Current Situation of Nuclear Power Generation in Japan

The Federation of Electric Power Companies of Japan
February 24, 2016
Due to the earthquake on March 11, 2011 and outage that followed, all 54 units were shut down in May 2012.

Since then, 6 units declared decommissioning due to the accident, and 5 units declared decommissioning in March 2015.

Sendai Unit 1 restarted commercial operation on September 10, 2015.
Due to increase of burnup at thermal power stations following shutdown of all nuclear power plants after the earthquake, approximately 90% of generated energy relies on thermal power. All 3E’s were impaired.

**Composition ratio of generated energy**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>25.0%</td>
<td>31.0%</td>
</tr>
<tr>
<td>LNG</td>
<td>29.3%</td>
<td>46.2%</td>
</tr>
<tr>
<td>Oil</td>
<td>7.5%</td>
<td>10.6%</td>
</tr>
<tr>
<td>Nuclear power</td>
<td>28.6%</td>
<td>9.0%</td>
</tr>
<tr>
<td>Hydraulic power</td>
<td>8.5%</td>
<td>3.2%</td>
</tr>
<tr>
<td>Renewable energy</td>
<td>1.1%</td>
<td>1.1%</td>
</tr>
</tbody>
</table>

Reliance on thermal power increases

**All 3E’s (energy security, economy, environmental conservation) are impaired**

- **Energy security**
  - (reliance on fossil fuel)
  - (approx. 60% ⇒ approx. 90%)

- **Economy**
  - (increase of thermal power fuel cost)
  - (increase of approx. 4 trillion yen)

- **Environmental conservation**
  - (increase of amount of CO₂ emitted)
  - (increase of approx. 100 million tons of CO₂)

Note: Figures in red in ( ) are comparison of FY2010 and FY2014
For simultaneous achievement of S and 3E’s, nuclear power generation is an important base load power supply.
Cost of nuclear power generation is cheap, even when taking accident risk response cost into account.
Ratio of nuclear power generation among power supplies will be maintained at around 20-22% in FY2030.

Framework of basic energy plan (related to nuclear power) [April 2014]
○ Nuclear power generation is an important base load power supply, but its ratio will be reduced as much as possible
○ Restart is promoted for nuclear power stations that have conformed to new regulatory requirements
○ Nuclear fuel cycle including reprocessing and use of MOX will continue to be promoted

Trial calculation of cost by power supply (trial calculation of 2014 model plant) [April 2015]

Development of energy mix plan [April 2015]
○ Composition ratio of power supply in 2030

<table>
<thead>
<tr>
<th>Power Supply</th>
<th>Nuclear power</th>
<th>Oil</th>
<th>Coal</th>
<th>LNG</th>
<th>Renewable energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY2030 composition ratio</td>
<td>Around 20-22%</td>
<td>Around 3%</td>
<td>Around 26%</td>
<td>Around 27%</td>
<td>Around 22-24%</td>
</tr>
</tbody>
</table>
We, the operators in Japan, continue to make efforts to use nuclear power station and to establish nuclear fuel cycle.

For use of nuclear power, major premise is safety.

Viewpoint of “S+3E” is important when thinking about energy

Approach of operators in Japan concerning “nuclear power”

(1) Continue to use nuclear power as an important power supply excelling in 3E’s.

(2) Promote restart of nuclear power stations that conform to regulatory requirements, in full-scale.

(3) Make efforts for the completion of the reprocessing facility as there is no change in importance of the nuclear fuel cycle.

For use of nuclear power, major premise is safety (S)
Years of Operation about Nuclear Power Generation in Japan (As of January 31, 2016)

- **January, 2009**: Chubu Electric Power Hamaoka 1, 2 were decommissioned.
- **January, 2014**: TOKYO ELECTRIC POWER COMPANY Fukushima Daiichi 1~4 were declared decommissioning. Being carried out decommissioning and contaminated water countermeasures based on medium and long term road map.
- **April, 2012**: TOKYO ELECTRIC POWER COMPANY Fukushima Daiichi 1~4 were declared decommissioning. Site decontamination and decommissioning (medium term & long term).
- **March, 1998**: The Japan Atomic Power Company Tokai was decommissioned.
- **April, 2015**: 5 units were declared decommissioning.
- **April, 2015**: After 20 ~ 29 years

