World's leading organization in oil management

The Policy and Quality Issues of Biodiesel in Korea

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1 Policy of Biofuels

Energy Situation in Korea

World Rankings

- 10th in Energy Consumption
- 9th in Petroleum Consumption
- 7th in GHG Emission
- 97% Dependence on Foreign Energy

Energy Security

- 2nd Master Plan for National Energy('14)
  - Renewable Energy 11%(~'35)

GHG Reduction

- National GHG Reduction Target ('09)
  - BAU 30%('20)

Need to Expand the Supply of Renewable Energy
(The Main Policies : RPS, RFS, RHO)

National GHG Reduction Target('09.11) and Road map('14.1)

Low Carbon Green Growth Act

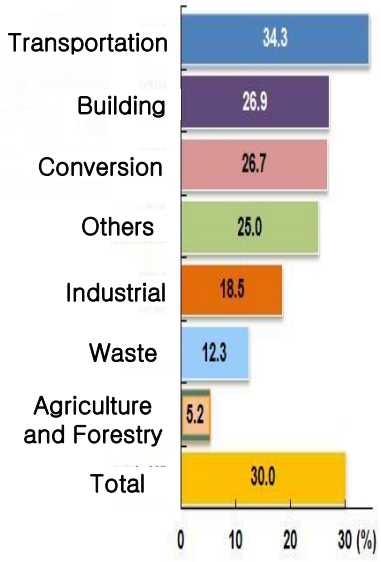
➢ GHG Reduction Target : 30% Based in BAU by 2020 (09.11.17)

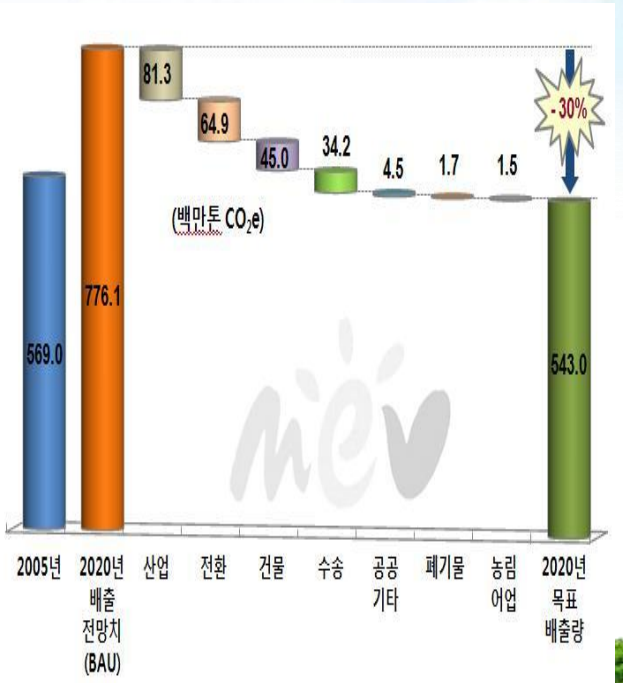
- The highest level in developing countries
- Amount of GHG emission by 2020 : 569 million ton(in case of GHG 30% reduction)

(Estimates of GHG emission without any effort to reduce by 2020 : 594('05) →813 million ton)

➢ National GHG Reduction Road Map (ME, Jan. 2014)

- Main Content : 34.3% reduction in the transport sector by 2020
- Promotion Strategy : Green Traffic Policy, Promote Energy Efficiency, Introduce Green Car, Expand Biofuels





2nd Master Plan for National Energy (Renewable Energy Sector)

Renewable Energy Target
11% (by 2035)

[Unit : %]

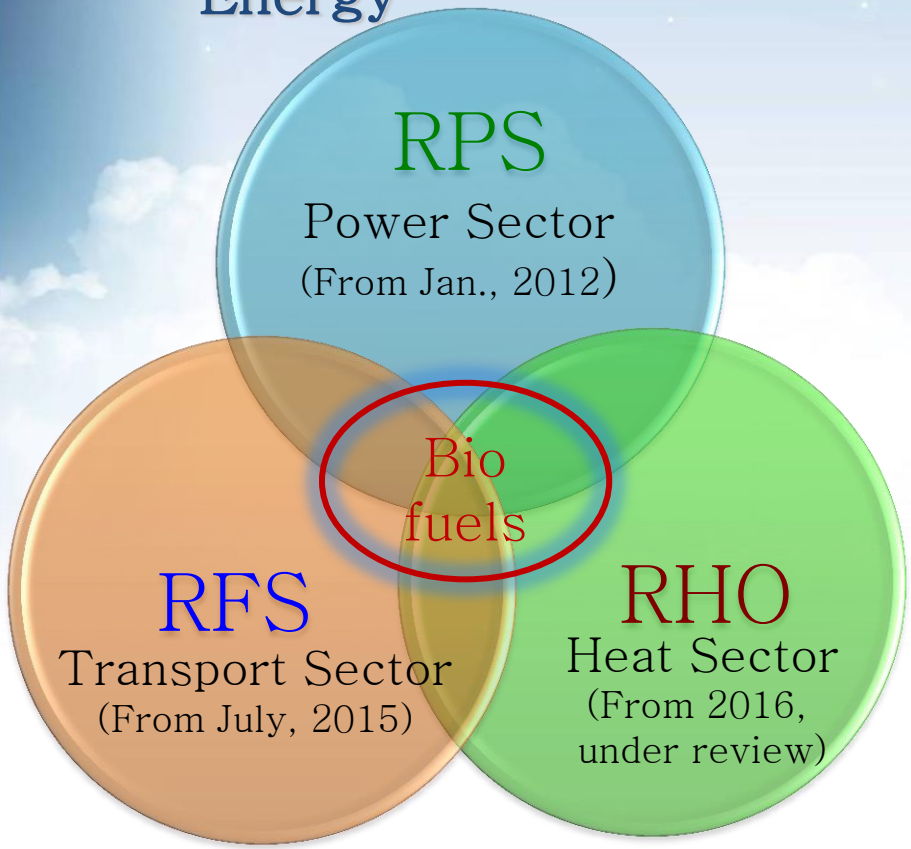
Increase

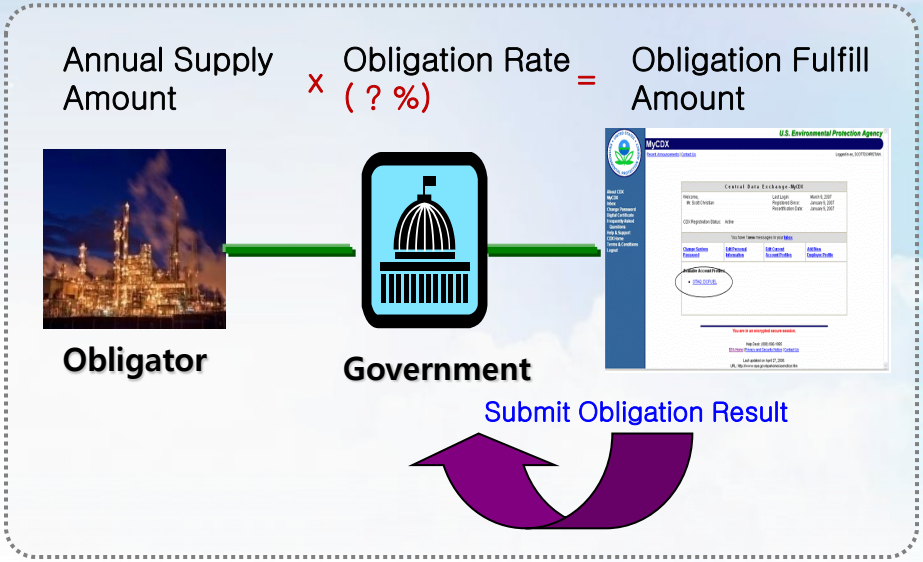
	'12	1st Plan('08)	2nd Plan('14)
Wind Power	2.18	13	18
Solar Light	2.68	4	4
Solar Heat	0.30	6	8
Geothermal Heat	0.74	4	9

