Experiences with the construction of EPR at Flamanville and Taishan

OECD/ Nuclear Energy Agency

Workshop : “Project and Logistics Management in Nuclear New Build”

NEA Headquarters, Issy-les-Moulineaux
March 11th, 2014
Agenda

- Background

- EPR Projects Status
  - Flamanville 3
  - Taishan 1&2

- Lessons learned
  - Process
  - Examples
  - Early Contractor Involvement
EDF’s NUCLEAR FLEET

Powerful, competitive, low CO₂ emissions
The demands of a zero error safety culture

- **EDF Group: the world’s No. 1 nuclear power operator**
  - 485.5 TWh generated
  - France: 58 PWRs* at 19 sites
    - 404.9 TWh generated: 74.8% of production
    - €2.7bn invested in maintenance
  - United Kingdom: 14 AGRs**, 1 PWR* at 8 sites
    - 60 TWh generated
  - USA: 5 PWRs* via CENG (49.99% EDF stake) at 3 sites

- **Building the future**
  - 3 PWRs under construction
    - 1 in France: Flamanville
    - 2 in China: Taishan (30% EDF stake)
  - 1 PWR project in the United Kingdom:
    - 2 reactors at Hinkley Point
    - Authorizations granted
    - Design approved by safety authorities
    - Final Investment Decision not yet taken.

* Pressurized water reactor
** Advanced gas-cooled reactor
EPR = European (Evolutionary) Pressurised water Reactor

Design derived from French N4 and German Konvoi series.

Increase nuclear safety

More competitive

EDF-Framatome N4

Siemens KONVOI

Feedback of experience
From 58 + 17 reactors in operation

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EPR: some design features to enhance safety

4 independent safety trains

Air Plane Crash shelter
Made with very thick concrete structure
EPR: some design features to enhance safety

Core melt stabilisation system

Digital Instrumentation & Control system
Computerised Man Machine Interface

In-containment water storage + passive cooling system
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FLAMANVILLE 3

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FLAMANVILLE 3

Civil engineering work almost completed.

Prestressing under preparation.
FLAMANVILLE 3

Electro – Mechanical work : more than 50 % completed
FLAMANVILLE 3

Conventional Island completed
FLAMANVILLE 3

- Cable pulling ongoing
- I&C cabinets ongoing
- HV& LV switchboards completed
FLAMANVILLE 3

Commissioning under progress

On track to reach the 2016 target.
TAISHAN 1
TAISHAN 1
TAISHAN 1
TAISHAN 2
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Lessons learned

Goal
Avoid repetition of problems encountered on in-progress EPR Projects
Informed about good practices and engineering choices

Method
- Establish a continuous improvement culture across organizations
- Implement a process which quickly defines, assesses applicability and implements Construction Lessons learned

Users All EPR Projects
Sharing for mutual benefit
Lessons learned:

a continuous improvement process

Lessons learned process:

◆ Capture Lessons Learned
  • Launch investigation on critical topics (top-down process)
  • Encourage LL implementation in the database (bottom-up process)

◆ Analyze LL
  • Sorting of LL by leader entities, by impact (cost, schedule, constructability)
  • Analysis (relevance, applicability to other projects)

◆ Process the LL
  • Appoint a pilot for each LL
  • Launch investigation & action plans
  • Follow-up of actions
  • Implement solution (best practices, issues, know-how)

◆ Communicate
  • Report
  • Share

Transforms experiences into valuable knowledge
Lessons learned: a continuous improvement process

Why?
- To prevent & eliminate difficulties for further projects, offers and ongoing projects: Enhance constructability
- To reduce and secure cost & time schedule

To improve the performance

How?
- Implement Lessons Learned in the database
- Redaction of reports, interviews,
- Missions on site
- With support of a LL network positioned in key entities

By dedicating people to this task

When?
- Day to day
- Lessons Learned is an ongoing process

Every day
Examples

- **Flamanville 3**
  - Issue with the liner containment erection
  - Liner leading to efficient welding

- **Taishan 1 & 2**
  - Reactor raft poured in one step
  - CW feedback in order to optimize construction methods

- **Hinkley Point 1 & 2**
  - Construction methods => prefabrications
  - Early Contractor involvement
  - Improvement of mechanical and electrical erection works

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### Hinkley Point C project key strengths

