

# DME Activities in Japan

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Japan DME Association (JDA)

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# First DME Introduction in Indonesia

- DME was introduced as a new clean fuel for the first time on ASCOPE '97 Conference held in Jakarta, Indonesia, Nov. 1997.

PROCEEDINGS, ASCOPE '97 CONFERENCE  
24-27 November 1997

DME (DIMETHYL ETHER) FUEL,  
A CLEAN AND ECONOMICAL ALTERNATIVE ENERGY IN THE 21ST CENTURY

Professor Dr. Yoshihiro Adachi\*  
Mitsuaki Komoto\*\*  
Dr. Yotaro Ohno\*\*\*

## ABSTRACT

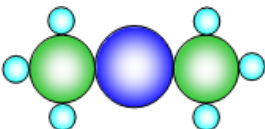
DME(Dimethyl Ether) is a clean and sustainable alternative fuel which can be produced from natural gas or coal resources through syngas. The properties of DME are similar to those of LPG and it can be used for various purposes; for example, power generation fuel, transportation fuel, etc.

The cetane number of DME is enough high to be used in the diesel engine of heavy vehicle without

very important to promote the future co-operation of related authorities in the region.

## INTRODUCTION

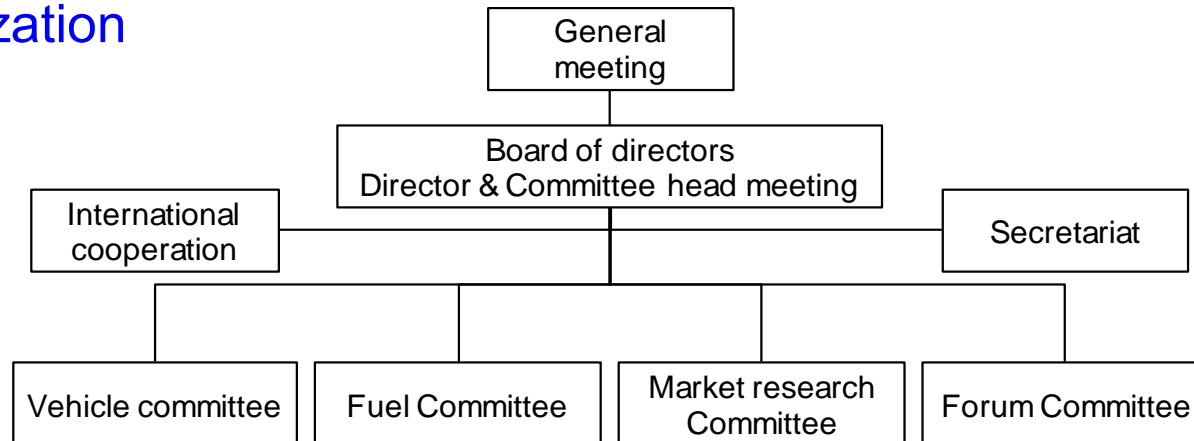
Economic growth seen in the nations of Asia Pacific region in recent years has pushed up energy demand to the extent that energy supply and demand will be a serious problem in the twenty-first century. The



# Japan DME Association has started

- Japan DME Association has started in April 2013 by merging of Japan DME Forum and Bio-DME & DME vehicle Promotion Committee to promote further use of DME.

- Organization



- **Members:** - Corporate and association members: 23

CHIYODA	Iwatani	Mitsui O.S.K. Lines
Electric Power Development Co.	Japan LP Gas Association	Miyairi Valve Mfg
ENEOS GLOBE	JAPEX	NIYAC
Hitachi	JGC	Sumitomo Chemical
Iino Kaiun Kaisha	KAGLA Vaportech	TOKICO Technology
INPEX	Kokuka Sangyo	TOTAL Di-Methyl Ether Japan
Isuzu Advanced Engineering Center	Mitsubishi Gas Chemical	Toyo Engineering
ITOCHU	Mitsubishi Heavy Industries	

- Individual members: 15 from Universities and Institutes



# Activities of Japan DME Association

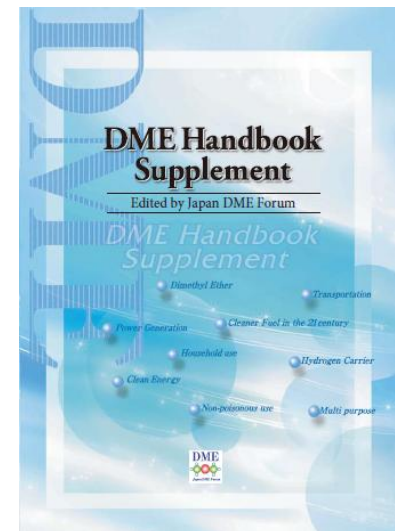
- **Activities by committee**

- Vehicle Committee: Technical development and standardization works to establish regulations for DME vehicle commercialization and fueling facility construction.
- Fuel Committee: Research & development on biomass-origin DME production toward the low carbon society.
- Market research Committee: Research studies of the global DME market and educational and promotional activities for further use of DME vehicles and fuels.
- Forum Committee: Research assistance and promotional activities for DME production & utilization, establishes strong connections to the international DME network, and organizes DME-related symposiums and events.