Decrease

	'12	1st Plan('08)	2nd Plan('14)
Waste	67.77	33	29
Bio	**15.08**	**31**	**18**
Ocean	1.11	5	1
Water Power	9.21	4	3

The Obligation Policy for the Promotion of Renewable Energy





- Solid : Wood Chip, Wood Pellet, etc.
- Liquid : BD, BE etc.
- Gas : Biogas, etc

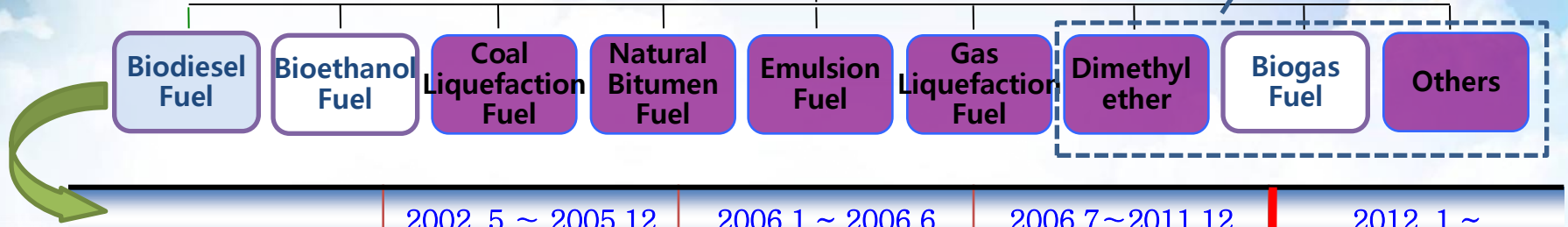
- RPS : Renewable Portfolio Standard
- RFS : Renewable Fuel Standard
- RHO : Renewable Heating Obligation

Kind of Petroleum Alternative Fuels in Korea

Kind of Petroleum Alternative Fuel

「Petroleum and Petroleum Alternative Fuel Business Act」

Reviced Aprill 30, 2009



		2002. 5 ~ 2005.12	2006.1 ~ 2006.6	2006.7~2011.12	2012. 1 ~
BD5	Stage	-	-	Commercialization	←
	Blender	-	Refineries/Importer	←	←
	Blending Rate	-	Max 5%	0.5->1.0->1.5->2	2~5 (Obligation)
	Target Area	-	The whole country	←	←
	Target Vehicle	-	All diesel car	←	←
BD20	Stage	Demonstration	←	Commercialization	←
	Blender	Gas S/BD Supplier	The whole country	←	←
	Blending Rate	20±3%	←	←	←
	Target Area	Capital Area, Jeolla-nam-buck-do	The whole country	←	←
	Target Vehicle	ALL Diesel Car (Bus/Truck Recommendation)	←	Bus, Truck, Construction Equipment, Train(Hold it's own repair shop and fueling facility)	←

Main Alternative Fuels based in Petroleum Products

Petroleum	Alternative Fuels
Diesel	Biodiesel
Gasoline	Bioethanol
CNG	Biogas

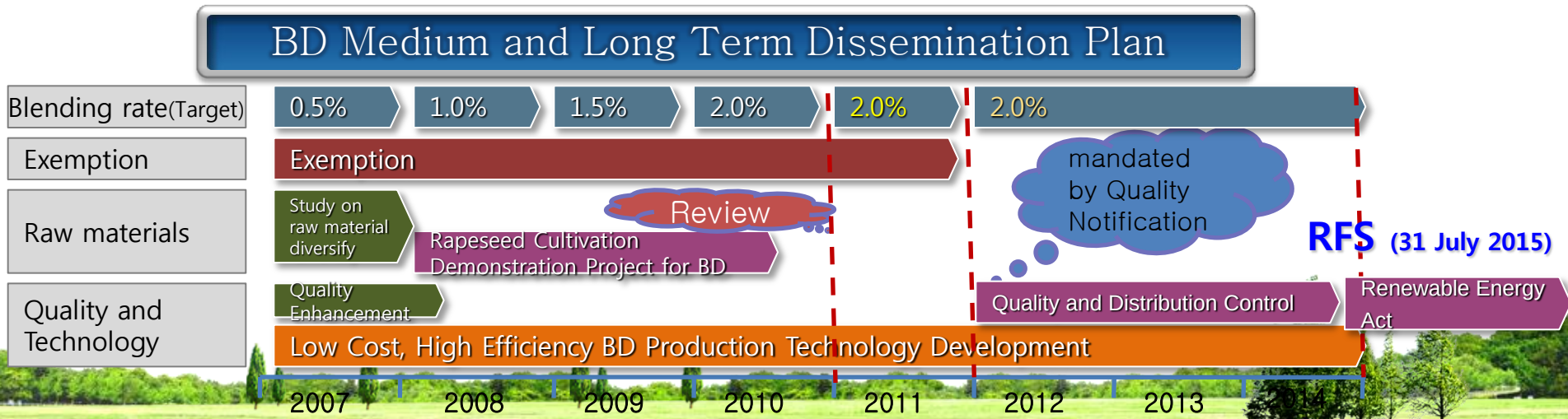
* Commercialized, HBD(Actual Assessment Stage), BTL etc.(under R & D)

* Demonstration Stage, Biobutanol and Cellulosic Bioethanol, etc.(under R & D)

* Supplied to City Gas, under R & D for Transport

Implementation Status of Petroleum Alternative Fuels

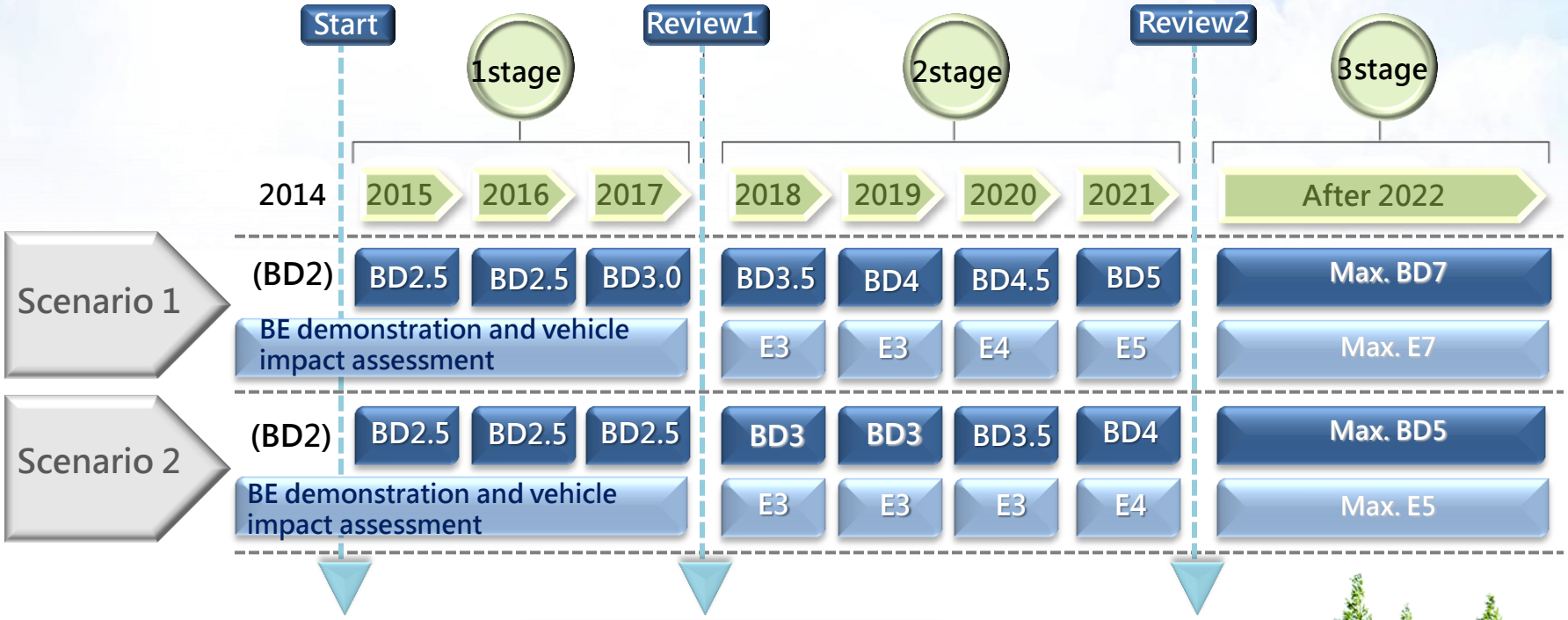
	Biodiesel	Bioethanol
2004	- BD 20 Demonstration Project (2002~2005)	BE and ETBE are permitted as gasoline oxygenate
2006 ~ 2008	- BD Commercialized in July 2006 - In 2007, 1st Biodiesel Medium and Long Term Dissemination Plan . Increase the BD blending ratio from 0.5→2.0% with exemption * Voluntary agreement between the government and refineries	BE Actual Assessment Project(2006~2008)
2009 ~ 2010	- Study on Introduction of RFS(Renewable Fuel Standard) into Korea	
2011	- 2nd Biodiesel Medium and Long Term Dissemination Plan . The mandating the BD 2~5% by the diesel specification from 2012 with taxation	
2012 ~ 2013	- RFS Operation Scheme Study ('12.5~'13.3)/RFS Proclamation('13.7.30)/RFS Implementation('15.7.31) - Study on Detailed Scheme of BE Demonstration Project ('13.5~'13.12)	
2014 ~	- Preparing the RFS Sub-legislation (Enforcement Ordinance, Enforcement Regulation and Notification)	



