The Challenges and Directions for Nuclear Energy Policy in Japan
- Japan’s Nuclear Energy National Plan -

Nuclear Energy Policy Planning Division
Ministry of Economy, Trade and Industry (METI)
December 2006
Structural Change of the Nuclear Energy Industry (Plant makers)

**1980s**
- 4 European Companies
  - Brown Boveri et Cie, Asea, Framatome, Siemens,
- 4 US Companies
  - WH, Combustion Engineering, GE, Babcock & Wilcox
- 3 Japan Companies
  - MHI*, Hitachi, Toshiba

**From Now**
- AREVA – MHI*
  - (France – Japan)
- WH** – Toshiba
  - (US – Japan)
- GE – Hitachi
  - (US – Japan)

Country by country independent makers

Only international alliances survive

Market (New Build of NPP)

**Past 10 years**
- Japan: 8
- US: 0
- Europe: 0
- Russia: 1
- India: 6
- China: 6
- S.E. Asia: 0

**From Now**
- Japan: 13
- US: 20?
- Europe: Fin, France, UK
- Russia: 20?
- India: 20?
- China: 20?
- S.E. Asia: Vietnam, Indonesia, Kazakhstan, Australia, Egypt, etc.

Market was concentrated

Market will be globalized

Nuclear Energy Policy needs to be coordinated internationally.

* MHI: Mitsubishi Heavy Industry ** WH: Westinghouse
Table of Contents

I. Recent Developments in Nuclear Energy Policy
II. Historical Position of the Nuclear Energy National Plan
III. Long Term Framework for Nuclear Energy in Japan
   1. Background – Why Nuclear Power in Japan?
   2. Direction of Energy Policy
   3. Long Term Framework

IV. Future Approach to Nuclear Power Policy
   1. Five Basic Guidelines for Nuclear Energy Policy
   2. Investment to Construct New Nuclear Power Plants and Replace Existing Reactors in an Era of Electricity Market Deregulation
   3. Appropriate Use of Existing Nuclear Power Plants with Assuring Safety as a Key Prerequisite
   4. Steady Advancement of the Nuclear Fuel Cycle and Strategic Reinforcement of Nuclear Fuel Cycle Industries
   5. Early Commercialization of the FBR Cycle
   6. Achieving and Developing Depth in Technologies, Industries and Personnel
   7. Support for International Development of Japan’s Nuclear Industry
   8. Positive Involvement in Creating an International Framework to Uphold both Nonproliferation and the Expansion of Nuclear Power Generation
   9. Coexistence of Nuclear Power with Local Residents and Communities
   10. Steady Promotion of Measures for Disposal of Radioactive Wastes

V. Why Nuclear Fuel Recycling in Japan?
I. Recent Developments in Nuclear Energy Policy

  
  1. Have nuclear power continue to account for at least approximately 30 to 40% of total electricity generation even after the year 2030
  2. Promote the nuclear fuel cycle
  3. Aim at the commercialization of fast-breeder reactors

- As for policies to realize the basic targets, the Nuclear Energy Subcommittee of the Advisory Committee at Ministry of Economy, Trade and Industry (METI) compiled the “Nuclear Energy National Plan.”

- The Nuclear Energy National Plan will form part of the revised Energy Basic Plan (Cabinet resolution) at the end of the current fiscal year.
II. Historical Position of the Nuclear Energy National Plan

1. Trends in Energy Policy
2. Relationships among the Government, Electric Power Utilities and Plant Makers
3. Interagency Nuclear Energy Policy Decision Making System
1. Trends in Energy Policy #1

(1) Initial Era of Nuclear Power in Japan

- Unified nationwide approach to nuclear power as “dream energy”
- 1956 Atomic Energy Basic Law comes into effect
- Japan ratifies the International Atomic Energy Agency (IAEA) Charter
- 1957 “Japan’s first nuclear energy fire is lit” (First criticality of Japan’s first nuclear reactor)
- 1970s Strong recognition of the significance of nuclear energy with the experience of the two oil crises

(2) Era of Energy Market Liberalization

- Japan consistently promoted nuclear power policies, but opinion was running against it at that time
  - US and other Western countries withdraw from the nuclear fuel cycle and the construction of new nuclear power plants; beginning of strong backlash against nuclear power worldwide with the 1979 accident at Three Mile Island in the US and the 1986 accident at Chernobyl in the former Soviet Union.
  - In parallel with these developments:
    - The worldwide supply-demand balance for energy eased, leading to stable low energy prices
    - Liberalization policies were aimed at making the energy sector more efficient
      - Crude oil prices fell below $10 per barrel and uranium prices fell below $7 per pound
1. Trends in Energy Policy #2

(3) Return to Energy Security

- In recent years, the situation has been greatly changing as the world enters a phase of global competition for resources
  - Sudden increase in global energy demand as a result of rapid economic growth in the Asian region, etc.
  - Supply of crude oil remains flat, with an emerging structural constraints in energy supply
    (*) Crude oil prices rose above $60 per barrel and uranium prices rose above $50 per pound
- Growing demand for measures to address global warming
  - Re-recognition of the necessity of nuclear power, which does not emit carbon dioxide in the electricity generation process
- Re-recognition of the importance of energy security in industrialized nations, which had been taking a cautious stance toward nuclear power, beginning with the US, the UK, and Finland, and a shift to policies aimed at a return to nuclear power

➢ It became imperative that Japan also create a new national strategy
  - New National Energy Strategy drafted (May 2005) emphasizing energy security
  - Nuclear Energy National Plan complied (August 2006) as the pillar of the New National Energy Strategy, stipulating a solid policy framework for promoting nuclear energy along with specific plans
2. Relationships among the Government, Electric Power Utilities and Plant Makers

After Electricity Market Deregulation → Three-way Standoff

The government:
placed the priority on electricity market deregulation
→ hesitate to take the leadership for introducing the long term target
From the perspective of the electric power utilities, there was an impression that the government was avoiding taking the initiative in nuclear energy strategy.

Electric power utilities:
fully occupied dealing with immediate troubles and responses to deregulation
→ tended to delay high-risk long-term investment strategies

Plant makers:
reduced their investments in technology development and focusing on survival strategies, because the government and electric power utilities have failed to indicate the future direction.

No one was taking the initiative for long term nuclear energy strategy, and as a result difficult issues were being put off.

Toward the Resolution of Three-way Standoff Structure

- The government, utilities and plant makers need to frankly communicate and share their visions regarding Japan’s long term nuclear energy strategy.
- The government should take the first step.

- The mutual understanding among the concerned parties greatly improved in the process of compiling the Framework for Nuclear Energy Policy and the Nuclear Energy National Plan.
- The government showed willingness to take the initiative, and clarified the policy framework along with the specific actions toward realizing policy goals.
3. Interagency Nuclear Energy Policy Decision Making System

■ Drafting the Framework for Nuclear Energy Policy

- The 2005 Framework for Nuclear Energy Policy was the first long-term plan drafted after the government reorganization whereby the Atomic Energy Commission (AEC) was incorporated into the Cabinet Office.
- The process of drafting the Framework for Nuclear Energy Policy created completely shared goals among the Cabinet Office, the Ministry of Education, Culture, Sports, Science and Technology (MEXT), and the Ministry of Economy, Trade and Industry (METI), and as a result the Framework became an extremely strong monolith.

■ Drafting the Nuclear Energy National Plan

- While gaining the cooperation of the Cabinet Office, MEXT, and the Ministry of Foreign Affairs (MOFA), the Nuclear Energy Subcommittee (an advisory body to METI and the Agency for Natural Resources and Energy) compiled the Nuclear Energy National Plan to stipulate concrete measures for achieving the basic direction of the Framework for Nuclear Energy Policy.
- In implementing the Nuclear Energy National Plan, the concerned government ministries are delivering a prompt and concerted response.

(1) Response to the US Global Nuclear Energy Partnership (GNEP) Concept.
   The most positive and quick response in the world is possible because the four concerned ministries (the Cabinet Office, MEXT, MOFA, and METI) customarily respond in a unified and swift manner.

(2) FY 2007 Budget Requests
   MEXT and METI are launching the following joint projects
   - Fast-breeder reactor cycle commercialization project
   - Nuclear energy personnel training project

(3) Japan’s Proposal on the “Concept for a Multilateral Mechanism for Reliable Access to Nuclear Fuel”
   Proposal jointly drafted by MOFA and METI. Formal Japanese government proposal drafted through discussions with the AEC (Cabinet Office). Announced by the Chairman of the AEC at the IAEA General Conference in September 2006.
III. Long Term Framework for Nuclear Energy in Japan

1. Background - Why Nuclear Power in Japan?
2. Direction of Energy Policy
3. Long Term Framework
1. Background – Why Nuclear Power in Japan?

< Japan’s Self-Sufficiency >

- If nuclear power is discounted, **we have the lowest energy self-sufficiency ratio among the major industrialized countries — a mere 4%**.
- Our energy self-sufficiency is even lower compared to **our food self-sufficiency ratio (also low at 40%)**.

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**Energy Self-Sufficiency of Major Countries <2003>**

- Japan has one of the lowest self-sufficiency rates among the advanced industrial countries. Our energy self-sufficiency is even lower compared to our food self-sufficiency ratio.

**Food Self-Sufficiency of Major Countries <2002>**

- Source: *Food Balance Sheet of Japan, Agriculture, Forestry and Fisheries Ministry*

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* The self-sufficiency ratio figures are based on the assumption that nuclear power is imported (figures in parentheses are based on the assumption that nuclear power is domestically produced).

Source: *Energy Balances of OECD Countries 2002-2003, IEA*
At the same time, with regard to oil supply, for the past 40 years, new oil discoveries have continued to decline. Over the last 20 years, increases from newly discovered reserves have been below total production volume and there is concern that we may be reaching the limits of available oil resources.

China is expected to rely on imports for nearly 80% of its petroleum consumption in 2030, and to become a net importer of natural gas by 2010 and then rapidly increase natural gas imports. The global competition for securing natural resources may intensify.
1. Background - Why Nuclear Power in Japan?

< China #2 >

- China’s power demand is growing each year *at a rate equivalent to the total electricity generation of TEPCO (Tokyo Electric Power Company), Mexico or Spain.*

![Increase in Volume of Total Electricity Generation in China](chart.png)


*Total electricity generation in 2003: Mexico 217 billion kWh, Spain 258 billion kWh*

* Total electricity generation in 2004: TEPCO 262 billion kWh
1. Background - Why Nuclear Power in Japan?

< India >

- **India’s** domestic supply of oil will steadily decrease in the future, while demand will rapidly increase. **By 2030, dependence upon imports may approach 90 percent.**

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**Projections for India’s Demand for Oil and Import Dependency**

- **Demand**
- **Domestic Supply**
- **Import dependency** (percent, right scale)

Source: *World Energy Outlook 2005, IEA*
1. Background - Why Nuclear Power in Japan?

< Preventing Global Warming #1 >

- Global CO₂ emissions may greatly increase along with the growth in energy consumption and **could reach three or more times the present volume in 2100**.

- The increase in CO₂ emissions in developing countries will be especially outstanding and will account for almost all of the increase in total global emissions. Emissions from developing countries are projected to surpass those from industrialized countries around 2020-2030, and to reach about 6 times their present levels (and about three times the amounts from the industrialized countries) in 2100.

Source: *Sustainable Future Framework on Climate Change*: Interim Report by the Special Committee on a Future Framework for Addressing Climate Change, Global Environmental Sub-committee, Industrial Structure Council.
1. Background - Why Nuclear Power in Japan?

< Preventing Global Warming #2 >

- With regard to the entire life-cycle including such factors as power plant construction and fuel transport, the CO₂ emissions from natural gas fired power plants are about 30% less than those from oil fired power plants, but still about 22 times higher than those from nuclear power plants.

**Volume of CO₂ Emissions Produced per Unit of Electric Power by Various Power Sources (including methane)**

<table>
<thead>
<tr>
<th>Power Source</th>
<th>Lifecycle volume of CO₂ emissions [g-CO₂/kWh (net supply)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal combustion</td>
<td>975</td>
</tr>
<tr>
<td>Oil combustion</td>
<td>742</td>
</tr>
<tr>
<td>Natural gas combustion</td>
<td>608</td>
</tr>
<tr>
<td>Natural gas combined cycle</td>
<td>519</td>
</tr>
<tr>
<td>Nuclear</td>
<td>22~25</td>
</tr>
<tr>
<td>Hydroelectric</td>
<td>11</td>
</tr>
<tr>
<td>Geothermal</td>
<td>15</td>
</tr>
<tr>
<td>Solar</td>
<td>53</td>
</tr>
<tr>
<td>Wind</td>
<td>29</td>
</tr>
</tbody>
</table>

- 30% reduction in CO₂ emissions compared with oil combustion
- Still 22 times higher than those from nuclear power plants


1. Background - Why Nuclear Power in Japan?  
< Preventing Global Warming #3 >

- Hypothetically, if Japan were to replace its existing nuclear power generation (as of 2002) with oil and coal power generation, the volume of energy-derived CO₂ emissions for the same year would increase by about 20%. If natural gas were adopted in place of nuclear power, emissions would increase by about 10%.