- **DME Handbook and DME Handbook Supplement**

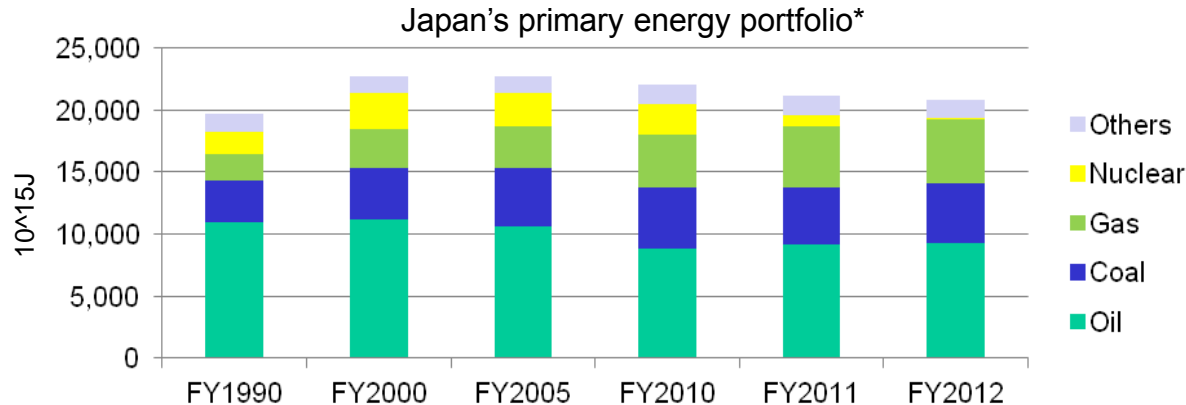
DME Handbook published in 2007 and its Supplement published in 2011 are comprehensive knowledge sources on DME.

( URL: <http://www.japan-dme.or.jp>, E-mail: [info@japan-dme.or.jp](mailto:info@japan-dme.or.jp))



# Japan's Primary energy highlights

- Nuclear energy, historically one of Japan's major energy sources, represented average 11.5% of the total primary energies between 1991 and 2010.
- Following Fukushima incident, the government issued new safety guidelines for nuclear power plants and all nuclear power plants need to comply the guidelines.
  - As of end October 2013, none of 50 nuclear reactors is restarted yet.
  - Since FY2011, Japan has been running a large trade deficit mainly due to increased fossil energy (especially LNG) imports.

