New Clean Fuel DME

Yotaro Ohno
JFE R&D Corporation, Japan
Contents

- What’s DME?
- DME Utilization technologies update
  Residential, Power generation, Transportation
- DME Production technologies update
  JFE’ Direct synthesis technology
- Market overview & Projects update
- Conclusion
What’s DME?

- **DME (Dimethyl ether):**
  - Simplest ether: \( \text{CH}_3\text{-O-CH}_3 \)
  - Burns like Natural gas
    - Wobbe index 52 (Natural gas 54)
  - Handles like LPG
    - Boiling point -25°C (Propane -42)
    - Vapor pressure 0.53MPa (Propane 0.91)
  - Outstanding diesel alternative fuel
    - Cetane number 55-60 (Gas oil 40-55)
- **Today,** 150,000t/y as aerosol propellant, plus 300,000 t/y for emerging fuel market
DME: Clean and Green

• **HEALTH**
  - Approved as consumer product propellant
  - No human hazard relative to toxicity or carcinogenicity within exposure limits

• **SAFETY**
  - Flammable liquid like LPG
  - Thermally stable
  - No tendency to peroxide formation found
  - Similar safety guidelines and codes as LPG

• **ENVIRONMENT**
  - Does not deplete ozone
  - Minimal impact on land/water due to volatility
  - Low emission fuel like LPG and Natural gas
  - Biomass-based DME (Renewable)
DME: Multi-Use Fuel from Multi-Resources

Resources
- Natural gas
- Associate gas
- Coal bed methane
- Coke oven gas
- Coal, Lignite
- Heavy oil
- Bio-mass
- Wastes

DME Production
(1 Step process)
H₂, CO

(2 Step process)
Methanol

DME Usage
DME Clean Fuel for
- Residential
  - LPG substitute
- Transportation
  - Diesel fuel
  - FC vehicle
- Power generation
  - Gas turbine
  - Diesel co-generation
- Chemical use
DME as LPG Substitute

• DME can be used neat or blend with LPG.
• For neat DME, minor changes required as sealing materials and burner tip.
• Same efficiency and emission as LPG from cooking stove to industrial boiler.
• DME and LPG are completely miscible. Below 20 % DME, existing LPG infrastructure can used without any modification.
• Coal derived DME can mitigate Indoor pollution caused by direct solid firing (Sox, Nox, PM, Formaldehyde etc.) and improve Total energy efficiency (Conversion+Heating).
DME/LPG mixture combustion test

LPG Center Japan is conducting DME/LPG mixture combustion test by existing equipments specified to LPG.

- Up to 20% DME, DME/Propane gas mixture can be used as same as pure Propane for Tabletop stove, Infrared stove, Hot-water unit, 30% with minor modification
- Vaporized gas composition is almost constant from liquid LPG/DME mixture less than 20% DME.
- Durability of above appliances: No problem after 800hrs.
Sulfur-free Odorant for DME/LPG

The High Pressure Safety Institute of Japan is conducting Selection test for sulfur-free odorant (2005-2006)

- Primary evaluation conditions for odorant:
  strong discomfort odor, threshold level less than 1.0 ppm, boiling point lower than 120°C, stable at ambient temperature, negligible effect on human body
- Primary selection: 10 candidates
  iso-nitrile 3, hydrocarbon 4, oxygenate 2, cyclo-amine 1

Further study (2007-2008)

- Secondary evaluation conditions for odorant:
  condensation, combustibility, corrosiveness, adsorption on soil, safety
- Practicability evaluation: field test, economics
Gas turbine
• MHI verified low NOx burner for both gas-fired and liquid-fired combustion. Hitachi developed Multi-cluster Burner for low Nox emission. KHI developed liquid injection nozzle for gas turbine.
• TEPCO, Mitsubishi chemicals and JFE are conducting running test of 4 MW gas turbine with DME. Power output and emission as same as for natural gas firing period.
• Gas turbine suppliers guarantee power output, heat rate and performance for their gas turbines.

