World Population Projections

(Note) Figures may not add up to the totals due to rounding.

Source: UN “World Population Prospects, the 2012 Revision”
World Population and Energy Consumption

Population by Countries (2011)

World Total 6.96 billion

- China 19%
- India 18%
- Others 47%
- U.S.A. 5%
- Brazil 3%
- Russia 2%
- Japan 2%
- Germany 1%
- France 1%
- Canada 1%
- South Korea 1%
- Italy 1%
- U.K. 1%
- Others

Primary Energy Consumption by Countries (2011)

World Total 13.11 Btoe

- China 21%
- U.S.A. 17%
- India 6%
- Russia 6%
- Brazil 2%
- South Korea 2%
- U.K. 1%
- France 2%
- Canada 2%
- Germany 2%
- Italy 1%
- Others 35%

(Note) Figures may not add up to the totals due to rounding.
Btoe: billion tons of oil equivalent

Primary Energy Consumption per Capita

(tons of oil equivalent / person) (2011)

Canada 7.3
U.S.A. 7.0
South Korea 5.2
Russia 5.2
France 3.9
Germany 3.8
Japan 3.6
U.K. 3.0
Italy 2.8
China 2.0
Japan 1.9
U.K. 1.4
Brazil 1.4
India 0.6

World Average

Per Capita GDP and Primary Energy Consumption


(Note) Total domestic production based on purchasing power parity conversion (US dollars, 2005 prices)
Proven Reserves of Energy Resources

(Note) Reserves-to-production (R/P) ratio = Proven Reserves / Annual Production
RAR (reasonably assured resources) of Uranium is estimated at a production cost less than USD 130/kg/U.

- **Oil**
  - 1.669 trillion barrels
  - 53 years
  - (at the end of 2012)

- **Natural Gas**
  - 187 trillion cubic meters
  - 56 years
  - (at the end of 2012)

- **Coal**
  - 861 billion tons
  - 109 years
  - (at the end of 2012)

- **Uranium**
  - 5.33 million tons
  - 93 years
  - (Jan. 2011)

Source: ① BP Statistical Review of World Energy 2013  ② OECD, IAEA "Uranium 2011"
The World’s Primary Energy Consumption

<table>
<thead>
<tr>
<th>Year</th>
<th>Btoe</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1965</td>
<td>0.56</td>
<td>4.5%</td>
</tr>
<tr>
<td>1970</td>
<td>3.73</td>
<td>29.9%</td>
</tr>
<tr>
<td>1975</td>
<td>2.99</td>
<td>23.9%</td>
</tr>
<tr>
<td>1980</td>
<td>4.13</td>
<td>33.1%</td>
</tr>
<tr>
<td>1985</td>
<td>0.83</td>
<td>6.7%</td>
</tr>
<tr>
<td>1990</td>
<td>0.24</td>
<td>1.9%</td>
</tr>
<tr>
<td>2000</td>
<td>0.24</td>
<td>1.9%</td>
</tr>
<tr>
<td>2005</td>
<td>0.83</td>
<td>6.7%</td>
</tr>
<tr>
<td>2010</td>
<td>3.73</td>
<td>29.9%</td>
</tr>
<tr>
<td>2012</td>
<td>2.99</td>
<td>23.9%</td>
</tr>
<tr>
<td>2012 Total: 12.5 Btoe</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Note) Figures may not add up to the totals due to rounding. The figures in parentheses are share of total.

Btoe: billion tons of oil equivalent

Source: BP Statistical Review of World Energy 2013
## Primary Energy Consumption in Major Countries

### Total Primary Energy Consumption (Btoe)

<table>
<thead>
<tr>
<th>Country</th>
<th>Oil</th>
<th>Natural Gas</th>
<th>Coal</th>
<th>Nuclear</th>
<th>Hydroelectric</th>
<th>Renewable Energy</th>
<th>Total Btoe</th>
</tr>
</thead>
<tbody>
<tr>
<td>World Total</td>
<td>33</td>
<td>24</td>
<td>30</td>
<td>4</td>
<td>7</td>
<td>2</td>
<td>12.48</td>
</tr>
<tr>
<td>China</td>
<td>18</td>
<td>5</td>
<td>68</td>
<td>1</td>
<td>7</td>
<td>1</td>
<td>2.74</td>
</tr>
<tr>
<td>U.S.A.</td>
<td>37</td>
<td>30</td>
<td>20</td>
<td>8</td>
<td>3</td>
<td>2</td>
<td>2.21</td>
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<tr>
<td>Russia</td>
<td>21</td>
<td>54</td>
<td>14</td>
<td>6</td>
<td>5</td>
<td></td>
<td>0.69</td>
</tr>
<tr>
<td>India</td>
<td>30</td>
<td>9</td>
<td>53</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>0.56</td>
</tr>
<tr>
<td>Japan</td>
<td>46</td>
<td>22</td>
<td>26</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>0.48</td>
</tr>
<tr>
<td>Canada</td>
<td>32</td>
<td>28</td>
<td>7</td>
<td>7</td>
<td>26</td>
<td>1</td>
<td>0.33</td>
</tr>
<tr>
<td>Germany</td>
<td>36</td>
<td>22</td>
<td>25</td>
<td>7</td>
<td>2</td>
<td>8</td>
<td>0.31</td>
</tr>
<tr>
<td>Brazil</td>
<td>46</td>
<td>10</td>
<td>5</td>
<td>1</td>
<td>34</td>
<td>4</td>
<td>0.27</td>
</tr>
<tr>
<td>South Korea</td>
<td>40</td>
<td>17</td>
<td>30</td>
<td>13</td>
<td>4</td>
<td></td>
<td>0.27</td>
</tr>
<tr>
<td>France</td>
<td>33</td>
<td>16</td>
<td>5</td>
<td>39</td>
<td>5</td>
<td>2</td>
<td>0.25</td>
</tr>
<tr>
<td>U.K.</td>
<td>34</td>
<td>35</td>
<td>19</td>
<td>8</td>
<td>1</td>
<td>4</td>
<td>0.20</td>
</tr>
<tr>
<td>Italy</td>
<td>40</td>
<td>38</td>
<td>10</td>
<td>6</td>
<td>7</td>
<td></td>
<td>0.16</td>
</tr>
</tbody>
</table>

(Entries in the chart signify the percentage of total energy consumed in each category for the respective country.)

**Source:** BP Statistical Review of World Energy 2013

(Note) Figures may not add up to the totals due to rounding. Btoe: billion tons of oil equivalent
Electricity Generated by Major Countries (Rates of Growth)

Source: BP Statistical Review of World Energy 2013
Electricity Consumption per Capita in Major Countries

<table>
<thead>
<tr>
<th>Country</th>
<th>kWh/Capita/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Italy</td>
<td>2,933</td>
</tr>
<tr>
<td>U.S.A.</td>
<td>13,227</td>
</tr>
<tr>
<td>South Korea</td>
<td>10,162</td>
</tr>
<tr>
<td>Japan</td>
<td>7,847</td>
</tr>
<tr>
<td>France</td>
<td>7,318</td>
</tr>
<tr>
<td>Germany</td>
<td>7,083</td>
</tr>
<tr>
<td>Russia</td>
<td>6,533</td>
</tr>
<tr>
<td>U.K.</td>
<td>5,518</td>
</tr>
<tr>
<td>Italy</td>
<td>5,393</td>
</tr>
<tr>
<td>China</td>
<td>3,298</td>
</tr>
<tr>
<td>World Average</td>
<td>2,933</td>
</tr>
<tr>
<td>Brazil</td>
<td>2,441</td>
</tr>
<tr>
<td>India</td>
<td>673</td>
</tr>
</tbody>
</table>

Electricity Consumption by Countries

- **World Total**: 20,400TWh
- **China**: 22%
- **U.S.A.**: 20%
- **Japan**: 5%
- **Russia**: 5%
- **India**: 4%
- **Germany**: 3%
- **Brazil**: 2%
- **France**: 2%
- **South Korea**: 3%
- **Canada**: 3%
- **Italy**: 2%
- **U.K.**: 2%

(2011)

(Note) Figures may not add up to the totals due to rounding.

Source: IEA “KEY WORLD ENERGY STATISTICS 2013”
Dependence on Imported Energy Sources in Major Countries

(Note) Canada and Russia are net-exporting countries.

Changes of Japan’s Primary Energy Supply Structure

**Total Primary Energy Supply**

- **FY2011**: 21,960 PJ
- **FY1973 (The first oil crisis)**: 16,133 PJ
- **FY1979 (The second oil crisis)**: 17,210 PJ

**Domestic Energy Ratio**

- FY2011: 12%
- FY1979: 13%
- FY1973: 11%

(Note) Figures may not add up to the totals due to rounding.

1PJ (=10^15 Joules) is equivalent to approx. 25,800 kiloliters of crude oil in calorie. Nuclear energy is classified into semi-domestic energy due to its characteristic.

Source: Agency for Natural Resources and Energy “FY2011 Energy Supply & Demand Performance” etc.
Historical Trend of Japan’s Primary Energy Supply

(Note) 1PJ (=10^15 Joules) is equivalent to approx. 25,800 kiloliters of crude oil in calorie.

Source: Agency for Natural Resources and Energy “FY2011 Energy Supply & Demand Performance” etc.
Japan’s Fossil Fuel Imports by Country of Origin

**Crude Oil**

- Saudi Arabia: 30.4%
- United Arab Emirates: 22.1%
- Qatar: 11.4%
- Indonesia: 6.6%
- Others: 7.3%

**Coal**

- Australia: 61.9%
- Indonesia: 20%
- Others: 1.3%
- Canada: 5.3%

**Natural Gas**

- Qatar: 17.6%
- Malaysia: 16.4%
- Russia: 9.6%
- Brunei: 6.8%
- Others: 7.3%

FY 2012 result

*Note* Figures may not add up to the totals due to rounding.

Source: 1 Petroleum Association of Japan  2 Trade Statistics of Japan
Japan’s Dependence on Middle East Crude Oil of Total Imports

The first oil crisis

The second oil crisis

Source: Petroleum Association of Japan
Historical Trend of Power Generation Volume by Source in Japan

(Note) Oil etc. includes LPG and other gases.
Figures may not add up to the totals due to rounding.
Total of 10 electric power companies and power purchased.
Figures within the graph represent the composition ratio.

Source: The Federation of Electric Power Companies
Historical Trend of Generation Capacity by Source in Japan

(Note) Figures may not add up to the totals due to rounding.
※The shares of Geothermal & Renewables are less than 1%.
Percentage of Electric Power in Primary Energy (Electrification Ratio)

Supply of Primary Energy in Japan

<table>
<thead>
<tr>
<th>Year</th>
<th>Supply of Primary Energy (PJ)</th>
<th>Percentage of Electric Power in Primary Energy Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>13,383</td>
<td>26%</td>
</tr>
<tr>
<td>1975</td>
<td>15,330</td>
<td>29%</td>
</tr>
<tr>
<td>1980</td>
<td>16,627</td>
<td>33%</td>
</tr>
<tr>
<td>1985</td>
<td>16,967</td>
<td>37%</td>
</tr>
<tr>
<td>1990</td>
<td>19,657</td>
<td>40%</td>
</tr>
<tr>
<td>1995</td>
<td>22,001</td>
<td>41%</td>
</tr>
<tr>
<td>2000</td>
<td>22,761</td>
<td>41%</td>
</tr>
<tr>
<td>2005</td>
<td>22,757</td>
<td>42%</td>
</tr>
<tr>
<td>2006</td>
<td>22,881</td>
<td>42%</td>
</tr>
<tr>
<td>2007</td>
<td>23,022</td>
<td>43%</td>
</tr>
<tr>
<td>2008</td>
<td>21,853</td>
<td>43%</td>
</tr>
<tr>
<td>2009</td>
<td>20,885</td>
<td>43%</td>
</tr>
<tr>
<td>2010</td>
<td>22,066</td>
<td>44%</td>
</tr>
<tr>
<td>2011</td>
<td>21,147</td>
<td>43%</td>
</tr>
</tbody>
</table>

(Note) 1PJ (=10¹⁵ Joules) is equivalent to approx. 25,800 kiloliters of crude oil in calorie.

Source: Agency for Natural Resources and Energy “General Energy Statistics”
Hourly Power Usage on Peak Power Days

Source: The Federation of Electric Power Companies

(Note) The value for 1975 uses only 9 power companies.
Optimal Combination of Power Sources to Correspond to Demands (Example)

Load Curve

Peak Demand

Electricity for Pumped-storage Hydroelectric

Inflow type Hydroelectric

Thermal

Nuclear

Hydroelectric

Pumped-storage Type
Reservoir Type
Regulating Pondage Type
(Note) The values are the average for 9 power companies.

Source: The Federation of Electric Power Companies
Mechanism of Greenhouse Effect

In spite of high light transmissivity, greenhouse gases such as CO₂ absorb infrared rays (heat) and then reflect some of the radiation to the earth’s surface (re-radiation mechanism).

Further increase in greenhouse gas causes...
Contribution of Greenhouse Gases to Global Warming

Direct contribution to global warming of GHGs emitted by Japan (for the single year of fiscal 2011)

- Dinitrogen monoxide (N$_2$O): 1.7%
- Ozon-unfriendly Chlorofluorocarbon: 14%
- Ozon-friendly Chlorofluorocarbon etc. below 0.5%
- Methane: 1.6%
- Chlorofluorocarbon and other gases: 1.9%

Total emissions in FY2011: 1.31 billion t-CO$_2$

Carbon dioxide (CO$_2$): 60%

Direct contribution to global warming of GHGs emitted by human activities after the Industrial Revolution

- Methane: 20%
- Dinitrogen monoxide (N$_2$O): 6%
- Carbon dioxide (CO$_2$): 94.9%

(Note) Figures may not add up to the totals due to rounding.

GHGs: Greenhouse Gases

Source: Ministry of the Environment "White Paper on the Environment, the Sound Material-Cycle Society and the Biodiversity 2013" etc.
Changes in CO₂ Emissions from Fossil Fuels and Atmospheric CO₂ Concentration in Japan

CO₂ concentration (ppm)

Global CO₂ emissions

Industrial Revolution

World War II

Others (cement production + exhaust gas from incineration)
Natural Gas
Oil
Coal, wood, etc.

