34th Research Session

Japan's Biodiesel Fuel Introduction

June 24, 2008

The Institute of Energy Economics, Japan

Harumi Hirai, Senior Researcher

Yu Nagatomi, Researcher

Contents:

1. Introduction

1-1 Biodiesel Materials

1-2 Production Regions and Production Conditions for Four Major Oils

1-3 Supply/Demand Balance for Major Oil Seeds (2006)

1-4 Changes in Prices of Four Major Oils

1-5 Changes in Biofuel Output

1-6 EU's Biofuel Introduction Policy

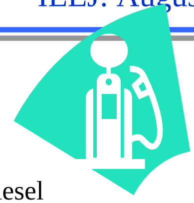
1-7 Competition between Food and BDF

1-8 U.S. Biofuel Policy and Its Spillover Effects on Food Oil and BDF Prices

1-1 Biodiesel Materials

- Collecting seeds (or fruit pulp) from oil plants
- Refining and processing oil produced from seeds

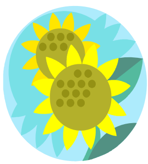
BD5 sold at service stations



Mixed with diesel

(Carbon water C10~C20)

Soybean oil



Sunflower oil

Rapeseed oil

Palm oil

Jatropha oil

Non-food

Vegetable oils

Agricultural production → **Crushing** → **Refining (Refiners)** → **Food oil** (Food)

Deodorization, decolorization, antioxydication

Rapeseed and palmoils are produced through crushing Soybean oil is extracted through solvents

Methanol, catalysts

Esterification → **Glycerin** (By-product)

Esterification → **FAME** (Fuel)

Waste oil recovery

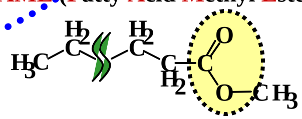
Waste food oil

Biodiesel

Chemical material

- *C18 standard, with an oxygen content of some 11%*
- *Mainly C14~C18 carbon number, even molecular size*
- *Fatty acid methyl ester*

FAME (Fatty Acid Methyl Ester)

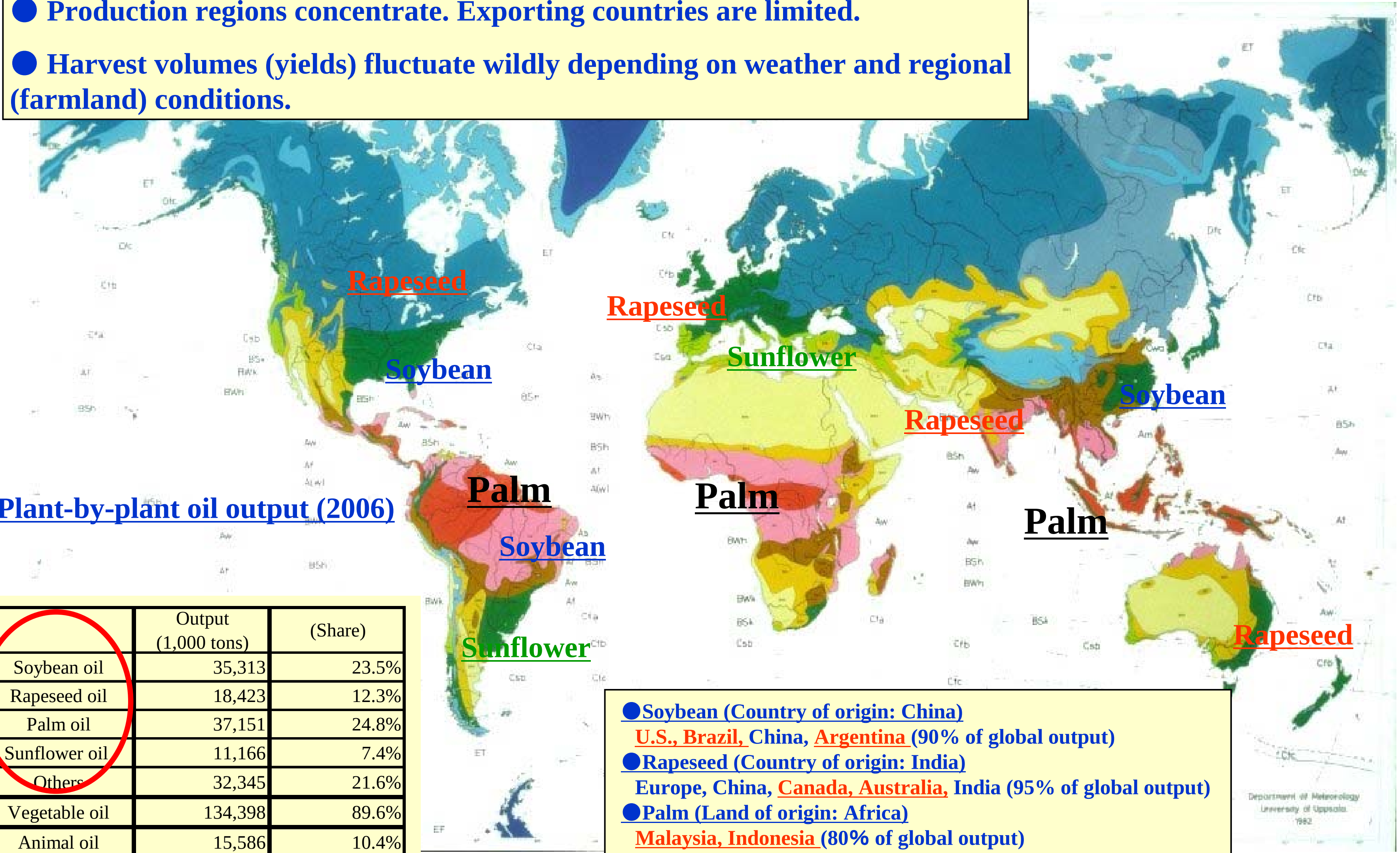


Characteristics of Palm Oil

Nuts taken from palm trees must be crushed within 24 hours for extraction of oil (Lipase contained in nuts is activated to break down ester and produce free fatty acid)

1-2 Production Regions and Production Conditions for Four Major Oils

- Production regions concentrate. Exporting countries are limited.
- Harvest volumes (yields) fluctuate wildly depending on weather and regional (farmland) conditions.



Plant-by-plant oil output (2006)

	Output (1,000 tons)	(Share)
Soybean oil	35,313	23.5%
Rapeseed oil	18,423	12.3%
Palm oil	37,151	24.8%
Sunflower oil	11,166	7.4%
Others	32,345	21.6%
Vegetable oil	134,398	89.6%
Animal oil	15,586	10.4%
Total	149,984	100.0%

Source: OIL WORLD (2007)

Note: Palm oil output excludes palm kernel oil (2,386,000 tons).

