Lesson Learned of China AP1000

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Background Information

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China AP1000 Project

Optimization of CAP1000
Background Information

Major Nuclear Power Plants Scale and Quantity

Data from IAEA Nuclear power plants in the world
Background Information

Risk of Project Delay

Close to Poisson Distribution

$T = 66$ (Month)
The construction period has obvious positive correlation with complexity of NPP.
How designer plays an important role to project success?

- Concept Design
  - Simplified
  - Modularized
  - Integrated

- Reduce Complexity of NPP

- Engineering Design
  - Adaptability
  - Convenient
  - Service

The designer commits to increasing probability of project success.
Background Information

China AP1000 Project

Optimization of CAP1000
Critical Milestones of the First AP1000 Unit

Original Plan

FCD --- March 31st, 2009
End of performance test --- November 30th, 2013
Duration --- 56 months
## Critical Milestones of the First AP1000 Unit (Sanmen 1#)

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Original plan</th>
<th>Actual Dates</th>
<th>Deviation (Months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FCD</td>
<td>Mar 31(^{st}), 2009</td>
<td>Mar 29(^{th}), 2009</td>
<td>0</td>
</tr>
<tr>
<td>CV top head set</td>
<td>Oct 30(^{th}), 2011</td>
<td>Jan 29(^{th}), 2013</td>
<td>-15</td>
</tr>
<tr>
<td>RCP delivered to site</td>
<td>Mar 31(^{st}), 2012</td>
<td>Feb 8(^{th}), 2016</td>
<td>-46</td>
</tr>
<tr>
<td>RCS turned over</td>
<td>Jun 30(^{th}), 2012</td>
<td>Apr 9(^{th}), 2016</td>
<td>-45</td>
</tr>
<tr>
<td>Cold hydro test started</td>
<td>Oct 30(^{th}), 2012</td>
<td>May 24(^{th}), 2016</td>
<td>-43</td>
</tr>
<tr>
<td>Hot functional test started</td>
<td>Dec 31(^{st}), 2012</td>
<td>Jul 30(^{th}), 2016</td>
<td>-43</td>
</tr>
<tr>
<td>Fuel loading</td>
<td>May 31(^{st}), 2013</td>
<td>Apr 25(^{th}), 2018</td>
<td>-59</td>
</tr>
<tr>
<td>Initial criticality</td>
<td>Jul 31(^{st}), 2013</td>
<td>Jun 21(^{st}), 2018</td>
<td>-59</td>
</tr>
<tr>
<td>Initial grid connection</td>
<td>Aug 31(^{st}), 2013</td>
<td>Jun 30(^{th}), 2018</td>
<td>-58</td>
</tr>
<tr>
<td>End of performance test</td>
<td>Nov 30(^{th}), 2013</td>
<td>Sep 30(^{th}), 2018</td>
<td>-58</td>
</tr>
</tbody>
</table>
Summary for Features of the First AP1000 Unit

New Requirements
Safety: Prevention and mitigation of severe accident conditions + BDBE
Economy: 60-year design life, Plant availability (93%), Less maintenance + Spare parts
Human Factor: Automaticity and flexibility
Environment: Low radioactivity, Waste minimization, Low emissions

New Equipments
- Canned RCP, Squib Valve, DCS,

New Technology
- Passive safety concept, Modularization

New Materials
- Borosilicate neutron shielding material

New Process Systems
- ADS1-3, ADS4

New Engineering Cooperation
- JPMO+2 SPMO
Major Challenges of the First AP1000 Unit

- Design Finalization and Regional Adaptability of the First Unit
- R&D and Localization of Key Equipment
- Major Construction Techniques
- Commissioning for “Passive” Safety Systems
- Engineering Management of International Cooperation Project
Major Challenges of the First AP1000 Unit

Design Finalization

- It has been a complex process to convert the passive design concept into specific construction drawings.
- More strictly design is required due to passive safety system and new construction plan.

Regional Adaptability
Due to the FOAK nature of key equipment, it poses great challenges to R&D and manufacturing since it’s required to meet 60-year design life, which places stronger demands on materials, manufacturing and installation accuracy, and requires more strict acceptance criteria for its qualification testing.
Major Challenges of the First AP1000 Unit

**Major Construction Techniques**

- Modularization and Open Top Construction

  This construction method promotes a work model in which civil works and installation activities are carried out in parallel, and that the installation logic of such major large mechanical equipment must be inextricably and effectively coordinated with modularization. In addition, transport and lifting of large modules, precise fitting up for module installation and high standards and requirements in equipment installation are also the great challenges in the project construction.
Innovative design which a whole new GEN III technology with fresh equipment and tests brings higher commissioning requirements. As the first a variety of new design concepts and new key equipments ever used, the AP1000 has more strict requirements on the test conditions, test modes and test results in the commissioning process.
Major Challenges of the First AP1000 Unit

Engineering Management of International Cooperation Project
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- Background Information
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- Optimization of CAP1000
Further Increasing Safety Margin after Fukushima Nuclear Accident

Design Improvement basing on lessons learned in relying Project, feedback to review questions in following project, AP1000 technology transfer assimilation achievements and lessens from Fukushima nuclear accident.

Key Design Optimization Features

- Safety Review Question Implementation
- Bulk Material Localization
- Equipment Localization
- Conversion of Metric and British system
- Improvement and optimization basing on Relying Project Design

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Extension and Application of Standardized Design

Requirements of rules, standard and localization of production in China Inland and costal condition requirement

Nuclear Island design document of Relying project Files, data and software of AP1000 technology transfer Training and design participation of AP1000

Maximum Standardization on Nuclear Island Envelop most of site conditions.

Conventional Island & BOP Maximum Standardization

CAP1000 Standardized Design

Standardized Design (Complete Engineering Design)

Feedback from Design, Fabrication and Construction

Adaptive Design for Plant Site

Adaptive Design on Equipment

Equipment design and procurement base on Unit Version

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Sanmen Phase II

- Unit 3# Nuclear Inland Reinforcement binding Completion
- Unit 3# Nuclear Inland Excavation Completion
- CA01 Main Part Assembly Completion
- CA20 Main Part Assembly Completion
- CV Bottom Head Main Part Assembly Completion
- CV First Ring Main Part Assembly Completion
Haiyang Phase II

- Unit 3# Base Plate Reinforcement binding and Model Fabricate Completion
- CA01 Module Assembly Completion
- CV Bottom Head Site Assembly Completion
- CR10 Integrally Assembly Completion
- CA20 Module Assembly Completion
- Building 40&12 After Backfill Condition
Lufeng Phase I

Unit 1# Nuclear Inland Reinforcement binding Completion

Lifting field and Heavy Road Completion

CA20 Main Part Assembly Completion

CV Bottom Head Main Part Assembly Completion

CA01 Main Part Assembly Completion

Unit 2# Nuclear Island Fill and Level up Completion