Source: CDIAC “Global Fossil-Fuel Carbon Emissions” etc.

(Note) Figures may not add up to the totals due to rounding.
Historical Trends in World’s CO₂ Emissions

Until 1990, Russia’s CO₂ emissions are included in "Other countries".

(Note) Figures may not add up to the totals due to rounding.

Kyoto Protocol Targets and Current Status of GHG Emissions

(Note) The United States has ratified the Kyoto Protocol, and Canada withdrew in December 2012.
CO₂ emissions intensity is calculated from all energy consumed in mining, plant construction, fuel transports, refining, plant operations and maintenance, etc. as well as burning of fuel.

Date for nuclear power: 1) includes spent fuel reprocessing in Japan (under development), MOX fuel use in thermal reactors (assuming recycling once) and disposal of high level radioactive waste, and 2) is based on the capacity-weighted average of CO₂ emissions intensities of existing BWR and PWR plants in Japan, which are 19g- CO₂/kWh and 21g- CO₂/kWh respectively.

Source: Central Research Institute of Electric Power Industry “Evaluation of Life Cycle CO₂ Emissions of Power Genevations technologies (July 2010)”
Japan’s Changes in CO₂ Emissions by Sector

Source: National Institute for Environmental Studies “Greenhouse gas emission (fixed annual) in FY2011”

(Note) The numerical values show the indirect emissions (CO₂ emissions associated with power generation or heat generation are allocated to individual end demand sectors according to the electricity and heat consumption.)
Changes in GHGs Emissions in Japan

1,400
1,200
1,000
800
0

(million t-CO₂)


(FY)

Baseline year for Kyoto Protocol

Source: Greenhouse gas Inventory office of Japan

Emissions of SF₆, PFCs and HFCs in 1995 add to the total emissions in 1990.
Increase/Decrease in CO₂ Emissions by Sector in Japan

(Note) The numerical values show the increase and decrease of the indirect emissions (CO₂ emissions associated with power generation or heat generation are allocated to individual end demand sectors according to the electricity and heat consumption.)

Source: National Institute for Environmental Studies “Greenhouse gas emission (fixed annual) in FY2011”
Changes in CO₂ Emissions by Energy Source

Total CO₂ emissions from energy sources in FY2011: 1.17 billion t-CO₂

Oil (44%) 3.1 1.0 6.5 6.6 6.8 6.7 6.4 6.4 6.2 6.0 5.6 5.2 4.8 5.1
Coal (35%) 3.0 1.1 6.6 3.2 3.4 3.4 3.8 4.1 4.3 4.4 4.2 4.3 4.1
Natural Gas (21%) 1.2 1.3 1.4 1.6 1.6 1.7 1.9 2.0 2.1 2.5

(Note) Figures may not add up to the totals due to rounding.

Source: Greenhouse Gas Inventory Office of Japan “National GHGs Inventory Report of JAPAN”
Measures by Japan’s Electric Power Industry to Reduce CO₂ Emissions

**Efforts in domestic business activities**

- Expanding the use of non-fossil energy sources
  - Using nuclear power with safety as a major premise
  - Using renewable energies
    - Using hydropower, geothermal, solar and wind power, and biomass
    - Studies for dealing with the output fluctuation of renewable energies and for expanding their introduction

- Improving the efficiency of power facilities
  - Improving the efficiency of thermal power
    - In developing thermal power, adopting the highest level of technology suitable for the size of the plant
    - Appropriately maintaining and controlling the thermal efficiency of existing plants

**Promoting international contributions**

- International efforts
  - Assisting developing countries to reduce carbon through international partnership (GSEP) activities
    - Transfer and granting of Japanese electricity technology through coal thermal facility diagnosis and CO₂ emissions reduction activities
  - Reducing carbon in all parts of society through international efforts
    - Developing and introducing advanced and feasible technology through international efforts such as the "International Electricity Partnership"

**Strongen the collaboration between the supply and demand sides including customers**

- Energy conservation
  - Promoting high-efficiency electrical devices to enhance the efficient use of electricity
    - Heat pumps (EcoCute, etc.), TES air-conditioning systems
  - PR activities and providing information on energy-saving and CO₂ reduction
    - Environmental housekeeping books, exhibitions on energy appliances, seminars on energy saving
  - Introducing smart meters for the efficient use of electricity

- Efforts by electric utility industry as users
  - Efforts in office-use energy conservation and the use of company-owned vehicles
    - Reduction of amount of power consumption
    - Introduction of electric vehicles and fuel-efficient vehicles

**Developing innovative technologies**

- Research and development
  - Supply-side
    - Clean coal technology, CCS, next-generation power transmission and distribution technology
  - Customer-side
    - Ultra-high efficiency heat pump, EV-related technologies

Historical Trends in CO₂ Emissions from Electricity Production in Japan

(Note) The marker (○△) indicates user-end CO₂ emissions intensity after the Kyoto Mechanism credit was reflected and CO₂ emissions after adjustment. The electric utility industry targets approximately 20% reduction (approx. 0.34kg-CO₂/kWh reduction) for the average of 5 years between fiscal 2008 and fiscal 2012, compared to 1990.
Gross thermal efficiency (maximum designed value)

Gross thermal efficiency (actual average)

(Nota) Lower Heating Value: Estimated from higher heating value standard based on the conversion factor of the comprehensive energy statistics (FY2010).

Source: Agency for Natural Resources and Energy “Japan Electric Utilities Handbook” etc.
Comparison of CO$_2$ Emissions Intensity by Country

<table>
<thead>
<tr>
<th>Country</th>
<th>CO$_2$ emissions intensity (kg-CO$_2$/kWh)</th>
<th>Breakdown of Non-fossil-fuel Generation ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>0.07</td>
<td>76 (Nuclear), 15 (Hydroelectric)</td>
</tr>
<tr>
<td>Canada</td>
<td>0.17</td>
<td>15 (Nuclear), 13 (Hydroelectric)</td>
</tr>
<tr>
<td>Italy</td>
<td>0.41</td>
<td>19 (Nuclear), 8 (Hydroelectric)</td>
</tr>
<tr>
<td>U.K.</td>
<td>0.44</td>
<td>19 (Nuclear), 5 (Hydroelectric)</td>
</tr>
<tr>
<td>Japan</td>
<td>0.47</td>
<td>18 (Nuclear), 3 (Hydroelectric)</td>
</tr>
<tr>
<td>Germany</td>
<td>0.47</td>
<td>19 (Nuclear), 7 (Hydroelectric)</td>
</tr>
<tr>
<td>U.S.A.</td>
<td>0.51</td>
<td>15 (Nuclear), 2 (Hydroelectric)</td>
</tr>
<tr>
<td>China</td>
<td>0.77</td>
<td>12 (Nuclear), 3 (Hydroelectric)</td>
</tr>
<tr>
<td>India</td>
<td>0.88</td>
<td>5 (Renewables)</td>
</tr>
</tbody>
</table>

(Note) Fiscal 2010 figures. The figures contains Combined Heat and Power (CHP) plants. The figures of Japan contains non-utility generation facilities.

SOx and NOx Emissions per Unit of Electricity Generated in Major Countries

**Graph:**

- **SOx:** Sulfur oxides
- **NOx:** Nitrogen oxides

**Thermal Power Plant**

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>SOx (g/kWh)</th>
<th>NOx (g/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.A.</td>
<td>2005</td>
<td>3.3</td>
<td>1.2</td>
</tr>
<tr>
<td>Canada</td>
<td>2005</td>
<td>3.4</td>
<td>1.6</td>
</tr>
<tr>
<td>U.K.</td>
<td>2005</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>France</td>
<td>2005</td>
<td>3.1</td>
<td>3.2</td>
</tr>
<tr>
<td>Germany</td>
<td>2005</td>
<td>0.7</td>
<td>0.8</td>
</tr>
<tr>
<td>Italy</td>
<td>2005</td>
<td>0.8</td>
<td>0.6</td>
</tr>
<tr>
<td>Japan</td>
<td>2011</td>
<td>0.2</td>
<td>0.2</td>
</tr>
</tbody>
</table>

*10 electric power companies and Electric Power Development Co. Ltd.

What is New Energy?

"New Energy" is defined under Japanese law as "something that although it has reached the stage of being capable of implementation on a technical level, has not been deployed fully due to economic restraints, and has specific requirements in order to introduce it as an energy to replace oil," and 10 types have been specified, such as solar and wind power generation, bio-mass, etc. Most of the new energies result in purely domestic energy products, and the promoting the development of such technologies offers enormous value to resource-poor Japan.

Renewable Energy

New Energy

Power Generation Field

- Photovoltaic power generation
- Wind power generation
- Biomass power generation
- Small & medium-scale hydroelectric power generation (1,000kW or less)
- Geothermal heat (Binary power generation only)

Thermal Field

- Utilization of solar thermal
- Use of the heat from temperature differentials
- Biomass heat use
- Use of snow and ice

Biomass fuel fabrication

Large-scale hydroelectric / Ocean thermal power generation

*Act on Special Measures for the Promotion of New Energy Use, abbreviated as New Energy Act

Source: Agency for Natural Resources and Energy
### Evaluation & Problems of New Energy

#### Photovoltaic Power
- Merits:
  - No fear of exhaustion
  - Emit no CO₂ or other gases in the process of power generation
  - Due to neighboring the demand area, there is no transmission loss
  - Generate at daytime when the demand rises
- Demerits:
  - Due to low energy density, it needs much larger area than thermal and nuclear power generation for the same amount of power generation
  - Unstable due to no generation at night and low power output in rainy or cloudy days
  - High costs on facilities

#### Wind Power
- Merits:
  - No fear of exhaustion
  - Emit no CO₂ or other gases in the process of power generation
  - Due to low energy density, it needs much larger area than thermal and nuclear power generation for the same amount of power generation
- Demerits:
  - Unstable due to occasional and seasonal volatility in wind directions and speed
  - Makes noises when windmills rotate
  - Locations where the wind situation is good are unevenly distributed
  - High costs on facilities

#### Waste Power (Biomass Power)
- Merits:
  - No additional CO₂ emission by power generation
  - Continuously supplied stable power source among new energies
- Demerits:
  - Low generation efficiency
  - Needs further environmental loads reduction measures such as dioxin emission control measures and ash reduction

<table>
<thead>
<tr>
<th>Necessary Site Area</th>
<th>to substitute for a 1,000MW-class nuclear power plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photovoltaic Power</td>
<td>approx. 58 km², almost as same as the area inside the Yamanote Line (Tokyo Loop Line)</td>
</tr>
<tr>
<td>Waste Power</td>
<td>approx. 214 km², approx. 3.4 times larger than the area inside the Yamanote Line</td>
</tr>
</tbody>
</table>

| Load Factor | 12% | 20% |

---

1. Energy density is the figure which shows the amount of generation in area.
2. Figures from the Study Group on Low Carbon Power Supply System (July 2008)
Solar Power Generation Capacity in Japan and the World

Actual Data in Japan

At the end of 2012
89.21 GW in World Total

Belgium 3%
Others 4%
Germany 36%
Japan 7%
Spain 5%
France 5%
U.S.A. 8%
China 8%
Italy 18%

Source: IEA “TRENDS 2013 IN PHOTOVOLTAIC APPLICATIONS”/Agency for Natural Resources and Energy

(Note) Figures may not add up to the totals due to rounding.
Wind Power Generation Capacity in Japan and the World

Actual Data in Japan

(MW)

3,000
2,500
2,000
1,500
1,000
500
0

1900 95 2000 01 02 03 04 05 06 07 08 09 10 11 12 (year)

1 10 144 313 464 681 925 1,085 1,490 1,674 1,882 2,186 2,442 2,556 2,642

At the end of 2012 282.75 GW in World Total

China 27%
U.S.A. 21%
Germany 11%
Spain 8%
India 6%
U.K. 3%
Italy 3%
France 3%
Others 10%
Japan 1%
Sweden 1%
Denmark 2%
Portugal 2%
Canada 2%

(Note) Figures may not add up to the totals due to rounding.

Sources: WWEA “World Wind Energy Report 2012”; NEDO
Mechanism of Heat Pump System Utilizing CO₂ Refrigerant

## Mega Solar Power Generation Plant Projects in Japan

(as of August, 2012)

Mega Solar Power Generation Plant Projects in Japan, as of August 2012, are shown in the table below. The projects are distributed across various regions in Japan, including Hokkaido, Tohoku, Tokyo, Chubu, Kansai, Chugoku, Shikoku, Kyushu, and Okinawa. The table provides details such as the company name, site numbers, total capacity, operating capacity, commissioning date, location, and prefecture.

