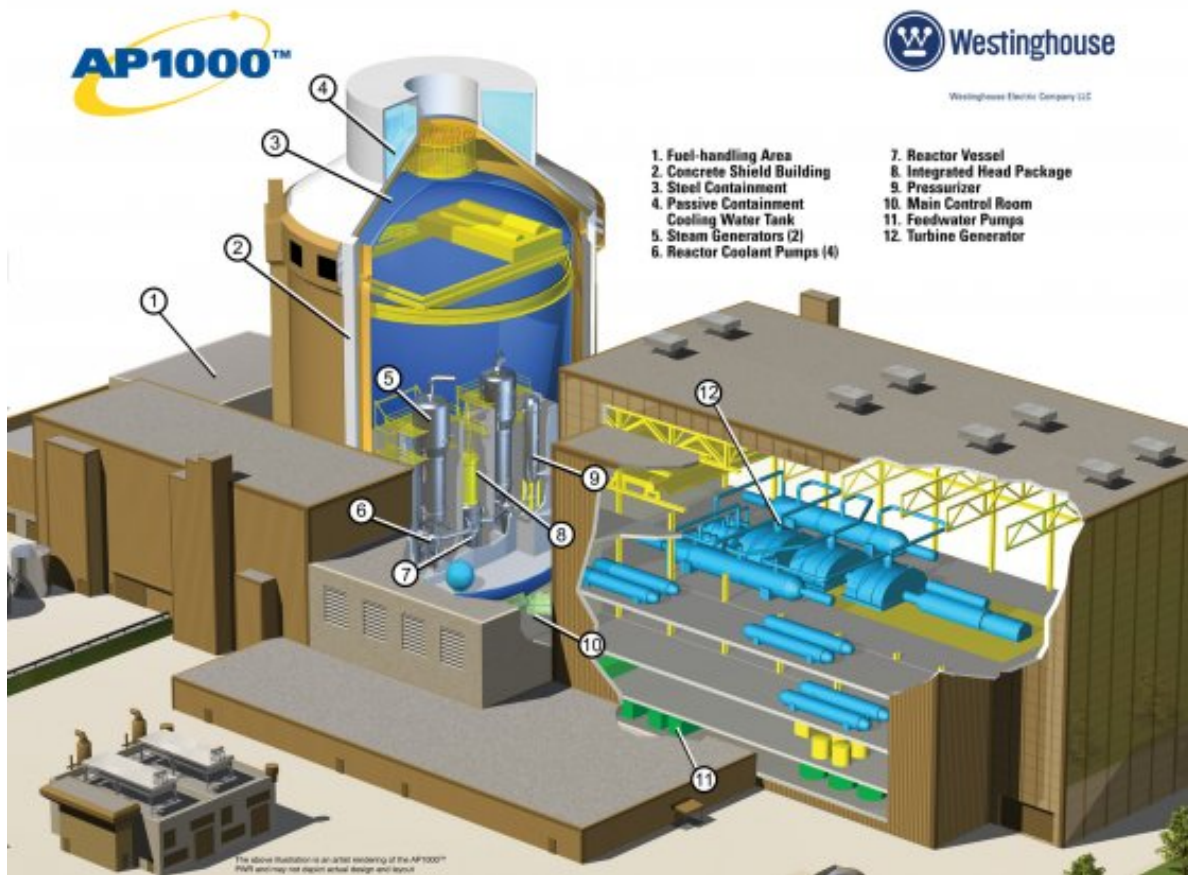




New Nuclear Reactors: Generic Design Assessment

Summary of the GDA issue close-out assessment of the Westinghouse Electric Company AP1000® Nuclear Reactor

March 2017



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Foreword

This is our final summary report for the Generic Design Assessment (GDA) of the Westinghouse **AP1000**[®] reactor. This report explains the work that we have undertaken to assess the Westinghouse submissions to address the 51 GDA issues that were attached to its interim Design Acceptance Confirmation (iDAC) issued in 2011, and summarises our conclusions.

Through the joint GDA process with the Environment Agency, we have completed our assessment of the **AP1000** reactor. We are content that Westinghouse has made sufficient progress against each of the GDA issues to complete this phase of regulatory assessment. Therefore, I have awarded a Design Acceptance Confirmation (DAC), which marks the closure of GDA and means that the reactor design is suitable for construction on licensed sites in the UK, subject to other regulatory permissions.

This is the culmination of almost three years regulatory work by ONR in the closure phase of GDA, and marks a significant milestone for the Moorside development project to build and operate three **AP1000** reactors at its site in Cumbria.

I recognise the effort that has been applied both by ONR and Westinghouse to achieve this considerable step in the project, and it is a great example of organisations working collaboratively in an enabling manner to achieve a shared outcome.

Completion of this first phase of regulatory work is only the start for the Moorside development and there is much to be done in subsequent phases. We anticipate an application for a nuclear site licence from NuGen later this year and we have the capability and capacity to deliver this within our New Reactors Division. This equally important work also features in our regulatory plan for 2017/18.

This is the second DAC that ONR has awarded to a nuclear reactor designer - referred to throughout this report as a requesting party - and it further confirms the value of the GDA process. The clarity on the suitability of the design and regulatory certainty that a DAC provides should help improve stakeholder confidence in the overall project, give NuGen a catalyst to further develop and optimise the reactor design and progress the site-specific safety case.

We have learned from this project and will use these lessons to inform how we regulate further reactor designs that may come forward from government for assessment.

ONR remains committed to delivering effective and efficient regulation of new nuclear build in line with UK Government policy for new nuclear in the energy mix.

We are prepared for and able to meet requests for design assessments and developer's programmes for construction. We continue to recruit high calibre inspectors and we are transforming our approach to training and development to optimise the progression opportunities for new recruits to achieve their inspector's warrant.

I am confident that we are in an increasingly strong position to deliver effective and efficient regulation of the national nuclear estate.