Scenario of Biofuel Obligation in Korea

RFS Public Hearing('13.2)

- The BD is the first to be introduced in 2015
- The bioethanol and biogas will be reviewed in 2017
- This scenario is changeable before starting RFS



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2 Status of Biodiesel

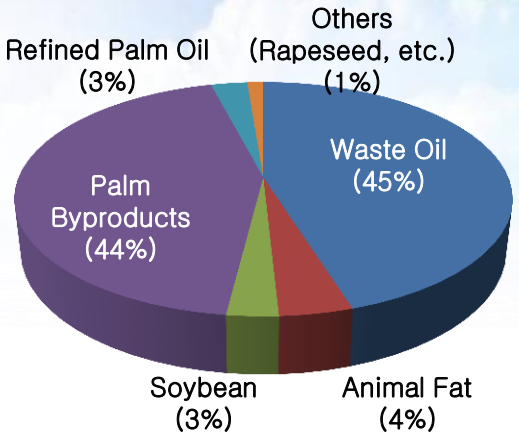
Status of Supply and Demand of Biodiesel Feedstock

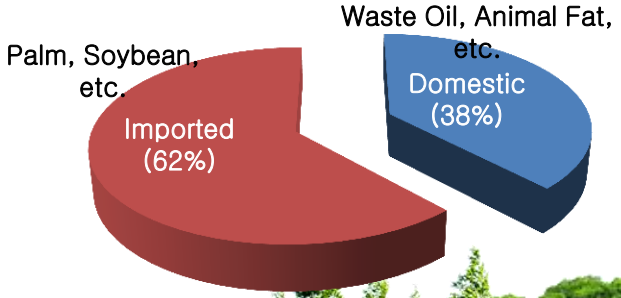
- Main BD Feedstocks are Domestic Waste Oil and Imported Palm Oil
- Domestic Feedstock Ratio was 38% in 2013

[Unit : 1,000ton]

구 분		'06	'07	'08	'09	'10	'11	'12	'13
Domestic	Waste Oil	16	36	57	77	78	109	121	150
	Animal Fat	-	-	-	-	-	-		13
	Others	0.4	-	0.1	2.2	-	3	-	0.5
	Subtotal	**16.4**	**36**	**57.1**	**79.2**	**78**	**112**	**121**	**163.5**
Imported	Soybean	46	62	69	52	80	34	19	12
	Palm Byproducts			30	63	102	115	136	187
	Refined Palm Oil	-	0.2	34	59	69	74	62	12
	Waste Oil	-	-	0.1	16	25	35	38	44
	Animal Fat(Tallow)	-	-	-	-	-	-	-	3.2
	Others(Rapeseed etc.)	-	1.3	16	13	4	14	9	5.3
	Subtotal	**46**	**63.5**	**149.1**	**203**	**280**	**272**	**264**	**263.5**
Total		**62.4**	**99.5**	**206.2**	**282.2**	**358**	**384**	**385**	**427**
Domestic Ratio(%)		**26.3**	**36.2**	**27.7**	**28.1**	**21.8**	**29.2**	**31.4**	**38.3**

(2013)





Biodiesel Distribution Structure

✓ Distribution

- B2~5 is manufactured by refiners and supplied to gas station
- B20 is manufactured by BD Co. and supplied to bus, truck and construction equipment operators who are equipped with certified storage tank and self-repairshop

BD suppliers(15)

BD100

Refiners(4)

Diesel (BD2)

Gas Station

Diesel (BD2)

BD20
10% during winter season(11/1~3/31)

Bus, truck and construction equipment operators who are equipped with 'certified storage tank' and 'self-repair shop'

Costumer

Status of Biodiesel Production and Consumption

- 15 Domestic BD Companies (Production Capacity. : 1.2 million kL) in Korea
- Only 9 BD Companies are Supplying to Refineries (supply amount : 400 thousand Kl)

✓ BD5

- Since July 2006, Consumption of BD5 was about 2,213,000kL

	2006.7~ 2006.12	2007	2008	2009	2010	2011	2012	2013
B100(1,000KL)	46	109	195	288	395	389	398	393
Blending Rate(%)	0.5	0.5	1	1.5	2	2	2	2

✓ BD20

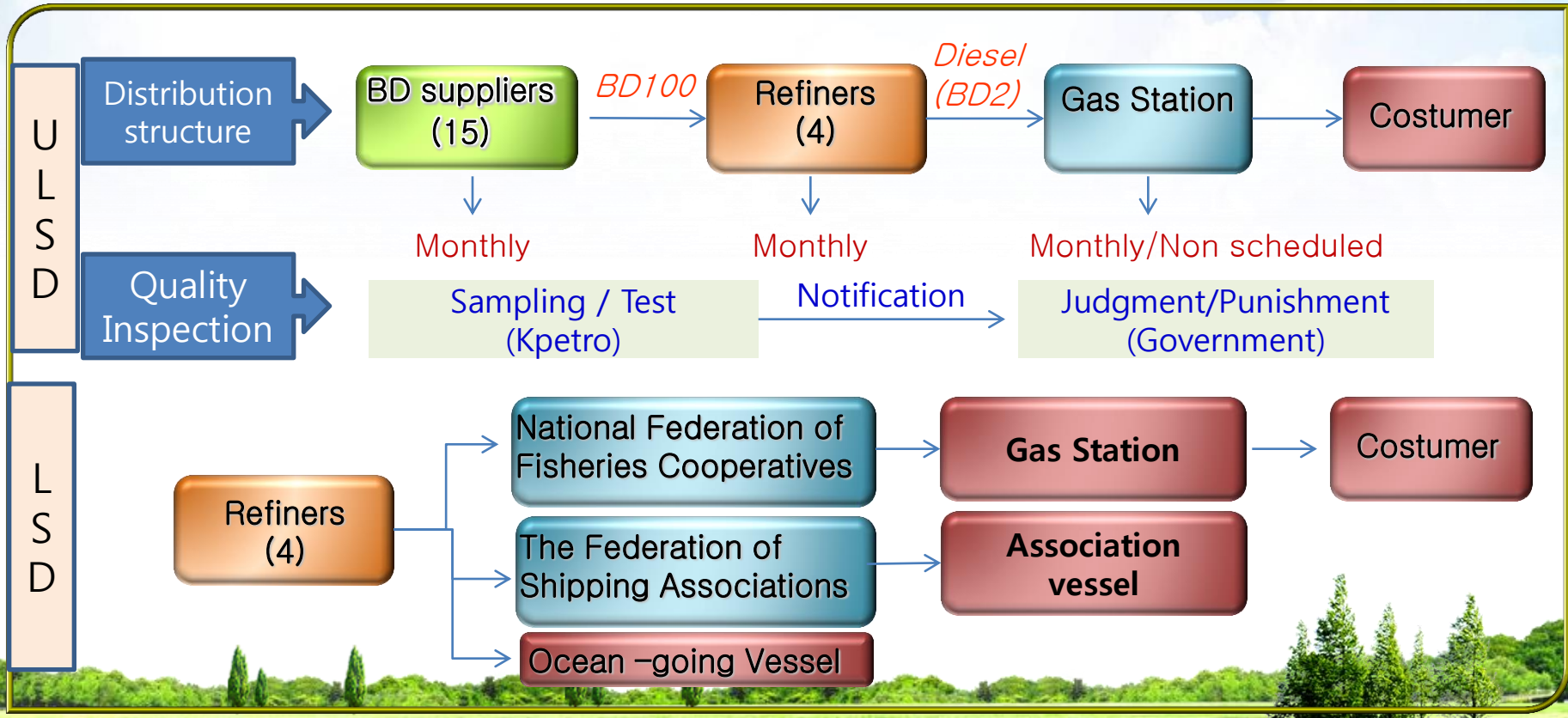
- Since July 2006, Consumption of BD5 was about 5,400kL