### Table: Mega Solar Power Generation Plant Projects

<table>
<thead>
<tr>
<th>Company (EPCO)</th>
<th>Site</th>
<th>Total Capacity (MW)</th>
<th>Operating Capacity (MW)</th>
<th>Commissioning</th>
<th>Location</th>
<th>Prefecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hokkaido</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>Jun.2011</td>
<td>Date Solar Power Plant</td>
<td>Hokkaido</td>
</tr>
<tr>
<td>Tohoku</td>
<td>3</td>
<td>1.5</td>
<td>1.5</td>
<td>Dec.2011</td>
<td>Hachinohe Solar Power Plant</td>
<td>Aomori</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>2</td>
<td>May.2012</td>
<td>Sendai Solar Power Plant</td>
<td>Miyagi</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>Jan.2015</td>
<td>Haramachi Thermal Power Station site</td>
<td>Fukushima</td>
</tr>
<tr>
<td>Tokyo</td>
<td>3</td>
<td>7</td>
<td>7</td>
<td>Aug.2011</td>
<td>Ukishima Solar Power Plant</td>
<td>Kanagawa</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>10</td>
<td>Jan.2012</td>
<td>Yonekuriyama Solar Power Plant</td>
<td>Yamanashi</td>
</tr>
<tr>
<td>Chubu</td>
<td>3</td>
<td>7.5</td>
<td>7.5</td>
<td>Oct.2011</td>
<td>Mega Solar Taketoyo</td>
<td>Aichi</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>Jan.2011</td>
<td>Mega Solar Iida</td>
<td>Nagano</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>8</td>
<td>Feb.2015</td>
<td>Mega Solar Shimizu</td>
<td>Shizuoka</td>
</tr>
<tr>
<td>Kansai</td>
<td>4</td>
<td>10</td>
<td>10</td>
<td>Set.2011††††</td>
<td>Sakai Solar Power Plant</td>
<td>Osaka</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18</td>
<td></td>
<td>unsetted</td>
<td>Sharp Corp. property etc. in Sakai City</td>
<td>Osaka</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.5</td>
<td></td>
<td>FY2013</td>
<td>Kansai EPCO property in Ooi Town</td>
<td>Fukui</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.5</td>
<td></td>
<td>FY2014</td>
<td>Kansai EPCO property in Takahama Town</td>
<td>Fukui</td>
</tr>
<tr>
<td>Chugoku</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>Dec.2011</td>
<td>Fukuyama Solar Power Plant</td>
<td>Hiroshima</td>
</tr>
<tr>
<td>Shikoku</td>
<td>1</td>
<td>4.5†</td>
<td>2</td>
<td>Dec.2010</td>
<td>Matsuyama Solar Power Plant</td>
<td>Ehime</td>
</tr>
<tr>
<td>Kyushu</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>Nov.2010</td>
<td>Omutsa Mega Solar Power Plant</td>
<td>Fukuoka</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13††††</td>
<td></td>
<td>FY2012-2013</td>
<td>Kyushu EPCO property in Omutsa City</td>
<td>Nagasaki</td>
</tr>
<tr>
<td>Okinawa</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>Oct.2010</td>
<td>Miyako Island Mega Solar Demonstration Research Facility</td>
<td>Okinawa</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>Mar.2012</td>
<td>Abe Mega Solar Demonstration Research Facility</td>
<td>Okinawa</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>25</td>
<td>116.3</td>
<td>68</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Notes

1. Start of partial operation in October 2010.
2. Full operation (4.3MW total) will be scheduled by FY2020.
3. Operation (3MW) will be scheduled by FY2012, and Operation (10MW) will be scheduled by FY2013.
Basic Concept of Smart-Grid in Japan

Concentrated Power Supply
(Nuclear Power/Thermal Power/Hydroelectric Power)

Electricity/Information

Power Transmission and Distribution Network
(Electric Power System)

Distributed Power Supply
(Solar Power, Wind Power, Cogeneration etc.)

Consumer

Electricity/Information

- Accumulating and analyzing solar power output data
- Developing forecasting system of solar power output
- Developing high efficiency storage battery system that sustains frequent battery charge and discharge control
- Developing supply and demand control system combining thermal power generation, etc. with storage battery

Smart-Grid in Japan

Source: The Federation of Electric Power Companies "Environmental Action Plan by the Japanese Electric Utility Industry"
Outline of Feed-in Tariff Scheme for Renewable Energies

Supply Side
- generators which generate electricity by renewable energies
  - solar (photovoltaic)
  - middle- & small-sized hydro
  - wind
  - biomass
  - geothermal

In-house power generation

Electric power companies
- to sell electricity generated from energy Sources
- to purchase the electricity at fixed prices during the certain periods set by the Act
- to grant purchasing costs
- to pay the collected surcharges

an organization for the cost adjustment
- (which will collect & allocate surcharges)

Government
- Minister of METI
  - Advice on purchase prices/terms
- Procurement Price Committee
  - Advice on purchase prices/terms

Demand Side
- to supply electricity
- to collect surcharges in addition to normal electricity bills
- to set a unit cost per kWh of surcharge (annually)

 ※The sunlight below 10 kW is surplus acquisition.

Source: Agency for Natural Resources and Energy etc.
Comparison of Various Fuels Required to Operate a 1GW Power Plant per Year

- Enriched Uranium: 21 tons
- Natural Gas: 0.95 million tons
- Oil: 1.55 million tons
- Coal: 2.35 million tons

Source: Agency for Natural Resources and Energy "NUCLEAR ENERGY 2010"
### Proven Reserves of Uranium

- **Australia**: 31%
- **Niger**: 8%
- **Brazil**: 5%
- **Namibia**: 5%
- **South Africa**: 5%
- **Russia**: 9%
- **Canada**: 9%
- **Kazakhstan**: 12%
- **Russia**: 9%
- **Canada**: 9%
- **Spain**: 5%
- **Namibia**: 5%
- **South Africa**: 5%
- **Niger**: 8%
- **Jordan**: 1%
- **Others**: 2%
- **U.S.A.**: 4%
- **Ukraine**: 2%
- **Uzbekistan**: 2%
- **Mongolia**: 1%
- **Tanzania**: 1%

(proven reserves as of Jan. 2011)

### Japan's Procurement of Uranium

<table>
<thead>
<tr>
<th>Contract type of Import</th>
<th>Supply countries</th>
<th>Contract quantity (in U₃O₈ short ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long and short term contracts, and purchase of products</td>
<td>Canada, U.K., South Africa, Australia, France, U.S.A. and others</td>
<td>Approx. 379,800</td>
</tr>
<tr>
<td>Development and import scheme</td>
<td>Niger, Canada, Kazakhstan and others</td>
<td>Approx. 82,100</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>Approx. 461,900</td>
</tr>
</tbody>
</table>

**Notes**:
- Figures may not add up to the totals due to rounding.
- 1 short ton = approx. 0.907 metric ton

Source: Japan Oil, Gas and Metal National Corporation “Uranium 2011 resources, production, demand” / The Denki Shimbun “Nuclear Pocket Book FY2013”
Nuclear Power Plants in Japan

The Tokyo Electric Power Co.- Kashiwazaki Kariwa
Hokuriku Electric Power Co.- Shika
The Japan Atomic Power Co.- Tsuruga
The Kansai Electric Power Co.- Mihama
The Kansai Electric Power Co.- Ohi
The Kansai Electric Power Co.- Takahama
The Chugoku Electric Power Co.- Shimane
The Chugoku Electric Power Co.- Kaminoseki
Kyushu Electric Power Co.- Genkai

Kyushu Electric Power Co.- Sendai
Tohoku Electric Power Co.- Higashidori
Hokkaido Electric Power Co.- Tomari

Operating
Under Construction
Preparing for Construction

Output Scale
<500MW <1,000MW Over 1,000MW

Operating 48 Total Output (MW) 4,426.4
Under Construction 3 414.1
Preparing for Construction 6 1,158.2
Total 59 5,998.7

Chubu Electric Power Company abolished the unit 1 and 2 of Hamaoka Nuclear Power Station on January 30, 2009 and is currently decommissioning them.
The Japan Atomic Power Company abolished Tokai Power Station on March 31, 1998 and is currently decommissioning it.

Source: Japan Nuclear Energy Safety Organization "Operational Status of Nuclear Facilities in Japan (2013)" etc.
Generating Capacity of Nuclear Power Plants in Major Countries

(as for Jan. 2013)

<table>
<thead>
<tr>
<th>Country</th>
<th>Generating Capacity (MW)</th>
<th>Under Construction &amp; Planning</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.A.</td>
<td>10,658.2(104)</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>6,588.0(58)</td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>1,572.3(11)</td>
<td>163.0 (1)</td>
</tr>
<tr>
<td>Russia</td>
<td>2,841.0(28)</td>
<td>2,519.4(29)</td>
</tr>
<tr>
<td>South Korea</td>
<td>1,220.0(9)</td>
<td>2,071.6(23)</td>
</tr>
<tr>
<td>Canada</td>
<td>1,424.0 (19)</td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>1,269.6 (9)</td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>6,082.4(55)</td>
<td>1,259.8(15)</td>
</tr>
<tr>
<td>U.K.</td>
<td>326.0 (2)</td>
<td>1,092.7 (16)</td>
</tr>
<tr>
<td>India</td>
<td>478.0(20)</td>
<td>1,060.0 (11)</td>
</tr>
<tr>
<td>Brazil</td>
<td>199.2(2)</td>
<td>140.5 (1)</td>
</tr>
</tbody>
</table>

World Total

- In Operation: 386,350MW (427)
- Under Construction & Planning: 184,922MW (169)

### Power Generation Composition by Source in Major Countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Coal</th>
<th>Oil</th>
<th>Natural Gas</th>
<th>Nuclear</th>
<th>Hydroelectric</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>World Total</strong></td>
<td>41.3</td>
<td>4.8</td>
<td>21.9</td>
<td>11.7</td>
<td>15.8</td>
<td>4.5</td>
</tr>
<tr>
<td><strong>China</strong></td>
<td>78.9</td>
<td>0.2</td>
<td>0.9</td>
<td>20.1</td>
<td>14.7</td>
<td>2.4</td>
</tr>
<tr>
<td><strong>U.S.A.</strong></td>
<td>43.4</td>
<td>0.9</td>
<td>24.2</td>
<td>19.0</td>
<td>7.4</td>
<td>5.2</td>
</tr>
<tr>
<td><strong>Russia</strong></td>
<td>15.6</td>
<td>2.6</td>
<td>49.3</td>
<td>16.4</td>
<td>15.8</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>India</strong></td>
<td>67.9</td>
<td>1.2</td>
<td>10.3</td>
<td>3.2</td>
<td>12.4</td>
<td>5.0</td>
</tr>
<tr>
<td><strong>Japan</strong></td>
<td>27.0</td>
<td>14.7</td>
<td>35.9</td>
<td>9.8</td>
<td>8.0</td>
<td>4.7</td>
</tr>
<tr>
<td><strong>Canada</strong></td>
<td>12.0</td>
<td>1.0</td>
<td>9.8</td>
<td>59.0</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td><strong>Germany</strong></td>
<td>45.1</td>
<td>0.6</td>
<td>13.9</td>
<td>17.9</td>
<td>2.9</td>
<td>19.1</td>
</tr>
<tr>
<td><strong>France</strong></td>
<td>3.1</td>
<td>4.8</td>
<td>79.4</td>
<td>8.1</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td><strong>Brazil</strong></td>
<td>2.3</td>
<td>2.8</td>
<td>4.7</td>
<td>80.6</td>
<td>6.7</td>
<td></td>
</tr>
<tr>
<td><strong>South Korea</strong></td>
<td>43.2</td>
<td>3.2</td>
<td>22.3</td>
<td>29.8</td>
<td>0.9</td>
<td>0.7</td>
</tr>
<tr>
<td><strong>U.K.</strong></td>
<td>30.0</td>
<td>1.0</td>
<td>40.2</td>
<td>18.9</td>
<td>1.6</td>
<td>8.3</td>
</tr>
<tr>
<td><strong>Italy</strong></td>
<td>16.7</td>
<td>6.6</td>
<td>48.1</td>
<td>15.2</td>
<td>13.4</td>
<td></td>
</tr>
</tbody>
</table>

(Note) Figures may not add up to the totals due to rounding.

Electricity Generated and Share of Nuclear Power in Major Countries

### Generated Electricity by Countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Generated Electricity (TWh)</th>
<th>Share of Nuclear Power (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>4,754.7 (1.8%)</td>
<td></td>
</tr>
<tr>
<td>U.S.A.</td>
<td>4,326.6 (19.0%)</td>
<td></td>
</tr>
<tr>
<td>Russia</td>
<td>1,053.0 (16.4%)</td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>1,052.3 (3.2%)</td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>1,042.7 (9.8%)</td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>636.9 (14.7%)</td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>602.4 (17.9%)</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>556.9 (7.9%)</td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td>531.8 (2.9%)</td>
<td></td>
</tr>
<tr>
<td>South Korea</td>
<td>520.1 (29.8%)</td>
<td></td>
</tr>
<tr>
<td>U.K.</td>
<td>364.9 (18.9%)</td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>300.7 (0.0%)</td>
<td></td>
</tr>
</tbody>
</table>

(Note) Figures may not add up to the totals due to rounding.

New Regulatory Requirements for Nuclear Power Plants

Previous Regulatory Requirements:
- Design basis to prevent severe accidents (Confirm that a single failure would not lead to core damage)
- Consideration of natural phenomena
  - Fire Protection
  - Reliability of power supply
  - Function of other SSCs*
- Seismic/tsunami resistance

New Regulatory Requirements:
- Response to international aircraft crashes
- Measures to suppress radioactive materials dispersion
- Measures to prevent containment vessel failure
- Measures to prevent core damage (Postulate multiple failures)
- Consideration of internal flooding (newly introduced)
- Consideration of natural phenomena in addition to earthquakes and tsunamis-volcanic eruptions, tornadoes and forest fires
- Fire Protection
- Reliability of power supply
- Function of other SSCs
- Seismic/tsunami resistance

*SSC: Structure, Systems and Components

Source: Nuclear Regulation Authority
Periodic Safety Review of Nuclear Power Plant and Measures for Aging Management

- Periodic Operator's Inspection (every 13 months)
- Periodic Operator's Inspection (every 13 months)
- Periodic Operator's Inspection (every 13 months)
- Periodic Operator's Inspection (every 13 months)

Periodic Safety Review (every 10 years)

- Operational Safety Inspection / etc.

Aging Management Technical Assessment (AMTA)

To develop a Long-term Maintenance Management Policy

Additional Maintenance based on a Long-term Maintenance Management Policy

Maintenance Management as usual

- Strengthen monitoring for the deterioration status to be considered for measures for aging management
  - possibly deviated from the projected drop of the performance

Source: White paper on Nuclear Energy 2009
Historical Trends in Reported Incidents and Failures at NPPs in Japan

Source: Japan Nuclear Energy Safety Organization “Operational Status of Nuclear Facilities in Japan (2013)” etc.

Diagram showing the number of notification-based reports and reports per unit from 1992 to 2012. The number of reports and reports per unit are depicted for each year, with a trend line for reports per unit over the years.
Unplanned Automatic Scrams per 7,000 Hours Critical in Major Countries

The unplanned automatic scarms per 7,000 hours critical (UA7) is calculated as:

\[
\text{UA7} = \frac{\text{total unplanned scrams while critical in the previous 4 qtrs} \times 7,000 \text{ hrs}}{\text{total number of hours critical in the previous 4 qtrs}}
\]

(Note) Automatic Scram: Emergency shutdown of the reactor

Source: IAEA PRIS
Historical Trends in Capacity Factors of NPPs in Major Countries

- **Japan**
- **U.S.A.**
- **France**
- **Germany**
- **Canada**

**Source:** Japan Nuclear Energy Safety Organization “Operational Status of Nuclear Facilities in Japan (2013)”
Causes of the Accident at Chernobyl Nuclear Power Plant

Lack of Safety Culture

**Design Defects**
- No Containment Vessel
- Designed to easily turn off safety equipment
- Positive void coefficient; during low power operation, the more voids (froths) in cooling water, the more output, etc.