Chemically recuperated gas turbine system
• Toshiba and KEPCO developed 30kW system with Micro gas turbine. Heating value of reformed gas increases by about 10% after reforming of DME with waste heat. Power generation efficiency also increases by the same increment with lower NOx emission.
DME for Power Generation-2

**Diesel engine**
- JFE is conducting 1,150 kW DME Diesel power generation system with Daihatsu and Iwatani.

**Diesel co-generation system**
- JFE is testing 8 kW system with Yanmar and Iwatani.
- AIST developed mobile 50 kW system with Isuzu.
- Kitakyushu Univ. etc. are testing 41 kW system with MHI.

DME fueled diesel engines achieve same efficiency as with gas oil. Much low NOx emission with high EGR rate without smoke.

**Fuel cell**
- JGC developed Prototype of 30kW DME reforming system (On board type for vehicle and Stationary type) with short startup time and quick response.

DME is easily reformed to get hydrogen at low temperature like methanol.
4MW Gas turbine power generation test

Joint project (TEPCO, Mitsubishi Chemicals and JFE)
Start-up and Load change conducted as smoothly as natural gas without any modification on gas turbine.

Receiving tank & Vaporizer
Tank capacity: 42ton
Vaporizer: 3.2ton/hr

Gas turbine generator
Power output: 4.2 MW (retrofit from Natural gas firing)
1,150kW DME Diesel power generation test
Joint project (JFE, Daihatsu Diesel and Iwatani)

Same efficiency as heavy oil. Less than 110ppm of NOx emission (which can be installed in Tokyo area) with no smoke.
Proto-type DME vehicles in Japan

A ISUZU/COOP / JOGMEC TRUCK

B ISUZU / MLIT BUS

C HINO / NEDO BUS

D ISUZU/JOGMEC TRUCK

E NissanDiesel/NTSEL/MLIT TRUCK
**Emissions of Proto-type DME vehicles**

Efficiency same as with Gas oil, Emission much improved

<table>
<thead>
<tr>
<th>PM (g/kWh)</th>
<th>NOx (g/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>0.2</td>
</tr>
<tr>
<td>0.25</td>
<td>0.1</td>
</tr>
<tr>
<td>0.25</td>
<td>0.027</td>
</tr>
<tr>
<td>0.25</td>
<td>0.01</td>
</tr>
</tbody>
</table>

1997 regulation in JAPAN

2003 regulation in JAPAN

2005 regulation in JAPAN (PM = 0.001/ NOx 0.11)

2009 regulation in JAPAN

Japan

A ISUZU / JOGMEC TRUCK

B ISUZU / MLIT BUS

C HINO / NEDO BUS

D ISUZU/JOGMEC TRUCK

E NissanDiesel/MLIT TRUCK (EGR+de-NOx cat.+Oxid cat)

△ VOLVO AFFORHD project

▲ AVL (USA)
Durability and Reliability of DME Vehicles

• MLIT/NTSEL: with Nissan Diesel, ISUZU & Bosch
  Long distance fleet tests by 5 -10 vehicles to evaluate practicability of DME vehicles & to get test data for technical standard & safety regulations, aiming Initial market introduction in 2010.

  *Light duty truck (inline pump, jerk-type, 5.8 ton):* After 13,000km, emissions are lower than 2009 regulation.

• JOGMEC: *Isuzu Medium duty truck with crane (common rail type, 7.9 ton):* Total cruising distance reached to 6,000km.

• Isuzu: *Light duty truck (common rail type, 4.9 ton):* 32,000km without serious trouble.
Route & Area of Road Test by NTSEEL

- Route of HDT Road Test
  Long distance fleet between Yokohama and Niigata where DME fuelling stations are already set up.
- Running Distance
  - HDT : 400km/day x 20days/month
  - LDT : 140km/day x 20days/month
- Payload condition
  With zero, half and full payload by dummy weights

modified from Dr. Sato’s presentation at 4th Asian DME Conference, Kitakyushu, November, 2007
# Road Map of DME Vehicle Introduction in Japan

