

**Development and Promotion of Environmental friendly Heavy Duty Vehicles
such as DME Trucks
Ronald Reagan building and International Center
Washington DC.
Friday, March 17th, 2006**

Prospects of Fuel DME

Shuichi kajitani

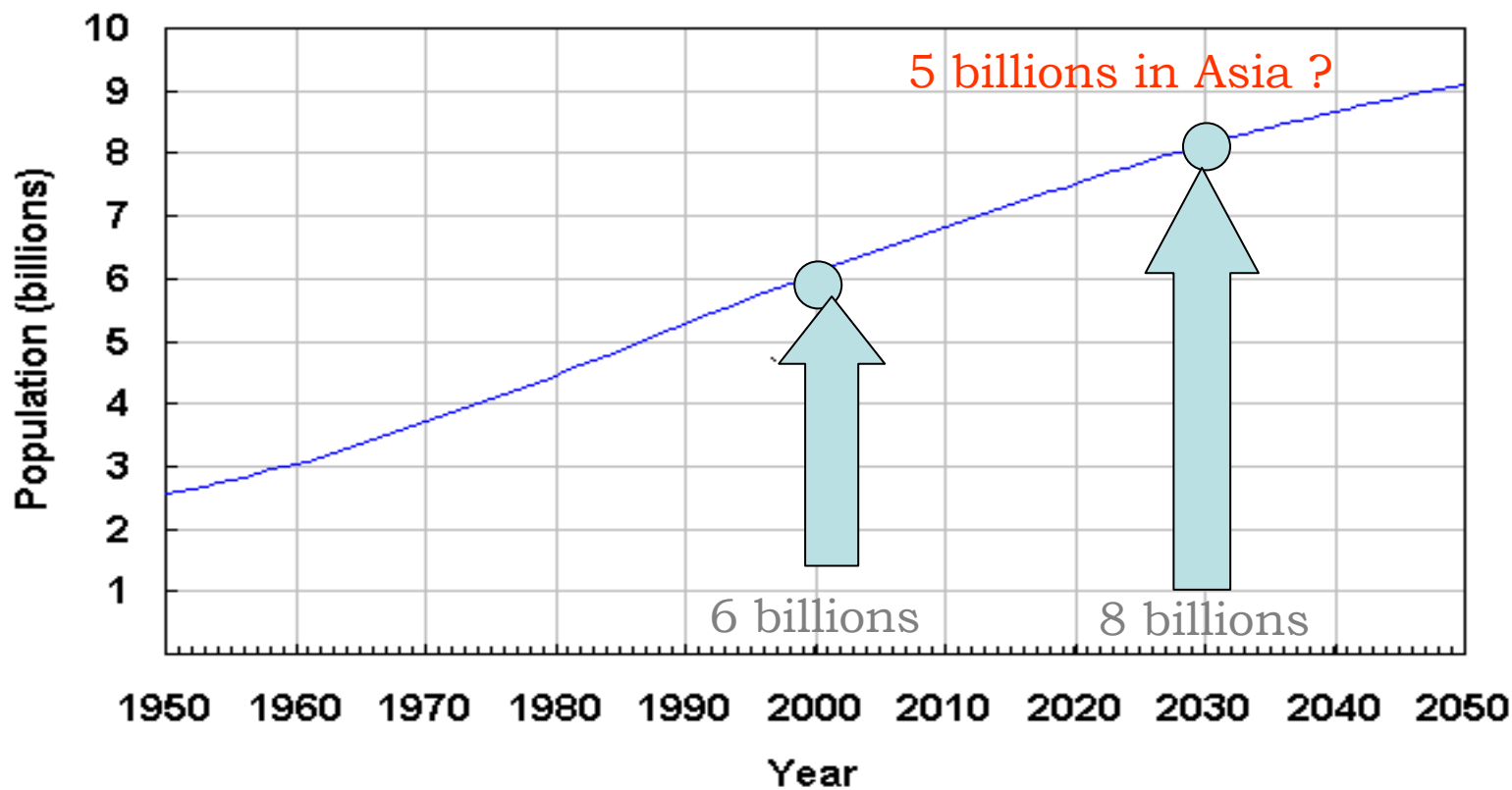
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Prospects of fuel DME

- Background
- What is DME?
- DME as a fuel for Diesel engine
- DME combustion in the cylinder
- And
- Conclusions

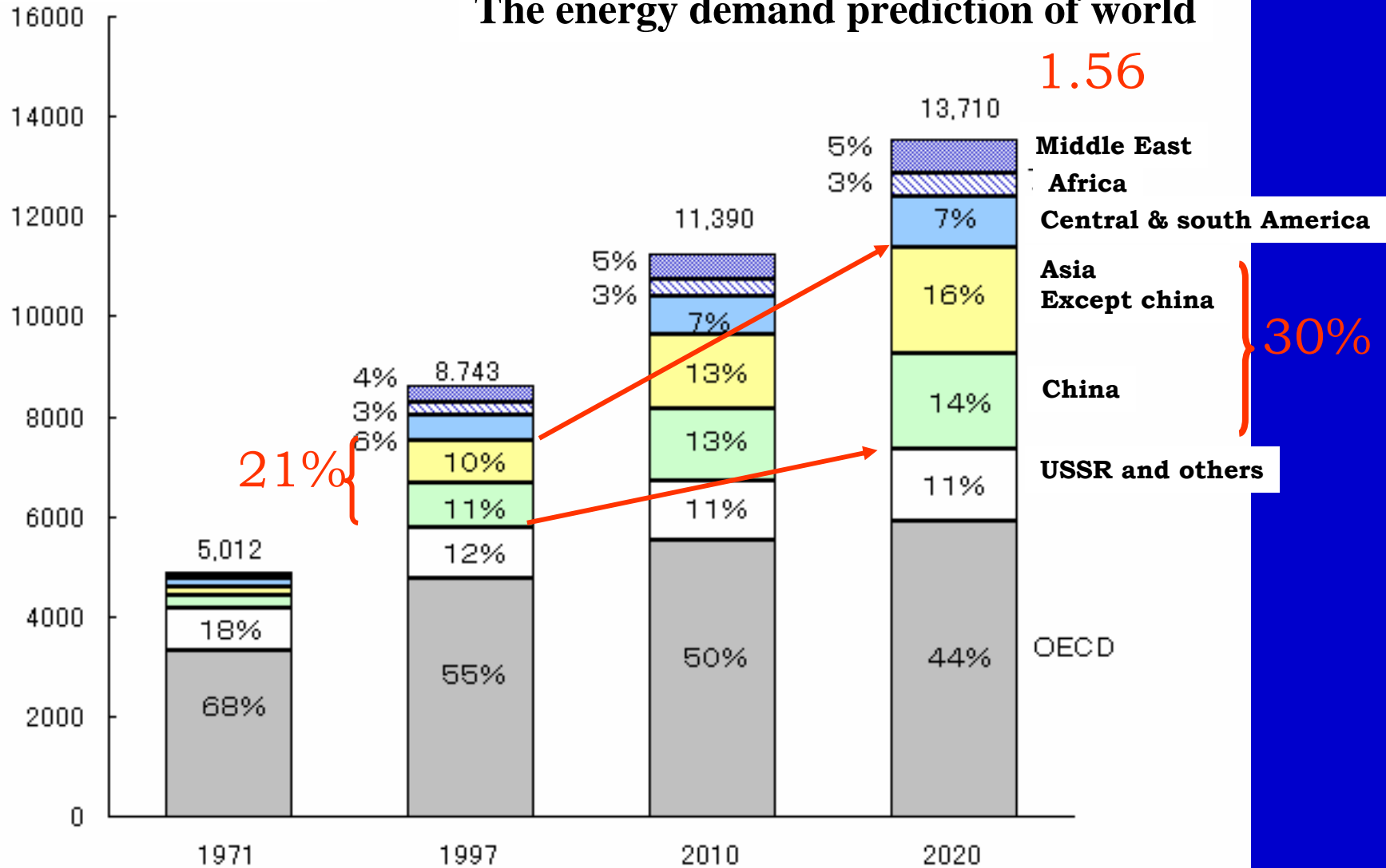
World Population: 1950-2050



Source: U.S. Census Bureau, International Data Base 5-10-00.