**Operator’s Regulation Violation**
- Withdrew control rods more than regulated
- Operated with Emergency Core Cooling System (ECCS) turned off
- Conducted a special test at lower power than planned

Continuous operation was prohibited due to instability at low power range (less than 20% of total output), etc.

**Operational Mismanagement**
- Managed by a non-reactor-specialist
- A special test was conducted without due processes or approval throughout the power plant
- Inadequate examinations on safety measures, etc.
Enhancement of the Nuclear Emergency Preparedness System

As a precaution against emergencies, a new Nuclear Emergency Preparedness Commission (NEPC) will be permanently established under the Cabinet to promote nuclear emergency preparedness measures throughout the government from normal times.

**Ordinary times**

**Nuclear Emergency Preparedness Commission**
- **Chairperson**: Prime Minister
- **Vice-Chairman**: Chief Cabinet Secretary, Minister of the Environment, NRA Chairman
- **Commissioners**: Minister of State, Deputy Chief Cabinet Secretary for Crisis Management, Vice Ministers, Parliamentary Secretaries, etc.
- **Secretary General**: Minister of the Environment

(Role)
- Promoting policy enforcement, etc. based on the Nuclear Emergency Response Guidelines
- Promoting the long-term comprehensive policy enforcement in the case of nuclear accident occurrence

**Relevant Ministries and Agencies**
- National Police Agency, MEXT, MHLW, MLIT, Japan Coast Guard, Ministry of the Environment, Ministry of Defense, etc.

**Emergency**

**Nuclear Emergency Response Headquarters**
(Provisional installation under the Cabinet Office at the time of Declaration of the State of Nuclear Emergency)
- **Director-general**: Prime Minister
- **Deputy director-generals**: Chief Cabinet Secretary, Minister of the Environment, NRA Chairman
- **Members**: Minister of State, Deputy Chief Cabinet Secretary for Crisis Management, Vice Ministers, Parliamentary Secretaries, etc.

(Role)
- General coordination of nuclear emergency response measures and post accident measures.

**Relevant Ministries and Agencies**
- National Police Agency, MEXT, MHLW, MLIT, Japan Coast Guard, Ministry of the Environment, Ministry of Defense, etc.

※These are guidelines prepared by the Nuclear Regulation Authority for nuclear operators and local governments, etc. to ensure smooth implementation of nuclear emergency preparedness measures, emergency response measures, and measures for restoration from nuclear emergency.
Clarification of Nuclear Emergency Categories (3 Stages)

Operational Chart—From Alert to General Emergency

Alert

- Crisis Management Center
  - Regulatory Agency Deputy Director-general

- ERC (Emergency Response Center)
  - Regulation Authority Chairman, Regulatory Agency Director, Etc.

- Launch Situation Rapid Response Center
  - Nuclear Safety Inspector
  - Senior Specialist for Nuclear Emergency

Site Area Emergency

- Emergency Meeting Team
  - Deputy Chief Cabinet Secretary for Crisis Management

- Regulation Authority Accident Response Headquarters
  - Regulation Authority Chairman for Crisis Management

- ERC

- Situation Rapid Response Center
  - Director General for Emergency Response

- Off-site Center

General Emergency

- Nuclear Emergency Response Headquarters
  - Director-general: Prime Minister
  - Deputy Director-general: Regulation Authority Chairman
  - Secretariat
    - Regulatory Agency Director

- ERC

- Situation Rapid Response Center
  - Director General for Emergency Response

- Off-site Center

Top-Level Government

Central

Nuclear Regulation Authority

Natural Disaster

Onsite Measures

Licensee Company

Offsite Measures

Accident
Expansion of Nuclear Emergency Response Action Zone

**Approx. 5 km Radius**

**PAZ**
(Precautionary Action Zone)

Upon the declaration of a general emergency, residents within this zone should evacuate immediately and, as a general rule, should each administer stable iodine.

**Approx. 30 km Radius**

**UPZ**
(Urgent Protective Action Planning Zone)

As a general rule, residents should first take shelter indoors. Next, residents should prepare to evacuate or temporarily relocate and also to administer stable iodine according to the developing situation at the nuclear power plant.
### Extent of Emergency

<table>
<thead>
<tr>
<th>Extent of Emergency</th>
<th>PAZ (≤5 km)</th>
<th>UPZ (5–30 km)</th>
<th>30– km</th>
</tr>
</thead>
<tbody>
<tr>
<td>According to the situation at the facility, the nuclear power plant operator reports the emergency category to both the national government and local authorities.</td>
<td>• Local authorities will prepare and implement necessary evacuations in response to instructions or orders from the national government. • Either the national government or local authorities may issue instructions to residents to prepare and administer stable iodine.</td>
<td>• Preparations for evacuation of persons requiring special assistance (those who are ill or injured, the elderly, physically challenged persons, infants, expectant and nursing mothers, etc.). • Evacuation of persons requiring special assistance. • Preparations for general evacuation. • Preparations for administration of stable iodine.</td>
<td>• Assistance with preparations for the evacuation of persons requiring special protection. • Reception of persons requiring special assistance. • Reception of evacuees. • Assistance with evacuation, etc. • Preparations for administration of stable iodine. • Receptions for indoor sheltering. • Indoor sheltering. • Preparations for administration of stable iodine. • Preparations for evacuation, etc. • Start of emergency monitoring by national government, local authorities and nuclear power plant operator.</td>
</tr>
</tbody>
</table>

**EAL1** (Alert)  
(Ex.) Occurrence of large tsunami, earthquakes with seismic intensity of 6 or higher, etc.  
**EAL2** (Site Area Emergency)  
(Ex.) Station Blackout over 30 minutes beyond, etc.  
**EAL3** (General Emergency)  
(Ex.) Station Blackout over 1 hour over, etc.

- **Newly Established**
- **No Emission of Radioactive Materials**
- **Emission of Radioactive Materials Outside of the Facility**

### Radiation Protection for Residents

Based on the results of emergency monitoring, the national government will implement necessary protective measures, such as evacuations, on the basis of air dose rates or other appropriate standards.

- **OIL1**  
  Air dose rate of 500 microsieverts per hour.

- **OIL2**  
  Air dose rate of 20 microsieverts per hour.

- **OIL4**  
  Body surface beta radiation exposure of 40,000 cpm. (Dropping to 13,000 cpm after 1 month.)

- **OIL6, etc.**  
  Radioactive iodine in drinking water. 300 becquerels/kg, etc.

- **Evacuation**
- **Temporary Relocation**
- **Restrictions on the intake of local produce, etc.**
- **Screening of food and drink, restrictions on intake.**
- **Contamination Examination**
- **Body Surface Decontamination**

**OIL:** Standard for determining the necessity and extent of measures to be implemented for the protection of residents when radioactive materials have been emitted, based on the results of monitoring, etc.

*Source: Nuclear Regulation Authority, Federation of Electric Power Companies*
Reinforcement of Network between Government and Nuclear Power Plant Operators

Operational Chart—Initial Response and Thereafter

Nuclear Emergency Response Headquarters

Related Ministries and Agencies

Communication Satellite

Local Government

Outside of Nuclear Power Plant

Nuclear Emergency Response Headquarters Secretariat

ERC Team

Offsite Disaster Victim Support

Off-site Center (OFC)

Logistical Support Base

Nuclear Emergency Response

Facility Situation

Rapid Response Center

(Head Office of Nuclear Power Plant Operator)

Emergency Response Base (within Site)

Meetings of Related Agency Directors, Etc.

Chairperson: Regulatory Agency Director

Related Ministries and Agencies

Supervision, Instructions, Orders

Onsite Crisis Management Support

Central Onsite
Nuclear Damage Compensation System

- **Nuclear Damage Liability Facilitation Fund**
  - JPY 120 billion for compensation measures (including amount stipulated by government decree)
  - Relief funding (grants, investments, loans, etc.)
  - Approval of compensation measures
  - Appointment

- **Minister of Education, Culture, Sports, Science and Technology**
  - Approval of compensation measures
  - Appointment

- **Dispute Reconciliation Committee for Nuclear Damage Compensation**
  - Guidelines for determining scope of nuclear damage
  - Mediated settlement (ADR)

- **Losses and Damage Assumed by Nuclear Operator (Unlimited Liability)**
  - + Government assistance when recognized as necessary

- **Private Insurance Contract**
  - Liability Insurance Contract for Nuclear Damage Compensation

- **Government Compensation Contract**
  - Contract for Indemnification of Nuclear Damage Compensation

- **Nuclear Operator**
  - (no-fault liability, channeled liability)

- **Measures**
  - Government measures
  - Measures required for supporting claimants and preventing widespread damage

- **Claimants**
  - Compensation

- **Operator exemption from liability**

- **Government**
  - Social unrest and unusually severe natural disasters
  - Earthquake, volcanic eruption, tsunami
  - General accident

- **Source:** Ministry of Education, Culture, Sports, Science and Technology
Acute Radiation Effects

Projected threshold estimates of the acute absorbed does for 1% incidence of morbidity and mortality.

Gy (absorbed dose)

<table>
<thead>
<tr>
<th>Organ/Tissue</th>
<th>Morbidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Testes</td>
<td>Permanent sterility</td>
</tr>
<tr>
<td>Lungs</td>
<td>Pneumonitis</td>
</tr>
<tr>
<td>Small Intestine</td>
<td>Gastro-intestinal syndrome</td>
</tr>
<tr>
<td>Skin</td>
<td>Temporary hair loss</td>
</tr>
<tr>
<td>Bone Marrow</td>
<td>Death (with good medical care)</td>
</tr>
<tr>
<td>Bone Marrow</td>
<td>Death (without medical care)</td>
</tr>
<tr>
<td>Testes</td>
<td>Temporary sterility</td>
</tr>
</tbody>
</table>

Skin (large areas) Skin burns

Small Intestine Gastro-intestinal syndrome (with good medical care)

Skin (large areas) Main phase of skin redding

Ovaries Permanent sterility

Eye Cataract (visual impairment)

Bone Marrow Depression of blood-forming

※Threshold: the maximum level of radiation considered to be acceptable or safe

Source: ICRP “Publication 103.11B”
## Relative Cancer Risk Estimation for Radiation Exposure and Lifestyle Factors

(Targeted for Japanese between the ages of 40 and 69)

<table>
<thead>
<tr>
<th>Factors</th>
<th>Cancer Risk Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiation exposure (1,000 - 2,000 mSv)</td>
<td>x1.80</td>
</tr>
<tr>
<td>Smoking</td>
<td>x1.60</td>
</tr>
<tr>
<td>Drinking (above 0.54 litter/day)</td>
<td>x1.29</td>
</tr>
<tr>
<td>Underweight</td>
<td>x1.29</td>
</tr>
<tr>
<td>Obesity</td>
<td>x1.22</td>
</tr>
<tr>
<td>Radiation exposure (200 - 500 mSv)</td>
<td>x1.19</td>
</tr>
<tr>
<td>Inactivity (too little physical activity)</td>
<td>x1.15 - 1.19</td>
</tr>
<tr>
<td>Too much salt intake</td>
<td>x1.11 - 1.15</td>
</tr>
<tr>
<td>Radiation exposure (100 - 200 mSv)</td>
<td>x1.08</td>
</tr>
<tr>
<td>Lack of vegetable intake</td>
<td>x1.06</td>
</tr>
</tbody>
</table>

(Note) Risk estimates for radiation exposure are based on the analysis of instantaneous dose effects in the case of A-bomb at Hiroshima and Nagasaki (solid cancer incidence only) and not based on the observations on prolonged dose effects.

Source: National Cancer Center
Control is especially needed to preserve a nuclear power plant (except a controlled area).

Entry is restricted to prevent a damage by radiation and radioactive materials.

Within the area, unnecessary entry of the general public is restricted to prevent them from being exposed to more dose emitted from nuclear facilities than regulated by laws.

Classified in detail according to the extent of radiation or contamination
Radiation Exposure Control for Radiation Workers

**Radiation Control Flow**

- **Radiation Workers**
  - Medical examination / Education / Exposure records check
  - Controlled-area entry permit
  - Carrying a portable individual dosimeter
  - To wear protective clothing (wearing a protective mask, if necessary)

- **Section responsible for an assignment**
  - Making a work plan
  - Setting dose equivalent target
  - Measures to reduce radiation exposure (ex. Installation of shields)
  - To instruct radiation protection

- **Experts in radiation Control**
  - To make a work plan
  - Measuring radiation exposure
  - Setting dose equivalent target
  - Making a work plan

**Work within a controlled area**

- **Completion of work**
  - Surface contamination test
  - To measure and evaluate individual effective dose

- **To measure and evaluate individual effective dose**
  - Recording measurement results and notifying them to individuals

- **Recording measurement results and notifying them to individuals**
  - Registering the data to the Radiation Dose Registration Center for Radiation Workers

- **Employees with protective clothing are working**
  - Surface contamination test to check workers' body
  - Individual effective dose is measured by the entrance and exit control equipment.
  - Radioactive materials in a body are periodically checked by a whole body counter.

**Left : Glass badge**
**Right : Alarm-equipped dosimeter**

**Employees with protective clothing are working**
Environmental Radiation Monitoring around Nuclear Facilities

Monitoring Area

Environment Sample Collection (Land)
Sample of vegetable leaves, milk, soil, rain, and river water, etc., are collected to measure radioactivity.

Environmental Sample Collection (Sea)
Fish, shellfish, seaweed, and seawater, etc. are sampled to measure radioactivity.

Monitoring Station
Radioactivity within and weather data are dust floating in the air measured, in addition to measuring environmental radiation.

Monitoring Post
Around nuclear facilities environmental radiation is continuously measured.

