

Indonesia's experience: The application of biodiesel in the transportation sector

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1

CONTENTS

- I. INTRODUCTION**
- II. BIODIESEL POLICIES**
- III. BIODIESEL IMPLEMENTATIONS**
- IV. CHALLENGES OF BIODIESEL**
- V. RESEARCH AND DEVELOPMENT**
- VI. BIODIESEL TESTING RESULTS**

2

I. INTRODUCTION



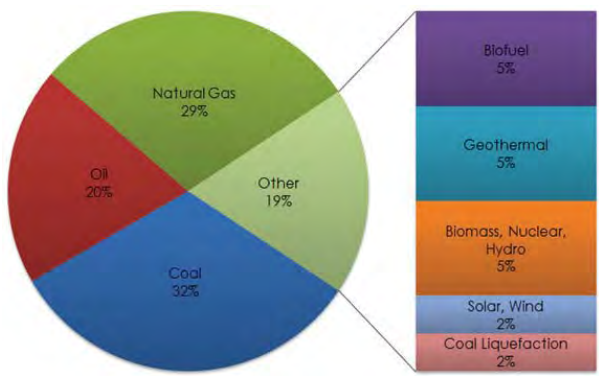
3

Why Biofuel in Indonesia?

- ❖ BIOFUEL provides energy security and prevent global warming
- ❖ BIOFUEL reduces greenhouse gas emission in transportation sector
- ❖ BIOFUEL promotes industrial development, innovation and jobs creation
- ❖ Indonesia has various BIOFUEL feedstocks and land plantation
- ❖ Proven BIOFUEL technology by domestic potential (Engineering, Research and Development)

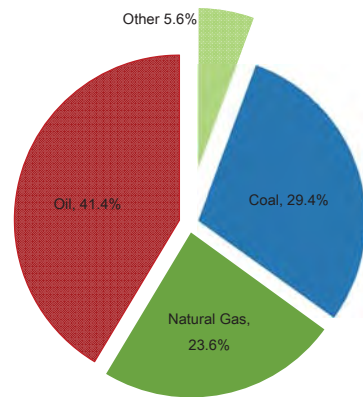
4

Indonesia Energy Diversity Planning



Energy Elasticity < 1

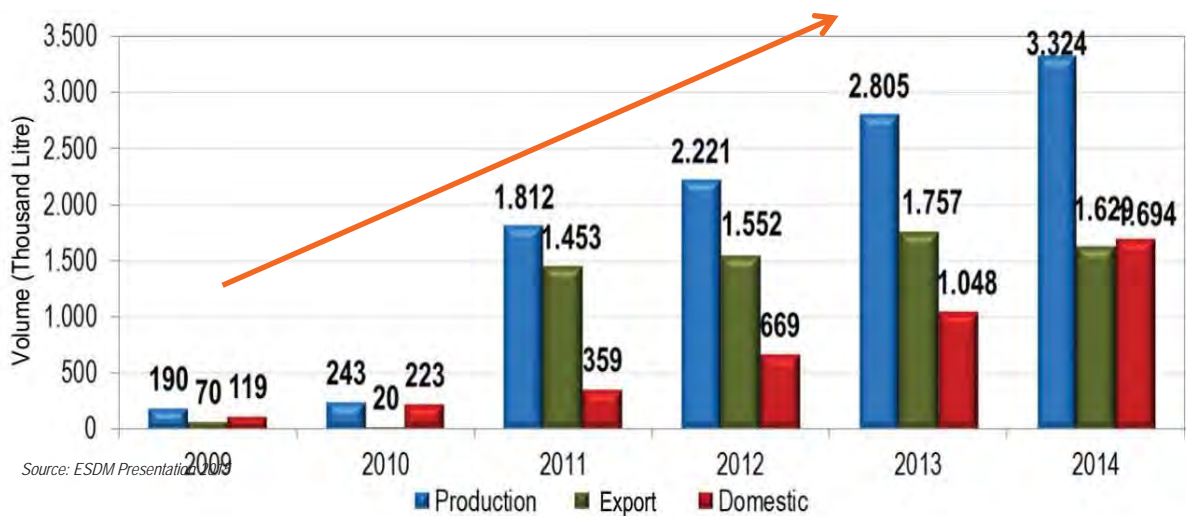
- National energy mix target in 2025
- Presidential decree No. 5 / 2006



Energy Elasticity < 1.65

- National energy mix in 2013
- Average of increasing energy consumption: 7%/year

Utilization Achievement of Biodiesel



- The content of biodiesel/fame (now 10%, B-10) will be increase to 20% (B-20) in 2016
- Mandatory biofuel realization is around 1,69 billion kL in 2014 or increase of 62% compared to 2013

Resources of Biofuel

- 46 type of plantations has been identified as potential resources in Indonesia .
- Considering cultivation area, production process and plant properties, the best 4 of plants are as follow:

Comparison of Biodiesel Raw Material				
Raw Material	Production Area -ha (Prediction 2013)	Productivity (kg/ha)	Production Availability*)	Ease of Production*)
Palm	9.149.919	3.689	30 years	seed and pulp
Coconut	3.796.149	1.157	50 years	pulp
Jathropa	47.407	302	50 years	seed
Rubber	3.492.042	1.104	20 years	seed

Source: Statistik Perkebunan Indonesia 2009-2012, Ditjen Perkebunan, Kementan
*): Priyohadi Kuncahyo,2013

- Indonesia is the biggest producer of palm oil in the world
- Palm is still the most potential as resource for biofuel !!!