<table>
<thead>
<tr>
<th>Power Generation Volume (FY 2002)</th>
<th>Nuclear Power [billion kWh(e)]</th>
<th>Natural Gas</th>
<th>Coal</th>
<th>Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Emissions Factor [t-C/TJ(h)]</td>
<td>0</td>
<td>13.47</td>
<td>24.71</td>
<td>18.66</td>
</tr>
</tbody>
</table>

- **FY 2002 Energy Derived CO₂ Emissions Volume:** 1.16 billion yen [t-CO₂]

**Nuclear Power Replaced by Oil and Coal**

- Nuclear-generated Electricity Volume Generated Instead by Oil and Coal
  - Increase of approximately 230 million tons* CO₂
  - Approximately 19% increase

**Nuclear Power Replaced by Natural Gas**

- Nuclear-generated Electricity Volume Generated Instead by Natural Gas
  - Increase of approximately 120 million tons* CO₂
  - Approximately 11% increase

**Sources**
1. CO₂ emissions volumes and carbon emissions factor: Report on Energy Supply and Demand in FY 2002 Agency for Natural Resources and Energy website
2. Generated Electricity Volume: FY 2004 Power Source Development Outline

*Unit: [t-CO₂]
Introducing solar, wind and other renewable energy sources is also an extremely efficient means of reducing CO₂ emissions. At present, however, these renewable energy sources still have issues of supply stability (energy cannot be generated on rainy days or when the wind does not blow), economic feasibility, etc.

**Comparison of Each Type of Electricity Generation**

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Power Output</th>
<th>Area Required</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>One Nuclear Power Reactor</td>
<td>1 million kW class</td>
<td>An area the size of Manhattan Island (approx. 67km²)</td>
<td>300 billion yen</td>
</tr>
<tr>
<td>Photovoltaic Power Generation</td>
<td>An area 3.5 times the size of Manhattan Island (approx. 246km²)</td>
<td>(6–7 trillion yen)</td>
<td>1 trillion yen</td>
</tr>
<tr>
<td>Wind Power Generation</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Under the present conditions, the power output of systems using natural energy such as solar power generation and wind power generation is prone to fluctuation, so backup power sources are essential.
2. Direction of Energy Policy

The direction of energy policy is not

**Nuclear energy “OR” Renewable energy**

but

**Nuclear energy “AND” Renewable energy**

Considering stable energy supply and the response to global warming, it is appropriate to expect that:

**nuclear power generation will continue to account for at least its present level of 30-40% of Japan’s total power generation beyond 2030, even after the replacement of the existing plants.**
3. Long Term Framework for Nuclear Energy in Japan

- Make the greatest possible use of existing nuclear power plants while assuring the safety and security and steadily address the siting of new power plants.

- Maintain or increase nuclear power’s present share of 30-40% of Japan’s total power generation beyond 2030. (The time of replacement for the exiting plants.)

- From around 2030, an improved version of existing light water reactors (LWRs) should be utilized. These should mostly be large LWRs, to enjoy the advantage of scale.

  However, standardized medium-size LWRs may also be an option depending on the demand scale, demand developments and economics of each utility.

- From around 2050, work toward introducing fast breeder reactors (FBRs) on a commercial basis, considering the supply-demand trends for uranium and the performance of Monju and other facilities with achieving economic feasibility and other required conditions.

  If the conditions required for introducing FBRs are not fulfilled by around 2050, continue introducing improved LWRs until those conditions are met.
The installed capacity is assumed to reach saturation at 58GW, for illustrative purpose.
IV. Future Approach to Nuclear Power Policy

1. Five Basic Guidelines for Nuclear Energy Policy
2. Investment to Construct New Nuclear Power Facilities and Replace Existing Reactors in an Era of Electric Power Liberalization
3. Appropriate Use of Existing Nuclear Power Plants with Assuring Safety as a Key Prerequisite
4. Steady Advancement of the Nuclear Fuel Cycle and Strategic Reinforcement of Nuclear Fuel Cycle Industries
5. Early Commercialization of the Fast Breeder Reactor Cycle
6. Achieving and Developing Depth in Technologies, Industries and Personnel
7. Support for International Development of Japan’s Nuclear Power Industry
8. Positive Involvement in Creating an International Framework to Uphold both Nonproliferation and the Expansion of Nuclear Power Generation
9. Coexistence of Nuclear Power with Local Residents and Communities
10. Steady Promotion of Measures for Disposal of Radioactive Wastes
IV. Future Approach to Nuclear Power Policy


1. Aim at maintaining or increasing the current level of nuclear power generation (30 to 40% of the total electricity generation) even after 2030
2. Steady advancement of the nuclear fuel cycle
3. Aim at commercial introduction of fast breeder reactors by 2050


1. Investment to construct new nuclear power plants and replace existing reactors in an era of electric power liberalization
2. Appropriate use of existing nuclear power plants with assuring safety as a key prerequisite
3. Steady advancement of the nuclear fuel cycle and strategic reinforcement of nuclear fuel cycle industries
4. Early commercialization of the fast breeder reactor cycle
5. Achieving and developing depth in technologies, industries and personnel
6. Support for the international development of Japan's nuclear power industry
7. Positive involvement in creating an international framework to uphold both nonproliferation and the expansion of nuclear power generation
8. Fostering trust between the state and communities where plants are located; highly detailed public hearings and public relations
9. Steady promotion of measures for disposal of radioactive wastes
1. Five Basic Guidelines for Nuclear Energy Policy

- It is important to advance nuclear energy policy based on the following five basic guidelines while gaining public understanding and cooperation, and a key prerequisite is assuring safety at every stage – from the design, construction, operation, and decommissioning of nuclear power facilities to the processing of radioactive waste materials and the transportation of nuclear fuel material.

1. Establish a steadfast national strategy and policy framework that will not blur over the mid- to long-term.

2. At the same time, retain strategic flexibility for individual policies and specific times, responding to international conditions and technology trends.

3. Strengthen constructive cooperative relations among the government, electric power utilities and plant makers. To this end, adopt a shared vision and achieve genuine communications among the concerned parties, with the government taking the first step by indicating the general direction.

4. Emphasize policies for individual regions in line with the national strategy.

5. Secure policy stability by setting policy based on open and fair discussions.
If new construction is implemented in accordance with the FY 2006 Supply Plan, depending on capacity utilization ratios, the share of nuclear power generation is projected to rise to about 40% of total electric power generation over roughly the next 10 years.

If new construction is not implemented, even if a relatively high capacity utilization ratio is maintained, there are concerns that the share of nuclear power generation may drop below 30% of total electric power generation.

New construction must be implemented to assure the policy target stipulated by the Framework for Nuclear Energy Policy is met (to maintain a share of at least around 30-40% of total electric power generation).
2. Investment to Construct New Nuclear Power Plants and Replace Existing Reactors in an Era of Electric Power Liberalization
(Issues and Responses)

1. Reducing and Dispersal of Nuclear-Power-Specific Risks
   - Introduce an accounting system aimed at leveling reprocessing and other expenses at the second reprocessing plant in FY 2006.
   - Examine measures to address unpredictable risk through public-private sector cooperation, using the US approach as a reference.
   - Electric power utilities to indicate the specific operating methods when the need for load-following operations increases, and the government to examine the necessity of safety regulation changes based on these methods.

2. Reducing and Leveling the Initial Investment and Decommissioning Costs
   - Introduce an accounting system that can level the initial operating period depreciation expenses burden in FY 2006.
   - Examine the surplus or shortage of accumulated funds under the system of reserve for decommissioning costs of nuclear power units in light of the 2005 revisions to the Nuclear Reactor Regulation Law.

3. Promote Wide-area Operations
   - Upgrade the environment for smooth coordination among electric power utilities for the construction and reinforcement of linkage lines and transmission lines.

4. Make the Merits of Nuclear Power Generation Visible
   - Draft unified standards for the means used to calculate electric power utilities CO2 emissions volume units, etc.
3. Appropriate Use of Existing Nuclear Power Plants with Assuring Safety as a Key Prerequisite (Capacity Utilization Ratio)

The capacity utilization ratio of nuclear power plants depends on the frequency of unscheduled shutdowns, the average operating period, the length of periodic inspections and other factors.

- The capacity utilization ratio in Japan has topped out at just above 80%.
- The capacity utilization ratios in the Western and South Korea have been around the 90% level in recent years.

**Capacity Utilization Ratio (1990–2004)**

![Graph showing capacity utilization ratio from 1990 to 2004 for Japan, US, France, Germany, and South Korea.](graph.png)


**Frequencies of Unscheduled Shutdowns (2004)**

![Graph showing frequencies of unscheduled shutdowns for US, France, Japan, Germany, South Korea, and Finland in 2004.](frequencies.png)

*Source: Japan Nuclear Energy Safety Organization (JNES).*

**Operation Period and Inspection Period**

- **Average Operating Periods**
  - US: 18.1 months
  - France: 14.1 months
  - South Korea: 11.9 months
  - Finland: 11.5 months
  - Japan: 11.5 months

- **Length of Periodic Inspections**
  - US: 43 days
  - France: 79 days
  - South Korea: 98 days
  - Finland: 12 days
  - Japan: 11 days

*Source: Federation of Electric Power Companies materials.*
3. Appropriate Use of Existing Nuclear Power Plants with Assuring Safety as a Key Prerequisite
(More Sophisticated Operations Maintenance)

(1) Efforts by the Government

- Enhance and reinforce the inspection system, emphasizing quality assurance, to improve safety at nuclear power facilities.
- Work toward a transition from inspections centered on facilities that are presently shut down to inspections for accurate confirmation of the overall safety activities at individual plants, including those in operation, to boost the effectiveness of safety regulations.

(2) Efforts by Electric Power Utilities

- Electric power utilities should build up operating performance under existing systems with safety as the top priority, refer to knowledge from the US and other countries while maintaining the best points of the Japanese approach, and resolve all necessary issues to achieve more sophisticated operations maintenance.
- The Japan Nuclear Technology Institute is expected to objectively collect, collate and evaluate data from all the electric power utilities, and to support the realization of more sophisticated operations maintenance.
- Such efforts may include expanding conditions-based maintenance, broadening the range of on-line maintenance, making better use of risk data, etc.
<Reference> US-Japan Comparison

Source: Federation of Electric Power Companies materials.
Work toward the early establishment of the LWR nuclear fuel cycle, including the necessary research and development, and efforts to gain the widespread understanding and cooperation of local residents and citizens nationwide will continue to be essential.