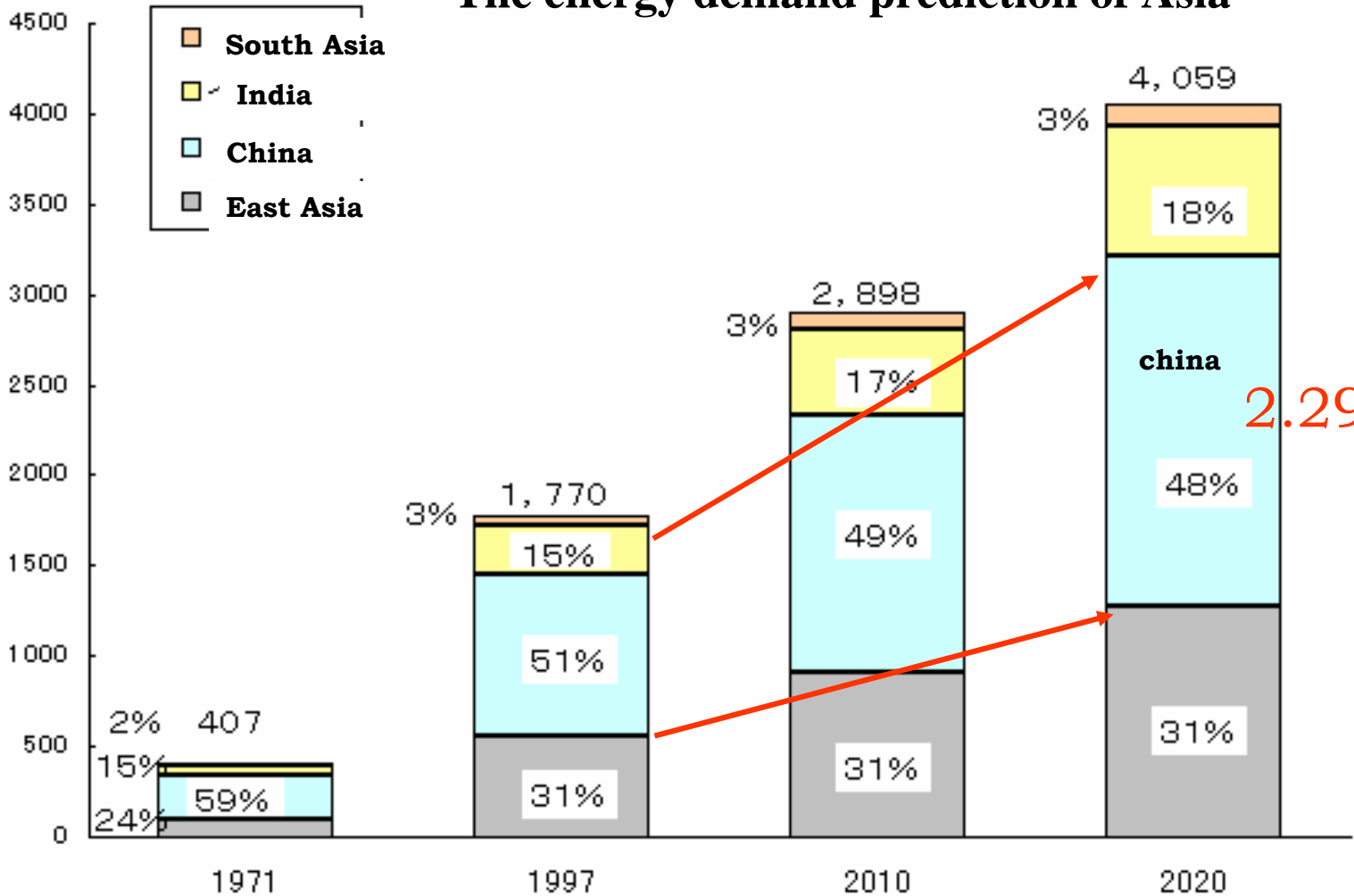
Equivalent to oil MMT

The energy demand prediction of world



石油換算百万トン

The energy demand prediction of Asia

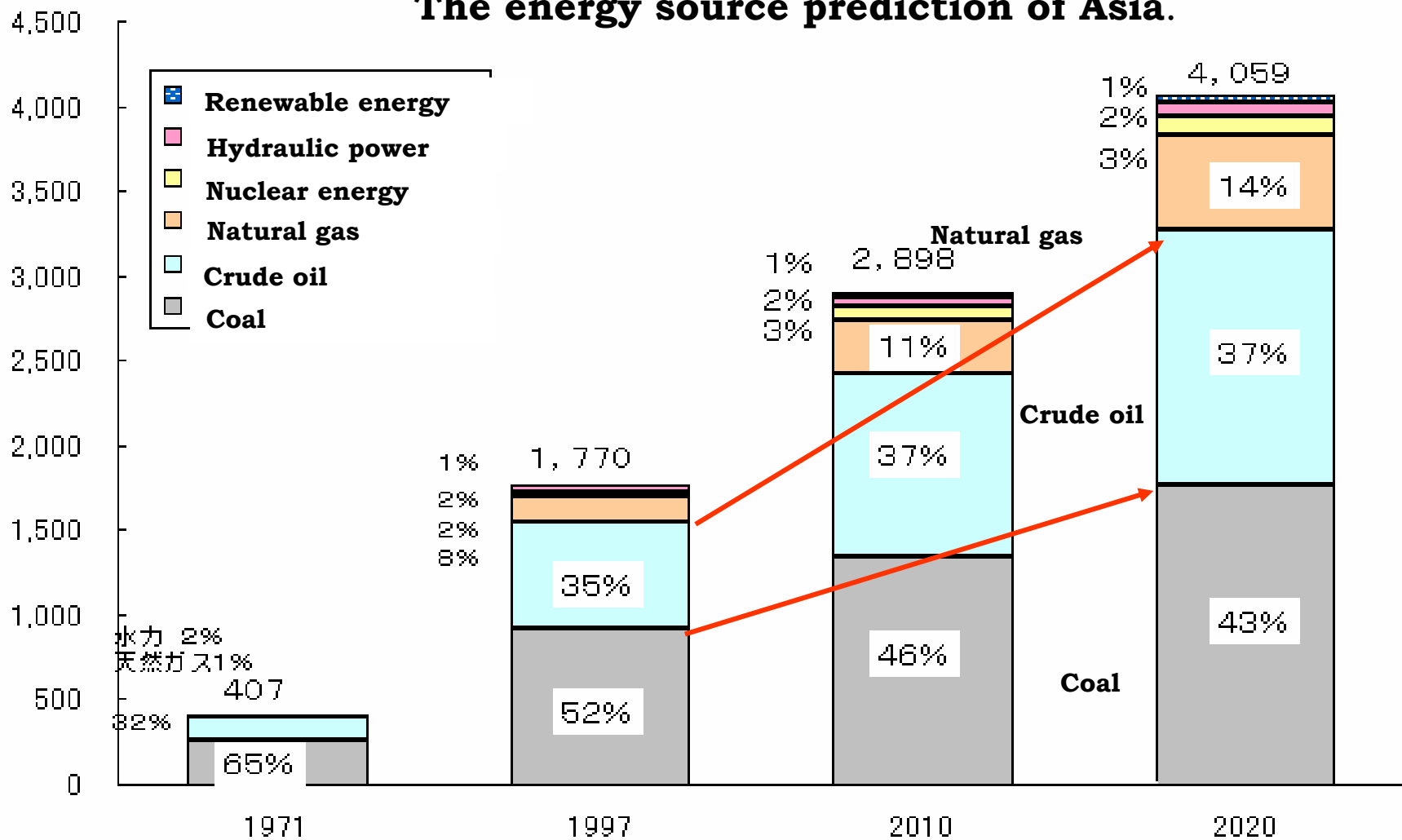


(注) 東アジア: ASEAN、韓国、台湾等
南アジア: パキスタン、バングラディッシュ等

(出所) IEA/World Energy Outlook 2000

石油換算百万トン

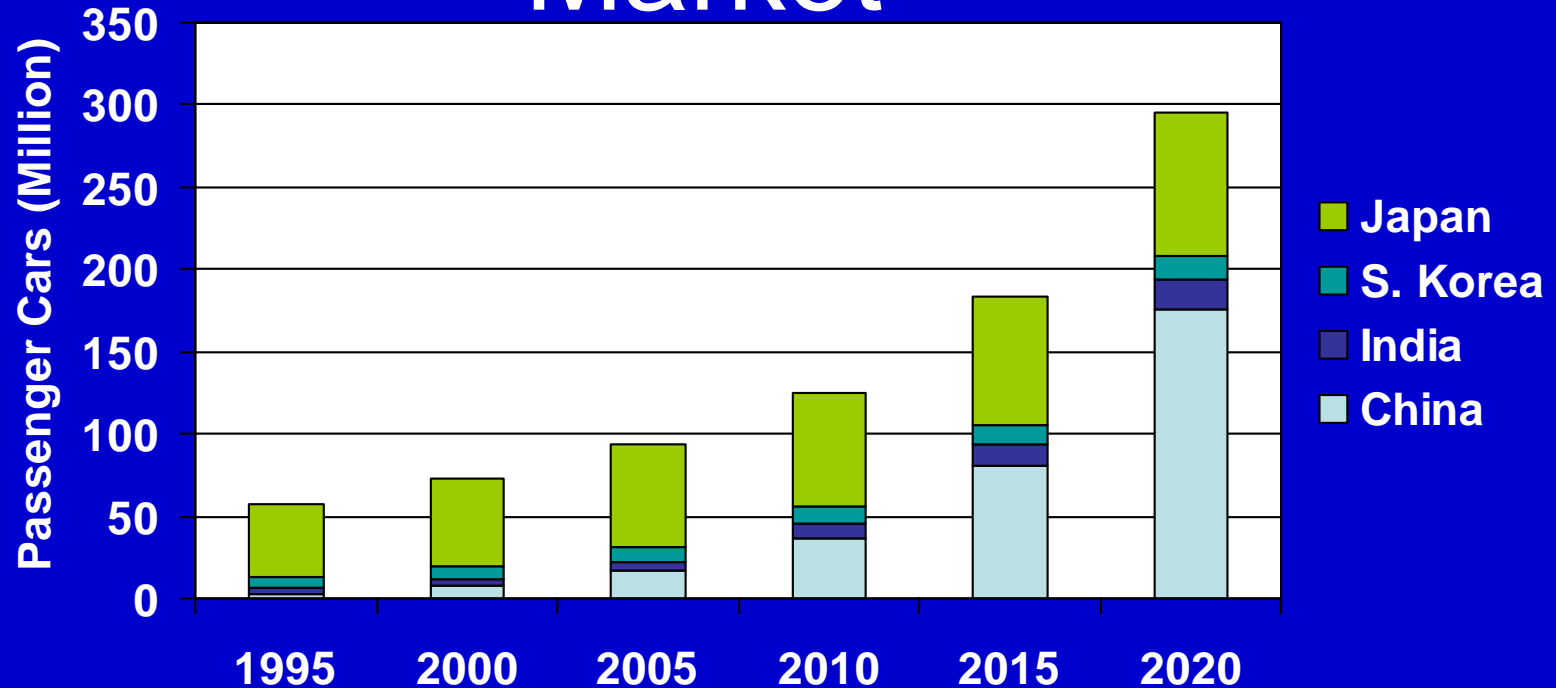
The energy source prediction of Asia.



(注) アジア地域: 中国、韓国、アセアン、インド、台湾、パキスタン等

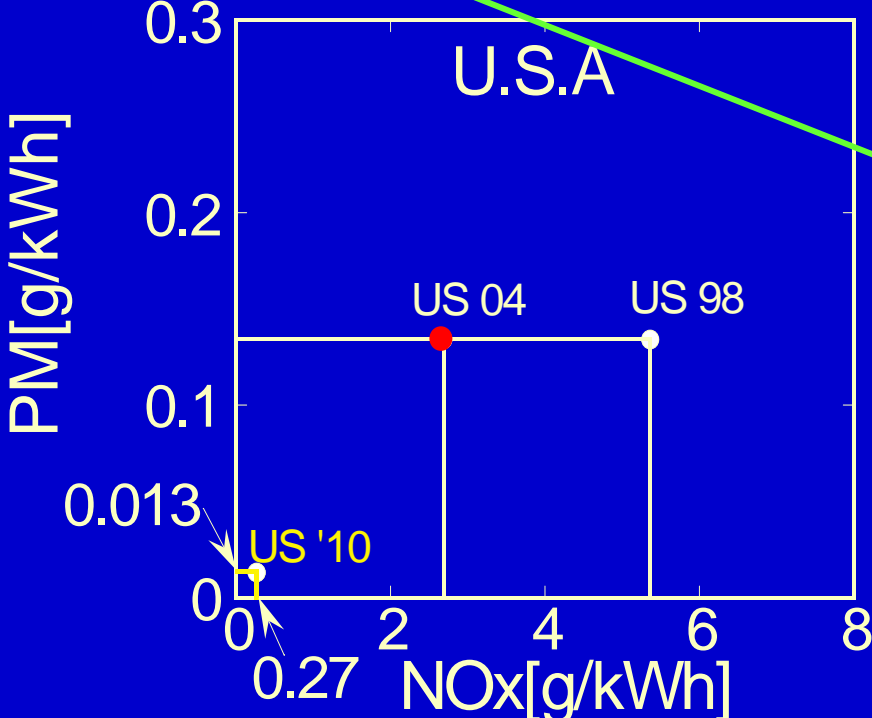
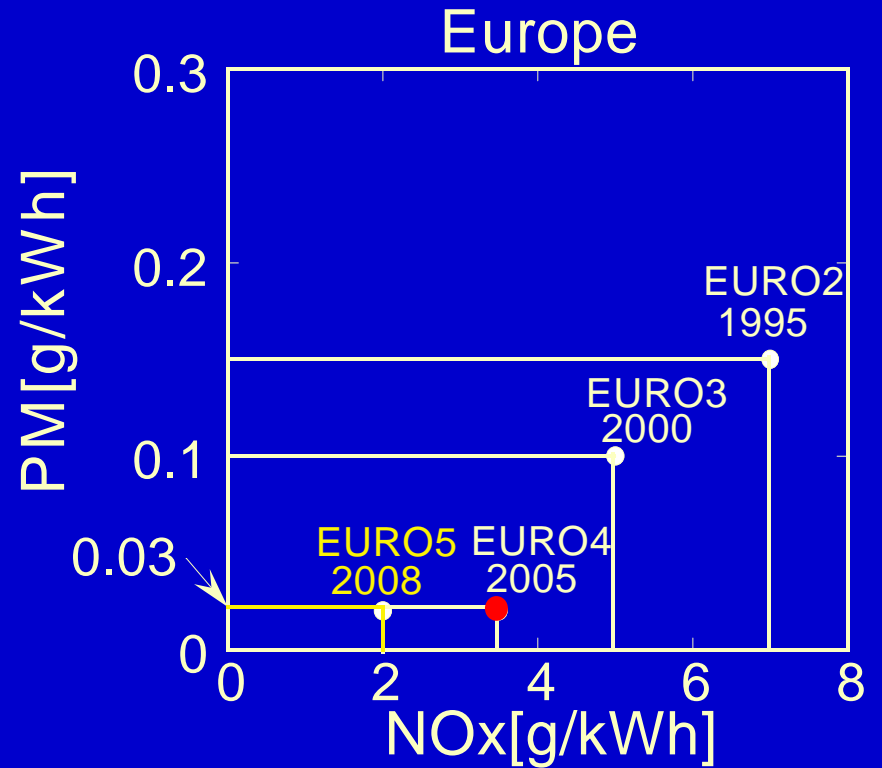
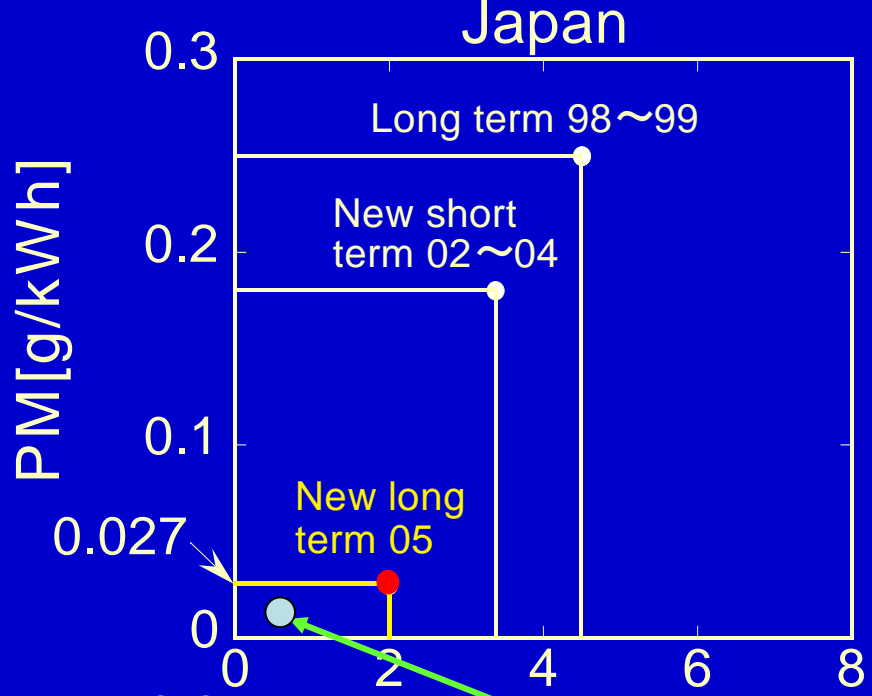
(出所) IEA/World Energy Outlook