- **Soybean (Country of origin: China)**
  U.S., Brazil, China, Argentina (90% of global output)
- **Rapeseed (Country of origin: India)**
  Europe, China, Canada, Australia, India (95% of global output)
- **Palm (Land of origin: Africa)**
  Malaysia, Indonesia (80% of global output)
- **Sunflower (Country of origin: Mexico)**
  Europe, CIS, Argentina (70% of global output)

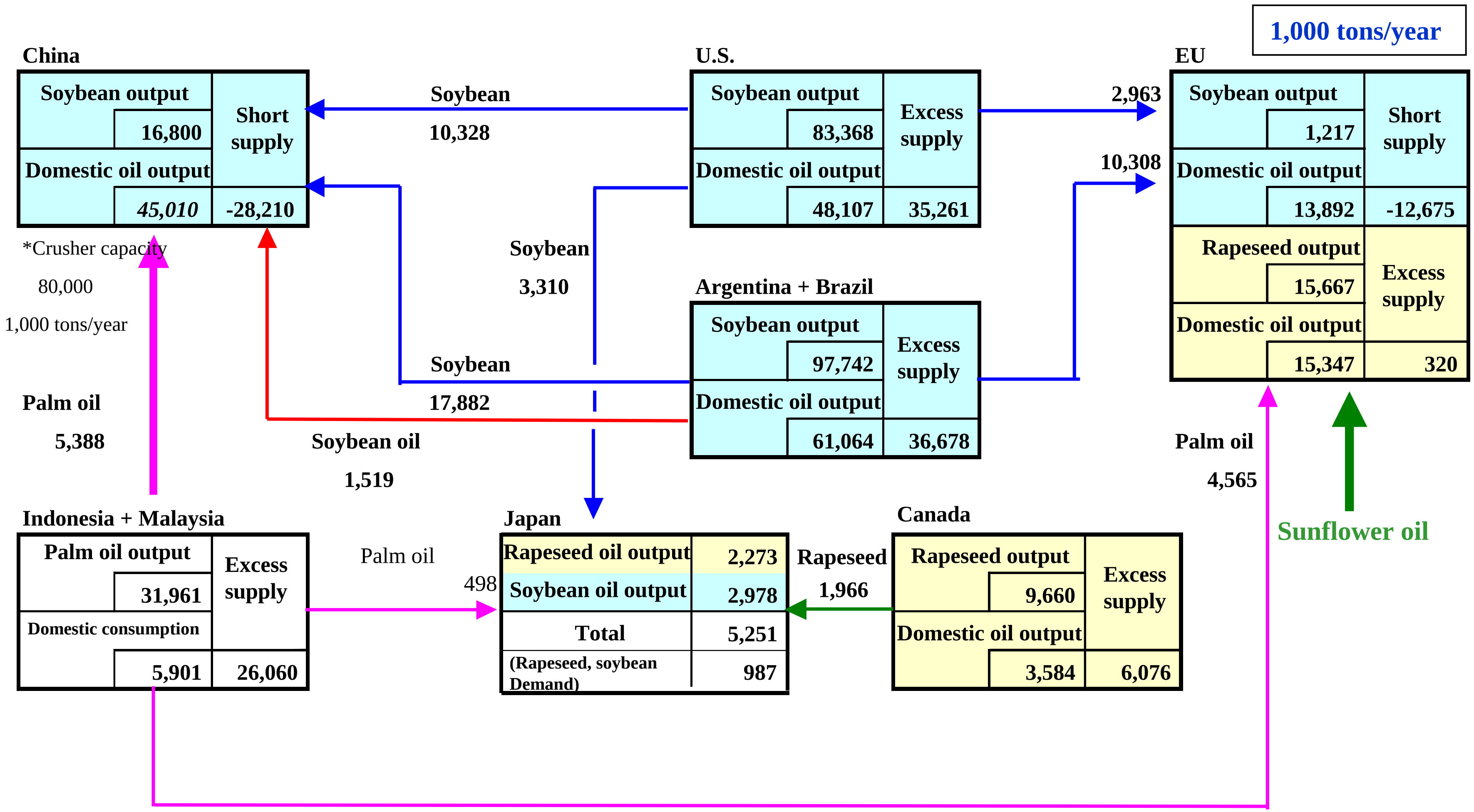
Red: exporters

1-3 Supply/Demand Balance for Major Oilseeds (2006)

●Soybean: The United States, Brazil and Argentina are exporters. Among importers is China (importing 40% of exports from the three).

●Rapeseed: The largest rapeseed consumer is the European Union whose rapeseed output meets its demand. Exporters are Canada and Australia.

●Palm: Indonesia and Malaysia are exporters. Among importers are China (importing 25% of exports) and India.

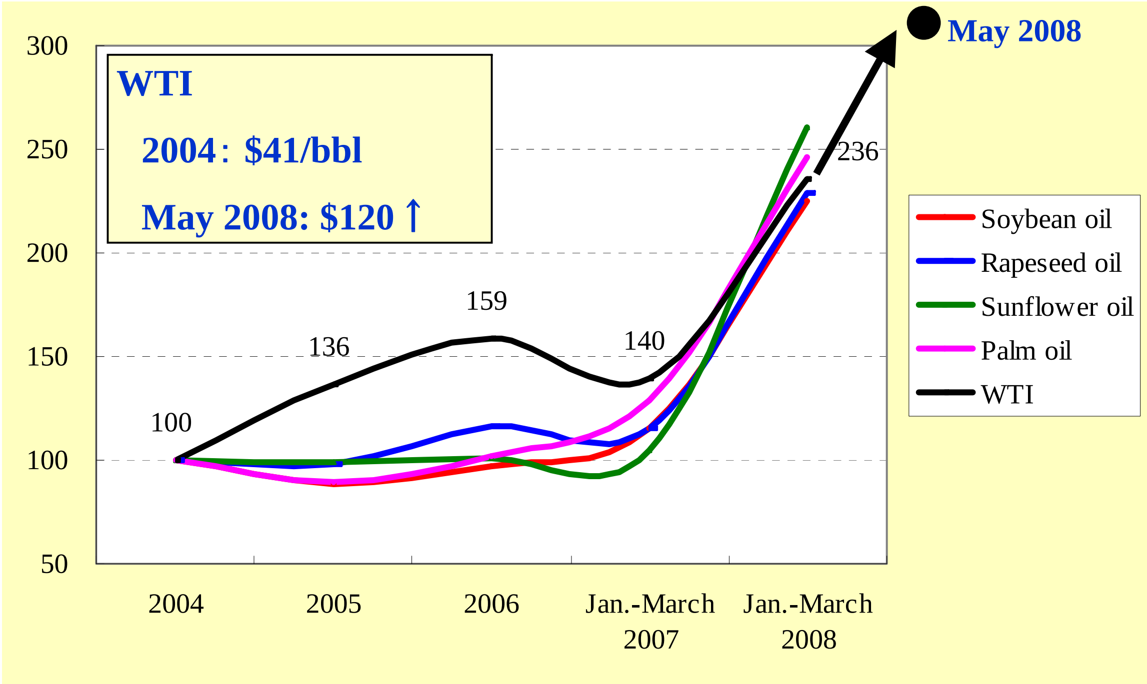


Source: WORLD OIL

1-4 Changes in Prices of Four Major Oils

●The biofuel boom has prompted vegetable oil prices to be linked to crude oil prices.

