Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY

MTEC
a member of NSTDA

The adaptive measures and experience for the quality variation effects of blended biodiesel

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On behalf of Department of Alternative Energy Development and Efficiency (DEDE)

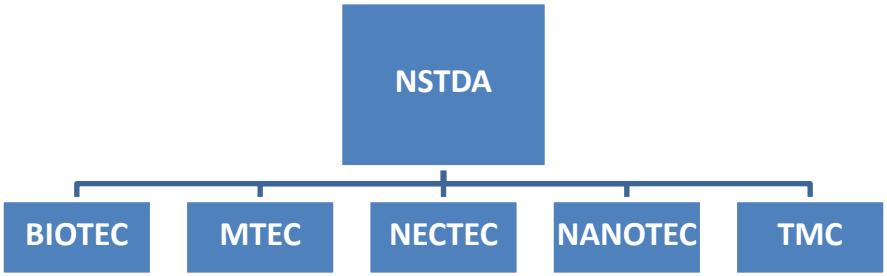
2014 APEC Workshop on Biodiesel Application Experiences
GIS NTU Convention Center, Taipei, Taiwan

10 September 2014

Outline

- Brief Introduction of my organization
- Biodiesel development in Thailand
  - History of various national energy policy & plans
  - Current Alternative Energy Development Plan (AEDP: 2012-2021)
  - Current situation
  - Step towards increased biodiesel utilization
    - ✓ B20 (FAME) in fishery project
    - ✓ B20 (FAME) in heavy duty truck project
    - ✓ BHD (Bio-Hydrotreated Diesel) project
    - ✓ H-FAME (partially Hydrogenating Fatty Acid Methyl Ester) project
- Lessons learned and experiences shared
  - Quality assurance of biodiesel in actual market
  - BDF blends and based diesel specification
  - Contamination prevention
- Concerns for Taiwanese biodiesel market
  - Issues of BDF blending in ULSD promoting microbial growth

NSTDA at a glance



Established: December 1991

by the National Science and Technology Development Act, 1991

Governance: A quasi-government agency with
Minister of Science and Technology as chairman of the board

Location: Thailand Science Park (30 kilometers north of Bangkok)

Vision: Key S&T partner towards knowledge based society/economy

Missions: R&D, Technology Transfer, HRD, and Infrastructure

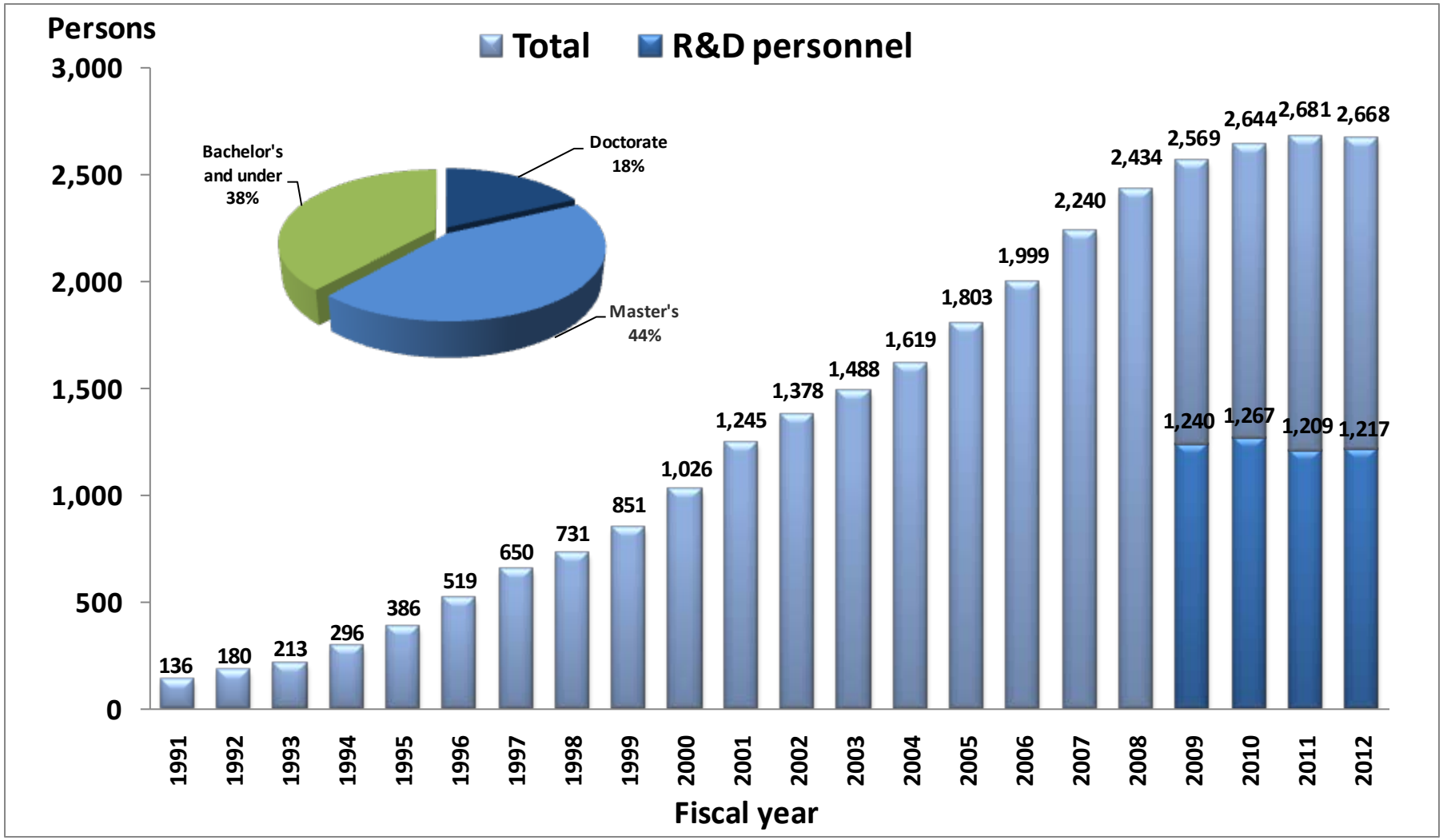
Org chart : **Four national R&D centers** (total 98 laboratories):

BIOTEC National Center for Genetic Engineering and Biotechnology
MTECNational Metal and Materials Technology Center
NECTEC National Electronics and Computer Technology Center
NANOTEC National Nanotechnology Center