- Initiation of operations at the Rokkasho Reprocessing Plant, scheduled for August 2007.
- Initiation of operations at a MOX fuel fabrication plant for LWRs from 2012.
- Selection of candidate sites for a high-level radioactive waste materials final disposal facility.
4. Steady Advancement of the Nuclear Fuel Cycle and Strategic Reinforcement of Nuclear Fuel Cycle Industries
(Nuclear Fuel Cycle in LWRs)
### 4. Steady Advancement of the Nuclear Fuel Cycle and Strategic Reinforcement of Nuclear Fuel Cycle Industries
(Recent Developments concerning the Nuclear Fuel Cycle)

<table>
<thead>
<tr>
<th>Rokkasho Reprocessing Plant</th>
<th>At the reprocessing plant built in the village of Rokkasho in Aomori Prefecture, the final tests (active tests) are conducted under the same conditions as those of actual operation. The reprocessing plant is scheduled to go into operation in 2007.</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOX Fuel Plant</td>
<td>In April 2005, Aomori Prefecture and Rokkasho Village entered into a basic siting agreement with Japan Nuclear Fuel Limited. Regulatory authorities are now in the process of conducting the safety review required for a business license. Construction of the MOX fuel plant will begin by the end of 2007, and the plant will go into service by the end of 2012.</td>
</tr>
<tr>
<td>Plutonium Utilization in LWRs</td>
<td>The Kyushu Electric Power Company’s plutonium utilization in LWRs was formally approved by Saga Prefecture and Genkai Town in March 2006. The Shikoku Electric Power Company’s plutonium utilization in LWRs was formally approved by Aichi Prefecture and Ikata Town in October 2006. The Chugoku Electric Power Company, with the understanding of the municipality involved, submitted an application to the government for a safety review of the nuclear reactor it had installed. J-Power and the Chubu Electric Power Company are making steady progress in plutonium utilization in LWRs.</td>
</tr>
<tr>
<td>Interim Storage Facility</td>
<td>The Recyclable-Fuel Storage Company, established jointly by the Tokyo Electric Power Company and the Japan Atomic Power Company, is planning to build an interim storage facility in Mutsu City, Aomori Prefecture. In October 2005, Aomori Prefecture and Mutsu City agreed on an interim facility construction plan. The interim storage facility is scheduled to go into service by the end of 2010.</td>
</tr>
<tr>
<td>Monju Reactor (prototype fast-breeder reactor)</td>
<td>In February 2005, Fukui Prefecture and Tsuruga City consented to a plan to remodel the Monju reactor. In May of that same year, the Supreme Court handed down a ruling in favor of the national government. The Monju reactor is scheduled to resume operation within two years after remodeling work on it is completed.</td>
</tr>
<tr>
<td>High-Level Radioactive-Waste Ultimate Disposal Facility</td>
<td>Several applications have been submitted in response to an invitation for a site for an ultimate disposal facility. In response to these applications, The Nuclear Waste Management Organization of Japan (NUMO) is engaged in activities to gain the understanding of each region.</td>
</tr>
<tr>
<td>Enactment of the Reprocessing Reserve Law</td>
<td>In its ordinary session in 2005, the Diet passed a law and a taxation system designed to put approximately JPY 12.6 trillion in a reserve to cover expenses involved in the construction of the Rokkasho Reprocessing Plant and other facilities (the Liberal Democratic Party, the New Komeito Party, and the Democratic Party of Japan voted for the law). The law became effective in October 2005.</td>
</tr>
</tbody>
</table>
4. Steady Advancement of the Nuclear Fuel Cycle and Strategic Reinforcement of Nuclear Fuel Cycle Industries
(Strategic Reinforcement of Nuclear Fuel Cycle)

➢ Continue to establish the structure for an independent Japanese nuclear industry amid the trend toward oligopoly in the international nuclear power industry and developments in the nuclear non-proliferation regime.

1. **Uranium Enrichment**
   Technological development of a new-model centrifuge and introduction from around 2010; achievement of cost reductions by establishing a mass production structure, etc.

2. **Reprocessing**
   Accumulation of technological capabilities and operations experience through stable and reliable operations at the Rokkasho Reprocessing Plant; maintenance and development of human resources, technology assistance via the Japan Atomic Energy Agency (JAEA), etc.

3. **Uranium Mine Development**
   Support for private enterprise prospecting and rights acquisition through provision of risk money and policy financing; expanded accumulation of knowledge, expertise, and technologies; reinforcement of resource diplomacy, etc.

4. **Other Related Industries**
   Uranium Reconversion: Consideration of expanding domestic capacity, including the construction of a second reconversion facility, etc.
   Fuel Fabrication: Determination of specific processing policies for the resulting uranium waste products
   MOX Fuel Fabrication Plant for LWRs: Human resources development toward the launch of operations; technology cooperation from JAEA, etc.
   Recovered Uranium: Preparation of the environment for conversion at overseas facilities, enrichment, securing consignees for reconversion works, etc.
4. Steady Advancement of the Nuclear Fuel Cycle and Strategic Reinforcement of Nuclear Fuel Cycle Industries (Nuclear Fuel Cycle Industries)

- **Milling**
  - **Uranium Mine**
  - In Japan: (The former PNC withdrew from exploration in 2000. Only a few private businesses have obtained new mining interests since the 1990s.)
  - Overseas: Eight companies, including Cameco (Canada), COGEMA/AREVA (France), ERA (Australia), together account for about 80% of the world's total output.

- **Conversion**
  - Natural Uranium
  - In Japan: No conversion service is provided.
  - Overseas: Five companies, including Cameco (Canada), ConverDyn (U.S.A.), COMURHEX/AREVA (France), together account for nearly 100% of the world's conversion capacity.

- **Enrichment**
  - In Japan: JNFL (provides about 10% of the domestic demand)
  - Overseas: Four companies, including URENCO (Britain, the Netherlands and Germany), Eurodif/AREVA (France, et al.), together account for more than 90% of the world's installed capacity.

- **Reconversion**
  - In Japan: Mitsubishi Nuclear Fuel Co. Ltd. (provides about 40% of the domestic demand)
  - Overseas: (Most of the companies provide reconversion service in their fuel-fabrication facilities.)

- **Fabrication of MOX Fuel for LWRs**
  - Plutonium (MOX)
  - In Japan: (JNFL's Rokkasho reprocessing facility is scheduled to go into service in 2007.)
  - Overseas: Commercial-scale reprocessing facilities are operating in France, Britain, and Russia.
  - Overseas: COGEMA (France), NDA (BN-GS) (U.K.), and Belgonucléaire (Belgium) are operating MOX-fuel plants.

- **Fuel Fabrication**
  - In Japan: Mitsubishi Nuclear Fuel (PWR), GNF-J (BWR), Nuclear Fuel Industries, Ltd. (BWR/PWR) (Nearly 100% of the domestic demand)
  - Overseas: Framatome ANP, BNFL/WH, and GNF(GE)-affiliated manufacturers account for 2/3 of the world's fabrication capacity.

In Japan: Mitsubishi Nuclear Fuel Co. Ltd. (provides about 40% of the domestic demand)

Overseas: (Most of the companies provide reconversion service in their fuel-fabrication facilities.)
5. Early Commercialization of the FBR Cycle
(Nuclear Fuel Cycle)
(1) Basic Policy (“The Framework for Nuclear Energy Policy”)

- The government will strive to make possible the commercial use of FBRs from around 2050, on the premise of meeting the necessary conditions, including economic viability and the progress of nuclear fuel cycle projects for LWRs, while considering the supply-and-demand situation concerning uranium. In this way, the government will promote commercialization efforts that reflect the results of the “Feasibility Study on Commercialization of the Fast-Breeder Reactor Cycle Systems” and operation of the Monju reactor.

(2) Current Efforts

**Feasibility Study on Commercialization of the FBR Cycle Systems**
- The Japan Atomic Energy Agency and electric power utilities are carrying out this study in cooperation with manufacturers, etc.
- This study aims to come up with “a vision of the commercial FBR cycle”* and “a research and development program for the commercialization of FBR technology” by around 2015.
  * An optimum combination of elemental technologies, such as reactor type, the form of fuel, and the reprocessing process, and a conceptual design based on this combination.

**The Monju Prototype FBR**
- Electrical output: 280,000 kW
- The desired goals are “to demonstrate the reliability of the Monju reactor as a power plant” and “to establish sodium-handling technology.”
- The Monju reactor is now being remodeled.
- The program aims to resume operation of the Monju reactor by around 2008 and to accomplish the desired goals in about 10 years.
5. Early Commercialization of the FBR Cycle
(Develop the Transition Scenario for Commercialization of the FBR Cycle)

In line with the basic principles under the Framework for Nuclear Energy Policy, a basic scenario should be formulated and necessary measures should be taken to realize it.

* In order to secure flexibility to meet future uncertainties, given possible changes in the climate surrounding the nuclear industry — such as technological trends, trends in uranium supply and demand, and the international situation — the subscenarios such as accelerated Introduction of FBRs, in addition to the following Basic Scenario, should be developed, necessary response measures must be implemented to meet the developments assumed in these scenarios.

**<Basic Scenario>**

1. Resume the operation of *Monju*, the prototype FBR, at the earliest possible time
   (with the aim of achieving the goals of “demonstrating its reliability as an operational power plant” and “establishing sodium handling technology based on operational experience.”)
2. By 2015, present an appropriate picture of the commercialized FBR cycle and a research and development plan until commercialization is achieved
   (Complete the “Feasibility Study on Commercialized the FBR Cycle Systems”)
3. Aim for the realization of demonstration FBRs and other related facilities by around 2025
4. Start operation of the second reprocessing facility by the time the Rokkasho reprocessing facility finishes operation (around 2045)
   Reuse plutonium recovered from the reprocessing facility for FBRs
5. Start introducing commercial FBRs before 2050
   Subsequently replace existing LWRs with FBRs when they finish operation
5. Early Commercialization of the FBR Cycle  
(Clarification of the Role of the Government in the Transition Scenario)

- At the FBR cycle demonstration stage, the costs and risks equivalent to those associated with light water reactor power generation will in principle be borne by the private sector, with the government bearing a substantial burden of the further costs.

(Reasons)

① The risks that electric power utilities can take are limited amid the electricity market deregulation, and FBR technology is an extremely high-risk technology which still has just a minimal commercial performance record worldwide.

② Amid the global trend toward strengthening nuclear non-proliferation measures, international cooperation and other policy demands are expected, so active government involvement is essential.

- As for the implementing body, if economic feasibility is realistically within sight, practical operation by private enterprises will be appropriate. If the conditions are such that operation by private enterprises is difficult, it is conceivable that while maintaining flexibility in the schedule, substantial government involvement may be necessary for the time being.

It will be beneficial for JAEA to participate in the implementing body for the smooth transfer and succession of technologies from the basic and fundamental research and development stage through to the demonstration process. On the other hand, participation by private enterprises will be essential for technology transfer and human resources development from the demonstration stage through to the commercialization stage.
5. Early Commercialization of the FBR Cycle
(Initiation of Discussions for a Smooth Transition to Trial and Commercialization)

- Discussions aimed at a smooth transition from the “Feasibility Study on Commercialized FBR Cycle Systems” presently being advanced (research and development stage) to the demonstration and commercialization stages should promptly be initiated between the research and development bodies and those who will introduce the technologies, without waiting for the completion of the commercialization strategy study (Ministry of Economy, Trade and Industry (METI), Ministry of Education, Culture, Sports, Science and Technology (MEXT), electric power utilities, manufacturers, JAEA).

- Moreover, a study group including academic and industry experts should be established to determine the scope of such discussions.
5. Early Commercialization of the FBR Cycle
(Securing Budgets for Demonstration and Commercialization)

- The demonstration and commercialization of FBR cycle technologies will not be achieved by just drafting a vision for the future.

- Accordingly, particular efforts are required to secure budgets toward the demonstration and commercialization of FBR cycle technologies.
The number of nuclear power plants under construction in Japan has fallen off sharply since the 1990s.
6. Achieving and Developing Depth in Technologies, Industries and Personnel
(Number of Nuclear Power Plants under Construction in Japan #2)

- Over the next twenty years domestic construction of new nuclear power plants will continue to stagnate.
- Demand for a significant number of replacement projects is expected as early as 2030.

- How the Japanese nuclear industries can maintain sufficient robustness in the fields of technology, safety, and personnel in the twenty-five years or more before this new wave of construction begins.
6. Achieving and Developing Depth in Technologies, Industries and Personnel
(Countermeasures: Development of a Japanese next-generation LWRs with international competitiveness)

- Have the public and private sectors jointly launch a feasibility study on developing a Japanese next-generation light water reactor with an eye to the global market to prepare for the replacement demand from around 2030. The following points should be noted in considering the study.
- The feasibility study should take about 2 years. After it is completed, proceed to the full-scale development stage (about 7 years). This development of a next-generation light water reactor would constitute the first national project in Japan in about 20 years.

**<Points on the Technologies to Be Developed>**
- The project should be clearly focused, rather than trying to please everyone, and consistent with the reactor type strategies of the electric power companies.
- The reactors should have world-class performance and economic efficiency, and incorporate breakthroughs with global appeal.
- The approach should incorporate the manufacturers, be based on user needs, and aim at a standardized reactor.
- The project should contribute to the development of technologies and human resources as required for the replacement demand from around 2030.