<table>
<thead>
<tr>
<th>Year</th>
<th>2000</th>
<th>2005</th>
<th>2010</th>
<th>2015</th>
<th>2020</th>
</tr>
</thead>
</table>
| **Emission Regulation** | ▼’03 :New Short Term Reg. (NSTR)  
▼’05 :New Long Term Reg. (NLTR)  
▼’09 :Post NLTR | | | | |
| **MLIT Next Gen.EFV Project (DME vehicle)** | ‘Dev. Promotion Project’  
- DME HDT dev.  
- Emissions and performances assessment  
- Practicability study | ‘P/P Project’  
- Dev. of DME vehicle  
- Vehicle on road test  
- Study of ‘Tech. STD for DME Vehicle’  
- Proposal for promotion of practical use | **Introduction into market** | | Mass production |
| | ‘Verification Model Project’  
- Dev. of practical vehicles and road test  
- To arrange the ‘Tech. STD for DME vehicle’  
- To verify adaptability to market needs | | | | |
| **DME Supply** | Small scale Promotion plant | 50-100k t/year | | | |
| | Commercial scale plants | 0.6-1.0m t/year | 1.7- 2.0m t/year |

modified from Dr.Sato’ presentation at 4th Asian DME Conference, Kitakyushu, November, 2007
Diesel engine test with PME/DME mixture fuel

Fuel viscosity and Smoke emission decrease with DME.

Reference: Prof. M. Konno, Ibaraki Univ. Japan
Olefins Production

Methanol
1.7MMt → DME
- H₂O
1.2MMt → DTO
1.7MMt → Olefins
0.5MMt

• Olefins demand have the same magnitude as LPG, LNG demand worldwide. (Ethylene: 100MMt, Propylene: 60MMt)
• Process development:
  ExxonMobil (MTO), UOP/HYDRO (MTO), Lurgi (MTP), JGC (DTO)
• Commercial Projects: 1 Project with Lurgi tech. under construction, 1 Project with domestic tech. under construction in China, 1 Project with UOP tech. under planning in Nigeria.
DME Production Technology from Natural gas

- **Two step process (Methanol Synthesis+Dehydration):**
  
  Licensor: Haldor Topsoe, Lurgi, Toyo, MGC, SWI, etc.

  1. Methanol Synthesis:

     \[
     2\text{CH}_4 + \text{O}_2 + \text{H}_2\text{O} \rightarrow 4\text{H}_2 + 2\text{CO} + \text{H}_2\text{O} \downarrow \rightarrow 2\text{CH}_3\text{OH}
     \]

  2. Dehydration of Methanol:

     \[
     2\text{CH}_3\text{OH} \rightarrow \text{CH}_3\text{OCH}_3 + \text{H}_2\text{O} \downarrow
     \]

- **One step process (Direct DME Synthesis):**

  Licensor: JFE

  \[
  2\text{CH}_4 + \text{O}_2 + \text{CO}_2 \rightarrow 3\text{H}_2 + 3\text{CO} + \text{H}_2\text{O} \downarrow \rightarrow \text{CH}_3\text{OCH}_3 + \text{CO}_2
  \]
Equilibrium conversion for Methanol synthesis and DME synthesis

\[ 3\text{CO} + 3\text{H}_2 \rightarrow \text{DME} + \text{CO}_2 \]

\[ \text{CO} + 2\text{H}_2 \rightarrow \text{MeOH} \]
Comparison of Direct synthesis process with Indirect process (two step)

<table>
<thead>
<tr>
<th>Process</th>
<th>Direct (JFE)</th>
<th>Indirect (Two Step)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Methanol</td>
<td>Dehydration</td>
</tr>
<tr>
<td>Reaction pressure (MPa)</td>
<td>5</td>
<td>8-10</td>
</tr>
<tr>
<td>Reaction temperature (°C)</td>
<td>240-280</td>
<td>180-270</td>
</tr>
<tr>
<td>One through conversion (%)</td>
<td>50</td>
<td>38</td>
</tr>
<tr>
<td>Reaction by-product</td>
<td>CO₂</td>
<td>-</td>
</tr>
<tr>
<td>(Water+MeOH)/DME (molar ratio)</td>
<td>0.1</td>
<td>-</td>
</tr>
<tr>
<td>Reactor</td>
<td>Slurry Phase</td>
<td>Fixed Bed</td>
</tr>
<tr>
<td>Cold gas efficiency from Natural gas (%)</td>
<td>71(83)</td>
<td>57(83)</td>
</tr>
<tr>
<td>( ) – Theoretical value</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cold gas efficiency from Coal (%)</td>
<td>66.3</td>
<td>53.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Development History of JFE Direct DME Synthesis