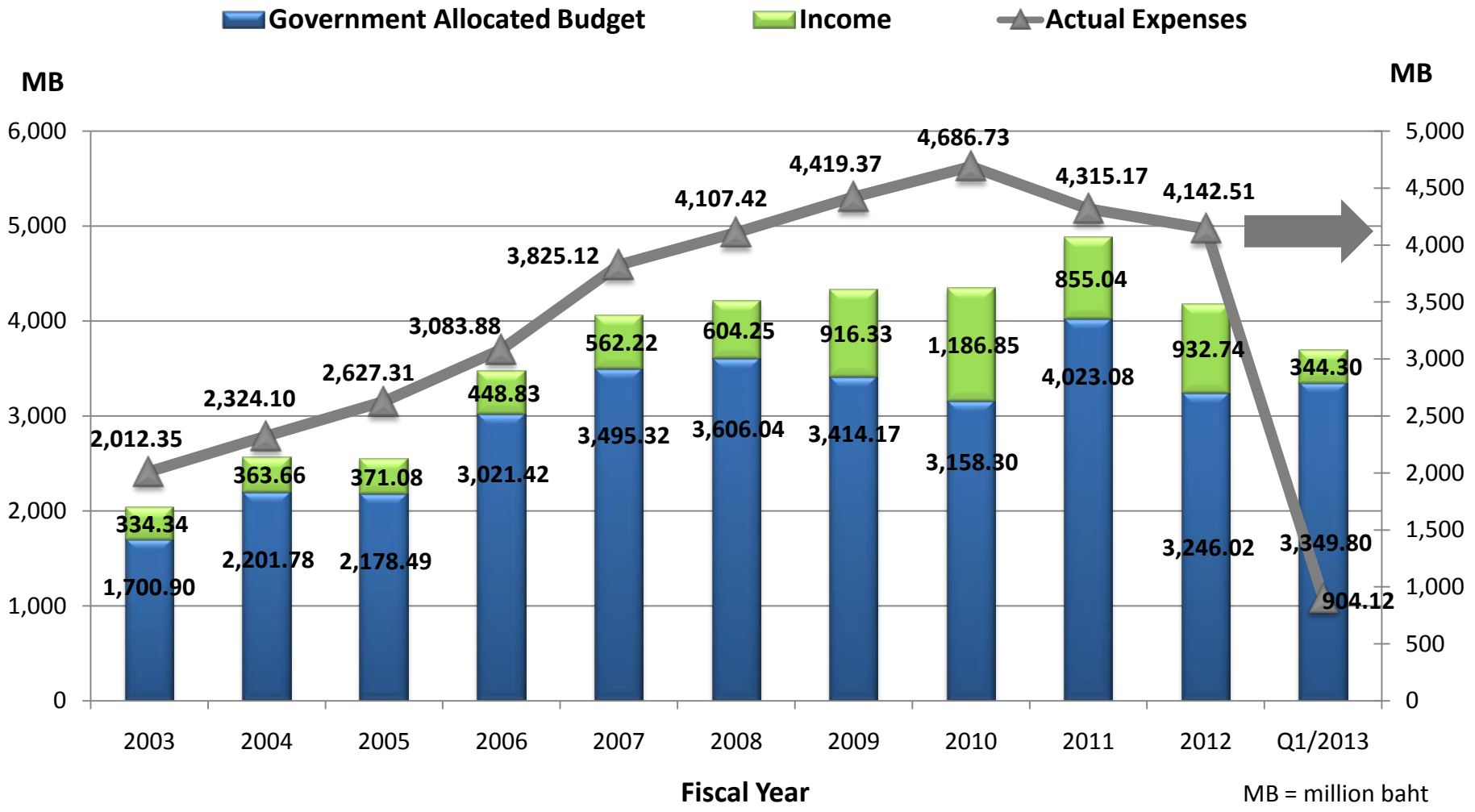
One technology management center
TMC Technology Management Center

Focal point: NSTDA is national focal point for EU's Framework Program

Personnel Distribution

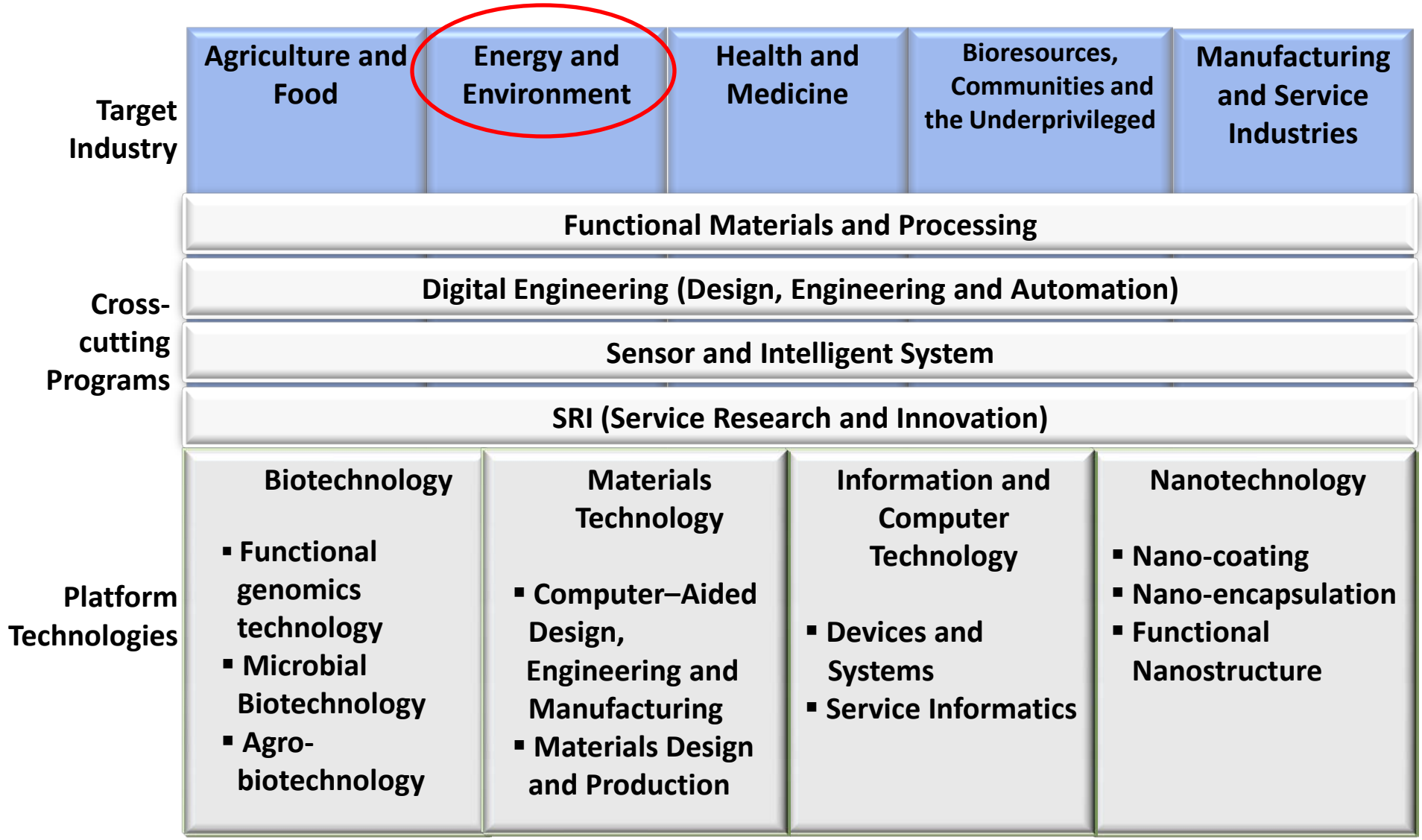


Budget, Income and Expenses



MB = million baht

R&D Strategy (2011-2016)



S&T Infrastructure of NSTDA

Software Park Building

Science Camp

Convention Center

National centers

Pilot Plant

Innovation Cluster I and II (or INC I and INC II) @ Thailand Science Park

To be completed by 2013

Innovation Cluster I

- 60 Tenant Companies , 12 Incubatees
- 70% Thai : 30% Foreign
- ~500 Staffs with over 300 researchers

Innovation Cluster II

- 4 integrated Towers
- Gross area of 124,000 sqm.
- World class R&D infrastructure
- Sensitive lab, heavy equipment area
- Superb ICT infrastructure & business services
- Additional 150 Companies
- To be open in 2014