Dr Richard Savage
Chief Nuclear Inspector

Contents

Introduction	4
Management of GDA issue close-out assessment	6
Programme of work undertaken	6
Residual Matters	7
The assessment standards and demonstration of “as low as reasonably practicable”	9
Governance of GDA issue close-out	10
Joint working with the Environment Agency using the Joint Programme Office	11
Technical Support Contractors	11
Openness and transparency	12
Working with overseas regulators	13
Summary of AP1000 reactor GDA safety and security submissions	17
Evolution of the AP1000 Safety Case	17
Progress made on PCSR development in closure phase	17
Conclusion on adequacy of AP1000 PCSR for DAC issue	19
Master Submission List (UKP-GW-GLX-001)	19
Design Reference	20
Out of Scope Items	20
Summary of design changes that result from our assessment	21
Conclusions	23
Glossary and Abbreviations	24
References	25

Introduction

1. This is ONR's final report on the GDA of the **AP1000**[®] reactor design and marks the closure of the GDA. This report does not contain information on the GDA process¹, its background and development² or the regulatory process and legal basis of our work. This is all clearly documented in published guidance on our website.³
2. Westinghouse commenced GDA in 2007, completed Step 4 in 2011 and was awarded an iDAC by ONR. The iDAC represented ONR's confidence that the design is capable of being built and operated in Great Britain in a way that is safe and secure. However, the interim acceptance was granted on the basis that there were some GDA issues⁴ remaining that needed to be addressed to ONR's satisfaction. The Westinghouse iDAC had 51 GDA issues attached to it⁵. The outstanding issues needed to be addressed before any construction of a reactor based on the design could commence.
3. The DAC in itself does not allow construction to commence; further regulatory permissions are required from ONR including the granting of a nuclear site licence and a consent to start construction (required under Licence Condition 19).
4. Westinghouse paused the GDA process in 2011 and recommenced in 2014 to address the 51 GDA issues, with the aim of securing a DAC. In parallel, NuGen announced its intention to deploy three **AP1000** reactors on the Moorside site in West Cumbria, which they anticipate operating from 2024.



Artists impression of Moorside – Courtesy of NuGen



5. This report provides an overview of the work that has been done during the GDA closure phase, and is supported by 42 individual technical assessment reports. It is these assessment reports that describe our work in detail against each of the 51 GDA issues⁶. These reports, in combination with the published Step 4 reports⁷ provide a comprehensive description of the totality of our work in GDA. They intend to inform our stakeholders of our work and provide transparency of the basis of our decision. We have also reported on our work throughout GDA and the closure phase in our published progress reports⁸. These describe the assessment development and highlight the challenges that faced Westinghouse and ONR during the closure phase.

6. Westinghouse has completed all of the work required to address the 51 GDA issues and they have subsequently been closed by ONR. We have therefore decided to issue a DAC for the **AP1000**, indicating that we are content that the design is suitable for construction on Great Britain licensed sites, subject to further regulatory assessment.

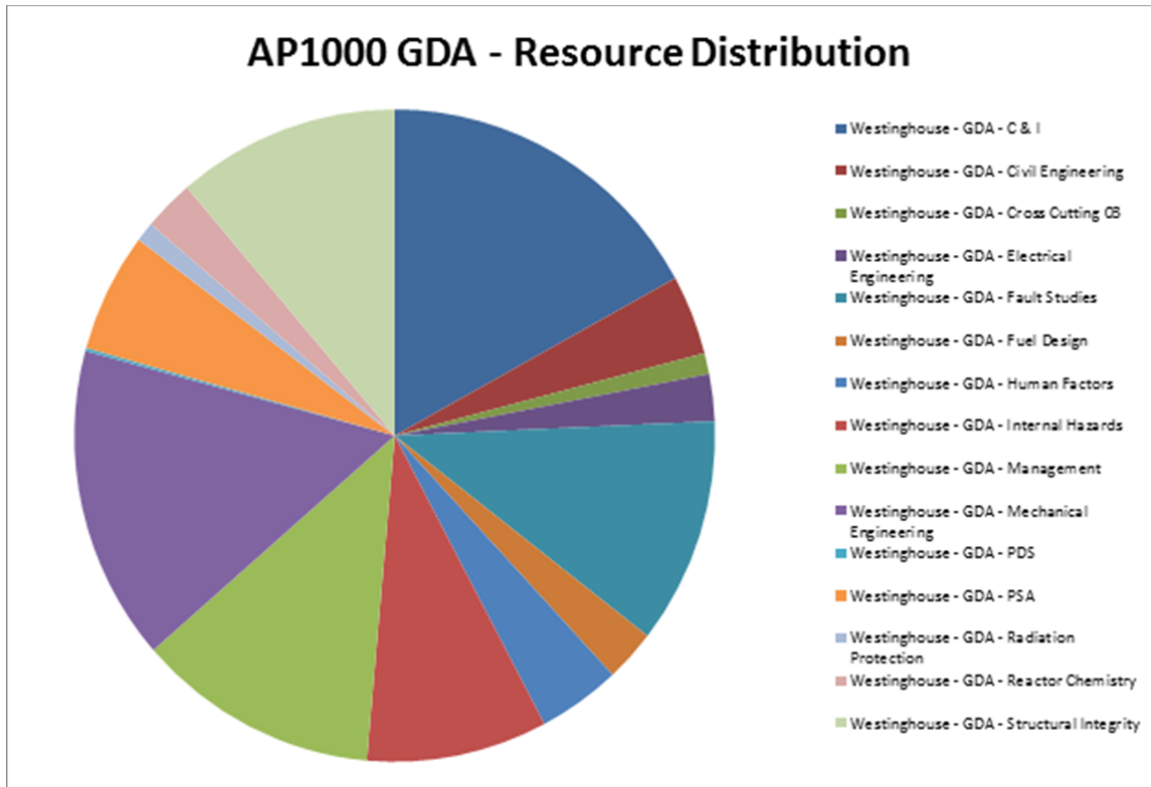


Management of GDA issue close-out assessment

Programme of work undertaken

7. The **AP1000** GDA closure phase applied the same regulatory processes as steps 1-4 of GDA.
8. ONR developed assessment plans for each topic area to set out the assessment approach. These assessment plans were discussed with Westinghouse and reviewed by ONR's heads of specialism to ensure that our work was proportionate for a generic pre-construction safety report (PCSR), targeted to those areas of most risk significance or safety contribution and consistent with previous GDAs. ONR does not assess safety submissions in their entirety; we sample submissions using a range of criteria including risk significance, novelty of approach etc. and aim to ensure that a coherent, complete and logical account of the safety/security claims, arguments and evidence has been made.
9. GDA is not about ensuring a reactor design is suitable for commissioning or operation; it is the first stage in the regulatory process and aims to provide clarity on the suitability of the generic design for construction. Further, detailed development of the design and safety case is required to account for site specific parameters, layout, equipment and operational matters for example. This is described in more detail in our technical assessment guide on safety cases⁹.
10. However in order to be able to provide a DAC, ONR must have completed a 'meaningful assessment'; where ONR has:
 - received sufficient information (submissions that cover the full scope and depth necessary for ONR to carry out its assessments) on the generic design in the safety and security submissions to allow assessment in all relevant technical topic areas; and
 - completed a sufficiently thorough and detailed assessment of that information.
11. This means that ONR has looked in detail at the submissions and judged them against the safety assessment principles (SAPs), including the need to demonstrate that risks are reduced, or are capable of being reduced, as low as reasonably practicable (ALARP). The depth and scope of ONR's assessment is unlikely to be the same across all technical areas, as this will depend on the relevance of each area to the safety and security case.
12. ONR has worked rigorously to ensure that Westinghouse completed the GDA in a good position. The closure period was very intensive and a great deal has been achieved in terms of safety submission development. Over the three years of the closure phase, ONR has deployed a team of inspectors dedicated to the programme, in the majority of technical areas. Almost 6000 days of internal effort was deployed, at a cost to Westinghouse of around £11.5M. Figure 1 below is a breakdown of ONR resource against the technical disciplines.