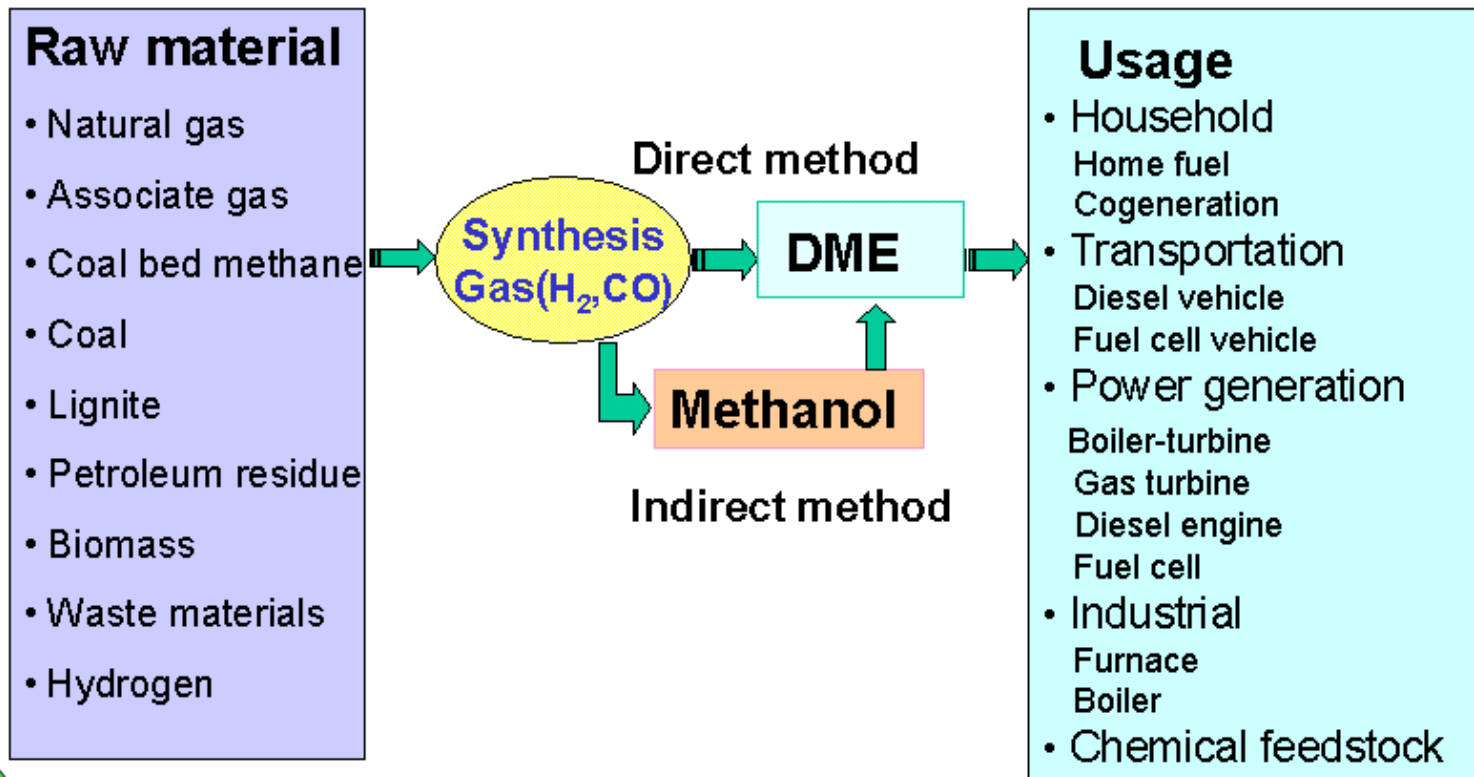


- Diversification of energy sources and decrease of dependence on fossil energies are crucially important for Japan's mid-term energy strategy.
- DME, which can be produced from renewable and low-value fossil energies, should play an important roles in Japan.

\*source: Ministry of Economy, Trade and Industry

# Overview of DME from production to utilization

- DME can be produced selecting adequate raw materials depending on local conditions.
- DME production technologies and wide range of utilization technologies have been developed and demonstrated at practical level. Almost of technical development results are introduced in DME Handbooks.



# DME production from Methanol

- DME fuel production

Fuel DME Production Co. has started DME production from imported methanol (annual capacity of 80,000tons) in 2009, supplying fuel DME to Boilers of Food industries and DME trucks of Transportation companies in near region.

- DME Promotion Plant located in Mitsubishi Gas Chemical's Niigata factory



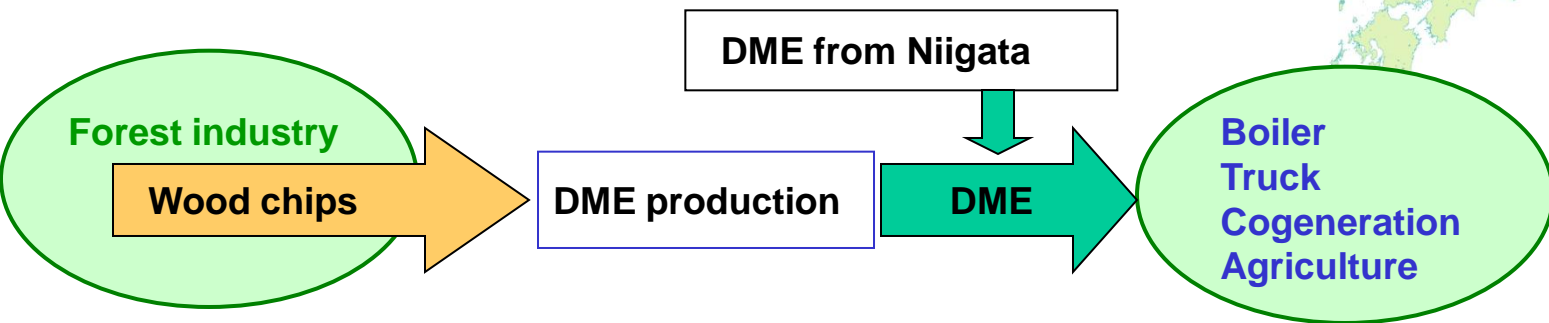
- Trinidad Tobacco project

Mitsubishi Corporation and Mitsubishi Gas Chemical have announced to start feasibility study for Methanol and DME production in Trinidad & Tobacco to be used for DME truck and DME power generator. [presented by Mr.Okada]



# Bio-DME business development in Japan

- As a value-added solution for further DME promotion in Japan, biomass-origin DME (bio-DME) has been developed and studied:
  - The Japan first DME vehicle driving event with bio-DME by DMEVPC (current JDA) in 2010
  - Nagahama-city model bio-DME business study by local (ongoing) (local DME production from locally available wood biomass)
    - Promote its forestry industry by utilization of thinning residues as bio-DME feedstock
    - Blend bio-DME with Niigata fossil-based DME to ensure cost effectiveness and stable supply to customers



- The government-subsidized project for standardization of bio-DME use in the transportation sector by AIST, JDA, and Isuzu (ongoing)

# DME Production technology Development

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- Experimental study on Effect of gas composition on DME synthesis

Gas composition of biomass derived gas varies in regard to gasifier types and gasifying agents. DME direct synthesis test was conducted using a bench-scale slurry phase reactor to clarify effect of gas compositions and synthesis conditions (temperature, pressure, etc.).