구분	2006.7~ 2006.12	2007	2008	2009	2010	2011	2012	2013
B100(1,000kL)	3.7	0.2	0.3	0.3	0.3	0.3	0.2	0.1
Blending Rate(%)	20(10 for winter)							

Diesel Quality Inspection Process

✓ Distribution/ Inspection

- ULSD is distributed for automobile mixed with 2% BD
  - The BD suppliers and Refiners are inspected monthly and the gas station monthly and non scheduled
- HSD is distributed for vessel without BD



Biodiesel Quality Specification

- The BD Spec. is a little difference with Taiwan
- The CFPP act as prevention of palm oil in winter season
  * Palm oil BD has over 10℃ CFPP

Properties			Spec. (Different Spec. with Taiwan)	Test Method
FAME(wt%)		Min.	96.5	EN 14103
Flash Point(℃)		Min.	120 (101)	KS M ISO 2719
Kinematic Viscosity (40℃, ㎟/s)			1.9 (3.5)~ 5.0	KS M 2014
Carbon Residue (wt%)		Max.	0.1 (0.3)	KS M ISO 10370
Sulfur Content (㎎/㎏)		Max.	10	KS M 2027
Ash (wt%)		Max.	0.01 (0.02)	KS M ISO 6245
Copper Strip Corrosion (50℃, 3h)		Max.	1	KS M 2018
CFPP (℃)		Max.	0	KS M 2411
Density (15℃, ㎏/㎥)			860 ~ 900	KS M 2002
Moisture (wt%)		Max.	0.05	KS M ISO 12937
Sediment (mg/kg)		Max.	24	EN 12662
TAN (㎎ KOH/g)		Max.	0.50	KS M ISO 6618
Total Glycerol (wt%)		Max.	0.24 (0.25)	KS M 2412
Monoglyceride (wt%)		Max.	0.80	KS M 2412
Diglyceride (wt%)		Max.	0.20	KS M 2412
Triglyceride (wt%)		Max.	0.20	KS M 2412
Free Glycerol (wt%)		Max.	0.02	KS M 2412
Oxidation Stability (110℃, h)		Min.	6	EN 14112
Methanol (wt%)		Max.	0.2	EN 14110
Alkali Metals (mg/kg)	(Na + K)	Max.	5	EN 14108, 14109
	(Ca + Mg)	Max.	5	EN 14538
Phosphorus (mg/kg)		Max.	10 (4)	EN 14107

* CFPP is applied to the winter season (11. 15. ~ 2. 28)

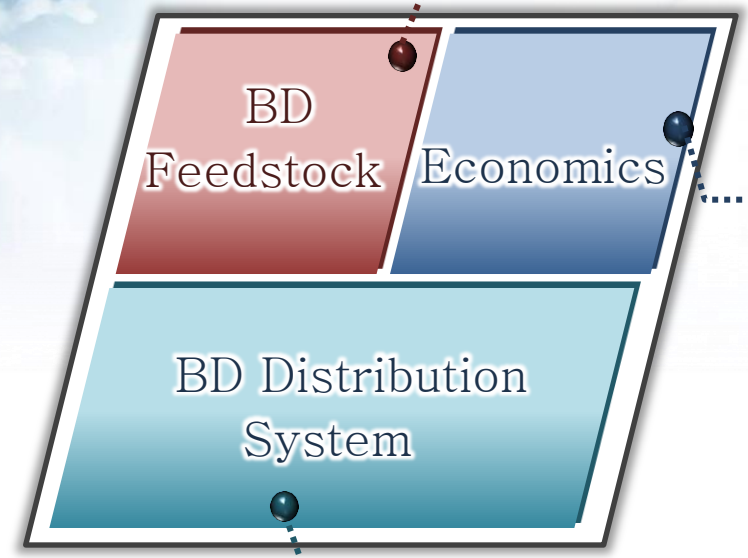
Diesel Quality Specification

- The BD content has been 2~5 vol% from 2012(mandated over 2%)
- The serious cold performance problems(startability and driveability) occurred in 2010
  - •There were many reasons such as cold weather, diesel quality, BD blending ratio, vehicle battery capa., fuel filter position, and etc.

➡ The CFPP and Pour point were intensified
(CFPP : from -16℃ to -18℃ on Nov. 2011, PP : from -17.5℃ to -23℃ on Jan. 2014)

Properties		For automobile	For vessel
Pour Point (℃)	Max.	0.0 (Winter : -23)	0.0 (Winter : -12.5)
Flash Point (℃)	Min.	40	
Kinematic Viscosity (40℃, mm^2/s)		1. 9 ~ 5.5	1.5 ~ 6.0
Distillation (90 vol%, ℃)	Max.	360	-
Carbon Residue in 10% Residual Oil (wt%)	Max.	0.15	0.20
Water & Sediment (vol%)	Max.	0.02	
Sulfur Content (㎎/㎏)	Max.	10	0.05(wt%)
Ash (wt%)	Max.	0.02	0.01
Cetane Number (Cetane Index)	Min.	52	40
Copper Strip Corrosion (100℃, 3h)	Max.	1	
CFPP (℃)	Max.	-18	-
Lubricity@60℃ (HFRR WSD, ㎛)	Max.	400	-
Density@15℃ (kg/m^3)		815 ~ 835	-
Polycyclic Aromatic Content (wt%)	Max.	5	-
Aromatic Compound Content (wt%)	Max.	30	
Biodiesel Content (vol%)		2 ~ 5	-
Color		-	Red

Issues of Biodiesel



- Most of Feedstocks depend on Importation except waste oil
  - -Need to develop utilization technology of domestic sources (waste oil, animal fat, micro algae, etc.)
  - -Need to develop overseas plantation

- BD Price is expansive 1.1 times[934won/ 1,150won) than Diesel occupying mostly the Feedstock cost at over 70%
  - - Need to develop utilization technology of low price and high acid feedstocks (Byproducts of Palm Oil and sewage sludge, etc.)

- Most of the BD suppliers are lack of surplus funds
- The long-term investment is difficult because of the annual BD supply contract system.