Trend of Price Hikes (100 for 2004)

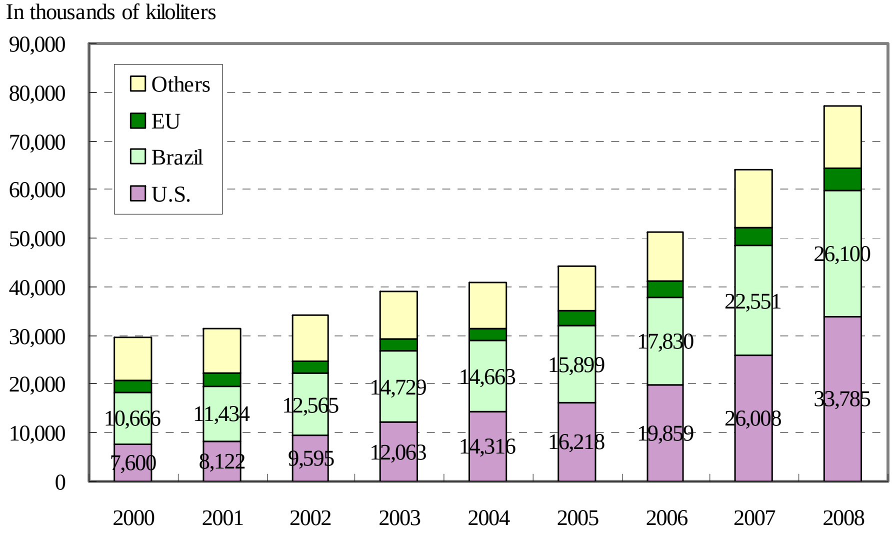


Average price for 2004
- ●Soybean oil: $616 per ton (on European plant delivery)
- ●Rapeseed oil: $685 per ton (on European plant delivery)
- ●Sunflower oil: $684 per ton (European FOB)
- ●Palm oil: $471 per ton (European CIF)

May 2008
- ●Soybean oil: $1,450 per ton ↑
- ●Rapeseed oil: $1,500 per ton ↑
- ●Sunflower oil: $2,000 per ton ↑
- ●Palm oil: $1,200 per ton ↑

1-5 Changes in Biofuel Output

Changes in Ethanol Output



Source: F.O.Licht's

Ethanol output

2004: 40 million kl

2008: 77 million kl (estimated)

- U.S. (corn)
- Brazil (sugar cane)

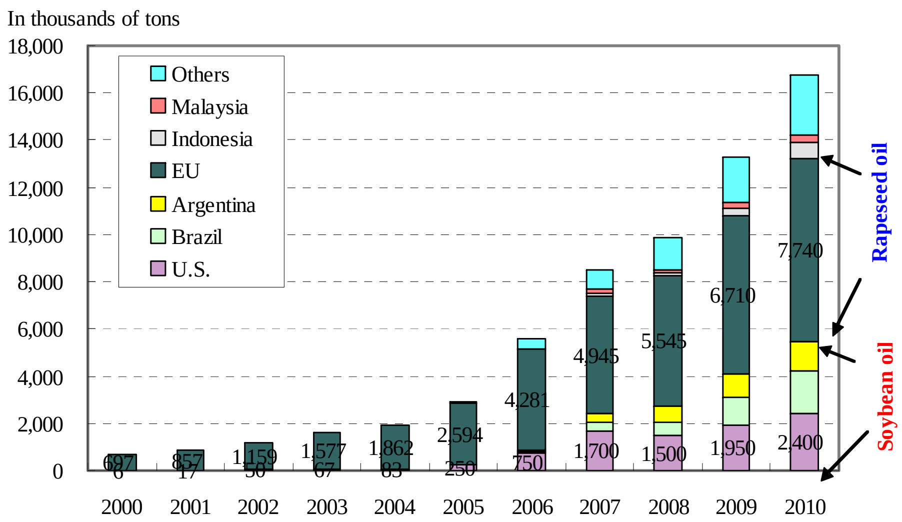
BDF Output

2004: 2 million tons

2008: 10 million tons (estimated)

- EU (rapeseed)
- U.S., Brazil, Argentina (soybean)
- Indonesia, Malaysia (palm) ?

Changes in Biodiesel Output



1-6 EU's Biofuel Introduction Policy

EU's Targets for 2020

● **The target biofuel share of 5.75% for 2010 has become difficult to achieve as some EU members are less eager to introduce biofuels.**

●**In 2007, the EU set a new target biofuel share of 10% for 2020.**

(1) Of biofuel consumption, bioethanol is projected at some 16.5 million tons and biodiesel fuel (BDF) at some 19.2 million tons.

(2) Of the projected BDF consumption, rapeseed-based FAME accounts for about 8.8 million tons, imports for about 5.1 million tons and BTL for about 5.3 million tons.

EU Policy

2003 ●**EU Biofuel Directive**
Plan to use biofuel for transportation
2% in 2005, 5.75% in 2010

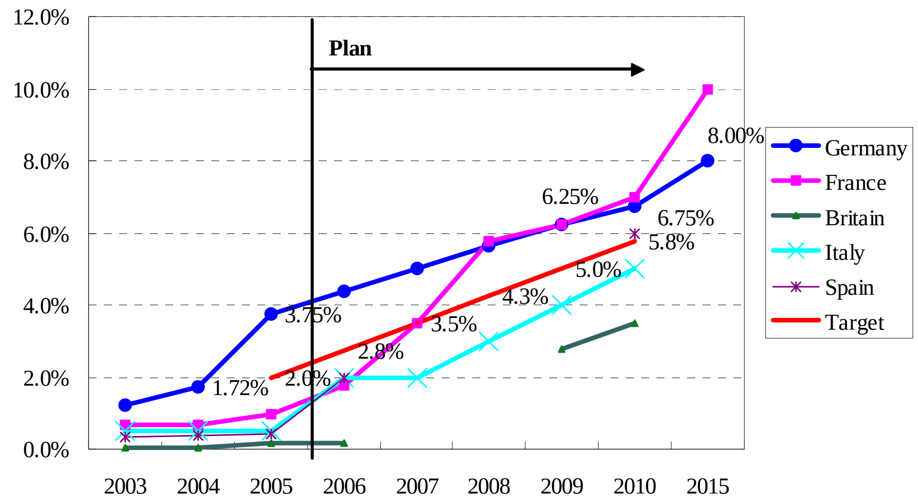
2005 ● **Biomass Action Plan (Biofuel expansion measures)**

2006 ● **EU Biofuel Strategy**

2007 ● **European Energy Policy**
EU GHG reduction (2020 emissions should be cut by 20% from 1990)
Plan to use biofuel for transportation
(At least 10% by 2020)

2008 ●**The European Commission announces a proposal for a directive on the promotion of the use of energy from renewable sources (including biofuel targets, target-achieving measures and environmental sustainability standards).**

Changes in Biofuel Contents in EU Countries



Only Germany and Sweden achieved above the planned level of 2% for 2005.

