6th Research and Development 20 (RD20)
Technical Session on "Sustainable Biofuels and Bio-chemicals"

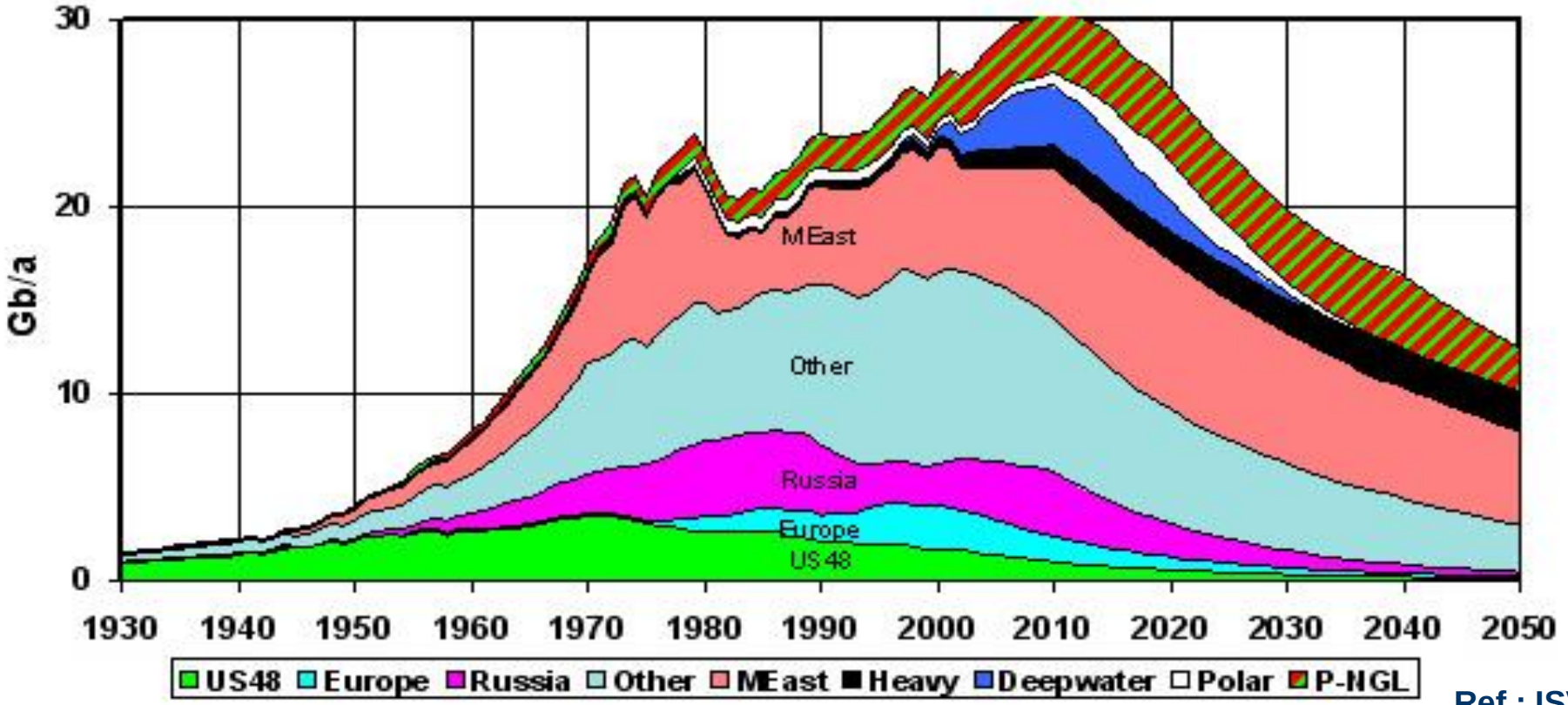
in Convention Centre,
India Habitat Center, Delhi, India
Day 1 December 2, 2024

Assessment of biofuels: quality management and standardization

Mitsuharu OGUMA

Energy Process Research Institute,
National Institute of Advanced Industrial Science and Technology (AIST)

