DME Promotion Project in Japan
- As A Future Alternative Clean Energy -

Akira Ishiwada
Fuel DME Production Co., Ltd.
November 2011
Governmental Support

- Ministry of Economy, Trade and Industry Policy
  - Supports for technology development of DME production and application have been provided
  - 2007 Fiscal Year
    - Demonstration of boiler, household gas appliance, gas engine with LPG/DME mixed fuel
    - Demonstration of diesel power generation system with DME/bio mixed fuel
- Ministry of Land, Infrastructure and Transport
  - Supports for DME truck practical use have been provided
  - DME truck practical model project is under planning for promotion of the next-generation low emission heavy-duty vehicles
- Ministry of the Environment
  - Supporting system for municipality’s introduction of DME vehicles is under examination
### History of development of DME applications by subsidies from Japanese Government

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<td>Combustion (Boiler)</td>
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<td>AutoMobile</td>
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<td>Chemical Feedstock</td>
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<td>Handling Safety (as LPG subsitute)</td>
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<td>Standardization</td>
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Others from above, lot of basic experiments and demonstration studies was done!
Situation of Road Test of DME Vehicles

- Kanetsu Highway, H/D Truck
- Road Cleaning Work, Yokohama
- Up-Slop Driving Test, Mt. Hakone, M/D Truck
- Niigata Fuelling Station, H/D Truck
- High Speed Driving Test, Tsukuba, L/D Truck
- Kawasaki Fuelling Station, M/D Truck

Source: National Traffic safety and environment laboratory
Mitsubishi Heavy Industries (MHI) conducted verification tests of DME combustion (2002-2003).

- Multi-burner (Boiler) 1.5 ton/h
- Single Burner 2 ton/h
LP Gas Center of Japan carried out the demonstration tests by utilizing LPG/DME mix. in existing household LPG equipments.

**Demonstration Period:** 2005～2007

- Combustion Test of Gas Cooker
- Combustion Test of LP Gas Boiler
- Combustion Test of LP Gas Engine

Source: LP Gas Center
Build “DME Promotion Plant” in Niigata

Promotion Plant in Japan by FDME(JV incl. JDME participants)

Fuel DME Production Co., Ltd.

- **Plant Site**: Within MGC Niigata Factory
- **Production**: DME 80KT/A using imported Methanol
- **Production Start**: September 2008
DME Promotion Plant Aims for DME Market Development

- Market Development of DME
  - Physical demonstration for various applications

- Establishment of the Sable Supply and Distribution System for DME Within Japan
  - Establishment of fuel standards (regulatory)
  - Cooperation with other projects

- Establishment of Legislation (Relaxation of Regulation)
  - Establishment of support measure, such as Taxation system

- Securement of Economic Efficiency and Competitiveness
  - Establishment of DME distribution logistics

- Acquisition of Social Cognition
Participants of DME Promotion Project

Name: Fuel DME Production Co., Ltd.

Capital: 465,000,000JPY (581,250USD ← 80JPY/USD)

Shareholders:

- Mitsubishi Gas Chemical Company, Inc. (29.15%)
- ITOCHU Corporation (13.25%)
- Japan Petroleum Exploration Co., Ltd. (12.00%)
- Taiyo Oil Company, Limited (10.00%)
- TOTAL Di-Methyl Ether Japan Ltd. (10.00%)
- Toyota Tsusho Corporation (10.00%)
- JGC Corporation (5.30%)
- Mitsubishi Heavy Industries, Ltd. (5.30%)
- Mitsubishi Chemical Corporation (5.00%)

Date of Establishment: 3 April 2007
**Project Scheme**

**Fuel DME Production Co., Ltd.**

**Contractor (JGC)**

Plant Construction Contract

**Process License**

**Licensor (Mitsubishi Gas Chemical/JGC)**

**Fuel DME Promotion Members (Participation Ratio)**

- Mitsubishi Gas Chemical
- Itochu
- Japan Petroleum Exploration
- TOTAL
  - Di-Methyl Ether
  - Japan
- Toyota Tsusho
- Mitsubishi Heavy Industries
- Mitsubishi Chemical

**Equity**

**Production Order**

**DME Offtake Right**

(Participation Ratio)

- Fuel DME Production Co., Ltd.
  - Equity Ratio = Participation Ratio

**Operation/Production Order**

**Japan DME Ltd.**

**Production Order**

**Mitsubishi Gas Chemical**

*(Promotion/Application Development Purpose) Sales, Own Consumption*
Plant Outline