1-7 Competition between Food and BDF

Competition between food and fuel: <u>four major vegetable oils' and BDF' shares of demand</u>

- **EU: 78% for food, 22% for fuel**
- **U.S.: 92% for food, 8% for fuel**
- **Malaysia and Indonesia: 98% for food, 2% for fuel**
- **World: 95% for food, 5% for fuel**

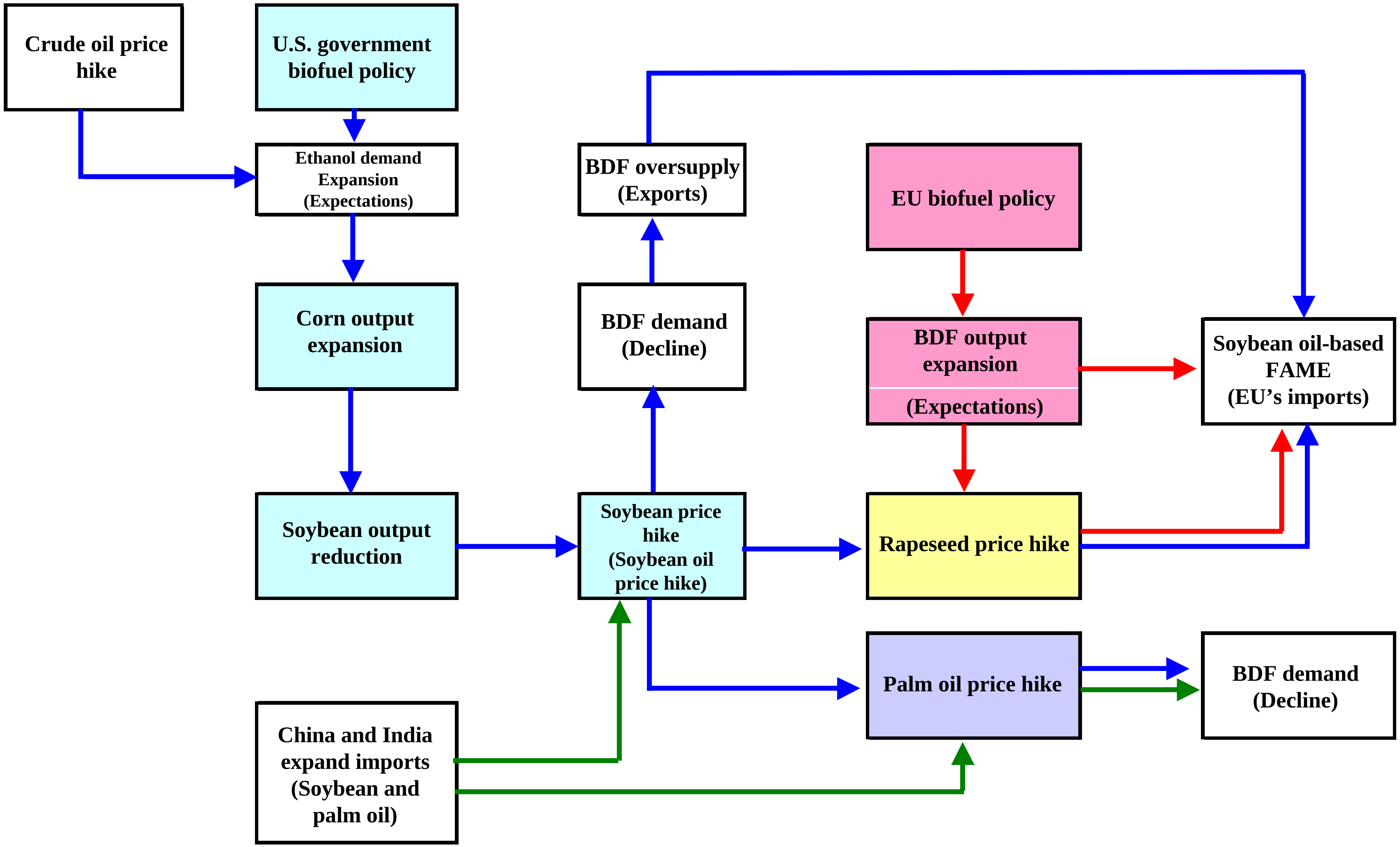
Region-by-Region Demand for and Production of Four Major Vegetable Oils (2006)

	Vegetable oil demand (in thousands of tons)						Vegetable oil production (in thousands of tons)				
	Rapeseed oil	Soybean oil	Sunflower oil	Palm oil	Total	BDF (of total)	Rapeseed oil	Soybean oil	Sunflower oil	Palm oil	Total
27 EU countries	6,849	3,228	3,399	4,565	18,041	3,885	6,304	2,590	2,250	0	11,144
CIS	125	250	2,808	768	3,951	0	195	165	4,719	0	5,079
U.S.	905	8,247	171	570	9,893	750	495	9,262	258	0	10,015
Canada	377	354	74	35	839	40	1,546	275	22	0	1,843
Brazil	48	3,138	45	218	3,449	60	41	5,428	34	170	5,673
Argentina	1	331	295		626	30	8	6,161	1,580	0	7,749
Japan	987	631	22	498	2,138	0	973	576	0	0	1,549
China	4,669	7,426	238	5,430	17,762	60	4,750	6,001	220	0	10,971
India	2,383	2,756	584	3,074	8,796	30	2,448	1,226	497	49	4,220
Indonesia		17	4	3,721	3,742	1	0	0	4	16,080	16,084
Malaysia	19	53	62	2,180	2,313	120	0	67	0	15,881	15,948
Subtotal	16,363	26,430	7,700	21,060	71,552	4,976	16,760	31,751	9,584	32,180	90,275
World total	18,182	34,767	11,079	36,254	100,282	5,416	18,423	35,313	11,166	37,151	102,053

Source: WORLD OIL

1-8 U.S. Biofuel Policy and Its Spillover Effects on Food Oil and BDF Prices

- U.S. farmers' corn output expansion → Soybean output reduction →Soybean (soybean oil) price hike → Food oil price hike
- U.S. farmers' expectations: Ethanol output expansion (U.S. biofuel policy, crude oil price spike)