Polyplastics
Solution Platform for Engineering Plastics

SHISEIDO

wincell

UENO

TPC

DISCO
Kiru · Kezuru · Migaku Technologies

Access to your success
SHIMADZU

NSTDA International Collaboration

Europe: EU-FP7, UK-Thailand Partners in Science, Thai-German Mobility Scheme, BMBF, Fraunhofer-Gesellschaft, Fraunhofer-ISE, Fraunhofer-IFF, University of Magdeburg, Karlsruhe Institute of Technology, Imperial College London, University of Zurich, CNRS, CIRAD, Institut National Polytechnique de Toulouse (INPT), Universite de Bourgogne, The Franco - Thai Scholarship program, Ecole Polytechnique, DESY, Lindau, CEP[illegible]

China: CAS, GUCAS, Xiamen University, SAAS, KIB, SSRC, Sino – Thai Scientific and Technical Coorperation, Sichuan Academy of Agricultural Science (SAAS)

Japan: AIST, RIKEN, JICA, JST, e-ASIA, JAXA, JETRO, METI, MEXT, NUT, NIMS, NISTEP, NEDO, Tokyo Tech, Hiroshima U., Toyota, Shiseido, Shimadzu, Ube, Denso, ATPIJ, YU, Yamagata Univ., etc.
Korea: KRIBB, KRISS, STEPI, Korea Science Foundation
Taiwan: ITRI

U.S.A.: NSF, IBM, NBIA, Carnegie Mellon U., MIT, REI Int'l, PSU, UWM, GEC, TMS, U of Wisconsin-Madison

ASEAN: ASEAN COST, SIRIM, MIGHT, LIRE, VAST, NISTPASS, A*STAR, Singapore Polytechnic, CEBU Technological University

Latin America: Brazil, Argentina

Middle-east: Technion – Israel institute of Technology, Ben-Gurion University of the Negev (BGU), Israel

Australia: QUT, U. of Queensland, Australasian Corrosion Association

History of Various National Energy Policy & Plan

Strategic Plan for Renewable Energy 2003 – 2011 (Old plan)

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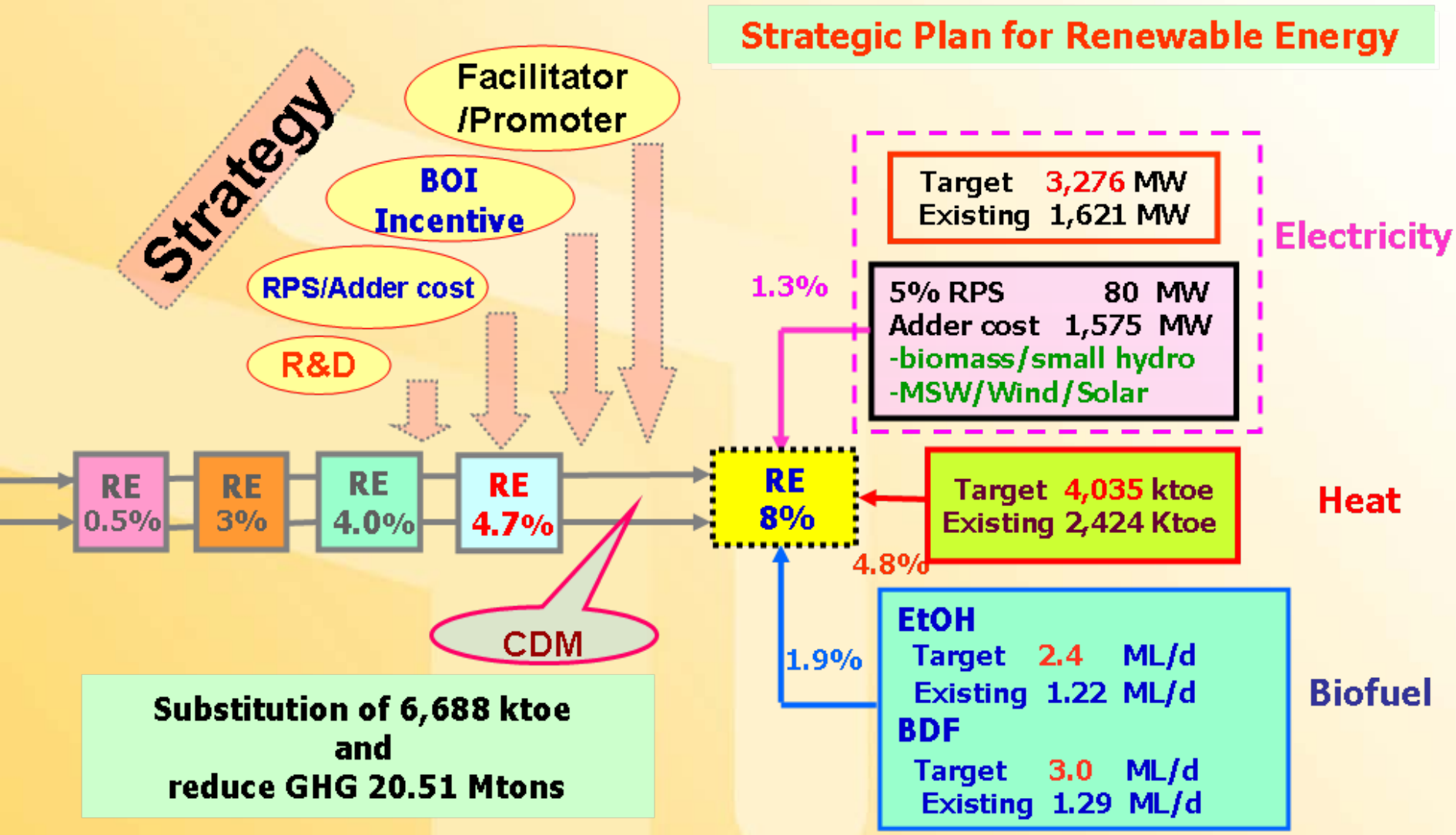
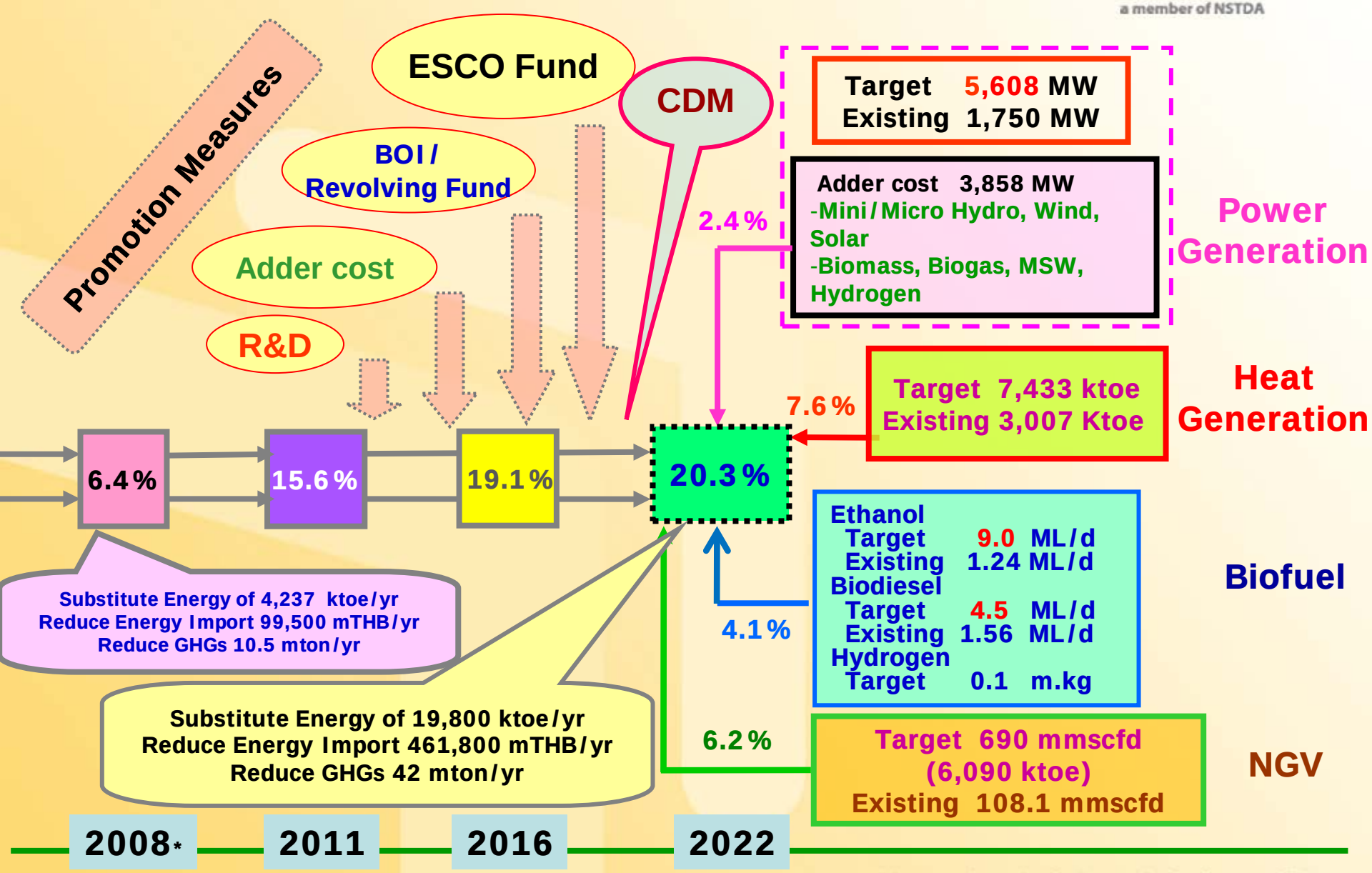