It was found that DME conversion is roughly relative to the partial pressure of H<sub>2</sub> & CO, CO<sub>2</sub> & N<sub>2</sub> contents must be as low as possible, and the reaction pressure should be higher than 3 MPa.

[presented by Dr. Oguma]

- Experimental study on Catalyst performance of DME synthesis from CO<sub>2</sub> and H<sub>2</sub>

DME direct synthesis from CO<sub>2</sub> and H<sub>2</sub> was tested using a laboratory-scale fixed bed reactor with several kinds of catalyst.

A newly developed catalyst gave a better result than those in the literature, but to be improved more for practical use.

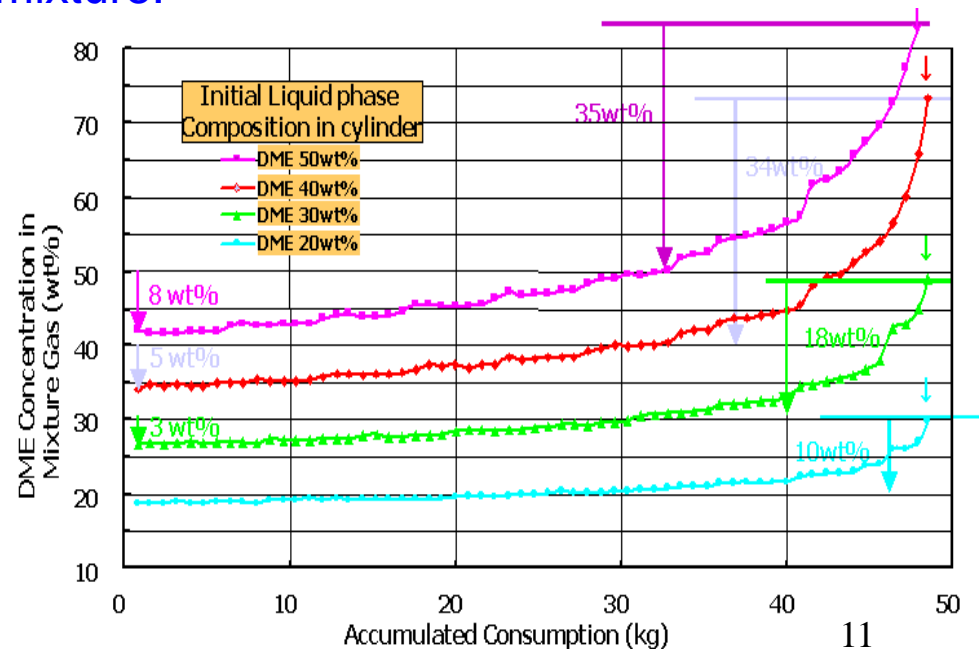
[presented by Prof. Takeishi]

# DME Utilization as Home fuel

- DME can be used as neat or blended with LPG, depending on distribution network.
- Neat DME is similar to Natural gas as gaseous fuel, which can be used by Natural gas appliance. As for LPG appliance, minor change such as burner tip is required.
- DME/LPG mixture can be used by LPG appliances without any modification up to 20% DME blend ratio.
- Vaporized gas composition from cylinder is almost constant when DME is less than 20% in initial liquid DME/LPG mixture.



**DME burning by cooking stove for natural gas**



# Development of DME vehicle

- As DME emits no soot, DPF is unnecessary. This is a big advantage for emission regulation to be reinforced in future. Starting from DME engine development, DME bus and trucks were manufactured and tested.
- Durability of DME truck was well demonstrated by running over 100,000km on test course, high way and urban way without serious trouble.
- Two medium duty trucks were developed and used for transportation business. Total mileage is about 100,000km and 130,000km each. [presented by Mr.Takase]