Estimate crude oil production



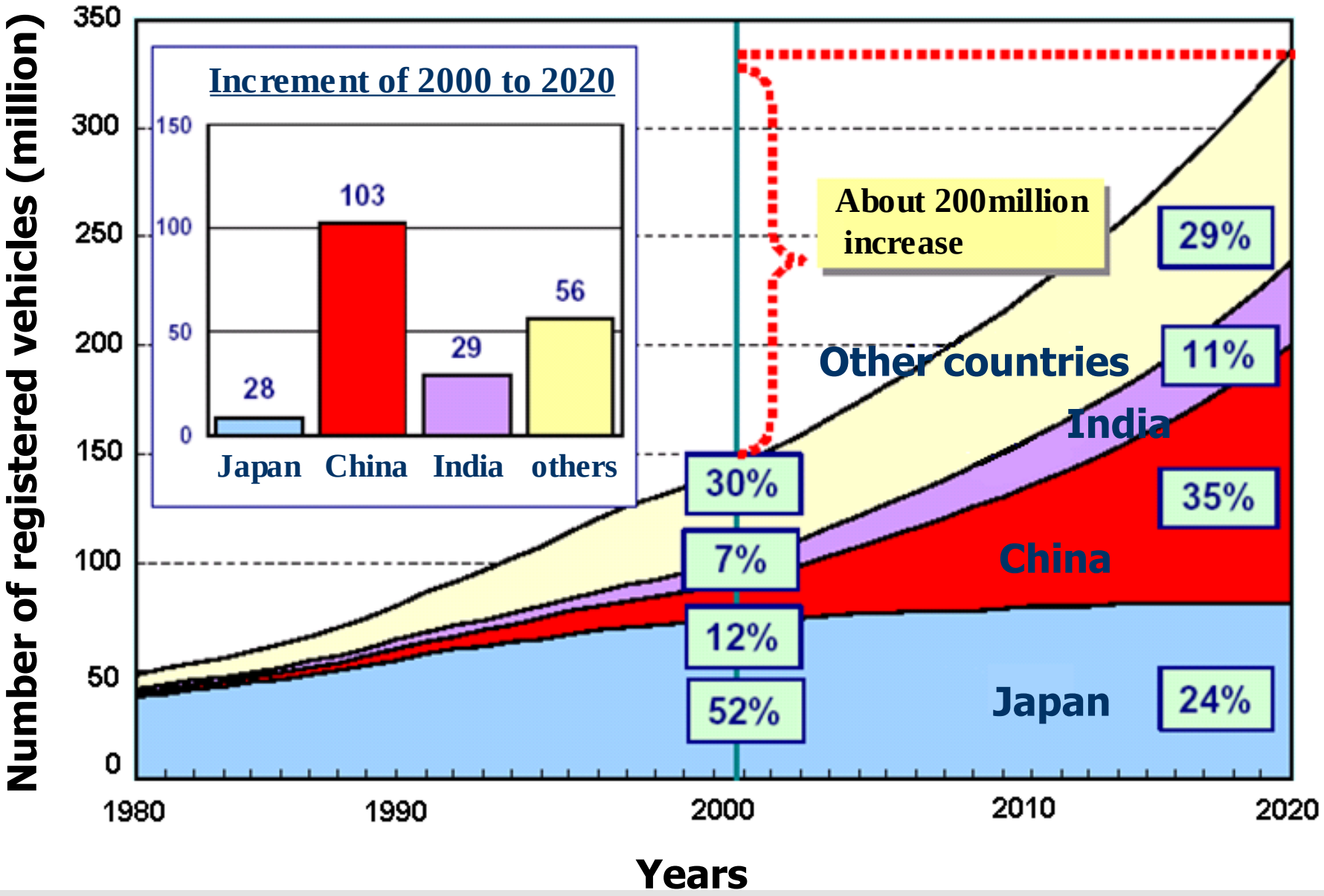
Ref.: ISV

Gb/a : Giga barrels of oil equivalent per annum

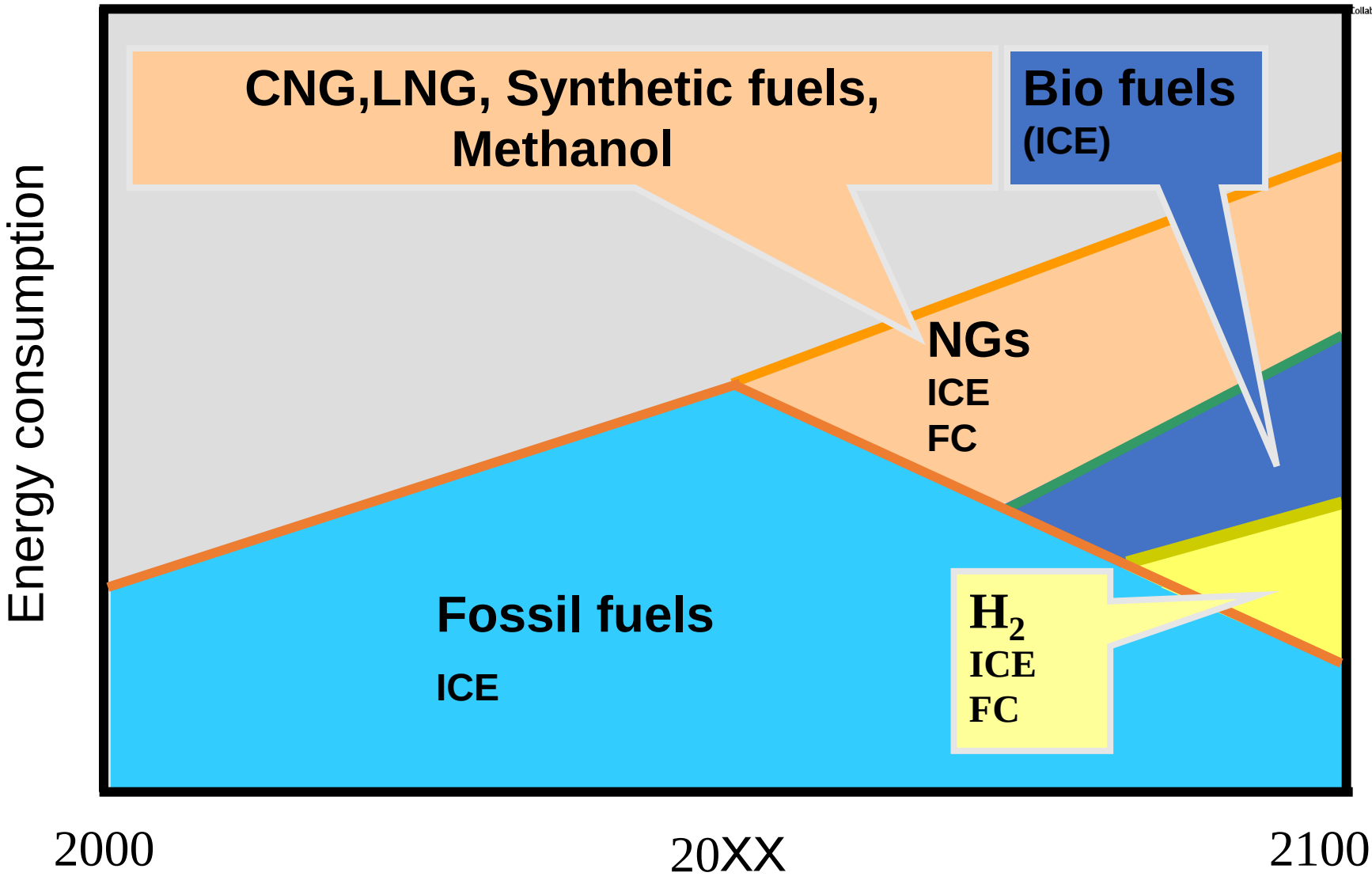
- “Oil peak”, turning point to lose the balance of crude oil supply and demand, will come in future.
- Fossil fuel (energy) is limited energy.

