task starts with modification of the internal events one top fault tree to capture potentially fire risk-relevant failures not included in the internal events analysis. The task then develops a quantification process for calculating scenario CCDPs and CLRPS using the EPRI FRANX software.

Task 6 Ignition Frequency – This task first identifies each credible ignition source within the global plant analysis boundary. Then, fire frequencies for each ignition source and each fire compartment are calculated.

Task 7 Quantitative Screening – This task uses quantitative criteria to screen low risk fire compartments from further consideration. Note that a new, and more stringent, set of quantitative screening criteria than those used by legacy plants will be applied to the **AP1000** plant fire PSA. Use of a more stringent screening criteria is to avoid screening too many fire compartments based on the **AP1000** plant's inherently low fire risk, as compared to legacy plants.

Task 8 Scoping Fire Modelling – This task allows the analyst to screen out a fraction of fire frequency that is not anticipated to cause damage beyond the ignition source itself. Note that this approach has had minimal benefit at legacy plants due to the general proximity of ignition sources and targets. For this reason, the limited availability of detailed source-target geometric data for a pre-operational plant, and the expectation that most fire compartments will not require refinement beyond the "full room burnup" approach, it is anticipated that scoping fire modeling will be applied in very limited circumstances, if at all, for the **AP1000** plant fire PSA.

Task 9 Detailed Circuit Analysis - In the cable selection task, all cables associated with a particular component may be assumed to fail all basic events associated with that component. This assumption may be identified during quantification of the initial fire PSA as too conservative for specific components. For those components, this task performs a detailed review of circuit and cable documentation to identify the specific cables that will cause the specific failures of concern.

Task 10 Circuit Failure Likelihood Analysis - In earlier tasks, if a cable were damaged by a particular fire scenario, the BEs associated with that cable were set TRUE during quantification. This task develops and applies a conditional probability that, if a cable is damaged by fire, a hot short will occur on any specific cable of concern. It is applied primarily to refine fire CDF and LRF associated with risk significant fire-induced spurious operations.

Task 11 Detailed Fire Modelling – This effort consists of three sub-tasks: 1) Single Compartment Analysis, 2) Multi-Compartment Analysis, and 3) Main Control Room Analysis. The single compartment analysis refines the initial "full room burnup" quantification by subdividing each selected compartment into individual fire scenarios. The multi-compartment analysis assesses risk associated with fires originating in one compartment and propagating to an adjacent compartment. The Main Control Room analysis assesses risk associated with fires originating inside the control room, including the risk contribution of both abandonment and non-abandonment scenarios.

Task 12 Fire Human Reliability Analysis – This task starts with identifying Human Failure Events (HFEs) to include in the fire PSA, which generally includes all HFEs from the internal events model required to mitigate fire-induced initiators as well as a limited set of new HFEs developed specifically for fire. Then, Human Error Probabilities (HEPs) are calculated based on the potential fire-induced impact on the performance shaping factors (e.g., cues, stress, travel path, etc.) associated with each HFE. Finally, a recovery rule process is developed to apply each relevant HFE to the fire cutsets.

Task 13 Seismic Fire Risk Assessment - This task includes a qualitative evaluation of seismically-induced fires, seismic degradation of fire suppression equipment, and seismic actuation of fire suppression systems.

Task 14 Quantification – This task quantifies the fire-induced CDF and LRF for each fire scenario developed in previous steps. The fire PSA results, including significant fire risk contributors and fire risk insights, are identified and documented in accordance with the Section IV FQ requirements of ASME/ANS RA-Sa-2009.

Task 15 Uncertainty and Sensitivity Analysis – This task performs a fire PSA uncertainty analysis to the extent afforded by current technology. It begins with identification of all potentially significant sources of uncertainty. Then, each source is assessed using for example, propagation of probability distributions using a Monte Carlo sampling technique, performance of a sensitivity study by varying the value of certain parameters and re-quantifying the model, or simply performing a qualitative assessment. Finally, insights are documented and model refinements are made, if necessary, to minimise significant sources of uncertainty.

Task 16 Configuration Control Procedure – This task will develop a procedure for the long-term configuration control of the fire PSA. This procedure will ensure that future changes to the plant design, operating strategies, and fire PSA methodology are incorporated into the fire PSA.

A mapping of the ONR Action Items for this Issue to the above planned fire PSA tasks is included below:

- GI-**AP1000**-PSA-02.A1 – This action item is already complete.
- GI-**AP1000**-PSA-02.A2 – Broad action, with elements of Tasks 1-15
- GI-**AP1000**-PSA-02.A3 – Corresponds to Tasks 2 and 5
- GI-**AP1000**-PSA-02.A4 – Corresponds to Task 4
- GI-**AP1000**-PSA-02.A5 – Corresponds to Tasks 3, 9, and 10
- GI-**AP1000**-PSA-02.A6 – Corresponds to Task 6
- GI-**AP1000**-PSA-02.A7 – Corresponds to Task 7
- GI-**AP1000**-PSA-02.A8 – Corresponds to Tasks 11 and 14
- GI-**AP1000**-PSA-02.A9 – Corresponds to Task 11
- GI-**AP1000**-PSA-02.A10 – Corresponds to Task 11
- GI-**AP1000**-PSA-02.A11 – Corresponds to Task 12
- GI-**AP1000**-PSA-02.A12 – Corresponds to Task 14
- GI-**AP1000**-PSA-02.A13 – Corresponds to Task 14
- GI-**AP1000**-PSA-02.A14 – Corresponds to Task 1-15
- GI-**AP1000**-PSA-02.A15 – Corresponds to Task 16