Development Strategy on Alternative Energy for 2008 - 2022



Projected with 2008 average crude oil price of $94.45/barrel

Remarks: *as of Jan 2009

Renewable energy Plan & Policy

Development of low-carbon society

Budget to support Research & Development

Alternative Energy Development Plan (AEDP : 2012-2021)

Support the investment of Private sector and community

Target on using Renewable Energy at 25 % of Total Energy Consumption By 2021

New energy resources		solar	wind	Hydro power plant			Bio-energy			Biofuels		
Tidal wave	Geothermal			Mini	Micro	Pumped-Storage	Biomass	Bio-gas	MSW	Ethanol	Bio-diesel	New Fuel for diesel
2 MW	1 MW	2,000 MW	1,200 MW	324 MW		1,284 MW	3,630 MW	600 MW	160 MW	9 ML/day	5.97 ML/day	25 ML/day
		100 ktoe					8,200 ktoe	1,000 ktoe	35 ktoe			
3 MW		**3,200 MW , 100 ktoe**		**1,608 MW**			**4,390 MW , 9,235 ktoe**			**44% Replacing Oil**		

AEDP Goal	2555	2559	2564
	3,283 MW	4,987 MW	7,633 MW

Renewable energy Plan & Policy

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2 MW	1 MW	2,000 MW	1,200 MW	324 MW		1,284 MW	3,630 MW	600 MW	160 MW	9 ML/day	5.97 ML/day	30 ML/day
		100 ktoe					8,200 ktoe	1,000 ktoe	35 ktoe			
3 MW		3,200 MW , 100 ktoe		1,608 MW			4,390 MW , 9,235 ktoe			44% Replacing Oil		

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Current Renewable energy Plan & Policy

Development of low-carbon society

Budget to support Research & Development

Alternative Energy Development Plan (AEDP : 2012-2021)

Support the investment of Private sector and community

Target on using Renewable Energy at 25 % of Total Energy Consumption By 2021

New energy resources		solar	wind	Hydro power plant		Bio-energy			Biofuels			
Tidal wave	Geothermal			Micro	Mini	Biomass	Bio-gas	MSW	Ethanol	BDF	NED (BHD)	CBG
2 MW	1 MW	3,000 MW	1,800 MW	324 MW		4,800 MW	3,600 MW	400 MW	9 ML/d	7.2 ML/d	3 ML/d	1,200 ton
		100 ktoe				8,500 ktoe	1,000 ktoe	200 ktoe				
3 MW		**4,800 MW , 100 ktoe**		**324 MW**		**8,800 MW, 9,700 ktoe**						

- ⇑ Solar, Wind, Biomass, Biogas, MSW, BDF
- **Add** NED (New Energy Replacing Diesel) such as BHD and CBG
- **Remove** Pump-Storage, New fuel for diesel

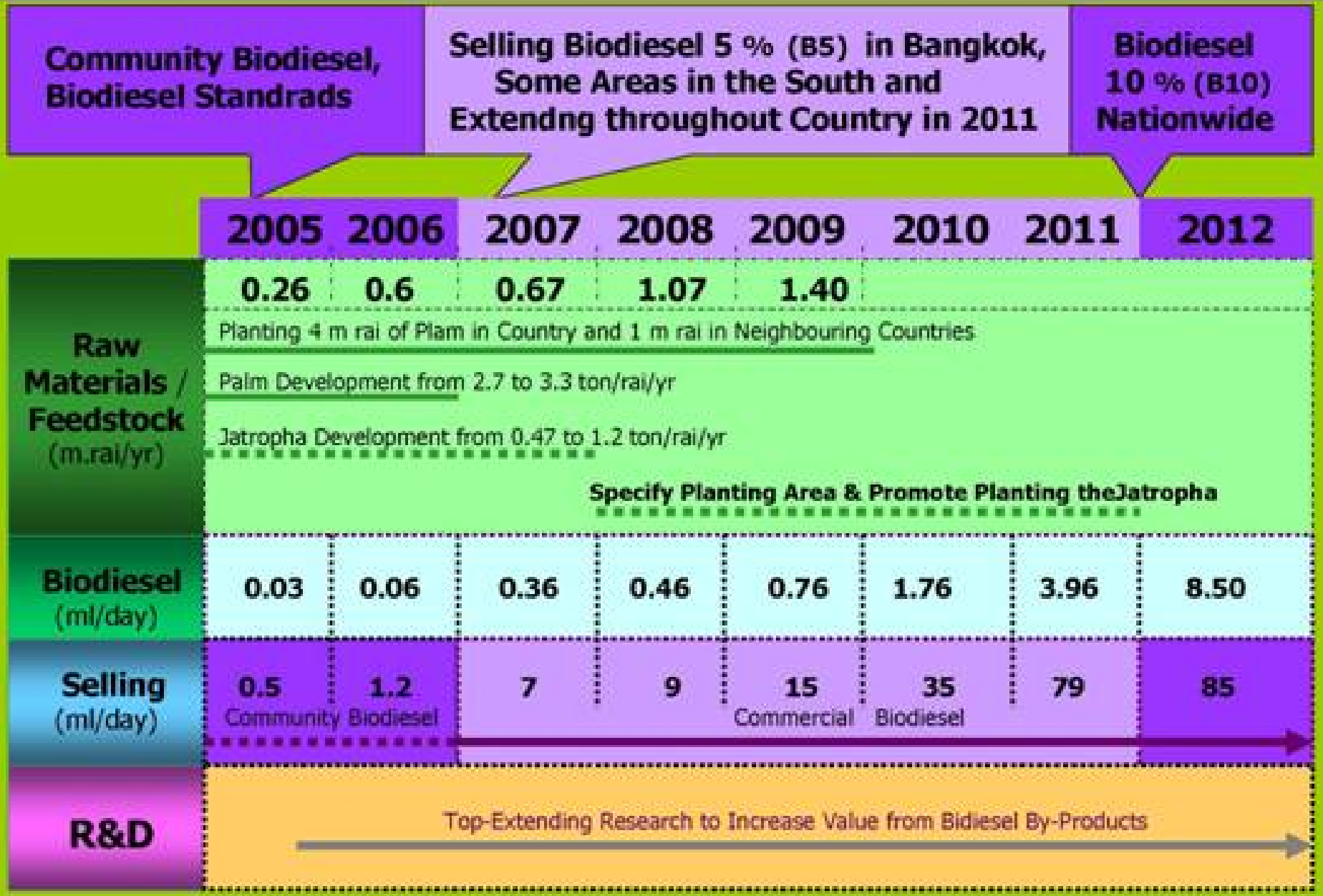
Revised by National Energy Policy Committee on 16 July 2013