Estimate number of registered vehicles in Asia

Ref.: IEEJ

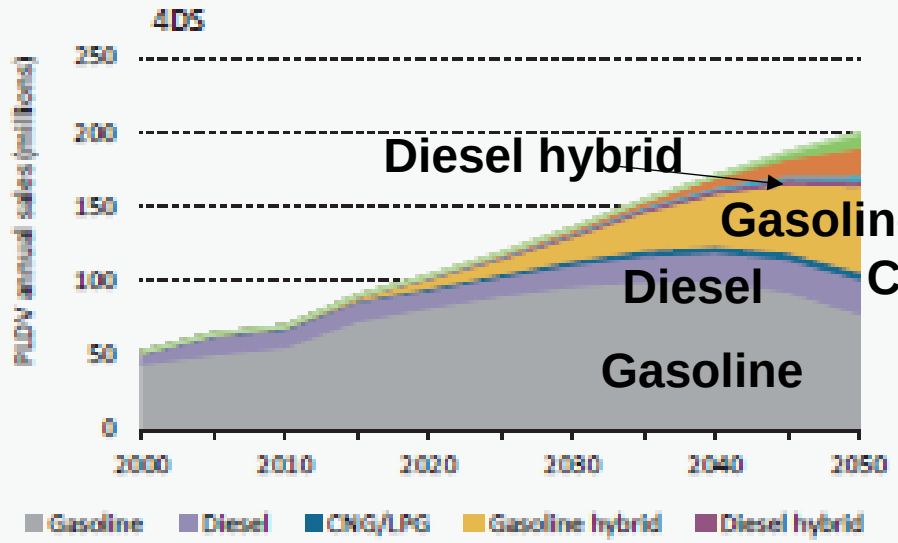


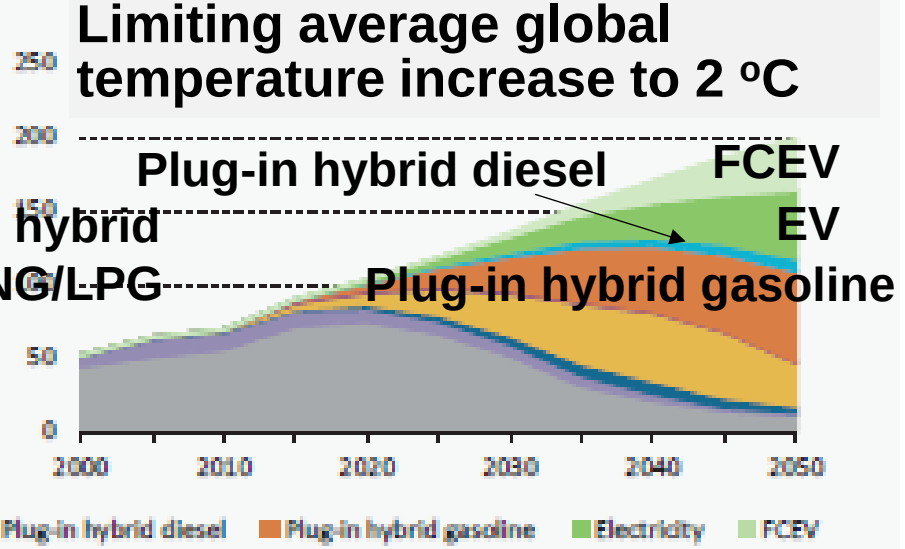
Energy and powertrain in the 21st century



Supplement decreasing fossil fuel supply is necessary by the other energy....

PLDV sales by technology type and scenario





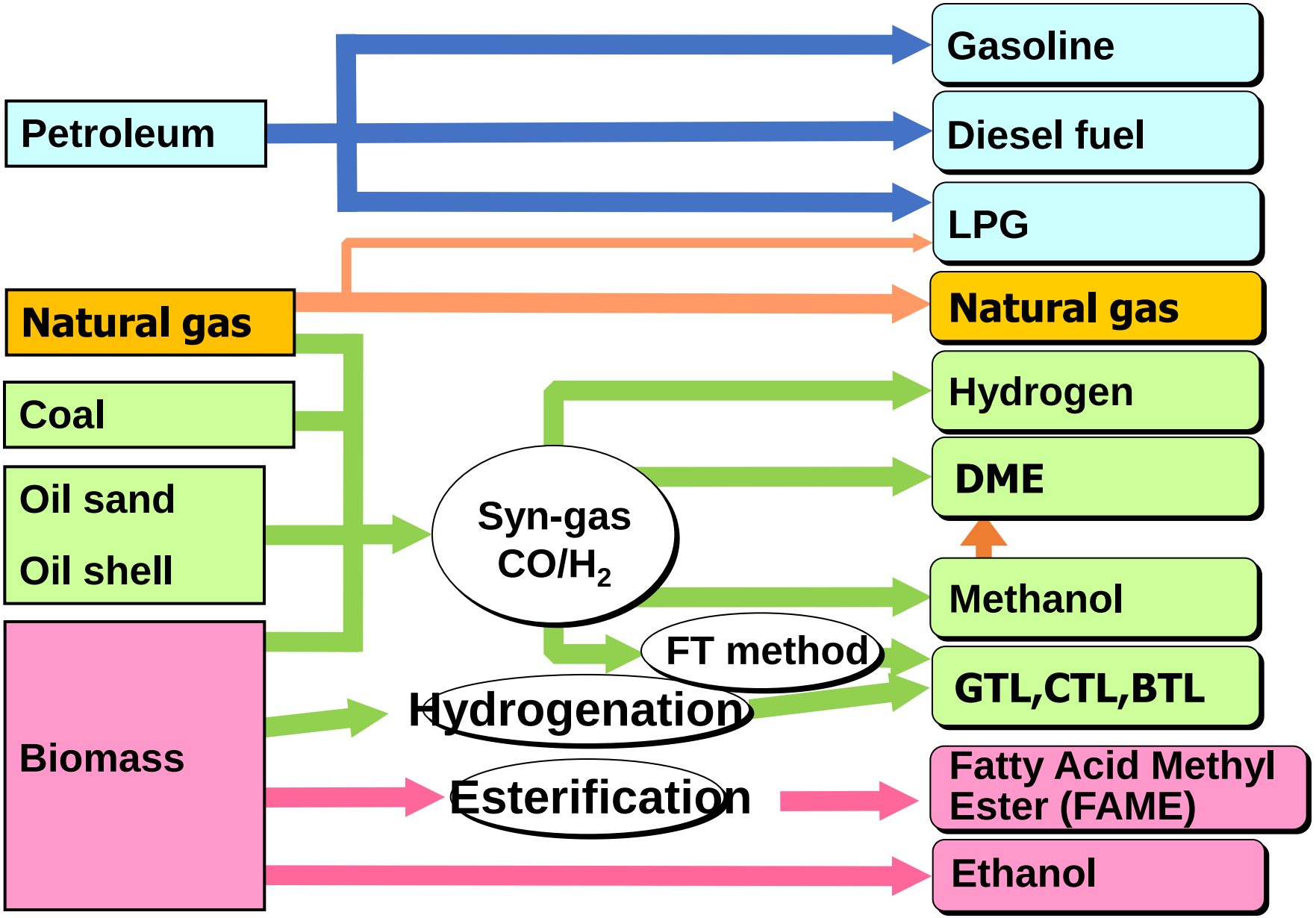
Key point: In the Improve case, electric, PHEV and FCEVs together account for nearly three-quarters of new vehicle sales in 2050

Internal combustion engine will be still used (still important!!) with over 50 % of new vehicle sales in 2050.

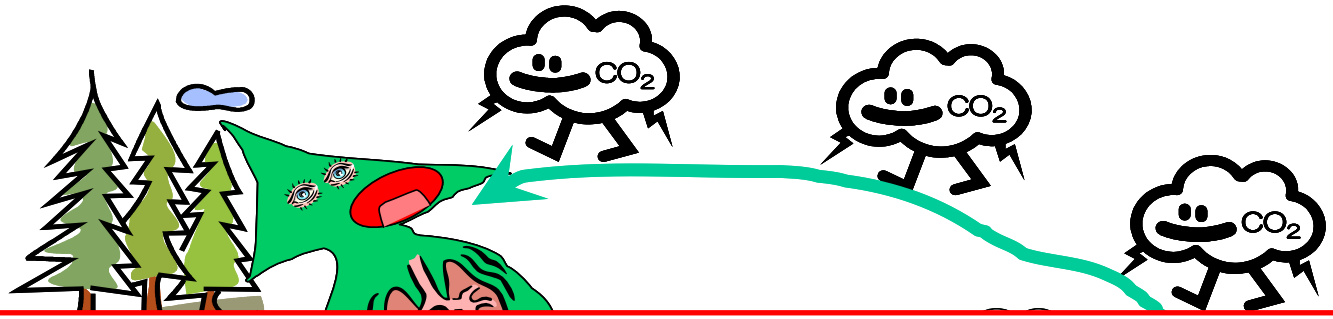
Supplement decreasing fossil fuel supply is necessary by the other energy....