Monitoring Car
Carrying equipment for measuring radiation and radioactivity, it travels in wide area for monitoring.
① Fission Rate of Uranium and Plutonium in Reactor Core
(BWR equilibrium core)

- Uranium Fuel
  - Approx. 60~70%
  - Approx. 30~40%

- Plutonium Fuel
  - Approx. 40~50%

② (Ex.) Composition change of uranium fuel through generation

Before Generation
- Fissile uranium
  - (Uranium 235)
  - Approx. 3~5%
- Plutonium
  - Approx. 1%
- Fission Products
  - Approx. 3~5%
- Non-fissile uranium
  - (Uranium 238)
  - Approx. 95~97%

After Generation
- Fissile uranium
  - (Uranium 235)
  - Approx. 1%
- Plutonium
  - Approx. 1%
- Fission Products
  - Approx. 3~5%
- Non-fissile uranium
  - (Uranium 238)
  - Approx. 93~95%
Utilization of Uranium Resources

1 70TWh is equivalent to annual output of ten 1GW capacity nuclear reactors. (1)
2 Usage of plutonium can utilize the use of uranium by about 30 times when Fast Breeder Reactor came into practical use. (2)

Nuclear Fuel Cycle

(Note) MOX Fuel: Uranium-Plutonium mixed oxide fuel
# Outline of JNFL's Nuclear Fuel Cycle Facilities

(As of December, 2013)

<table>
<thead>
<tr>
<th>Location</th>
<th>Capacity</th>
<th>Current Status</th>
<th>Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reprocessing Plant</strong></td>
<td>Maximum capacity: 800 t-U/y Storage capacity for spent fuel: 3,000 t-U</td>
<td>Under Construction</td>
<td>Start of construction: 1993 Commissioning: 2014 (planned)</td>
</tr>
<tr>
<td><strong>Vitrified Waste Storage Center</strong></td>
<td>Storage capacity for wastes returned from overseas plants: 2,880 canisters of vitrified waste</td>
<td>Cumulative number of stored canisters: 1,442</td>
<td>Start of construction: 1992 Commissioning: 1995</td>
</tr>
<tr>
<td><strong>MOX Fuel Fabrication Plant</strong></td>
<td>Maximum capacity: 130 t-HM/y&lt;sup&gt;1&lt;/sup&gt; MOX fuel assemblies for domestic light water reactors (BWR and PWR)</td>
<td>Under Construction</td>
<td>Start of construction: 2010 Commissioning: 2017 (planned)</td>
</tr>
<tr>
<td><strong>Uranium Enrichment Plant</strong></td>
<td>Design capacity of 1,500 t-SWU&lt;sup&gt;2&lt;/sup&gt;/year</td>
<td>In operation</td>
<td>Start of construction: 1988 Commissioning: 1992</td>
</tr>
<tr>
<td><strong>Low-level Radioactive Waste Disposal Center</strong></td>
<td>Planned to be expanded to 600,000 m³ (equivalent to 3 million 200 liter drums)</td>
<td>Number one disposal facility: 147,507 drums Number two disposal facility: 113,112 drums</td>
<td>Start of construction: 1990 Commissioning: 1992</td>
</tr>
</tbody>
</table>

--

<sup>1</sup> HM indicates the weight of plutonium and uranium metallic content in MOX.

<sup>2</sup> SWU: Separating work units when the natural uranium is separated from enriched uranium.

<sup>3</sup> Construction expense regarding 200,000 m³ low-level radioactive waste (equivalent to 1 million of 200 liter drums).

Source: Japan Nuclear Fuel Ltd., etc.
Flow of Reprocessing

1. Receiving/Storage
2. Chopping/Dissolving
3. Separation
4. Purification
5. Denitration
6. Product Storage

- Uranium
- Plutonium
- Mixed oxide (MOX)
- Separation of fission products
- Separation of Uranium and Plutonium
- Uranium Purification
- Uranium denitration
- Uranium oxide
- Uranium-plutonium mixed oxide (MOX)
- Vitrified and stored safely
- Metal Chips, etc.
- High-level radioactive liquid waste
- Sealed into containers and stored safely

Source: Japan Nuclear Fuel Ltd.
MOX Fuel Use in LWRs in the World

Source: Agency for Natural Resources and Energy “NUCLEAR ENERGY 2010” etc.

(Note) Fugen, an advanced thermal reactor (ATR), loaded 772 MOX fuel assemblies in Japan. (Fugen was closed down in March 2003)

The end of December 2012, MOX fuels were loaded in 22 plants in France, 8 plants in Germany, 3 plants in Switzerland, 1 plant in Belgium.

* Further total 88 MOX fuel assemblies have been loaded into 4 reactors on and after December 2009.

Source: Agency for Natural Resources and Energy “NUCLEAR ENERGY 2010” etc.
Mechanism of Fast Breeder Reactor (FBR)

Mixture of uranium and plutonium fuel is loaded in the reactor.

FBR uses liquid metal sodium (primary system sodium) with high heat conductivity as the coolant.

Heat generated in the reactor is transmitted to liquid metal sodium in the other system (secondary system sodium) via the intermediate heat exchanger.

Heat conducted by sodium converts water to steam which drives the turbine.

Source: Ministry of Education, Culture, Sports, Science and Technology
Spent Fuel Interim Storage Facility

Image for the Recyclable Fuel Storage Center which is under construction in Mutsu City, Aomori Prefecture (storage capacity: 3,000tU)

Cask for Transport & Storage

- **Confinement**: Cask is sealed by metal gasket between double lids (Primary & Secondary Lids).
- **Shielding**: Spent fuel assemblies are shielded by 2 layers (Gamma Shielding & Neutron Shielding) and their radiation are decreased by one millionth.
- **Spent Fuel Assembly**
- **Criticality Prevention**: Basket (partition plate) prevents spent fuel from criticality (chain reaction of nuclear fission)
- **Heat Removal**: The heat generated from spent fuel is cooled by the outside air through the heat transfer fin.

Source: Recyclable-Fuel Storage Company “Outline of construction work for the storage building” etc,
Approval of designs of materials to be transported

Authorities:
- Land transport included: Nuclear Regulation Authority or Ministry of Land, Infrastructure, Transport and Tourism
- Marine transport only: Ministry of Land, Infrastructure, Transport and Tourism

Approval of containers

Authorities:
- Land transport included: Nuclear Regulation Authority or Ministry of Land, Infrastructure, Transport and Tourism
- Marine transport only: Ministry of Land, Infrastructure, Transport and Tourism

Inspection of materials to be transported

Authorities:
- Land transport included: Nuclear Regulation Authority or Ministry of Land, Infrastructure, Transport and Tourism
- Marine transport only: Ministry of Land, Infrastructure, Transport and Tourism

Inspection of transport methods

Authorities: Ministry of Land, Infrastructure, Transport and Tourism

Notification of transport

Authorities:
- Land transport: Public Safety Commission
- Marine transport: Regional Coast Guard Headquarters of the Japan Coast Guard

Confirmation on agreement of nuclear materials physical protection

Authorities: Nuclear Regulation Authority

Transportation

In case of land transport, a truck is accompanied with escort cars to lead or guard.
Transport Casks for Spent Fuel

Gamma Shielding (lead and others)

Shock Absorber

Neutron Shielding (ethylene glycol)

Cooling Fin

Inner Shell

Outer Shell

Fuel Assemblies

Basket

(Note) Figure shown is NFT-38B(Dry Cask) used for domestic transport.

Source: Nuclear Fuel Transport Co., etc.
(1) **Securing safe navigation**
   - Collision prevention radar, etc.

(2) **Safe structure**
   - Double hulled structures
   - Enhanced buoyancy

(3) **Fire preventions**
   - Hold flooding system, etc.
The depths and barriers are selected based on the radioactivity level, and the disposal of radioactive waste is divided into shallow ground disposal, intermediate depth disposal, and geological disposal.

### Waste Types

<table>
<thead>
<tr>
<th>Source</th>
<th>Waste Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear power plant</td>
<td>- Power plant waste</td>
</tr>
<tr>
<td>Uranium enrichment and fuel processing plant</td>
<td>- Low-level radioactive waste</td>
</tr>
<tr>
<td>MOX Fuel Fabrication Plant</td>
<td>- Power plant waste</td>
</tr>
<tr>
<td>Reprocessing plant</td>
<td>- Power plant waste</td>
</tr>
</tbody>
</table>

- **Low-level radioactive waste**
  - Waste having an extremely low radioactive level
  - Waste having a relatively low radioactive level
  - Waste having a relatively high radioactive level
- **Uranium waste**
- **Transuranic (TRU) radioactive waste**
- **High-level radioactive waste**

### Disposal Method

- **Trench disposal**
- **Pit disposal**
- **Intermediate depth disposal**
- **Geological disposal**
  - Burial at depths of 300m or more
Structure of No.1 Disposal Facility

- Bentnite/sand Mixture
- Bedrock (Takahoko formation)
- Inspection Tunnel
- Drainpipe and Inspection Equipment
- Waste
- Cement-based Backfill
- Porous Concrete Layer
- Cover soil layer (4m or more)

Structure of No.2 Disposal Facility

- Bentnite/sand Mixture
- Bedrock (Takahoko formation)
- Inspection Tunnel
- Drainpipe and Inspection Equipment
- Waste
- Cement-based Backfill
- Porous Concrete Layer
- Cover soil layer (9m or more)
Transport Casks for High-level Radioactive Waste (Vitrified Waste) Shipment container

Diameter: approx. 2.4 meters
Length: approx. 6.6 meters

<table>
<thead>
<tr>
<th>TN28VT-type Cask</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Weight</td>
</tr>
<tr>
<td>Capacity</td>
</tr>
</tbody>
</table>

Source: Nuclear Fuel Transport Co.
Safety features of Transport Vessels for HLW (vitrified waste)

- Double hulls and hull reinforcement to withstand collision damage
- Enhanced buoyancy to ensure the ship will continue to float even in extreme circumstances
- Dual navigation, communication, cargo monitoring and cooling systems
- Satellite navigation and tracking
- Twin engines, rudders and propellers
- Additional firefighting equipment, including hold spray and flooding systems and spare electrical generators
- Fixed radiation monitors for each hold that are linked to an alarm system on the bridge

(Ex.) Specification of a transport vessel

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size</strong></td>
<td></td>
</tr>
<tr>
<td>Length: approx. 104 meters</td>
<td>Width: approx. 17 meters</td>
</tr>
<tr>
<td><strong>Gross Tonnage</strong></td>
<td>approx. 5,000 tons</td>
</tr>
<tr>
<td><strong>Deadweight</strong></td>
<td>approx. 3,500 tons</td>
</tr>
</tbody>
</table>

Source: The Federation of Electric Power Companies
Temporary Storage for High-level Radioactive Waste (Vitrified Waste)

- Storage Pits
- Stainless Steel Canister
- Ventilation Inlet
- Ventilation Outlet
- Thimble Tube Seal
- Approx. 1.9m Plug
- Low atmospheric pressure Ventilation Outlet
- Stainless Steel Canister
- Solidified Glass
- Thimble Tube
- Ventilation Pipe
- Vitrified Waste
- Cooling air

Source: Making it in reference a brochure by Japan Nuclear Fuel Ltd.
Examination of Methods for Disposing of High-Level Radioactive Waste

Given the difficulties of people managing wastes into perpetuity and not burdening future generations with monitoring them, we examined methods that would allow safe disposal without the need for human management.

- Disposal in geological formations, highly feasible, given the numerous examples of underground resources already being maintained for a long time.
- With disposal in space, Problems exist in reliability of launching technologies.
- Disposal at bottom of ocean, banned under the London Convention, which regulates dumping at sea.
- Disposal in polar ice, banned under the Antarctic Treaty. Further, features of the ice sheet are not fully known.

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geological disposal</td>
<td>Use the properties inherent to geological formation to lock up materials.</td>
</tr>
<tr>
<td>Space disposal</td>
<td>Problems with reliability of launch technologies.</td>
</tr>
<tr>
<td>Ocean disposal</td>
<td>Banned by London Convention regulating ocean dumping.</td>
</tr>
<tr>
<td>Ice sheet disposal</td>
<td>Banned by Antarctic Treaty Features of ice sheet not fully known.</td>
</tr>
<tr>
<td>Long-term management</td>
<td>Human management. In perpetuity difficult Burdens future generations with monitoring</td>
</tr>
</tbody>
</table>

Source: Nuclear Waste Management Organization of Japan (NUMO)
Example of layout in case of co-location with TRU waste disposal facility

Example of specifications (crystalline basement, depth of 1,000m)

<table>
<thead>
<tr>
<th>Facility Type</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Facility</td>
<td>Ground area: 1 ~ 2km²</td>
</tr>
<tr>
<td>Underground Facility for HLW</td>
<td>Disposal area: Approx. 3km x 2km</td>
</tr>
<tr>
<td>Underground Facility for TRU waste</td>
<td>Disposal area: Approx. 0.5km x 0.3km</td>
</tr>
</tbody>
</table>

Source: Nuclear Waste Management Organization of Japan
Objects of the Additional Protocol
- Plants to manufacture and assemble nuclear related materials
- Uranium mines, etc.

※1 Except supplemental access, such as arises during a normal inspection
※2 Nuclear materials control center specified based on the Nuclear Reactor Regulation Law (public property) as a designated organization for implementing safeguards and inspections or as a designated information processing organization.

Source: Nuclear Regulation Authority
Electric Power Development based on the Three Laws

1. Law on Tax for Promotion of Electric Power Development

- **Tax rate**
  - Until Sep. 2003: JPY 0.445/kWh
  - Apr. 2005 - Mar. 2007: JPY 0.400/kWh
  - Apr. 2007: From JPY 0.375/kWh

2. Law on Special Accounts

- **Consumers**
  - JPY 330 billion
- **Electric Power Companies**
  - JPY 275 billion
- **General account**
  - JPY 275 billion

3. Law on the Development of Areas Adjacent to Power Generating Facilities

- Surplus from previous fiscal year, etc. JPY 37.1 billion
- Fund for developing surrounding areas JPY 6.6 billion
- Independent administrative corporation contribution JPY 1.9 billion

**Special Accounts for Energy Measures Accounts for Promotion of Power Development**

- JPY 322.1 billion

**Budget by Ministries**

- Cabinet Office: JPY 11 billion
- Ministry of Education, Culture, Sports, Science and Technology: JPY 113.8 billion
- Ministry of Economy, Trade and Industry: JPY 152.9 billion
- Ministry of Environment: JPY 44.3 billion

**Measures for Electric Power Plant Location Accounts**

- Development of power supply region
  - Development of power generation facilities
  - Industrial development
  - Emergency preparedness measures for power source region
  - Promotion of public understanding of long-life fixed generation facilities
  - Enhancement and strengthening of activities for harmonious coexistence in power supply regions
  - Measures for enhancement of public understanding of nuclear power generation

**Electric Power Generation Diversification Accounts**

- Promotion of development of power generating facilities etc.
- Measures for smoother power supply
- Nuclear safety measures
- Promotion of research and development concerning the nuclear fuel cycle
- Promotion of advanced nuclear science and technology
- Measures for securing the safety and others

**Nuclear safety regulation measure**

- Ensuring the safety of nuclear power facilities, etc.
- Disaster prevention measures around nuclear facilities
- Health management for victims of nuclear accidents

**Grants for location electric power plants**

- Subsidy for supporting industrial development in power supply regions
- Subsidy for development of power supply regions

*“Special Accounts for Promotion of Electric Power Development Acceleration Measures” and “Special Accounts for Petroleum and Sophisticated Structure of Energy Supply and Demand” were merged into “Special Accounts for Energy Measures” in FY2007. In that, “Accounts for Promotion of Electric Power Development” succeed to the operation of “Special Account for Promotion of Electric Power Development Acceleration Measures”.