Asian Passenger Car Market



- Chinese passenger car registrations expected to increase by a factor of 24 between 2000 and 2020.
- Indian demand to increase by a factor of 3 to 4 over the same period.

Source: Schipper et al: 2001 IEA and Hart/IRI estimates.



'09 Regulation of Japan
NOx 0.7g/kWh
PM 0.01g/kWh

What is DME ?

Most simple Hydrocarbon

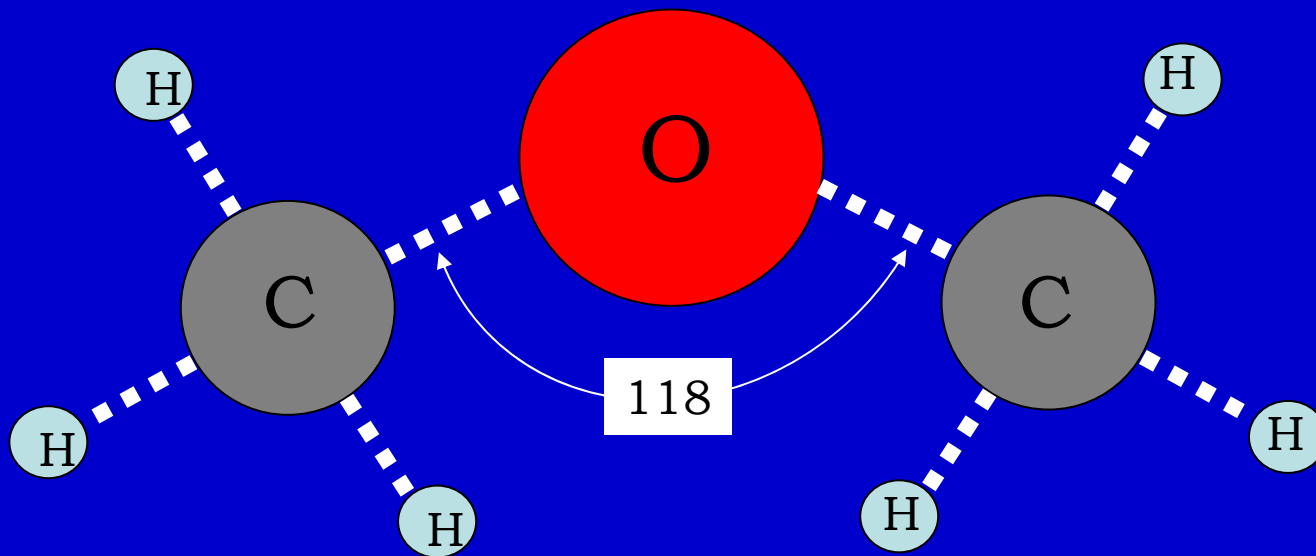
Methane : CH₄

Most simple Alcohol

Methanol : CH₃OH

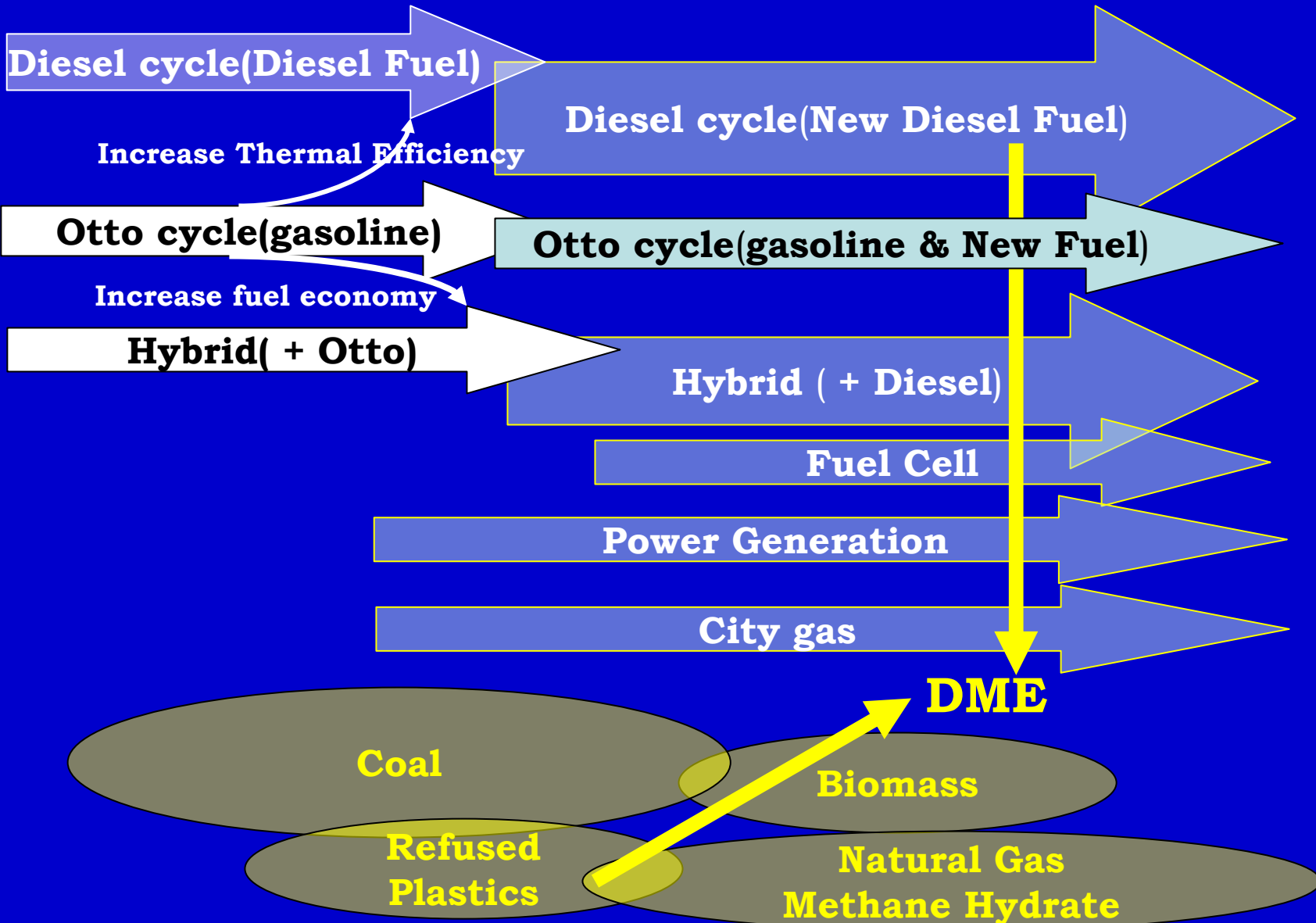
Most simple Ether

DME : CH₃OCH₃



Today

Near Future



Utilization technologies of DME

- 1) Power Generation (Gas turbine, boiler)
- 2) Diesel Engine (light and Heavy duty)
- 3) *LPG alternative Under utilization in china*
- 4) Fuel cell (Direct and Reformer type)
- 5) SNG (synthesized natural gas) from DME
- 6) Resources for chemical substances
- 7) *Propellant Under utilization in the world*

Toxicity
DME

1979

Bohnen,K.J.M “DME-A promising Alternative Propellant in the Fluorocarbon Crisis”, Areosole Report,18(3),pp70-77,1979

Property
DME

1988

H.Holldorff,et al. “ Vapor Pressure of N-Butane, Methyl Chloride, Methanol and Vapor-Liquid Equilibrium of DME-Methanol”, Fluid Phase Equilibria, 40, pp.113,1988

Starting aid

1988

K.H.Kozole et al.”, *The use of DME as a Starting Aid of Methanol-Fueled SI Engines at Low Temperatures*, SAE Paper 881677

1990

C.J.Gree,et al, SAE Paper 902155

Ignition aid

1991

Cilolat D. “*Methanol/DME Fueling of C.I.Engine*” 11th ISAF pp.441,Flrenze,1991
M.K.Karpukl, et al, SAE Paper 912420

1992

T.Murayama et al, SAE Paper 922212

1994

Guo, T, et al, SAE paper 941908

Fuel DME

1995

Kapus,P et al, SAE Paper 950062(Injection System)
Macarthy,C. et al., SAE paper 950061(ULEV HD Engine)
Hansen,J.B. et al.,SAE Paper 950063(DME Production)
S,C.Sorenson, et al.SAE Paper 950064(Small Engine DI)
Fleish,T.et al., SAE Paper 950061(ULEV1994 Model Passenger Car)
Kapus,P.E.et al.,SAE paper 952754(ULEV Passenger Car)

Injection System

1996

Michel Glensvig,et al.”High Pressure Injection of Dimethyl Ether”, ICE-Vol.27-3 Fall Technical Conference, Vol.3 ASME 1966

Methanol

(Low cost fuel) → (High cost Engine)

Complex or Sophisticated Engine System

① Crude oil



Pre-combustion

(Inter cooling, Low Swirl, **Fuel quality**
low oil consumption)

During combustion

(Injection, Electronics, Combustion chamber)

After combustion

(EGR, Particulate Trap, SCR, DeNOx Cat.)