## Developed DME engines and DME vehicles in IAEC

2001

2005

2010

2015

Feasibility study

Public road test

Commercial use

To Promotion stage

DME vehicle



DME Engine



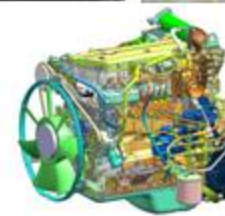
NA

6HH1 engine



NA

4HL1 engine



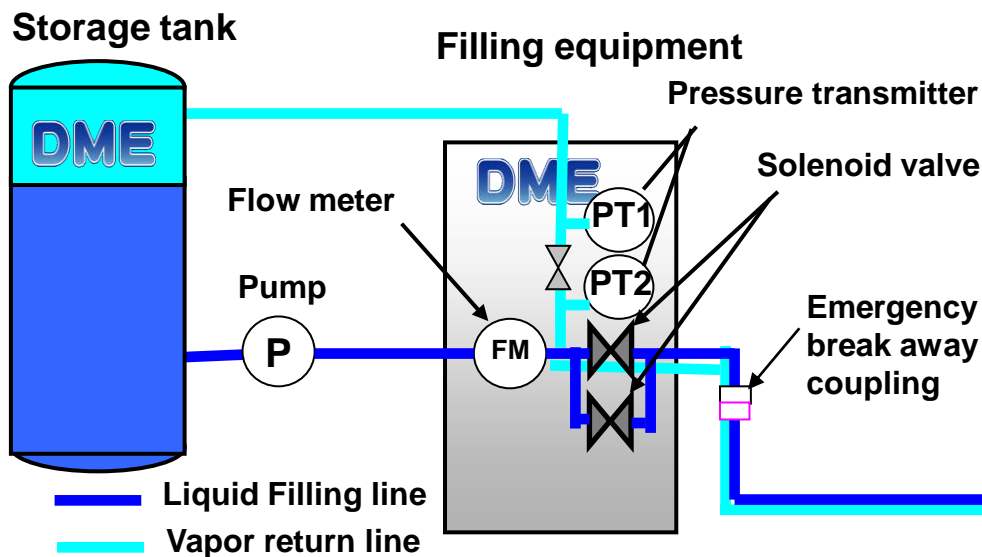
TC

4HK1 engine

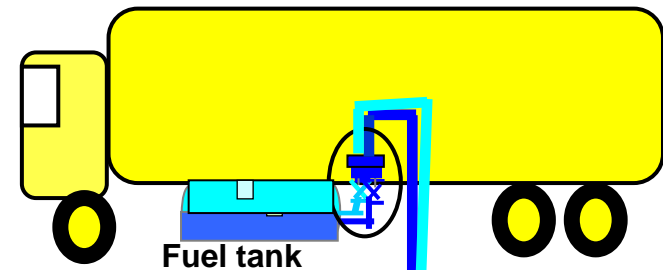
# Development of DME filling equipment

- High-speed filling equipment at 80 L/min has been developed for DME medium-heavy duty trucks to be competitive against existing diesel oil filling speed.

[presented by Dr. Ohno]



DME heavy duty truck: 250 to 600 L tank capacity



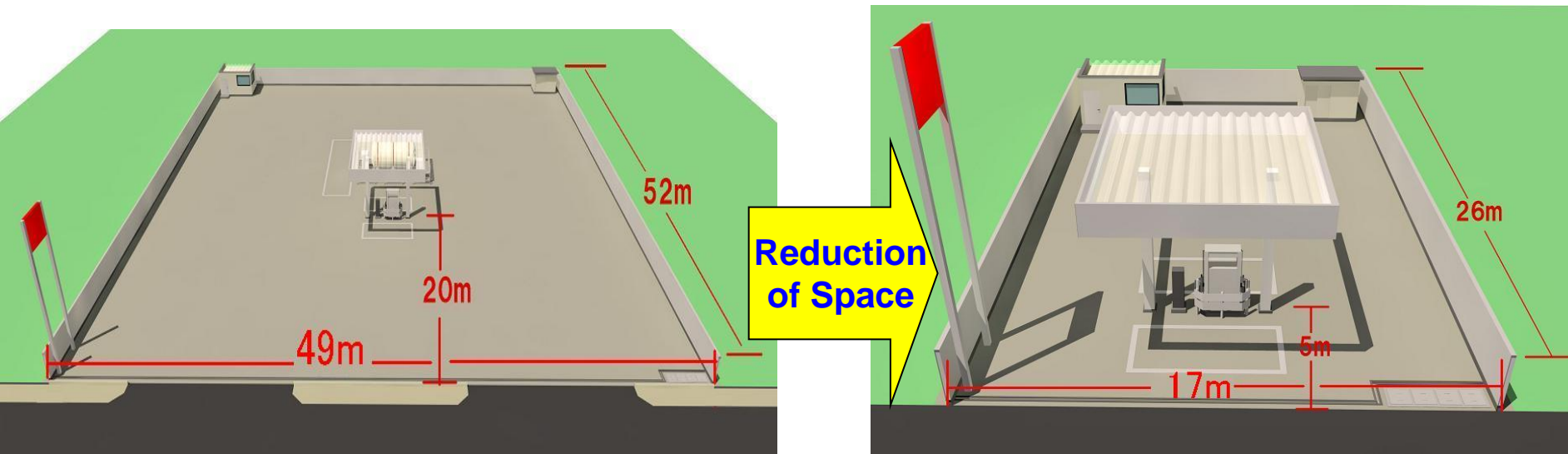
Pressure balanced filling system



# Technical assessment for DME filling station safety

- Space requirement of DME filling station under the current High Pressure Gas Safety Law is too large in urban areas.
- Tests and simulation analysis were conducted on diffusion of DME gas and flame propagation from small leakage and rupture of filling hose.