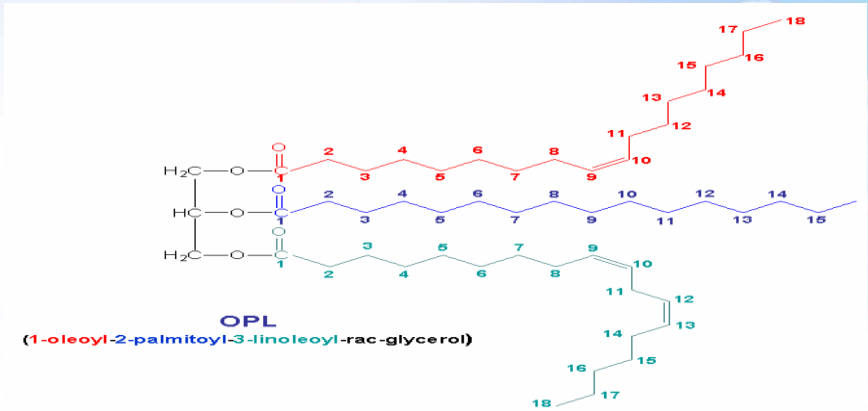
Contents

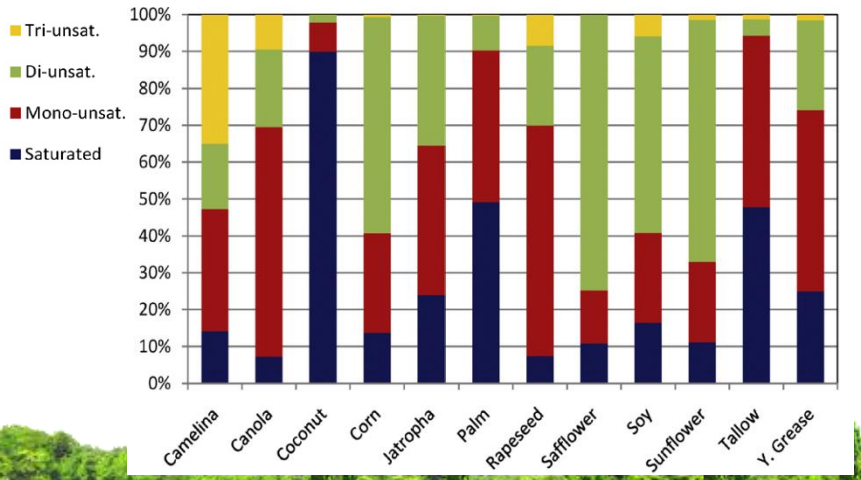
3 Quality Issues of Biodiesel

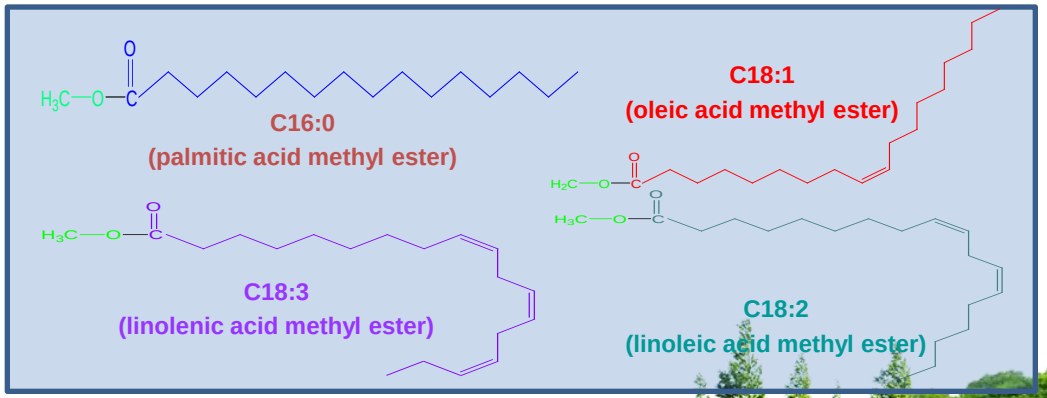
Main Qualities of Biodiesel

- The most critical BD qualities are cold flow and oxidative stability
- These properties depend on the degree of unsaturation
  - lower degree of unsaturation lead to poorer cold flow property, but better oxidative stability

Low		No. of double bond		High
High		Cetan number		Low
Good	←	Oxidation stability	→	Bad
Bad		Cold performance		Good
Low		Iodine number		High



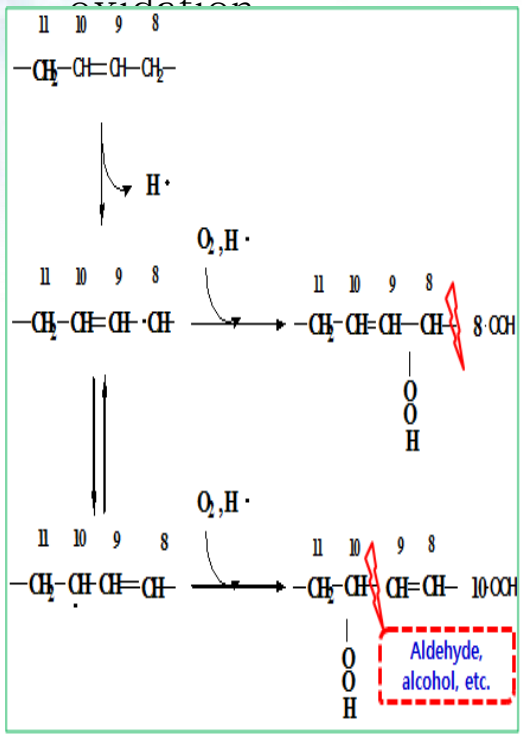




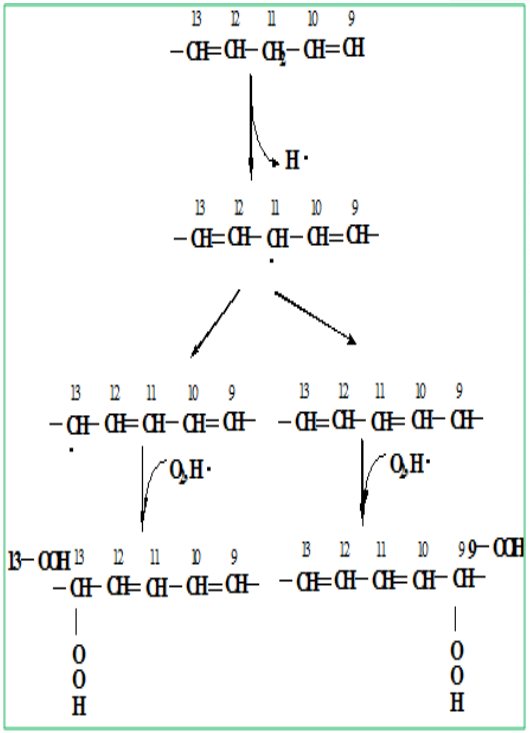
SOURCE : 'Review of biodiesel compositions, properties, and specifications' Renewable and sustainable Review, 2009

Oxidation mechanism of Biodiesel

- The oxidation stability is strongly affected by the degree of unsaturation
- When using purified methyl ester of stearic acid(C18:0), oleic acid(C18:1), linoleic acid(C18:2), linolenic acid(C18:3), the relative rates of oxidation is to be 1:10:100:150
- The properties are also changed according to the oxidation progress
- The FT-IR spectrum at 1700cm^{-1} goes up with increasing the oxides produced by oxidation

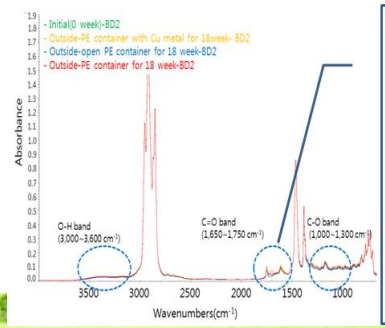


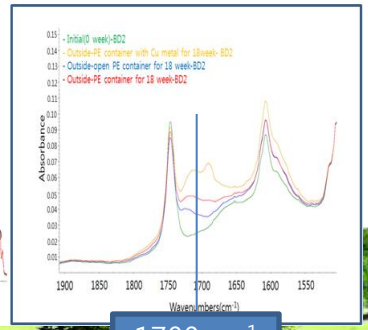
oleic acid(C18:1)



linoleic acid(C18:2)

Properties	Change
Cetane No.	Increase (the Organic peroxides)
Density/Kinematic viscosity	Increase (Poly condensation materials)
TAN	Increase(Oxides such as Formic acid. Etc.)
Color	Color change to brown





Microbial problems of Biodiesel

➢ BD blends are more susceptible to biological attack by micoorganisms due to its water affinity.