http://weben.dede.go.th/webmax/content/dede-adjusts-alternative-energy-target

History of Various National Energy Action Plans

Action Plan for Biodiesel Development and Promotion

2003-2011 Plan



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Action Plan for Biodiesel Promotion 15-Year (2008-2022) Plan

Target ⇨ **2009 ➲ 1.6 ML/d** ⇨ **2011 ➲ 3 ML/d** ⇨ **2016 ➲ 3.64 ML/d** ⇨ **2022 ➲ 4.5 ML/d**

Action Plan ⇨ **Biodiesel**

	2010	2011	2012	2013-2016	2017-2022
1. Promote	Commercial BDF usage Vehicle Fishery Rail Supply การผลิตไบโอดีเซลชุมชน	Promote B5 for vehicle usage Promote B20 in fishery boat Increase efficiency in logistic Review BDF pricing formula to align with worldwide price Support plantation area increase (via BAAC) จัดตั้งกลุ่มและเครือข่ายผู้ร่วมพัฒนาการใช้ไบโอดีเซลระดับชุมชน		Promote B10 for vehicle usage Use B10 in rail Expand plantation area: Rangsit, upper N & NE (Kong river)	
2. Prototype and Demonstration	Prototyped community BDF usage	integrate Complex (Biomass + biogas+ biodiesel)		Prototype BDF from algae	
3. Research & Development	R&D on new plantation area BDF production from non-food biomass, e.g. Jatropha, alga Increase yield Biomass to Liquid Production of liquid fuel from biomass: BHD		Support BDF-related industry (oleochemical)		
4. Standard for confidence	R&D B10 in diesel vehicle Learning center	Issue B10 standard Establish biofuel management organization			
5. Public relation and info dissemination	PR Green Diesel Raise public awareness in sustainable production of BDF	Discussion on B10 usage with vehicle manufacturers		PR campaign for B10 usage in car	
6. Improve database system	Database of oil palm growers on website with GIS technology to track plantation area				

Development Scheme of the Future New Fuel for Diesel Substitution

10-Year (2012-2021) Plan

Development Plan	Indicator	Phase 1	Phase 2
1. Research Plan 1.1 ED95 1.2 Diesohol 1.3 FAEE 1.4 BHD 1.5 Seaweed/Algae 1.6 Jatropha 1.7 BTL	- Study result of new fuel development in the future is clear enough to make decision on policy and ready to implement the Pilot Project and commercial development respectively.	2014: ED 95, Diesohol 2015: FAEE, BHD 2016: Seaweed/Algae, BTL, Jatropha	
2. Pilot Project and Trial Fleet Test	- Emerge the Pilot Project and Trial Fleet Test. - Decide to select the most optimal new fuel.	2014-2016 - Pilot Project for ED95 or Diesohol or FAEE 2015-2017 - Pilot Project for seaweed, Jatropha + BHD 2015-2017 - Pilot Project for BioJet, BHD	
3. Commercial Development	- Emerge the commercial production plants with a total capacity of 2 ml/d in 2018. - Increase capacity to 25 ml/d in 2021.		Commercial Production Capacity (ml/d) 2018: 2 2019: 6 2020: 15 2021: 25

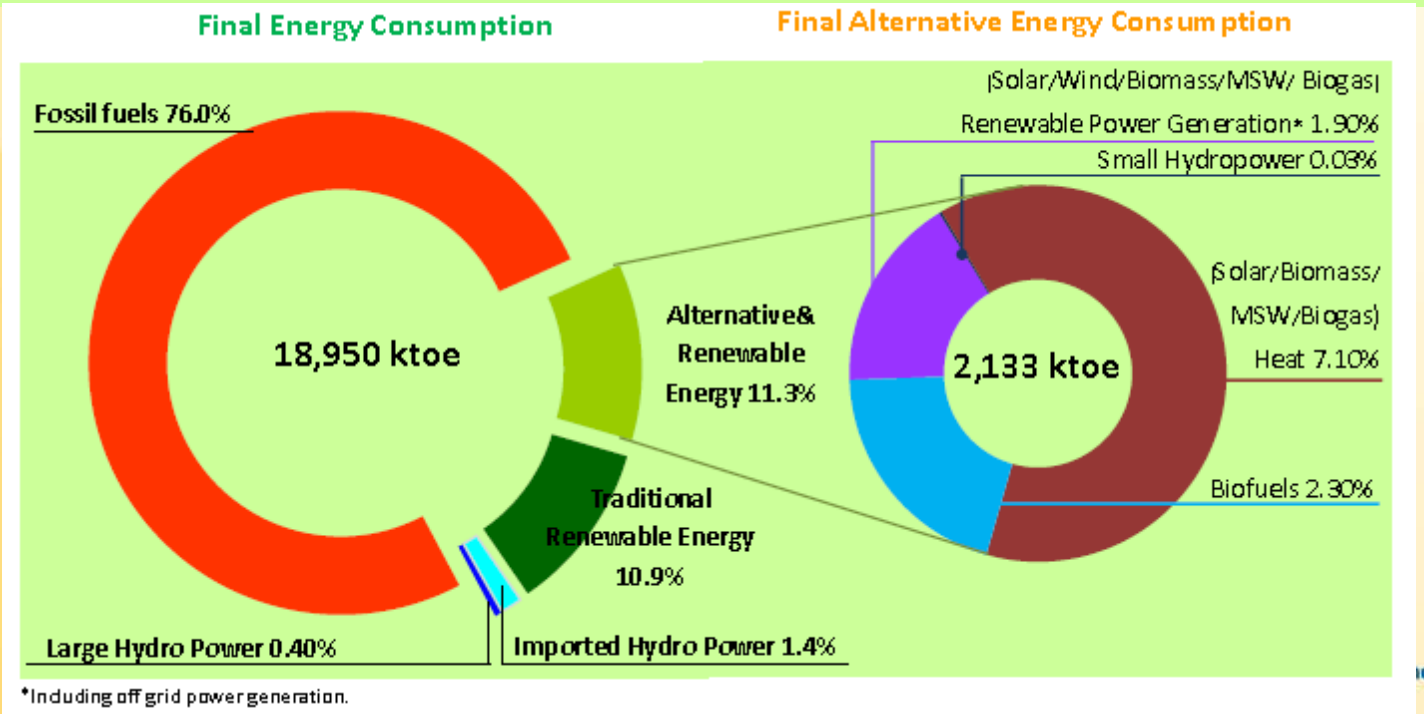
http://www.dede.go.th/dede/images/stories/dede_aedp_2012_2021.pdf