Figure 1 – ONR resource deployment



13. Within the closure period:
 - Westinghouse submitted around 600 documents for regulatory assessment.
 - ONR issued around 500 regulatory questions; all of which were responded to by Westinghouse.
 - ONR and Westinghouse held around 1020 meetings.

14. For the GDA in total:
 - 29000 days of regulatory effort was expended.
 - 3300 documents were assessed by ONR.
 - 2003 questions were posed to and answered by Westinghouse.

Residual Matters

15. As GDA is focused on assessment of a generic PCSR, it is expected that ONR will identify a number of 'residual matters'. Some of these will be identified as 'assessment findings' which ONR will require the nuclear site licensee to resolve. Others will be recorded by ONR as 'minor shortfalls' concerning the safety or security case, but which are not considered significant enough to require specific action to be taken by the licensee.

16. Assessment findings are primarily concerned with the provision of site-specific safety / security case evidence that will typically become available as the project progresses through the detailed design, construction and commissioning stages. A residual

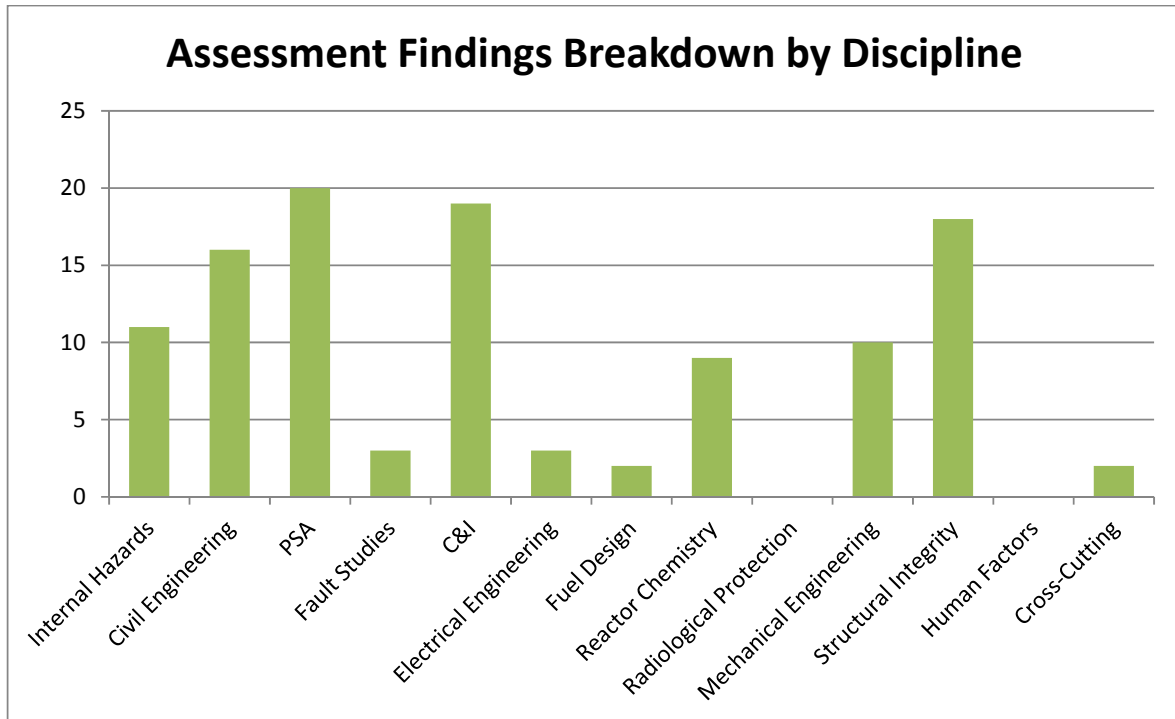


matter will generally be recorded as an assessment finding if one or more of the following apply:

- to resolve this matter site-specific information is required;
- the way to resolve the matter depends on licensee design choices;
- the matter raised is related to operator-specific features / aspects / choices;
- the resolution of this matter requires licensee choices on organisational matters;
- to resolve this matter the plant needs to be at some stage of construction / commissioning; or
- to resolve this matter the level of detail of the design needs to be beyond what can reasonably be expected in GDA (for example, manufacturer/supplier input is required; or areas where the technology changes quickly, to avoid obsolescence of design).

17. Assessment findings will be subject to appropriate control as part of ONR's normal regulatory oversight of new nuclear power station projects, and the target date for resolution of a finding will be a matter for the licensee to determine, appropriate to its project. Identifying assessment findings in GDA alerts future licensees to matters which will require their attention, and maximises the time available to address them. This reduces regulatory uncertainty and is one of the key benefits of the GDA process.
18. Sentencing of assessment findings by the licensee was a major area of learning from the UK EPR GDA project¹⁰. At the end of the UK EPR GDA¹¹ ONR prescribed 17 (construction hold) points at which licensees were required to close assessment findings against. These 'hold points' did not equate to the licensees (four hold point) milestone schedule and was unhelpful. ONR convened an industry-wide workshop to develop the assessment findings process and one of the key points taken forward was that ONR would not prescribe the timescales for which the findings should be addressed. This would be a matter for the licensee to discuss with ONR as part of the agreement of the construction schedule submitted under Licence Condition 19.
19. For the GDA closure phase, ONR has recorded 112 assessment findings. Figure 2 below is a breakdown of findings by topic area for the closure phase only. In total for the GDA of the **AP1000** ONR has raised 708 assessment findings.

Figure 2 – Closure Phase assessment findings by topic area



20. A residual matter will be recorded by ONR assessors as a minor shortfall if it does not:
- undermine ONR’s confidence in the safety or security of the generic design;
 - impair ONR’s ability to understand the risks associated with the generic design;
 - require design modifications;
 - require further substantiation to be undertaken.
21. These are included in the individual topic assessment reports. In total ONR has raised 27 minor shortfalls.