Schedule/ programme milestones:

This effort will result in 4 deliverables:

APP-PRA-GSC-XX1 – Fire Scenario Development Report
Includes Tasks 1, 6, 8, 11, and 16

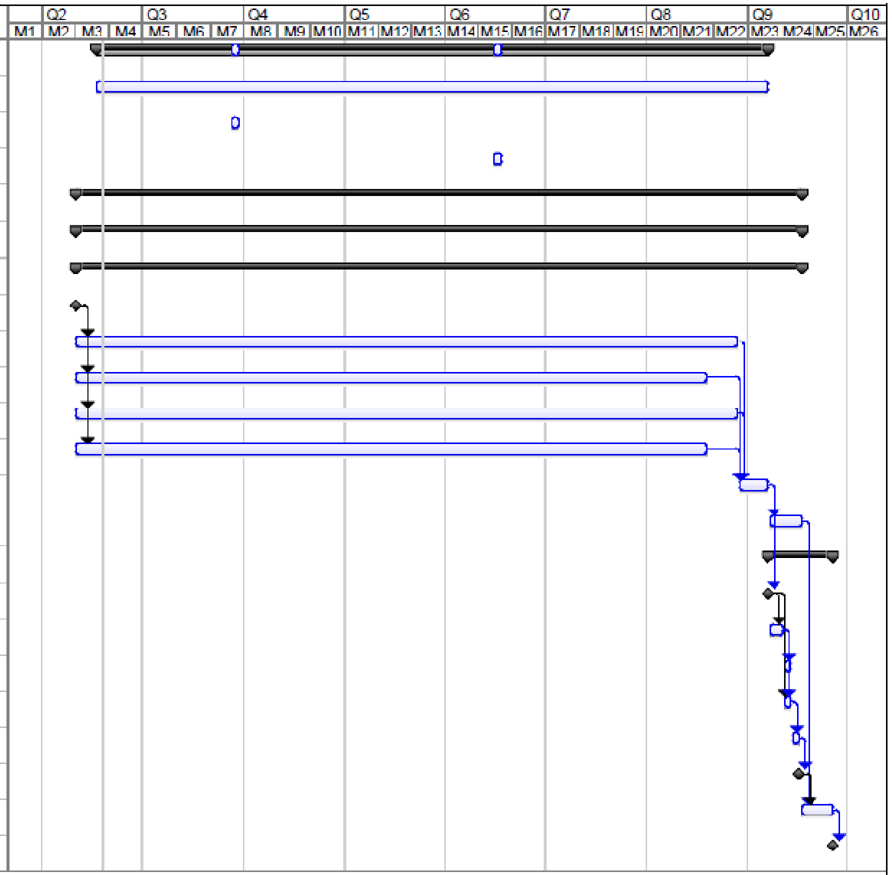
APP-PRA-GSC-XX2 – Fire PSA Model Development Report
Includes Tasks 2,4, 5, 7, 12, 13, and 15

APP-PRA-GSC-XX3 – Fire PSA Circuit Analysis Report
Includes Tasks 3, 9, and 10

APP-PRA-GSC-XX4 – Fire PSA Quantification and Results
Task 14

Because all Resolution Plan start dates are subject to future contract placements, dates are presently undefined; therefore schedule dates have been anonymised for consistency. Actual dates will be inserted when contracts are place.

ID	Task Name
1	**Meetings**
2	Meet with Assessors as needed
3	Technical Workshop 1
4	Technical Workshop 2
5	**Issue Resolution Plan**
6	**Issue**
7	**Issue**
8	Solution to Action
9	APP-PRA-GSC-XX1 – Fire Scenario Development Report (Tasks 1,6,8,11 and 16)
10	APP-PRA-GSC-XX2 – Fire PSA Model Development Report (Tasks 2,4,5,7,12,13 and 15)
11	APP-PRA-GSC-XX3 – Fire PSA Circuit Analysis Report (Tasks 3, 9 and 10)
12	APP-PRA-GSC-XX4 – Fire PSA Quantification and Results (task 14)
13	ONR Review GDA Issue Response
14	TQ/Question Response
15	**Preparation of Safety Submission Documentation**
16	Process start
17	Preparation of Safety Submission
18	Technical Review
19	Licensing Review
20	Update with comments from reviews
21	Issue draft to Regulator
22	Regulator to confirm response to action
23	Response received from ONR/ EA



Resolution Plan for GI-AP1000-PSA-02

Methodology:
The fire PSA will primarily be developed using the methodology document in NUREG/CR-6850 and its supplemental reports. The project will use the following computer codes: CAFTA, FRANX, HRA Calculator, FTREX, NRC Fire Dynamics Tools, NIST Fire Dynamics Simulator.

Justification of adequacy:
The proposed plan of work will result in a state-of-the art, modern fire PSA, using the best available methodology (NUREG/CR-6850).

Impact assessment:
The results of this project will completely supersede and replace the current **AP1000** plant fire PSA. No significant impacts on other technical and licensing areas are expected. Results could potentially impact the PCSR Chapter 10, and the E-DCD. However, it is not anticipated at this time. Time has been placed in the schedule after completion of the GDA Issue to provide these updates, if necessary.