*Since FY2007, the revenue from “Promotion of Power-resources Development Tax” has transferred to the annual revenue of general account. Necessary amount has been transferred from the general account to “Special Accounts for Energy Measures” each year.

*In addition, approximately 5 trillion yen is decided as atomic energy compensation for damages support calculation.

Source: The Denki Shimbun “Nuclear Pocket Book FY2013”
Outline of the Tohoku-Pacific Ocean Earthquake

Date of Occurrence:
14:46 on Friday, March 11, 2011

Epicenter:
Offshore Sanriku

Latitude, Longitude and Depth of Hypocenter:
38°06.2’ N, 142°51.6’ E, 24km

Magnitude:
9.0 (Moment magnitude scale)

Seismic Intensity (Japanese seismic scale)
7: Kurihara City of Miyagi Pref.
Upper 6: Naraha Town, Tomioka Town, Okuma Town and Futaba Town of Fukushima Pref.
Lower 6: Ishinomaki City and Onagawa Town of Miyagi Pref. and Tokai Village of Ibaraki Pref.
Lower 5: Kariwa Village of Niigata Pref.
4: Rokkasho Village, Higashidori Village, Mutsu City and Ohma Town of Aomori Pref. and Kashiwazaki City of Niigata Pref.
Height of Tsunami triggered by the Tohoku-Pacific Ocean Earthquake

Source: Japan Meteorological Agency “Prompt Disaster Repots of Earthquake & Tsunami, the Tohoku-Pacific Ocean Earthquake, 2011”
### Current Status of NPSs Affected by the Tohoku-Pacific Ocean Earthquake

**Epicenter**

#### Tohoku Electric Power’s Higashidori NPP

- Unit 1
- Outage status for periodic inspection at the time the earthquake occurred

#### JNFL reprocessing plant

- No significant event

#### Tokyo Electric Power’s Fukushima Daiichi NPPs

<table>
<thead>
<tr>
<th>Unit 1</th>
<th>Unit 2</th>
<th>Unit 3</th>
<th>Unit 4</th>
<th>Unit 5</th>
<th>Unit 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shutdown automatically due to the earthquake</td>
<td></td>
<td></td>
<td>Outage status for periodic inspection at the time the earthquake occurred</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Tokyo Electric Power’s Fukushima Daini NPPs

<table>
<thead>
<tr>
<th>Unit 1</th>
<th>Unit 2</th>
<th>Unit 3</th>
<th>Unit 4</th>
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<tbody>
<tr>
<td>Shutdown automatically due to the earthquake</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Tohoku Electric Power’s Onagawa NPPs

- Unit 1
- Unit 2
- Unit 3
- Shutdown automatically due to the earthquake

#### JAPC’s Tokai II NPP

- Shutdown automatically due to the earthquake

---

**Definition of cold shutdown state**

- Temperature at the bottom of the pressure vessel is at/below 100°C
- The release of radioactive material from the containment vessel is under control and the dosage of radiation to the public from additional releases is greatly suppressed (the target at the time of evaluation for the dosage of radiation at the boundary of the site from additional releases from the container vessel is 1 mSv/year)
- In order to maintain the two conditions above, must be able to ensure the medium-term safety of the circulating injection cooling system.

**Note:**

- as of December 2013

---

10-2-1
Cool down
Cool the reactor coolant and spent fuel pool water to maintain a low temperature.

Loss of power to the pumps in order to cool reactor and spent fuel pool resulted in the loss of the cooling function.

Containment
Prevent radioactive materials from being released outside the reactor building.

A hydrogen explosion blew off the top side of the reactor building and damaged the fuel rods, resulting in a partial loss of the containment function.

Shutdown
Shut down the reactor by inserting all control rods to prevent neutrons from causing nuclear fission.
Predicted maximum amplitude of tsunami

- O.P. +6.1m

Inundation depth (considering the vestiges on buildings and facilities)
- Approx 1.5-5.5m (Unit1-Unit4)

Inundation height (considering the vestiges on buildings and facilities)
- Approx 11.5-15.5m (Unit1-Unit4)

Inundation area (considering the vestiges on buildings and facilities)
# Outline of Safety Assurance Measures implemented after the Fukushima Daiichi Accident

<table>
<thead>
<tr>
<th>Short Term Measures (completed)</th>
<th>Mid &amp; Long Term Measures (to be implemented in a few years)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Emergency Safety Measures</strong></td>
<td></td>
</tr>
<tr>
<td>☐ Review of emergency response manuals, etc.</td>
<td>☐ Installation of coastal levee</td>
</tr>
<tr>
<td>☐ Additional deployment of emergency power source vehicles</td>
<td>☐ Strengthening watertightness of the buildings</td>
</tr>
<tr>
<td>☐ Additional deployment of fire engines</td>
<td>☐ Preparing the spare equipments (seawater pump, etc.)</td>
</tr>
<tr>
<td>☐ Additional deployment of fire hoses</td>
<td>☐ Installation of large-sized air cooled generators</td>
</tr>
<tr>
<td>☐ Conduct of emergency response drills</td>
<td></td>
</tr>
<tr>
<td><strong>Measures for enhancing Power Supplies</strong></td>
<td></td>
</tr>
<tr>
<td>☐ Interconnection of emergency diesel generators between units</td>
<td>☐ Connection between all units and grids</td>
</tr>
<tr>
<td></td>
<td>☐ Inspection of transmission line towers and measures against earthquake and tsunami</td>
</tr>
<tr>
<td></td>
<td>☐ Seismic measures for switch yards, etc.</td>
</tr>
<tr>
<td><strong>Severe Accident Measures</strong></td>
<td></td>
</tr>
<tr>
<td>☐ Securing work environment at the main control room</td>
<td>☐ Transfer of equipments (PBX, etc.) on high ground</td>
</tr>
<tr>
<td>☐ Securing hydrogen discharge measures</td>
<td>☐ Installation of the static hydrogen combiner, etc. (PWR)</td>
</tr>
<tr>
<td>☐ Securing communication tools</td>
<td>☐ Installation of ventilation and hydrogen detectors (BWR)</td>
</tr>
<tr>
<td>☐ Preparing high-dose-resistant protective clothing</td>
<td></td>
</tr>
<tr>
<td>☐ Deployment of wheel loaders</td>
<td></td>
</tr>
</tbody>
</table>

Source: Atomic Energy Commission's New Nuclear Policy-planning Council
### Examples of Safety Assurance Measures implemented after the Fukushima Daiichi Accident

<table>
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<tr>
<td><strong>Deployment of wheel loaders</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Measures for enhancing Power Supplies

- Installation of coastal levee
- Installation of protection walls
- Inspection of transmission line towers and measures against earthquake and tsunami

#### Severe Accident Measures

- Settlement of procedure manuals for drilling work/preparation for equipment and materials
- Installation of hydrogen detector in the reactor building ventilation system
- Installation of hydrogen detectors (BWR)