Catalyst Development

Catalyst production Process Development

DME Synthesis Process Development

Syn-gas Process Development

Laboratory scale test

Bench scale test

Pilot scale test

Demonstration test

1kg/day

50kg/day

5t/day

100t/day

89 90 91 92 93

94 95 96

97 98 99 00 01

02 03 04 05 06

Development History of JFE Direct DME Synthesis

Catalyst Development

Catalyst production Process Development

DME Synthesis Process Development

Syn-gas Process Development

Laboratory scale test

Bench scale test

Pilot scale test

Demonstration test

1kg/day

50kg/day

5t/day

100t/day

89 90 91 92 93

94 95 96

97 98 99 00 01

02 03 04 05 06
DME Production from Natural gas by JFE Process

- **Syngas Production (Auto-Thermal Reformer)**

\[2\text{CH}_4 + \text{O}_2 + \text{CO}_2 \rightarrow 3\text{CO} + 3\text{H}_2 + \text{H}_2\text{O}\downarrow\]

- **DME Synthesis (Slurry phase reactor, Catalyst)**

\[3\text{CO} + 3\text{H}_2 \rightarrow \text{CH}_3\text{OCH}_3 + \text{CO}_2\]

- **Overall reaction**

\[2\text{CH}_4 + \text{O}_2 \rightarrow \text{CH}_3\text{OCH}_3 + \text{H}_2\text{O}\]
Characteristics of JFE Autothermal Reformer

1. Burner design and furnace profile
   - Enhanced mixing of feed
   - Water cooled burner

2. Catalyst bed
   - Complete methane reforming

3. Rapid quench
   - Prevent Boudouard reaction
     \[ 2\text{CO} \rightarrow \text{CO}_2 + \text{C} \]
Slurry Phase Reactor for DME Synthesis

1. Homogeneous temperature distribution

2. Possibility of changing catalyst during operation

3. NO need for Catalyst/Liquid separation

4. JFE Proprietary catalyst

Steam

Water

DME, CO₂

unreacted CO, H₂

CO, H₂

Slurry
(Catalyst + Solvent)

gas bubble
DME 100 tons/day Demonstration Plant
## Results of Test Operation

- **Operation time and production**

<table>
<thead>
<tr>
<th>RUN NO.</th>
<th>Period</th>
<th>Duration (day)</th>
<th>DME production(t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RUN100</td>
<td>2003/12/12-2004/1/26</td>
<td>43</td>
<td>1,240</td>
</tr>
<tr>
<td>RUN200</td>
<td>2004/6/20-7/31</td>
<td>39</td>
<td>2,500</td>
</tr>
<tr>
<td>RUN300</td>
<td>2004/10/6-12/16</td>
<td>72</td>
<td>4,230</td>
</tr>
<tr>
<td>RUN400/500</td>
<td>2005/6/15-11/13</td>
<td>152</td>
<td>9,070</td>
</tr>
<tr>
<td>RUN600</td>
<td>2006/4/3-5/12</td>
<td>40</td>
<td>2,480</td>
</tr>
<tr>
<td>(Total)</td>
<td></td>
<td>346</td>
<td>19,520</td>
</tr>
</tbody>
</table>

- Cold gas efficiency from natural gas:
  
  69.4% ( ATR: 84.9%, DME synthesis: 81.7% )
  
  (71% expected for commercial scale plant)

- Stable DME synthesis catalyst activity:
  
  152 days ( 1 year expected for commercial scale plant)

- Purity of produced DME: 99.8%
Scaling-up of Slurry Phase Reactor

D: 0.55m
H: 15m
(Slurry 12m)
(Hs/D=22)
P: 5t/d

20times

D: 2.3m
H: 22m
(15m)
(6.5)
P: 100t/d

30times

D: 7.0m
H: 50m
(46m)
(6.6)
P: 3000t/d

(1)
Summary of JFE Process Development

• JFE has completed the development of Direct DME synthesis process and CO$_2$ recycle type ATR.

• JFE has developed own efficient catalyst system and its mass production technology.

• Scale-up technology has been established. FEED and VE have been completed for a commercial scale plant.

• JFE process configuration is more compact and less expensive and more efficient than two step technology.