Natural gas

Coal

Biomass

Refused
plastics
and so on

Various resources

(High cost fuel) → (Low cost Engine)

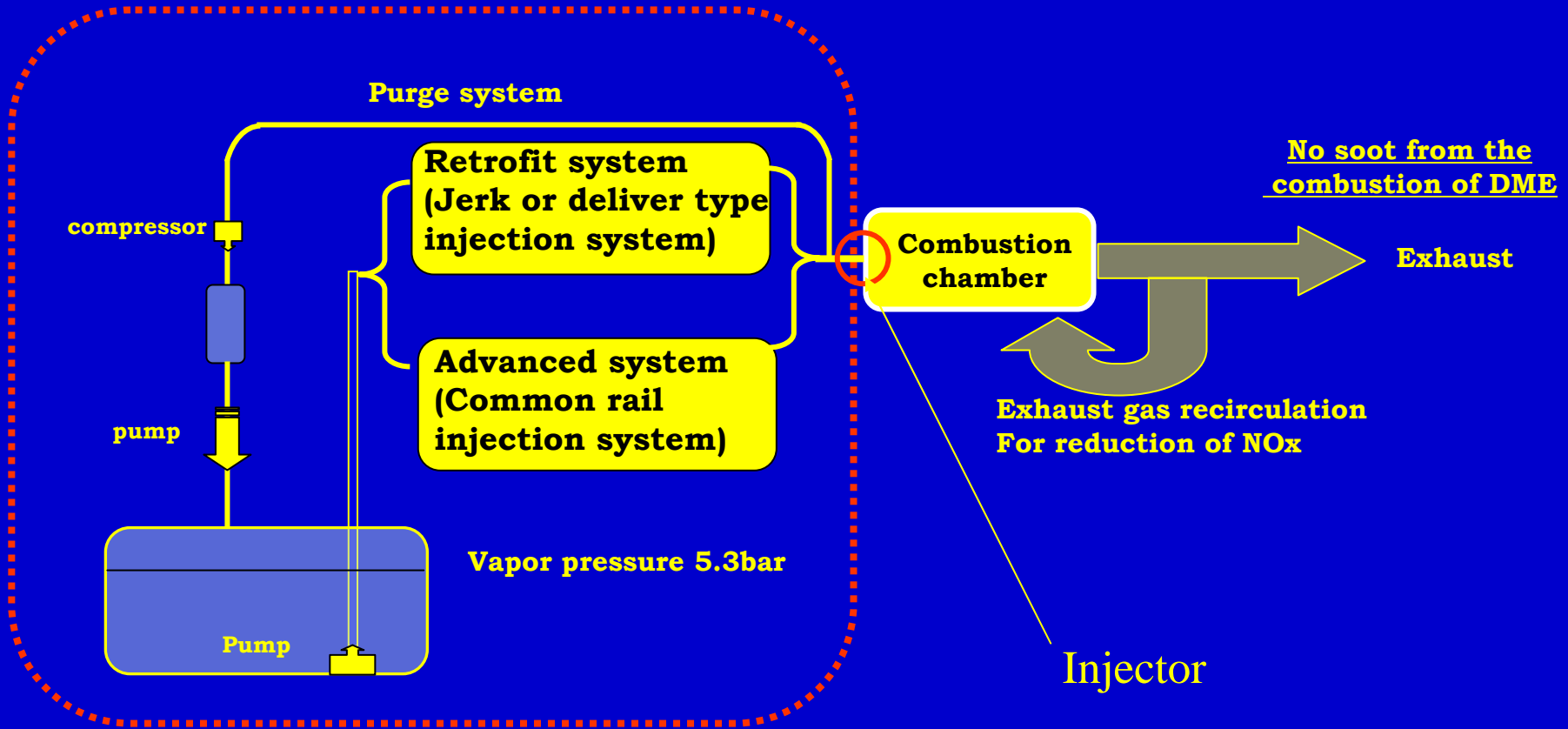
Clean fuel



Simple Engine System

(high cost fuel, but sustainable)

How to use DME for diesel engines ?



Diesel fuel combustion in the cylinder



960rpm, Swirl ratio 1.95

DME combustion in the cylinder

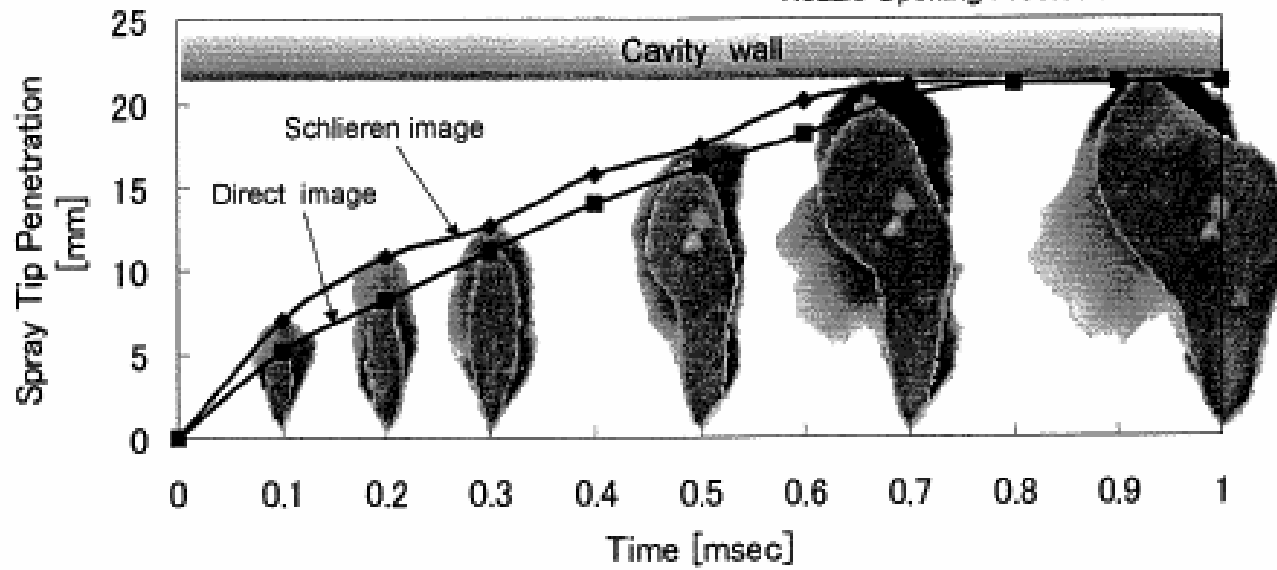
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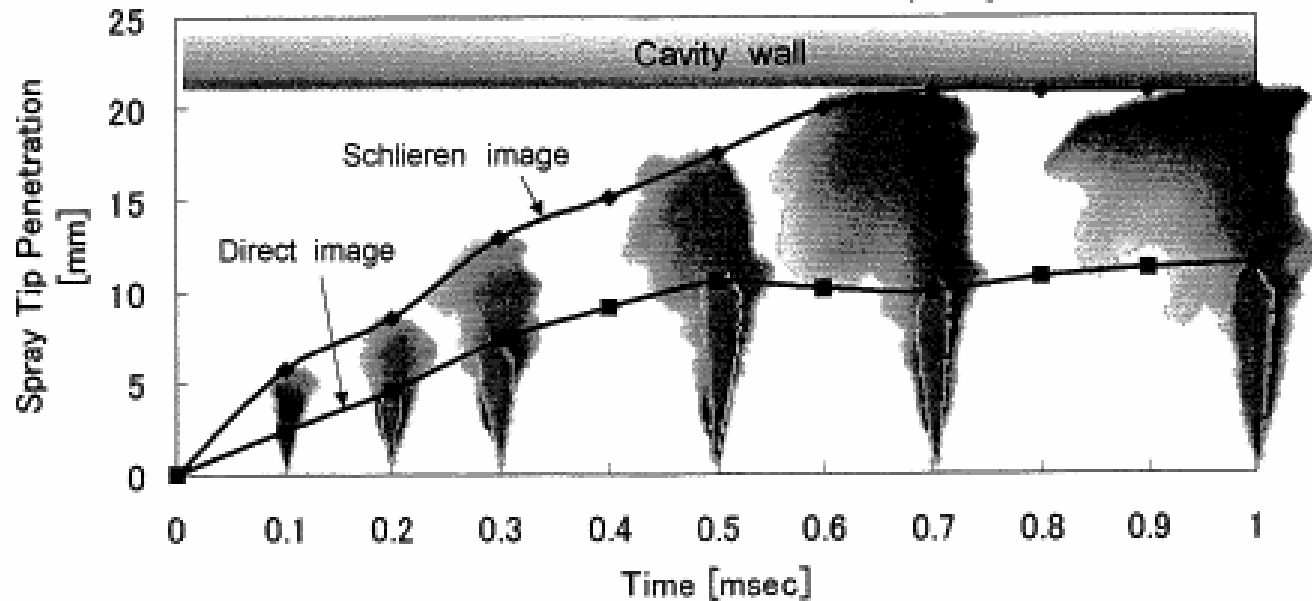
START 5 ▶ 9000FPS

960rpm, Swirl ratio 1.95

Engine Speed : 960rpm
Fuel : Light Oil
Nozzle Opening Press. : 19.6MPa



Engine Speed : 960rpm
Fuel : DME
Nozzle Opening Press. : 8.83MPa



Low injection Pressure at low engine speed and High Injection Pressure at high engine speed