Ref.: IEA Energy Technology Perspectives 2012

Energy resources and fuels

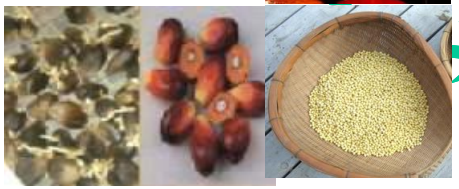


Carbon neutral concept of biofuels



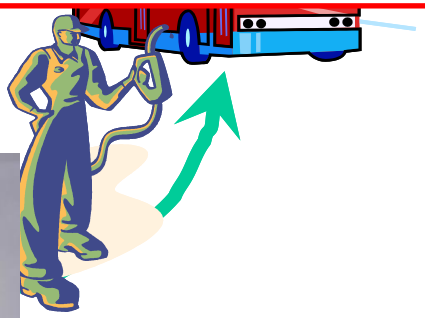
In Asian countries, actively promoting the introduction of biodiesel fuels due to;

- **Soaring oil prices and increased energy consumption**
- **Countermeasure for global warming, Carbon Neutrality.**



バイオディーゼル燃料製造装置

バイオディーゼル燃料
（脂肪酸メチルエステル）



CO_2, emitted from biofuels' combustion, is "CO_2" which biomass, feedstock of the biofuels, absorbed from atmosphere.

It's not necessary to count as CO_2 emission quantity

Introduction status of biodiesel fuel in EAS countries

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Country	Mixing rate	Main Feedstocks	Strategy / Goal	Standard
Australia	Up to 5% in automotive diesel. NSW B2 mandate (January 2010)	Tallow Waste cooking oil Soy (imported)	No Federal mandate. Up to 5% allowed in automotive diesel. NSW mandate - B2 in January 2010 and B5 in 2012 – as supply is available.	Fuel Standard (Biodiesel) Determination 2003. Fuel Standard (Automotive Diesel) Determination 2001. Biofuels Act 2007 (NSW Government).
China	5%	Waste cooking oil Waste oil Jatropha	National Goal : 2 M tons at 2010; 12M tons at 2020;	GB/T20828-2007 (BD100) GB/T25199-2010 (BD5)
India	5%	Jatropha	Jatropha BDF demonstration 2005 - 2007Jatropha BDF introduction 2011- 2012	Bio-diesel (B100) blend stock for diesel fuel – specification IS 15607 : 2005
Indonesia	up to 10%	Palm	National Energy Program / BDF usage 10.22 million kL in 2025	SNI-04-7182-2006
Japan	Up to 5% in diesel fuel (no mandate)	Waste cooking oil	No national mandate. Up to 5% allowed in automotive diesel. The reduction of crude oil dependence in the country's transportation sector to ca. 80% in 2030	Compulsory Diesel Fuel Standard (FAME Blended Diesel Fuel) JIS K2390:2008 (Blend-stock for B5)
Malaysia	5%	Palm	National Biofuel Policy 2006 / B5	MS 2008:2008
New Zealand	Up to 5% for retail sales	Tallow, Rapeseed, Waste cooking oil	Up to 5% biodiesel permitted in diesel for retail sale.	Engine Fuel Specifications Regulations 2008 (B100 and biodiesel blend quality requirements)

Data from around 2012

Introduction status of biodiesel fuel in EAS countries

AIST
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Country	Mixing rate	Main Feedstocks	Strategy / Goal	Standard
Philippines	- B1 (2004) for government - owned and controlled vehicles - B1 (2007) for all diesels - B2 (2009) for all diesels	Coconut Coconut Coconut (Research on-going for Jatropha and other feedstocks)	Memorandum Circular #55 Biofuel Law 2006 ➢ National Biofuels Board Renewable Energy Law 2009 ➢ National Renewable Energy Board	- PNS/DOE QS 002:2003 (B100) (Biodiesel: Cocomethyl ester) - PNS/DOE QS 002:2007 (B100) (review on-going) - PNS/DOE QS 004:2007 (B1) - PNS/DOE QS 004:2009 (B2)
Singapore	-	-	-	Nil
Republic of Korea	B0.5(2007) B1.0(2008) B1.5(2009) B2(2010, 2011) by voluntary agreement. B2(2012 - : mandatory) by RFS (Renewable Fuel Standard)	Soybean, Palm (imported) Waste cooking oil	PPAFB Act, MOCIE BD100 from Apr. 2006 BD 20 from Jul. 2006 BD5 from Jan. 2006	have
Thailand	B3(2011)	Palm	Biodiesel Development and Promotion Strategy nationwide / Mandate B3 From May 1, 2011 (4.5 ML/D in 2022 target)	DOEB-2006 (B100 Community level) DOEB-2007 (B100 Industrial level) DOEB-2011 (B3)
Vietnam	B5 (by 2010)	Basa fish	50,000 t/year of B5 (by 2010)	TCVN 7717: 2007 (B100)

Data from around 2012

Carbon chain profile of fatty acid (by group) in %

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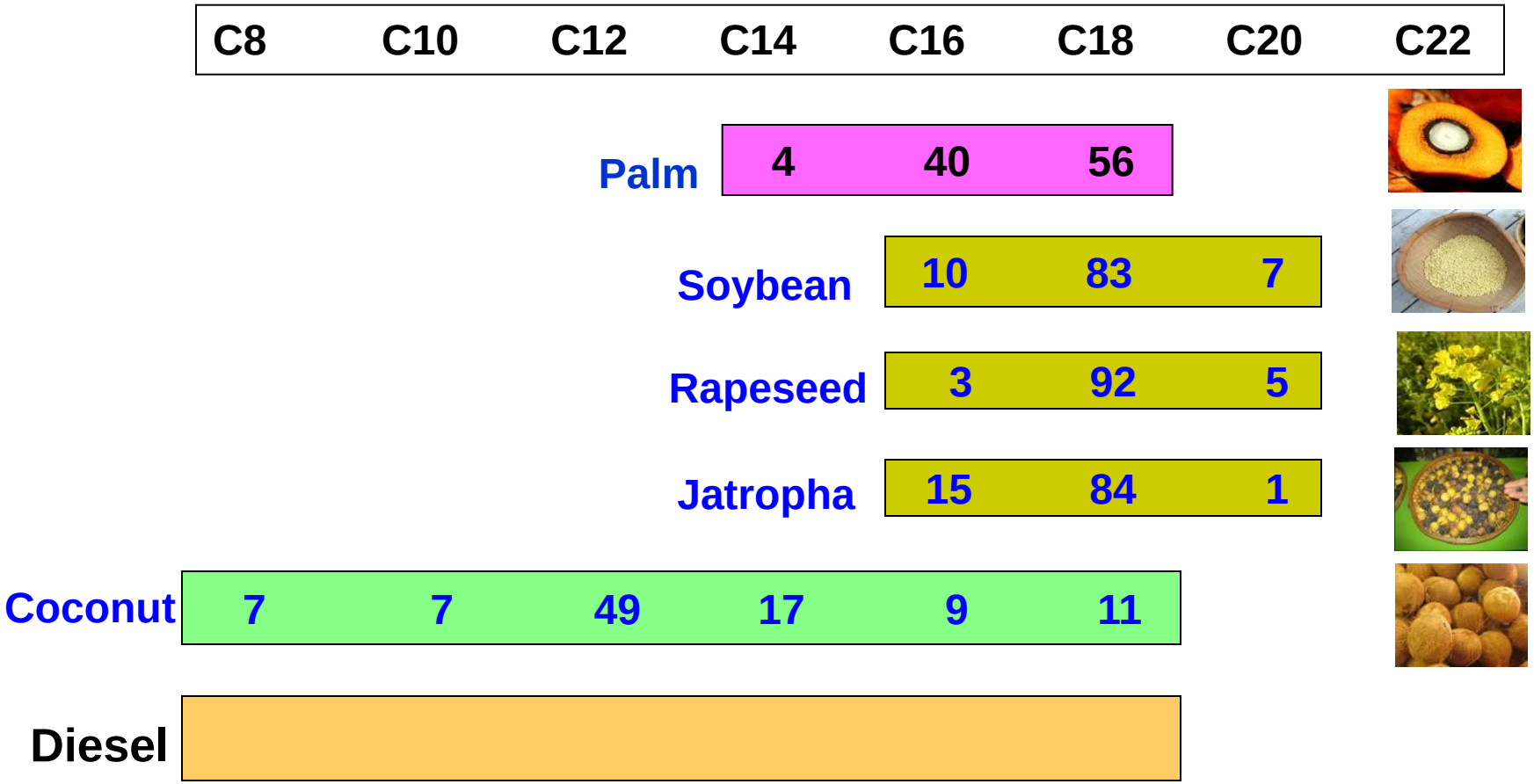