The assessment standards and demonstration of “as low as reasonably practicable”

22. ONR's decision making process is based on the approach described in ‘reducing risks, protecting people’¹². This includes an explanation of the concept of ALARP and describes the legal requirement in Great Britain to demonstrate that risks are reduced ALARP, such that any further measures to reduce the risk would entail a gross disproportion between the sacrifice (time, trouble and money) and the risk averted by their adoption.
23. The way in which ONR assesses submissions to ensure that risks have been reduced ALARP is set out in an ONR Technical Assessment Guide (TAG)¹³. The development of standards defining relevant good practice often includes ALARP considerations, so in many cases meeting these standards may be sufficient to demonstrate that the



design would satisfy legal requirements in Great Britain. In other cases, for example where standards and relevant good practice are less evident or not fully applicable, or the demonstration of safety is complex, the onus will be on the requesting party to implement risk reduction measures. This should be to the point where it can demonstrate to ONR that the costs of any further measures would be grossly disproportionate to the risk averted.

24. While meeting good practice is a fundamental requirement for safety cases, this is expected to be supported by a demonstration of how risk assessments have been used. A risk assessment should identify any potential weaknesses in the design and operation of the proposed facility, showing where improvements have been considered and to demonstrate that safety is not unduly reliant on a small set of particular safety features.
25. In addition, the documents published by Western European Nuclear Regulators Association (WENRA)¹⁴ set out safety reference levels, safety objectives and common positions for new reactors which can be considered as relevant good practice. A demonstration that these have been met is one way of contributing to the demonstration that risks have been reduced ALARP.
26. Furthermore the requesting party is required to show that the technical standards it has used result in a design in which risk has been reduced ALARP. This will need to include consideration of any updates to those technical standards since the original design and safety analysis were completed. This can be difficult where original reactor analysis is old or when there has been a significant pause between assessment periods.
27. Westinghouse has improved their safety submissions in the technical topic areas in response to the GDA issues, and the PCSR has moved on significantly in some areas. As ONR has closed all of the GDA issues we consider that at this stage Westinghouse has demonstrated that the generic design, at the PCSR stage, is capable of reducing risks ALARP.

Governance of GDA issue close-out

28. Closure of each GDA issue was a robust process. The topic inspector responsible for ONR's assessment, upon completion of their work, presented their case for closure to the GDA regulatory review meeting (RRM). This is a technical governance panel comprising GDA managers and chaired by the Head of GDA. Each topic presentation considered whether all:
 - GDA issue resolution plans had been received and assessed by ONR;
 - Regulatory Queries had been satisfactorily answered by Westinghouse;
 - Assessment findings had been drafted; and
 - The information submitted was adequate to address the GDA issue.
29. The RRM challenged the basis for issue closure and provided guidance on the suitability of assessment findings. The output from this panel was an agreement to close the issue in principle. GDA issues were not formally closed until the final assessment report was approved.



30. The first GDA issue was formally closed on 14 October 2016. The last GDA issue was formally closed on 21 March 2017.
31. Following closure of all GDA issues the decision to award a DAC or not was initially taken by the RRM, with oversight from ONR's independent regulatory assurance function. As all GDA issues had been closed, the panel decided to award a DAC.
32. This decision was then presented to and ratified by ONR's New Reactors Programme Board, chaired by a Deputy Chief Inspector. The final decision to award a DAC was confirmed by the Chief Nuclear Inspector on March 24 2017.

Joint working with the Environment Agency using the Joint Programme Office

33. As with all other previous GDA projects, and building on lessons learnt from those projects, ONR continued to work with the Environment Agency throughout the closure phase. One of the main benefits of this approach, as identified in the lessons learnt from the earlier GDA is that the projects are jointly administered by a joint programme office (JPO) and the application of common processes.
34. Two of the GDA issues are joint with the Environment Agency:
 - GI-AP1000®-CC-02 relating to the PCSR to support GDA.
 - GI-AP1000®-CC-03 relating to lessons learnt from the Fukushima event.
35. The Environment Agency will report separately on their decision on whether to award a Statement of Design Acceptability (SoDA).

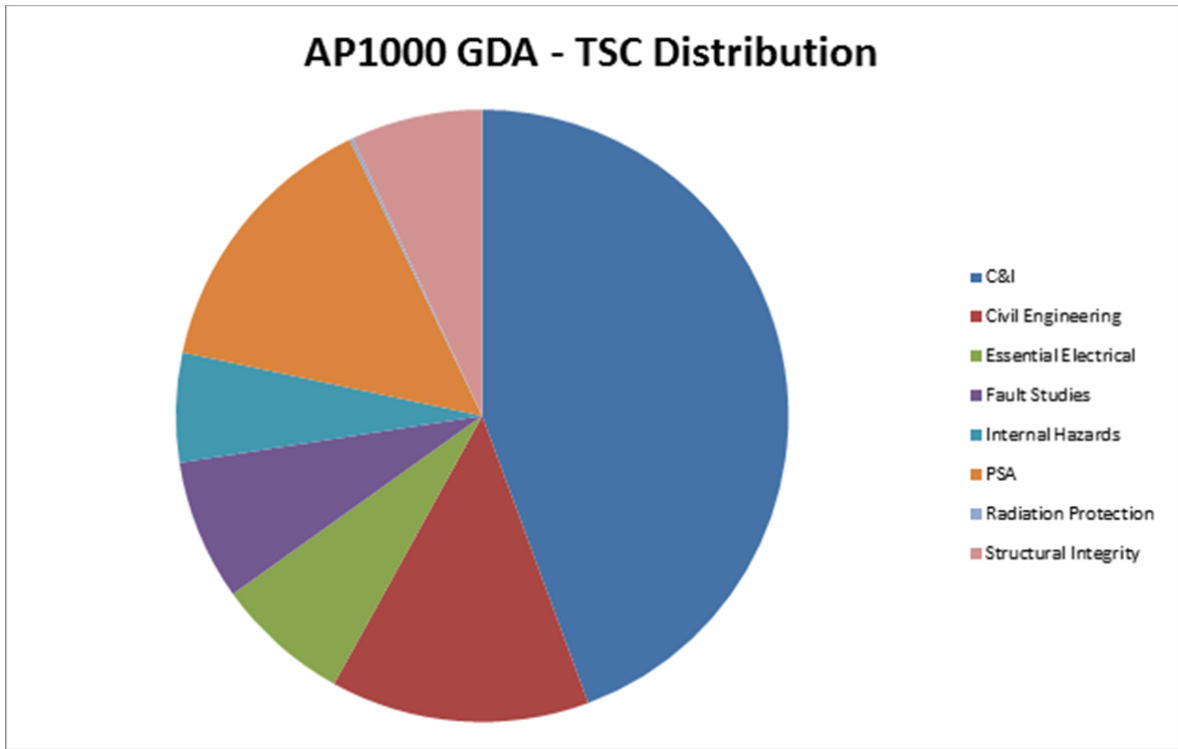


Technical Support Contractors

36. ONR uses technical support contractors (TSCs) to provide specific capability, enhance capacity and/or to secure access to computer codes and models. The work of TSCs is used to inform regulatory decisions; all of which are taken by ONR inspectors only.
37. As with previous GDA projects ONR used TSCs for the **AP1000** closure phase. In this period ONR placed 14 contracts at a cost of around £2.47m. This cost was fully recovered from Westinghouse.