2. Biodiesel Supply Potential

2-1 BDF Material Procurement Sources

2-2 Malaysia’s BDF Export Potential

2-3 Indonesia’s BDF Export Potential

2-4 Japan’s Domestic Supply Potential

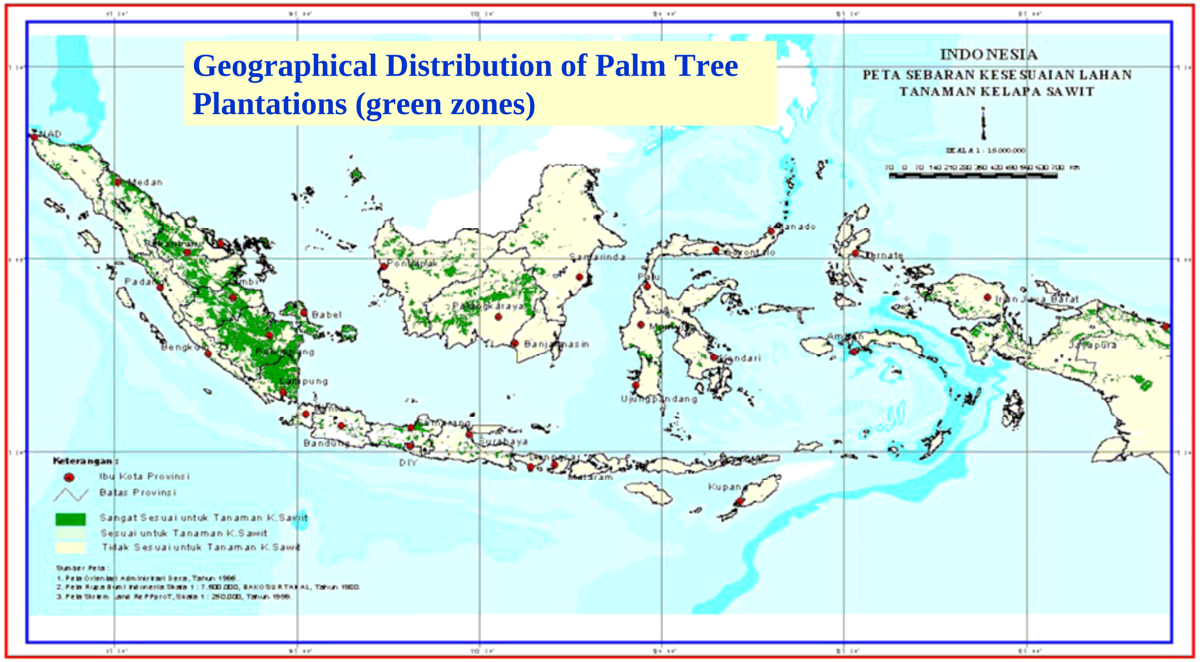
2-5 Conclusion

2-1 BDF Material Procurement Sources

●Diesel oil sales in Japan totaled some 36 million kiloliters in 2007. If BDF's content in diesel oil is given at 5% (B5) , BDF demand may be estimated at about 1.8 million kl (about 1.65 million tons).

● Japan is expected to compete with China for soybean imports, while overseas rapeseed supply sources are limited to such countries as Canada and Australia. If Japan were to import soybean and rapeseed oil for BDF, importers would have to compete with the domestic food oil industry.

●If Japan were to depend on BDF material imports as well as domestic supply, palm oil would be a realistic choice for imports. Potential palm oil supply sources would be Malaysia and Indonesia.



(Source) "Indonesia's Alternative Energy Development," 5th Asian Oil Technology Symposium sponsored by PEC (January 2007)

2-2 Malaysia's BDF Export Potential

- **Malaysia's future substantial palm oil output expansion would be difficult.**

Difficult expansion of plantation area → Overseas expansion (into Indonesia, etc.) and yield improvement through breeding and the like.

- **BDF export potential at 1 million to 1.5 million tons. It would be difficult to secure exports in and after 2020.**

- **Present Situation**

BDF production capacity stands at some 1 million tons per year. The capacity utilization rate has declined as palm oil price hikes have deteriorated BDF's economic efficiency against conventional diesel oil. Many BDF projects given approval are left pending.

Preconditions

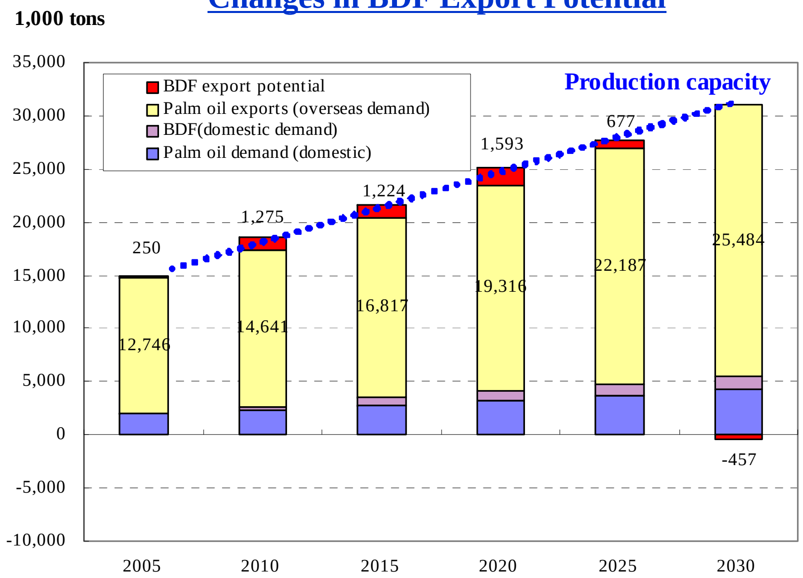
	Plantation area (1,000 ha)	Oil yield (tons per ha)	GDP(per capita) US$ (at 2000 value)	Transportation fuel (1,000 kl)
2005	3,552	4.2	4,436	4,998
2010	3,981	4.7	5,239	5,879
2015	4,289	5.0	6,038	6,949
2020	4,620	5.4	7,027	8,213
2025	4,856	5.7	8,145	9,754
2030	5,104	6.0	9,534	11,585
Average growth	1.5%	1.4%	3.1%	3.4%

Changes in Palm Oil Supply/Demand Balance

(1,000 tons)

	Palm oil production capacity	Palm oil demand (domestic)	BDF(domestic demand)	Palm oil exports (overseas demand)	BDF export potential
2005	14,961	1,965	0	12,746	250
2010	18,607	2,366	326	14,641	1,275
2015	21,594	2,783	770	16,817	1,224
2020	25,061	3,242	910	19,316	1,593
2025	27,683	3,738	1,081	22,187	677
2030	30,579	4,268	1,284	25,484	-457
Average growth	2.9%	3.2%	13.8%	2.8%	

Changes in BDF Export Potential



(Note) The domestic BDF content is assumed at 5% for 2010. A plan to implement 5% BDF content in 2008 has been suspended. 2% BDF content is now being considered.

2-3 Indonesia's BDF Export Potential

- Indonesia can afford to expand palm oil production (plantation area) substantially in future.
- BDF export potential at 2.5 million tons per year or more. Indonesia has great BDF supply potential.
- Plans to expand palm oil production have come under fire at home and abroad because of environmental destruction through tropical forest felling.
- Present Situation

BDF production capacity stands at about 1.2 million tons per year. Palm oil price hikes have deteriorated BDF's economic efficiency against conventional diesel oil. Capacity utilization is limited to 15%

Preconditions

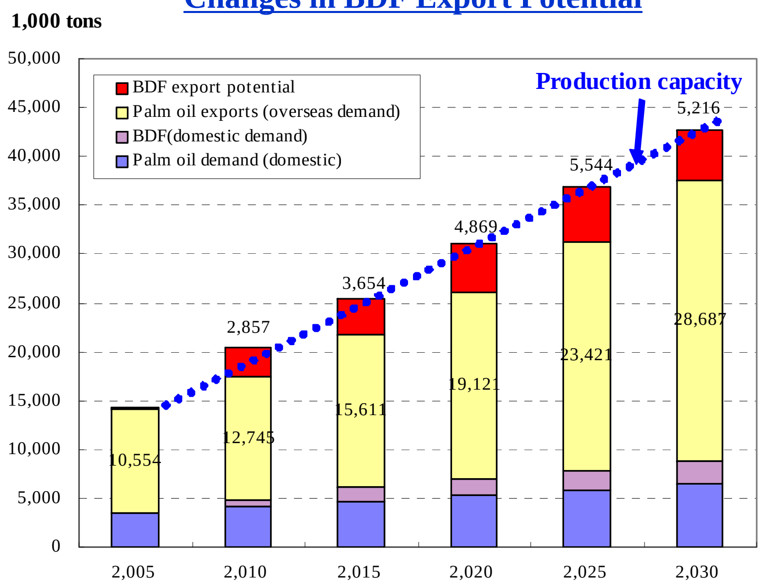
	Plantation area (1,000 ha)	Oil yield (tons per ha)	GDP(per capita) US$ (at 2000 value)	Transportation fuel (1,000 kl)
2005	3,690	3.8	930	9,974
2010	4,820	4.2	1,145	11,395
2015	5,587	4.6	1,359	13,731
2020	6,477	4.8	1,627	16,230
2025	7,329	5.0	1,912	18,906
2030	8,091	5.3	2,256	22,024
Average growth	3.2%	1.3%	3.6%	3.2%

