Nuclear Energy Systems
Business Presentation Meeting

[Document 1]

July 23, 2007
Nuclear Energy Systems Headquarters
Mitsubishi Heavy Industries, Ltd.
1. Overview of Nuclear Energy Business

2. Current Status of Nuclear Plants both Domestic and Overseas

3. Activities on Nuclear Energy Business in Japan

4. Activities on Nuclear Energy Business Overseas

5. Medium and Long Term Plan
1. Overview of Nuclear Energy Business

(1) Position of Power Systems segment
1. (1) a) Position of Power Systems segment

Orders received in 2006 (consolidated)
¥1,008.2 billion
(MHI Total : ¥3,274.7 billion)

Net sales in 2006 (consolidated)
¥890.7 billion
(MHI Total : ¥3,068.5 billion)
1. (1) b) Business Output
(consolidated figures of Power Systems segment)

Operating profitability

(Unit: ¥100 million)

<table>
<thead>
<tr>
<th>Year</th>
<th>Net sales</th>
<th>Orders received</th>
<th>Net sales</th>
<th>Orders received</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>8,728</td>
<td>7,109</td>
<td>10,082</td>
<td>8,907</td>
</tr>
<tr>
<td>2006</td>
<td>9,600</td>
<td></td>
<td>10,350</td>
<td></td>
</tr>
</tbody>
</table>

Profitability
6%

Business
¥1 trillion
1. Overview of Nuclear Energy Business

(2) Activities on Nuclear Energy Business
1. (2) a) Vision of Nuclear Energy Business

Vision:
“A comprehensive nuclear energy systems company” that leads the world

A company that leads “safety” and “security” with own technology throughout the whole life of nuclear power plants

Development, design, manufacture, construction and maintenance

Design and Development Center Building at MHI Kobe Shipyards & Machinery Works
1. (2) b) Field of Nuclear Energy Business

“A comprehensive nuclear energy systems company” that covers all fields

- **PWR (pressurized-water reactor) Power Plant**
  - Development, Design, Manufacture, Construction, Maintenance and Repair services

- **Advanced Reactor Plant**
  - Fast Breeder Reactor (FBR)
  - High-Temperature Gas Cooled Reactor
  - Nuclear Fusion Reactor

- **Nuclear Fuel**
  - Uranium Fuel
  - MOX Fuel
  - Advanced Reactor Fuel

- **Nuclear Fuel Cycle**
  - Spent Fuel Reprocessing Plant
  - Waste Disposal System Equipment
  - Radioactive Material Transport Cask
1. (2) c) Organizations of Nuclear Energy Business

(Overall Control)

MHI Kobe Shipyard & Machinery Works
- Nuclear Island
  (Reactor Loop)

MHI Takasago Machinery Works
- Conventional Island
  (Turbine Loop)

Mitsubishi Electric Corporation
- Electrical Equipment

Mitsubishi Nuclear Fuel Co., Ltd.
- Nuclear fuel manufacture

Nuclear Fuel Transport System Co., Ltd. (NFTS)
- Nuclear fuel transportation

Nuclear Development Corporation
- Research and development of nuclear fuels

Nuclear Plant Service Engineering Co., Ltd.
- Maintenance services

Nuclear Power Training Center Ltd.
- Operator Training

MHI Takasago R&D Center
- Advanced Technology R&D Center

[United States]: MNES
(Mitsubishi Nuclear Energy Systems, Inc.)
2. Current Status of Nuclear Plants both Domestic and Overseas
2. (1) Reactor share of World Nuclear Plants

PWR is in the mainstream.