38. The distribution of TSCs contracts across the technical areas is outlined in Figure 3.

Figure 3 - Breakdown of TSC use per discipline

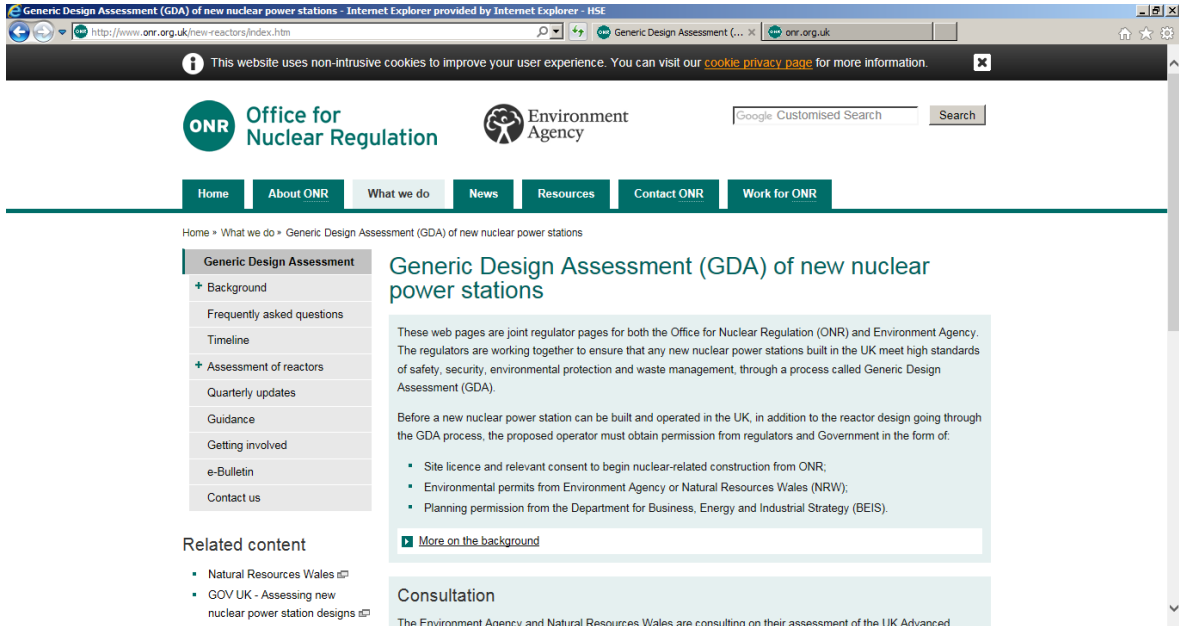


Openness and transparency

39. ONR aims for openness and transparency of our work and publishes material to ensure that our stakeholders can see the basis of our regulatory decisions. The GDA programme, since its inception, has published assessment reports, summary reports and periodic progress reports to help build public confidence in the work that we do. We also require the GDA requesting parties to host a public comments process and publish their safety and security documentation.
40. In 2015, ONR participated with the Environment Agency and Natural Resources Wales (NRW) in a project run by 'Sciencewise'.¹⁵ The project aimed to identify how to better understand the needs of the public in relation to engagement in the GDA of new nuclear reactor designs, by undertaking a dialogue with members of the public.
41. We used information from this work to inform development of our progress reports and it will be taken forward in our future GDA projects.
42. For the **AP1000** GDA ONR published the GDA issues and original resolution plans in 2011, and as soon as the project recommenced, ONR published revised resolution plans to provide greater clarity on timescales for addressing the GDA issues.



43. 42 assessment reports describing the ONR work completed for the 51 GDA issues have been published in parallel with this report.¹⁶
44. Westinghouse has updated its website to incorporate revisions to the safety case for the **AP1000** that have arisen from the GDA issue responses.



Working with overseas regulators

45. ONR's strategy for working with overseas regulators is set out in a published document¹⁷. In accordance with this strategy, ONR collaborates with overseas regulators, both bilaterally and multi-nationally. ONR is a member of the Organisation for Economic Co-operation and Development (OECD) facilitated Multinational Design Evaluation Programme (MDEP) **AP1000** working group. MDEP is a multinational initiative undertaken by national nuclear safety authorities to develop innovative approaches to leverage the resources and knowledge of the national regulatory authorities tasked with the review of new reactor power plant designs.
46. This helps to promote consistent nuclear safety assessment standards among different countries. At the **AP1000** working group biannual meetings, ONR and other nuclear safety regulators considering the **AP1000** design, notably the United States (US) Nuclear Regulatory Commission (NRC) and China's National Nuclear Safety Administration (NNSA) share and discuss issues of common interest.
47. Since Westinghouse re-entered the GDA process in summer 2014, there have been five meetings on the MDEP **AP1000** working group in which ONR has participated. Three of these meetings included a site-visit to an **AP1000** construction site (Sanmen, Haiyang and VC Summer). These meetings and visits have proved to be very useful to ONR in its assessment of the **AP1000** design, although it should be noted that given



the more advanced status of the **AP1000** programmes in both China and the US, the respective regulators have moved beyond their regulatory equivalents of GDA.