7

Fatty Acids Composition

Composition	Palm	Coconut	Jatropha	Rubber
Kaproat Acid (6:0)	-	0 - 0.8	-	-
Kaprilat Acid (8:0)	-	5.5 - 9.5	-	-
Kaprat Acid (10:0)	-	4.5 - 9.5	-	-
Laurat Acid (12:0)	0 - 0.4	44 - 50	-	-
Miristat Acid (14:0)	0.6 - 1.7	13 - 19	-	-
Palmitat Acid (16:0)	41.1 - 47.0	7.5 - 10.5	14 - 15	7 - 8
Stearat Acid (18:0)	3.7 - 5.6	1 - 3	7	9 - 10
Arakhidat Acid (20:0)	-	0 - 0.45	-	0.5
Palmitoleat Acid (16:1)	-	0 - 1.3	1	-
Oleat Acid (18.1)	38.2 - 43.6	5 - 8	34 - 45	28 - 30
Linoleat Acid (18:2)	6.6 - 11.9	1.5 - 2.5	31 - 43	33 - 35
Linolenat Acid (18:3)	0 - 0.6	-	0.2	20 - 21

- ✓ Palm oil is dominated by palmitat acid : high cetane number
- ✓ Palm oil has lower linolet acid content (good oxidation stability)

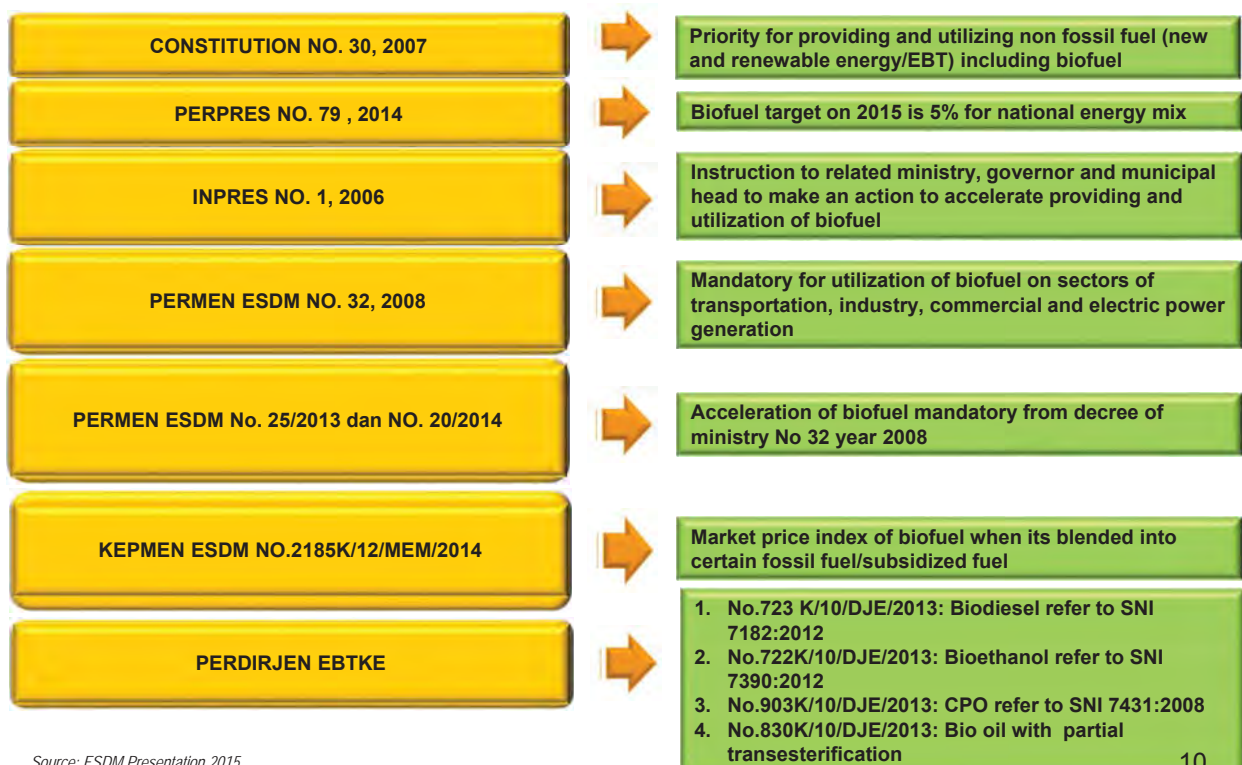
8

II. BIODIESEL POLICIES



9

BIOFUEL POLICIES



Source: ESDM Presentation 2015

10

Mandatory of Biofuel

BIODIESEL (Minimum)

Sector	July 2014	Jan. 2015	Jan. 2016	Jan. 2020	Jan. 2025
Transportation, Public Service Obligation (PSO)	10%	10%	20%	30%	30%
Transportation Non PSO	10%	10%	20%	30%	30%
Industry	10%	10%	20%	30%	30%
Electricity	20%	25%	30%	30%	30%

BIOETANOL (Minimum)

Sector	July 2014	Jan. 2015	Jan. 2016	Jan. 2020	Jan. 2025
Transportation, Public Service Obligation (PSO)	0,5%	1%	2%	5%	20%
Transportation Non PSO	1%	2%	5%	10%	20%
Industry	1%	2%	5%	10%	20%
Electricity	-	-	-	-	-