**<Reference>**
- The results from the previous national project for next-generation LWR development (1981-1986, total budget JPY 57.3 billion) have been adopted into present day ABWRs (Advanced Boiling Water Reactors) and APWRs (Advanced Pressurized Water Reactors).
- ABWRs include the Kashiwazaki Kariwa No. 6 and No. 7 reactors, the Hamaoka No. 5 reactor and the Shika No.2 reactor which are all operating, as well as the Lungmen No. 1 and No. 2 reactors (in Taiwan), which are under construction. Preparations are now underway for the construction of two APWRs, the Tsuruga No. 3 and No. 4 reactors.
6. Achieving and Developing Depth in Technologies, Industries and Personnel
(Countermeasures: Strengthening of international competitiveness of Japan’s Nuclear Industry)

Changes in the World’s Major Makers of Nuclear Power Plants

1980s
- Babcock & Wilcox (U.S.A.)
- Framatome (France)
- Siemens (Germany)
- Mitsubishi Heavy Industries
- Combustion Engineering (CE, U.S.A.)
- Asea (Sweden)
- Brown Boveri et Cie (Switzerland)

1990s
- Toshiba

2000s
- ABB was created as a result of a merger (1988).
- Siemens
- Mitsubishi Heavy Industries
- BNFL bought ABB's nuclear business division and consolidated it into WH (2000).
- Toshiba acquired WH (October 2006).
- BNFL bought out WH (Note 2) and made it a subsidiary (1999).
- Toshiba

Current Major Manufacturers of Nuclear Power Plants
(as of November 2006)
- AREVA NP (Note 1)
- GE (U.S.A.)
- Hitachi
- Toshiba

Note 1. Renamed AREVA NP on March 1, 2006.
Note 2. The company’s defense/environment-related operations in the U.S.A. were acquired by Washington Group International (U.S.A.).
In order to improve the qualitative aspects of technicians, including on-site supervisors, measures will be taken to promote local initiatives regarding personnel development and passing down of skills beyond the boundaries of individual business enterprises.

Support will be provided for these initiatives as model projects reflecting local needs and diversity, instead of adopting a uniform system nationwide.

**A Vision of the Personnel Development Initiative**

- A business enterprise will provide training courses in quality control and maintenance skills for on-site supervisor-class employees using existing educational and training facilities in the local area.

- An environment will be created to allow a business enterprise to keep records of training sessions attended by on-site technicians and records of operations performed during periodic inspections, and to secure skilled workers by certifying employees’ qualifications in terms of knowledge and skills and registering qualified employees.

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**Business Scheme**

- Planned number of projects to be adopted: 2-4
- JPY 20–JPY 50 million per project
- Period: within three years

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**Educational institutions, etc.**

**Participating enterprises**

**Commissioning**

**Recommissioning/outsourcing**

**Council**

<XXXX Area>

(A commissioning organization will be chosen from among applicants.)

(Overall Management)

(Preparation and implementation of training programs)
6. Achieving and Developing Depth in Technologies, Industries and Personnel

**R&D for Fast Breeder Reactor (¥ 28 billion)**
- Prototype FBR: "Monju"
- Experimental FBR: "Joyo"

**R&D for Nuclear Fuel Cycle (¥ 47 billion)**
- R&D for Full Mox Reactor
- R&D for Uranium Concentration
- Tokai Reprocessing Plan

**R&D for Radioactive Waste Disposal (¥27 billion)**
- R&D for Geological Disposal of High-level Radioactive Waste

**Basic and Advance Research for Nuclear Technology (¥72 billion)**
- International Thermo nuclear Experimental Reactor (ITER)
- High-Intensity Proton Accelerator
- High-Temperature engineering Test Reactor (HTTR)

**R&D for Nuclear Safety (¥ 53 billion)**
- Safety for Aged Reactor
- Advancement of Inspection
- Seismic and Fuel Safety of Nuclear Installation
- Safety for Nuclear Fuel Cycle Installation
- Safety for Radioactive Waste disposal
- Fundamental Safety Research

**Innovative reactor system**

**Generation IV International Forum**
(Japan, US, UK, France, Canada etc)

※ (): The budget for 2005
7. Support for International Development of Japan’s Nuclear Industry
(Policy Implications)

- Nuclear non-proliferation and securing safety in the recipient countries are major prerequisites to the transfer of nuclear materials, equipment and technologies.

- Provided that nuclear non-proliferation and safety are ensured

(1) Plans to introduce and expand nuclear power generation worldwide are effective from the viewpoints of easing tight global energy supply and responding to global environmental issues.

- Recently, there has been a marked re-evaluation of the status of nuclear energy at the international level in light of global environmental problems.
- Japan has achieved the lowest level of unscheduled shutdowns worldwide. The use of such safe and highly reliable technologies is beneficial to both Japan and the entire world.

(2) International development of Japanese nuclear industry would be effective to maintain sufficient robustness in the field of industry’s technologies and personnel during the lull in domestic construction until large-scale replacement works begin from around 2030.
<Reference> Number of unscheduled shutdowns (International Comparison)

- France
- US
- Sweden
- Belgium
- Spain
- Finland
- South Korea
- Germany
- Japan

Unscheduled shutdown (Shutdowns/Reactor year*)

* The average from 1995 to 2004
Source: IAEA-PRIS (Power Reactor Information System) Database
7. Support for International Development of Japan’s Nuclear Industry (Countermeasures #1)

With nuclear non-proliferation and the securing safety as the two most important prerequisites, the international development of the Japanese nuclear industry will be encouraged proactively through the following basic policy and related policy measures.

(1) Basic Policy

- While due consideration is given to a positive approach regarding a strengthened international mechanism for ensuring nuclear non-proliferation, elaborately structured measures — including those for securing safety, ensuring nuclear non-proliferation, and introducing nuclear power generation — will be implemented to meet the actual situations in foreign countries.

- For the actual export of nuclear materials, equipment and technologies, the basic approach will be to secure cooperation from foreign countries, while considering nuclear-reactor-related technology licenses, nuclear fuel supplies, and various international commitments.
7. Support for International Development of Japan’s Nuclear Industry
(Countermeasures #2)

(2) Measures for the International Development of the Nuclear Industry

a. Government Support

The Japanese government will actively express its clear intention to provide high-level support for the
international development of Japanese nuclear industry while giving due consideration to host
countries’ situations relating to nuclear non-proliferation and safety measures.

b. Enhancing Dialogues with Host Countries

Considering that countries have different needs and different issues relating to the introduction or
expansion of nuclear power, the Japanese government and the private sector will enhance dialogues
with host countries so as to obtain a clear understanding of the situations and issues facing host
countries in order to make Japan’s cooperation effective.

c. Cooperation in Personnel Development

Japan will actively extend cooperation in personnel development through the concerted efforts of
academia, industry, and the government, in line with the actual situations in foreign countries,
 focusing on countries that are expected to introduce or expand their use of nuclear power over the
coming years. In extending this cooperation, Japan should enhance its communications and
coordination among relevant government agencies to ensure that Japan’s stance is communicated
clearly to host countries.

- Expansion of the safety training program for China
- Expansion of the safety training program for Vietnam and other countries

d. Positive Participation in Reviews by an International Organization

Because safety reviews by an international organization can often be effective in insuring improved
safety in a host country, Japan will continue to cooperate in and to contribute to such safety reviews.
7. Support for International Development of Japan’s Nuclear Industry
(Countermeasures #3)

e. Use of Public Financing for Exports to Developed Countries
- Because funds availability is most likely to create a bottleneck in exports to developed countries, a plan to provide public financial support, in addition to trade insurance, will be positively considered to the extent that a public financing scheme will not put a strain on private financial institutions.

f. Support for Countries in Developing Proper Systems
- The first consideration regarding a country intending to newly introduce nuclear power plants will be to ensure that it is politically stable for a long period of time. It also will be important to ensure that the country successfully resolves a series of challenges, such as introducing a nuclear-safety regulation system, creating a nuclear non-proliferation system, and enacting a nuclear-damage compensation program. Japan will provide host countries with its expertise and know-how, and will provide support for the development of these systems in an appropriate manner as the countries meet these challenges.

g. Creation of a Framework Such As Bilateral Agreements
- The government should devote its efforts to creating frameworks, such as bilateral agreements, for the transfer of materials and equipment, with due consideration for the issues noted in f. above, such as the creation of nuclear-safety regulation systems, and host countries’ specific needs.

h. Incorporation of Nuclear Power in CDM (Clean Development Mechanism) and JI (Joint Implementation) Projects
- The present Kyoto Protocol dictates that a nuclear power project will be excluded from CDMs and JIs (mechanisms that allow a country that has carried out a project to achieve greenhouse-gas emission reductions in a foreign country, to share the emission reductions with that country).
- However, because the importance of nuclear power as an effective tool for addressing global environmental problems has been recognized anew at the global level, Japan should use every possible opportunity to propose incorporating nuclear power projects in CDMs and JIs within a framework to be established and to call upon foreign countries also to do so.
i. Flexible Operation of Export Controls and Export Credit Providing Procedures
- Export controls will continue to be implemented rigorously. However, the procedures must be operated flexibly, because an international tender might sometimes require a participant to obtain an export license. Most notably, bidders are often required to submit a prospectus for gaining an export license before entering into an agreement. The export-control procedures must therefore be enforced flexibly on a case-by-case basis so as to allow bidders to meet this requirement.
- Export credits by the Japan Bank for International Cooperation (JBIC) and Nippon Export and Investment Insurance (NEXI) should continue to be provided actively on the premise that safety must be checked by the Ministry of Economy, Trade and Industry. In providing export credits, quick action must be taken in close cooperation with JBIC, NEXI, and exporters, so as to meet the rate at which commercial transactions are performed.

j. Enhancing Cooperation between the Public and Private Sectors
- In order to promote this international development effectively through the concerted efforts of the public and private sectors, communications between the government and the private sector must be enhanced regarding policies and the two sectors’ respective roles.

k. Expansion of Academia’s Cooperative Relations
- An important strategy — in addition to promoting government-level and private-sector-level cooperation with host countries — for building cooperative relations with host countries in the nuclear field is to expand cooperative relations between Japan’s academia and those of the host countries, including promoting exchanges among academic societies and building relations with universities in host countries.
7. Support for International Development of Japan’s Nuclear Industry (China #1)

- China is actively advancing nuclear power generation to ease its tight energy supply conditions.
- At the end of September 2004, China announced that a formal international tender for the following four nuclear power plants would take place by the end of February 2005. The schedule for a formal decision of a contractor for the tender has yet not been decided. The construction is scheduled to start around 2007.
  - Sanmen (Zhejiang Province) 2 reactors (1 million kW class PWR)
  - Yangjiang (Guangdong Province) 2 reactors (1 million kW class PWR)
- Of the bidders of these projects in February 2005, the probable bidders are the following two groups.
  - Consortium of Westinghouse and Shaw, Mitsubishi Heavy Industries (will supply part of the facilities)
  - AREVA (France)
- China intends to adopt the future standard reactor for the reactor type, and because China plans to construct a great number of new nuclear power plants from now on, there is a strong possibility that the winners of this international tender may gain large market shares over a substantial period of time in the massive Chinese market for nuclear power plant construction in the future.
7. Support for International Development of Japan’s Nuclear Industry (China #2)

(1) Dispatch of Letter of Support from Minister of Economy, Trade and Industry
   → Sent to Chinese Vice Premiers Wu Yi and Zeng Peiyan (February 2005)

   **Summary**
   
   Japanese business enterprises’ participation in projects to build nuclear power plants in China forms a vitally important basis for further deepening long-term friendly relations between Japan and China in the nuclear field and strengthening the overall cooperative relationship between the two countries in the future. From this standpoint, the Japanese government intends to provide support for Japanese business enterprises that are taking part in projects in China.

(2) Background of the support letter from METI’s minister

   ➢ Considering the importance of these policy implications, to clarify the Japanese government’s stance of providing maximum support to Japanese nuclear industry, the Minister of Economy, Trade and Industry took the unprecedented step of sending a support letter to Chinese Vice Premier Wu Yi and Zeng Peiyan. The letter is an expression of the entire government’s policy, and was issued after coordinating with the Prime Minister’s Office and the Ministry of Foreign Affairs.

   ➢ In conjunction with this, Nippon Export and Investment Insurance (NEXI) and Japan Bank for International Cooperation (JBIC) began examinations of issuing export credits.

   ➢ With these kinds of government actions, Japanese nuclear power firms are expected to participate in new nuclear power plant construction projects in China, and the Japanese nuclear power industry’s technologies, safety practices and personnel are expected to be fully utilized in China.
At present, 9 nuclear power plants are in operation in China, and their total capacity is about 7 million kW.

There are also 2 nuclear power plants under construction, which will generate about 2 million kW.

China plans to increase its nuclear generation capacity to about 40 million kW by the year 2020 to respond to its energy supply shortage.