• JFE is ready for process licensing and catalyst supply.
DME Production from Multi-resources

• JFE process is suitable to produce DME from such feedstock as
- \(\text{CO}_2\) rich natural gas
- Coal (Bituminous to Lignite)
- Biomass (Wood chip, Corn Stover, other crop residues)
  Bio-DME is a Second generation Biomass fuel which has no conflict with food supply.
- Locally stranded or recycled resources as Coke oven gas, Coal bed methane, Heavy residue, Agriculture/forestry waste, Municipal waste, etc.

• \(\text{CO}_2\) sequestration should be integrated to DME production in future.
DME production from Natural gas

Cold gas efficiency (including fuel): 70.2%
Natural gas consumption: 1032 Nm$^3$/t-DME, Oxygen consumption: 1.02 t/t-DME
Natural gas composition: C1 87.9%, C2 8.6%, C3 2.7%, C4 0.4%, N2 0.4%

CO$_2$ emission
DME production from CO$_2$ rich natural gas

- With increasing CO$_2$ up to 40% in natural gas, recycle CO$_2$ decreases to keep H$_2$/CO=1 of synthesis gas. Excess CO$_2$ is separated and compressed up to 8Mpa for storage.

- Thermal efficiency of DME production almost constant up to 40% CO$_2$. 

![Graph showing thermal efficiency and recycle CO2 ratio vs CO2 in natural gas](image-url)
DME production from Coal

CO2 Emission, Conversion efficiency from Coal to DME: 66.3%

Coal consumption: 1.5 dry-t/t-DME, Oxygen consumption: 1.2 t/t-DME
DME production from Biomass (wood chip)

DME from Biomass is carbon neutral. If CO$_2$ emitted at production is stored, it creates negative emission.

Auxiliary feed such as coal

Wood chip → Drying → Gasifier → De-S De-CO2 → DME Synthesis → Purification → DME

- Drying: HP Steam, CO2 Sequestration
- Gasifier: CO2, Purge Gas, Auxiliary feed as coal, O2, Steam, Ash
- De-S De-CO2: Sulfur Water, Methanol
- DME Synthesis: CO2, Purge Gas, Purification: CO2

1000t-DS/d → 350t/d

25.1g-C/MJ-wood
25.1/0.533 = 47.1g-C/MJ-DME

: CO2 Emission, Conversion efficiency from Wood chip to DME: 53.3%
Feasibility for DME production from Coal

Plant Site: China
Plant Capacity: 500t/d
Plant Construction: 170MM US$ ± 20% - Including Coal Gasifier
DME Price: 4,000Yuan/T (US$500/T)
Coal Price: 1~4US$/MMBTU

1.0US$/MMBTU = 200Yuan/T
DME Commercialization Activities in China

• Annual production of DME increases sharply, 20kt in 2002 to 320kt in 2006 as LPG /DME mixture, produced from methanol.

• NDRC announced in June 2006
  - Importance of DME. A production capacity should be more than 1 million t/y and from coal. **NDRC target: 20 Mt/y in 2020.**

• A 3 million t/y DME plant in Inner Mongolia has been approved by the government. There are a lot of DME production projects, total production capacity is **expected to reach 15 million t/y in 2010.**

• DME pipeline is under planning from Inner Mongolia to Beijing region.

• Development of Diesel alternative through Shanghai bus project.
  - Environmental need for clean transportation fuels.
DME Plants operating in China

(as of September 2007)