- **Products:** Fuel grade DME, Purity > 99% (according to JIS TS)
- **Annual Production Capacity:** 80,000 ton/year (240 ton/day)
- **Plant Cost:** approx. 2.5 billions Japanese Yen (31 million USD) including 2000m³ of product tank
- **Feedstock:** Imported Methanol (Federal Grade AA)
  Transportation by pipeline form Mitsubishi Gas Chemical (MGC)’s owned existing methanol import terminal at Niigata East Port to MGC Niigata Factory
- **Production Process:** MGC Methanol Dehydration Process (commercially established technology)
Process Flow of DME Promotion Plant

$2\text{CH}_3\text{OH} \rightarrow \text{CH}_3\text{OCH}_3 + \text{H}_2\text{O}$

**MeOH Feed (Federal Grade AA)**

MeOH Vaporizer

DME Reactor

DME Refining Column

Recovered MeOH

MeOH Vaporizer

DME Reacting Column

MeOH Recovery Column

Product DME

Off Gas to Flare Stack

Heat Integration

MeOH Feed (Federal Grade AA)

Heat Integration

Heat Integration

Heat Integration

Waste Water to Waste Water Treatment Unit
DME Plant completed in Niigata, and Commercial Delivery Started

1st DME Promotion Plant in Japan

Plant Site: Within MGC Niigata Factory
Production: DME 80KT/Y using imported Methanol

Production Start: August 2008
Delivery Start: January 2009
Overview of 80,000tpa Plant

DME Plant

DME Column

DME Storage Tank

Methanol Recovery Column

DME Reactor

Overview of 80,000tpa Plant
**Specification of Raw Methanol**

- Federal Grade AA : Purity of Methanol $\geq 99.9\%$ -

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Requirement</th>
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<tbody>
<tr>
<td>Acetone, wt. percent max.</td>
<td>0.002</td>
</tr>
<tr>
<td>Ethanol, wt. percent max.</td>
<td>0.001</td>
</tr>
<tr>
<td>Acidity (as acetic acid) wt. percent max.</td>
<td>0.003</td>
</tr>
<tr>
<td>Appearance</td>
<td>Free of opalescence, suspended matter and sediment</td>
</tr>
<tr>
<td>Carbonizable substance color, Pt-Co scale max.</td>
<td>No. 30</td>
</tr>
<tr>
<td>Color, Pt-Co scale max.</td>
<td>No. 5</td>
</tr>
<tr>
<td>Distillation range at 760 mmHg, max.</td>
<td>1.0 degC (and shall include $64.6 \pm 0.1$ degC)</td>
</tr>
<tr>
<td>Specific gravity at 20/20 degC, max</td>
<td>0.7928</td>
</tr>
<tr>
<td>Non volatile matter, wt. percent max.</td>
<td>0.001</td>
</tr>
<tr>
<td>Odor</td>
<td>Characteristic, non residual</td>
</tr>
<tr>
<td>Permanganate time</td>
<td>No discharge of color in 30 minutes</td>
</tr>
<tr>
<td>Water, wt. percent max.</td>
<td>0.1</td>
</tr>
</tbody>
</table>
### Result of Test Run - DME Promotion Plant -

<table>
<thead>
<tr>
<th></th>
<th>Unit</th>
<th>Spec.</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Production Rate</strong></td>
<td>ton/day</td>
<td>&gt;240</td>
<td>245</td>
</tr>
<tr>
<td><strong>Purity of DME</strong></td>
<td>wt%</td>
<td>&gt;99.0%</td>
<td>99.99%</td>
</tr>
<tr>
<td><strong>Unit Consumption</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methanol</td>
<td>ton/ton-DME</td>
<td>&lt;1.46</td>
<td>1.41</td>
</tr>
<tr>
<td>Steam</td>
<td>ton/ton-DME</td>
<td>-</td>
<td>1.42</td>
</tr>
<tr>
<td>Electricity</td>
<td>kW/ton-DME</td>
<td>-</td>
<td>10.2</td>
</tr>
<tr>
<td><strong>1 Pass Conversion of Methanol</strong></td>
<td>%</td>
<td>-</td>
<td>70 - 80</td>
</tr>
<tr>
<td><strong>DME Selectivity</strong></td>
<td>%</td>
<td></td>
<td>98.6</td>
</tr>
</tbody>
</table>