*Country names in parentheses indicate suppliers of primary system technologies.*
8. Positive Involvement in Creating an International Framework to Uphold both Nonproliferation and the Expansion of Nuclear Power Generation
(Japan’s Contribution and Efforts #1)

(1) Japan’s Contribution to IAEA Safeguards

- Japan took the lead in examining, developing, and verifying safeguards methods for large-scale commercial reprocessing facilities in cooperation with the US, the UK, France, the IAEA, etc. As a result, in January 2004, IAEA applied for the first time the safeguards measures for large-scale commercial reprocessing facilities to the Rokkasho Reprocessing Facility.

- Furthermore, the IAEA officially acknowledged Japan’s achievements in peaceful uses of atomic energy, and in September 2004, started to implement integrated safeguards* for Japan’s nuclear facilities for the first time among countries engaged in large-scale nuclear energy activities.

  * This is a safeguards system whereby the IAEA confirms that it finds no indication of diversion of nuclear material or no indication of undeclared nuclear material or activities in a country with both Comprehensive Safeguards Agreement and Additional Protocol in force, and then works towards the rationalization and greater efficiency in its safeguards activities in the country.

(2) Frontier of Technology Development

- Japan for the first time in the world developed technologies for generating MOX powder from a mixture of uranium nitrate and plutonium nitrate solutions, to ensure that there will be no unmixed pure plutonium oxides.
8. Positive Involvement in Creating an International Framework to Uphold both Nonproliferation and the Expansion of Nuclear Power Generation (Japan’s Contribution and Efforts #2)

(3) Firm Maintenance of the Three Non-Nuclear Principles
Since Japan is the only country in the world that has suffered nuclear attack, its citizens are firmly opposed to nuclear armament. The Atomic Energy Basic Law restricts the use of atomic energy to peaceful purposes and Japan firmly maintains the Three Non-Nuclear Principles of not possessing, not producing and not permitting the introduction of nuclear weapons into Japan.

(4) Outcome of Long Consultations with the US
As a result of Japan’s nuclear fuel reprocessing negotiations with the US, Carter and Reagan administrations over a period of more than 10 years, an agreement was reached for the introduction of the comprehensive prior agreement system, which gives prior approval for reprocessing activities.

→ It is internationally accepted that, as a result of Japan’s considerable and sustained contribution and efforts including those described above, Japan is the only non-nuclear-weapon state to possess commercial-scale nuclear fuel recycling facilities, including facilities for enrichment and reprocessing.
8. Positive Involvement in Creating an International Framework to Uphold both Nonproliferation and the Expansion of Nuclear Power Generation  
(Japan’s Contribution and Efforts #3)

- Regarding the strengthening of the international nuclear non-proliferation regime, Japan considers the strengthening of the IAEA safeguards, particularly the universalization of the IAEA Additional Protocol, and the reinforcement of international export control mechanisms such as the NSG guidelines, to be the most realistic and effective policies.

- Based on this recognition and in order to promote the speedy implementation of the matters agreed at the G8 Sea Island Summit, Japan is actively engaged in discussions with relevant countries and organizations at the G8 Senior Group Meetings, G8 Non-Proliferation Experts Group Meetings, and the NSG. Regarding restrictions on the transfer of enrichment and reprocessing equipment and technologies, Japan is actively engaged in discussions at the G8 and NSG in order to establish “objective criteria.”
8. Positive Involvement in Creating an International Framework to Uphold both Nonproliferation and the Expansion of Nuclear Power Generation
(Japan’s Policy #1)

- Japan will continue to demonstrate to the world a model as a state successfully ensuring both nuclear non-proliferation and the peaceful uses of atomic energy, by implementing strict export controls, IAEA safeguards, and physical protection of nuclear materials.
8. Positive Involvement in Creating an International Framework to Uphold both Nonproliferation and the Expansion of Nuclear Power Generation  
(Japan’s Policy #2)

- Japan is prepared to participate actively in discussions regarding proposals for multilateral approaches to the nuclear fuel cycle, such as an “assurance of nuclear fuel supply”.

1. In these talks, the following points should be fully discussed:

   a. How would a new approach concretely strengthen the international nuclear non-proliferation regime? (For example, would it practically restrict the nuclear activities of states of concern?)

   b. Would not a new approach unduly affect the peaceful uses of nuclear energy of countries that carry out nuclear activities with the confidence of the international community by faithfully fulfilling their NPT obligations and by ensuring high transparency of their nuclear activities?
8. Positive Involvement in Creating an International Framework to Uphold both Nonproliferation and the Expansion of Nuclear Power Generation (Japan’s Policy #3)

2. Japan is also prepared to positively examine how it can contribute to the introduction of a new international mechanism to deal with nuclear non-proliferation issues at the global level.

a. Front-End

- **Uranium mine development:**
  Participation in uranium mine development through international cooperation.

- **Enrichment:**
  The production capacity of the current facility in Japan is approximately 10% of domestic demand, which makes it physically difficult to provide service internationally at present. However, when Japan’s enriched uranium production capacity is increased using the new centrifuge that is presently under development (scheduled for introduction after FY 2010), it may become possible to provide enriched uranium overseas.

- **Fuel fabrication:**
  Domestic facilities are designed to meet the specifications of domestic nuclear reactors, but there are excess fuel fabrication capacity.
8. Positive Involvement in Creating an International Framework to Uphold both Nonproliferation and the Expansion of Nuclear Power Generation (Japan’s Policy #4)

b. Back-End

- Reprocessing:
  ✓ Since the existing capacity at the current Rokkasho is insufficient to meet domestic demand, it would physically be difficult to provide service internationally.
  ✓ There is, however, leeway to develop a high proliferation-resistant reprocessing technology and to examine the possibility of providing some service internationally from a new reprocessing plant, planned for around 2050. Nevertheless, several issues would have to be addressed, including how to serve countries which only have light water reactors when the reprocessing is aimed for fast breeder reactors, and gaining approval of the local community that host the facilities.

- Interim storage and final disposal facilities:
  It is Japan’s basic policy to pursue interim storage and final disposal within its territory. Nevertheless, Japan would welcome the creation of an international framework of such facilities in relevant countries to receive foreign nuclear waste from countries that are engaged (or will be engaged) in small-scale nuclear power generation.
<Reference> The United States’ Global Nuclear Energy Partnership (GNEP)

Expression of the expectation for Japan’s cooperation in GNEP by U.S. President Bush and Clay Sell, U.S. Deputy Secretary of Energy
(Excerption)

①President’s Radio Address (Feb.18, 2006)
  “America will work with nations that have advanced civilian nuclear energy programs, such as France, Japan, and Russia.”

②Press briefing by Clay Sell, Deputy Secretary of Energy (Feb.16, 2006)
  “Japan has great capability in recycling technologies. They're about to open, or they will soon open, the world's newest commercial reprocessing facility*. We're think there are potential opportunities there to test and demonstrate new technologies and they have at least two**, I believe, operating fast spectrum reactors that could prove useful as a test bed in the near term. So we think there are many great opportunities for participation. And the commitment is one not just of -- it's not just an agreement on the objectives, but it is a commitment of each of our nation's talent and each of our nation's resources to develop these technologies as quickly as reasonably possible.”

* Rokkasho Reprocessing Plant
** Monju and Joyo
The Government of Japan welcomes the United States` new initiative to enhance the worldwide development and expansion of nuclear power generation while ensuring nuclear non-proliferation.

It is particularly noteworthy that this initiative indicated clearly the orientation of the US nuclear policy towards the promotion of spent fuel recycling in order to increase energy efficiency and reduce the volume of radioactive waste.

The Government of Japan will study further this initiative with a view to identifying the potential areas of cooperation.
The United States’ Global Nuclear Energy Partnership (GNEP) (Nuclear Fuel Cycle)

Natural Uranium Ore

Uranium Mine

Fuel-Manufacturing Processes (enrichment, etc.)

Uranium Fuel

Highly-Enriched Uranium (HEU)

Caution against diversion of plutonium and HEU to the production of nuclear weapons

Interim-Storage Facility

Nuclear Power Plants (light-water reactors, FBRs in the future)

Reprocessing Plant

MOX Fuel Plant

MOX Fuel

Plutonium

Uranium-Plutonium

The Plutonium Utilization in LWRs

High-Level Radioactive Waste

High-Level Radioactive-Waste Ultimate-Disposal Facility

Caution against diversion of plutonium and HEU to the production of nuclear weapons

Uranium Fuel-Manufacturing Processes (enrichment, etc.)

Interim-Storage Facility

Reprocessing Plant

Uranium-Plutonium

High-Level Radioactive Waste

High-Level Radioactive-Waste Ultimate-Disposal Facility
Japan’s Proposal on the “Concept for a Multilateral Mechanism for Reliable Access to Nuclear Fuel” #1

- Japan’s strategic goals in joining international discussions on assured access to nuclear fuels

1. To establish Japan’s presence as an influential member of international rulemaking by having other countries recognize Japan’s contributions to international rulemaking.

2. To propose rules that ensure flexibility in terms of future exports, in order to avoid restricting the position of “Nuclear Fuel Supplier State” to the six countries which are currently exporting enriched uranium.

3. To clearly demonstrate our strong desire to take part in international discussions (including expert meetings) on assured access to nuclear fuels by presenting our proposal at the IAEA General Conference and its 50th anniversary commemorative event this past September.
1. Basic position
Japan supports the objective put forward in the “Concept for a Multilateral Mechanism for Reliable Access to Nuclear Fuel” proposed by the six countries. However, bearing in mind the concerns and questions expressed by the Board Members of the IAEA at the IAEA Board of Governors Meeting in June 2006, Japan feels it useful to make a proposal complementary to the above-mentioned six-nation proposal.

2. Issues to be improved in the six-nation proposal

1) While the six-nation proposal focuses on remedial responses to possible disruption of uranium fuel supply, consideration should also be given to a preventive mechanism to avoid occurrence of the market disturbance.

   To this end,
   i. it is desirable to establish a mechanism to share relevant data and information about countries’ capacity and market situation in order to avoid market disturbance and bridge the information gap on uranium market.
   ii. it is also desirable to establish a mechanism that covers not only uranium enrichment but also all important phases of whole front end of the nuclear fuel cycle, namely, uranium ore supply, conversion, enrichment, fuel assembly and uranium reserve) in order to prevent market disturbance and to effectively respond to it if it happens.

2) Whereas the six-nation proposal is based upon a dichotomy between supplier States and recipient States, a country like Japan, which is producing enriched uranium for domestic uses and not currently exporting it but planning to export it in the future, cannot be categorized under the dichotomy. It is more appropriate to establish a mechanism which reflects the real diversity and many States can participate in and contribute to on a voluntary basis.
In relation to international discussions on assured access to nuclear fuels, Japan proposes an idea of a **Standby Arrangements System** to be established under the auspices of the IAEA. This proposal is put forward with a view to improving the “Concept for a Multilateral Mechanism for Reliable Access to Nuclear Fuel” proposed by France, Germany, the Netherlands, Russian Federation, the United Kingdom and the United States at the IAEA Board of Governors Meeting in June, 2006.

### Proposed concept of an “IAEA Standby Arrangements System for Nuclear Fuel Supply”

1) **Member States voluntarily notify the IAEA, as the depository organization, of their intentions to participate in the system by registering their nuclear fuel supply capacity in terms of current stock and supply capacity in the following areas:**

   i. Uranium Ore Supply Capacity
   
   ii. Uranium Reserve Supply Capacity, including Recovered Uranium
   
   iii. Uranium Conversion Capacity
   
   iv. Uranium Enrichment Capacity
   
   v. Fuel Fabrication Capacity

Any member State is eligible to participate in the system provided that the IAEA Board of Governors finds no non-compliance of the IAEA safeguards agreements by that State.
Proposed concept of an “IAEA Standby Arrangements System for Nuclear Fuel Supply” (continued)

2) A participating State periodically (annually) notifies the level of availability of such capacity at the following three levels:
   i. Level 1: It has already started commercial activities and is providing products/services domestically, but not providing products/services to foreign countries on a commercial basis. Therefore although it has willingness to cooperate the emergency request to supply, the quantity may be limited and considerable time might be required to start the supply.
   ii. Level 2: It has already started exporting products/services to foreign countries on commercial basis. Therefore in case of receiving the emergency request to supply, it has the willingness to do so as soon as possible within the range of available capacities.
   iii. Level 3: It has reserves that can be exported at a short-term notice.

3) IAEA is expected to play the following roles:
   i. to conclude bilateral “standby arrangements” with respective participating States by receiving Letters of Intent and to administer the overall system.
   ii. to administer, as the depository, the data-base utilizing information periodically provided by participating States on their commitment areas as well as levels of availability and information routinely gathered by the Agency such as potential demands for the system, e.g. programs of future nuclear power generation in member States and the situation of the international uranium market. To prepare an annual report on the situation (adequacy) of world nuclear fuel supply market based on the data-base will be one of the ways to contribute to the improvement of the transparency of the market.
   iii. to play an intermediary function should actual disruption of fuel supply occur in a State.