<table>
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<tr>
<th>Leverage from nuclear and large infrastructure projects</th>
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<tr>
<td>▪ World-class team with significant experience in nuclear projects and large infrastructure projects (2012 Olympics, Heathrow Terminal 5)</td>
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<tr>
<td>▪ Lessons from other EPR projects fully included</td>
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<td>▪ Involvement of strategic industrial partners, sharing construction risk</td>
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<th>Specific project strengths</th>
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<td>▪ Strong project organisation and clear processes</td>
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<td>▪ Basic design agreed with UK regulator together with strict change management process</td>
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<td>▪ Robust cost model and schedule developed</td>
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<td>▪ Constructability and interface management improved by 4D modeling</td>
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<th>Alignment through contractual framework</th>
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<td>▪ Supply chain aligned to delivery and management of risk</td>
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<td>▪ Early contractor involvement improves constructability and interface management</td>
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HPC Project
Examples of benefits – pre construction

4D Construction Planning Model

Detailed on site / off site logistics planning:

• Monthly time slice
• Cranes; scaffold & access
• Welfare & facilities
• Temporary roads, utilities & works
• Materials handling; lay down & traffic control
• Interfaces between other contracts
New build contracts - Major lessons learned

- Analysis of FA3 main contracts and their management
  - Significant increase in initial quotation, mostly due to many configuration changes
  - Insufficient control of contractual milestones

- Major areas of improvement, in particular:
  - A more precise definition of technical scope: engineering studies, equipment/system list, BoQ, erection, etc
  - The right moment to sign the final contract: some contracts signed too early compared to detailed design status and works
  - Setting up of contractual milestones: notice dates, contract steps (studies, qualification, procurement, manufacturing, erection, tests)
  - Cost firming up
Early contract Involvement (ECI)

- ECI phase: a firming-up phase to conduct early and limited works to get a better level of certainty of contract scope, costs and schedule
  Through an Early Work Agreement (EWA)

- Early Work Agreement may cover the following activities (depending on the Contractor’s activities)
  - Critical engineering activities
  - Technical configuration and interface management
  - Project management activities ramp-up
  - Plot plan finalisation / optimisation
  - Site Preparatory work
  - Support to licensing
  - Schedule
Interests of ECI – project & construction aspects

Win-Win approach: an integrated team to set the environment for success

• Entering in a smooth and simplified dialogue with the contractor, working together to prepare the execution of the final contract

• Collaborative work with the contractor to develop a common solution and approach

– Risk management: engineering studies performed before FNTP allowing to reduce critical risks (with high probability and high impact), optimise design and secure planning
  • Reduction and management of changes in configuration with contractor: No work shall be started on construction until specifications, drawings sufficient and configuration enough stable. Freeze of a design reference.
  • Anticipation and clarification of interfaces between lots/contracts

– Appropriation of contractor methods, common development of process and procedures
  • Consider constructor methods at the very beginning of the detailed design phase
  • Integrate innovative methods and tools from contractors mastering their construction specialty (civil works, etc)
  • Improve constructability (pre-fabrication, etc) by considering it in the early engineering phase
  • Optimise delivery process

– Implementation of project management organisation in line with contractors’ one and associated preliminary activities to be ready to start construction just after the FNTP
**Interests of ECI – contractual aspects**

- Improvement of contract management system and process applying international best practices:
  - Formalisation: contractual exchanges, precise definition of milestones, deliverables, interfaces
  - Tools for contract managers
- Contractual integration of an agreed number of configurations and associated key milestones (in the final contract)
- Cost firm up: from an estimated target price to a final target price. Reduction of contingencies level
- Common work on schedule

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**Win-Win approach: an integrated team to set the environment for success**

- Entering in a smooth and simplified dialogue with the contractor, working together to prepare the execution of the final contract
- Collaborative work with the contractor to develop a common solution and approach
Heavy prefabrication of the pools has been studied in detail.

The pools will be prefabricated and lifted into position.

Significant improvement in schedule

Improvement in safety

Improvement in quality

ECI has identified and developed specific details to enable the prefabrication of the pools.
ECI - Main Civils Contract
Examples of benefits – design to build

Problems detected and resolved during the design phase giving better certainty on construction programme due to:

- Clash detection of rebar, plates and cast in items
- Construction sequencing and coordination
- Material control on site – lean processes using manufacturing techniques
- Improved quality and productivity
Precast concrete roof slab components with structural topping:
- Increases productivity,
- Improved quality with cast in items to be fitted in a factory environment,
- Avoids requirement for false work & propping pus early backfilling,
- Improves safety / reduced working at height.

It’s important to carry on the ECI through the key contracts
Thanks for your attention