(Theoretical Unit Consumption of Methanol = 1.39 ton/ton-DME)
## Analysis Result of Product DME

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>LDL</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Odor</td>
<td>-</td>
<td>-</td>
<td>Pass</td>
</tr>
<tr>
<td>Water</td>
<td>wt-ppm</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Acidity (as acetic acid)</td>
<td>wt-ppm</td>
<td>1</td>
<td>ND</td>
</tr>
<tr>
<td>Non volatile matter</td>
<td>wt-ppm</td>
<td>10</td>
<td>ND</td>
</tr>
<tr>
<td>Methanol</td>
<td>wt-ppm</td>
<td>10</td>
<td>ND</td>
</tr>
<tr>
<td>Ethyl methyl ether</td>
<td>wt-ppm</td>
<td>15</td>
<td>ND</td>
</tr>
<tr>
<td>Methyl formate</td>
<td>wt-ppm</td>
<td>15</td>
<td>ND</td>
</tr>
<tr>
<td>CO</td>
<td>wt-ppm</td>
<td>30</td>
<td>ND</td>
</tr>
<tr>
<td>CO2</td>
<td>wt-ppm</td>
<td>50</td>
<td>ND</td>
</tr>
<tr>
<td>Sulfur</td>
<td>wt-ppm</td>
<td>0.01</td>
<td>ND</td>
</tr>
</tbody>
</table>

ND : not detected  
LDL : Lower Detection Level
New Use of DME as Fuel

For Vehicle, Boiler, Agriculture and so on
Fuel DME first User in Japan

First DME Boiler started commercial operation in 13th, Jan, 2009 (consumption 1,000t/y)

New DME Steam Boiler (through flow type)
Second DME Boiler started commercial operation in 15\textsuperscript{th}, Feb, 2011 (consumption 700t/y)

New DME Steam Boiler (flue and smoke tube type)
Experimental study in Niigata Prefecture

DME fuel used warming machine for the greenhouse cultivation. Exhaust gas used to promote the plant.
**DME Vehicles Demonstration (Commercial Use)**

Niigata Prefecture, JDME/Niigata Unyu  
Transportation of medical materials (200km/day)

Niigata Road Test Area

DME Promotion Plant

IDEMITSU/Try-net logistics  
Transportation of resin materials (250km/day)

Kanto Road Test Area

Newly manufactured Medium duty DME truck

DME filling station (Niigata)

Newly manufactured Medium duty DME truck

DME Filling station (Saitama)
**Typical Environmental Features**

Exhaust Gas

- **Diesel Car**
- **DME Car**

**CO₂ Emission** (Index based on theoretical CO₂ emission of DME = 68.9g-C/1000kcal-HHV)

\[
\text{LNG} < \text{LPG} \div \text{DME} < \text{A Heavy Oil} < \text{C Heavy Oil} < \text{Coal}
\]

\[
(85) \quad (100) \quad (114) \quad (119) \quad (150)
\]
Fuel DME Production Co. Ltd.

The Importance of DME Power Generation

**Natural Gas, Petroleum, Coal**

**Feedstock**

**DME**

**Energy Security**
- Sources are ample and widely spread.
- Utilization of undeveloped gas resources (Small Gas Field.)
- Interchangeable fuel (DME⇔LPG)
- The diversification of fuel resources.

**Environmental**
- Low pollution (NOx, SOx, CO2, Marine Pollution etc.)
- High efficiency (= LNG)

**Economics Convenience**
- Utilization of existing LPG facility.
- Enable to build economical middle scale power station.
- Many ways of power generation.

Leading

DME Power Generation

**Future Potential**
- Power generation in remote island, spread generation
- Recycle of energy

Matters to be resolved
- Non existence of big scale production unit of DME. (Technically possible, similar to Methanol unit.)
- Non existence of commercial power plant using DME.

Energy Security

Economics Convenience
Future Plan of DME Fuel

DME station
DME fueled large truck
DME fueled route bus
DME station
DME fuel cell vehicle
DME station
DME fueled route bus
DME fueled garbage truck
DME import terminal
DME tank truck
DME secondary terminal
DME production plant (from Natural gas, Coal, Biomass etc)
DME ocean tanker
DME station
DME fueled route bus
DME fueled garbage truck
DME Cogeneration for district cooling and heating
Household DME fuel
Factories using DME fuel (petro chemistry etc)
presented by DME promotion center
Thank you for your attention