A State is eligible for enjoying the function of the system if the State has satisfied an international nonproliferation norm, which the IAEA Board of Governors Meeting should adopt after careful consideration at the start of the system.

This system is a virtual arrangement: as participating States are supposed to continue to possess and control nuclear fuel supply capacity, the IAEA does not need to actually possess or store them.
9. Coexistence of Nuclear Power with Local Residents and Communities
(Strengthening Relationships of Trust Between the Government and Communities Where Plants Are Located)

➢ To reinforce relationships of trust with the local community on a day-to-day basis, make earnest efforts at each level with visible government input, in accordance with the actual conditions in each area.

1. Strengthen direct dialog with local residents
   a. Symposiums and other events targeting large numbers of residents
   b. More highly detailed efforts for smaller groups of residents

2. Steadily build up relationships of trust before responsible parties communicate the government’s approach and policies

3. Continuously address regional development

4. Ensure local government participation in government inspections

5. Reinforce administrative systems
10. Steady Promotion of Measures for Disposal of Radioactive Waste
(Type of radioactive wastes)

➢ Radioactive wastes are classified into two types.

**High-level radioactive waste (HLW)**

The radioactive liquid containing most of the fission products and actinides present in spent fuel—which forms the residue from the first solvent extraction cycle in reprocessing—and some of the associated waste streams; this material following solidification.

**Low-level radioactive waste (LLW)**

A generic name for radioactive wastes other than high-level radioactive waste. LLW is classified by sources as follows:

- Waste from nuclear power plant
- Waste containing transuranium nuclides (hereinafter referred to as “TRU waste”) (Note1)
- Uranium waste (Note2)
- Waste from radioisotope usage, research facilities, etc.

Note1 TRU waste are mainly generated from reprocessing plant, MOX fuel fabrication plant, etc. including returns from overseas by reprocessing.

Note2 Uranium waste are generated from UO₂ fuel fabrication plant, U enrichment plant, etc.

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(Note1) TRU wastes are also generated from MOX fuel fabrication plant.

(Note2) The wastes that are reprocessed overseas and returned to Japan are included.
10. Steady Promotion of Measures for Disposal of Radioactive Waste
(Reinforcement of efforts to select candidate sites for final disposal)

Having the awareness that the selection of candidate sites for final disposal will reach a decisive moment over the next one or two years, those who are concerned have to make their utmost efforts in one including, among others, expansion of measures for regional support by the government, reinforcement of publicity activities, etc.

**Schedule of selection of final disposal sites**

- **Applicant areas and their surroundings**
- **Preliminary investigation areas**
- **Detailed investigation areas**
- **Site for construction of final disposal facility**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st stage</td>
<td>Selection of preliminary investigation areas through literature surveys</td>
</tr>
<tr>
<td>2nd stage</td>
<td>Selection of detailed investigation areas through preliminary investigations such as borehole program, etc. (The selection is slated to be made sometime around 2010.)</td>
</tr>
<tr>
<td>3rd stage</td>
<td>Selection of site for construction of final disposal repository through detailed investigations at underground facilities (The selection is slated to be made sometime around 2025.)</td>
</tr>
</tbody>
</table>

Opinions and decisions:
- Opinions in local communities and cabinet decision
- Commencement of final disposal (Final disposal is slated to be commenced sometime around 2035.)
The operations of geological disposal of TRU waste* must be carried out in a well-planned and reliable manner, getting the central government legally involved, from the viewpoints of long-term safety and social reliability. Therefore, a scheme of operations should be established as early as possible within the same framework of "Specified Radioactive Waste Final Disposal Act."

A framework that makes it possible to build a geological disposal repository for TRU waste close to a disposal facility for high-level radioactive wastes should be established. For this purpose, the scheme should be designed to allow the implementing entity of disposal of high-level radioactive wastes (Nuclear Waste Management Organization of Japan) to become the implementing entity of operations of geological disposal of TRU waste. However, the construction of a geological disposal repository for TRU waste close to a disposal facility for high-level radioactive wastes should be an option that can be selected by the implementing entity to allow for the intentions of local communities, rather than made obligatory under the scheme.

The government, research institutes, waste generators and the implementing entity should steadily promote the activities to foster understanding and technology development under close cooperation.

* "Geological disposal" refers to the disposal of solid radioactive waste in a facility located underground in a stable geological formation (more than 300 m below the surface in Japan) to provide long term isolation of the radionuclides in the waste from the biosphere. Disposal means that there is no intention to retrieve the waste, although such a possibility is not ruled out. Geological disposal was conceived as a method for disposing of the more hazardous types of radioactive waste, including heat generating and long-lived waste. The relevant waste includes high level waste from the reprocessing of nuclear fuel, other radioactive waste generating significant amounts of heat and other radioactive waste including TRU waste unsuitable for disposal in near and sub-surface disposal facilities.
10. Steady Promotion of Measures for Disposal of Radioactive Waste (To establish the institutional frame for geological disposal of TRU waste #2)

TRU waste generated from reprocessing facilities

< Types of TRU waste >

- **Hull**
  - Fuel clad that remains fragmented fuel rods are dissolved in a dissolver.

- **End-piece**
  - End pieces of spent fuel assemblies
  - Cut and removed when assemblies are chopped

- **Liquid concentrate**
  - Evaporated and concentrated liquid waste generated from processes such as acid recovery, chemical analysis, off-gas cleaning and equipment decontamination, etc.

- **Technological wastes**
  - Technological wastes generated in each process of reprocessing
  - Classified into combustible wastes (those wastes that can be easily incinerated such as paper, cloth, etc.) and Non-combustible wastes (those wastes that cannot be incinerated such as metal pipes, glass, etc.)
  - (Also generated by operation and dismantling of MOX fuel fabrication facilities)

- **Iodine filter (silver adsorbent)**
  - Used filters that adsorbed radioactive iodine in the off gas produced during chopping and dissolution of spend fuels

[Source: the materials for the Atomic Energy Commission's conference to develop new plans]
### Characteristics of TRU waste

<table>
<thead>
<tr>
<th>Disposal method</th>
<th>Geological disposal</th>
<th>Disposal at intermediate depth and shallow land repository</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outline</td>
<td>Hull (Cross section)</td>
<td>Liquid concentrate, etc.</td>
</tr>
<tr>
<td></td>
<td>End-piece</td>
<td>Drying and pelletizing</td>
</tr>
<tr>
<td></td>
<td>Iodine filter (silver absorbent)</td>
<td>Absorbent to remove radioactive iodine</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Poorly combustible wastes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-combustible wastes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Metal tools</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Metal pipes</td>
</tr>
<tr>
<td>Image of waste package</td>
<td>(Example)</td>
<td>(Example)</td>
</tr>
<tr>
<td>Characteristics</td>
<td>• Heat generation is relatively high</td>
<td>• Including I-129</td>
</tr>
<tr>
<td></td>
<td>• Including C-14</td>
<td></td>
</tr>
</tbody>
</table>

[Source: the materials for the Atomic Energy Commission's review meeting on the technology to dispose of long half-life and low-heat radioactive wastes]
10. Steady Promotion of Measures for Disposal of Radioactive Waste
(To establish the institutional frame for geological disposal of TRU waste #4)

**Methods of disposal of TRU waste**

- **Generation**
  - Reprocessing facility
  - MOX fuel fabrication facility
  - Overseas reprocessing facility

- **Wastes**
  - Generated mainly at the time of dismantling
  - Concrete
  - Metal
  - Solidification of liquid concentrate
  - Silver absorbent
  - Miscellaneous solid wastes
  - Hull and end-piece

- **Methods of disposal**
  - Reused
    - Disposed of as industrial wastes
    - Several meters
  - Shallow land pit disposal
    - About 88,400 m³
      - (About 63%)
  - Disposal at intermediate depth
    - (Disposal at the depth deep enough for general underground use such as subways, etc.)
    - About 25,200 m³
      - (About 18%)
  - Geological disposal
    - About 26,600 m³
      - (About 19%)

Amount of material: "Review meeting on technology to dispose of TRU wastes - Presentation of second report on research and development of disposal of TRU wastes" (herein after referred to as “Second TRU Report”)

- Appropriate disposal in proportion to radioactivity concentration
- Long-lived and low-heat generating waste subject to geological disposal
10. Steady Promotion of Measures for Disposal of Radioactive Waste (To establish the institutional frame for geological disposal of TRU waste #5)

- Outline of proposed scheme of operations of geological disposal of TRU waste

<table>
<thead>
<tr>
<th>Minister of Economy, Trade and Industry (METI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>○ Formulation of basic policy</td>
</tr>
<tr>
<td>● Basic directions to final disposal</td>
</tr>
<tr>
<td>● Matters to promote understanding among general public and local residents</td>
</tr>
<tr>
<td>○ Development of final disposal plan (a ten-year plan will be developed every five years)</td>
</tr>
<tr>
<td>● Final disposal schedule and amount of waste for disposal</td>
</tr>
<tr>
<td>● (In the near future, locations of preliminary investigation areas when they are selected) and others</td>
</tr>
</tbody>
</table>

- Co-disposal with high-level radioactive waste

○ The Atomic Energy Commission determined that the co-disposal with high-level radioactive wastes has technological viability.
○ The co-disposal with high-level radioactive wastes is positioned as an option that can be selected by the implementing entity to allow for the intentions of local communities, etc.
10. Steady Promotion of Measures for Disposal of Radioactive Waste (Institutional measures for wastes returned from overseas #1)

As for the U.K.'s proposal to exchange low-level radioactive wastes into high-level radioactive wastes and return to Japan, the validity of indicator (ITP) for such exchange is evaluated. Based on the results of evaluation, the government takes institutional measures necessary to accept such high-level radioactive wastes.

As for France's proposal to change the solidified form of low-level radioactive wastes (change from bituminization to vitrification), the government takes institutional measures necessary for disposal in consideration of the technological proprieties confirmed by the Atomic Energy Commission.

Advantages of the U.K.'s proposal (return of changed wastes)

- **Drastic reduction in volume**
  - Wastes solidified by cement
    - About 4,500 units
    - (About 2,500 m³)
  - Miscellaneous solidified wastes
    - About 6,000 units
    - (About 9,000 m³)
  - About 11,500 m³
  - Frequency of transport: about 37 times
    - (Necessary period: about 10 years)

- **Effect ①**: Reduction in frequency of transport
  - In the case where wastes are not changed
  - The number of units to be transported in a steady state is assumed.

- **In the case where wastes are changed**
  - Volume: about 1/400
  - Frequency of transport: about 1/37

- **Transport to return wastes**
  - Change
  - Transport to deliver wastes

- **Disposal**
  - BNGS reprocessing plant
  - Geological disposal

- **Storage volume**
  - About 11,500 m³ → about 30 m³

- **Effect ②**: Reduction in storage volume
  - (Reduction in size of storage facility)

- **Effect ③**: Reduction in scale of disposal repository
  - About 20,000 m² → about 8,000 m²

- **Volume**
  - High-level radioactive waste
  - Waste solidified by cement
  - Miscellaneous solidified waste

**Source**: materials of Federation of Electric Power Companies
10. Steady Promotion of Measures for Disposal of Radioactive Waste (Institutional measures for wastes returned from overseas #2)

- France's proposal (change in the form of solidification)

Advantages to adopt the proposed change in the solidification method:
- Reduction in frequency of transport and early completion of return of wastes
- Easier management of wastes because of the same form as that of other wastes to be returned
- Reduction in the area to be occupied by wastes at the time of storage and disposal

* COGEMA: the trade name was changed to "AREVA NC" in March 2006.
[Source: materials of Federation of Electric Power Companies]
V. Why Nuclear Fuel Recycle in Japan?

- Nuclear Fuel Recycling
- The Plutonium Utilization in LWRs
What Is a Nuclear Fuel Cycle?

- The term “nuclear fuel cycle” refers to the use of uranium and plutonium that have been extracted from the reprocessing of spent fuel from nuclear power plants. This enables:
  - Finite uranium resources to be used effectively, thus contributing to a stable supply of energy
  - Amounts of radioactive waste to be reduced
- In contrast, a path through which spent fuel is disposed of underground without using it in a nuclear-fuel cycle is referred to as “direct disposal (once-through).”
The Atomic Energy Commission of Japan (AEC) prepares the Long-Term Nuclear Program every five years, and new program the “Framework for Nuclear Energy Policy” was endorsed by the Cabinet in October 2005.