Changes in Palm Oil Supply/Demand Balance

(1,000 tons)

	Palm oil production capacity	Palm oil demand (domestic)	BDF(domestic demand)	Palm oil exports (overseas demand)	BDF export potential
2005	14,100	3,546	0	10,554	250
2010	20,362	4,142	618	12,745	2,857
2015	25,429	4,676	1,489	15,611	3,654
2020	30,983	5,233	1,760	19,121	4,869
2025	36,843	5,827	2,051	23,421	5,544
2030	42,753	6,460	2,389	28,687	5,216
Average growth	4.5%	2.4%	13.6%	4.1%	

Changes in BDF Export Potential



(Note) The domestic BDF content in diesel oil is planned at 5% for 2010 and 10% for the final phase.

At present (in 2008), domestic BDF (B2.5) sales total 180,000 tons.

2-4 Japan's Domestic Supply Potential

- Idled farms could be used for growing rapeseeds for production of 320,000 tons in rapeseed oil for BDF.
- Some 180,000 tons in waste food oil could be collected from households.
- Maximum domestic supply potential comes to some 500,000 tons.

Japan's Rapeseed Production and Supply Potential

	Rapeseed output (tons)	Rapeseed acreage (ha)	Idled farms (1,000 ha)	Potential (1,000 tons)
Aomori	454	420	11	26
Hokkaido	366		18	41
Shiga	45		7	15
Kagoshima	14		8	18
Toyama	7		5	12
Nagano	3		7	15
Others	-		311	703
Total	889		367	829

Sources: FY 2006 Survey (on Japan's ethanol introduction), Aichi Prefectural Government's Department of Agriculture, Forestry and Fisheries.

Note: Rapeseed yield at 2.26 tons per hectare, rapeseed oil yield at 38%, specific gravity at 0.91

Rapeseed oil: 320,000 tons

Waste Food Oil Supply Potential

	Supply (1,000 tons/year)	Per capita consumption (grams/year)		Waste food oil output (1,000 tons/year)
		Supply	Waste food oil	
Households	620	4,857	1,447	**181**
Restaurants	672	5,262	1,579	201
Food industry	768	6,017	602	77
Processed oil	425	3,330	166	21
Total	2,484	19,466	3,794	480

Note: Some 250,000 tons in waste food oil could be collected from restaurant and food industries, etc.

2-5 Conclusion

Supply Potential

●Diesel oil sales in Japan totaled some 36 million kiloliters in 2007. If BDF's content in diesel oil is given at 5% (B5) , BDF demand may be estimated at about 1.8 million kl (about 1.65 million tons).

●Maximum domestic supply would total some 500,000 tons. Japan would have to depend on imports for most BDF supply.

●The most realistic choice would be palm oil import from Indonesia over a medium to long term.

Concerns

●Criticisms against expansion of palm oil production have globally grown out of concerns about tropical forest destruction and other environmental problems.

●Priority given to palm oil for food can weaken incentives for using palm oil as fuel.

3. BDF Production Methods and Supply Cost

3-1 Oil Quality Gaps Resulting from Chemical Structures

●**BDF quality depends heavily on (1) oxidation stability and (2) low-temperature fluidity.**

●**Differences among material oils**

Soybean, sunflower: Higher unsaturation degree (higher iodine number)

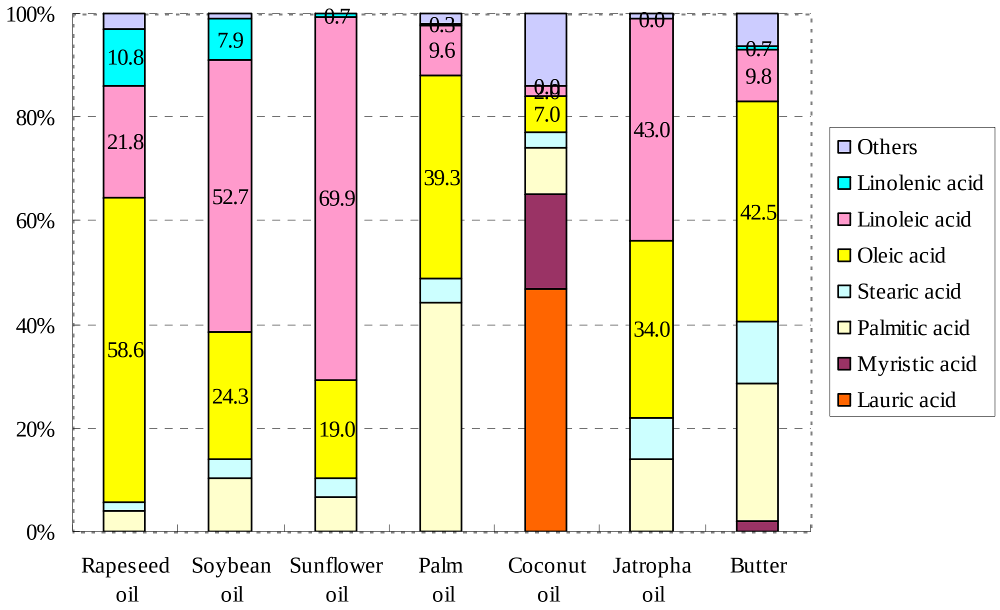
Rapeseed: Medium unsaturation degree

Palm: Lower unsaturation degree (lower iodine number)

Oil-by-Oil FAME Quality Indicators

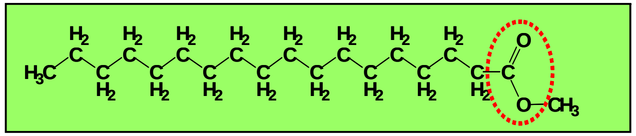
	Soybean	Rapeseed	Palm	Sunflower	Jatropha
Density	0.885	0.884	0.876	0.873	0.881
Kinetic viscosity (mm^2/s:30℃)	5.08	5.66	5.65		5.41
Ignition point (℃)	174	164	178	182	174
Fluid point (℃)	-2.5	-12.5	12.5	-5	2.5
Total acid number (mgKOH/g)	0.69	0.32	0.27		0.4
Iodine number	129	116	59	137	98
Oxidation stability (hr)	4.3	3.3	10		

Oil-by-Oil Fatty Acid Contents



Ester binding of even-number fatty acids

(Glyceride = oil)



Biodiesel FAME (Fatty Acid Methyl Ester)

●**Impurities and unreacted substances during production processes**

Unreacted substances: methanol, glyceride

Impurities: water, alkali catalysts, fatty acids, etc.

3-2 Qualitative Improvement and BDF Production Method Changes

●**Oxidation stability**:

Soybean and sunflower oils that have many unsaturated bonds (are high in iodine number) feature inferior oxidation stability and production of sludge and high polymer compounds with peroxide, causing troubles in the fuel injection pump system.