Commencement of commercial operation:
- 1966: Tomari 1
- 1967: Hamaoka-1, Mihama 2, Tsuruga 2
- 1968: Kashiwazaki Karaiwa-1
- 1969: Tsuruga 1
- 1970: Shimane 2
- 1971: Ohi 3
- 1972: Shimane 1, Tomari 2
- 1973: Kashiwazaki Karaiwa-2
- 1974: Kashiwazaki Karaiwa-1
- 1975: Genkai 4
- 1976: Genkai 3
- 1977: Onagawa 3
- 1978: Onagawa 4
- 1979: Tsuruga 3
- 1980: Ohi 4
- 1981: Genkai 2
- 1982: Hamaoka-2
- 1983: Shika 1
- 1984: Kashiwazaki Karaiwa-3
- 1985: Shika 2
- 1986: Tomari 3
- 1987: Tomari 5
- 1988: Kashiwazaki Karaiwa-4
- 1989: Kashiwazaki Karaiwa-5
- 1990: Sendai 1
- 1991: Sendai 2
- 1992: Hamaoka-3
- 1993: Genkai 4
- 1994: Hamaoka-4
- 1995: Onagawa 5
- 1996: Higashidori 1
- 1997: Shika 3
- 1998: Shimane 3
- 1999: Shimane 4
- 2000: Shimane 5
- 2001: Shimane 6
- 2002: Shimane 7
- 2003: Shimane 8
- 2004: Shimane 9
- 2005: Shimane 10
- 2006: Tomari 4
- 2007: Tomari 6
- 2008: Tomari 7
- 2009: Tomari 8

Number of Units:
- 1966: 1
- 1967: 3
- 1968: 4
- 1969: 5
- 1970: 8
- 1971: 10
- 1972: 13
- 1973: 14
- 1974: 18
- 1975: 21
- 1976: 22
- 1977: 24
- 1978: 27
- 1979: 32
- 1980: 35
- 1981: 37
- 1982: 39
- 1983: 41
- 1984: 45
- 1985: 48
- 1986: 49
- 1987: 50
- 1988: 52
- 1989: 53
- 1990: 55
- 1991: 56
- 1992: 57

□: Applied for over 40 years operation
■: Decided to be decommissioned
→: Being carried out decommissioning and contaminated water countermeasures based on medium and long term road map.
Decommissioning Schedule (Tokai Power Station)

- **September 30**: Termination of operation (Mar.31)
- **October 4**: Submission of reactor dismantling application (Oct.4)
- **May 28 to June 21**: Discharge and shipment of fuel

**Reactor area dismantling**
- **June 30**: Approval of decommissioning plan
- **July 30**: Notification of charge
- **December 19**: Notification of charge

**Removal of except reactor area**
- **Removal of conventional facilities etc.**
- **Removal of SRUs etc.**
- **Removal of conventional facilities of each building etc.**

**Actual achievement**
### Outline of Tokai Power Station Decommissioning Work

<table>
<thead>
<tr>
<th>First Phase</th>
<th>Second Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Removal of except reactor area</strong></td>
<td><strong>Removal of except reactor area (mainly SRUs)</strong></td>
</tr>
<tr>
<td>House Boiler and others</td>
<td>House Boiler and others</td>
</tr>
<tr>
<td>Charge machine</td>
<td>Charge machine</td>
</tr>
<tr>
<td>FeedWater Pump and others</td>
<td>SRU: steam raising unit</td>
</tr>
<tr>
<td>Turbine-generators and others</td>
<td></td>
</tr>
<tr>
<td>Cartridge Cooling Pond</td>
<td></td>
</tr>
<tr>
<td>and cleaning and draining of CCP</td>
<td></td>
</tr>
</tbody>
</table>

(Figures in red were completed)

- **Third Phase**
  - **Reactor area dismantling**
    - Reactor internals & Reactor Pressure Vessel
    - Biological shield
  - **Removal of building**
    - Note: Basement and foundation of building will not be removed
Outline of SRU Removal