The AEC established the New Nuclear Policy-Planning Council and started examining this new framework from June 2004. The Council began with intensive discussions regarding nuclear fuel cycle policy.

**<Characteristics of these AEC Deliberations>**

- Intensive examinations of the nuclear fuel cycle with thorough discussions over a total of 45 hours in 18 meetings including subcommittee deliberations, all open to the public.
- Evaluations of four “basic scenarios” from 10 evaluation perspectives (criteria), without viewing alternatives to reprocessing as taboo. These evaluations included cost estimates for the options, as well as the complete public disclosure of the 10 evaluations of each option.
- Subsequent comprehensive assessment analyzing the merits and demerits of each option under each perspective.

**<Four Basic Scenarios>**

1. Reprocessing of all waste
   (This is the approach under the present policy)
2. Reprocessing of some waste
   (Interim storage and subsequent final disposal of spent fuel beyond the capacity of the Rokkasho Reprocessing Facility.)
3. Direct disposal of all waste
4. Intermediate storage of all waste
   (interim storage of all waste, followed by either direct disposal or reprocessing)

**<10 Evaluation Perspectives>**

1. Ensuring safety
2. Energy security
3. Environmental compatibility
4. Economics
5. Nuclear non-proliferation
6. Technological feasibility
7. Social feasibility
8. Securing options
9. Issues if policy is changed
10. Overseas trends
While there is presently a sufficient supply of nuclear fuel, partially from the highly enriched uranium recovered from dismantled weapons, a supply shortage may emerge in about 10 years after the supply from dismantled weapons ceases.

- The supply of highly enriched uranium from dismantled weapons may dry up in about 10 years
- China’s demand for nuclear fuel may rapidly increase

* High-enriched uranium supplied from nuclear warheads that are to be reduced in number pursuant to the U.S.-Russia agreement that was entered into upon the end of the Cold War is diluted, and this low-enriched uranium is supplied for use in nuclear power plants for peaceful purposes.

The price of uranium has been on a rising trend in recent years. The recycling of uranium resources via the nuclear fuel cycle contributes to the stability of energy supply.

Graph: Uranium Price ($/lb. U₃O₈) vs. Year

- First oil shock (Oct. 1973)
- Three Mile Island Incident (March 1979)
- $54.00/lb. U₃O₈ (Oct. 30, 2006)

Source: Spot prices given by the Ux Consulting Company, LLC.
By recycling 1,000 kg of spent fuel, approximately 130 kg of MOX fuel and 130 kg of uranium fuel can be recovered, helping to boost Japan’s energy self-sufficiency ratio as a quasi-domestic source of energy. Once fast breeder reactors are introduced and a breeding cycle initiated, the securing of a semi-perpetual supply of domestic energy is possible.

Stable Energy Supply #3

- New uranium fuel
  - Electricity generation: 1,000 kg (4.1%)
- Spent uranium fuel
  - Reprocessing: 1,000 kg
- Recovered uranium
  - Re-enrichment: 940 kg (0.9%)
- Depleted uranium
  - MOX fuel fabrication: 810 kg (0.3%)
  - Vitrification processing: Approx. 50 kg
- Recovered plutonium
  - Reconversion & processing: approx. 10 kg
- Recovered uranium fuel
  - MOX Fuel fabrication: approx. 130 kg
  - New uranium fuel: 1,000 kg (4.1%)

Percentages inside parentheses indicate uranium concentration.
Harmfulness of High-Level Radioactive Waste

- Direct disposal results in disposal of high-level radioactive waste that contains uranium, plutonium, fission products, and other substances. In contrast, reprocessing results in radioactively less-harmful disposal, because vitrified waste assemblies produced after reprocessing contain fission products and very small amounts of uranium, plutonium, and other harmful substances. The harmfulness of radioactive waste produced by reprocessing decreases to 1/8 of the harmfulness of directly disposed of waste in the LWR cycle, and further to 1/30 of this level in the FBR cycle one thousand years later.

Harmfulness (maximum value) of radiation from natural uranium needed to produce the same amount of electricity.

* Source: Document No. 8 of the ninth meeting of the Atomic Energy Commission’s New Nuclear Policy-Planning Council

* Barriers between high-level radioactive waste and humans are not considered, and the harmfulness indicated is the potential harmfulness of high-level radioactive waste, not its actual harmfulness. It is a relative value, with the potential effect of spent fuel in the first year of disposal being 1.
### Environmental Compatibility #2

Types of radioactive waste and annual generation volumes

<table>
<thead>
<tr>
<th>Volume (assuming a nuclear energy facilities generation capacity of 58GWe)</th>
<th>Reprocessing of all waste</th>
<th>Direct disposal of all waste</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vitrified waste</strong></td>
<td>Approx. 1,400 m³</td>
<td>–</td>
</tr>
</tbody>
</table>
| **Spent uranium fuel** | – | Approx. 3,800 m³ *¹  
Approx. 5,200 m³ *² |

| Area required for disposal *³ |
|---|---|---|
| **Vitrified waste** | Approx. 140,000 m² | – |
| **Spent uranium fuel** | – | Approx. 210,000 m² *¹  
Approx. 250,000 m² *² |

* 1. Assuming 4 spent fuel assemblies per canister.  
* 2. Assuming 2 spent fuel assemblies per canister.  
* 3. Assuming disposal in soft rock formations.  

Assuming present uranium prices, the nuclear fuel cycle costs (which account for 20-30% of the power generation costs) under direct disposal are about **40% less expensive** than those under reprocessing.

The recycling costs are about ¥0.5-0.7/kWh (at a discount rate of 2%)*1 which is equivalent to about ¥600-¥840 (1% of annual electricity charges) per household per year.

[Reference] <Examples of other recycling fees (per unit)>
Automobile: approx. ¥13,000; air conditioner: ¥3,675; television: ¥2,835; refrigerator: ¥4,830; washing machine: ¥2,520.

<table>
<thead>
<tr>
<th>(Unit: yen/kWh)</th>
<th>(1) Reprocessing of All Waste</th>
<th>(2) Partial Reprocessing</th>
<th>(3) Direct Disposal of All Waste</th>
<th>(4) Interim Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power generation cost</td>
<td>Approx. 5.2</td>
<td>Approx. 5.0-5.1</td>
<td>Approx. 4.5-4.7</td>
<td>Approx. 4.7-4.8</td>
</tr>
<tr>
<td>Nuclear fuel cycle cost</td>
<td>Approx. 1.6</td>
<td>Approx. 1.4-1.5</td>
<td>Approx. 0.9-1.1</td>
<td>Approx. 1.1-1.2</td>
</tr>
<tr>
<td>(of which) (1) Front end</td>
<td>0.63</td>
<td>0.63</td>
<td>0.61</td>
<td>0.61</td>
</tr>
<tr>
<td>(2) Back end</td>
<td>0.93</td>
<td>0.77-0.85</td>
<td>0.32-0.46</td>
<td>0.49-0.55</td>
</tr>
<tr>
<td>Policy change cost</td>
<td>—</td>
<td>—</td>
<td>Approx. 1.9-1.5</td>
<td>Approx. 0.9-1.5</td>
</tr>
<tr>
<td>(of which) (1) Related to the Rokkasho Reprocessing Facility*2</td>
<td>—</td>
<td>—</td>
<td>Approx. 0.2</td>
<td>Approx. 0.2</td>
</tr>
<tr>
<td>(2) Related to substitute thermal power generation*3</td>
<td>—</td>
<td>—</td>
<td>Approx. 0.7-1.3</td>
<td>Approx. 0.7-1.3</td>
</tr>
<tr>
<td>(reference) Power generation cost + policy change cost</td>
<td>Approx. 5.2</td>
<td>Approx. 5.1-5.1</td>
<td>Approx. 5.4-6.2</td>
<td>Approx. 5.6-6.3</td>
</tr>
</tbody>
</table>

*1. Differential between “(1) Reprocessing of All Waste” and “(3) Direct Disposal of All Waste” for the power generation cost.
*2. Cost if the Rokkasho Reprocessing Facility could no longer be used.
*3. Cost of substitute thermal power generation if nuclear power plants had to sequentially shut down their operations.
Practical Issues Accompanying a Change in Policy #1

Handling of Spent Fuel When there are Difficulties with the Reprocessing Works

- Memorandum of Understanding among Aomori Prefecture, Rokkasho Village and Japan Nuclear Fuel Limited (July 29, 1998)

“In cases where it becomes markedly difficult to steadily implement the reprocessing works, Aomori Prefecture, Rokkasho Village and Japan Nuclear Fuel Limited will hold consultations and promptly implement all necessary and appropriate measures, including having Japan Nuclear Fuel Limited carry spent fuel away from the facilities.”
Practical Issues Accompanying a Change in Policy #2

Stoppage of nuclear power plants if spent fuel can no longer be transported because of a change in policy

<table>
<thead>
<tr>
<th>Electric Power Company</th>
<th>Power Plant</th>
<th>Installed Capacity (MW)</th>
<th>Year in which the volume of SF will exceed the on-site storage capacity when the transport of SF to Rokkasho becomes impossible and the SF that has already been transported to Rokkasho is returned.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hokkaido Electric Power Co.</td>
<td>Tomari (2 units)</td>
<td>1,158</td>
<td>2008</td>
</tr>
<tr>
<td>Tohoku Electric Power Co.</td>
<td>Onagawa (3 units)</td>
<td>2,174</td>
<td>2014</td>
</tr>
<tr>
<td>Tokyo Electric Power Co.</td>
<td>Fukushima Daiichi (6 units)</td>
<td>4,696</td>
<td>2011</td>
</tr>
<tr>
<td></td>
<td>Fukushima Daini (4 units)</td>
<td>4,400</td>
<td>2004</td>
</tr>
<tr>
<td></td>
<td>Kashiwazaki Kariwa (7 units)</td>
<td>8,212</td>
<td>2009</td>
</tr>
<tr>
<td>Chubu Electric Power Co.</td>
<td>Hamaoka (5 units)</td>
<td>4,997</td>
<td>2006</td>
</tr>
<tr>
<td>Hokuriku Electric Power Co.</td>
<td>Shika (1 unit)</td>
<td>540</td>
<td>2016</td>
</tr>
<tr>
<td>Kansai Electric Power Co.</td>
<td>Mihama (3 units)</td>
<td>1,666</td>
<td>2010</td>
</tr>
<tr>
<td></td>
<td>Takahama (4 units)</td>
<td>3,392</td>
<td>2004</td>
</tr>
<tr>
<td></td>
<td>Ohi (4 units)</td>
<td>4,710</td>
<td>2013</td>
</tr>
<tr>
<td>Chugoku Electric Power Co.</td>
<td>Shimane (2 units)</td>
<td>1,280</td>
<td>2012</td>
</tr>
<tr>
<td>Shikoku Electric Power Co.</td>
<td>Ikata (3 units)</td>
<td>2,022</td>
<td>2013</td>
</tr>
<tr>
<td>Kyushu Electric Power Co.</td>
<td>Genkai (4 units)</td>
<td>3,478</td>
<td>2009</td>
</tr>
<tr>
<td></td>
<td>Sendai (2 units)</td>
<td>1,780</td>
<td>2009</td>
</tr>
<tr>
<td>Japan Atomic Power Co.</td>
<td>Tsuruga* (2 units)</td>
<td>1,517</td>
<td>2014</td>
</tr>
<tr>
<td></td>
<td>Tokai Daini (1 unit)</td>
<td>1,100</td>
<td>2013</td>
</tr>
<tr>
<td>Total (53 units)</td>
<td>47,122</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Tsuruga Unit 1 is scheduled for shutdown in 2010.
Each country is making its own decision for reprocessing or direct disposal based on such factors as geopolitical conditions, resources, scale of nuclear power generation and cost competitiveness.

### Countries selecting direct disposal
- **Countries with small-scale nuclear power generation or which have adopted basic policies of withdrawing from nuclear power generation** including Finland, Sweden, Germany and Belgium.
- **Countries with abundant domestic energy resources** such as the US and Canada.

### Countries selecting reprocessing
- **Countries with large-scale nuclear power generation or which have adopted basic policies of continuing to utilize nuclear power generation** such as France, Russia and China.
- **Countries with scarce domestic energy resources**, etc.