It was confirmed that the safety in the DME filling station can be ensured by complying with the safety distances for CNG filling stations.



DME Filling Station under the current High Pressure Gas Safety Law

Targeted design equivalent to CNG filling station

# DME utilization by Industrial boilers

DME is used by two main types of industrial boiler.

- Through Flow type steam boiler  
Manufacturer: Miura Co.  
Evaporation capacity: 2ton/hour x 3 units  
Thermal efficiency: 96% same as LP gas  
DME consumption: 970ton/year  
Operation start: Jan,2009  
(Cumulative operation time:5,000hr, each unit)  
No trouble, as clean as LP gas boiler
- Flue and Smoke tube type steam boiler  
Manufacturer: IHI  
Evaporation capacity: 4ton/hour  
Thermal efficiency: 92%, higher than Heavy oil  
DME consumption: 700ton/year  
Operation start: Feb. 2011  
(Cumulative operation time:12,000hr)  
No trouble, cleaner than Heavy oil boiler



# DME for Chemical use

- DME to Propylene
  - Joint Development of JGC Corporation and Mitsubishi Chemical Corporation
  - On-purpose Propylene Production from Methanol/DME
  - Additional C<sub>4</sub>-C<sub>6</sub> Olefins Co-Feed
  - Developed proprietary zeolite catalyst
  - High Propylene Yield: more than 70%



**Demonstration Plant in Mizushima**

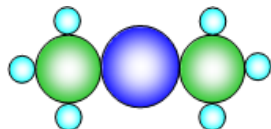
[presented by Dr.Honda]

- Dewatering technology with DME

Lignite or various biomass resources contain much water and drying process requires much energy.

By mixing such substance with liquid DME, water is removed to DME. DME is separated from water/DME mixture by Pressure or Temperature swing.

This technology under development is promising as efficient dewatering process, applicable to lignite, sewage sludge, oil rich algae, etc.

