HGNE’s Advanced Construction Methodology

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Isidro de la Fuente – GEH Nuclear Energy

Hitachi-GE Nuclear Energy, Ltd.
Alternative uses for the atom...navy nuclear propulsion

- USS Nautilus, first nuclear-powered submarine - W (PWR)
- USS Seawolf, second nuclear-powered submarine - GE (NaK)
- PWR prevalence heavily influenced by 6 ‘nuclear navy countries’*
- PWRs favored for nuclear naval propulsion due to:
  - compact, yet separated, high-power design
  - secondary loop isolates radioactive systems from sailors
  - nuclear ships/subs are nationally built, PWR skills developed

- Vendors chose technologies early also...even GE made navy PWRs
- Should not be a primary reason for selecting commercial reactor

*L, Russia (and countries of former Soviet Union), UK, France, China, India

LWRs in Nuclear Navy Countries

- >4 to 1
  - ~6 countries*
  - ~250 reactors

LWRs in NON-Nuclear Navy Countries

- <2 to 1
  - ~28 countries
  - ~180 reactors
PWRs and BWRs - the basics

Typical Pressurized Water Reactor

Typical Boiling Water Reactor
Basic Principles of Steam Generation

**BWR**
- Direct Cycle (Single Cycle)
- RPV Pressure ~7 MPa (1020 psig)
- RPV Temperature 288 °C (550 ºF)
- Steam Generated in RPV (with Separator & Dryer)
- Bulk Boiling Allowed in RPV
- Pure Water H₂O

**PWR**
- Indirect Cycle (Dual Cycle)
- RPV Pressure ~15 MPa (~2240 psig)
- RPV Temperature 326 °C (~618 ºF)
- Steam Generated in Steam Generator (via Second Loop)
- No Bulk Boiling in RPV
- Water + Boric Acid

**BWR Has Lower RPV Pressure and Simplified Steam Cycle**
Simplicity
Simplification of design

PWR

BWR

ABWR

ESBWR
PRA of Core Damage Frequency

- U.S. PWRs: 2 E-5 (avg.)
- U.S. BWRs: 8 E-6 (avg.)
- APR1400: 2 E-6
- APWR: 1.2 E-6
- EPR: 2.8 E-7
- AP-1000: 2.4 E-7
- ABWR: 1.6 E-7
- ESBWR: 1.7 E-8

PWR Complication

BWR Simplification

Generation II

Generation III

Note: PRA of CDF is represented in at-Power internal events (per year)
Note: NSSS diagrams are for visualization purposes only
1. Global Nuclear Alliance

Hitachi-GE Nuclear Energy
(Established on July 1, 2007)

GE-Hitachi Nuclear Energy
(Established on June 4, 2007)

Hitachi Strength
- Design
- Manufacturing
- Construction
- Latest method
- Integrated CAE

GE Strength
- GE Brand
- Global supply chain
- US origin Technology Transfer
- Sales
- Licensing

Hitachi GE nuclear business collaboration for more than 50 years
First alliance for comprehensive BWR technology in 1967
Committed to develop and promote latest BWR technologies and services
2. HGNE’s Construction Experience

- 40 years continuous construction and maintenance
- 20 NPP’s of 54 LWR’s operated in Japan
  (30 BWR’s / 24 PWR’s)

Power (MWe)

- SHIMANE – 1
  (First Made-in-Japan NPP by Hitachi)

Under construction

Under planning

* COOPERATION CONSTRUCTION

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3. BWR Experience in JAPAN (Total 20 Plants)
4. Participation in all the ABWR projects in JAPAN
5. HGNE construction experience of ABWR

Hitachi-GE: ABWR Leading Company

- Over 35 yrs Continuous Construction Experience
- Engaged to All Japanese ABWR Constructions
- ABWR Share No.1 (67%*)

1970
- Tsuruga No.1
- Fukushima-1-1
- TEPCO/Kashiwazaki-Kariwa No.4

1996
- 1st ABWR

1997
- Commercial Operation Year
- TEPCO/Kashiwazaki-Kariwa No.6
- TEPCO/Kashiwazaki-Kariwa No.7

2005
- Chubu EPC*/Hamaoka No.5
- Hokuriku EPC*/Shika No.2
- The Chugoku EPC*/Shimane No.3

2006
- J-Power/Ohma
- Full MOX
- MOX Mixed Oxide fuel

(Plan) 2011
- NI & TI Island
- Nuclear Island (NI)
- Turbine Island (TI)
- BWRs

(Plan) 2014
- NI and TI Island
- Nuclear Island (NI)
- Turbine Island (TI)
- BWRs

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6. Hitachi-GE’s Construction Strategy

- **Construction oriented eng’g**
  - Precise and on-time Design/Procurement with Advanced Plant Integrated CAE System

1. Reduce On-site Work
   - Modularization with Very Heavy Lift Crane

2. Level On-site Work
   - Open-top & Parallel Construction Floor Packaging

3. Improve On-site Work Efficiency
   - Front-Loaded Construction Engineering Detailed Schedule Management

4. Improve Site Support Work Efficiency
   - Construction Work Support System
7. Detailed engineering before on-site work
8. ABWR modularization – proven in Japan
9. Front-Loaded Construction Engineering

Previous Design Process

- Basic Design
- Detailed Design
- Construction
- Construction Engineering

Front-Loaded Construction Engineering

- Basic Design
- Detailed Design
- Construction Engineering

Requirements from Construction Engineering

Inputs from Plant Design (BOQ, Composite Design, etc.)

- Just Do It As Planned -
Planed schedule has been kept at actual construction scene.