- BWR: 93 units, 26%
- PWR: 263 units, 74%

Source: Nuclear News March 2006,
World List of Nuclear Power Plants
(as of December 31, 2006)
2. (2) Nuclear Power Plants in Japan

<table>
<thead>
<tr>
<th></th>
<th>In operation</th>
<th>Under construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>PWR</td>
<td>23 units</td>
<td>3 units</td>
</tr>
<tr>
<td>BWR</td>
<td>32 units</td>
<td>3 units</td>
</tr>
<tr>
<td>FBR</td>
<td>1 unit</td>
<td></td>
</tr>
</tbody>
</table>

Nuclear Power Plants in Japan

- Toshiba 27%
- Hitachi 24%
- GE 7%
- Mitsubishi Heavy Industries 42%

(Mitsubishi Heavy Industries 55 units)

(As of March 31, 2007)
3. Activities on Nuclear Energy Business in Japan
3. (1) Activities on Nuclear Energy Business in Japan

(1) New plants:
   Hokkaido Electric Tomari Unit 3 : under construction
   The Japan Atomic Tsuruga Units 3 and 4 (APWR)
   Kyushu Electric Next plant

(2) Existing plants: expansion of maintenance business
   (focus on preventive maintenance)

(3) Expansion of fuel-related business
   (high burnup fuels and MOX fuels)

(4) Global leadership in FBR development
   (selected by the government as the core company
   → established MFBR → Leadership in GNEP as well)
3. (2) Activities on PWR

Applying all Mitsubishi’s “engineering capabilities” and “manufacturing capabilities”

<table>
<thead>
<tr>
<th>1970s</th>
<th>1980s</th>
<th>1990s</th>
<th>2000s</th>
<th>2010s</th>
<th>~ 2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>[9 units]</td>
<td>[7 units] / 16 units in total</td>
<td>[7 units] / 23 units in total</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- New plant construction
  - Introduction of WH technology in 1959
  - Operational launch of the Mihama No.1 reactor (MHI’s first PWR) in 1970
  - Establishment of Mitsubishi own technology

- Improvement in economy, operability and maintainability
  - Operational launch of the Mihama No.1 reactor (MHI’s first PWR) in 1970
  - Establishment of Mitsubishi own technology

- New plant construction
  - Operational launch of the Mihama No.1 reactor (MHI’s first PWR) in 1970
  - Establishment of Mitsubishi own technology

- Improvement in economy, operability and maintainability
  - Operational launch of the Mihama No.1 reactor (MHI’s first PWR) in 1970
  - Establishment of Mitsubishi own technology

- APWR
  - Established MNES
  - Entry in the U.S. market
  - Expansion of US-APWR
  - Joint development of a strategic reactor with AREVA of France
  - Joint development with AREVA

- S-APWR for TXU #1 #2
  - Replacement plants

- Tomari Unit 3
- Tsuruga Units 3 and 4
- Sendai Unit 3

Enhance further safety and security technology including foreign information
### 3. (2) Activities on PWR

Providing continuous high-level maintenance services for “safe and secure” operation of existing plants