● **Low-temperature fluidity**:

Palm oil that has many saturated bonds features higher fluid points, clogging fuel filters in cold areas or in the winter.

●**Additives can improve the BDF quality to some extent. But limits exist on such improvement. No additive can improve the fluid point of BDF from palm oil. → Limits on qualitative improvement during FAME production through ester exchange**

●**Hydrorefining of oil**

If hydrogen is added to the material under high temperatures and pressures, double bonds hydrogenation, decarbonation, dehydration and broken down make high-quality diesel fractions that are high in carbon hydride.

Hydrorefining Process

Company	Process	Plant	Material
Petrobras (Brazil)	H-BIO Mixing the material with materials in existing diesel desulfurization systems (hydrodesulfurization) Straight diesel, FCC-LCO, coker diesel	Operation started in late 2007. 260,000 kl/year (2007) 430,000 kl/year (2008)	Soybean oil
Nesteoil (Finland)	NE×BTL Independent process (hydrogeneration＋isomerization)	Operation started in autumn 2007. 450,000 kl/year in late 2009	Rapeseed oil
Nippon Oil	BHD Independent process (hydrogeneration)	Toyota Motor and the Tokyo Metropolitan Government conducted demonstration tests in 2007.	Palm oil

Chemical Process

FAME

Oil (glyceride)

$$\begin{array}{l} CH_2OOC\text{-}R \\ CHOOC\text{-}R \\ CH_2OOC\text{-}R \end{array} + 3CH_3OH \underset{}{\overset{\text{Ester exchange}}{\rightleftarrows}} \begin{array}{l} CH_2\text{-}OH \\ CH\text{-}OH \\ CH_2\text{-}OH \end{array} + \begin{array}{c} RCOOCH_3 \\ + \\ RCOOCH_3 \\ + \\ RCOOCH_3 \end{array}$$

(Triglyceride) (Glycerin) (fatty acid methyl ester)

+H_2 (Hydrogeneration)

$R'\text{-}CH_2\text{+}CH_3 + 2H_2O$

(Dehydration)

$R'\text{-}CH_3 + CO_2$

(Decarbonation)

CH3-CH2-CH3

Hydrorefined oil

Reducing molecular weight to average levels for diesel oil (C_{10}-C_{20})

Appearance of fruit cluster

Cross-section diagram of fruit

3-3 Japan's BDF Introduction Cost

As of May 2008

- **Retail price for BDF from palm oil: 207 yen/l (61 yen higher than diesel)**
- **Retail price for BDF from waste food oil: 159 yen/l (13 yen higher)**
- **Retail price for BDF from domestic rapeseeds: 562 yen/l (416 yen higher)**
- **As materials prices have been rising, it is difficult for BDF introduction to be economically viable for the immediate future.**

		FAME price				Diesel oil price	
		(Palm imports)		(Waste food oil)	(Domestic rapeseeds)		
		2004	2008.5	2007.6	2004	2004	2008.5
Standard crude oil (Dubai: fob)	($/bbl)	-	-			33.6	110
Production cost (shipment from factory)	($/MT)	200	200			-	-
Palm oil (fob)	($/MT)	450	1,200			-	-
CIF price	($/MT)	486	1,255			35.4	113.7
	(Yen/KL)	50,907	119,896			25,637	75,111
Price for acceptance at refineries	(Yen/KL)	50,912	119,908	26,000	420,420	27,680	77,159
Price for shipment from refineries	(Yen/KL)	65,327	146,865	102,000	485,030	34,680	88,659
	(Yen/L)	65.3	146.9	102.0	485.0	34.7	88.7
Retail price (including consumption tax)	(Yen/L)	120.5	207.2	159.1	562.3	88.4	146.1
(Compared with diesel oil price)	(Yen/L)	32.2	61.1	13.0	473.9	-	-

4. Environmental Problems

●Production of FAME from palm oil

(1) CO_2 emissions for diesel oil come to 80.7 g/MJ against 20.6-23.5 g/MJ for BDF from palm oil. A 70-75% emission reduction is possible.

(2) If BDF accounts for 5% of diesel oil, CO_2 emissions may be cut by some 4 million tons annually.

●Hydrorefining of palm oil

CO_2 emissions come to 24.1 g/MJ close to 23.5 g/MJ for LCA assessment of FAME.

●CO_2 emission reductions for production of FAME from rapeseed oil in the EU are not so different from those for hydrorefining of rapeseed oil.

(g-CO2/MJ)

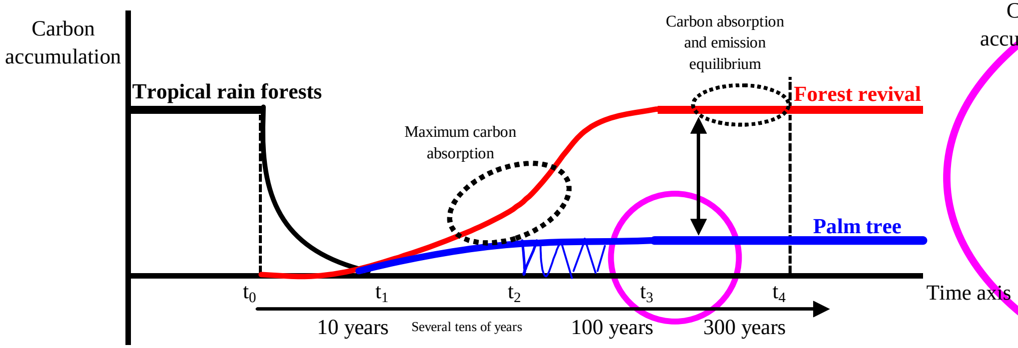
Material	Palm oil		Rapeseed oil (in EU)		Diesel oil
	FAME	Hydrorefining	FAME	Hydrorefining (NExBTL)	Toyota-Mizuho
Material production	14.4	14.4	31.0	31.0	1.5
Fuel prodution (crushing)	3.9	3.9			
(Esterification)	3.7		7.1～23.8		
Overseas transportation	1.2	1.2			0.9
Refining		4.2		5.3～13.6	3.6
Domestic transportation	0.4	0.4			0.4
Subtotal	23.5	24.1	38.1～54.8	36.3～44.6	6.4
Direct combustion	0.0	0.0	0.0	0.0	74.3
Total	23.5	24.1	38.1～54.8	36.3～44.6	80.7

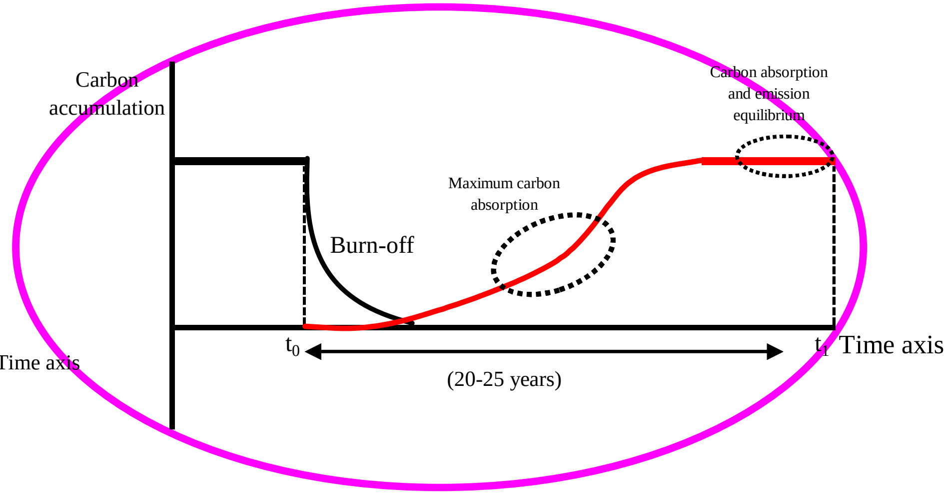
4-2 CO2 Releases Accompanying Tropical Rain Forest Destruction

●Tropical rain forests cover only less than 3% of the earth's surface but account for as much as 43% of global carbon fixation.
●Carbon accumulations in tropical rain forests come to 18.5 kilograms per square meter against 2.5 kg for palm trees, meaning a decline of up 16 kg on a shift from tropical forests to palm trees.

