Construction Technologies and Management for Nuclear Power Plant Projects

Garry G. Young

Director
Entergy Nuclear

IAEA/ANL Training Course on Leadership & Management of NPP Programmes
August 28, 2013
Topics

- Background
- Lessons Learned
- Examples of New Technology and Management
Background

U.S. Operating Nuclear Power Plants - 104

- 31 States with operating reactors
- 80 different designs
- 65 commercial reactor sites

Licensed to Operate (104)
Background

Commercial Nuclear Power Reactor Licenses

Note: No licenses were issued after 1996.
Background

Nuclear Research and Test Reactors in U.S.
Background

U.S. Net Electric Generation by Energy Source, 2011

Coal: 42%
Petro: 0.68%
Gas: 25%
Hydro: 8%
Nuclear: 19%
Renewable: 5%

Background


* Gas includes natural gas, blast furnace gas, propane gas, and other manufactured and waste gases derived from fossil fuel.
** Hydroelectric includes conventional hydroelectric and hydroelectric pumped storage.
*** Renewable energy includes geothermal, wood and nonwood waste, wind, and solar energy.
Background

Net Electricity Generated in Each State by Nuclear Power

Background

U.S. Commercial Nuclear Power Reactors—Years of Operation by the End of 2012

- 2 reactors (10–19 years)
- 37 reactors (20–29 years)
- 50 reactors (30–39 years)
- 15 reactors (>40 years)

Note: Ages have been rounded up to the end of the year.
Background

Nuclear Share of Electricity Generated by Country, 2011

Note: The country’s short-form name is used.
Source: IAEA, Power Reactor Information System database, as of May 2012
Topics

• Lessons Learned
Historical Perspective

20th Century Historical Summary
U.S. Commercial Nuclear Power Plant Projects

Number of Nuclear Power Units

<table>
<thead>
<tr>
<th>Projects Started Over 25 Years</th>
<th>Projects Cancelled Prior to Construction</th>
<th>Plants that Started Construction</th>
<th>Plants Cancelled During Construction</th>
<th>Plants Completed &amp; Operation Started</th>
<th>Plants De-Commissioned or To Be</th>
<th>Plants Still Operating</th>
</tr>
</thead>
<tbody>
<tr>
<td>223</td>
<td>53</td>
<td>170</td>
<td>44</td>
<td>126</td>
<td>22</td>
<td>104</td>
</tr>
</tbody>
</table>

%  

100.0%  

23.8%  

76.2%  

19.7%  

56.5%  

9.9%  

46.6%
# Lessons Learned

## Nuclear Plant Design

<table>
<thead>
<tr>
<th>THEN</th>
<th>NOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>• New Technology</td>
<td>• Proven Technology</td>
</tr>
<tr>
<td>– Scale up Problems from Military Reactors</td>
<td>– Plants are Based on Commercial Plant Designs</td>
</tr>
<tr>
<td>– Difficulties Adapting to New Requirements</td>
<td>– Plants are Designed Around Stable Requirements</td>
</tr>
<tr>
<td>• Rapid Changes In Designs</td>
<td>• Design Stability</td>
</tr>
<tr>
<td>– Competition Driven</td>
<td>– Based on Proven Designs</td>
</tr>
<tr>
<td>– Size Doubled Every Decade</td>
<td>– Certified Designs</td>
</tr>
<tr>
<td>– Unresolved Safety Issues</td>
<td>– USI’s Resolved</td>
</tr>
<tr>
<td>• Individually Designed Plants</td>
<td>• Standard Plant Designed</td>
</tr>
<tr>
<td>– Different A-Es</td>
<td>– Predetermined Design Teams</td>
</tr>
<tr>
<td>– Competitive Procurement</td>
<td>– Standardized Components</td>
</tr>
<tr>
<td>– Customized Designs</td>
<td>– Identical Units</td>
</tr>
<tr>
<td>• Plants Were Not Designed with Constructability in Mind</td>
<td>• Modular Plant Design For Construction</td>
</tr>
</tbody>
</table>
Lessons Learned

Construction Methodology

THEN
- Multiple Prime Contractors
- Immature design at onset of construction
  - 25% design completion at start
- Models were not detailed or used
- Stick-built approach
- Manual techniques
  - Scheduling tools
  - Document and Data control
  - Measurement and positioning systems
  - Primarily manual welding
- Complicated I&C cabling and systems
- Limited heavy lifting capabilities

NOW
- EPC Approach
- Design Complete before construction
  - Design at 85% before Construction
- 3D CAD models with interactive features
- Standardized modular approach
- Automation
  - Sophisticated scheduling software
  - Automated data and document control
  - GPS and Laser measurement and positioning systems
  - Automated and enhanced manual welding techniques
- Simplified Digital and Fiber Optic systems
- Expanded Lifting and hauling capabilities
## Lessons Learned