* It should be noted that the United States, which had hitherto adopted a direct-disposal option, has announced the Global Nuclear Energy Partnership (GNEP) that aims to pursue both the expansion of nuclear-power use and the nuclear non-proliferation, and in February 2006 came forward with a policy to promote the development of advanced reprocessing technology that also would be more proliferation-resistant, thus changing that nation’s stance to one favorable to a nuclear-fuel cycle involving reprocessing.

Position of the Nuclear Fuel Cycle in the “Framework for Nuclear Energy Policy”

**<Basic Policy>**

“Efforts to advancing nuclear power generation in Japan should be based on comprehensive considerations not only of economic efficiency but also taking into account the pursuit of a cyclical society, stable energy supply, and securing the ability to respond to future uncertainty… The basic policy of Japan is to recycle spent nuclear fuel and effectively utilize the recovered plutonium and uranium.”

**<Main Reasons for the Selection of Reprocessing>**

- Compared with direct disposal, reprocessing is economically inferior under present uranium prices and technological knowledge, if we do not consider the costs of changing policy, but it is superior under such criteria as stable energy supply, environmental compatibility, and ability to respond to future uncertainty, and recognized as superior under the comprehensive evaluation.

- Social assets that have been built up over many years (technologies, relationships of trust with communities where nuclear power plants are located, the various international agreements secured so that Japan can engage in nuclear fuel reprocessing) have a great value which is worth maintaining.

- A policy change from reprocessing to direct disposal would be expected to lead to difficulties in carrying spent fuel away from nuclear power plants, the sequential closures of nuclear power plants, and continued lack of progress in the siting of interim storage facilities and permanent disposal locations.
### Recent Developments concerning the Nuclear Fuel Cycle

Following the Atomic Energy Commission’s reconfirmation of the nuclear-fuel-cycle promotion policy, steady progress has been made toward realizing the nuclear fuel cycle in Japan.

| **Rokkasho Reprocessing Plant** | At the reprocessing plant built in the village of Rokkasho in Aomori Prefecture, the final tests (active tests) are conducted under the same conditions as those of actual operation. The reprocessing plant is scheduled to **go into operation in 2007**. |
| **MOX Fuel Plant** | In April 2005, Aomori Prefecture and Rokkasho Village entered into a **basic siting agreement** with Japan Nuclear Fuel Limited. Regulatory authorities are now in the process of conducting the safety review required for a business license. Construction of the MOX fuel plant will begin by the end of 2007, and the plant will go into service by the end of 2012. |
| **Plutonium Utilization in LWRs** | **The Kyushu Electric Power Company’s plutonium utilization in LWRs was formally approved by Saga Prefecture and Genkai Town in March 2006. The Shikoku Electric Power Company’s plutonium utilization in LWRs was formally approved by Aichi Prefecture and Ikata Town in October 2006. The Chugoku Electric Power Company, with the understanding of the municipality involved, submitted an application to the government for a safety review of the nuclear reactor it had installed. J-Power and the Chubu Electric Power Company are making steady progress in plutonium utilization in LWRs.** |
| **Interim Storage Facility** | The Recyclable-Fuel Storage Company, established jointly by the Tokyo Electric Power Company and the Japan Atomic Power Company, is planning to build an interim storage facility in Mutsu City, Aomori Prefecture. **In October 2005, Aomori Prefecture and Mutsu City agreed on an interim facility construction plan. The interim storage facility is scheduled to go into service by the end of 2010.** |
| **Monju Reactor (prototype fast-breeder reactor)** | In February 2005, Fukui Prefecture and Tsuruga City consented to a plan to remodel the Monju reactor. In May of that same year, the Supreme Court handed down a ruling in favor of the national government. **The Monju reactor is scheduled to resume operation within two years after remodeling work on it is completed.** |
| **High-Level Radioactive-Waste Ultimate Disposal Facility** | Several applications have been submitted in response to an invitation for a site for an ultimate disposal facility. In response to these applications, The Nuclear Waste Management Organization of Japan (NUMO) is engaged in activities to gain the understanding of each region. |
| **Enactment of the Reprocessing Reserve Law** | In its ordinary session in 2005, the Diet passed a law and a taxation system designed to put approximately JPY 12.6 trillion in a reserve to cover expenses involved in the construction of the Rokkasho Reprocessing Plant and other facilities (the Liberal Democratic Party, the New Komeito Party, and the Democratic Party of Japan voted for the law). **The law became effective in October 2005.** |
Present Conditions at the Rokkasho Reprocessing Facility

Outline

- Construction began in April 1993
- Maximum processing capacity of 800 tons/year; spent fuel storage capacity of 3,000 tons
- Construction expenses total approximately ¥2.19 trillion (as of March 2005)

Present Conditions

- Construction progress: approx. 98% of total construction is completed (as of September 30, 2006).
- Already completed phased implementation of “water trials” and of chemical trials using a nitric acid solution.
- The local government and Japan Nuclear Fuel Ltd. have concluded a Safety Agreement concerning the uranium trials (using depleted uranium), which began from December 21st 2004 and finished in January 2006.
  The final tests (active tests) are conducted under the same conditions as those of actual operation.
The Reprocessing Plant at the Tokai Research and Development Center of Japan Atomic Energy Agency (JAEA) has operated for 25 years and reprocessed 1,123 tons of uranium (as of May 26, 2006). Overseas, there are a total of 19 facilities in 7 countries* with operating performance. Facilities have been operating in the UK for 41 years, France for 15 years, and Russia for 34 years.

* Counting existing facilities as new facilities when they are reconstructed.

### Main Reprocessing Facilities Worldwide

<table>
<thead>
<tr>
<th>Country</th>
<th>Facility</th>
<th>Reprocessing Capacity (type of fuel)</th>
<th>Operations Commenced</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>Reprocessing Plant &lt;br&gt;Tokai Research and Development Center &lt;br&gt;JAEA</td>
<td>120 tU/year (enriched uranium)</td>
<td>1981</td>
<td>- Has been running for about 25 years, ever since full-scale operations began in 1981. &lt;br&gt;- Has reprocessed a cumulative total of 1,123 tons of uranium (as of May 26, 2006)</td>
</tr>
<tr>
<td>UK</td>
<td>B205</td>
<td>1,500 tU/year (natural uranium)</td>
<td>1964</td>
<td>- Facility reprocesses spent fuel from gas-cooled reactors.</td>
</tr>
<tr>
<td></td>
<td>THORP</td>
<td>850 tU/year (enriched uranium)</td>
<td>1994</td>
<td>- Reprocesses spent fuel from Germany, Japan and other foreign customers</td>
</tr>
<tr>
<td>France</td>
<td>UP2-800</td>
<td>1,000 tU/year each (enriched uranium)</td>
<td>1994</td>
<td>- Increased capacity from the UP2-400, which began operating in 1976</td>
</tr>
<tr>
<td></td>
<td>UP3</td>
<td>(total capacity below 1,700tU/year)</td>
<td>1990</td>
<td></td>
</tr>
<tr>
<td>Russia</td>
<td>RT-1</td>
<td>400 tU/year (enriched uranium)</td>
<td>1971</td>
<td></td>
</tr>
</tbody>
</table>

Source: *Nuclear Power Pocket Book FY 2005* (Japan Atomic Industrial Forum Inc.), Japan Atomic Energy Agency websites, etc.
The plutonium utilization in LWRs uses uranium-plutonium mixed oxide (MOX) fuel, recovered through the reprocessing of spent nuclear fuel in operational nuclear power plants (light-water reactors).
The Position of the Plutonium Utilization in LWRs in Energy Policy

The Basic Plan on Energy (endorsed by the cabinet in October 2003)

- The plutonium utilization in LWRs will be advanced steadily as it forms the immediate core of a plan for reliable use of plutonium recovered through the reprocessing of spent fuel, an important prerequisite for the nuclear fuel cycle.
- In order to advance the plutonium utilization in LWRs, the national government will take the lead in activities for gaining the understanding of the general public.

The Framework for Nuclear Energy Policy (approved by the Cabinet in October 2005)

- In accordance with the basic policy of reprocessing spent fuel and effectively using recovered plutonium and uranium within the country, the plutonium utilization in LWRs should be consistently promoted for the time being.
- Thus, the government needs to expend further efforts, including proactive public hearings and publicity activities, for mutual understanding of the safety and significance of the projects with the general public and the communities in which the facilities are located.
Introduction of the Plutonium Utilization in LWRs

- The plutonium utilization in LWRs is expected to allow the saving of approximately 10–20 percent of uranium resources and, consequently, to further improve the advantages of nuclear power in terms of a stable supply.
- Electric power utilities are planning to carry out the plutonium utilization in LWRs using a total of 16–18 nuclear reactors; Kyushu Electric Power, Shikoku Electric Power, and Chubu Electric Power, among others, are making steady progress in implementing the plutonium utilization in LWRs.
- The national government is actively committed to initiatives, including holding symposiums in hosting areas, designed to gain the understanding and cooperation of citizens.

The Plutonium utilization in LWRs of Electric Power Utilities

* Tokyo Electric Power Company intends to carry out the plutonium utilization in LWRs at 3–4 reactors in its nuclear power plants, in line with a basic policy of regaining public trust in the hosting areas.
Kyushu Electric Power Company
The official safety review of the reactor was completed in September 2005, and the company's plutonium utilization in LWRs was formally approved by Saga Prefecture and Genkai Town in March 2006. The company intends to implement this project by the end of fiscal 2010.

Shikoku Electric Power Company
The official safety review of the reactor was completed in March 2006, and the company's plutonium utilization in LWRs was formally approved by Aichi Prefecture and Ikata Town in October 2006. The company intends to implement this project by the end of fiscal 2010.

J-Power (EPDC)
With the understanding of the municipalities involved, J-Power followed the process for finding a site for a new power plant. In March 2004, the company submitted an application to the government for a safety review of the reactor. The government’s safety review is now in progress.

Chugoku Electric Power Company
In October 2006, the Chugoku Electric Power Company, with the understanding of the municipality involved, submitted an application to the government for a safety review of the nuclear reactor it had installed. The government’s safety review is now in progress.

Chubu Electric Power Company
In March 2006, the Chubu Electric Power Company, with the understanding of the municipality involved, submitted an application to the government for a safety review of the nuclear reactor it had installed. The government’s safety review is now in progress.

<Reference> Recent Developments in the Plutonium Utilization in LWRs
Foreign countries commenced the plutonium utilization in LWRs in the 1960s, and subsequently MOX fuel was used on a commercial basis (MOX fuel has been introduced in a total of 57 reactors over the years).

In Japan, MOX fuel has been used in pilot demonstrations, and most frequently used in the *Fugen* reactor, a reactor similar to a light-water reactor.

Based on the past records both at home and abroad, and after experts completed a study, the Atomic Energy Commission of Japan issued a report on the safety of the plutonium utilization in LWRs, suggesting that the safe use of MOX fuel in current nuclear power plants (light-water reactors) can be secured.

* More than 770 MOX fuel assemblies (the largest amount of MOX fuel loaded per unit in the world) were used in the Fugen advanced thermal reactor in Tsuruga City, Fukui Prefecture, for a 24-year period (from 1979 to 2003).

### The Current Status and Records of the Plutonium Utilization in LWRs in Foreign Countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Past Records</th>
<th>Current Status (as of end of 2004)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of MOX fuel assemblies Loaded by 2004 (assemblies)</td>
<td>Operational LWRs (units)</td>
</tr>
<tr>
<td>France</td>
<td>2466</td>
<td>58</td>
</tr>
<tr>
<td>Germany</td>
<td>2012</td>
<td>17</td>
</tr>
<tr>
<td>Belgium</td>
<td>313</td>
<td>7</td>
</tr>
<tr>
<td>Switzerland</td>
<td>308</td>
<td>5</td>
</tr>
<tr>
<td>U.S.A.</td>
<td>95</td>
<td>103</td>
</tr>
<tr>
<td>Italy</td>
<td>70</td>
<td>0</td>
</tr>
<tr>
<td>India</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Japan</td>
<td>6</td>
<td>54</td>
</tr>
<tr>
<td>Sweden</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Totals</td>
<td>5290</td>
<td>257</td>
</tr>
</tbody>
</table>

### Demonstrations of the Integrity of MOX Fuel Conducted in Japan Using LWRs

<table>
<thead>
<tr>
<th>Year</th>
<th>Kansai Electric Power Mihama 1</th>
<th>Japan Atomic Power Company Tsuruga 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>Used</td>
<td>Post-radiation examinations</td>
</tr>
<tr>
<td>1986</td>
<td>Used</td>
<td></td>
</tr>
<tr>
<td>1987</td>
<td>Used</td>
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<td>1988</td>
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<td>1989</td>
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<td>1995</td>
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