<table>
<thead>
<tr>
<th></th>
<th>1970s</th>
<th>1980s</th>
<th>1990s</th>
<th>2000s</th>
<th>2010s</th>
<th>~ 2030</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maintenance</strong></td>
<td><img src="image1.png" alt="Image 548x61 to 567x280" /></td>
<td><img src="image2.png" alt="Image 228x159 to 341x303" /></td>
<td><img src="image3.png" alt="Image 351x270 to 510x390" /></td>
<td><img src="image4.png" alt="Image 555x415" /></td>
<td><img src="image5.png" alt="Image 83x167" /></td>
<td><img src="image6.png" alt="Image 190x591" /></td>
</tr>
<tr>
<td>Replacement and renewal of large components</td>
<td><img src="image7.png" alt="Image 494x490" /></td>
<td><img src="image8.png" alt="Image 412x475" /></td>
<td><img src="image9.png" alt="Image 299x115" /></td>
<td><img src="image10.png" alt="Image 438x493" /></td>
<td><img src="image11.png" alt="Image 520x520" /></td>
<td><img src="image12.png" alt="Image 190x682" /></td>
</tr>
<tr>
<td>(Steam generators, core internals, reactor vessel heads etc.)</td>
<td><img src="image13.png" alt="Image 275x436" /></td>
<td><img src="image14.png" alt="Image 305x378" /></td>
<td><img src="image15.png" alt="Image 438x493" /></td>
<td><img src="image16.png" alt="Image 520x520" /></td>
<td><img src="image17.png" alt="Image 190x682" /></td>
<td><img src="image18.png" alt="Image 190x682" /></td>
</tr>
<tr>
<td>Comprehensive maintenance against aging of plants</td>
<td><img src="image19.png" alt="Image 555x415" /></td>
<td><img src="image20.png" alt="Image 83x167" /></td>
<td><img src="image21.png" alt="Image 190x591" /></td>
<td><img src="image22.png" alt="Image 83x167" /></td>
<td><img src="image23.png" alt="Image 190x591" /></td>
<td><img src="image24.png" alt="Image 190x591" /></td>
</tr>
<tr>
<td>(High-level inspections and facility renewal)</td>
<td><img src="image25.png" alt="Image 275x436" /></td>
<td><img src="image26.png" alt="Image 305x378" /></td>
<td><img src="image27.png" alt="Image 438x493" /></td>
<td><img src="image28.png" alt="Image 520x520" /></td>
<td><img src="image29.png" alt="Image 190x682" /></td>
<td><img src="image30.png" alt="Image 190x682" /></td>
</tr>
<tr>
<td>Rated thermal power operation and long-cycle operation</td>
<td><img src="image31.png" alt="Image 555x415" /></td>
<td><img src="image32.png" alt="Image 83x167" /></td>
<td><img src="image33.png" alt="Image 190x591" /></td>
<td><img src="image34.png" alt="Image 83x167" /></td>
<td><img src="image35.png" alt="Image 190x591" /></td>
<td><img src="image36.png" alt="Image 190x591" /></td>
</tr>
<tr>
<td>(Improvement of performance)</td>
<td><img src="image37.png" alt="Image 275x436" /></td>
<td><img src="image38.png" alt="Image 305x378" /></td>
<td><img src="image39.png" alt="Image 438x493" /></td>
<td><img src="image40.png" alt="Image 520x520" /></td>
<td><img src="image41.png" alt="Image 190x682" /></td>
<td><img src="image42.png" alt="Image 190x682" /></td>
</tr>
</tbody>
</table>
### 3. (3) Activities on Nuclear Fuel

Realizing economical plant with highly reliable and improved burnup fuel

<table>
<thead>
<tr>
<th>Nuclear fuels</th>
<th>1970s</th>
<th>1980s</th>
<th>1990s</th>
<th>2000s</th>
<th>2010s</th>
<th>~ 2030</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>39 GWd/t fuel</td>
<td>48 GWd/t fuel</td>
<td>55 GWd/t fuel</td>
<td>Further burnup</td>
<td>(Improvement in performance by 20%)</td>
<td>(Improvement in performance by 15%)</td>
</tr>
<tr>
<td></td>
<td>Approximately 17,600 fuel assemblies manufactured</td>
<td>MOX fuel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **1970s**: 39 GWd/t fuel
- **1980s**: 48 GWd/t fuel
- **1990s**: 55 GWd/t fuel
- **2000s**: Further burnup
- **2010s**: Challenge to achieve 70 GWd/t to 80GWd/t
- **~ 2030**: Challenge to achieve 70 GWd/t to 80GWd/t

*MOX fuel*
### 3. (4) Activities on Nuclear Fuel Cycle

Reprocessing is an indispensable technology for the future

→ Accumulating own technology to all fields

<table>
<thead>
<tr>
<th></th>
<th>1970s</th>
<th>1980s</th>
<th>1990s</th>
<th>2000s</th>
<th>2010s</th>
<th>~ 2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reprocessing Nuclear fuel cycle</td>
<td>(Development of spent fuel reprocessing technology)</td>
<td>Construction of the Rokkasho Reprocessing Plant</td>
<td>Maintenance business</td>
<td>FBR fuel cycle</td>
<td>Construction of the second reprocessing plant</td>
<td></td>
</tr>
<tr>
<td>Nuclear fuel cycle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Casks</td>
<td>In Japan</td>
<td>Manufactured approximately 140 casks</td>
<td></td>
<td></td>
<td></td>
<td>Overseas</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4 units / year</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3 to 5 units / year</td>
</tr>
</tbody>
</table>

(49 casks for transportation of spent fuel and high-level radioactive waste inclusive.)
3. (5) Activities on Advanced Reactors