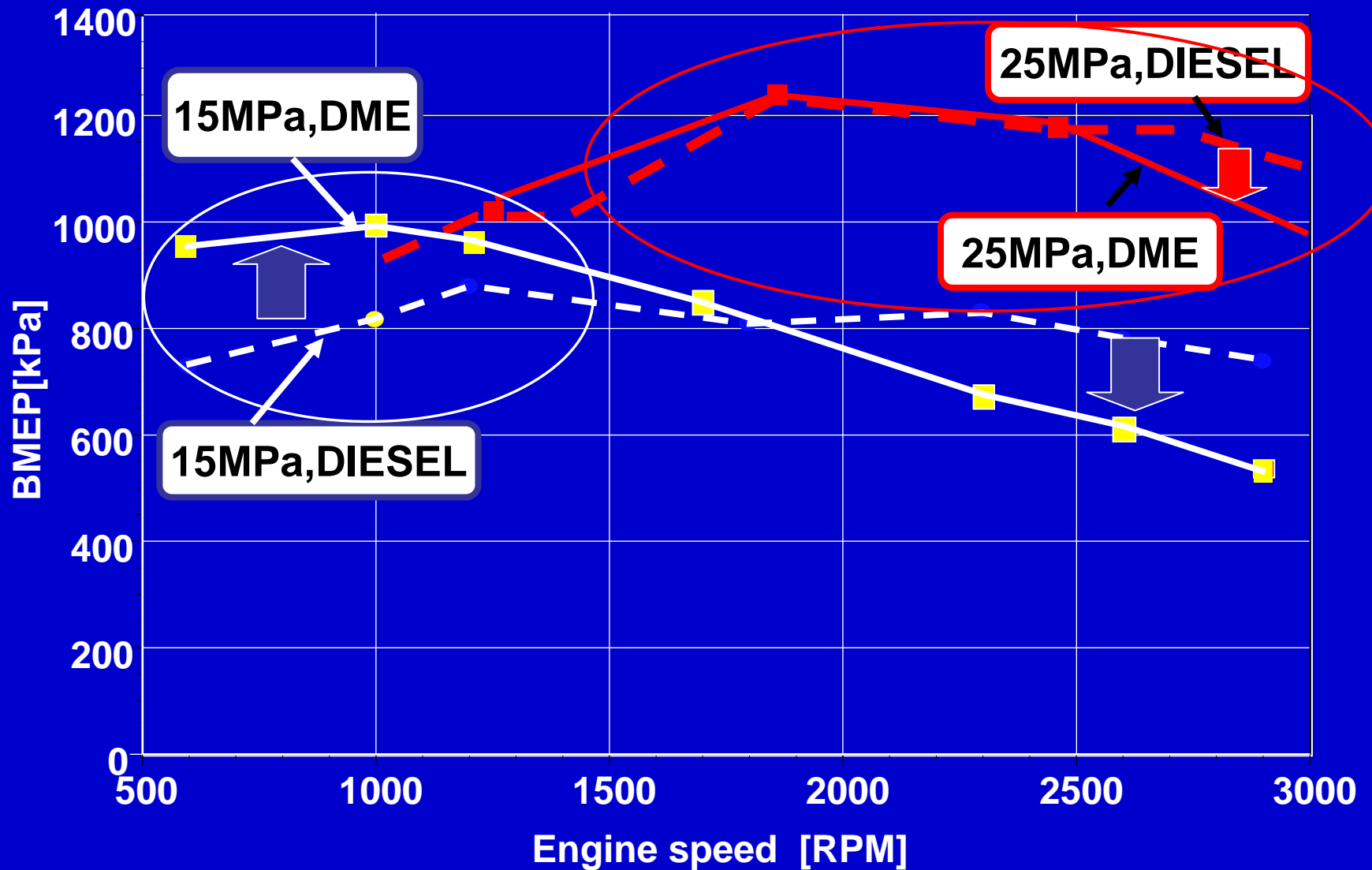


Image of split injection of DME

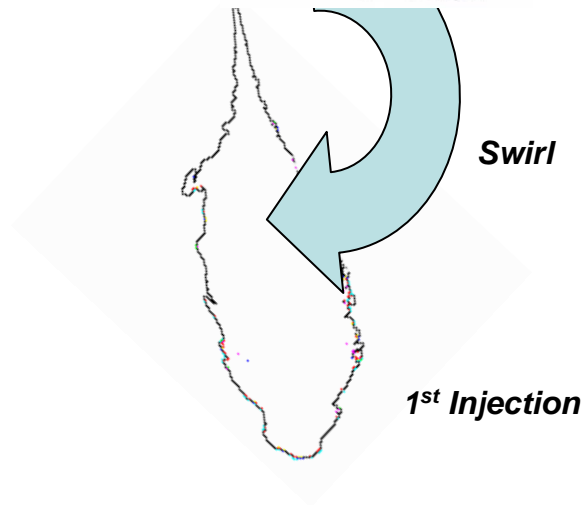
Fuel spray

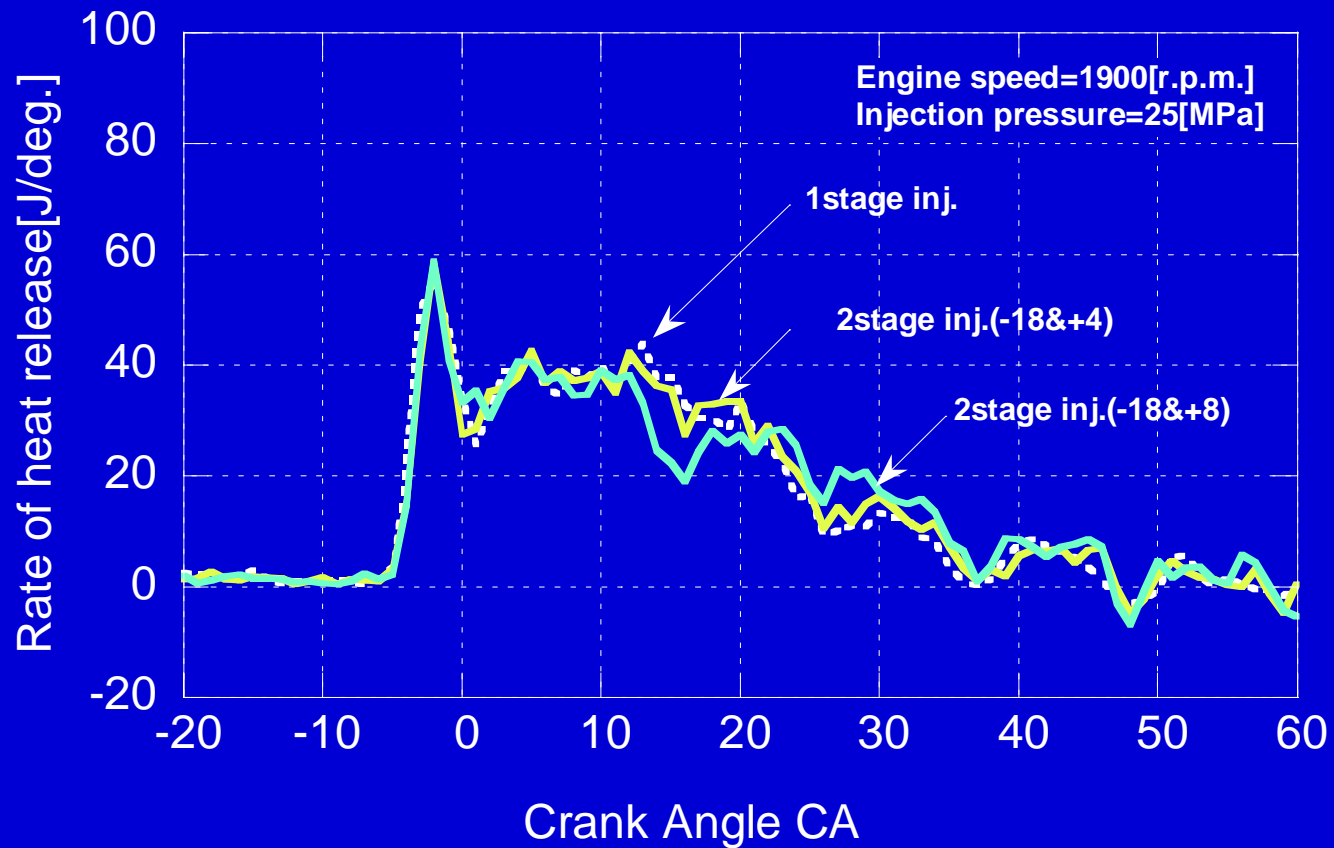
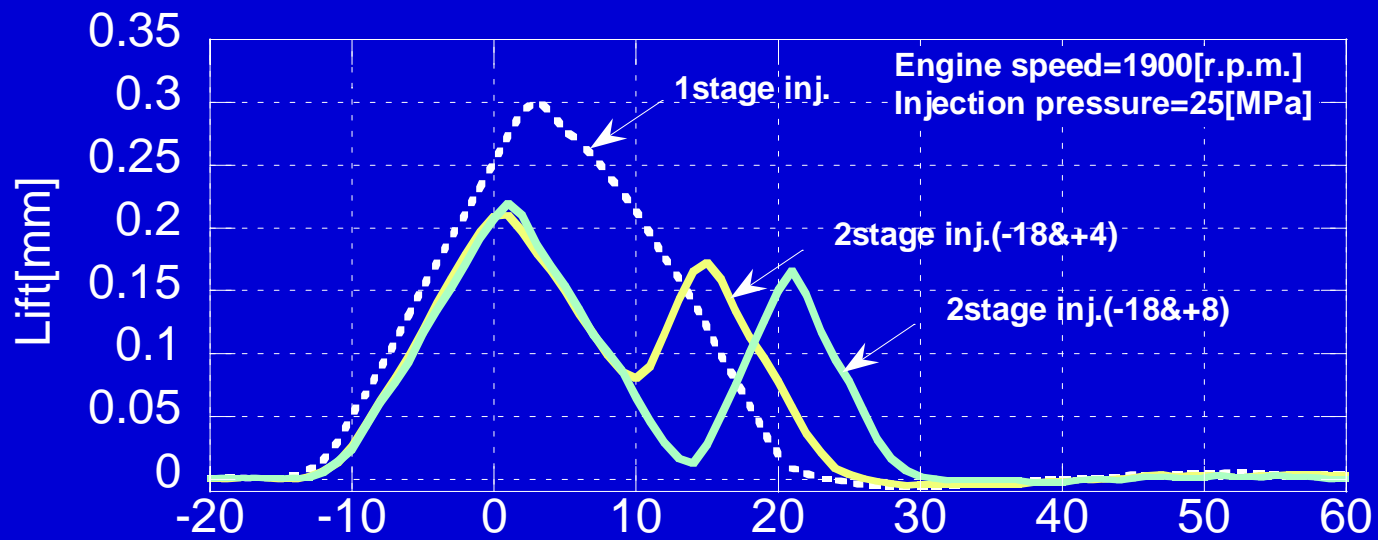


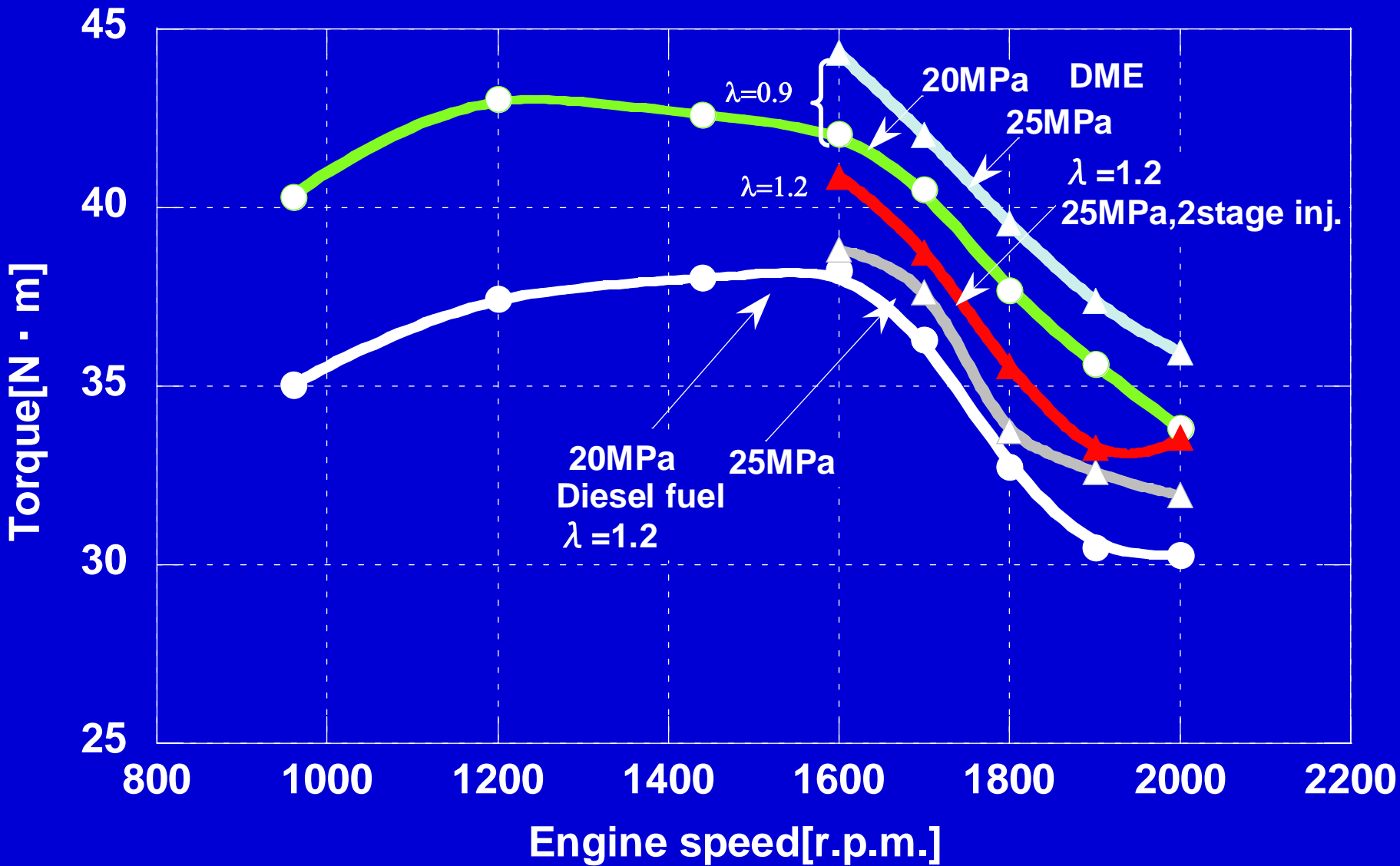
1st injection *For high degree of Constant volume*