**Source:** Atomic Energy Commission's New Nuclear Policy-planning Council
<table>
<thead>
<tr>
<th>Chart No.</th>
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<th>Summary of Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1-2</td>
<td>World Population Projections</td>
<td>World population in the year 2010 was 6.92 billion. It is forecast that the world’s population will reach 10.85 billion by 2100, which is 1.6 times more than that of 2010, due primarily to the increase in developing countries.</td>
</tr>
<tr>
<td>1-1-3</td>
<td>World Population and Energy Consumption</td>
<td>Although the population in China and India represented around 40% of the total world population in 2011, annual per capita primary energy consumption in both countries was below the global average. Japan with only 2% of the world’s population consumed as much as 4% of the total primary energy used. Annual per capita energy consumption was equivalent to that in European countries.</td>
</tr>
<tr>
<td>1-1-4</td>
<td>Primary Energy Consumption per Capita</td>
<td>As the per capita GDP increases, the primary energy consumption tends to increase. And so, as the economies grow in developing countries with extremely high rates of population growth, this is expected to lead to increased primary energy consumption over the coming years.</td>
</tr>
<tr>
<td>1-1-5</td>
<td>Per Capita GDP and Primary Energy Consumption</td>
<td>Because of the limited energy resources and future increases in energy consumption, the securing of energy resources remains a great challenge. For this reason, it is important to always strive to conserve resources and energy.</td>
</tr>
<tr>
<td>1-1-6</td>
<td>Proven Reserves of Energy Resources</td>
<td>The World’s Primary Energy Consumption</td>
</tr>
<tr>
<td>1-1-7</td>
<td>The World’s Primary Energy Consumption</td>
<td>Although world energy consumption is increasing as years go by, the growth in oil consumption has been moderated by positive use of alternative energy (nuclear energy and other forms) in advanced countries.</td>
</tr>
<tr>
<td>1-1-8</td>
<td>Primary Energy Consumption in Major Countries</td>
<td>The composition of primary energy consumption in major countries differs, depending on the situation in each country. Japan is one of the countries with a high dependence on crude oil. Another notable feature is that the composition of energy supplied from nuclear power is high (about 40%) in France.</td>
</tr>
<tr>
<td>1-1-9</td>
<td>Electricity Generated by Major Countries (Rates of Growth)</td>
<td>Because of the convenience of electric power, the power generation capacities of countries tend to increase year by year. Whereas the rate of increase is low in Japan, North and South America, and Europe, it is on the rise in China, South Korea, and India.</td>
</tr>
<tr>
<td>1-1-10</td>
<td>Electricity Consumption per Capita in Major Countries</td>
<td>Per capita electricity consumption in Canada and the U.S.A. is high. Moreover, China &amp; the U.S.A. consume approximately 40% of the world’s total electricity.</td>
</tr>
<tr>
<td>1-1-11</td>
<td>Dependence on Imported Energy Sources in Major Countries</td>
<td>Compared to other major countries, Japan’s energy supply structure is vulnerable because Japan imports approximately 90% of its energy resources (95% when nuclear energy is not included in domestic energy).</td>
</tr>
<tr>
<td>1-2-2</td>
<td>Changes of Japan’s Primary Energy Supply Structure</td>
<td>Since the oil crisis in the 1970s, Japan has attempted to reduce its dependence on oil. However, oil still accounts for about 50% of the total primary energy supply.</td>
</tr>
<tr>
<td>1-2-3</td>
<td>Historical Trend of Japan’s Primary Energy Supply</td>
<td>Japan’s primary energy supply has been almost constant in recent years and heavily depended on oil even after the oil crises in the 1970s.</td>
</tr>
<tr>
<td>1-2-4</td>
<td>Japan’s Fossil Fuel Imports by Country of Origin</td>
<td>Japan imports around 83% of its crude oil from Middle Eastern countries and imports coal mainly from Australia and liquefied natural gas (LNG) from Southeast Asian nations.</td>
</tr>
<tr>
<td>Chart No.</td>
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</tr>
<tr>
<td>1-2-5</td>
<td>Japan’s Dependence on Middle East Crude Oil of Total Imports</td>
<td>Japan’s dependence on Middle Eastern crude oil had decreased to 67.9% in the late 1980s. However, since then it has increased and is now at the same level as prior to the oil crises in the 1970s.</td>
</tr>
<tr>
<td>1-2-7</td>
<td>Historical Trend of Power Generation Volume by Source in Japan</td>
<td>The amount of electricity generated had been increasing over the years, but has been flat since the Great East Japan Earthquake. Consequent to the stoppage of nuclear power plants, the proportion of power generated with natural gas (LNG), oil, etc., is increasing.</td>
</tr>
<tr>
<td>1-2-8</td>
<td>Historical Trend of Generation Capacity by Source in Japan</td>
<td>In Japan’s generation capacity today, the share of oil fired plants, which was a major generation facility around 1995, has been gradually decreasing and the share of non-oil fired (gas-fired and others) has been increasing.</td>
</tr>
<tr>
<td>1-2-9</td>
<td>Percentage of Electric Power in Primary Energy (Electrification Ratio)</td>
<td>The need for convenient and easy-to-use electrical energy is increasing year by year, and the percentage of electric power in primary energy is currently 40% or more.</td>
</tr>
<tr>
<td>1-2-10</td>
<td>Hourly Power Usage on Peak Power Days</td>
<td>There is a wide gap between how power is used during the day and at night, and this gap tends to widen each year as power usage increases.</td>
</tr>
<tr>
<td>1-2-11</td>
<td>Optimal Combination of Power Sources to Correspond to Demands (Example)</td>
<td>Because Japan imports most of its energy resources, it is crucial not to depend on any particular energy source, but to seek an optimal combination of power sources in order to make the best use of the characteristics of each power source. Electric power companies currently use nuclear power for their base-load, because it excels in stability of generation cost and fuel supply. Thermal and pumped storage hydroelectricity adjust the total supply to meet demand fluctuations.</td>
</tr>
<tr>
<td>1-2-13</td>
<td>Power Consumption Per Household</td>
<td>Although power consumption per household was on the upswing with the proliferation of electric home appliances, since the Great East Japan Earthquake the monthly amount of energy consumed has decreased.</td>
</tr>
<tr>
<td>2-1-1</td>
<td>Mechanism of Greenhouse Effect</td>
<td>Greenhouse gases such as CO₂ absorb infrared rays (heat) radiated from the ground and return part of the heat to the ground, while easily transmitting sunlight with short wavelengths. Accordingly, as CO₂ concentrations increase, infrared rays which cannot be released to outer space increase the ground temperature.</td>
</tr>
<tr>
<td>2-1-2</td>
<td>Contribution of Greenhouse Gases to Global Warming</td>
<td>Global warming is thought to be caused by increases in greenhouse gases generated from burning fossil fuels. In particular, increased CO₂ emissions have the highest contribution.</td>
</tr>
<tr>
<td>2-1-3</td>
<td>Changes in CO₂ Emissions from Fossil Fuels and Atmospheric CO₂ Concentration in Japan</td>
<td>Atmospheric CO₂ concentration has risen dramatically since the Industrial Revolution due to the burning of large volumes of fossil fuels.</td>
</tr>
<tr>
<td>2-1-4</td>
<td>Historical Trends in World’s CO₂ Emissions</td>
<td>Worldwide CO₂ emissions in 2010 were 2 times higher than they were 39 years before in 1971. This increase of CO₂ emissions is mainly due to the rapid growth of emissions in Asia (especially in China and India). CO₂ emissions in Japan increased slightly in 2010 over the base year of the Kyoto Protocol (1990).</td>
</tr>
<tr>
<td>2-1-8</td>
<td>Kyoto Protocol Targets and Current Status of GHG Emissions</td>
<td>To reduce the greenhouse gas emissions of industrialized countries by at least 5% from the baseline year of 1990 by the year 2008 to 2012, the Kyoto Protocol sets specific reduction targets for each country during this period.</td>
</tr>
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<tr>
<td>2-1-9</td>
<td>Lifecycle Assessment CO₂ Emissions Intensity for Japan’s Energy Source</td>
<td>Nuclear power emits significantly less CO₂ per kWh than coal, oil or LNG-fired plants, and about the same as renewable energies such as solar and wind power.</td>
</tr>
<tr>
<td>2-1-11</td>
<td>Japan’s Changes in CO₂ Emissions by Sector</td>
<td>The industrial and transportation sectors accounted for about 52% of Japan’s CO₂ emissions in FY2011. The emissions from households and offices/commercial buildings (business sector) have increased from the 1990 level.</td>
</tr>
<tr>
<td>2-1-12</td>
<td>Changes in GHGs Emissions in Japan</td>
<td>Total emissions in FY2011 increased approximately 4% over the baseline year of the Kyoto Protocol.</td>
</tr>
<tr>
<td>2-1-13</td>
<td>Increase/Decrease in CO₂ Emissions by Sector in Japan</td>
<td>CO₂ emissions from industrial processes (cement manufacturing, etc.) and the industrial sector have fallen below the 1990 level through continuous efforts to reduce emissions. Although CO₂ emissions since 2008 decreased for a time due to the decrease in energy demand following the economic recession, it is on the rise again due to demand from households, businesses and other sectors.</td>
</tr>
<tr>
<td>2-1-14</td>
<td>Changes in CO₂ Emissions by Energy Source</td>
<td>Although CO₂ emissions from oil resources have decreased over 1990, they still accounted for about 44% of total emissions from energy sector in FY2011 in Japan.</td>
</tr>
<tr>
<td>2-1-15</td>
<td>Measures by Japan’s Electric Power Industry to Reduce CO₂ Emissions</td>
<td>Japan is working to cut the emission of CO₂ via initiatives such as Supply-side Efforts, Strengthening Cooperation among Drivers, including Demand-side, Promotion of International Contributions and Development of Innovative Technologies.</td>
</tr>
<tr>
<td>2-1-16</td>
<td>Historical Trends in CO₂ Emissions from Electricity Production in Japan</td>
<td>The introduction of nuclear power has contributed to a decrease in the percentage of CO₂ emissions. The user-end CO₂ emissions intensity (after the Kyoto credit was applied) for FY2012 was 0.487 kg-CO₂/kWh, which was an increase of 0.137 kg-CO₂/kWh from FY2010. This is attributed to the increase in thermal power generation due to the long-term shutdown of nuclear power plants in the wake of the Tohoku-Pacific Ocean Earthquake and tsunami.</td>
</tr>
<tr>
<td>2-1-17</td>
<td>Thermal Efficiency Factor in Japan</td>
<td>In Japan, introduction of combined-cycle power generation and other efforts have improved thermal efficiency in order to reduce CO₂ emissions from thermal power plants.</td>
</tr>
<tr>
<td>2-1-18</td>
<td>Comparison of CO₂ Emissions Intensity by Country</td>
<td>Those countries that utilize more hydroelectric and nuclear power emit less CO₂ from generation. This trend is especially significant in France where the composition of nuclear is high (about 80%).</td>
</tr>
<tr>
<td>2-2-2</td>
<td>SOx and NOx Emissions per Unit of electricity Generated in Major Countries</td>
<td>Compared to other countries, thorough combustion control at thermal power plants has made Japan’s SOx and NOx emissions per unit of electricity generated extremely low.</td>
</tr>
<tr>
<td>3-1-1</td>
<td>What is New Energy?</td>
<td>Renewable energy such as solar, wind, biomass, geothermal, and hydraulic is an energy derived from natural process and is supplied inexhaustibly. “New Energy” is defined as a part of renewable energy which needs support for the dissemination.</td>
</tr>
<tr>
<td>3-1-2</td>
<td>Evaluation &amp; Problems of New Energy</td>
<td>Although new and renewable energy sources are inexhaustible as well as environmentally friendly, they have several drawbacks such as low energy density, instability of supply and uneconomical performances in comparison to conventional energy sources.</td>
</tr>
<tr>
<td>3-1-4</td>
<td>Solar Power Generation Capacity in Japan and the World</td>
<td>More photovoltaic power has been introduced in Japan every year and Japan’s share accounts nearly 7% of the world’s total capacity.</td>
</tr>
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</tr>
<tr>
<td>3-1-5</td>
<td>Wind Power Generation Capacity in Japan and the World</td>
<td>More wind power has been introduced in Japan every year.</td>
</tr>
<tr>
<td>3-1-7</td>
<td>Mechanism of Heat Pump System Utilizing CO2 Refrigerant</td>
<td>Heat pump is a system for gathering heat from the air utilizing Boyle-Charle’s law (the volume of gas is directly proportional to the absolute temperature and inversely proportional to the pressure). If heat pump systems are spread through air conditioning and hot water supplying in Commercial and Residential sector, and drying processes and air conditioning in Industrial sector, it would allow CO2 emissions to be suppressed by max. 130 million t-CO2 per year. This is equivalent to approx. 10% of Japan's total CO2 emissions.</td>
</tr>
<tr>
<td>3-1-9</td>
<td>Mega Solar Power Generation Plant Projects in Japan</td>
<td>Mega solar is a large-scale solar power plants which the electric power companies and others has been promoting. In comparison with the in-house photovoltaic generation system (its capacity is around 2-4kW) being equipped with rooftops, mega solar has a capacity of 1,000-20,000kW.</td>
</tr>
<tr>
<td>3-1-10</td>
<td>Basic Concept of Smart-Grid in Japan</td>
<td>Smart-Grid in Japan is a next-generation electric power transmission and distribution technology. With the high dissemination goals for photovoltaic generation by government aiming for the realization of a low carbon society, the electric utility industry is advancing government-subsidized research on evaluation of the effect of the large-scale expansion of photovoltaic generation on the power system and measures to stabilize the power system using battery storage system.</td>
</tr>
<tr>
<td>3-1-11</td>
<td>Outline of Feed-in Tariff Scheme for Renewable Energies</td>
<td>The “Act on Purchase of Renewable Energy Sourced Electricity by Electric Utilities” was approved at the Diet and will come into force on July 1, 2012, for the purpose of enhancement of renewable energy utilization which can contribute to stable energy supply, mitigation of global warming and development in environment related industries as a driving power for the nation’s economic growth. The Act obliges electric power companies to purchase the electricity generated from renewable energy sources (solar PV, wind power, hydraulic power, geothermal and biomass) based on a fixed-period contract with fixed price. The costs for purchasing such electricity will be collected from customers in form of a surcharge in proportion to electricity consumption together with ordinary electricity rates.</td>
</tr>
<tr>
<td>4-1-1</td>
<td>Comparison of Various Fuels Required to Operate a 1GW Power Plant per Year</td>
<td>Nuclear power can generate a large amount of energy from a small amount of uranium fuel. It is also superior in terms of transportation and storage.</td>
</tr>
<tr>
<td>4-1-2</td>
<td>Proven Reserves and Japan's Procurement of Uranium</td>
<td>Uranium is superior in stability of supply because it is supplied mainly by politically stable countries.</td>
</tr>
<tr>
<td>4-1-3</td>
<td>Nuclear Power Plants in Japan</td>
<td>As of the end of FY2013, 48 commercial nuclear power reactors were in operation in Japan, with a total generation capacity of 44,264MW.</td>
</tr>
<tr>
<td>4-2-1</td>
<td>Generating Capacity of Nuclear Power Plants in Major Countries</td>
<td>As of January 1, 2013, there were 427 nuclear power plants in operation around the world, and this number of nuclear power plants reaches 596 when those under construction and being planned are also included. Japan is third in the world in nuclear power generation facilities (electric output), behind the United States and France.</td>
</tr>
<tr>
<td>4-2-2</td>
<td>Power Generation Composition by Source in Major Countries</td>
<td>Major countries have a different mix of power sources, depending on the abundance and type of domestic energy resources. Since Japan has limited resources and is far from energy independence, it has tried to diversify its power sources to improve its energy security and spread risk.</td>
</tr>
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</tr>
<tr>
<td>4-2-3</td>
<td>Electricity Generated and Share of Nuclear Power in Major Countries</td>
<td>China produces the most electricity in the world with a heavy bias toward coal generation, while the number 2, America, is a major nuclear power country with 104 plants in operation.</td>
</tr>
<tr>
<td>5-2-9</td>
<td>New Regulatory Requirements for Nuclear Power Plants</td>
<td>The new regulations are based on &quot;defense in depth,&quot; which aims to prevent the loss of all safety functions all at once from a common cause. In conjunction with enhancing the design standards, such as the ability to withstand earthquakes and tsunamis, the reliability of power supplies and performance of cooling equipment, they require countermeasures for terrorism and severe accidents that can cope with incidents that exceed the assumptions of such designs. The regulatory requirements prescribe performance based, and specific measures that fulfill those requirements are to be selected by the licensee according to the characteristics of each nuclear power plant.</td>
</tr>
<tr>
<td>5-2-11</td>
<td>Periodic Safety Review of Nuclear Power Plant and Measures for Aging Management</td>
<td>Before 30 years after commissioning the nuclear power plant, the utility implements the technical review for plant life management and establishes 10-year maintenance plan. After national government approves the plan, the utility draws up the additional maintenance program based on the maintenance plan. The technical review and long term maintenance plan is revised every 10 years with introducing the up-to-date technical information.</td>
</tr>
<tr>
<td>5-3-1</td>
<td>Historical Trends in Reported Incidents and Failures at NPPs in Japan</td>
<td>The number of reported incidents and failures of nuclear power plants in Japan has been decreasing since 1981. Due to the revision of the Law on the Regulation of Nuclear Source Material, Nuclear Fuels Material and Reactors in October 2003, quantification and clarification of reporting standard of incidents and failures have been reinforced and notification standards now comply with statutory standards.</td>