Realizing next-generation technologies (FBR, PBMR and nuclear hydrogen)

<table>
<thead>
<tr>
<th>New reactors</th>
<th>1970s</th>
<th>1980s</th>
<th>1990s</th>
<th>2000s</th>
<th>2010s</th>
<th>~ 2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>FBR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monju</td>
<td></td>
<td></td>
<td></td>
<td>Reoperation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The government selected MHI as the core company for FBR development.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PBMR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>By 2050</td>
</tr>
<tr>
<td>(South Africa)</td>
<td></td>
<td></td>
<td></td>
<td>Operation in 2025</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High-temperature gas reactors</td>
<td></td>
<td>HTTR at JAERI</td>
<td>Nuclear hydrogen (I-S method)</td>
<td></td>
<td>JAERI : Japan Atomic Energy Research Institute</td>
<td></td>
</tr>
</tbody>
</table>
4. Activities on Nuclear Energy Business Overseas
4. (1) Activities on Nuclear Energy Business Overseas

(1) Expanding sale of large-sized strategic reactor ⇒ United States
(1700 MWe class US-APWR: independent development)

(2) Development and introduction of mid-sized strategic reactor ⇒ Europe, United States, Southeast Asia
(1100 MWe class: joint development with AREVA of France)

(3) Development of small-sized strategic reactor ⇒ South Africa
(170 MWe class PBMR 〔pebble bed modular reactor〕)

(4) Expansion of major components export
(steam generators, reactor vessels, turbines etc.)

(5) Aggressive proposal to GNEP
(Lead the world with fast reactor and reprocessing)
4. (2) Activities on the Large Strategic Reactor
US-APWR

- US-APWR: world’s largest class (1700 MWe) reactor independently developed
  - World’s highest level of thermal efficiency (39%)
  - Highly economical
  - 20% reduction in plant building volume
  - 24 months continuous operation

- TXU decided to adopt US-APWR (2 units) in March 2007

- Under discussion with other U.S. utilities on adoption of US-APWR
4. (3) Activities on developing Mid-sized Strategic Reactor

- Under development on 1100 MWe class PWR jointly with AREVA

- Development at double speed by integrating both companies’ latest technologies
  (Excelling in safety, economy, efficiency and construction period)

- MOU for JV establishment executed on July 10, 2007
  (Acceleration of development and marketing)

MHI President Tsukuda and AREVA Chairman Lauvergeon
4. (4) Activities on developing Small-sized Strategic Reactor (PBMR for South Africa)

Mitsubishi Scope

- **Core barrel (core internal)**
- **Helium turbine generator**

- Operation of demonstration unit in 2012
- 3 units/year from 2013 to 2020
  (scheduled to construct 24 units in total)
4. (5) Activities in the U.S. market

By many experiences of exporting major components to U.S., expanding U.S. market activity with MNES (a liaison company in USA). both maintenance services and new plant business

<table>
<thead>
<tr>
<th>Product</th>
<th>Delivered</th>
<th>Under Manufacturing</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Reactor vessel head</td>
<td>11</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>(2) Steam generator</td>
<td>2</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>(3) Pressurizer</td>
<td>1</td>
<td>-</td>
<td>1</td>
</tr>
</tbody>
</table>
4. (6) Activities in the European market

Based on component delivery records and good customer relations in many countries

expanding both component and new plant business

<table>
<thead>
<tr>
<th>Country</th>
<th>Product</th>
<th>Delivered</th>
<th>Under Manufacturing</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) France</td>
<td>Steam generator</td>
<td>-</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>(2) Belgium</td>
<td>Steam generator</td>
<td>8</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>(3) Spain</td>
<td>Turbine HP x 1, LP x 3</td>
<td>4</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td>(4) Slovenia</td>
<td>Turbine LP</td>
<td>2</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>(5) Finland</td>
<td>Reactor vessel</td>
<td>-</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>(6) Sweden</td>
<td>RVH</td>
<td>3</td>
<td>-</td>
<td>3</td>
</tr>
</tbody>
</table>