Remarks on Thailand Renewable Energy Plan

- Despite various revisions, the trends are clear
  - Set rather ambitious utilization targets under estimated available resources
  - Focus on indigenous resources and appropriate technologies (e.g. biomass, biofuel, biogas) with supporting mechanism
  - Initial subsidy may be needed but gradually decreasing (or even removed) over time
- Issues on biofuel & biomass
  - Priority on domestic food and feed with surplus amount for biofuel production (export depending on market price)
  - Rearranging of cultivation land for food & fuel crops
  - Increasing use of biomass resource from agricultural residue/processing for heat and power production
  - 2nd generation biofuels are under R&D and demonstration phase

Current Situation


Q1/2014
High Speed Diesel (HSD) 60.2 ml/day
Diesel 57.2
Biodiesel 3.0
Gasohol 20.9 ml/day
Gasoline 18.0
Ethanol 2.9
0
10
20
30
40
50
60
70
million litres/day


Final Energy Consumption
Final Alternative Energy Consumption
Fossil fuels 76.0%
18,950 ktoe
Alternative& Renewable Energy 11.3%
Traditional Renewable Energy 10.9%
Large Hydro Power 0.40%
Imported Hydro Power 1.4%
(Solar/Wind/Biomass/MSW/ Biogas)
Renewable Power Generation* 1.90%
Small Hydropower 0.03%
(Solar/Biomass/ MSW/Biogas) Heat 7.10%
2,133 ktoe
Biofuels 2.30%
*Including off grid power generation.

Benefits of Biofuel

Reduce fossil fuel usage and dependency

Reduce carbon release to atmosphere

Increase agricultural product prices

Promote self-sufficiency economy

Status of Biodiesel

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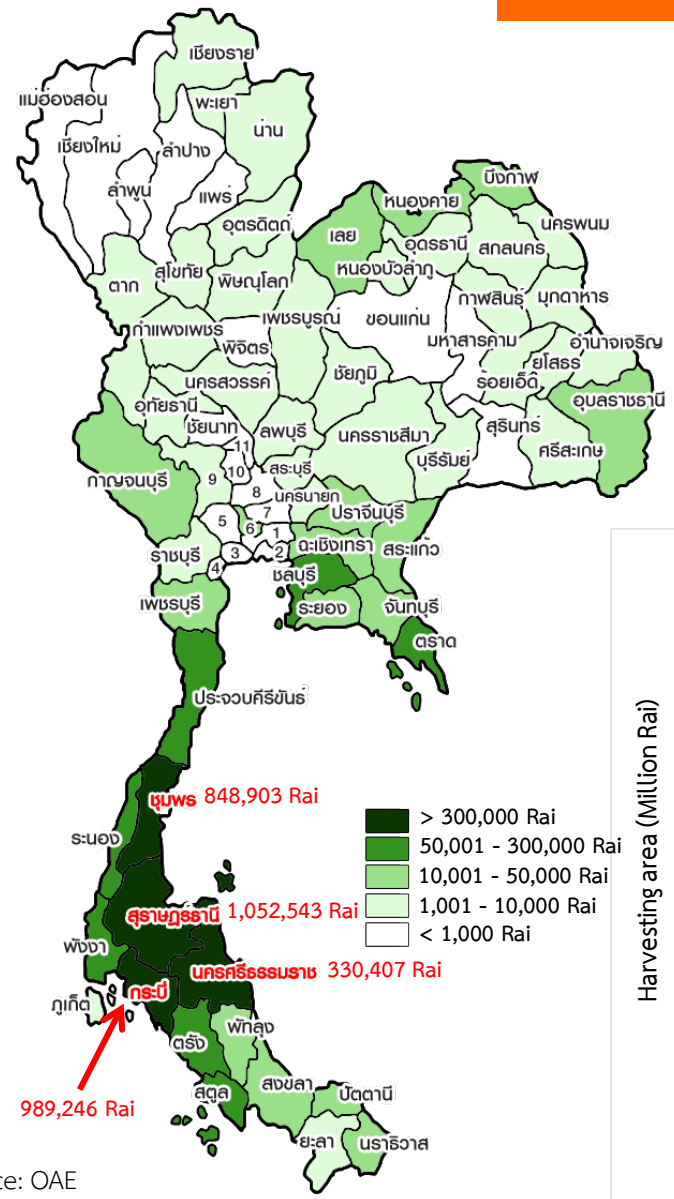
Oil Palm Production

Oil palm is mostly planted in the southern and eastern part of Thailand.