- **SRU**
  - height: 24m
  - diameter: 6m
  - weight: 750t

- **‘Tier’**
  - height: 1.7 ~ 3.2m
  - diameter: 6m
  - weight: 54 ~ 135t
  - thickness: 54 ~ 94mm

**Cutting area (3FL)**

Install of temporary frame and jack device

Jacking down (tier 1-9)

Removal of temporary frame and jack device

**Illustrated image of work**

Remote-operated cutting device

[Layout of cutting device]

[Primary cutting]

[Transport of cut piece]

[Secondary cutting]
### Enhancement of Safety Improvement Measures after the Fukushima Daiichi Accident

<table>
<thead>
<tr>
<th>Design basis</th>
<th>Measures before the accident</th>
<th>Measures immediately after the accident</th>
<th>Further safety improvement measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st phase</td>
<td>Prevention of abnormality</td>
<td>Disaster prevention</td>
<td></td>
</tr>
<tr>
<td>2nd phase</td>
<td>Prevention of abnormal spread</td>
<td>Accident management</td>
<td>- Establishment of nuclear emergency support organization</td>
</tr>
<tr>
<td>3rd phase</td>
<td>Mitigation of impact of accident</td>
<td>Prevention of severe core damage</td>
<td>- Securing of power supply</td>
</tr>
<tr>
<td></td>
<td>Maintenance of containment vessel</td>
<td>Developing core damage and containment vessel damage caused</td>
<td>- Securing of cooling</td>
</tr>
<tr>
<td>4th phase</td>
<td>Beyond design basis (severe accident)</td>
<td>Prevention of large-scale release</td>
<td>- Anti-seismic administration building</td>
</tr>
<tr>
<td></td>
<td>- Prevention of damage of containment vessel (suppression of release/mitigation of spread)</td>
<td>Accident management management measures by normal system equipment to avoid core damage and containment vessel damage caused</td>
<td>- Filter vent facility</td>
</tr>
<tr>
<td>5th phase</td>
<td>Prevention of human damages, Recovery of environment</td>
<td>- Enhancement of emergency response structure</td>
<td>- Facilities for handling specific severe accidents</td>
</tr>
</tbody>
</table>

### Measures before the Fukushima Daiichi Nuclear Power Station accident
- Mitigation of impact of accident
- Prevention of abnormal spread
- Prevention of abnormality

### Measures immediately after the Fukushima Daiichi Nuclear Power Station accident
- Detection of abnormality / shutdown system, etc.
- Flooding measures
- Emergency core cooling system, containment vessel spray system, etc.

### Further safety improvement measures
- Establishment of nuclear emergency support organization
- Securing of power supply
- Securing of cooling
- Anti-seismic administration building
- Filter vent facility
- Facilities for handling specific severe accidents

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**Key**
- Scope of measures before the Fukushima Daiichi Nuclear Power Station accident
- Scope of measures after the Fukushima Daiichi Nuclear Power Station accident
Measures to Secure Power Supply and Cooling, and to Prevent Flooding (Examples of Measures by Hardware)

**Measures immediately after the accident**

**Emergency safety measures**
- **Securing of power supply**
  - Preparation of power source cars

- **Securing of cooling**
  - Preparation of portable pumps and hoses

- **Flooding measures**
  - Application of waterproofing seal to penetration

**Currently being implemented (examples of measures)**
- Preparation of air-cooled emergency generator
- Preparation of large-capacity pump truck
- Replacement to watertight door
- Seawater pump waterprooﬁng of wall

**Further safety improvement measures**
- Preparation of reserve seawater pump motor components
- Raising of seawall

**Anti-seismic building**
- Water cannon
Natural Event Measures (Examples of Measures by Hardware)

**Further safety improvement measures – natural event measures**

**Earthquake measures (example)**

1. Seismic reinforcement of pipe support
   - **Enhance seismic support**
   - **Add seismic support**

2. Stabilization of surrounding slope
   - **Amount of excavated earth and sand**
     - Mountaintop: 60,200m³
     - Hillside: 34,000m³