## Construction Achievement of ABWRs (months)

<table>
<thead>
<tr>
<th>Plant</th>
<th>F/C - F/L</th>
<th>Start up</th>
<th>Total</th>
<th>Plant status</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P *1</td>
<td>A *2</td>
<td>A *2</td>
<td>P *1</td>
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<tr>
<td>Kashiwazaki-Kariwa-6</td>
<td>37</td>
<td>37</td>
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<td>48</td>
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<td>Hamaoka-5</td>
<td>43*3</td>
<td>43*3</td>
<td>11</td>
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<td>Shika-2</td>
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<td>42</td>
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<td>53</td>
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<tr>
<td>Shimane-3</td>
<td>41</td>
<td>-</td>
<td>-</td>
<td>51</td>
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<tr>
<td>Ohma</td>
<td>42</td>
<td>-</td>
<td>-</td>
<td>53</td>
</tr>
</tbody>
</table>

*1: Planned months,  *2: Actual months,  *3: Including suspended time

Well coordinated Early Engineering with IT systems

Advanced Construction Technologies

On Schedule and On Budget

Benefit and Risk Management for Owner

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Shimane-3 Construction

http://www.energia.co.jp/atomy_atom13-07.html
12. ABWR Construction Sequence Outline

S/C: Start Construction
F/C: First Concrete (Mat Start)
M/C: Mat Completion
H/T: Hydro Pressure Test
F/L: Fuel Loading
C/O: Commercial Operation
EOTC: Electric Overhead Traveling Crane start
CW: Circulating Water
Mat Module Installation: Dec. 2007
Upper Mat Rebar, Anchor Bolts for Pedestal, and Embedded plates etc.
Weight: 650 MT/ Size: D 141 ft (43m) X H 15 ft (4.5m)
RCCV Liner Module Installation: Feb. 2008
1st to 5th RCCV Liners, Access tunnel, and penetrations
Weight: 400 MT/ Size: D 95 ft (29m) X H 69 ft (21m)
15. Shimane-3 Construction Report

HCU Room Module Installation: Feb. 2008
HCU, Building Structures including SC walls, Piping, Cable Tray, HVAC Duct etc
Weight: 270 MT/ Size: L 60 ft (18m) X  W 30 ft (9m) X H 29 ft (8.5m)
RPV Pedestal Module Installation: April 2008
1st & 2nd Layer of RPV Pedestal with RIP Hxs and its support, Platforms, embedded piping etc.
Weight: 550 MT/ Size: D 50 ft (15m) X H 50 ft (15 m)
Condenser upper shell with 2 neck heaters and piping inside. Heaviest shop module.
Weight: 270 MT/ Size: L 60 ft (18.5m) X W 35 ft (10.5m) X H 32 ft (9.5 m)
18. Shimane-3 Construction Report

RCCV Upper Drywell Module: Mar. 2009
Module consists of gamma shield, Piping, piping support, and Structures etc. Heaviest on-site module.
Weight: 610 MT  Size: L 87 ft (26m) X W 77 ft (23m) X H 30 ft (9 m)
Module consists of top slab steel frame, embedded piping. Module assembled at site.
Weight: 610 MT  Size: L 87 ft (26m) X W 77 ft (23m) X H 30 ft (9 m)
RPV Installation: Jul. 2009
Weight: 820 MT, Size: D 24.6 ft (7.5m) X H 62 ft (19 m). Heaviest Equipment in ABWR
Small & Medium size Reactor Technology

Double MS:
Modular Simplified & Medium Small Reactor
22. Overview of Hitachi-GE’s Small & Medium Reactor

- Simplified reactor internals and system
- Enhanced hybrid (passive & active) safety system
- Multi-purpose use of energy (non-electric use of energy: Co-generation)

### Specification

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<td>Thermal Power</td>
<td>840 MW</td>
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<tr>
<td>Electric Power</td>
<td>300 MW</td>
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<tr>
<td>Reactor Type</td>
<td>BWR</td>
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<tr>
<td>Cooling Method</td>
<td>Natural Circulation</td>
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<tr>
<td>Coolant Pressure</td>
<td>7.2 MPa</td>
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<tr>
<td>Power Density</td>
<td>44 kW/l</td>
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<tr>
<td>No. Of fuel bundle</td>
<td>400</td>
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<tr>
<td>Fuel Enrichment</td>
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<tr>
<td>Active Fuel Length</td>
<td>2 m</td>
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<tr>
<td>Refuel Interval</td>
<td>&gt;2 years</td>
</tr>
<tr>
<td>Construction Period</td>
<td>~2 years</td>
</tr>
<tr>
<td>Safety System</td>
<td>Hybrid (Passive + Active)</td>
</tr>
</tbody>
</table>

- Free Surface Separation (FSS)
  - Steam is separated from water by gravity force, hence, no “Separator” is required
- Natural Circulation
  - No reactor internal pumps (RIPs)
Concept of “Fixed standard area” enhances cost learning effect

Hybrid R/B layout concept

- Fixed standard area
  - Hardly influenced by conditions which depends on each site
  - Controlled area
  - RHR, hybrid RCIC, CUW, CRD, etc.
  - Cost Learning effect

- Variable flexible area
  - Depends on site condition
  - Non-controlled area
  - Electrical panel room, etc.
Factory-made modules can reduce construction period. Well-experienced modular construction range is expanded.

- Multi-Floor Module of electric panel room
  - Building framework (SC & Steel)
  - Electric panel
  - Cable tray

- Compact PCV with Shielding Wall
  - Compact PCV (Steel)
  - Shielding wall (SC)

Shop-fabrication

Land transportation