	Surface area		Total living phytomass				Net primary production			
			Dry matter	Carbon			Dry matter	Carbon		
	(10^6km^2)	(Share)	(1 billion tons)	(1 billion tons)	(Share)	(1,000 t/km^2)	(1 billion t/y)	(1 billion t/y)	(Share)	(t/km^2,year)
Forests	31.3	6.1%	951	428	76.2%	13.7	48.7	21.9	25.9%	700
Tropical forests	(14.8)	2.9%	(542)	(244)	43.4%	(16.5)	(30.5)	(13.7)	16.2%	(926)
Temperate forests	(6.0)	1.2%	(174)	(78)	13.9%	(13.1)	(8.4)	(3.8)	4.5%	(633)
Subarctic forests	(9.0)	1.8%	(205)	(92)	16.4%	(10.3)	(7.2)	(3.2)	3.8%	(356)
Forest plantations	(1.5)	0.3%	(30)	(14)	2.4%	(9.0)	(2.6)	(1.2)	1.4%	(800)
Other continental ecosystems	117.6	23.1%	293	132	23.5%	1.1	84.3	38.0	44.9%	323
Total continental	148.9	29.2%	1,244	560	99.7%	3.8	133.0	59.9	70.8%	402
Total marine	361.1	70.8%	4	2	0.3%	0.0	55.0	24.8	29.2%	69
Full total	510.0	100.0%	1,248	562	100.0%	1.1	188.0	84.7	100.0%	166

(Source) Ajtay,G.L..et al (1979) "Terrestrial primary production and phytomass"
(Note) Net primary production means carbon absorbed by plants through photosynthesis/breathing – death/breakdown.





- If all tropical rain forests are burnt off for palm tree plantations, carbon accumulation losses may total 16 kilograms per square meter (59 kg in CO2).
- If recovery takes 50 years, annual CO2 releases through tropical rain forest destruction may come to 79.3 g/MJ for palm trees. If this is taken into account, the LCA assessment may put emissions at 102.8 g, higher than 80.7 g for diesel oil.
- If timbers from tropical forests are used for housing and furniture, the emissions may come to 57.9 g, slipping below 80.7 g for diesel oil.

LCA Assessment

(g-CO2/MJ)

Material	Conventional case	Counting emissions from tropical rain forests		Diesel oil
		Burning off tropical rain forests	Effective utilization of timbers	
Tropical rain forest losses		79.3	34.4	
Material production	14.4	14.4	14.4	1.5
Fuel production (crushing)	3.9	3.9	3.9	
(Esterification)	3.7	3.7	3.7	
Overseas transportation (to Japan)	1.2	1.2	1.2	0.9
Refining				3.6
Domestic transportation	0.4	0.4	0.4	0.4
Subtotal	23.5	102.8	57.9	6.4
Direct combustion	0.0	0.0	0.0	74.3
Total	23.5	102.8	57.9	80.7
(Gain or loss)	-57.2	22.1	-22.8	-

Estimated Tropical Rain Forest Losses

	Burning off tropical rain forests	Effective utilization of timbers from tropical rain forests
1. Carbon accumulations in tropical rain forests (kg-C/m^2)	18.5	18.5
(Timber utilization rate)	0%	70%
(Rate of timber abandonment in less than 50 years)	0%	30%
Unutilized carbon accumulations	18.5	9.4
2. Carbon accumulations in palm trees (kg-C/m^2)	2.5	2.5
3. Loss of fixed carbon in tropical rain forests	16.0	6.9
(Annual loss (50 years))	0.32	0.14
Carbon loss per MJ for palm oil	21.6	9.4
(g-CO_2/MJ)	79.3	34.4

4-4 Various Problems Accompanying Tropical Rain Forest Destruction

- **Problems accompanying tropical rain forest destruction and cultivation must be considered scientifically and objectively. Any quick conclusions should be avoided.**
- **Tropical rain forest destruction is expected to lead not only to losses of fixed carbon but also to declines in forest animals and plants, water losses causing floods and other various adverse effects on ecosystems.**
- **Spurred by forest fires on Sumatra Island in 1997 and 1998, palm oil producers, consumers, government officials, NGO representatives and other stakeholders established the Roundtable on Sustainable Palm Oil (RSPO).**
- **The RSPO has established eight principles for environmentally friendly production of palm oil and the principles have been developing into the consensus for relevant operations.**

Principle 1: Commitment to Transparency
Principle 2: Compliance with Applicable Laws and Regulations
Principle 3: Commitment to Long-Term Economic and Financial Viability
Principle 4: Use of Appropriate Best Practices by Growers and Millers (for crushing and refining)
Principle 5: Environmental Responsibility and Conservation of Natural Resources and Biodiversity
Principle 6: Responsible Consideration of Employees and of Individuals and Communities by Growers and Millers
Principle 7: Responsible Development of New Plantings
Principle 8: Commitment to Continuous Improvement in Key Areas of Activity

5. Conclusion and Future Challenges

Like gasoline and diesel oil, BDF is fluid at ordinary temperatures and pressures. Therefore, existing oil fuel infrastructure is available for BDF. In this sense, BDF is very convenient.

●Key points for BDF (FAME) introduction

(1) Supply potential

BDF supply for B5 diesel can be secured mainly from Indonesia. But there are large risks.

(2) Costs

①BDF is relatively more expensive than diesel oil and does not pay at present.

②Crude oil prices are rising. But palm oil prices are increasing even faster.

(3) Quality

①The diversity of FAME materials will make it difficult to maintain high quality uniformly, if FAME is used as BDF.

②If BDF is diffused nationwide on a large scale, hydrorefining will be more desirable.

(4) Environmental problems

①LCA assessment taking into account releases of fixed carbon from tropical forests needs to be made.

②Impacts of tropical rain forest destruction on ecosystems must be taken into account.

③We should act in line with the eight RSPO principles.

● Conclusion

(1) Japan's nationwide introduction of BDF, other than local production for local consumption, will be difficult for the immediate future.

(2) From the medium to long-term perspective, Japan will have to positively tackle the development of technologies for wood biomass gasification, the Fischer-Tropsch Synthesis (biomass to liquid) and cellulosic ethanol that do not compete with food crops.

Contact: report@tky.ieej.or.jp