48. In the more recent meetings, a lot of the learning that ONR has taken from these interactions has been associated with challenges of regulating the construction and commissioning the **AP1000**. Given the novel passive features and modular construction techniques employed by the **AP1000**, as well the significant length of time since Sizewell B was built in the UK, ONR's involvement in MDEP provides a tremendous opportunity to gain from this overseas experience to the benefit of UK new build projects.
49. There were four significant areas discussed over several meetings of direct relevance to ONR's GDA issues:
 - **GI-AP1000-FS-06**: In GDA Step 4, ONR raised concerns about the lack of substantiation for the assumed condensate losses from the in-containment refuelling water storage tank (IRWST) during intact circuit faults, when the reactor core's decay heat is being removed by the passive residual heat removal (PRHR) heat exchanger. This matter was applicable to all **AP1000** projects around the world, and Westinghouse initiated a significant programme of work to address it. This included physical testing, design changes to the plant, revisions to analysis methods, and changes to safety case claims associated with the ability to achieve and maintain a stable, safe shutdown state using passive systems. The MDEP **AP1000** working group meetings allowed the regulators to share their opinions and progress this significant technical issue. ONR's and the US NRC's safety evaluation of the Westinghouse submissions has proved to be very influential in moving Westinghouse towards a final position which is adequate for GI-AP1000-FS-06 to be closed.
 - **GI-AP1000-CC-03**: Following the events in Japan in 2011, the regulators on the MDEP **AP1000** working group have produced a common position paper on the applicability of lessons the learnt from the Fukushima Daiichi accident to the **AP1000**¹⁸. ONR's significant input to this common position has been informed by its assessment of the Westinghouse submissions for GI-AP1000-CC-03, and the shared position of the regulators of the MDEP **AP1000** working group has been used to inform ONR's final judgements on the adequacy of the Westinghouse submissions for GI-AP1000-CC-03.
 - **GI-AP1000-ME-01**: The novel use of the explosive squib valves on the **AP1000** primary circuit has been an area of close scrutiny for all the regulators in the MDEP **AP1000** working group, and has been discussed at length in all of the meetings. Westinghouse instigated a common test programme for the Chinese and US plants to demonstrate the reliability and code compliance of the proposed valve designs, and ONR has been able to gain insights to the regulators' concerns; influencing and learning from these tests. The UK-specific submissions that Westinghouse has provided for GI-AP1000-ME-01 are supported by the same underpinning work that the other regulators have considered in detail. Bi-laterally, the US NRC observed some of ONR's meetings with Westinghouse on the topic of squib valves, and kept ONR



informed about its oversight of the squib valve test programme (including supplying its final report on the Westinghouse testing to ONR).

- **GI-AP1000-SI-05:** Through assessment of the Westinghouse demonstration that major vessels of the **AP1000** are compliant with the American Society of Mechanical Engineers (ASME) III design criteria, ONR found evidence of a potential non-compliance with the code, with potential safety implications for plants under construction. The meetings of the MDEP **AP1000** working group allowed ONR to quickly and effectively convey its concerns to other regulators, and for Westinghouse to articulate its response and corrective actions in a consistent and consolidated manner. Facilitated by links fostered through attending the meetings, a number of bilateral teleconferences were held with US NRC on this matter. US NRC and ONR also worked closely together to arrange complementary inspections at the Westinghouse US headquarters on its processes to prevent the identified problems occurring again.

50. In addition to the multilateral MDEP meetings, several topic areas have held informal bilateral conference calls and corresponded with counterparts in US NRC, to share information on common areas of interest and explain progress with the GDA issues:

- **Human factors** – two teleconferences on matters of common interest including main control room (MCR) habitability, integrated system validation trials to substantiate MCR actions, and human factors issues associated with maintenance and testing activities. This informed ONR’s assessment of GI-AP1000-HF-01.
- **Radiological protection** – one teleconference to discuss respective approaches to managing criticality safety in the spent fuel pool. This informed ONR’s assessment of GI-AP1000-RP-01.
- **Fuel and Core** – e-mail correspondence sharing ONR’s findings on the adequacy of the PAD fuel performance code following the assessment of GI-AP1000-FD-01 submissions.
- **Control and Instrumentation (C&I)** – one teleconference on the challenges and lessons learnt of regulating the design, development, procurement, and commissioning of **AP1000** digital systems.
- **Probabilistic Safety Assessment (PSA)** – one teleconference on the status of the **AP1000** PSA in the US and UK. Information exchange on a number of technical topics of mutual interest, including:
 - Hot functional testing in China highlighted a new source of debris which could contribute to blockage of the recirculation screens. This is being investigated by the US NRC.
 - Main control room simulator trials which showed that some human error probabilities claimed in the PSA are no longer justified. Risk sensitivity and post-GDA work discussed.
 - Beyond design basis work on spurious squib valve actuation undertaken by ONR.
 - ONR and NRC expectations for external hazards during licensing.



- **Structural integrity** - US NRC observation of one meeting between ONR and Westinghouse. Teleconferences to discuss GI-AP1000-SI-05 and e-mail correspondence to inform ONR's assessments for GI-AP1000-SI02, GI-AP1000- SI04 and GI-AP1000-SI06.



Summary of AP1000 reactor GDA safety and security submissions

Evolution of the AP1000 Safety Case

52. In December 2008 Westinghouse issued its first PCSR for GDA. ONR found that the report was not a coherent, holistic safety case and relied too heavily on the European Design Control Document (EDCD), which itself was heavily based on the US Design Control Document (DCD) produced for the US NRC. In April 2009 Westinghouse revised its PCSR and submitted a revision; this version addressed several editorial matters but made no technical changes to the report.
53. In reviewing Westinghouse's proposed programme of work to revise the PCSR in mid-2009 ONR reminded Westinghouse that neither the US DCD nor the EDCD address UK specific requirements. Westinghouse was asked to develop a safety case which consolidated the claims, arguments and evidence to show that the risks from operating the plant will be ALARP.
54. In December 2009 Westinghouse submitted the next revision of the PCSR, but ONR found this was still overly reliant on the EDCD. However by using regulatory queries (RQs) and regulatory observations (ROs) ONR was able to complete its Step 4 assessments based on the December 2009 version, and the iDAC issued in December 2011 was based on that version of the PCSR.
55. Throughout Step 4 Westinghouse was developing a further revision to the PCSR to take account of ONR's comments, and responses to ROs and RQs. An early draft of the intended revised PCSR was issued to interested utility firms and made available to ONR in the summer of 2010. Where possible, ONR commented on the content and format of revised sections of the PCSR in a series of letters.
56. In December 2010 a draft consolidated PCSR was submitted. ONR was unable to provide substantive comments at the time as it was focused on completing its assessment and writing reports, although some inspectors did manage to provide some brief comments. On 30 March 2011 Westinghouse submitted its final consolidated PCSR, but this was too late to be assessed as part of Step 4.
57. As a result, at the end of Step 4, GDA Issue CC-02 was raised, which required Westinghouse to submit a consolidated PCSR and associated references to provide the claims, arguments and evidence to substantiate the safety and security of the **AP1000** design, as described by the up-to-date Design Reference Point (DRP) document.