**Tsunami measures (example)**

1. Raising of seawall
2. Installation of tide gate
3. Seawater pump
   - Water proof wall

[Intake side]

**Enhancement of fire measures (example)**

1. Installation of sprinklers
   - **Installation of sprinklers**
   - (approx. 1600 areas / 2 units)

2. Installation of fire spread prevention wall

**Tornado measures (example)**

1. Measure to protect against flying objects
   - **<Top> Steel fence absorbs energy of flying objects**
   - **<Side> Penetration is prevented with steel plate**
Measures to Improve Emergency Response Structure (Examples of Measures by Software)

**Measures immediately after the accident**

- Increase of initial response personnel
- Development of operation assistance structure
- Enhancement of liaison and support structure with manufacturer
- Development of manual and training
- Securing of communication method that does not breakdown, etc.

**Establishment of nuclear emergency Support Center**

- 24-hour on-call standby for 365 days
- Training and development of personnel
- Maintenance and management of robots and other equipment and materials, etc.

**Further safety improvement measures**

Currently being implemented (examples of measures)

- 24-hour on-call standby for 365 days
- Training and development of personnel
- Maintenance and management of robots and other equipment and materials, etc.

**Transfer to nuclear emergency support organization**

Development as a disaster response organization with the world’s highest level of standards that is capable of diversified and high-level disaster response under high radiation dose

**Robot operation training**

Small robot, small UAV  Wireless heavy machinery  Wireless relay van

Collection of information, opening and closing of door  Removal of obstacles and debris  Heavy machinery control truck
24 units applied for review for checking conformity to New Regulatory Requirements. 5 units gained permission for changes in reactor installation, 1 unit restarted operation, 2 units are undergoing pre-service inspection, and 2 units are having their plan for construction works reviewed.

* Takahama Units 1 and 2 applied for approval of extension of operation period to 60 years.
## Restart status of nuclear power plants in Japan

### 【Restart status】

- Sendai unit 1 restarted commercial operation in September 2015, and Sendai unit 2 restarted commercial operation in November 2015.
- Takahama unit 3 started up the reactor (on January 29, 2016) and reached criticality (on January 30, 2016) and connected the generator in parallel and started generating power (on February 1, 2016) and now is preparing for commercial operation.
- Takahama unit 4 finished fuel loading and now is preparing for start-up.

<table>
<thead>
<tr>
<th>Plan for construction</th>
<th>Takahama unit 3</th>
<th>Takahama unit 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aug. 4, 2015 approval</td>
<td></td>
<td>Oct. 9, 2015 approval</td>
</tr>
<tr>
<td>Operational safety program</td>
<td>Oct. 9, 2015 approval</td>
<td></td>
</tr>
<tr>
<td>Pre-operational inspection</td>
<td>Aug. 4, 2015 applied</td>
<td>Oct. 14, 2015 applied</td>
</tr>
<tr>
<td></td>
<td>Aug. 17, 2015 started</td>
<td>Oct. 21, 2015 started</td>
</tr>
<tr>
<td>Fuel loading</td>
<td>finished (Dec. 25〜Dec. 28)</td>
<td>finished (Jan. 31〜Feb. 3)</td>
</tr>
<tr>
<td>Reactor startup</td>
<td>Jan. 29, 2016</td>
<td><strong>In Feb. 2016 scheduled</strong></td>
</tr>
<tr>
<td>Comprehensive inspection</td>
<td><strong>In late Feb. 2016 scheduled</strong></td>
<td><strong>In Mar. 2016 scheduled</strong></td>
</tr>
</tbody>
</table>
## Progress Toward Restart of operation