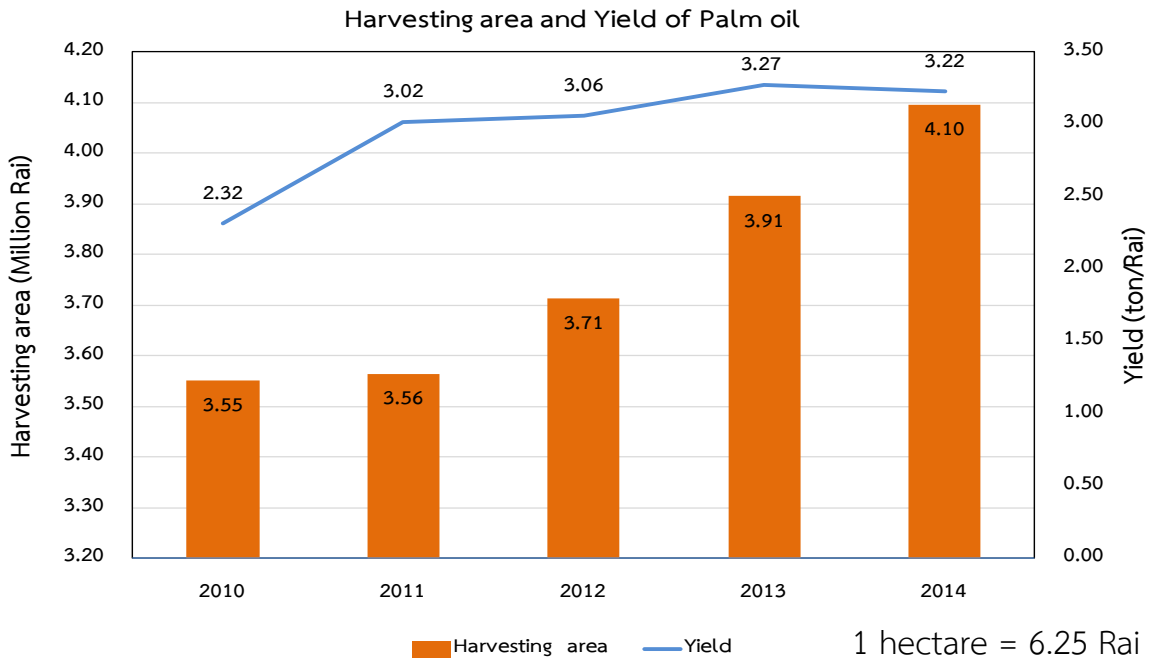
Oil palm plantation = 4.5 Million Rai



Source: OAE

Oil palm plantation in Thailand

6.25 Rai = 1 Ha.

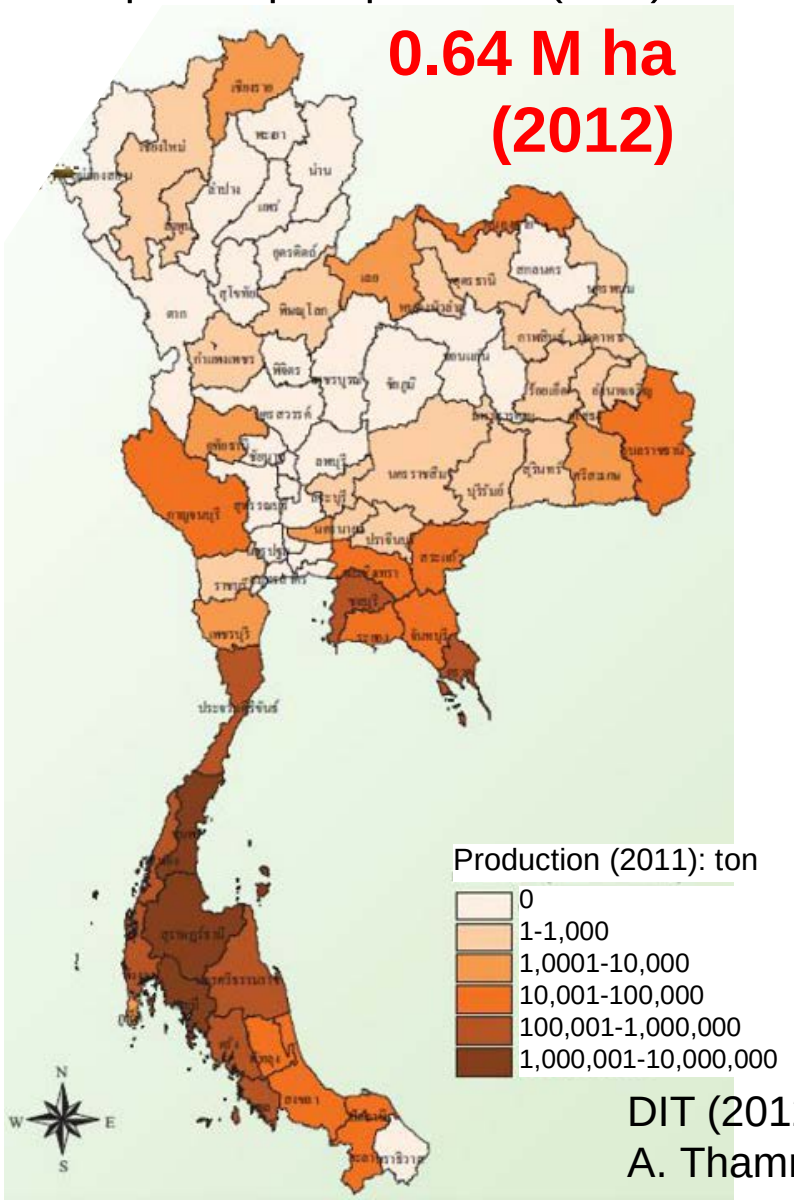


1 hectare = 6.25 Rai

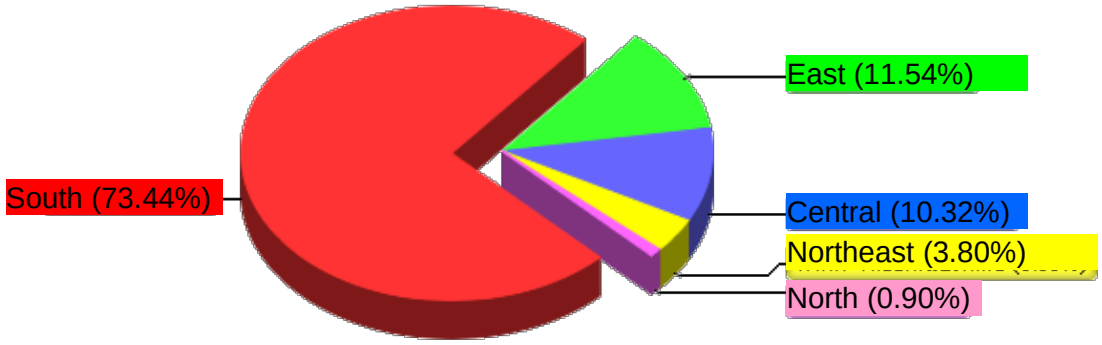
Source – Office of agricultural Economics

Biodiesel feedstock: Oil palm

Map for oil palm plantation (2011)