<table>
<thead>
<tr>
<th>Province</th>
<th>Feed-stock</th>
<th>Capa. ktpa</th>
<th>Start-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guangdong</td>
<td>Methanol</td>
<td>8</td>
<td>1994</td>
</tr>
<tr>
<td>Henan</td>
<td>Coal</td>
<td>10</td>
<td>1994</td>
</tr>
<tr>
<td>Shaanxi</td>
<td>Nat. Gas</td>
<td>10</td>
<td>1998</td>
</tr>
<tr>
<td>Shanxi</td>
<td>Methanol</td>
<td>10</td>
<td>2000</td>
</tr>
<tr>
<td>Sichuan</td>
<td>Nat. Gas</td>
<td>10</td>
<td>Aug/03</td>
</tr>
<tr>
<td>Shandong</td>
<td>Coal</td>
<td>150</td>
<td>May/05</td>
</tr>
<tr>
<td>Shanghai</td>
<td>Coal</td>
<td>5</td>
<td>Dec/05</td>
</tr>
<tr>
<td>Anhui</td>
<td>Methanol</td>
<td>20</td>
<td>Dec/05</td>
</tr>
<tr>
<td>Hubei</td>
<td>Methanol</td>
<td>100</td>
<td>May/07</td>
</tr>
<tr>
<td>Shandong</td>
<td>Methanol</td>
<td>10</td>
<td>May/07</td>
</tr>
<tr>
<td>Henan</td>
<td>Methanol</td>
<td>100</td>
<td>July/07</td>
</tr>
<tr>
<td>Jiangsu</td>
<td>Methanol</td>
<td>50</td>
<td>Aug/07</td>
</tr>
<tr>
<td>Guangdong</td>
<td>Methanol</td>
<td>300</td>
<td>Sept/07</td>
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<tr>
<td>Niingxia</td>
<td>Coal</td>
<td>210</td>
<td>May/07</td>
</tr>
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</table>

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By courtesy of Mr. Taupy of International DME Association
<table>
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<tr>
<th>Province</th>
<th>Feed-stock</th>
<th>Capa. ktpa</th>
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<tbody>
<tr>
<td>Jiangsu</td>
<td>Methanol</td>
<td>200</td>
</tr>
<tr>
<td>Jiangsu</td>
<td>Methanol</td>
<td>300</td>
</tr>
<tr>
<td>Yunnan</td>
<td>Coal</td>
<td>150</td>
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<tr>
<td>Guangdong</td>
<td>Methanol</td>
<td>200</td>
</tr>
<tr>
<td>Anhui</td>
<td>Methanol</td>
<td>100</td>
</tr>
<tr>
<td>Guizhou</td>
<td>Coal</td>
<td>180</td>
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<tr>
<td>Shandong</td>
<td>Methanol</td>
<td>250</td>
</tr>
<tr>
<td>Shanghai</td>
<td>Coal</td>
<td>50</td>
</tr>
<tr>
<td>Chongqing</td>
<td>Coal</td>
<td>80</td>
</tr>
<tr>
<td>I. Mongolia</td>
<td>Coal</td>
<td>3000</td>
</tr>
</tbody>
</table>

(As of September 2007)

By courtesy of Mr. Taupy of International DME Association
DME Commercialization Activities in Japan

- Japan DME: FS for 700 -1,200 Kt/y from Natural gas in Papua New Guinea
- Fuel DME Production Co.Ltd established to start 80 Kt/y production in June 2008 (by dehydration of imported methanol) (Japan DME, etc.)
- DME International: FS for 2,000 Kt/y from Natural gas in Middle East
- JFE etc.: FS for 200 - 1,000 Kt/y from Coal or COG in China

- DME Demand forecast for introductory period in Japan
  (DME promotion center(2006))

<table>
<thead>
<tr>
<th></th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010-2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand (Kt)</td>
<td>20</td>
<td>50</td>
<td>100</td>
<td>1,200</td>
</tr>
<tr>
<td>LPG substitute</td>
<td>19.7</td>
<td>40</td>
<td>50</td>
<td>800</td>
</tr>
<tr>
<td>Model project*</td>
<td>0.3</td>
<td>10</td>
<td>50</td>
<td>400</td>
</tr>
</tbody>
</table>

*Distributed Power generation, Vehicle, Boiler, Chemical feedstock
DME Commercialization Activities in other countries - 1

Iran
• Zagros Petrochemical Co. , 800kt/y DME plant next to Methanol Plant at Assaluyeh, expected production in 2009.
• 50% DME will be blended in LPG for local market as household fuel and surplus LPG (300kt/y) for export.
• Production Technology : Methanol dehydration, fixed-bed reactor,
  Engineering and License: NPC-RT and Haldor Topsoe AS

Egypt
• 1.3 million ton per year methanol plant under construction
• MOU signed with Egyptian government on DME plant
• 200 kt/y DME for blending into LPG
• Expected to be located adjacent to the methanol plant (Mubarak Gas and Petrochemicals Complex, Damietta)
DME Commercialization Activities in other countries-2

South Korea

• KOGAS 10 t/d DME Demo Plant under construction to complete in May 2008, DME demonstration project (2009)

• Target: 3,000t/d from small-medium size gas field in 2009-2012 to supply DME into Korea.