### Restart of operation
- Aug. 2015
- Aug. 2015

### Local consent
- Nov. 2014
- Nov. 2014
- Dec. 2015
- Dec. 2015
- Oct. 2015

### Technical Specifications
- May. 2015
- May. 2015
- Oct. 2015
- Oct. 2015

### Inspection
- Mar. – 2015
- Jun. – 2015
- Aug. – 2015
- Oct. – 2015

### Construction plan authorization
- Mar. 2015
- May. 2015
- Aug. 2015
- Oct. 2015

### Approval (Review period)
- Sep. 2014
- Sep. 2014
- Feb. 2015
- Feb. 2015
- Jul. 2016

### Ss finalized (Period)
- Mar. 2014
- Mar. 2014
- May 2014
- May 2014
- Dec. 2014
- May 2014
- May 2014
- Dec. 2015
- Dec. 2015
- Dec. 2014
- Dec. 2014
- Oct. 2014
- Oct. 2014
- Aug. 2014
- Dec. 2014
- Aug. 2014
- Dec. 2014

### Application
- Jul. 2013
- Jul. 2013
- Jul. 2013
- Jul. 2013
- Jul. 2013
- Jul. 2013
- Jul. 2013
- Jul. 2013
- Jul. 2013
- Jul. 2013
- Jul. 2013
- Sep. 2013
- Sep. 2013
- Dec. 2013
- Dec. 2013
- Feb. 2014
- May 2014
- Jun. 2014
- Aug. 2014
- Dec. 2014
- Mar. 2015
- Jun. 2015
- Nov. 2015

### No. of plants
- 19 plants

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### Examination teams
- Plants: 4 teams A–D
- Seismic ground motion: 1 team E

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※1: Issue presented by fracture zone inspection within site

※2: NRA decided to give priority to Kashiwazaki Kariwa 6&7 by reviewing TEPCO’s license application regarding their facilities (not the seismic issue) first among the applications of four utilities operating BWR reactors. NRA added that this does not mean these two reactors will restart the earliest among BWR plants.

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The Federation of Electric Power Companies
Thorough safety improvement measures are implemented under a strong leadership with the determination to “continue making reforms and aim for the world’s highest level of safety”.

Core damage is prevented even when all 3 functions (all AC power supply, seawater cooling function, spent fuel pool cooling function) are lost due to beyond-design-basis tsunami as it occurred at Fukushima Daiichi Nuclear Power Station.

Emergency safety measures
- Securing of power supply
- Securing of cooling
- Flooding measures etc.

Further safety improvement measures
- On-site electric facility measures
- Cooling and water injection facility measures
- Flooding prevention measures
- Containment vessel damage and hydrogen explosion measures
- Enhancement of disaster prevention measures

Before accident
- Immediately after accident

Reflection of good practices and new knowledge inside and outside Japan
Engage in the entire nuclear power industry
Establishment of JANSI and Nuclear Risk Research Center

Efforts aiming for the world’s highest level of safety
Reflection of Good Practices and New Knowledge Inside and Outside Japan

Role of JANSI and Nuclear Risk Research Center

- JANSI: Excellence setting
- Nuclear Risk Research Center: Research result
- Nuclear operator: Continuous improvement of safety
- Plant manufacturer: Proposal of improvement measures

- Good practices inside and outside Japan, etc.
- Sharing
- Suggestion and recommendation for achieving excellence through peer reviews
- Suggestion based on research result, checking of implementation status
JANSI

All presidents are to support activities of JANSI under the strong sense of crisis that “there will be no future for nuclear power in Japan unless JANSI functions”.

- JANSI was established in November 2012 aiming to become Japan’s version of INPO, under the determination to “never again let the Fukushima Daiichi accident occur”.

  ✓ Mission is “untiring pursuit of the highest standards of excellence” in Japan’s nuclear power industry.

  ✓ Aim to acquire equivalency as WANO peer review.

  ✓ Plan to establish a structure as a self-regulation organization after 5 years of establishment.
Operators are to commit to activities of NRRC and reflect the result in their safety improvement activities, in order to make the risk management structure more robust.

- On October 1, 2014, NRRC was established as the base for research and development necessary for voluntary improvement of safety of nuclear power generation.
  - Research concerning low-frequency external events such as earthquakes and tsunami
  - Supports structuring of PRA comparable to international standards, in order to structure “good PRA” which is helpful in decision-making of operators using risk information
We, nuclear operators in Japan, will continue to proactively take action aiming for world’s highest level of safety as the ones with prime responsibility for securing safety of nuclear power stations.

We will continue to operate nuclear power stations with safety first policy.