CRDM: control rod drive mechanism

HP: high pressure   LP: low pressure   RVH: Reactor vessel head
4. (7) Activities in Chinese and Southeast Asian markets

- **China**: Cooperate with China’s nationalization and self-reliance policies (responding through component export)
- **Taiwan**: Two turbines for ABWR delivered already
- **Indonesia**: International cooperation through long-term plans Independent MHI seminars since 2004
- **Vietnam and Thailand**: Active participation in the Japanese government plans for international cooperation

Candidate site for nuclear plant: Muria area

Undecided sites:
- Haiyang
- Sanmen
- Daya Bay
- Lingao
- Qinshan
- Tianwan

China

Taiwan

Indonesia

Vietnam and Thailand

Continue to promote activities carefully
4. (8) Activities on GNEP

- GNEP is a concept announced by the U.S. Department of Energy (DOE) in February 2006. Partners (United States, Japan, France, United Kingdom, Russia, China, etc.) study the development and use of advanced fast reactors and the reprocessing cycle.

- In May 2007, DOE invited applications from the public engaging in studies to realize the concept (study how to proceed the business plan etc.).

- In June 2007, MHI and AREVA proposed a joint application to DOE (MHI as the fast reactor leader and AREVA as the reprocessing leader).
5. Medium and Long Term Plan
5. (1) New PWR plant construction schedule

Substantial increase in new plant construction over medium and long terms (10 years)
Expansion in business scale

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tomari Unit 3</td>
<td>APWR</td>
<td></td>
<td>Tsuruga Unit 3</td>
<td></td>
<td>Kyushu Electric next plant</td>
</tr>
<tr>
<td></td>
<td>US-APWR</td>
<td></td>
<td>Tsuruga Unit 4</td>
<td></td>
<td>Subsequent reactors</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Construction 1 or 2 plants per year</td>
<td></td>
<td>Medium-sized strategic reactors</td>
<td></td>
</tr>
</tbody>
</table>

(Medium and long terms)
5. (2) Medium and long-term business scale

Medium and long terms (after 10 years):
Triple expansion in scale

Present

10 years from now

Triple Volume

Global business

Domestic business
Contribute to the world with safe and secure nuclear energy systems by leveraging the well-established engineering, manufacturing and technical support capabilities maintained and strengthened over the years.

“A comprehensive nuclear energy company” that leads the world.
1. Technologies to make sure “safety and security” and to improve economy

2. Development and market introduction of global strategic reactors

3. Establishment of the nuclear fuel cycle
1. Technologies for making sure “safety and security” and improving economy

Comprehensive technological capabilities for whole plant life

Capabilities

- High-level design technologies for reactor core design and safety analysis
- Development and design technologies for entire plants
- R&D technologies for manufacture, construction and maintenance
- High-level development and design technologies for fuel

Engineering

- Manufacturing technologies based on cutting-edge engineering and welding technologies
- Plant construction technologies based on half-century experience

Manufacturing

- Response to aging, maintenance and inspection efficiency improvement
  - Preventive maintenance technologies for more sophistication
- Design and maintenance technologies to bolster safety

Technological support

[Social needs]

- Safety and security of nuclear power plants
- Improvement in economy
1. (1) Engineering capabilities

[Technologies for reactor core design and safety analysis]

The only company capable of consistent reactor core design and safety analysis services

- Developed the most advanced analytic program in the world
- Proved the analytic program using a large demonstration equipment

- A demonstration equipment for a LOCA (loss-of-coolant accident) analyzing program

Safety analysis example
1. (1) Engineering capabilities

[Plant development and design technologies]

Manufacture and construction support using consistent common database for plant development, design, manufacture and construction.