CPO (Minimum)

Sector	July 2014	Jan. 2015	Jan. 2016	Jan. 2020	Jan. 2025
Low and Medium Speed Engine in Industry	5%	10%	20%	20%	20%
Low and Medium Speed Engine in Marine Transportation	5%	10%	20%	20%	20%
Air Transportation	-	-	2%	3%	5%
Electricity	6%	15%	20%	20%	20%

Current priority of biofuel application is on land transportation

Government plan to do field testing on marine applications in 2016

11

Biodiesel standard

Specification of B100 (SNI 7182:2012)

No	Parameter	Value	Unit	Method
1	Density at 40 ° C	850-890	kg/m ³	ASTM D-1298/D-4052/SNI 7182:2012
2	Kinematic Viscosity at 40 ° C	2.3-6.0	mm ² /s	ASTM D-445//SNI 7182:2012
3	Cetana Number	51	Min	ASTM D-613/D-6890//SNI 7182:2012
4	Flash Point	100	° C, Min	ASTM D-93//SNI 7182:2012
5	Cloud Point	18	° C, Max	ASTM D-2500//SNI 7182:2012
6	Copper Strip Corrossion (3 hours at 50 ° C)	1	-	ASTM D-130//SNI 7182:2012
7	Carbon Residue			
	In Original Sample	0.05	% of mass, Max	ASTM D-4530/D-189//SNI 7182:2012
	In 10% of Distillation Waste	0.3		
8	Water and Sediment	0.05	% of vol, Max	ASTM D-2709//SNI 7182:2012
9	Distillation Temperature 90%	360	° C, Max	ASTM D-1160//SNI 7182:2012
10	Sulfuric Ash	0.02	% of mass, Max	ASTM D-874//SNI 7182:2012
11	Sulfur	100	mg/kg, Max	ASTM D-5453/D-1266/D-4294/D-2622/SNI 7182:2012
12	Phosphorus	10	mg/kg, Max	AOCS Ca 12-55//SNI 7182:2012
13	Acid Number	0,6	mg KOH/g, Max	AOCS Cd 3d-63/ASTM D-664/SNI 7182:2012
14	Free Glycerol	0,02	% of mass, Max	AOCS Ca 14-56/ASTM D-6584/SNI 7182:2012
15	Total Glycerol	0,24	% of mass, Max	AOCS Ca 14-56/ASTM D-6584/SNI 7182:2012
16	Ester Methyl Level	96,5	% of mass, Min	SNI 7182:2012
17	Iodium Number	115	% of mass (g-l2/100g), Max	AOCS Cd 1-25//SNI 7182:2012
18	Oxidation Stability			
	Induction Method Period	360	Minute, Min	EN 15751/SNI 7182:2012
	Rancimat or Petro Oxy Method	27		ASTM D-7545/SNI 7182:2012

12

Biodiesel standard

Specification of B6 – B20 (ASTM D7467-10)

No	Parameter	ASTM Method	Restriction	Unit
1	Acid Number	D-664	Max 0.30	mg KOH/g, Max
2	Kinematic Viscosity at 40 °C	D-445	1.9-4.1	mm ² /s
3	Flash Point	D-93	Min 52	°C
4	Cloud Point	D-2500		°C
5	Sulfur			
	S15 Grade	D-5453	Max 0.0015 (15)	% of mass, ppm
	S500 Grade	D-5453	Max 0.05 (500)	% of mass, ppm
6	Physical Distillation T90	D-86	Max 650	°C
7	Ramsbottom Carbon Residue - 10% Residue	D-524	Max 0.35	% of mass
8	Cetana Number	D-613	Min 40	Min
9	Requirements			
	Cetana Index	D-976-80	Min 40	-
	Aromatic Compound	D-1319-03	Max 35	% of volume
10	Ash Content	D-482	Max 0.01	% of mass
11	Water and Sediment	D-2709	Max 0.05	% of volume
12	Copper Strip Corrosion	D-130	Max No. 1	
13	Phosphorus Content	D-4951	Max 0.001	% of mass
14	Oxydation Stability	EN-14112	Min 6	Hours
15	Biodiesel Content	D-7371	6-20	% of volume
16	Lubricity, HFRR at 140 °F	D-6079	Max 520	Micron

Automotive Diesel Oil, www.pertamina.com (accessed 19 June 2006)
SNI Biodiesel No. 04-7182-2006, based on ASTM D 6751 & EN 14214

