Japan’s LNG Utilization and Environmental Efforts

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Polar Alaska (November 4, 1969)
Contents

1. Japan’s energy scene and LNG

2. LNG terminals in Japan and its domestic chain

3. Countermeasures for environmental issues in LNG terminals
Japan’s Dependence on Imported Energy (2004)

- High dependence on imported energy resources

82% Import

18% Indigenous

Source: Energy Balances of OECD Countries 2003-2004, IEA

*IEA defines nuclear power as indigenous energy.
Total primary energy supply in Japan continues to increase.

LNG Consumption in Japan (as of 2005)

- Power Generation: 65%
- City Gas: 35%

Source: The Institute of Energy Economics, Japan
Trend of Feedstock of City Gas

Mil. m³

- Others
- Coal-based gas
- LPG
- Naphtha
- Domestic natural gas
- LNG

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The Position of Natural Gas in Japan’s Energy Policy

**Basic Energy Plan**  (Mar. ’07)
- Promote the introduction and expanded use of natural gas

**Energy Supply-Demand Outlook for 2030**  (Mar. ’05)
- Increase the overall share of natural gas by shifting to decentralized power sources
  (13% in 2000 to 16% in 2030)

**The Kyoto Protocol Targets Achievement Plan**  (Apr. ’05)
- Natural gas is a clean energy source, which has relatively small environmental impact.
- Accelerate the shift to natural gas while maintaining a balance with other energy sources
Contents

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LNG Receiving Terminals in Japan

Black: LNG terminal for ocean tankers
Blue: LNG terminal for coastal tankers
Newly Constructed LNG Facilities

LNG Terminals for Ocean Tankers

LNG Terminals for Coastal Tankers
Takamatsu (2003), Okayama (2003),

LNG Satellite Terminals
Increasing by approx. 10 terminals/year
→ Tsu, Sowa, Asahikawa, Kochi, etc.
Tsu LNG Satellite Terminal

<table>
<thead>
<tr>
<th>Units</th>
<th>Capacity</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trains</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>LNG Storage Tanks</td>
<td>360 kl</td>
<td>2</td>
</tr>
<tr>
<td>LNG Vaporizers</td>
<td>5 t/h</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>3 t/h</td>
<td>3</td>
</tr>
<tr>
<td>Other Facilities:</td>
<td>odorizing equipment, emergency generator</td>
<td></td>
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</tbody>
</table>
Contents

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Global Warming Countermeasures by Industry

- Keidanren Voluntary Action Plan on the Environment
- Annual check & review by the government

Gas industry has also established carbon dioxide reduction goals
Countermeasures for Environmental Issues at Receiving Terminals

1. Effective utilization of cryogenic energy
   - Cryogenic power generation
   - Air liquefaction separation plants (utilization of cryogenic energy)

2. Development of new LNG facilities with less energy consumption
   - Newly developed open-rack type LNG vaporizer
   - BOG liquefaction using LNG cold storage
   - Highly-efficient seawater pump (VVVF, variable vane type)

3. Reduction of greenhouse gas emissions by ingenious operation
   - Using ORV for the base load and SCV for peak shaving
   - Reduction of methane emission by accumulating improvements
   - Reduction in CO₂ and SOₓ emissions of LNG tankers at berth
Cryogenic Power Generation

Rankine cycle type:

Direct expansion type:

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# Cryogenic Power Plants in Japan