Progress made on PCSR development in closure phase

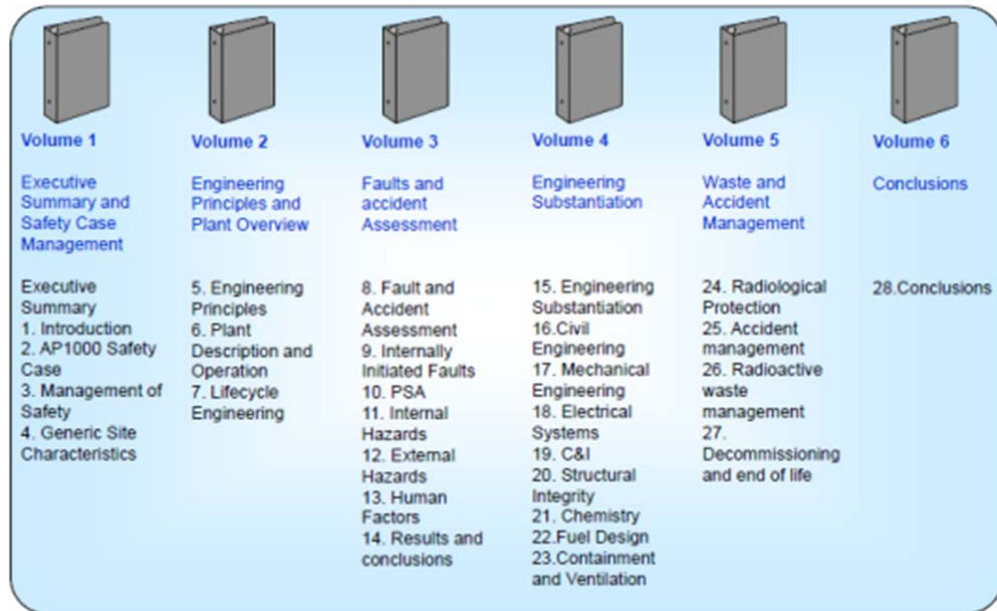
58. Subsequent to the commencement of the closure phase in 2015, Westinghouse revised its resolution plan for CC-02 and this was accepted by ONR as the basis for



closure of the issue. That plan envisaged the version of the PCSR referenced in the iDAC would be updated to incorporate responses to ONR RQs and ROs, as well as any Step 4 comments ONR had provided on the December 2010 redraft. In addition, the PCSR would be updated to take account of changes required by the work undertaken to close out the other GDA issues.

59. The PCSR is arranged into 28 chapters and assigned by Westinghouse into six volumes as shown below.

Figure 4 – PCSR arrangement



60. Volumes 1 and 2 cover introductory and general matters while volume 6 simply contains a concluding, summary chapter. The technical content is therefore in volumes 3-5 and resolution of the bulk of the GDA issues has had consequences for the contents of one or more of these chapters.

61. In July 2015 Westinghouse submitted individual strategies for the update of each of the 28 chapters, with each revised chapter being scheduled for submission between August 2015 and July 2016. Initial revisions of the chapters were designated Revision 0A. ONR provided comments and observations on the chapters leading to further revisions being submitted for ONR consideration. This allowed Westinghouse to follow an iterative approach to the development of acceptable versions of each chapter.

62. By late 2016, final draft versions of most chapters in volumes 1 and 2 of the PCSR were reached at Revision 0B, while in the more technical areas, where resolution of related GDA issues was more complex, the final drafts of the affected chapters reached Revisions 0D and 0E in early 2017.



Conclusion on adequacy of AP1000 PCSR for DAC issue

63. ONR assessed the adequacy of the final drafts of any PCSR chapters relevant to the closure of GDA technical issues. We concluded that:
- the final PCSR follows the same structure as the version submitted in 2010 and revised in 2011, but has been significantly improved in content during the GDA closure phase;
 - the comments made by ONR on the 2010 version of the PCSR have been addressed to a certain extent by Westinghouse; and
 - concerns expressed by ONR relating to certain parts of the PCSR either in the form of RQs or ROs, have generally been resolved by Westinghouse, either through additional written clarification or through textual amendment.
64. Overall, therefore, ONR concludes that the PCSR submitted as UKP-GW-GL-793 Revision 1, is acceptable for the purpose of the closure of GDA.
65. The licensee has the ultimate responsibility in law for ensuring the safety and security of the plant and by the end of GDA ONR will expect the generic PCSR to form a basis for a future licensee to develop a site-specific version. There is however a great deal of work to be done by the future licensee to develop the GDA PCSR into a holistic, complete and coherent site specific safety case that can be used to underpin the first consent for construction.
66. This will involve consideration of all of the residual matters from step 4 and the closure phase and will necessarily result in a significant update to the document.

Master Submission List (UKP-GW-GLX-001)

67. At the end of Step 4, and to support the issue of the iDAC, Westinghouse submitted its Master Submission List (MSL) which provided a reference to all of the documents submitted to the regulators throughout steps 1 -4 of GDA. That list included 4 tiers of documents
- Tier 1 – PCSR, environment report and security report.
 - Tier 2 – References from documents in Tier 1.
 - Tier 3 – GDA submissions for assessment.
 - Tier 4 – Documents submitted for information.
68. For GDA closure, with agreement of the regulators, Westinghouse has removed the Tier 4 documents from the MSL. These 'for information' documents were not assessed and therefore do not need to be formally referenced in assessment reports. This has resulted in a slimmer MSL with a focus only on those documents that are pertinent to the conclusions of the regulators in awarding the DAC or SoDA. ONR is satisfied that the submitted MSL adequately represents the documentation assessed in forming its decision on awarding the DAC.



Design Reference

69. GDA requesting parties are required to submit a design reference which lists all the documents that describe the design of the reactor and associated plant that the GDA submissions refer to. ONR will expect this to be 'frozen' at a specific date known as the DRP. The DRP for the iDAC was 16 September 2010, and the detail of the documents defining the design was set out in Document UKP-GW –GL-060, Revision 5.
70. As part of the normal design development for the Westinghouse standard plant, in the period between the issue of the iDAC and the commencement of the closure phase in 2015, a large number of Design Change Proposals (DCPs) were approved for incorporation into all **AP1000** design variants, including that subjected to GDA. In Step 4 ONR required Westinghouse to assign a UK specific category (ranging from 1 -4) to each DCP reflecting the potential safety impact of the change (with category 1 being the most significant potential safety impact).
71. Westinghouse management arrangements, originally set up in 2010 require it to notify ONR of all category 1 and 2 changes and for ONR's agreement to be sought for such DCPs to be accepted within GDA.
72. DRP revision 6 was set at 31 January 2015 and included 63 DCPs assessed by Westinghouse as UK category 1 or 2. These were subsequently considered by ONR assessors and accepted for inclusion into GDA. A further nine category 1 and 2 DCPs were later submitted by Westinghouse for inclusion in GDA, and following agreement by ONR were included in further revisions of the DRP.
73. The final DRP (UKP-FW-GL-060 Revision 10) was submitted in January 2017, and lists all category 1-4 DCPs included within GDA.
74. Design changes agreed for inclusion in GDA will need to be handed over by Westinghouse to a future licensee, to ensure that they can fully incorporate them into the site-specific design. This will be monitored by ONR as part of its site specific regulatory and permissioning activities.