Sweden

• AFFORHD: Alternative Fuel for Heavy Duty Engines

• Bio-DME project: from Wood chip (Växjö), Black liquor (Chemrec)

Russia

• Moscow program: "Alternative fuels use in city’s motor transport for 2002-2004". Dual fuel (DME, Gas oil) vehicle confirmed reliable.

• VNIIGAZ (GAZPROM Research Institute) developing technology to manufacture DME
## Potential markets of DME in Asia (MMt/y)

<table>
<thead>
<tr>
<th></th>
<th>Electricity</th>
<th>Transport</th>
<th>Residential</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>2.7 8.0</td>
<td>0.2 3.6</td>
<td>0.6 5.4</td>
<td>3.5 17.0</td>
</tr>
<tr>
<td>China</td>
<td>6.7 10.0</td>
<td>3.0 7.1</td>
<td>4.8 7.5</td>
<td>14.5 24.6</td>
</tr>
<tr>
<td>India</td>
<td>4.0 6.0</td>
<td>1.6 3.2</td>
<td>4.3 6.4</td>
<td>9.9 15.6</td>
</tr>
<tr>
<td>South Korea</td>
<td>2.0 3.0</td>
<td>1.0 2.0</td>
<td>1.0 1.5</td>
<td>4.0 6.5</td>
</tr>
<tr>
<td>Other Asia</td>
<td>4.1 8.1</td>
<td>- 2.3</td>
<td>2.6 4.2</td>
<td>6.7 14.6</td>
</tr>
<tr>
<td>Total</td>
<td>19.5 35.1</td>
<td>5.8 18.2</td>
<td>13.3 25.0</td>
<td>38.6 78.3</td>
</tr>
</tbody>
</table>

Coal reserves and DME production potential

Countries with more than 1 Billion coal reserves are plotted. (1 Billion coal = 10 Million t/year-DME for 50 years.)

Energy consumption per capita 2 TOE necessary for sufficient UN HDI.

Supply to Domestic market

Domestic/Export

Coal reserves (Billion ton)

Energy consumption per capita (TOE)
Standard and IGC code of Fuel DME

• Domestic Standard
  • In Japan, TS (Technical Specification) for DME standard for industrial and power generation fuel was published in Nov. 2005.
  • Standards for home use and vehicle are under study.
  As for vehicle use, effects of impurities and additives on durability and performance of engine are investigated by AIST.

• International Standard
  • International work for DME standard has started in 2007 in subcommittee SC4 and SC5 of ISO/TC28.
  (Countries involved: China, France, Germany, Japan, Poland, South Korea, Sweden, Turkey, USA)

• IGC code amended for maritime transportation of DME
  • Liquid DME can be transported by Bulk carrier from July 2008.
DME – International cooperation

Korea DME Association

China DME Association

• 4th Asian DME Conference, 12th-14th November 2007, Kitakyushu, Japan
  51 presentations, Proceedings available
  Please visit JDF Website: www.dmeforum.jp

• Sino-Japan Symposium on DME Vehicle
  3rd December 2007, Shanghai, China

• 5th Asian DME Conference & 3rd International DME Conference[DME3]
  21st-24th September 2008, Shanghai, China

Please visit IDA website: www.aboutdme.org
DME Handbook edited by JDF

English edition was published in October, 2007

Please visit JDF Website:
www.dmeforum.jp

Introduction
Fundamental properties
Combustion of DME
Reforming of DME
Production technologies
Utilization technologies
Distribution network
Economics and Market
Safety, Environment
Standard, etc.

600 pages, 40,000 JPY
Conclusion

• DME production and utilization technologies have been developed and are now ready for commercialization.

• DME is economically competitive against conventional fuels.

• Study for International standard has been started and will be finalized in a few years.

• Coal to DME and Biomass to DME will be promoted in view of resource potential and environmental conservation.

• For vehicle use, a certain amount of DME penetration is necessary for preparation of DME fueling station and to persuade vehicle manufacturers of mass production.

• DME will be an essential feedstock for chemicals as olefins.