</tr>
<tr>
<td>5-3-3</td>
<td>Unplanned Automatic Scrams per 7,000 Hours Critical in Major Countries</td>
<td>Until the Fukushima Daiichi Nuclear Power Station accident in 2011, the rate of unplanned automatic shutdowns of nuclear power plants in Japan had remained at a low level of 0.1 or less, indicating a good operating performance. Currently, at the end of fiscal 2012, all nuclear power plants are shut down.</td>
</tr>
<tr>
<td>5-3-4</td>
<td>Historical Trends in Capacity Factors of NPPs in Major Countries</td>
<td>Japanese nuclear power plants have maintained a favorable record of operation (high rate of facility use), regardless of the having regular inspections about once per year. Since the accident at the Fukushima Daiichi Nuclear Power Station, all nuclear power plants in Japan are currently stopped, as of the end of fiscal 2012.</td>
</tr>
<tr>
<td>5-4-3</td>
<td>Causes of the Accident at Chernobyl Nuclear Power Plant</td>
<td>The Chernobyl accident occurred due to various reasons, such as design defects, operators’ violating regulations, and operational mismanagement. The lack of a safety culture is thought to be the basis of these problems. Safety culture is the philosophy that all individuals and organizations involved in the nuclear industry or studies should give top priority to safety.</td>
</tr>
<tr>
<td>5-8-1</td>
<td>Enhancement of the Nuclear Emergency Preparedness System</td>
<td>To prepare for emergencies, Nuclear Emergency preparedness Council was newly established permanently within the Cabinet for implementing nuclear disaster prevention measures across the entire government in ordinary times.</td>
</tr>
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<tr>
<td>5-8-4</td>
<td>Clarification of Nuclear Emergency Categories (3 Stages)</td>
<td>In the early stages of an emergency, it is necessary to gather information in order to grasp the situation, as well as to judge the preparations and measure to take, such as evacuation to prevent radiation exposure, and having dosages of stable iodine. To this purpose, emergencies are divided into three categories, &quot;Site Area Emergency&quot;, &quot;General Emergency&quot; and a new one, &quot;Alert,&quot; each of which organizes the roles of operators and national and local governments. The newly established &quot;Alert&quot; facilitates the collection of information at an early stage, before a situation becomes an emergency.</td>
</tr>
<tr>
<td>5-8-5</td>
<td>Expansion of Nuclear Emergency Response Action Zone</td>
<td>Under previous disaster prevention guidelines, prevention measures indicated the criteria of a priority area with a radius of 8 to 10 km around nuclear power plants, but that range was reviewed based on the accident at the Fukushima Daiichi Nuclear Power Station and international standards.</td>
</tr>
<tr>
<td>5-8-6</td>
<td>Radiation Protection for Residents</td>
<td>When local governments decide on their local disaster management plans, it is important for them to establish areas such as PAZ's (precautionary action planning zone) or UPZ's (urgent protective action planning zone) as one aim, based on the circumstances of the areas, such as their topography, and natural and social circumstances, as well as the characteristics of the nuclear power plant.</td>
</tr>
<tr>
<td>5-8-7</td>
<td>Reinforcement of Network between Government and Nuclear Power Plant Operators</td>
<td>A satellite-based communication systems has been developed, with facilities such as a video conferencing system, to provide smooth and reliable contact among national and local government and operators, so they can share information even in an emergency situation.</td>
</tr>
<tr>
<td>5-8-9</td>
<td>Nuclear Damage Compensation System</td>
<td>In principle, nuclear operators are liable for all damages caused by accidents in nuclear power plants. The operators are legally bound to have insurance to compensate for any damages suffered. If compensation needs exceed insurance cover, the government will extend aid, pursuant to a Diet resolution.</td>
</tr>
<tr>
<td>6-3-4</td>
<td>Acute Radiation Effects</td>
<td>When a person is exposed to a large amount of radiation at one time, the effects vary in proportion with the quantity of radiation received.</td>
</tr>
<tr>
<td>6-3-12</td>
<td>Relative Cancer Risk Estimation for Radiation Exposure and Lifestyle Factors</td>
<td>According to the follow-up survey on health effects among people exposed to radiation at Hiroshima and Nagasaki, and the research results on cancer risks for lifestyle factors, it is found that the cancer risk estimates for 100 mSv of radiation exposure (100 times stronger than dose limit for general public) increases only 1.08 times. It is almost equivalent to a case of lack of vegetable intake.</td>
</tr>
<tr>
<td>6-4-2</td>
<td>Controls in a Nuclear Power Plant by Area</td>
<td>The site of a nuclear power plant is legally classified into three distinct areas: a controlled area, a protected area and a monitoring area.</td>
</tr>
<tr>
<td>6-4-3</td>
<td>Radiation Exposure Control for Radiation Workers</td>
<td>Radiation exposure is rigorously controlled in accordance with the predefined procedures for radiation workers in controlled areas.</td>
</tr>
<tr>
<td>6-4-6</td>
<td>Environmental Radiation Monitoring around Nuclear Facilities</td>
<td>Nuclear operators monitor environmental radiation around their facility and radioactivity in environmental samples in order to confirm that there is no harmful effect on the surrounding environment.</td>
</tr>
<tr>
<td>7-1-3</td>
<td>Nuclear Fission inside Light Water Reactors</td>
<td>In light water reactors, not only uranium 235 but also uranium 238 undergoes fission. Plutonium 239 is produced as a result of uranium 238 absorbing neutrons. About 30-40% of power output is generated by plutonium in light water reactors and plutonium recovered from spent fuel can be reused as fuel.</td>
</tr>
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<tr>
<td>7-1-4</td>
<td>Utilization of Uranium Resources</td>
<td>Uranium and plutonium obtained by reprocessing are classified as quasi-domestic energy resources. Japan, which has a scarcity of energy resources, needs to reprocess spent fuel to ensure effective use of uranium resources. When JNFL's Rokkasho reprocessing plant goes into full-scale operation and the recovered uranium and plutonium are used in light water reactors, it will correspond to 70TWh of electricity annually.</td>
</tr>
<tr>
<td>7-2-1</td>
<td>Nuclear Fuel Cycle</td>
<td>Spent fuel from nuclear power plants contains unburned uranium and plutonium that are produced during power generation. Both resources are recovered and used as fuel again.</td>
</tr>
<tr>
<td>7-2-2</td>
<td>Nuclear Fuel Cycle (Including FBR)</td>
<td>A fast breeder reactor is a nuclear reactor that can use plutonium directly as a fuel. While such a reactor is being developed for practical use, the use of plutonium (MOX) in light water reactors is planned to ensure effective utilization of uranium resources.</td>
</tr>
<tr>
<td>7-2-5</td>
<td>Outline of JNFL's Nuclear Fuel Cycle Facilities</td>
<td>Four different types of facilities are under construction or in operation at Rokkasho: reprocessing; high-level radioactive waste storage; uranium enrichment; and low-level radioactive waste underground disposal. The reprocessing plant will commission in 2014 and a MOX fuel fabrication plant is scheduled to start its operation in 2017.</td>
</tr>
<tr>
<td>7-4-1</td>
<td>Flow of Reprocessing</td>
<td>The purpose of reprocessing is to recover residual unburned uranium and newly produced plutonium that are left in spent fuel.</td>
</tr>
<tr>
<td>7-5-6</td>
<td>MOX Fuel Use in LWRs in the World</td>
<td>European countries such as France, Germany, Belgium and Switzerland have loaded nearly 6,350 MOX fuel assemblies into LWRs over the last 40 years. The U.S.A. recommenced MOX fuel usage in 2005. In Japan, an advanced thermal reactor, Fugen (closed down in March 2003), had safely consumed a total of 772 MOX fuel assemblies apart from light water reactors.</td>
</tr>
<tr>
<td>7-6-1</td>
<td>Mechanism of Fast Breeder Reactor (FBR)</td>
<td>A fast breeder reactor is a nuclear reactor that can use plutonium directly as a fuel. It uses sodium as a coolant and generates steam by transferring the heat from the sodium heated in the nuclear reactor to water.</td>
</tr>
<tr>
<td>7-7-3</td>
<td>Spent Fuel Interim Storage Facility</td>
<td>The spent fuel rods from the nuclear power plant are inserted in sturdy steel casks and safely stored until reprocessing in the interim storage facility. Interim storage of the spent fuel rods enables adjustment of the time schedule until they are reprocessed and is one effective way of providing flexibility in the operation of the entire nuclear fuel cycle.</td>
</tr>
<tr>
<td>7-8-1</td>
<td>Safety Regulation Flow of Nuclear Fuel Transport</td>
<td>Nuclear fuel is packed in transport containers that have been inspected by the government. The containers are shipped after being checked several times.</td>
</tr>
<tr>
<td>7-8-5</td>
<td>Transport Casks for Spent Fuel</td>
<td>Spent fuel is transported in exclusive-use casks. The casks possess the ability to shield radiation and prevent radioactive materials from escaping in cases of collision or fire.</td>
</tr>
<tr>
<td>7-8-6</td>
<td>Transport Vessels for Spent Fuel</td>
<td>Vessels used exclusively to transport spent fuel are equipped with ample safety measures including double-hulls and double-bottomed construction to prevent foundering, even in case of collision or stranding.</td>
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<tr>
<td>8-1-5</td>
<td>Radioactive Waste Types and Disposal</td>
<td>Generally, low-level radioactive waste is planned to be disposed by burying underground, and high-level radioactive waste is to be vitrified and stored for 30 to 50 years, and then it is disposed of underground at depths of 300 meters or more (geological disposal).</td>
</tr>
<tr>
<td>8-2-1</td>
<td>Structure of Low-level Radioactive Waste Disposal Facility</td>
<td>Metal drums containing LLW are emplaced in the facility with various barriers and under strict control.</td>
</tr>
<tr>
<td>8-3-2</td>
<td>Transport Casks for High-level Radioactive Waste (Vitrified Waste) Shipment container</td>
<td>High-level radioactive waste is transported in exclusive-use casks. The casks can shield radiation and are designed and built in accordance with national standards to ensure reliability in cases of severe accidents such as fire, collision or sinking.</td>
</tr>
<tr>
<td>8-3-3</td>
<td>Transport Vessels for High-level Radioactive Waste (Vitrified Waste)</td>
<td>Vessels used to transport high-level radioactive waste (vitrified waste) have the following features: (1) a doublehulled structure; (2) wide-ranging fire fighting equipment; and (3) radar installation.</td>
</tr>
<tr>
<td>8-3-4</td>
<td>Temporary Storage for High-level Radioactive Waste (Vitrified Waste)</td>
<td>HLW (vitrified waste) storage pits have many thimble tubes. Each thimble tube can store 9 vitrified wastes. Indirect natural air cooling system is employed, and cooling air ventilate outside of the thimble tubes not to contact the vitrified waste directory.</td>
</tr>
<tr>
<td>8-3-6</td>
<td>Examination of Methods for Disposing of High-Level Radioactive Waste</td>
<td>Bearing in mind the difficulties of people managing wastes into perpetuity and not burdening future generations with monitoring them, we are examining methods that allow the disposal of high-level radioactive wastes safely without the need for human management.</td>
</tr>
<tr>
<td>8-3-8</td>
<td>Geological Disposal of High-level Radioactive Waste</td>
<td>HLW will be disposed of in a stable geological formation at a depth of more than 300 meters. All disposal tunnels will be backfilled at the end and sealed up completely.</td>
</tr>
<tr>
<td>9-2-2</td>
<td>Safeguards System in Japan</td>
<td>Under the Treaty on the Non-proliferation of Nuclear Weapons (NPT), all nuclear facilities in Japan receive inspections by the International Atomic Energy Agency (IAEA) as well as the Japanese government to ensure that nuclear energy is only used for peaceful purposes.</td>
</tr>
<tr>
<td>9-3-1</td>
<td>Electric Power Development based on the Three Laws</td>
<td>The three laws consist of 1) the Law on Tax for Promotion of Electric Power Development, 2) the Law on Special Accounts, and 3) the Law on the Development of Areas adjacent to Power Generating Facilities. These laws were enacted to develop public facilities and other facilities in order to boost local industries and provide infrastructure for the convenience of local communities where nuclear, thermal and hydro power generation facilities stand.</td>
</tr>
<tr>
<td>10-1-1</td>
<td>Outline of the Tohoku-Pacific Ocean Earthquake</td>
<td>14:46 on March 11, 2011, the “Tohoku-Pacific Ocean Earthquake” (the Great East Japan Earthquake) with magnitude 9.0 in Richter scale struck the eastern part of Japan. The epicenter was offshore Sanriku (around 130 km east-southeast of the Ojika Peninsula) and the depth of hypocenter was approx. 24 km.</td>
</tr>
<tr>
<td>10-1-2</td>
<td>Height of Tsunami triggered by the Tohoku-Pacific Ocean Earthquake</td>
<td>As the Tohoku-Pacific Ocean Earthquake, a series of tsunami was observed widely at the Pacific coast (mainly from Tohoku region to the northern part of Kanto region). According to the Japan Meteorological Agency’s field survey on tsunami, over-10-meters-high tsunami struck the coast of Iwate prefecture and fewmeter-high traces of tsunami strike was found everywhere at wide range of Pacific coast (from Hokkaido to Shikoku).</td>
</tr>
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<tr>
<td>10-2-1</td>
<td>Current Status of NPSs Affected by the Tohoku-Pacific Ocean Earthquake</td>
<td>When the Great East Japan Earthquake struck, all the reactors operating at the time at Tohoku Electric Power’s Onagawa Nuclear Power Station, Tokyo Electric Power’s Fukushima Daini Nuclear Power Station and Japan Atomic Power’s Tokai No.2 Power Station shut down automatically and their cooling systems functioned properly. Consequently, all these reactors went into cold shutdown in a few days. On the other hand, although Tokyo Electric Power’s Fukushima Daiichi Nuclear Power Station shut down automatically, the reactors and the spent fuel pools cooling functions failed due to the loss of all AC power because of the tsunami. This led to hydrogen explosions and release of radioactive materials into the atmosphere.</td>
</tr>
<tr>
<td>10-2-2</td>
<td>Outline of the Accident at the Fukushima Daiichi Nuclear Power Station</td>
<td>When the earthquake struck at the Fukushima Daiichi Nuclear Power Station, of the six units at the plant, the nuclear reactors for units 1, 2, and 3, which were operating at the time, automatically shut down. Although the earthquake caused all the external power supplies to fail, the emergency diesel generators started up automatically to provide the necessary power supplies. However, when the massive tsunami struck, many electrical power boards were flooded and damaged by sea water, and except for unit 6, the emergency diesel generators stopped, and all AC power was lost. As a result, the cooling functions of the nuclear reactors and spent fuel pool for units 1 to 3 remained stopped for a considerable period of time. This caused damage to the cladding of the nuclear reactor fuel rods, and hydrogen was generated due to the chemical reaction with water vapor. Then, an explosion thought to be due to the hydrogen that leaked from the primary containment vessel occurred in units 1 and 3, damaging the upper section of the nuclear reactor buildings, and causing the release of radioactive materials into the environment.</td>
</tr>
<tr>
<td>10-2-3</td>
<td>Scale of Tsunami and Inundation at the Fukushima Daiichi Nuclear Power Station</td>
<td>The Fukushima Daiichi Nuclear Power Station used seafloor topography data and other information to estimate the height of a potential tsunami of 6.1 meters, but the tsunami that followed the Great East Japan Earthquake greatly surpassed that estimate and reached a height of some 14 to 15 meters. The massive tsunami overran the main building site (units 1 to 4 are 10 meters high and units 5 and 6 are 13 meters above sea level), flooding the entire area and penetrating the main buildings. As a result, all power was lost in units 1 to 4 of the Fukushima Daiichi Nuclear Power Station.</td>
</tr>
<tr>
<td>10-3-1</td>
<td>Outline of Safety Assurance Measures implemented after the Fukushima Daiichi Accident</td>
<td>Taking on the lessons from the accident at the Fukushima Daiichi Nuclear Power Station, where all power failed due to the earthquake and the tsunami, the electric power companies in Japan have undertaken safety measures at their nuclear power plants, with a focus on measures against tsunamis. The companies have taken measures (such as enhancing internal communication procedures and preparing clothing to protect against high doses of radiation), to enable work to progress steadily even in the face of a severe accident, including deploying additional emergency power source vehicles and fire engines, as emergency safety measures to prevent fuel damage no matter what by ensuring the continuous cooling of the reactor and spent fuel pools. They are also proceeding with medium and long-term measures, such as additional installation of uninterruptible emergency power supplies on high ground, building seawalls and deploying watertight construction, as well as temporary large capacity seawater pumps.</td>
</tr>
<tr>
<td>10-3-2</td>
<td>Examples of Safety Assurance Measures implemented after the Fukushima Daiichi Accident</td>
<td>After the earthquake the electric power companies promptly took emergency safety measures including deploying additional emergency power source vehicles and wheel loaders, etc. The companies are also taking medium- to long-term measures which include constructing coastal levees and tide walls in order to increase safety margin of the nuclear power stations.</td>
</tr>
</tbody>
</table>
The Federation of Electric Power Companies of Japan

Keidanren-kaikan,
1-3-2, Otemachi, Chiyoda-ku, Tokyo
100-8118, Japan
http://www.fepc.or.jp/english/index.html