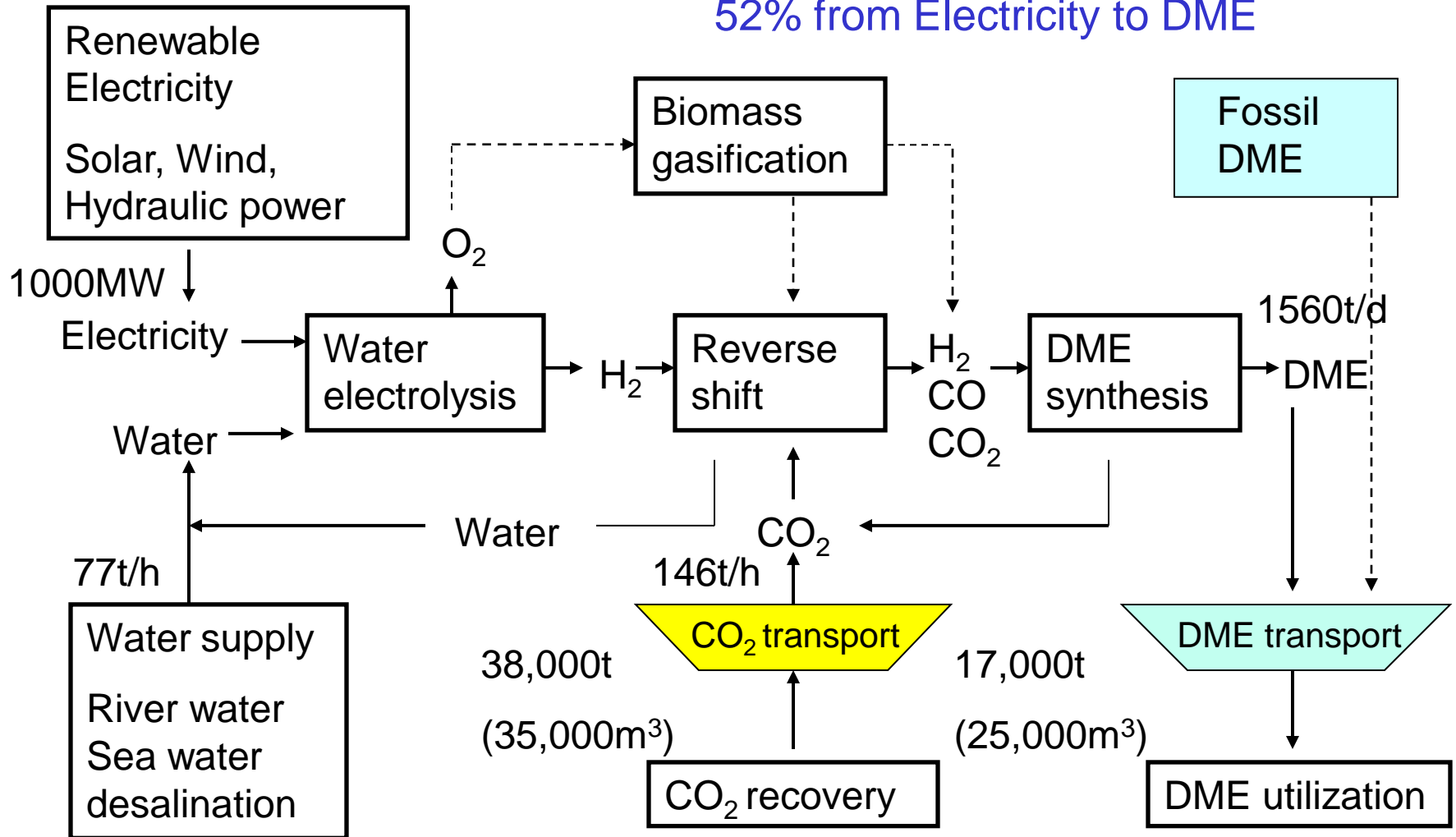




# Global Renewable DME Network

Total system efficiency : 70% from H<sub>2</sub> to DME

52% from Electricity to DME



# Physical properties of DME as Energy carrier

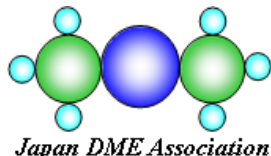
Temperature and pressure condition of liquid DME Transportation is easy, Energy density is high, and DME is safe and non toxic.

	Liquid hydrogen	Liquid ammonia	Methanol	MCH	DME	CO <sub>2</sub>	Toluene
Molecular formula	H <sub>2</sub>	NH <sub>3</sub>	CH <sub>3</sub> OH	C <sub>7</sub> H <sub>14</sub>	CH <sub>3</sub> OCH <sub>3</sub>	CO <sub>2</sub>	C <sub>7</sub> H <sub>8</sub>
Liquid density [kg/m <sup>3</sup> ]	70.8	700	795	774	670	1100	867
Boiling point [°C @0.1MPa]	-253	-33.4	64.4	101.1	-25	(-50)*2	110.6
Vapor pressure [MPa @25°C]	-	1.02	0.0129	0.0061	0.53	(0.7)*2	0.0039
Energy density by weight [MJ/kg]	120.8	19.2	21.1	(7.4)*1	28.8	-	-
Energy density by volume [MJ/L]	8.5	13.4	16.8	(5.7)*1	19.3	-	-
Explosion limit [%]	4 - 75	15 - 28	6.7 - 36	1.2 - 6.7	3.4 - 27	-	1.1 - 7.1
Toxicity allowance [ppm]	-	25	200	400	-	-	50

\*1: Calorific value of transported 3H<sub>2</sub> (C<sub>7</sub>H<sub>14</sub> ⇌ C<sub>7</sub>H<sub>8</sub>+3H<sub>2</sub>)

\*2: Transportation condition of liquid CO<sub>2</sub>

MCH: Methyl Cyclo-Hexane



# Conversion from H<sub>2</sub> and Utilization technology

DME synthesis condition is relatively easier. DME utilization technologies have been demonstrated and efficient.

	Liquid hydrogen	Liquid ammonia	Methanol	MCH	DME
<b>Conversion</b> Auxiliary material	-	N <sub>2</sub> (Air separation)	Liquid CO <sub>2</sub>	Toluene	Liquid CO <sub>2</sub>
Process	Liquefaction	Synthesis	Synthesis	Hydrogenation	Synthesis
Temp. [°C]	-253	400-500	210-260	150-200	240-280
Pres. [MPa]	ambient	20-30	8-10	3	5
<b>Usage</b> <b>Combustion</b> <b>Engine</b>	Safety problem SI engine	Safety problem SI engine NOx removal	Smokeless combustion SI engine	(not used as fuel)	Smokeless combustion CI engine
<b>H<sub>2</sub> generation</b> Process	Evaporation	Pyrolysis NH <sub>3</sub> removal	Steam reforming	Dehydrogenation	Steam reforming
Temp. [°C]	ambient	700	220	350	330
H <sub>2</sub> amount [kg/kg]	1	0.18	0.19* <sup>1</sup>	0.06	0.26* <sup>1</sup>
Reaction heat [MJ/H <sub>2</sub> -kmol]	0.9	30.5	16.5	68.3	20.6