➢Refer to ASTM D6469-12(Standard Guide for Microbial Contamination in Fuels and Fuel Systems)

-	Content
Major microorganismes	Bacteria and Fungi
The places of formation	Overhead surface in fuel tank, Tank wall, Fuel/Water Interface, Pipe, Filter
Products	Sludge, Biosurfactants, Sulfide(SBR, sulfate reducing bacteria), Organic acids
Symptoms	Filter plugging, Engine deposit, Emulsification, Metal corrosion, Deplasticize of coating on fuel tank, Additive degradation
Diagonostic methods	Acid/base number, Water content, Density/Viscosity, Copper corrosion, Pour Point
Remedial efforts	Monitoring and removal of water and contaminants, Minimize contaminants entry, Biocide use, Tank cleaning

The Compositional Profiles of BD from Various Feedstocks

- The animal fat BD has highly saturated C16:0 FA and highly unsaturated C18:1, 2 FA
  - Relatively Poorer cold property and oxidation stability
- The coconut and PKO BD have over 60% of highly saturated C12:0 and C14:0 FA
  - Relatively good oxidation stability and cold flow property by short carbon chain
- The soybean and waste oil have bad oxidation stability due to the high C18:1, 2 FA
- The palm BD has bad cold property due to the highly saturated C16:0 FA

Items	Animal fat BD		Vegetable oil BD				
	Lard	Tallow	Coconut	Palm Kernel	Soybean	Waste oil	Palm
C8:0			6	3			
C10:0			5	4			
C12:0			*44*	*52*			
C14:0	2	3	17	16			1
C14:1		1					
C15:0							
C16:0	*23*	*25*	9	7	10	16	*48*
C16:1	3	4				1	
C17:0	0.5	0.5					
C17:1							
C18:0	11	11	3	1	5	4	5
C18:1n9c	*44*	*43*	7	11	22	33	37
C18:2n6c	11	8	2	2	*51*	*37*	9
C18:2n6t							
C18:3n3	1	1	1	1	7	5	1
C20:1n9c	1						
C20:4n6							
C20:5n3							
Others	2	2	3	1	3	3	0
Total	98.5	98.0	96.7	97.6	97.5	98.5	
Olefin content	60	57	10	14	80	76	
CFPP(℃)	8.0	7.0	-8.0	-9.0	-5.0	0.0	
Oxidation stability(hr)	1.57	1.57	33.47	11.61	2.2	1.8	10.5

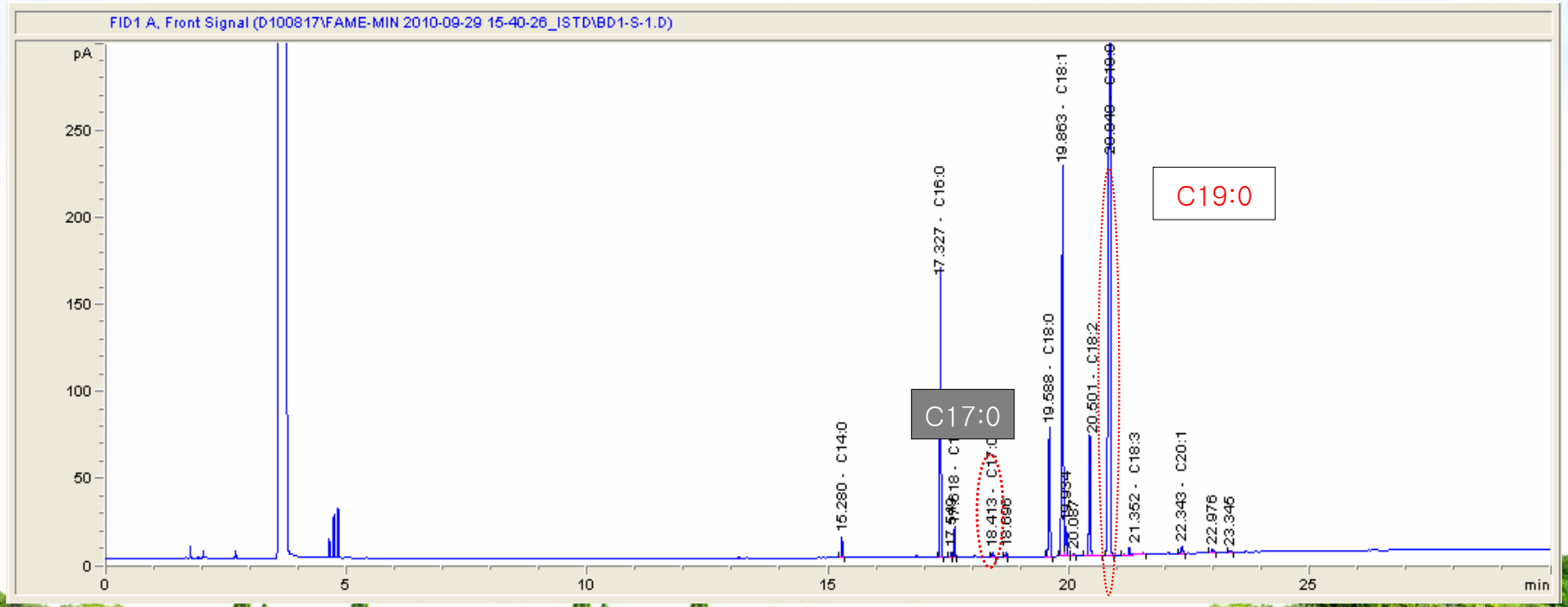
The Quality of Biodiesel of Various Feedstocks

- The animal fat BD shows relatively the worst qualities.
- The coconut and PKO BD show the low flash point, viscosity and density due to the short chain components(below C14 FA) and the much higher free glycerol content exceptionally due to its overlapping with C10:0 FAME peak in existing method.

Items	Spec.	Animal fat BD		Vegetable oil BD				
		Lard	Tallow	Coconut	Palm kernel	Soy bean	Waist oil	Palm
Methyl ester content (wt%)	96.5	98.5	98.0	96.7	97.6	98.5	99.2	99.7
Flash point (℃)	120↑	178	180	142	148	179	178	178
Viscosity (40℃, ㎟/s)	1.9-5.0	4.472	4.455	2.56	2.80	4.02	4.20	4.44
Carbon residue (wt%)	0.1↓	0.01	0.02	0.09	0.02	0.03	0.03	0.03
Sulfur content (mg/kg)	10↓	1.03	1.04	0.90	0.00	1.03	1.64	0.15
Ash (wt%)	0.01↓	0.001↓	0.001↓	0.001↓	0.001↓	0.001↓	0.001↓	0.001↓
Copper corrosion (50℃, 3h)	1↓	1a	1a	1a	1a	1a	1a	1a
CFPP (℃)	0↓	8.0	7.0	-8.0	-9.0	-6.0	0.0	10.0
PP (℃)	-	9.0	9.0	-6.0	-7.0	-5.0	1.0	14.0
Density (15℃, kg/㎥)	860-900	876.0	875.0	864.0	860.5	884.0	881.0	874.0
Water content (wt%)	0.05↓	0.0151	0.0264	0.0199	0.0600	0.0074	0.0402	0.0130
Total contamination (mg/kg)	24↓	5.3	4.7	7.8	5.4	6.2	6.5	8.8
Acid value (mg KOH/g)	0.50↓	0.13	0.04	0.03	0.02	0.01	0.08	0.03
Total glycerol content (wt%)	0.24↓	0.038	0.032	3.389	2.613	0.047	0.033	0.047
Monoglyceride content (wt%)	0.80↓	0.006	0.000	0.012	0.000	0.032	0.023	0.013
Diglyceride content (wt%)	0.20↓	0.000	0.000	0.002	0.000	0.006	0.000	0.006
Triglyceride content (wt%)	0.20↓	0.000	0.000	0.000	0.000	0.009	0.000	0.008
Free glycerol content (wt%)	0.02↓	0.032	0.032	3.375	2.613	0.000	0.009	0.019
Oxidation stability (110℃, h)	6↑	1.57	1.75	33.47	11.61	2.24	13.10	10.50
Methanol content (wt%)	0.2↓	0.000	0.000	0.004	0.000	0.000	0.000	0.009
Alkali metals (mg/kg) (Na + K)	5↓	0.1 ↓	0.1 ↓	0.1 ↓	0.1 ↓	0.1 ↓	0.1 ↓	0.1 ↓
Alkali metals (mg/kg) (Ca + Mg)	5↓	0.1 ↓	0.1 ↓	0.1 ↓	0.1 ↓	0.1 ↓	0.1 ↓	0.1 ↓
Phosphorous content (mg/kg)	10↓	0.1 ↓	0.1 ↓	0.1 ↓	0.1 ↓	0.1 ↓	0.1 ↓	0.1 ↓

The Introductory Background and Issues of the Animal fat Biodiesel

- In 2009, The Working Group was held to introduce the animal fat BD
  - It need for diversifying the domestic BD feedstock but BD content test method should be reviewed
    - ※ The animal fat BD has C17 FAME unlike vegetable BD which has been using an ISTD material of existing method (EN 14013), Therefore it was not applicable to animal fat BD
- In 2010, the revised version of EN 14103 method was reviewed and then the following year the animal fat BD was commercialized.