Common database example

CAM: Computer aided manufacture
1. (1) Engineering capabilities

[Technologies for PWR fuel development and design]

Abundant supply and high reliability

(Only one reconversion process in Japan)

- Experience of numbers of Fuel Assembly: approx. 17,600 (as of July 1, 2007)
- Leakage rate of fuel rod
  - MHI: $\sim 10^{-6}$
  - Overseas: $\sim 10^{-5}$

Development for economic and flexible plant operations

- **High burnup fuel**: $39 \rightarrow 48 \rightarrow 55$GWd/t * (Current level)
  - Further burnup improvement (targeted 70-80GWd/t)
- Extended cycle length and up-rate of reactor power

Effective use of reprocessed Pu and U

- MOX fuel supply
- Supply of recycled uranium fuel

*GWd/t: Energy production per ton of uranium
1. (2) Manufacturing capabilities

- Keep innovating high-accuracy, high-efficiency, high-quality manufacturing technologies

<table>
<thead>
<tr>
<th>150 kW electron beam welding component</th>
<th>Super-large combined machine tool “Super Mirror”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application of the world’s highest accuracy welding technologies to large structures</td>
<td>The only super-large machine tool in the world offering high-accuracy, high-quality processing in upright installation position</td>
</tr>
</tbody>
</table>

- Electron beam gun
- Turntable
- Reactor vessel
1. (2) Manufacturing capabilities

**Welding of integrated reactor vessel-barrels and nozzles**
- Develop super large rotating fixture
- Weld the rotating fixture weighing 200t in total

**Insertion of heat transfer tubes to steam generators**
- Insert approx. 10,000 heat transfer tubes to a heat generator with high accuracy
1. (2) Manufacturing capabilities

[Plant construction technologies]

♦ Reduction in on-site work

- Super large-capacity cranes (Reduction in on-site work)
- Upper reactor containment measuring 40m in diameter

Internal structures using SC (steel plate reinforced concrete)

Large prefabricated blocks

Super large-capacity cranes

Comprehensive project management for civil engineering and construction work

[Record of construction periods]
(First Concrete to fuel loading)

<table>
<thead>
<tr>
<th>Plant</th>
<th>Loops</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ikata Unit 2</td>
<td>2</td>
<td>34.5</td>
</tr>
<tr>
<td>Takahama Unit 3</td>
<td>3</td>
<td>37.5</td>
</tr>
<tr>
<td>Ohi Unit 3</td>
<td>4</td>
<td>40.0</td>
</tr>
</tbody>
</table>
1. (3) Technological support capabilities

[Support for maintenance technologies]

Increase the plant availability factor with high-level inspection, preventive maintenance, repair and component replacement technologies.

*Fastest and most precise intelligent eddy current test (ECT) in the world*

Source: “Annual Report about the Status of Nuclear Facilities in Japan” issued by Japan Nuclear Energy Safety Organization
1. (3) Technological support capabilities

[Support for maintenance technologies (large component replacement)]

- Comprehensive plant engineering
- Manufacturing technologies (high accuracy, high quality, quick manufacturing capabilities)

Steam generator replacement backed by solid record
- 29 units in Japan
- Many orders received from abroad

World’s first replacement of reactor internal
- Quick, highly-precised installation in a high radiation environment

World’s first replacement of main control board
- Simultaneous digitalization of control units and central control panel replacement.

Reliability improvement and lifetime extension for aging component

Substantial operability improvement

MITSUBISHI HEAVY INDUSTRIES, LTD.
2. Development and market introduction of global strategic reactors

Acceleration of strategic reactors using cutting-edge technologies

- **Market introduction of large-sized strategic reactor (US-APWR)**
  - Large, highly-advanced reactors able to handle large output demand
  - Independently developed reactors using verified APWR technologies
  - U.S. certificate acquisition and early market introduction

- **Joint development of mid-sized strategic reactor with AREVA**
  - 1100MWe class PWR in high demand worldwide
  - Early market introduction of jointly-developed mid-sized reactor (incorporating cutting-edge technologies of the two companies) that boast leading performance

- **Development of small-sized strategic reactor (PBMR)**
  - Small, decentralized reactors close to power demand sites
  - Early construction of demonstration units using Mitsubishi’s comprehensive technologies
2. (1) Market introduction of large-sized strategic reactor

US-APWR deployment in the United States
Characteristics of US-APWR

Response to early realization requested by U.S. power companies

Output expansion based on APWR in Japan

- Largest power output in the world (1700 MWe class)
- Fuel economy improvement through 24-month continuous operation
- Highest safety and reliability levels in the world
  - Best combination of passive and active technologies
  - Measures against airplane clash
- Target construction period: 41 months
Early introduction of US-APWR to the U.S. market