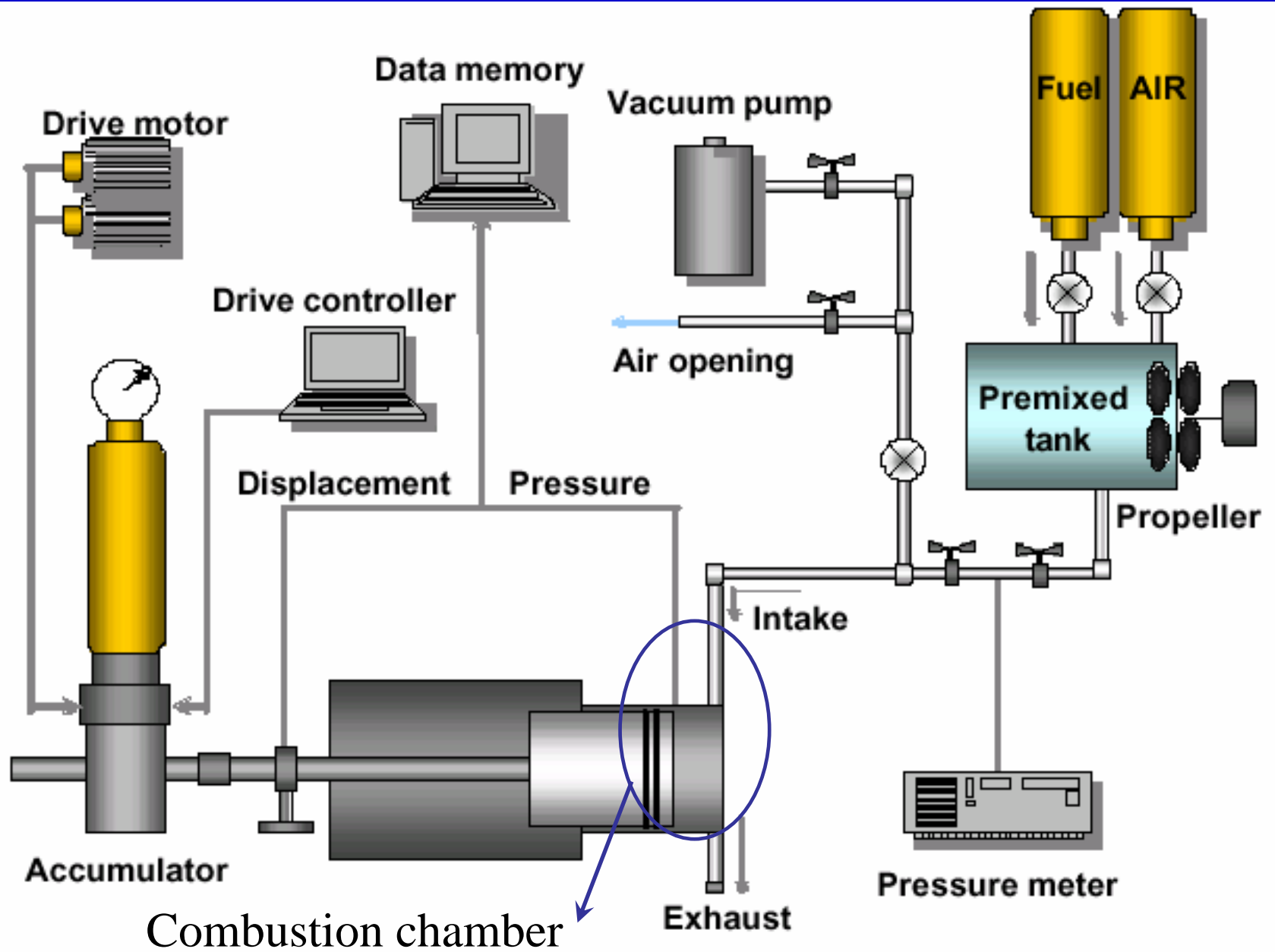
2nd Injection *For high air utilization*

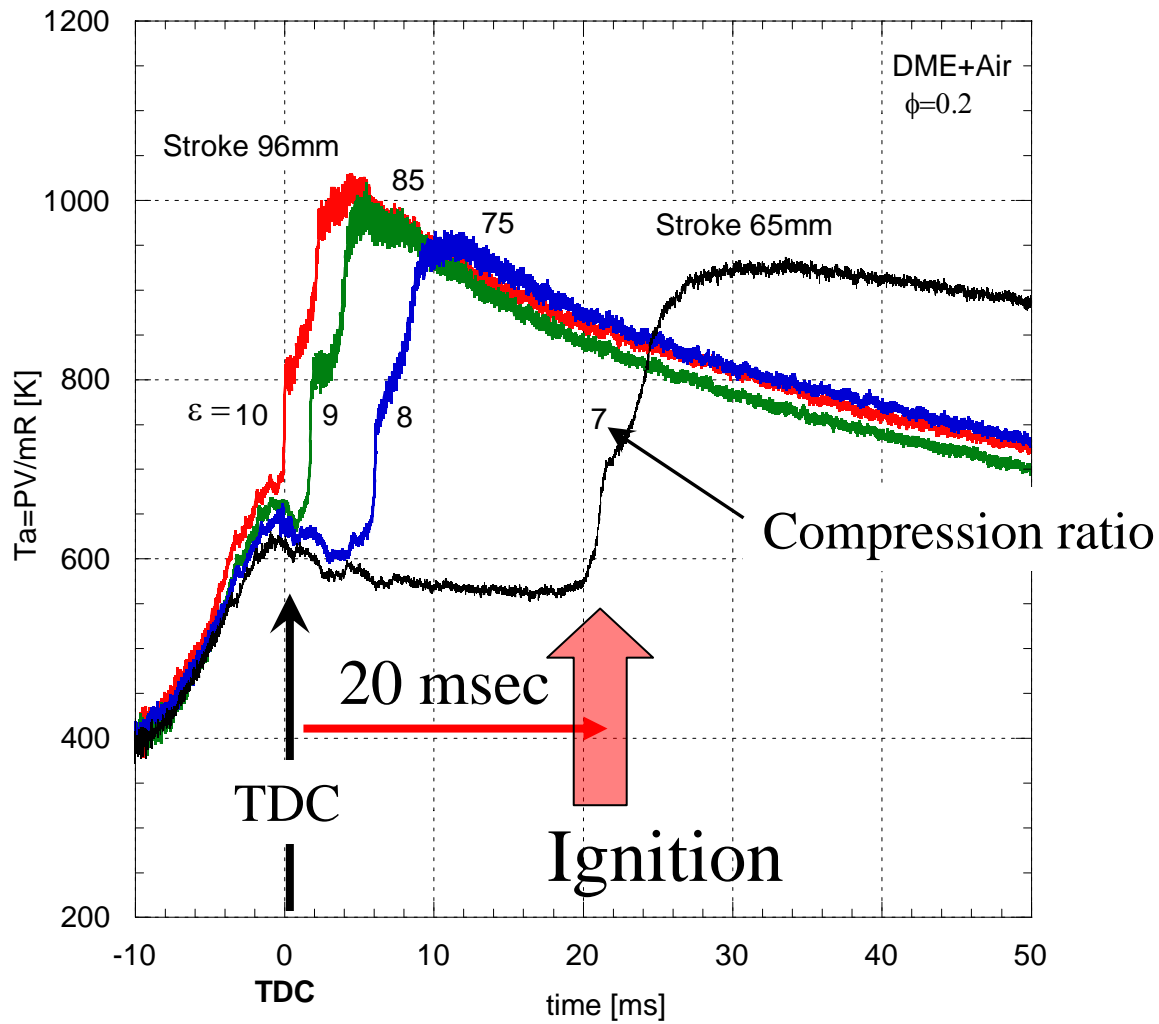






And

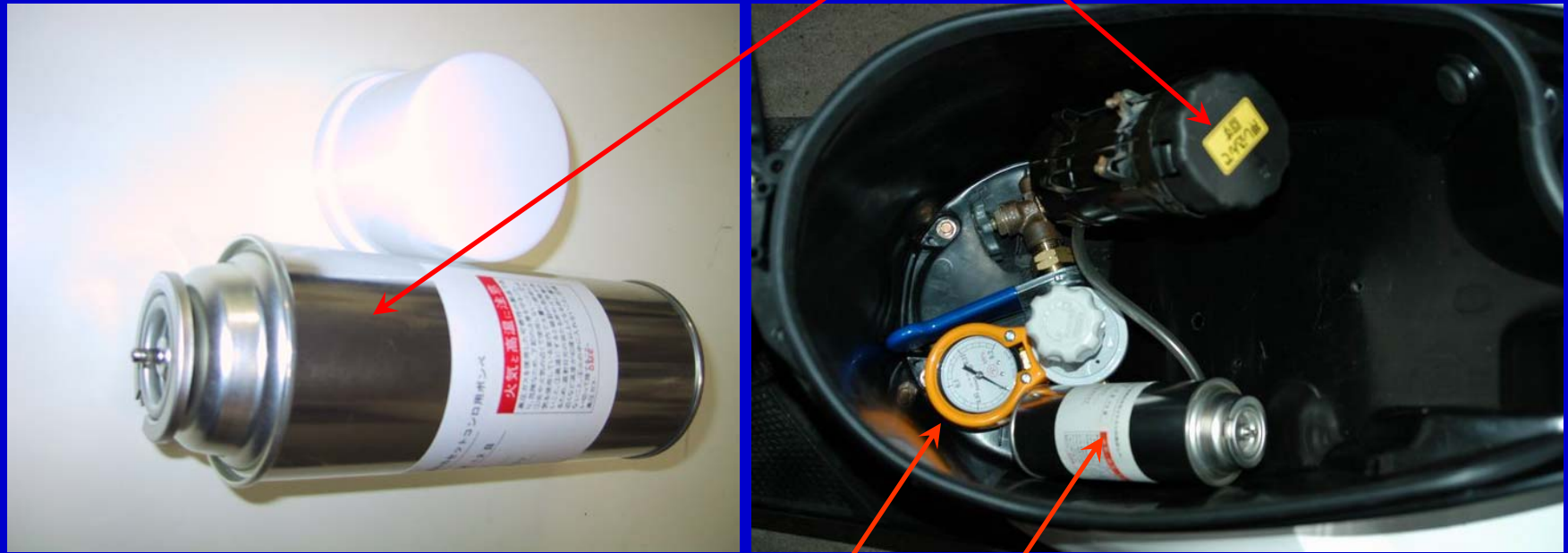




DME Bike



- (1) Small engine → Low fuel consumption
- (2) Can get a fuel at store



DME cassette

Pressure regulator

Spare DME cassette



2003 China DME forum (Shanghai)
(LPG+DME)
Spark ignition Engine

CO₂



Well-to-Wheel (Natural Gas)