### Owner/Operators

<table>
<thead>
<tr>
<th>THEN</th>
<th>NOW</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Little Nuclear Background</strong></td>
<td></td>
</tr>
<tr>
<td>– Technology was too new</td>
<td></td>
</tr>
<tr>
<td>– When Most Started it was too late to gain experience</td>
<td></td>
</tr>
<tr>
<td>– Most Personnel were new hires</td>
<td></td>
</tr>
<tr>
<td><strong>Misunderstood Nuclear QA</strong></td>
<td></td>
</tr>
<tr>
<td>– Record Keeping was Seen as a Nuisance</td>
<td></td>
</tr>
<tr>
<td>– Compliance with Procedures was Spotty</td>
<td></td>
</tr>
<tr>
<td>– Quality was Inspected In rather than Built in</td>
<td></td>
</tr>
<tr>
<td><strong>No Confidence in Payoff</strong></td>
<td></td>
</tr>
<tr>
<td>– No operating history</td>
<td></td>
</tr>
<tr>
<td>– No basis for optimism</td>
<td></td>
</tr>
<tr>
<td><strong>All Operate Many Plants</strong></td>
<td></td>
</tr>
<tr>
<td>– Industry has Consolidated into the hands of Specialist Companies</td>
<td></td>
</tr>
<tr>
<td>– Lots of experienced personnel available</td>
<td></td>
</tr>
<tr>
<td><strong>Committed to Nuclear QA</strong></td>
<td></td>
</tr>
<tr>
<td>– Record Keeping is Ingrained in organizations</td>
<td></td>
</tr>
<tr>
<td>– Compliance with Procedures is Demonstrated</td>
<td></td>
</tr>
<tr>
<td>– Quality Programs are Robust and Effective</td>
<td></td>
</tr>
<tr>
<td><strong>Certain in Payoff</strong></td>
<td></td>
</tr>
<tr>
<td>– Positive operating history</td>
<td></td>
</tr>
<tr>
<td>– Best Economical Solution to Electricity Production</td>
<td></td>
</tr>
</tbody>
</table>
Lessons Learned

Regulatory Process

THEN
- 10CFR50
- Two-Step Process
  - Construction Permit
  - Operating License
- Ratcheting Requirements
  - New Technology
  - Uncertain Safety
  - Uncertain Environmental Impact
  - Political Pressure Driven by Fear of the Unknown
  - Activist Interveners
- Issues Can Be Raised Repeatedly
- Few People Trained in Process

NOW
- 10CFR52
- One-Step Process
  - Combined License
  - ITAAC
- Stable Requirements
  - Proven Technology
  - Demonstrated Safety
  - Documented Environmental Impact
  - Political Pressure to License New Plants
  - Activist Interveners Fragmented by Global Warming Issue
- Issues Can Be Raised Only Once
- Many People Trained in Process
Today’s Improved U.S. Industry Efforts

– Advanced nuclear plant designs
– Streamlined regulatory process
– Federal incentive program for financing and insurance
– Modest inflation and financing rates
– Standardized designs for nuclear power plants
– More sophisticated management processes/software
– Modularization approach to construction
– Integrated material management planning techniques

Lessons Learned: First-of-a-kind projects are not fully understood, degraded nuclear supply chain, and global supply chain logistics and risks
Lessons Learned

One-step process, 10 CFR 52, COL authorizes construction and operation

**THEORY:** Pre-approved certified standard design and site in advance of large financial commitment

**ACTUAL:** Process allows COL to incorporate a design that is not yet approved and for optional early site permit inclusion

- Opportunity to “bank” ESP in advance of financial commitment
- Issues decided once - finality at each stage
- COL design-centered reviews provide further standardization

**Demonstrated improvements in hearing process:**

- Rules of practice tightened
- ASLB case management tightened
- Objective basis for operational decision
Overview of 10 CFR 50 vs. 52

**Old Process 10 CFR 50**

- Construction Permit Application*
- Construction
- Operating License Application
- Operating License Issued*
- Operations

Significant capital committed with no assurance that facility would ultimately be approved

**New Process 10 CFR 52**

- Early Site Permit*
- Combined License*
- Design Certification*
- Construction
- Inspection & Test Acceptance Criteria*
- Operation

Upfront approval of plant design, site acceptability and operational plan; with demonstration of overall implementation of approved plan

* Public Hearing/Comment Opportunity
The NRC’s new licensing process offers multiple opportunities for public input.
Regulatory and Legislative Development

10 CFR Part 52, New Reactor Licensing Process

Diagram showing the flow of the licensing process:
- Combined License Application
- Safety Review
- Public Comments
- Notice of Hearing
- Public Involvement
- Environmental Review
- Final Environmental Impact Statement
- Final Safety Evaluation Report
- Hearings
- Commission Decision on Application
Examples of New Technology and Management
Schedule Impact of Example Improvements

- **US BWR**
- **Japan BWR**
- **Japan ABWR**

**Improves Construction Method**
- **Drawing**
- **Plastic Model**
- **3D-CAD**
- **6D-CAD**
Strategies for Reduced Construction Period

Reduced Construction Period to ~ 38 months*

* based on actual first ABWR in Japan
Resource Hour Reduction with Early Engineering

Reduced Site Resource Hours by ~ 40% *

* Detailed engineering before construction start
Resource Hour Reduction with Early Engineering

Source: From Hitachi construction experiences
Construction Management with 6D Model

3D-model linked with schedule, resources, and quantities of material = 6D-model
Open Top Construction

- Integrating the construction of the building walls/slabs with the modules, equipment/mechanical and electrical commodities installation.

- Reduces temporary openings, the material handling costs of bulk commodities

- Require Very Heavy Lift Cranes

SG Installation in Qinshan, China
All Weather Construction

All Weather construction method to mitigate severe weather conditions, i.e. heavy snowfall, seasonal high wind:

- A temporary/structural steel frame covered with a tent;
- Movable temporary roofs for the open top construction by a VHL crane;
- A temporary/permanent overhead crane and hoists with monorails;
- Permanent stair cases providing the floor access during the construction
Steel Plate Reinforced Concrete Construction

- The SC Structure was fully applied to a incinerator building, which deals with wastes from the nuclear power plants in Kashiwazaki-Kariwa site in Japan.
- The SC structure has been demonstrated to be applied to a building related to the nuclear facilities by TEPCO.
- The construction duration has been reduced by 25% compared with the RC structure.
Questions?