Source: AIPSI

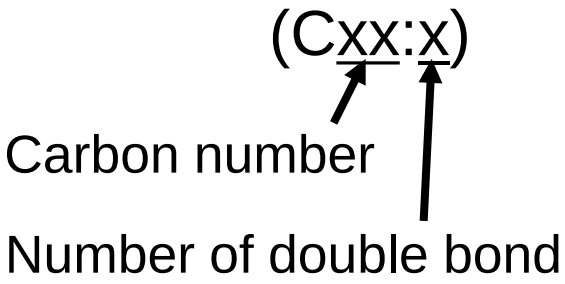
Expected feedstock give various base oil which are different from conventional diesel oil.

Properties of biodiesel fuels

Fatty acid components of raw materials

		Palm	Jatropha	Coconut	Rapeseed	Soybean	Sunflower
Caprylic acid	(C8:0)	—	—	8.3	—	—	—
Capric acid	(C10:0)	—	—	5.8	—	—	—
Lauric acid	(C12:0)	—	—	48.7	—	—	—
Myristic acid	(C14:0)	1.0	—	18.0	—	—	—
Palmitic acid	(C16:0)	44.2	14.0	8.6	4.0	10.3	6.7
Stearic acid	(C18:0)	4.5	8.0	2.6	1.7	3.8	3.7
Oleic acid	(C18:1)	39.3	34.0	6.5	58.6	24.3	19.0
Linoleic acid	(C18:2)	9.6	43.0	—	21.8	52.7	69.9
Linolenic acid	(C18:3)	0.3	—	—	10.8	7.9	0.7

Source : http://www.suncarefuels.com/bdfoil.html



Influence of double bond

Low ← Number of double dond → High
Good ← Oxidation stability → Poor
Poor ← Low temperature performance → Good

Properties of biodiesel fuels

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Index compared to diesel fuel: better > even > poor > worse

Items	Unit	Palm oil methyl ester (PME)	Rapeseed oil methyl ester (RME)	Soybean oil methyl ester (SME)	Diesel fuel (JIS#2)
Oxidation stability	hr.	6.65	4.5	1.28	>10
CFPP*	^{o}C	12	-11	-3	-15.0
Sulfur content	mass ppm	1	2	4	9
Cetane number		63.6	50.7	52.7	61.8

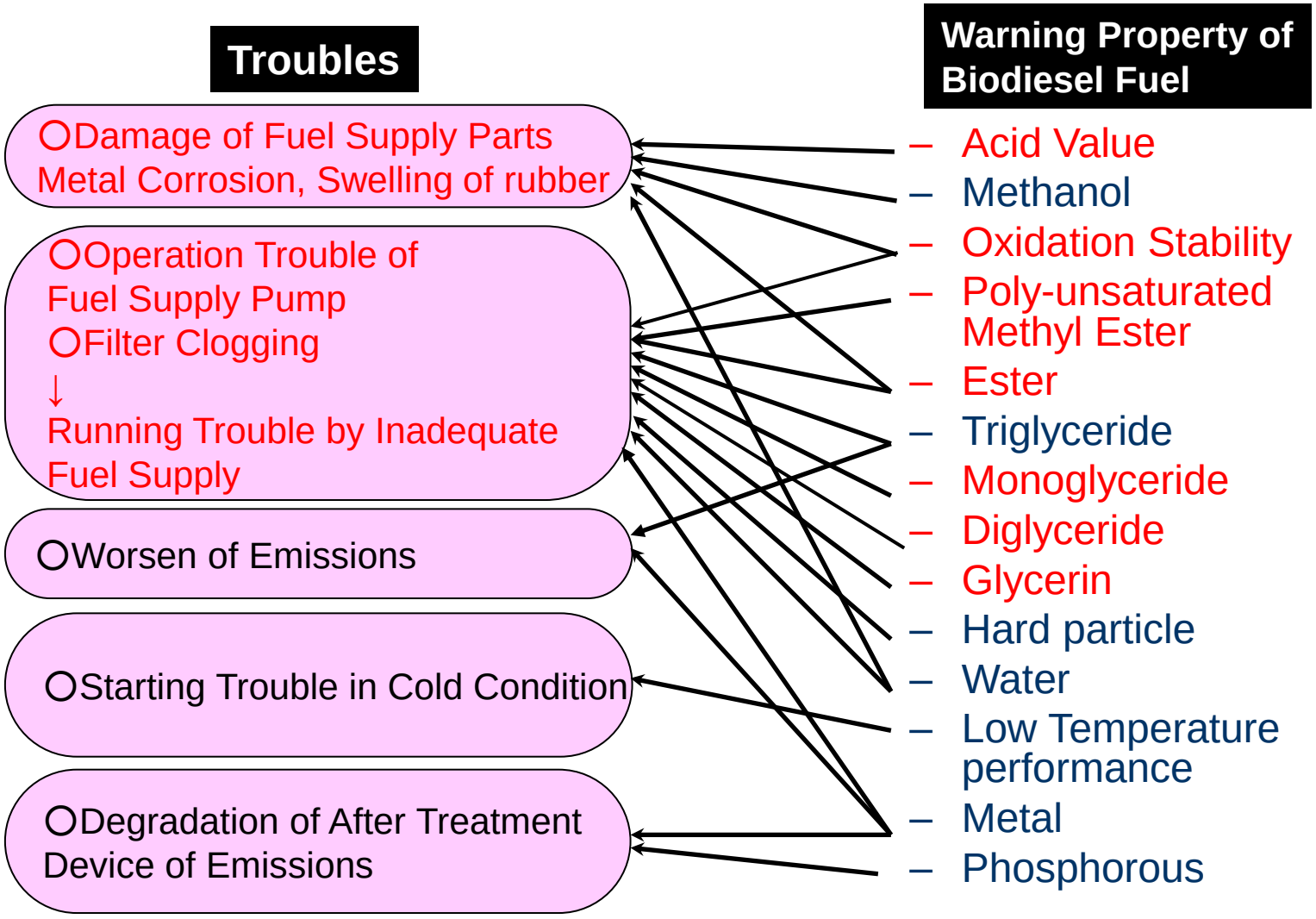
*Cold filter plugging point



Biodiesel fuel has
- **Low sulfur content: expected clean emissions**
- **Poor oxidation stability: worried metal parts corrosion**
- **Poor low temperature performance: worried filter plugging of fuel lines in winter**