Comparing the Condition of the FAME Test Methods

- The main differences are the FAME calculation range and ISTD
  - The new version can cover the C6~C24 FA, Therefore it can be applied to the coconut and PKO BD containing mainly below C14 FA
  - The C19:0 FAME is used as ISTD instead of C17:0, Therefore it can also be applied to the animal fat BD including the C17 FAME component.

Method	KS M 2413 = EN 14103-2003(Old)	EN 14103 (New version)
Scope	FAME C14 ~ C24 * Not applicable to Coconut, Palm(C12 FAME is most) and Animal fat BD	FAME C6~C24 * Applicable to Coconut, PKO and Animal fat BD
Internal standard	Methyl heptadecanoate (FAME C17)	Methyl nonadecanoate (FAME C19)
Column	Polyethylene glycol stationary phase (Carbowax 20m, DB wax, CP wax etc.)	
	30m(L), 0.35mm(I.D), 0.25μm(film thick)	30m(L), 0.25mm(I.D), 0.25μm(film thick)
Temp. condition	250℃(25min)	60℃(2min)→10℃/min→200℃→5℃/min→240℃(7min)
Flow rate	1~2 mL/min	←
Split rate	50mL/min	100mL/min
Sample (10mL base)	Sample : 250mg STD : Take 5mL of 10mg/mL(Heptan)	Sample : 100mg STD : 100mg Solvent : toluene

The Test Results analyzed by the New Method

- The animal fat BD content analyzed by the new method was 1.1 ~ 4.1 wt% higher as compared to the old method
- Coconut and PKO BD was 56 ~ 59 wt% higher as compared to the old method

Items	Animal fat BD									
	Tallow		Chicken		Lard		Leather Lard		Leather Tallow	
	A	B	A	B	A	B	A	B	A	B
FAME contents	88.8	90.4	89.5	93.6	96.2	98.5	97.4	98.5	96.3	98.0
Difference (B-A)	1.6		4.1		2.3		1.1		1.7	
C17:0 content	0.7		0.3		0.4		0.5		0.5	
Items	Vegetable oil BD									
	Coconut		Palm kernel		Soy bean		Waist oil		Palm	
	A	B	A	B	A	B	A	B	A	B
FAME contents	37.9	96.7	40.7	97.6	97.1	97.5	98.6	99.2	99.9	99.7
Difference (B-A)	58.8		56.0		0.4		0.6		0.2	
C17:0 content	0		0		0		0		0	

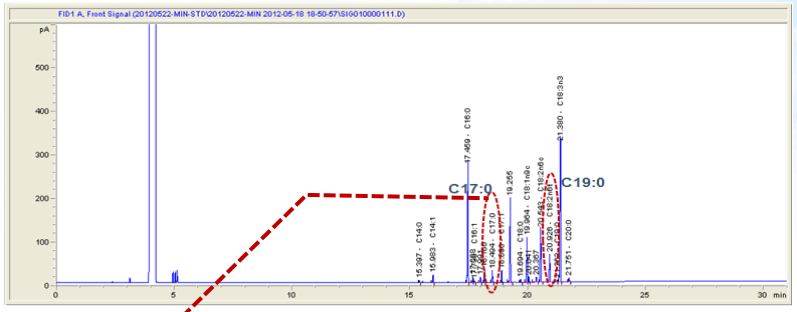
* A test method is applied by the current method (KS M 2413=EN 14103)
B test method is applied by the new method (EN 14103)

The Quality of Microalgae BD Produced in Korea

The national project has been conducted by Marin Bioenergy Research Center(2009-2019)

Properties		Spec.	Results
FAME(wt%)	Min.	96.5	98.8
Flash Point(℃)	Min.	120	170
Kinematic Viscosity (40℃, ㎟/s)		1.9 ~ 5.0	3.3
Carbon Residue (wt%)	Max.	0.1	0.01이하
Sulfur Content (㎎/㎏)	Max.	10	4
Ash (wt%)	Max.	0.01	0.001이하
Copper Strip Corrosion (50℃, 3h)	Max.	1	1a
CFPP (℃)	Max.	0	6
Density (15℃, ㎏/㎥)		860 ~ 900	894
Moisture (wt%)	Max.	0.05	0.05
Sediment (mg/kg)	Max.	24	7
TAN (㎎ KOH/g)	Max.	0.50	0.28
Total Glycerol (wt%)	Max.	0.24	0.001이하
Monoglyceride (wt%)	Max.	0.80	0.001이하
Diglyceride (wt%)	Max.	0.20	0.001이하
Triglyceride (wt%)	Max.	0.20	0.001이하
Free Glycerol (wt%)	Max.	0.02	0.001이하
Oxidation Stability (110℃, h)	Min.	6	6
Methanol (wt%)	Max.	0.2	0.01이하
Alkali Metals (㎎/㎏) (Na + K)	Max.	5	0.1이하
Alkali Metals (㎎/㎏) (Ca + Mg)	Max.	5	5
Phosphorus (mg/kg)	Max.	10	4

- All of the properties are satisfying the BD spec.
- But the oxidation stability and some metals(Ca, Mg) content are close to spec. limit



- Microalgae BD has overlap peaks with C17 FAME and C19 FAME which are using the internal standards of the current FAME content methods

Need to optimize the quality and develop the new method for the microalgae BD

The Relationship of compositional profiles and quality

- Microalgae BD compositional profiles are different as its species and more diverse than other conventional BDs
- The Dunaliellat BD contains the significant level of polyunsaturated constituents (C18:3 FA of 32.4%) which can cause the bad oxidation stability.
- The Botryococus BD contains high C18:1 FA similar to rapeseed BD profile.
- The Tetraselmis BD contains high C16:0 FA sImIlar to palm BD profile.

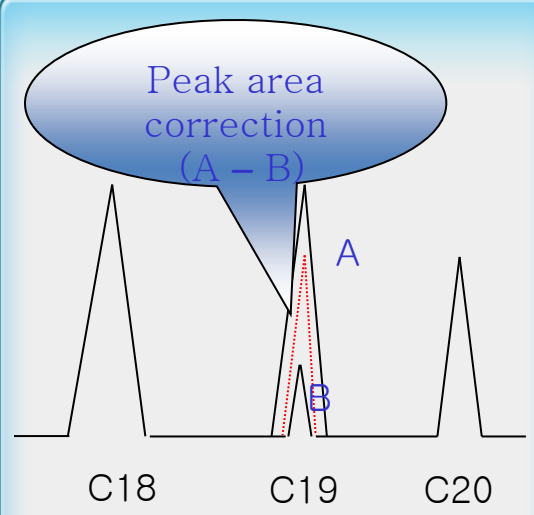
Items	Microalgae BD			Animal fat BD		Vegetable oil BD				
	Dunaliellat ertiolecta	*Botryococcus braunii*	*Tetraselmis Sp.*	Lard	Tallow	Coconut	Palm Kernel	Soybean	Waste oil	Palm
C8:0						6	3			
C10:0						5	4			
C12:0						***44***	***52***			
C14:0			0.6	2	3	17	16			1
C14:1		2.6			1					
C15:0		0.3								
C16:0	19.6	9.5	***33.3***	23	25	9	7	10	16	***48***
C16:1		2.4	1.1	3	4				1	
C17:0	1.8		4.2	0.5	0.5					
C17:1	1.8	0.8	0.9							
C18:0	0.5	1.2	0.6	11	11	3	1	5	4	5
C18:1n9c	7.5	***44.8***	16.4	***44***	***43***	7	11	22	33	37
C18:2n6c	9.7	7.5	11.3	11	8	2	2	***51***	***37***	9
C18:2n6t	5.0	0.4	2.4							
C18:3n3	***32.4***	7.8	7.3	1	1	1	1	7	5	1
C20:1n9c		0.8	0.6	1						
C20:4n6			0.5							
C20:5n3			0.6							
Others	20.1	12.7	16.3	2	2	3	1	3	3	0
Total	98.4	90.8	96.1	98.5	98.0	96.7	97.6	97.5	98.5	
Olefin content	56.4	67.1	41.1	60	57	10	14	80	76	
CFPP(℃)	6	-	-	8.0	7.0	-8.0	-9.0	-5.0	0.0	
Oxidation stability(hr)	1	-	-	1.57	1.57	33.47	11.61	2.2		10.5