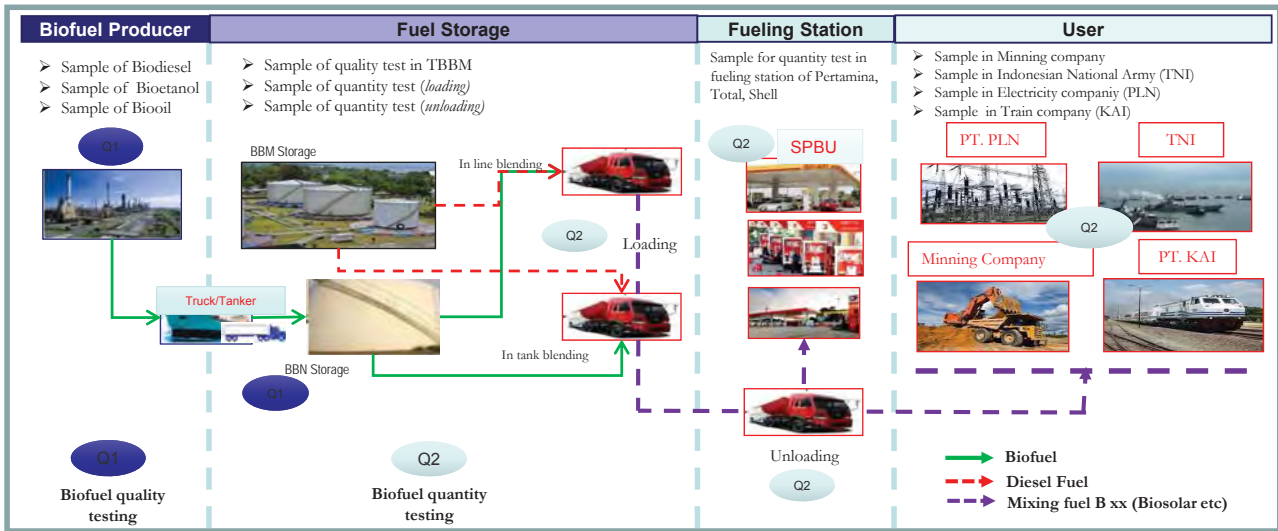
13

III. BIODIESEL IMPLEMENTATIONS



14

Monitoring and Evaluation of Biodiesel Utilization



Biodiesel Quality

	Biodiesel Quality Test Result				
	2010	2011	2012	2013	2014
SNI	7182:2006	7182:2006	7182:2006	7182:2012	7182:2012
Total of samples	-	15	15	15	12

Source: ESDM Presentation 2015

Biodiesel Blending Quantity (Volume)

	Blending Biodiesel with Diesel Fuel				
	2010	2011	2012	2013	2014
Total of samples	8	14	65	95	223
% Mandatory	5%	5%	7,5%	7,5% - 10%	10%
Average	6,08%	5,2	7,46%	9,61% *)	8,3%

15

IV. CHALLENGES OF BIODIESEL



CHALLENGES

➤ Improving quality of biofuel

Revision SNI: stability, glyceride content, acid number etc
Development of HVO

➤ Improving national technological capabilities on biofuel processing

Research and Development on biofuel process

➤ The price of biofuel that has not yet competitive in compare with fossil fuel

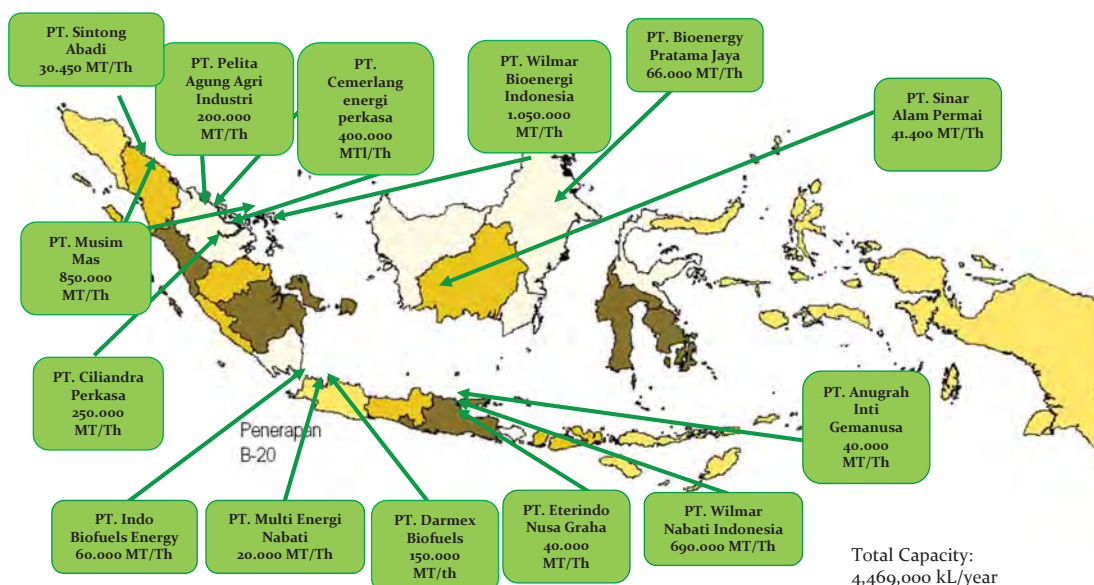
Feedstock diversification and effective technology will decrease the price of biofuel ; subsidize

➤ Land availability for biofuel development

Land availability inventory, synchronizing data among Forestry Department, National Land Affairs Agency and Regional Government

17

Biodiesel Issues



- Feedstock sustainability (volume and price)
- Automotive and heavy equipment industry readiness
- Support facilities and biodiesel production in east area of Indonesia