Necessary to establish how to use the many kinds of biodiesel fuel to prevent these troubles

Envisioned troubles by biodiesel fuel



21st Fuel Policy Subcommittee, the Petroleum Committee, and Advisory Committee for Natural Resources and Energy, METI

Importance to control fuel quality

In Asian countries, actively promoting the introduction of biodiesel fuels due to;

- Soaring oil prices and increased energy consumption
- Countermeasure for global warming

Impurities and the oxidation of biodiesel fuel (1st generation biodiesel fuel, fatty acid methyl ester (FAME)) caused serious influences on engine performance.

Examples of mechanical defects caused by using "inferior biodiesel fuel"

Injector
(source : JAMA)

Fuel tank
(source: Fuel Policy Subcommittee)

Engine
(source: JAMA)

It is necessary to use "High-quality biodiesel fuel" to prevent these troubles.

Motivations

It is necessary to use "High-quality biodiesel fuel" to prevent these troubles.

Harmonization of standards within the East Asia region will facilitate the use and trading of high-quality biodiesel fuel.
- **Considering all feedstocks harvested in Asia region**
- **To prevent vehicle's troubles**
- **To control fuel quality in the actual market**

Established a WG (FY2007-2014) to discuss these issue in ERIA*

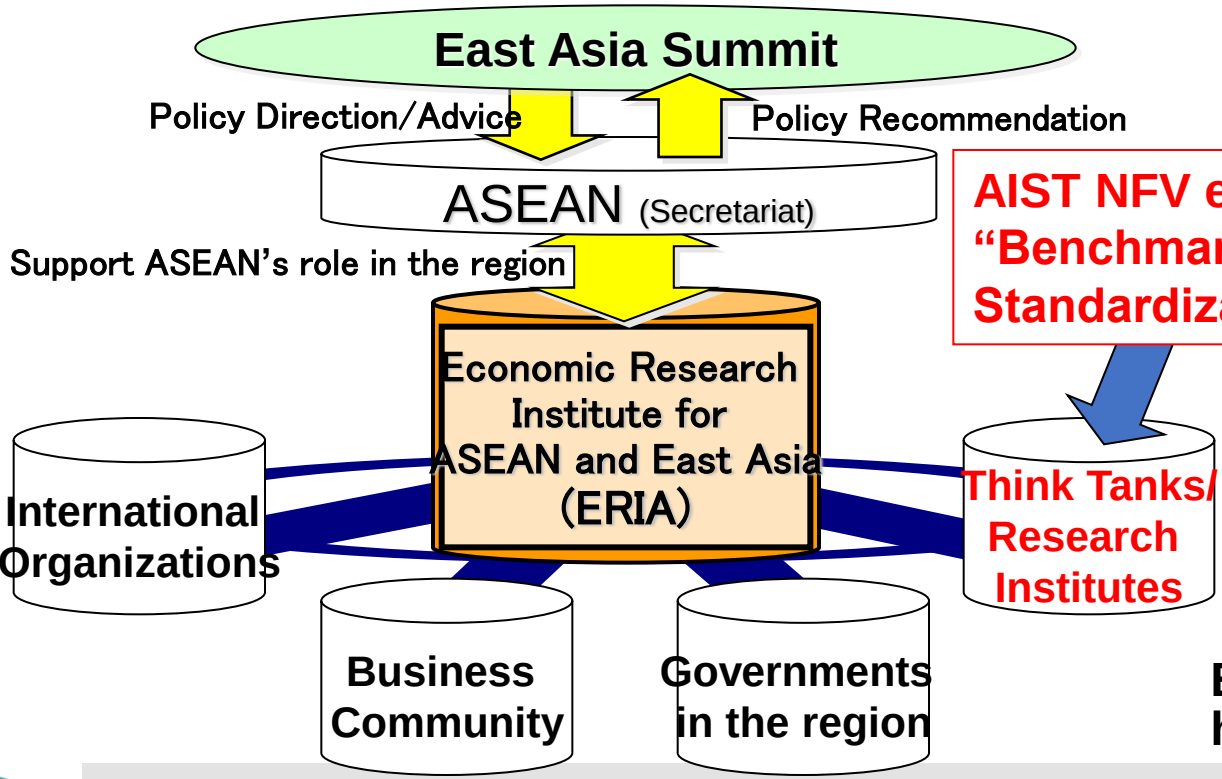
***Economic Research Institute for ASEAN and East Asia (ERIA)**

The goal:
Define appropriate utilization of biodiesel fuel, by establishing quality standard and quality control and management method required in actual market

What is ERIA?

- ERIA is a new kind of international organization to conduct policy research and make policy recommendations to promote economic integration in East Asia.
- ERIA will intellectually support the role of the ASEAN Secretariat to give shape to regional policy directed by leaders at the East Asia Summit.
- ERIA will make policy recommendations as a "Center of Excellence" in the region in strong partnership with governments in the region, other related international organizations, research institutes and the business community.

Intellectual Contribution for Economic Integration in East Asia



AIST NFV established a WG named "Benchmarking of Biodiesel Fuel Standardization in East Asia"

ERIA website: http://www.eria.org/

Membership (Overseas)

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Australia
Dr. Lesley Dowling & Dr. Daniel Sheedy
Fuel and Used Oil Policy Section, Department of Environment and Water Resources

China
Prof. Wugao Zhang
Shanghai Jiao Tong University

India
Dr. Alok Adholeya
Director, The Energy and Resources Institute (TERI)

Indonesia
Dr. Tatang Hernas Soerawidjaja
Chairman, Indonesian Biodiesel Forum/Head, Center for Research on Natural Resource Utilization, Institut Teknologi Bandung
Mr. Soni Solistia Wirawan
Head of Institute for Engineering and Technology System Design, Agency for the Assessment and Application of Technology

Lao PDR
Mr. Syvang Xayyavong
Deputy Director, Renewable Energy Development Division, Institute of Renewable Energy Promotion

Malaysia
Mr. Harrison Lau Lik Nang
Research Officer, Engineering and Processing Research Div., Malaysia Palm Oil Board (MPOB)

New Zealand
Mr. Andrew Saunders
Policy Analyst, Fuels & Crown Resources Group, Ministry of Economic Development