<table>
<thead>
<tr>
<th>Company and terminal names</th>
<th>No. of units</th>
<th>Start of operation</th>
<th>Output (kW)</th>
<th>Type</th>
<th>LNG consumption (t/h)</th>
<th>Delivery (MPa)</th>
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</thead>
<tbody>
<tr>
<td>Osaka Gas, Senboku Daiini</td>
<td>1</td>
<td>12/1979</td>
<td>1,450</td>
<td>Rankine</td>
<td>60</td>
<td>3.0</td>
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<tr>
<td>Toho Gas, Chita Kyodo</td>
<td>1</td>
<td>12/1981</td>
<td>1,000</td>
<td>Rankine</td>
<td>40</td>
<td>1.4</td>
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<tr>
<td>Osaka Gas, Senboku Daiini</td>
<td>1</td>
<td>2/1982</td>
<td>6,000</td>
<td>Rankine / NG direct expansion</td>
<td>150</td>
<td>1.7</td>
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<tr>
<td>Kyushu Electric Power and Nippon Steel, Kitakyushu LNG</td>
<td>1</td>
<td>11/1982</td>
<td>9,400</td>
<td>Rankine / NG direct expansion</td>
<td>150</td>
<td>0.9</td>
</tr>
<tr>
<td>Chubu Electric Power, Chita LNG</td>
<td>2</td>
<td>#1 6/1983</td>
<td>7,200</td>
<td>Rankine / NG direct expansion</td>
<td>150</td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#2 3/1984</td>
<td>7,200</td>
<td>Rankine / NG direct expansion</td>
<td>150</td>
<td>0.9</td>
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<tr>
<td>Tohoku Electric Power, Nihonkai LNG</td>
<td>1</td>
<td>9/1984</td>
<td>5,600</td>
<td>NG direct expansion</td>
<td>175</td>
<td>0.9</td>
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<tr>
<td>Tokyo Gas, Negishi</td>
<td>1</td>
<td>4/1985</td>
<td>4,000</td>
<td>Mixed refrigerant Rankine</td>
<td>100</td>
<td>2.4</td>
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<tr>
<td>Tokyo Electric Power, Higashi Ogishima</td>
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<td>#1 5/1986</td>
<td>3,300</td>
<td>NG direct expansion</td>
<td>100</td>
<td>0.8</td>
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<tr>
<td>Osaka Gas, Himeji</td>
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<td>3/1987</td>
<td>2,800</td>
<td>Rankine</td>
<td>120</td>
<td>4.0</td>
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<tr>
<td>Tokyo Electric Power, Higashi Ogishima</td>
<td>2</td>
<td>#2 9/1987</td>
<td>8,800</td>
<td>NG direct expansion</td>
<td>170</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#3 9/1991</td>
<td>8,800</td>
<td>NG direct expansion</td>
<td>170</td>
<td>0.4</td>
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<tr>
<td>Osaka Gas, Senboku Daiichi</td>
<td>1</td>
<td>2/1989</td>
<td>2,400</td>
<td>NG direct expansion</td>
<td>83</td>
<td>0.7</td>
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<tr>
<td>Chubu Electric Power, Yokkaichi</td>
<td>1</td>
<td>12/1989</td>
<td>7,000</td>
<td>Rankine / NG direct expansion</td>
<td>150</td>
<td>0.9</td>
</tr>
<tr>
<td>Osaka Gas, Himeji</td>
<td>1</td>
<td>3/2000</td>
<td>1,500</td>
<td>NG direct expansion</td>
<td>80</td>
<td>1.5</td>
</tr>
</tbody>
</table>
Air Liquefaction Separation Plant

Air Separation Flow

Recycled Nitrogen

Distillation Column

- Liquefied Ar
- Liquefied O₂
- Liquefied N₂

Air

Pre-cooler

NG

LNG
Countermeasures for Environmental Issues at Receiving Terminals

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   - Cryogenic power generation
   - Air liquefaction separation plants (utilization of cold energy)

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Newly Developed Open-rack Type LNG Vaporizer
- SUPERORV - and - HiPerV -

SUPERORV: Reducing seawater flow rate by 15% compared with conventional ORV.

Specifications of SUPERORV

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td>150 t/h</td>
</tr>
<tr>
<td>Design Pressure</td>
<td>4.61 MPa</td>
</tr>
<tr>
<td>Seawater Flow Rate</td>
<td>4500 t/h (283 K)</td>
</tr>
<tr>
<td>Number of Panels</td>
<td>9</td>
</tr>
<tr>
<td>Number of Heat Transfer Tubes / Panels</td>
<td>60</td>
</tr>
<tr>
<td>LNG Vaporizing Capacity / Tube</td>
<td>300 kg/h</td>
</tr>
</tbody>
</table>
BOG Liquefaction Using LNG Cold Storage

**BOG Liquefaction Capacity (15 t/h)**

**900 kW Energy Saving**

**Mechanism of cold energy storage system**

- **Daytime**
  - BOG
  - LNG

- **Nighttime**
  - BOG
  - LNG

Liquefied

Two-phase flow

Cold energy

Freezing PCM

LNG

Cold energy

Melting PCM

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Highly-efficient Seawater Pump

Top: Motor for 780kW seawater pump
Bottom: VVVF unit

Top: 940kW seawater pump
Bottom: Variable vane component
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Communication with Local Communities at PR Centers

Example of a PR center

Inside the PR center

Visitors to the PR center

Scientific experiment for experience

Low temperature experiment
Communication with Local Communities

Support for local sport activities

Plant tour

Support for the local government’s environmental education programs

Cleaning campaign in the local community
Japan’s LNG Utilization and Environmental Efforts

END

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