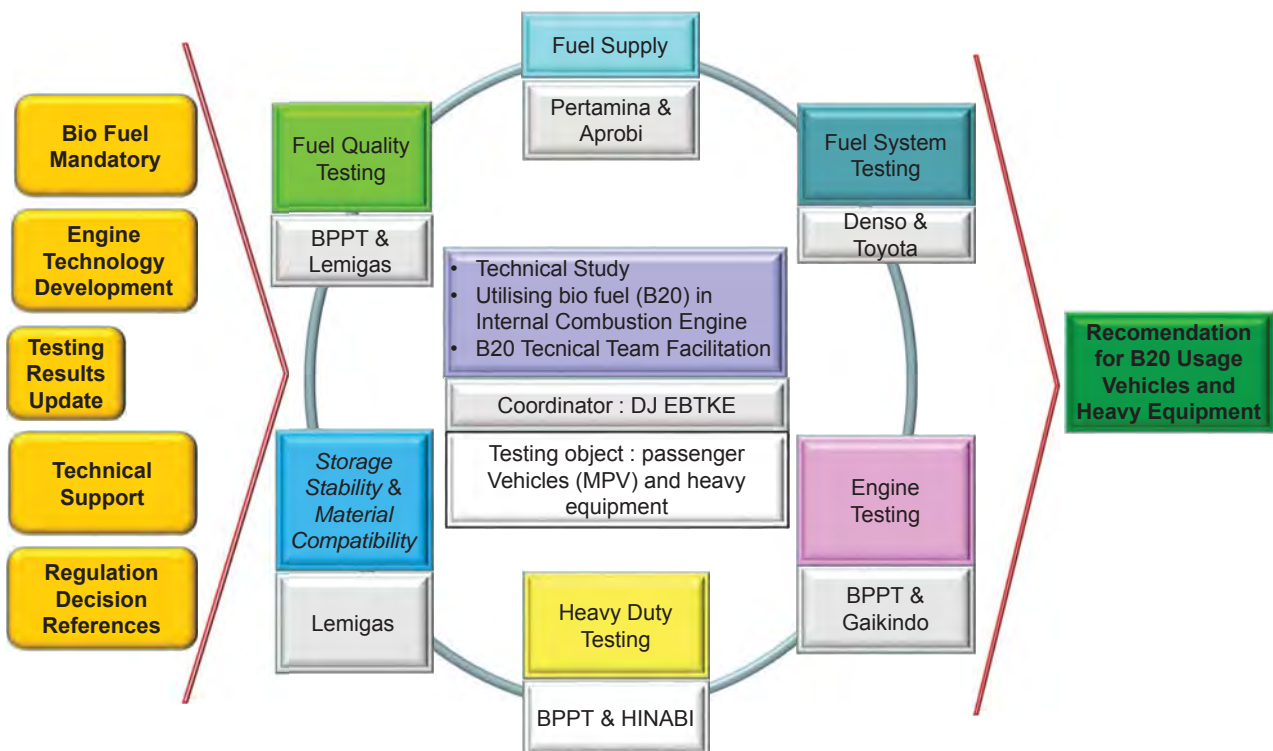
18

V. RESEARCH AND DEVELOPMENT



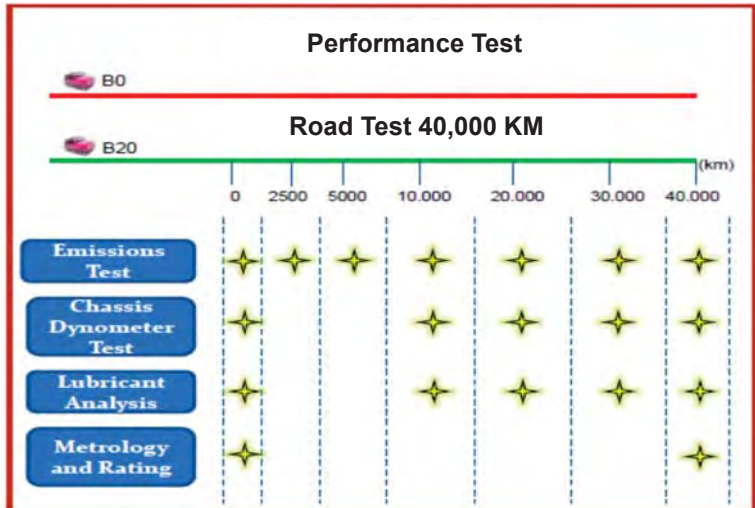
19

R&D Activities on B20 (2014-15)



20

Field Testing of B20 on Vehicles

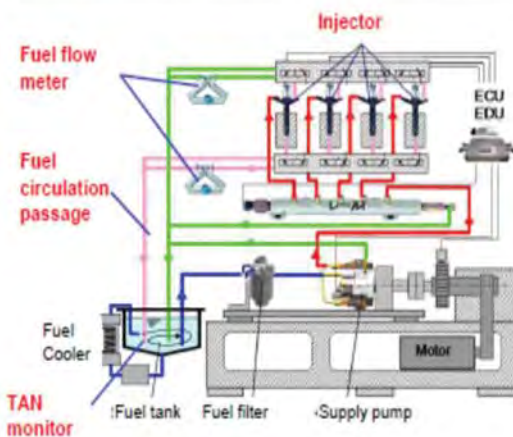


Road Condition	Distance (km)	Perc %
Highway (Asphalt+Concrete)	220	43,3
General Asphalt	81	15,9
Climbing-Down hill	195	38,4
City road	12	2,4
Total per day	508	

Fuel System Test of B20

Test bench

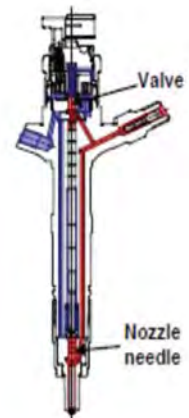
Operation Condition		Fuel Temperature	
Pump speed	2000rpm	Pump inlet	80°C
Injection pressure	200MPa	Injector return	150°C