Philippines
Ms. Zenaida Ygnacio Monsada
Oil Industry Management Bureau, Department of Energy

Singapore
Dr. Rong Yan
Institute of Environmental Science and Engineering, Nanyang Technological University

South Korea
Dr. Young Jae Lee
Leader, Transportation Energy Research Center, Korea Institute of Energy Research

Thailand
Ms. Peesamai Jenvanitpanjakul
Technical Advisor, Thailand Institute of Scientific and Technological Research (TISTR)
Dr. Nuwong Chollacoop
National Metal and Materials Technology Center (MTEC), National Science and Technology Development Agency (NSTDA), Thailand

Vietnam
Ms. Hoang Thi Tinh
Standard Expert, TCVN/TC28/SC5 Biofuels, Vietnam Institute for Standards and Quality

Membership (Japan)

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***Dr. Shinichi Goto (*NG leader)**
National Institute of Advanced Science and Technology (AIST)

Mr. Shoichi ICHIKAWA
Representative of Japan Automobile Manufactures Association (JAMA), Toyota Motor Corporation, Japan

Dr. Takashi HOSHINO
Representative of Japan Automobile Manufactures Association (JAMA), Isuzu Motors Limited, Japan

Prof. Koji YAMANE
Representative of Academia, University of Shiga Prefecture, Japan

Mr. Akio IMAI
Representative of Petroleum Association of Japan (PAJ), Showa Shell Sekiyu K.K., Japan

Mr. Takao IKEDA
New and Renewable Energy Group, Strategy and Industry Research Unit, Institute of Energy Economics, Japan

Prof. Mitsuru KONNO
Representative of Academia, Ibaraki University, Japan

Dr. Yuji YOSHIMURA
National Institute of Advanced Science and Technology (AIST)

Dr. Mitsuharu OGUMA
National Institute of Advanced Science and Technology (AIST)

Outputs of the ERIA project

2007-08	Established a "EAS-ERIA Biodiesel Fuel Standard:2008", and welcomed in 2nd EMM
2008-09	Made an "ERIA Biodiesel Fuel Trade Handbook (1st edition for comments)", and appreciated in 3rd EMM
2009-10	Published the "EAS-ERIA Biodiesel Fuel Trade Handbook: 2010"
2010-14	- Investigation of quality control and management method in actual markets for EAS countries. - Updating EAS-ERIA BDF standard: 2008 - Investigation of biomass resources such as inedible oils, agricultural residues, forest resources… - Investigation of fuel/vehicle adaptation to reach emission targets (including ethanol) - Updating the Biodiesel Fuel Trade Handbook (for example, adding and expanding 2nd generation biodiesel fuel) every two years

Technical Tour to Indian Oil-R&D by 16th ERIA WG meeting

16th ERIA WG meeting @TERI

Concepts of harmonized specifications

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- **Based on EU's standard (EN14214)**
  - Cover a whole of factor in BDF
  - EU's standard: Focusing Rapeseed oil only

- **Consideration of various oils**
  - Coconut : Viscosity and Flashpoint
  - Soybean : Iodine number

- **Oxidation stability**
  - Critical impact on metal fuel tanks
  - Metal tanks are popular for vehicles in Asia
  - Oxidation stability of 10 hours prevented metal tank corrosion in Japanese conformity test

- **Polyunsaturated components**
  - Mainly included in fish oil
  - Risk of sludge formation
  - Measurement method hasn't developed yet

Effects of oxidation stability on fuel tank corrosion

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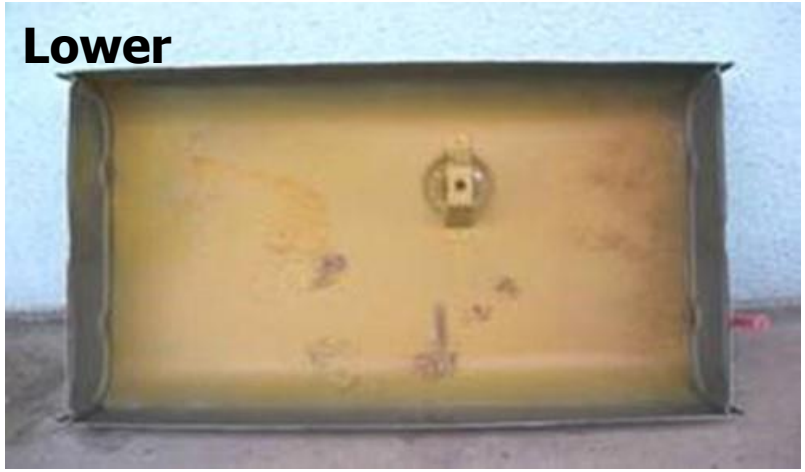
TEST: 2000hr TEST with 8hr (60℃) & 16hr (Normal Temp.) interval

Test Fuel: Commercial diesel fuel blended 5% BDF

Oxy. Stab of B100 : 6 Hrs



Test Fuel: Same BDF above with 400ppm of anti-oxidant (20ppm as B5)

Oxy. Stab of B100 : 10 Hrs

Source:METI BDF Conformity Test

EAS-ERIA Biodiesel Fuel Standard (EEBS): 2008

Items	Units	U.S. ASTM D6751-07b	EU FprEN14214:2012	Japan JIS K2390:2008	EAS-ERIA Biodiesel Fuel Standard:2013
Ester content	mass%	-	96.5 min.	96.5 min.	96.5 min.
Density	kg/m3	-	860-900	860-900	860-900
Viscosity	mm2/s	1.9-6.0	3.50-5.00	3.50-5.00	2.00-5.00
Flashpoint	deg. C	93 min.	101 min.	120 min.	100 min.
Sulfur content	mass%	0.0015 max.	0.0010 max.	0.0010 max.	0.0010 max.
Distillation, T90	deg. C	360 max.	-	-	-
Carbon residue (100%) or Carbon residue (10%)	mass%	0.05 max. -	- 0.30 max.	- 0.3 max.	0.05 max. 0.3 max.
Cetane number		47 min.	51.0 min.	51.0 min.	51.0 min.
Sulfated ash	mass%	0.02 max.	0.02 max.	0.02 max.	0.02 max.
Water content	mg/kg	0.05[vol%] max.	500 max.	500 max.	500 max.
Total contamination	mg/kg	-	24 max.	24 max.	24 max.
Copper corrosion		No.3	Class-1	Class-1	Class-1
Acid value	mgKOH/g	0.50 max.	0.50 max.	0.50 max.	0.50 max.
Oxidation stability	hrs.	3 min.	8.0 min.	(**)	10.0 min.
Iodine value		-	120 max.	120 max.	Reported(1)
Methyl Linolenate	mass%	-	12.0 max.	12.0 max.	12.0 max.
Polyunsaturated FAME(1) (more than 4 double bonds)	mass%	-	1 max.	N.D.	1 max.
Methanol content	mass%	0.2 max. (*)	0.20 max.	0.20 max.	0.20 max.
Monoglyceride content	mass%	-	0.70 max.	0.80 max.	0.70 max. 0.60(2) max.
Diglyceride content	mass%	-	0.20 max.	0.20 max.	0.20 max.
Triglyceride content	mass%	-	0.20 max.	0.20 max.	0.20 max.
Free glycerol content	mass%	0.020 max.	0.02 max.	0.02 max.	0.02 max.
Total glycerol content	mass%	0.240 max.	0.25 max.	0.25 max.	0.25 max.
Na+K	mg/kg	5 max.	5.0 max.	5.0 max.	5.0 max.
Ca+Mg	mg/kg	5 max.	5.0 max.	5.0 max.	5.0 max.
Phosphorous content	mg/kg	10 max.	4.0 max.	10.0 max.	10.0 max.(3)
Cloud point	deg.C		16 max. (Grade a) 13 max. (Grade b) ... -3 max. (Grade f)		Reported(4)
CFPP(1)	deg.C		13 max. (Grade 1) 10 max. (Grade 2) ... -10 max. (Grade 6)		Reported