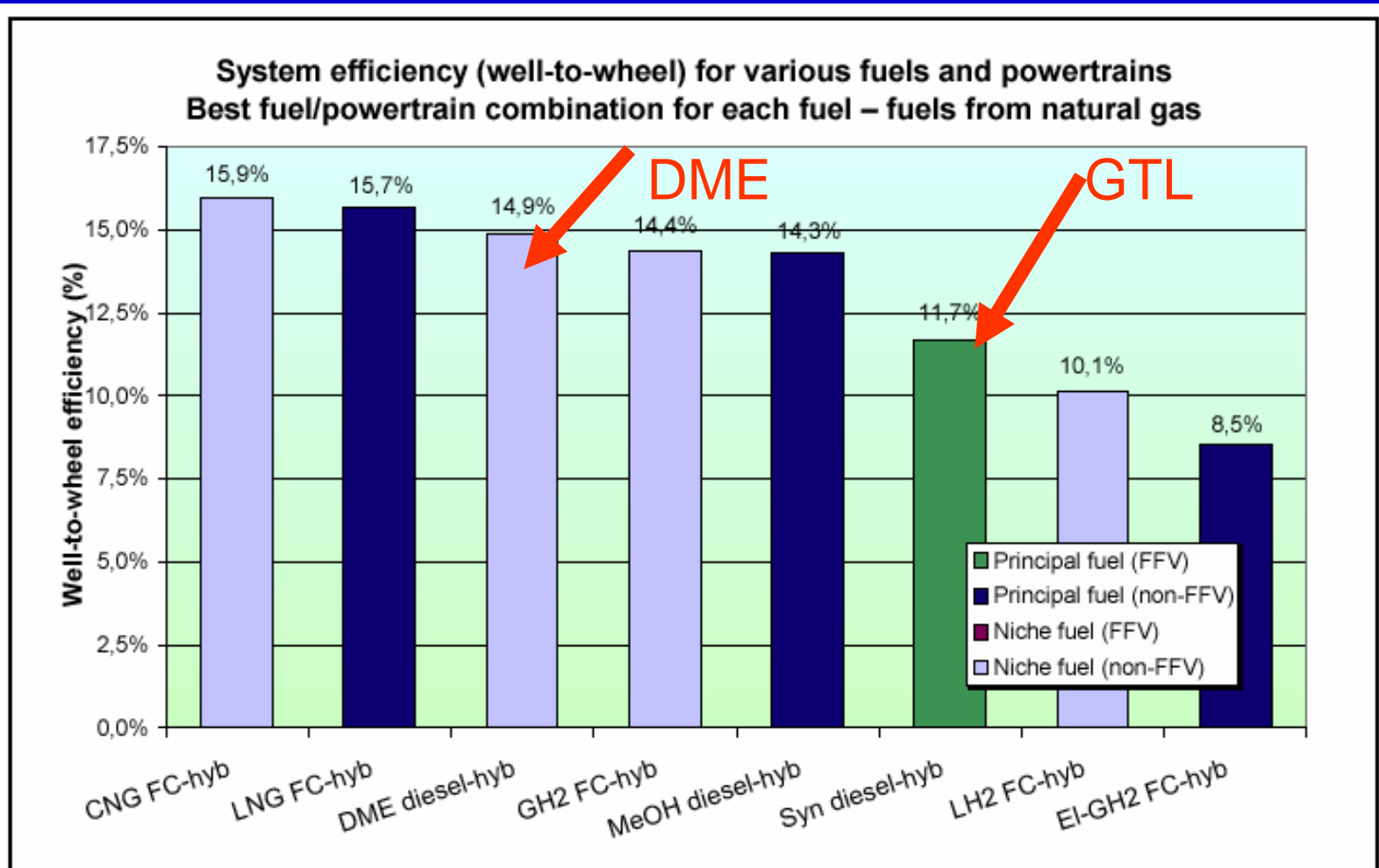


Figure ES-1. System efficiency for the best combinations of fuel/powertrain. Fuels from natural gas feedstock.

Well-to-Wheel (Biomass)

DME

MeOH, LH2, EtOH, GTL

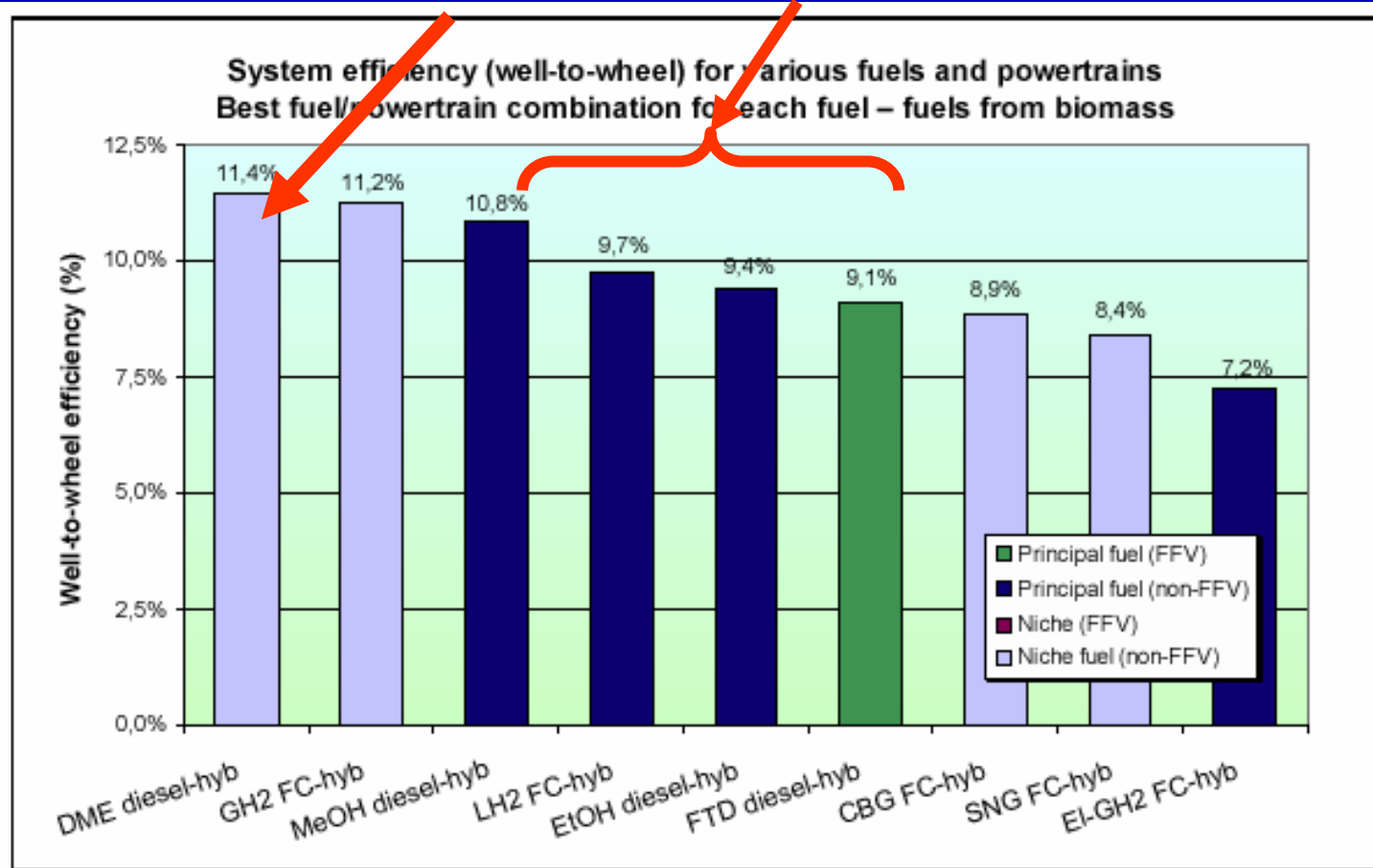
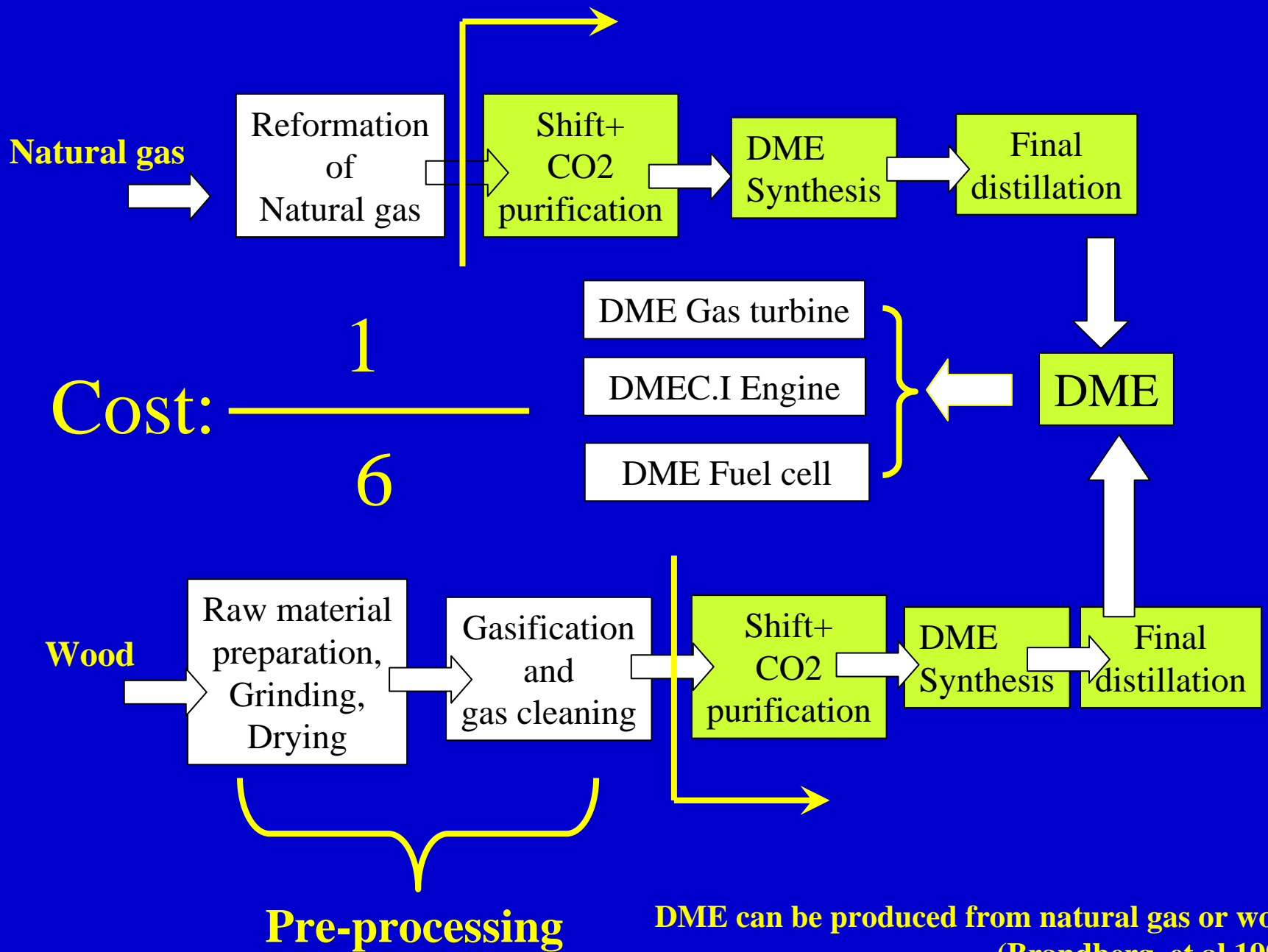
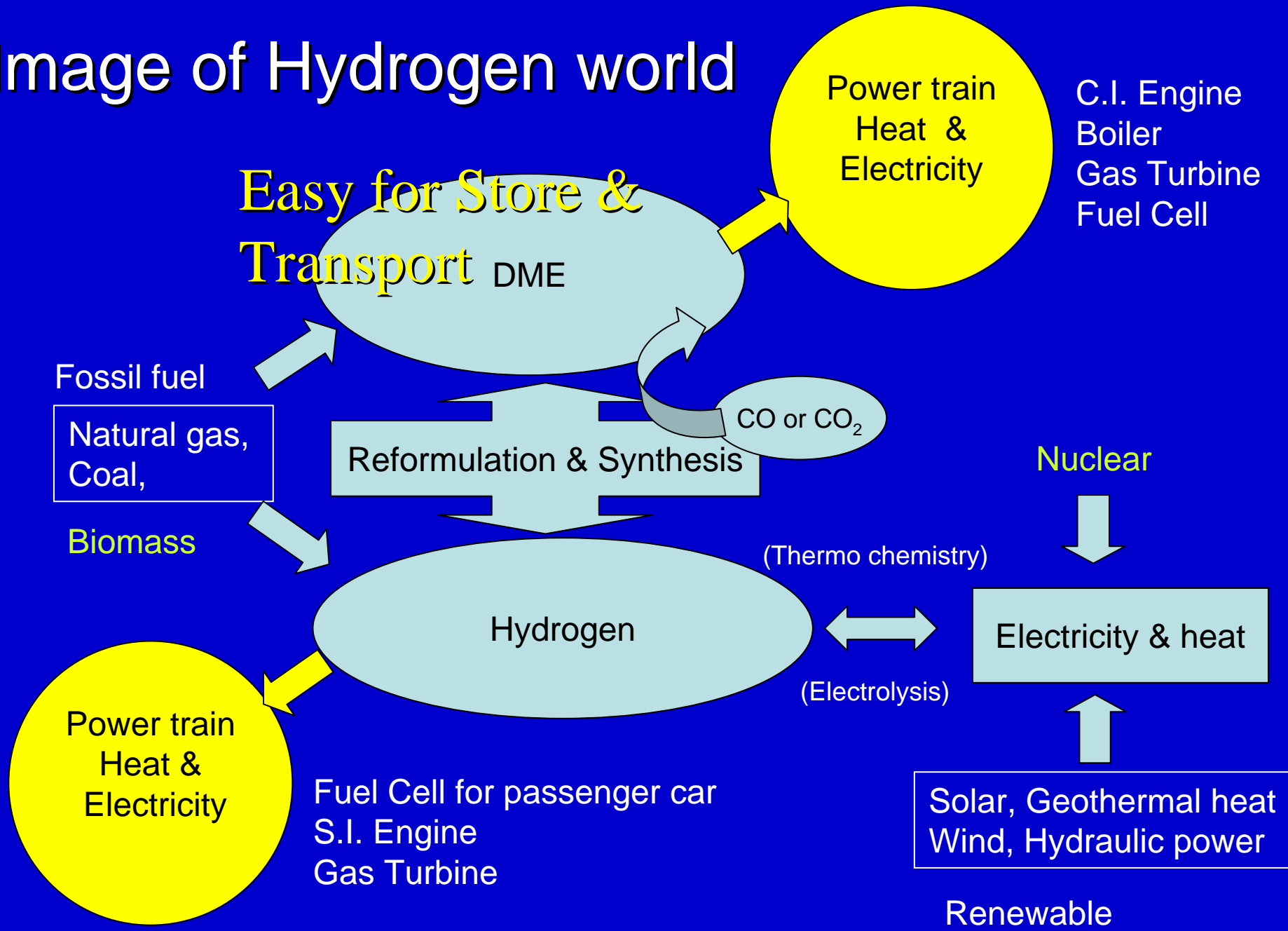