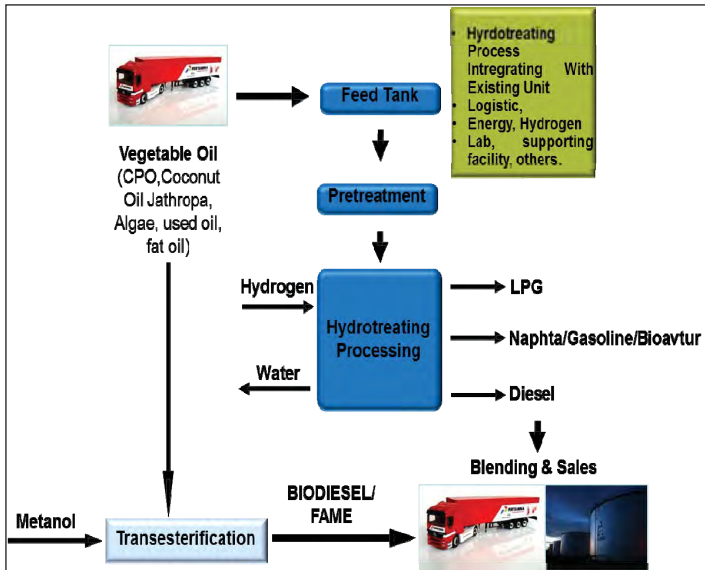
Injector specification

	DLC ¹ coating	
	Valve	Nozzle needle
Injector A	No	No
Injector B	Yes	Yes

(DLC: Diamond Like Carbon)



Development Of HVO Process (PERTAMINA)



Source : Nippon Oil / TOYOTA JSAE Nov.29, 2006 & Pertamina

Hydro-treating of Vegetable Oil

Vegetable Oil

$$\begin{matrix} \text{CH}_3 & \text{CO-O-CH}_2 \\ | & | \\ \text{CH}_2 & \text{CO-O-CH} \\ | & | \\ \text{CH}_2 & \text{CO-O-CH}_2 \end{matrix}$$

Hydro-treating

+H₂ +CH₃OH FAME

Hydrogenated

$$\text{H}_3\text{C} \text{---} \text{C} \text{---} \text{C} \text{---} \text{CH}_3$$

+ H₂O
+ CO₂, CH₄
+ CH₃-CH₂-CH₃

Double bond

$$\text{H}_3\text{C} \text{---} \text{C} \text{---} \text{C} \text{---} \text{CO-O-CH}_3$$

CH₂OH
+ CH OH
CH₂OH
(glycerin)

Green Diesel is Best Performer

VI. BIODIESEL TESTING RESULTS

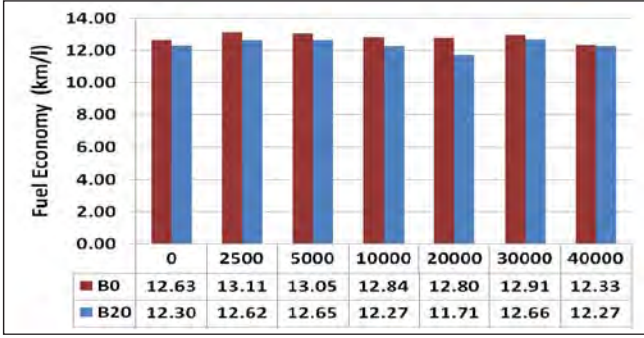
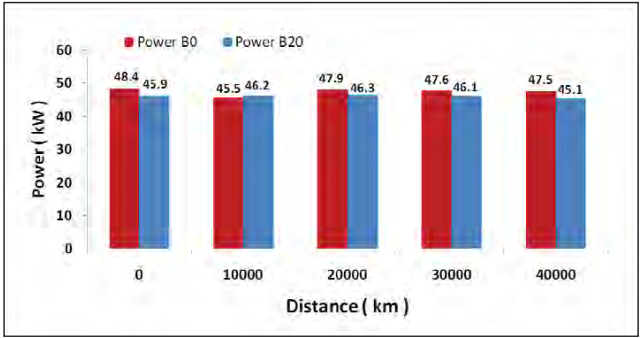


Rating of Engine Components (TOYOTA Innova)