Development of FAME Content Test Method for Microalgae

- This method focused on developing an applicable method to any BD regardless of any feedstocks
  - Therefore, we selected double test and area correction method
- But this method can have a precision problem because of the double test for one sample
  - we are trying to round robin test for domestic labs to check the precision

	EN 14103	Suggested method
Coverage	FAME C6~C24	←
ISTD	Methyl nonadecanoate(FAME C19)	←
Colum	Polyethylene glycol (Carbowax 20m, BD wax, CP wax, etc.)	←
	30m(L), 0.25mm(I.D), 0.25μm(F.Thick)	←
Temp. conditions	60℃(2min)→10℃/min→200℃→5℃/min→240℃(7min)	←
Flow rate	1~2 mL/min	←
Split ratio	100mL/min	←
Sampling (10mL)	Sample 1 : ISTD(C19:0)	- Sample 1 : ISTD(C19:0) - Sample 2 : without ISTD(C19:0)
Others	1 sample measurement	2 sample measurement

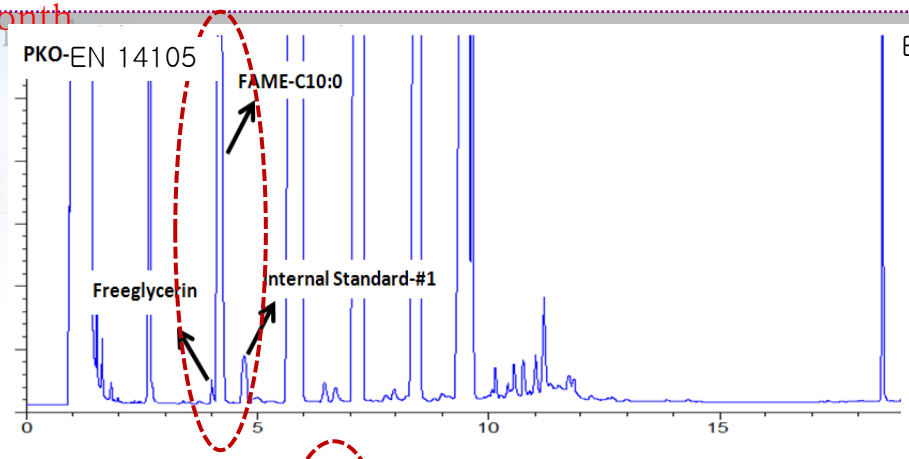
Test method principle

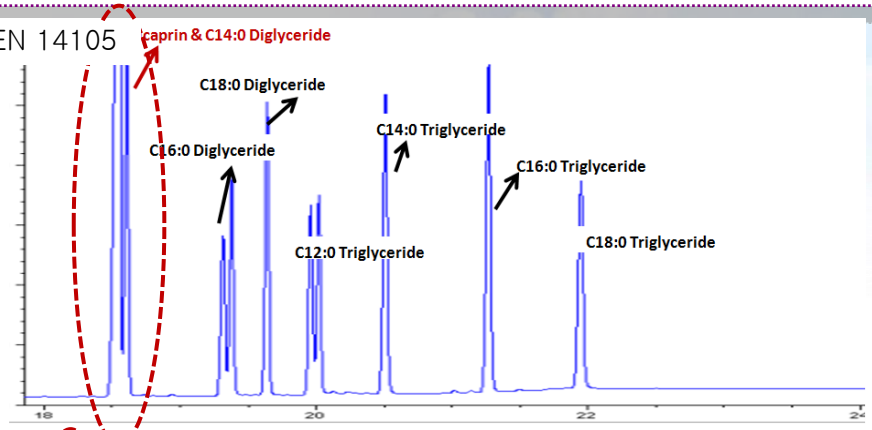


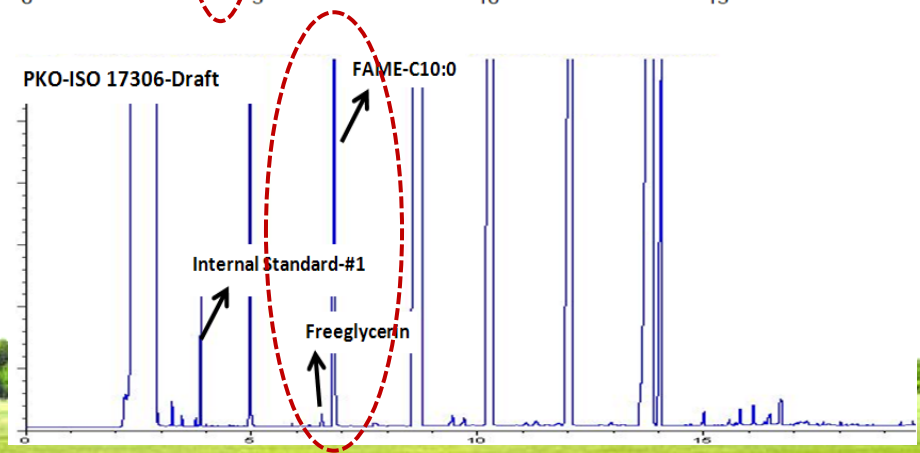
A : ISTD(C19) + B
B : Microalgae(Including ISTD)

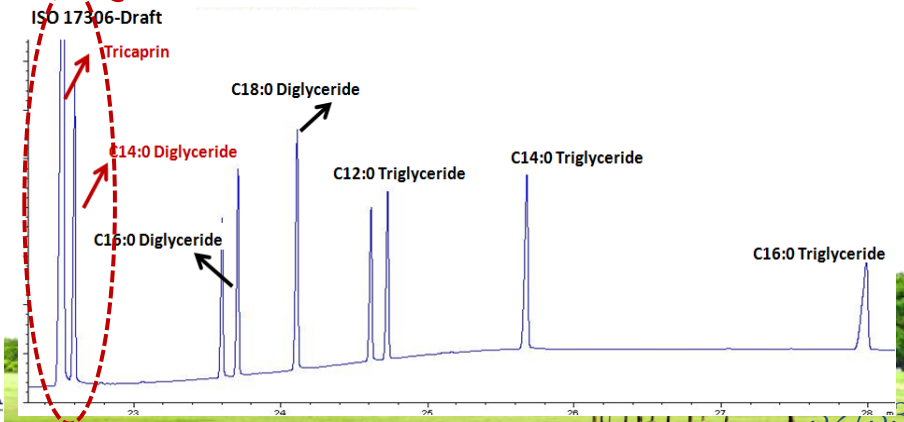
Glycerin Analysis Method of Coconut and PKO BD

- The current glycerin test method(EN 14105) is not applicable to Coconut and PKO BD
  - The C10 FAME overlapped with free glycerol and Tricaprin (ISTD 2) is overlapped with C14 diglyceride peak because this method has been made for BD containing the C16 and C18 FA
- We reviewed the new method(ISO/DIS 17306(Draft) suggested in 2013 and verified that all the problems (free glycerol and tricaprin peak overlapping) of the current method have been solved
- This new method(ISO/DIS 17306(Draft)) is going to more review in ISO/TC28 at the end of this month









Thank you