Out of Scope Items

75. Towards the end of Step 4 Westinghouse clarified those items that were considered to be out of scope of the GDA assessment¹⁹. Further details were also contained in the individual ONR Step 4 assessment reports. In addition, ONR agreed with Westinghouse that documentation provided for information only, rather than part of the MSL (such as detailed design with supplier specific information and/or site/specific or operator specific documentation) would also be out of scope.
76. Westinghouse subsequently confirmed that the out of scope items identified at the end of Step 4 remain unchanged as a result of the closure of GDA.



Summary of design changes that result from our assessment

77. The UK regulatory regime is robust, and the goal setting approach often means that standard plant designs require some enhancement to meet our regulatory requirements for nuclear safety and security. One of the aims of the GDA is to agree these enhancements as early as possible, and ONR's Step 4 reports describe the enhancements agreed for the UK **AP1000**.
78. For the closure phase there has not been any new, significant (category 1 or 2) design enhancements put forward by Westinghouse. The DRP and DCPs contained within, relate to:
- Material and testing specifications.
 - Inspection and testing.
 - Routine design development incorporating lessons learned from the plants under construction internationally.
 - Changes due to code compliance and UK environmental conditions.
79. ONR does not consider that these changes have a significant impact on the generic design.
80. As a result of the Fukushima lessons learned review, Westinghouse identified DCPs covering resilience enhancements:
- Increased protection of class 1 batteries from beyond design basis flood.
 - Improved post 72 hour cable connections and addition of flange connections for the passive containment cooling ancillary water storage tank.
 - Enhanced power supply for the UK **AP1000** communication system.
 - Enhanced off-site equipment (diesel generators, pumps) location / connections during sustained flood.
 - Additional connections for on-site water storage tanks.
81. The resilience enhancements are intended to improve the **AP1000** design resistance to beyond design basis external hazard events and increase the resilience of the plant.





Conclusions

82. This final **AP1000** GDA report describes ONR's assessment of the 51 GDA issues remaining at the end of step 4 and attached to the iDAC issued 2011. The aim of the closure phase was for Westinghouse to complete work against all of the GDA issues to ONR's satisfaction such that every issue could be closed. This was required for ONR to issue a DAC. ONR's assessment has been rigorous and wide ranging and Westinghouse has significantly improved the safety case from step 4.
83. ONR has closed all of the GDA issues and therefore concluded that a DAC can be awarded to Westinghouse for the **AP1000** reactor design.
84. A DAC represents ONR's expert judgement at the time it is provided as it relates to a generic design and the associated generic safety and security case. A DAC does not guarantee that ONR will give permission for the start of construction of a nuclear power station based on that design; it means that ONR is confident that, based on the GDA submissions, the design is capable of being built and operated in Great Britain, on a site bounded by the generic site envelope, in a way that is acceptably safe and secure. Further site specific licensing and assessment activities are required. A DAC is however required before ONR will consider granting permission for the start of nuclear island safety related construction for a power station based on that design.
85. This is significant achievement for Westinghouse and the culmination of a ten year regulatory assessment period and ONR considers that a significant reduction in regulatory uncertainty has been achieved.

Glossary and Abbreviations

ALARP	As low as reasonably practicable
C&I	Control and Instrumentation
DAC	Design Acceptance Confirmation (Office for Nuclear Regulation)
DR	Design Reference
DRP	Design Reference Point
GDA	Generic Design Assessment
JPO	Joint Programme Office
MDEP	Multinational Design Evaluation Programme
ONR	Office for Nuclear Regulation
PCSR	Pre-construction Safety Report
PSA	Probabilistic Safety Analysis
SAP	Safety Assessment Principles (ONR)
SoDA	Statement of Design Acceptability (Environment Agency)
TAG	Technical Assessment Guide (ONR)
TSC	Technical Support Contractor
US NRC	United States Nuclear Regulatory Commission
WENRA	Western European Nuclear Regulators' Association



References

¹ <http://www.onr.org.uk/new-reactors/index.htm>

² <http://www.onr.org.uk/new-reactors/background.htm>

³ <http://www.onr.org.uk/index.htm>

⁴ GDA Issues are defined as “unresolved issues judged by regulators to be significant but resolvable, requiring resolution before regulatory permission for the start of nuclear island safety-related construction of such a reactor could be considered.”

⁵ <http://www.onr.org.uk/new-reactors/AP1000/idac-isoda.htm>

⁶ <http://www.onr.org.uk/new-reactors/ap1000/gda-issues-res-plan.htm>

⁷ <http://www.onr.org.uk/new-reactors/AP1000/reports.htm>

⁸ <http://www.onr.org.uk/new-reactors/quarterly-updates.htm>

⁹ http://www.onr.org.uk/operational/tech_asst_guides/ns-tast-gd-005.pdf

¹⁰ <http://www.onr.org.uk/new-reactors/reports/onr-gda-sr-13-001.pdf>

¹¹ <http://www.onr.org.uk/new-reactors/uk-epr/index.htm>

¹² <http://www.hse.gov.uk/risk/theory/r2p2.pdf>

¹³ http://www.onr.org.uk/operational/tech_asst_guides/ns-tast-gd-005.pdf

¹⁴ <http://www.wenra.org/>

¹⁵ <http://www.sciencewise-erc.org.uk/cms/new-nuclear-power-stations-reviewing-how-to-engage-with-members-of-the-public-in-reactor-design-assessments-known-as-the-generic-design-assessment-or-gda>.

¹⁶ <http://www.onr.org.uk/new-reactors/ap1000/gda-issues-res-plan.htm>

¹⁷ <http://www.onr.org.uk/new-reactors/ngn05.pdf>

¹⁸ https://www.oecd-nea.org/mdep/common-positions/cp-AP1000@wg-02-common_position_fukushima.pdf

¹⁹ GDA Out of Scope Items. WEC letter 000728, 7th November 2011

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