(*) 130 deg.C of flashpoint is available instead of measuring methanol content (**) Meet diesel oil specification

(1) Depending on requirement of each country (2) Applicable in the region where out-side temp. bellow 10°C in Winter (at cool condition)

(3) 4 ppm limit could be apply if the appropriate equipments and methods are available

(4) After blending to diesel fuel, it must meet diesel fuel specification of each country

Outputs of the ERIA project
EAS-ERIA Biodiesel Fuel Standard: 2013

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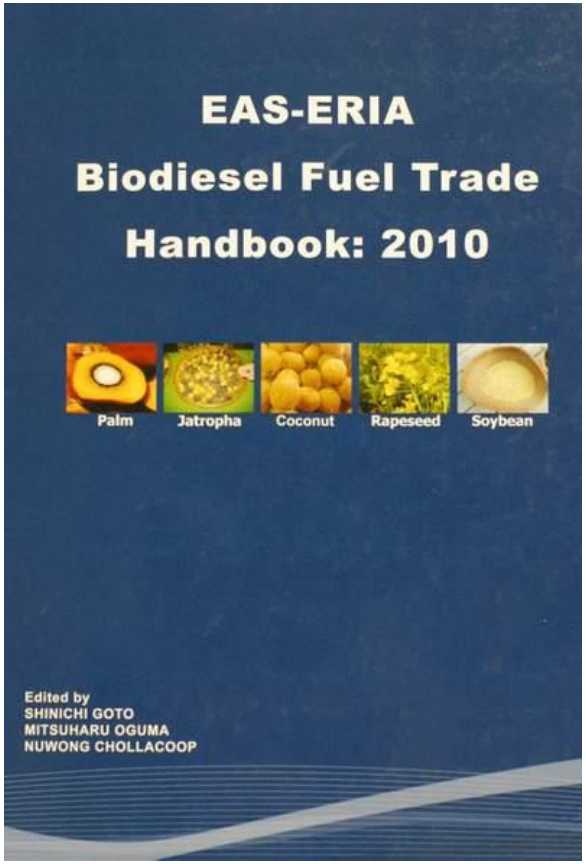
- Our benchmark standard suggested for member countries for the purpose of harmonizing biodiesel standards in East-Asia.

- This standard is for B100 aimed for low level blending with diesel fuel.

- In case of the use as a final fuel, further considerations are necessary, especially in regards to oxidation stability.

Outputs of the ERIA project

Contents of "ERIA Biodiesel Fuel Trade Handbook: 2010"



You can download the handbook (PDF version) from ERIA website; https://www.eria.org/publications/eas-eria-biodiesel-fuel-trade-handbook-2010

Summary of the ERIA project

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Progress of revision or reconsideration of national biodiesel fuel standard in member countries resulted from ERIA WG's discussion

Country	Revision or reconsideration of the national BDF standard	
China	not yet	
India		
Indonesia	Yes	Oxidation stability and copper strip corrosion
Japan	Yes	Finished wording the draft of revision to harmonize to EEBS: 2013
Malaysia	Yes	Under consideration to revise certain specs
Philippines	Yes	Oxidation stability
Rep. of Korea	not yet	
Thailand	Yes	Oxidation stability
Viet Nam	Yes	Under consideration to revise oxidation stability
Singapore	-	-
Australia		
New Zealand		

Summary of the ERIA project

Safety “Automobile Industry” and “Our Beautiful Earth” with Carbon neutral...

Quality Control/Management Method: 2011-2012

Standard (EEBS: 2008)

Items	Units	U.S. ASTM D6751-07b	EU EN14214:2003	Japan JIS K2390:2008	EAS-ERIA BDF Standard (EEBS):2008
Ester content	mass%	-	96.5 min.	96.5 min.	96.5 min.
Density	kg/m3	-	860-900	860-900	860-900
Viscosity	mm2/s	1.9-6.0	3.50-5.00	3.50-5.00	2.00-5.00
Flashpoint	deg. C	93 min.	120 min.	120 min.	100 min.
Sulfur content	mass%	0.0015 max.	0.0010 max.	0.0010 max.	0.0010 max.
Distillation, T90	deg. C	360 max.	-	-	-
Carbon residue (100%) or Carbon residue (10%)	mass%	0.05 max. -	- 0.30 max.	- 0.3 max.	0.05 max. 0.3 max.
Cetane number		47 min.	51.0 min.	51.0 min.	51.0 min.
Sulfated ash	mass%	0.02 max.	0.02 max.	0.02 max.	0.02 max.
Water content	mg/kg	0.05[vol%] max.	500 max.	500 max.	500 max.
Total contamination	mg/kg	-	24 max.	24 max.	24 max.
Copper corrosion		No.3	Class-1	Class-1	Class-1
Acid value	mgKOH/g	0.50 max.	0.50 max.	0.50 max.	0.50 max.
Oxidation stability	hrs.	3 min.	6.0 min.	(**)	10.0 min. (****)
Iodine value		-	120 max.	120 max.	Reported (***)
Methyl Linolenate	mass%	-	12.0 max.	12.0 max.	12.0 max.
Polyunsaturated FAME (more than 4 double bonds)	mass%	-	1 max.	N.D.	N.D. (***)
Methanol content	mass%	0.2 max. (*)	0.20 max.	0.20 max.	0.20 max.
Monoglyceride content	mass%	-	0.80 max.	0.80 max.	0.80 max.
Diglyceride content	mass%	-	0.20 max.	0.20 max.	0.20 max.
Triglyceride content	mass%	-	0.20 max.	0.20 max.	0.20 max.
Free glycerol content	mass%	0.020 max.	0.02 max.	0.02 max.	0.02 max.
Total glycerol content	mass%	0.240 max.	0.25 max.	0.25 max.	0.25 max.
Na+K	mg/kg	5 max.	5.0 max.	5.0 max.	5.0 max.
Ca+Mg	mg/kg	5 max.	5.0 max.	5.0 max.	5.0 max.
Phosphorous content	mg/kg	10 max.	10.0 max.	10.0 max.	10.0 max.

EAS’s Initiative

Handbook: 2010

Produce, Trade and Use “High-quality Biodiesel Fuel”...