- Speedy DC application based on technologies verified at APWR in Japan
- Application for COL in parallel with DC with customers

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>DC pre-application meeting</td>
</tr>
<tr>
<td>2007</td>
<td>PAR</td>
</tr>
<tr>
<td>2008</td>
<td>DC application (Dec. 2007)</td>
</tr>
<tr>
<td>2009</td>
<td>Design Certification</td>
</tr>
<tr>
<td>2011</td>
<td>Approval (scheduled in June 2011)</td>
</tr>
<tr>
<td>2008</td>
<td>COL application (July 2008)</td>
</tr>
<tr>
<td>2012</td>
<td>Combined License</td>
</tr>
<tr>
<td>2013</td>
<td>Construction of the first US-APWR</td>
</tr>
<tr>
<td>2014</td>
<td>Construction of other power plants</td>
</tr>
</tbody>
</table>

DC: Design Certification  COL: Combined Construction and Operating Licenses
PAR: Pre Application Review
US-APWR major technologies

Large output and fuel economy

- 14ft fuel
- Neutron reflector
- High-performance steam-water separator
- High-function moisture separator
- Compact size

Improvement in safety, reliability and maintainability

- Four trains system
- Best passive and active combination (Advanced accumulator)
- Refueling water storage pit (RWSP) inside containment vessel

Emergency core cooling system

- Steam generator
- Reactor core
- Turbine
- I & C
Verification of US-APWR major technologies

- Verification tests for major technologies

- Comprehensive flow tests for reactor internals

- Pressure application tests for high-performance accumulators

- High pressure high temperature tests for steam-water separators of steam generator

- Anti-vibration bar seismic tests for steam generators

- Rotational vibration tests for low-pressure turbines
## Major US-APWR major performance

### Highest performance in the world

<table>
<thead>
<tr>
<th></th>
<th>US-APWR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Power output</strong></td>
<td>1700 MWe class</td>
</tr>
<tr>
<td><strong>Plant efficiency</strong></td>
<td>Up to 39%</td>
</tr>
<tr>
<td><strong>Reactor core function (uranium consumption)</strong></td>
<td>18% reduction from existing reactors</td>
</tr>
<tr>
<td><strong>Safety (reactor core damage ratio)</strong></td>
<td>$1 \times 10^{-7}$/reactor/year or lower</td>
</tr>
<tr>
<td><strong>Availability factor</strong></td>
<td>95.7% or higher</td>
</tr>
<tr>
<td><strong>Unplanned plant shutdown rate</strong></td>
<td>0.1/reactor/year or lower</td>
</tr>
<tr>
<td><strong>Operational maintainability</strong></td>
<td>Online maintenance by 4-train system</td>
</tr>
<tr>
<td><strong>Construction period</strong></td>
<td>41 months</td>
</tr>
</tbody>
</table>
3. (2) Development of mid-sized strategic reactor

Joint MHI-AREVA development
Cooperation of two nuclear plant manufacturers in collective strength that lead the world

(1) Integration of the latest technologies (US-APWR, EPR)

(2) Sharing of know-how and human resources  ➔ Enabling quick market introduction

(3) Realization of synergy
  - 12 factories in nuclear fields ➔ Bottleneck prevention in component manufacture, etc.
  - Construction experience from more than 120 commercial nuclear power plants

Conceptual design already completed: Oct. 2006 to June 2007
Agreed to establish JV for development and sales expansion: July 10, 2007

Early market introduction by halving the development period
Reactor jointly developed by MHI and AREVA

Basic Plant Concept

- Power output: 1100 MWe class
- 3-loop, pressurized water reactor (PWR)
- Response to customer needs
  - Flexible operability and economy
    - Respond to long-cycle operations
    - Respond to MOX fuels (mixed uranium-plutonium oxide fuels)
  - Safety
    - Resistance and durability against airplane clash
  - Environmental measures
    - Substantial reduction in spent fuel and waste volumes
2. (3) Development of small strategic reactor

PBMR development
PBMR development  PBMR: Pebble Bed Modular Reactor

[Characteristics of PBMR]