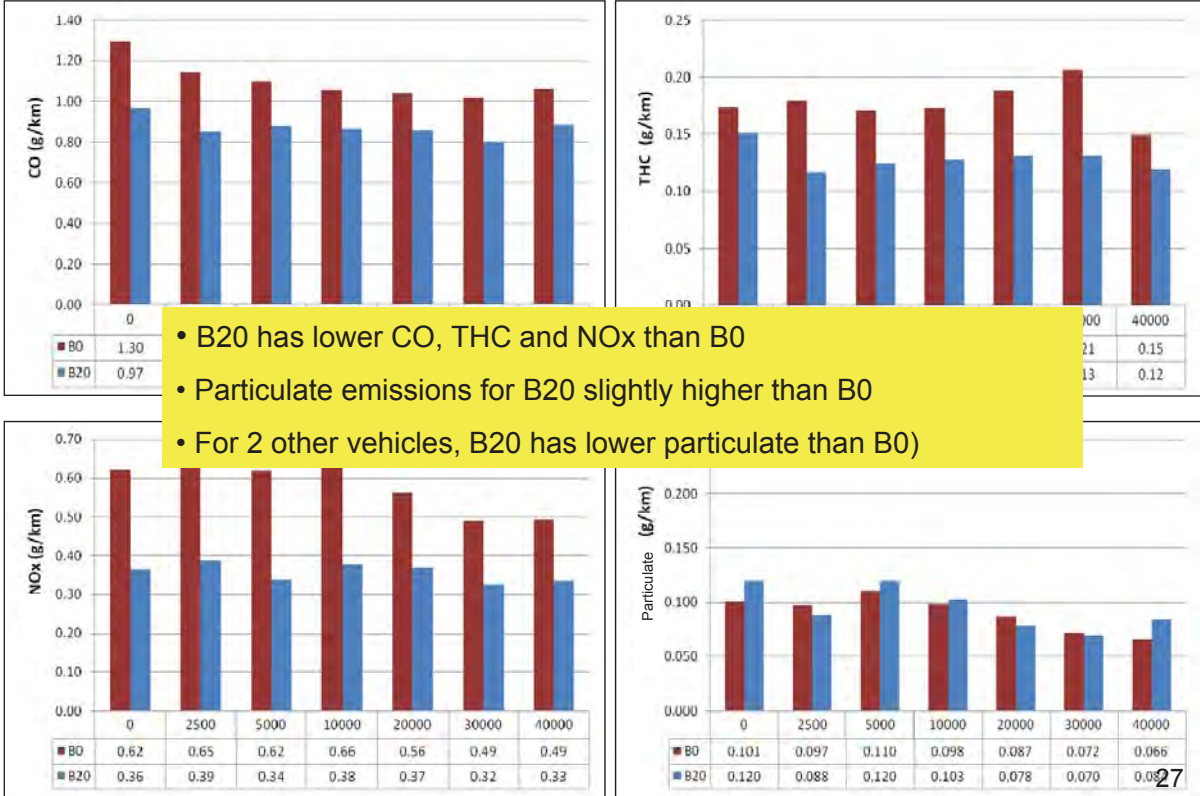
Quantity of deposit, sludge & scratch between B20 and B0 were similar 25

Power & Fuel Economy



B20 has a slightly less Power and lower FE (km/l) compared to B0 26

Emissions of TOYOTA Innova

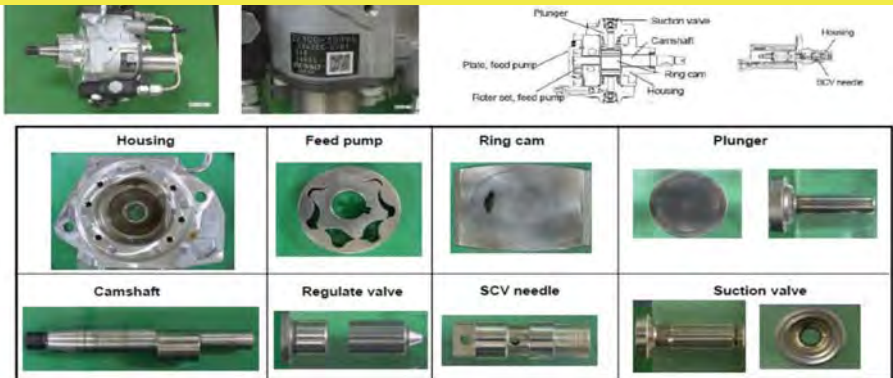


- B20 has lower CO, THC and NOx than B0
- Particulate emissions for B20 slightly higher than B0
- For 2 other vehicles, B20 has lower particulate than B0)

Rating on Fuel Injection parts (Denso)

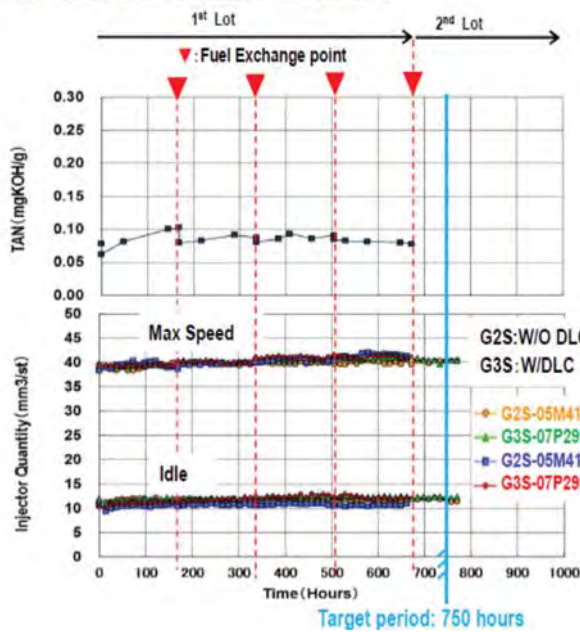


Utilization of B20 did not effect on fuel injection components

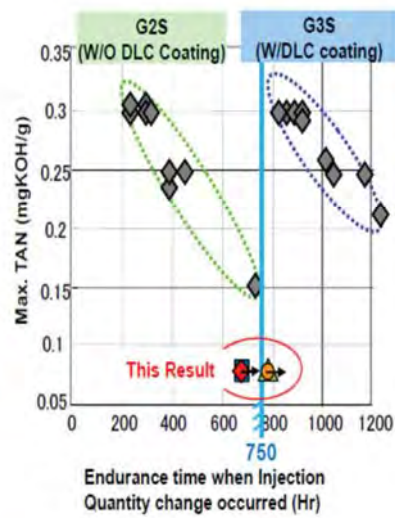


Fuel Injection Characteristics of B20 (Denso)