Figure 2. Well-to-wheel efficiency for the best combinations of fuel/drivetrains. Fuels from biomass feedstock.



DME can be produced from natural gas or wood (Brandberg, et al,1997)

Image of Hydrogen world



Conclusions

- 1) DME is multi purpose fuel and made from various resources.
- 2) DME is used for LPG alternative in china in this moment
- 3) The modification of fuel supply system enables to use diesel engine, and its performances is comparable to those of diesel engine operated with conventional diesel fuel.
- 4) Future severe emission requirement is satisfied by the use of DME diesel engines.
- 5) DME is a member of hydrogen world.

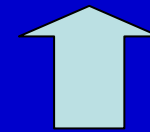
Thank You !
- Any Questions ?

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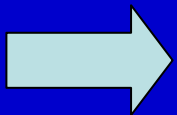


DME



DME Diesel Truck
Modified by NKK

Fuel supply
system



Isuzu DME Bus (2002)



KIER DME Track(2003)

Korea Institute of Energy Research



Volvo DME Truck (2005)

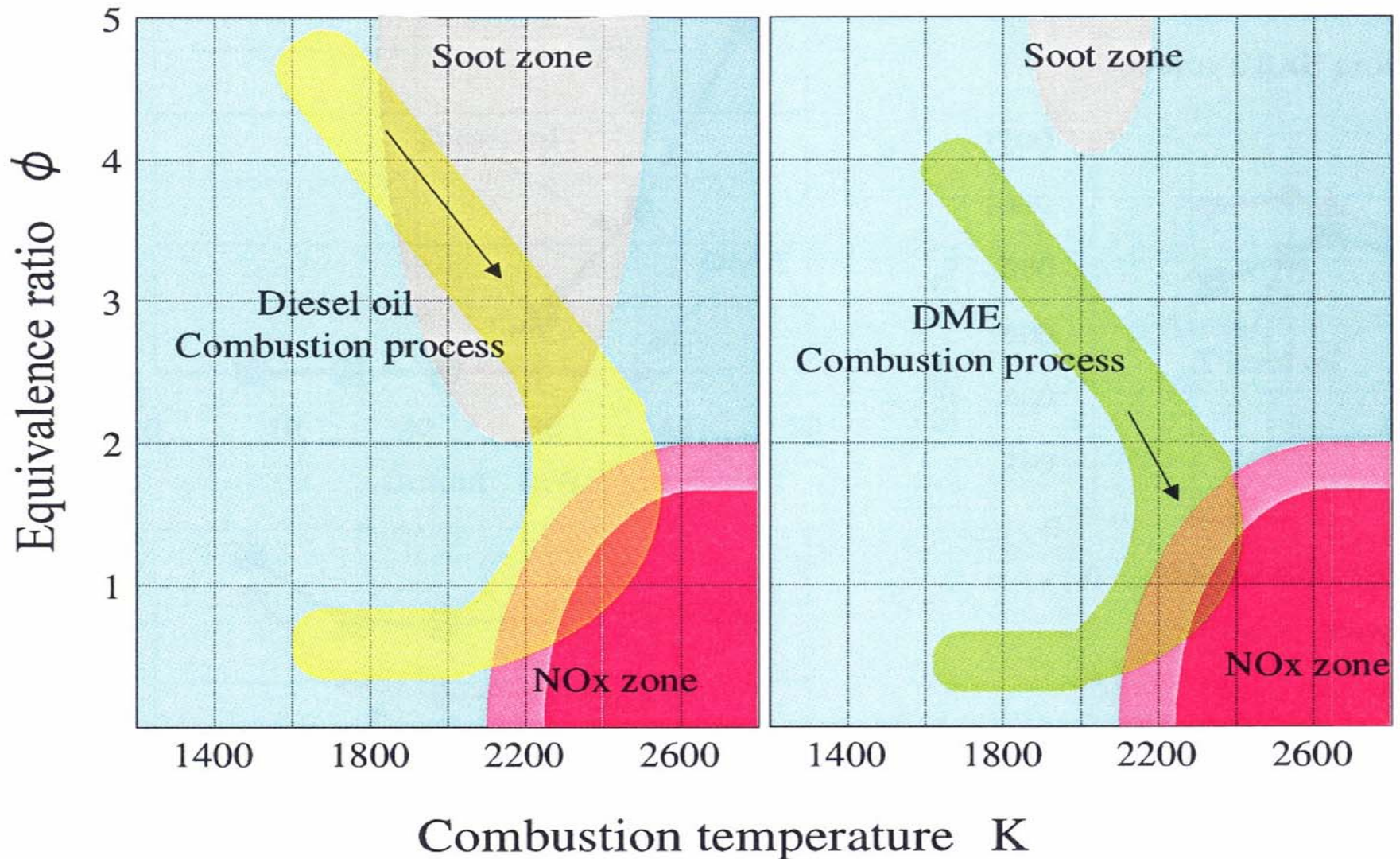




Combustion of DME

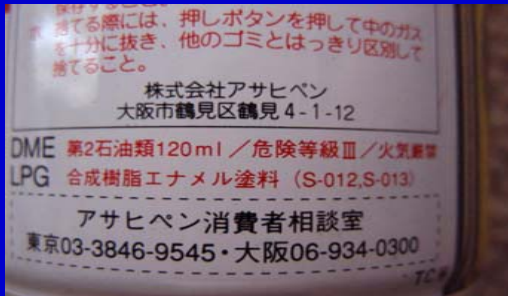
Diesel oil combustion

(DME:CH₃OCH₃) combustion

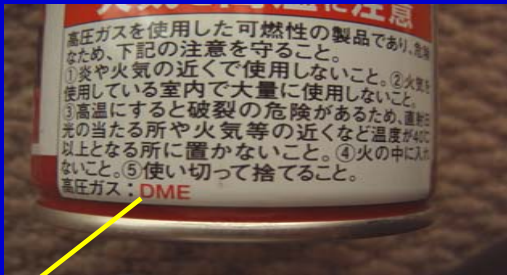


DME has been used as a propellant and LPG alternative

spray cans



Blend



Neat

cosmetics



10,000 tons/year
in Japan
150,000 tons/year
in the world



About 20,000 households are using DME as a LPG alternative.
The production cost from coal is around $\backslash 18/\text{kg}$ (17¢/kg)
Market price is twice of production cost. (**35,000ton/year**)
Good business in china in this moment.