\*1: including H<sub>2</sub> from Steam

# Public recognition of DME

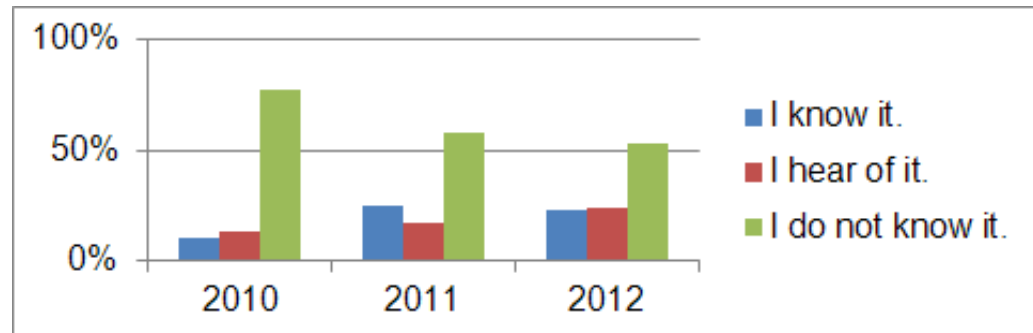
- DME Promotion Center made activities for promoting recognition of DME among the common people in the exposition [ECO-Products] in Tokyo.

Public recognition of DME is still weak, but it is improved slowly.

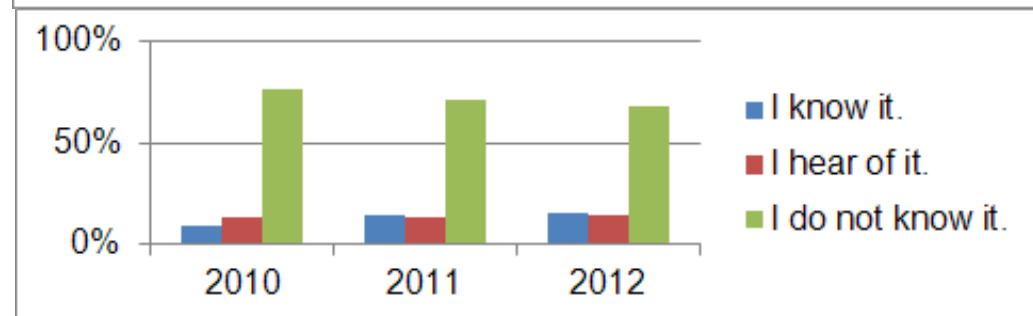
[Questionnaire investigation on site]

>Before guidance on DME

Do you know DME previously ?

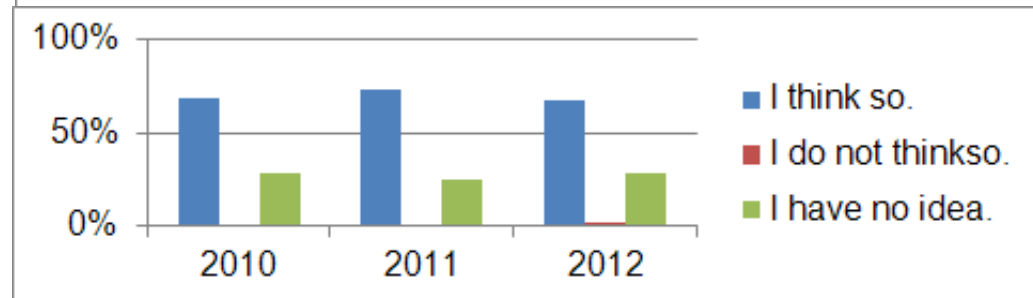


Do you know DME can be produced from biomass ?



>After guidance

Do you suppose DME is necessary as a future fuel ?



# Standardization activities of DME

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- Standardization of DME fuel

- Japan Industrial Standard(JIS) of fuel DME

The examination of DME quality standardization has been progressing in consideration of DME production method, DME distribution method, and conditions on DME utilization equipment, and JIS standard K2180 of fuel DME was issued in March, 2013.

- JIS of DME fuel for the vehicle is at present under examination.

- International Standard ISO of fuel DME is now under examination and expected to be issued in 2014.

[presented by Dr.Oguma]

- Technical standard of DME vehicle and DME filling interface

- DME Vehicle Technical Standard including DME filling interface was drafted and submitted to MLIT, and now under review in MLIT.

- DME Vehicle Fuel Tank Regulations Proposal drafted was submitted to METI, and now under review in METI.

[presented by Dr.Ohno]



# Conclusion

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- Energy demand is increasing in the world, especially in the growing economies where the energy consumption per capita is still low.

However, the environmental issue such as PM is becoming more serious with increase of energy consumption. DME has a big chance to be used in future as clean fuel produced from various resources.

- In order to promote commercial DME use, legislative frameworks are necessary in various utilization fields, for example, DME Vehicle and DME filling station.
- International cooperation, technical information exchange and harmonization of various standards are indispensable in order to promote DME globally.
- Use of DME as renewable energy carrier is thought to be a promising option for the global warming issue.
- JDA is willing to cooperate with our overseas friends.