- **Safety**: Inherent safety with no chance of reactor core dissolution
- **Operability**: able to supply and remove fuel without suspending reactor operation

Coolant: helium gas (nonradiative medium)
Modular type: able to extend according to power demand
Fuel: pebble bed fuel
  (Uranium oxide particles + graphite powder ⇒ compaction molding into a spherical shape)
PBMR project

MHI participates in PBMR project since 2001

- MHI’s gas turbine technologies, design and manufacturing technologies for nuclear components
- PBMR’s gas reactor technologies

[Customer]: Eskom
(South African power company)

Demonstration unit: scheduled for construction in Koeberg
Operation Start: 2013

- Power output: 165 MWe
- Generating efficiency: > 40%
- Temperature at reactor outlet/inlet: 900°C/500°C
3. Establishment of the nuclear fuel cycle

Contribution to the development of nuclear recycle technologies by reflecting with results of the passed R&D and the cutting-edge technologies

(1) Development of Fast Breeder Reactor (FBR)
- Effective use of FBR technologies based on the results of “Joyo” and “Monju”
- Establishment of Mitsubishi FBR Systems, Inc. (MFBR)
  - Perform development of FBR demonstration and commercial reactors
- Joint application to international program (GNEP) with AREVA

(2) Activities for the fuel cycle
- Participation in all fuel cycle fields Contribution to establishment of fuel cycle
- Design and manufacture of major equipments with the advanced technologies at Rokkasho reprocessing plant
- Participation in construction of 2\textsuperscript{nd} reprocessing plant and Rokkasho MOX fuel plant
3. (1) Development of Fast Breeder Reactor (FBR)
Activities for Development of Commercial FBR

- **Improvement of economy**

- **Power generation demonstration**

- **Fast neutron technologies**
  - Prototype reactor “Monju”
    (Power output: 280 MWe)
  - Experimental reactor “Joyo”
    (Power output: 140 MWt)

- **Sodium handling technologies**

- **Commercial reactor [by 2050]**
  (Power output: 1500 MWe)

- **Demonstration reactor**
  [Operation start in 2025]
  - Demonstration of innovative technologies

- Being performed mainly by MFBR
“Advanced sodium-cooled loop type reactor” proposed by MHI selected as commercial reactor in Japan by adoption of innovative technologies

[Features of innovative technologies]

- Scale-up (1500 MWe twin plant)
- High-strength high-chromium steel
- Decay heat removal system based on complete natural circulation
- L-shaped piping (Shortening of piping)
- Compact reactor (vessel diameter: ~10 m)
- 2 loops (reduced number of loop)
- Steam generator with double-walled heat transfer tube (Countermeasure of sodium-water reaction)

**Improvement of safety and economy**

**Specifications**

- Power output: 1500 MWe
- Loop number: 2 loops
- Fuel: Mixed oxide (MOX) fuel
- Generating efficiency: 42.5%
3. (2) Activities for nuclear fuel cycle
Participation in nuclear fuel cycle fields

### Reprocessing plant
- Plant engineering
- Design and manufacture of major processing (shearing and dissolution) equipment
- Operational support and maintenance

### Fuel transportation and storage
- Fresh fuel transportation casks
- Spent nuclear fuel transportation and storage casks

### Uranium Enrichment plant
- Design and manufacture of peripheral facilities for centrifuge renewal

### MOX fuel fabrication plant
- Plant engineering
- Design and manufacture of fuel rod processing and fuel assembling facilities
Design and manufacture of major processing equipment at Rokkasho reprocessing plant

Major processing equipment manufactured by MHI
- Fuel assembly shearing equipment
- Dissolution equipment
  - Equipment for fuel pellets dissolution and waste separation (fuel cladding tubes, etc.)

Construction coordination by MHI
- Reprocessing plant completion under global attention
- Latest processing technologies in non-proliferation level
  - mixed denitration
- Participation in 2nd reprocessing plant

Spend nuclear fuel assembly shearing technologies

Manufacturing technologies using nitric acid resistant material (zirconium)
“A comprehensive nuclear energy company” that leads the world