■ TAN and Injection quantity during the test

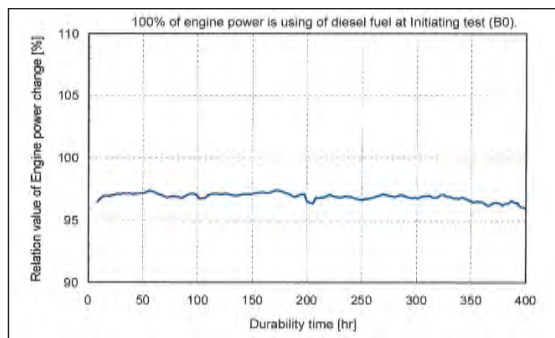
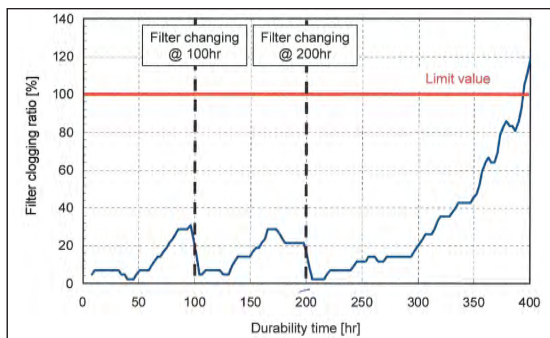
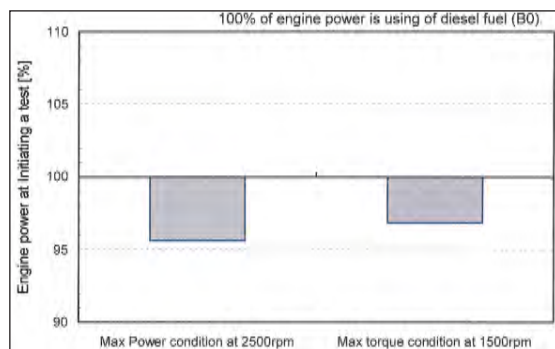
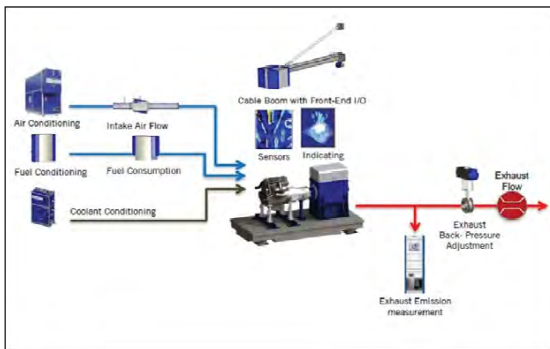


■ Relationship between the Max. TAN and the time to start the change in the Injection Quantity



Injector shows constant injection quantity during 750 h durability test

Engine Durability Test (200 kW at BTMP)



- Maximum power has slightly lower for B20
- Maximum power tends to decrease 3-5%
- Fuel filter is recommended to be changed earlier



Hydrotreating of Vegetable Oil (Pertamina)

	Petroleum ULSD	Biodiesel (FAME)	Pertamina HBD	Commercial HBD
Oxygen Content, %	0	11	0	0
Specific Gravity	0.84	0.88	0.776	0.779
Sulfur content, ppm	<10	<1	< 3	< 3
Heating Value MJ/kg	43	38	-	
Cloud Point ° C	-5	-5 to +15		7
Pour Point, ° C			+15 s/d +18	
Distillation, ° C	200 to 350	340 to 355	269 to 317	269 to 313
Cetane Number	40	50-65		
Cetane Index			65-67	>56.5
Stability	Good	Marginal	Good	Good
Parrafin % wt			100%	100%
Total Aromatic	19		0	0.2
Ash Content wt%	<0.001		<0.004	<0.001
Flash Point C			116	99
Lubricity (HFRR) um	324		200- 500	360

Source : Renewable Energy Directorate of MEMR & Pertamina

31

Testing Results : Hydrotreated Biodiesel (HBD)



	CO (g/km)	HC (g/km)	NOx (g/km)	HC+NOx (g/km)	CO ₂ (g/km)	Particulate (g/km)	FE km/litre
Based Market Diesel	1,239	0,132	0,235	0,367	262,940	0,163	9,91
Hydrotreated Biodiesel	0,725	0,075	0,227	0,302	242,917	0,049	10,78
Changes (%)	- 41.5	-43,2	-3,4	-17.7	-7.6	-69.9	8,8

- Higher Cetane Number and Low Sulphur Content
- Lower emissions than the best commercial diesel fuel in Indonesia
- Better fuel consumption
- Potential candidate as blending component for B30 & higher (FAME limitations)

32

Biodiesel Application on Marine Engine

- ❖ Engine for land transportation is commonly used as marine engine
- ❖ Very few research of utilization biodiesel on marine engine in Indonesia
- ❖ Testing results of biodiesel in NMRI will be valuable additional information for marine engine user in Indonesia and fuel quality standard
- ❖ More comprehensive study on marine application will be proposed to Ministry of Energy and Mineral Resources on 2016

33

Thank you for your attention

34