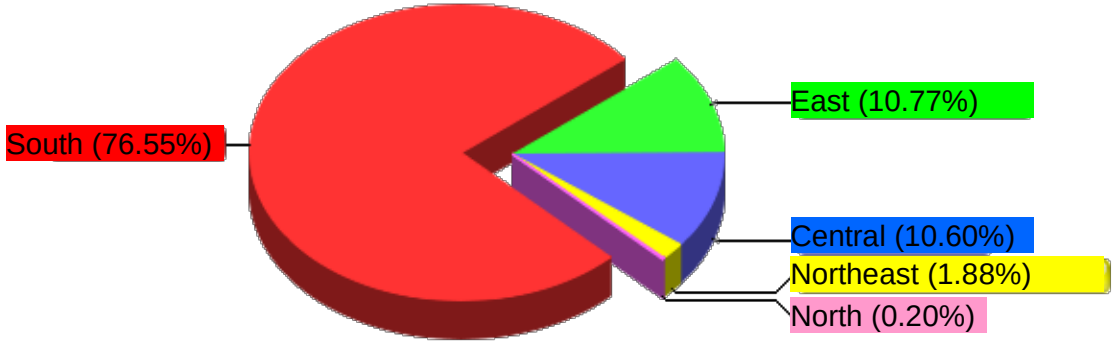
Oil palm plantation area



Total (2012) area of 3,982,623 Rai

2.72% of arable land in Thailand

Oil palm production

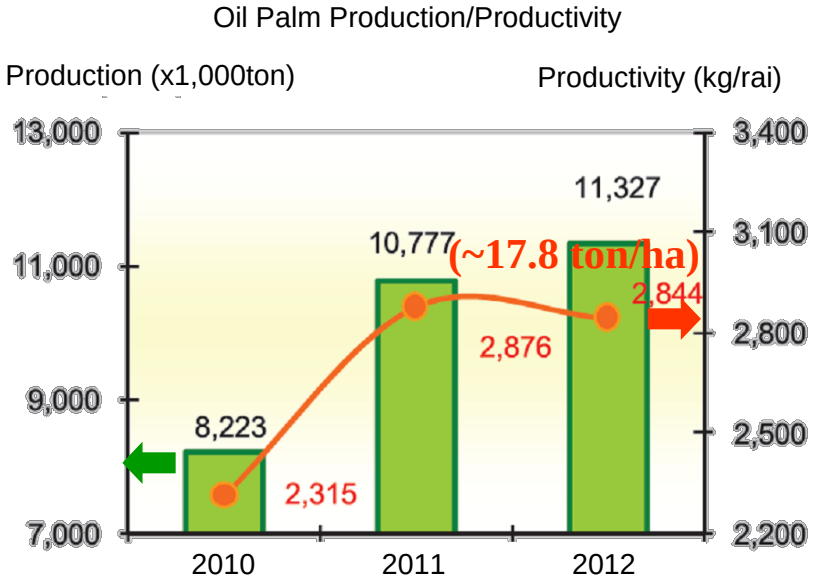


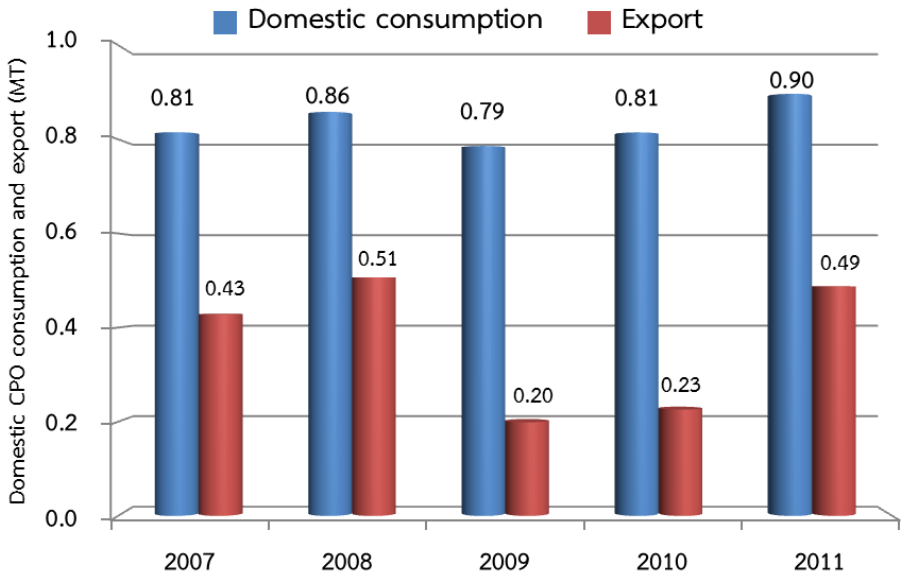
Total (2012) production of 11,326,660 Ton

DIT (2012), http://gis.dit.go.th/gis56/agri/Report/palm_product.aspx

A. Thammanomai (2012)

Oil palm production, productivity & utilization



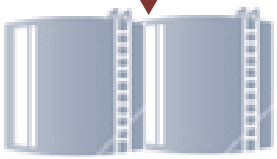


- 2010-2011, large increase in oil palm (20-30% on both production and productivity) due to additional demand from biodiesel
- 2011-2012, a drop in productivity due to the inadequate rainfall.
- Palm oil usage in 2011,
  - 49% of palm oil used for domestic consumption,
  - 22% for biodiesel production,
  - 16% for export → potential as feedstock for biodiesel
  - 13% for stock.

Source: OAE (2012) & A. Thammanomai (2012)

Palm Oil Usage

	CPO Production	Stock at the beginning	Import
2012	1.89	0.30	0.04
2013	2.14	0.36	-
	MMT	MMT	MMT



	Domestic Consumption	Biodiesel production	Export	Stock at year end
2012	0.93	0.63	0.31	0.36
2013	0.96	0.77	0.57	0.20
	MMT	MMT	MMT	MMT

Source : Department of Internal Trade of Thailand, Ministry of Commerce

Biodiesel Production

Palm Oil

Biodiesel
Fatty acid methyl ester (FAME)

Biodiesel Fuel

In-line blending
B2 - B7

Government Policy & Regulation

Biodiesel ratio management

- Biodiesel is produced from the surplus palm oil in the country.
- Biodiesel blending is varied according to the domestic supply

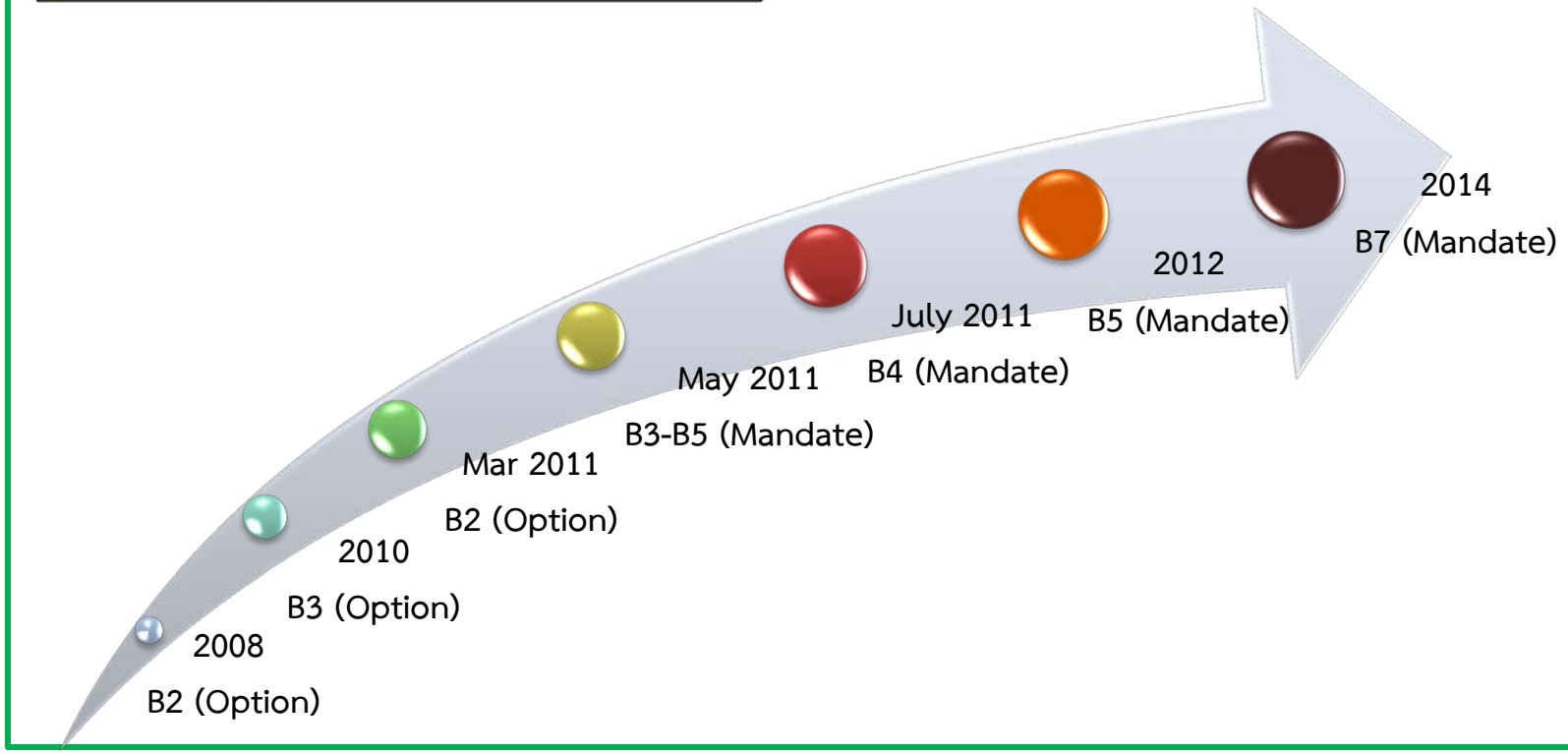
Biodiesel Situation

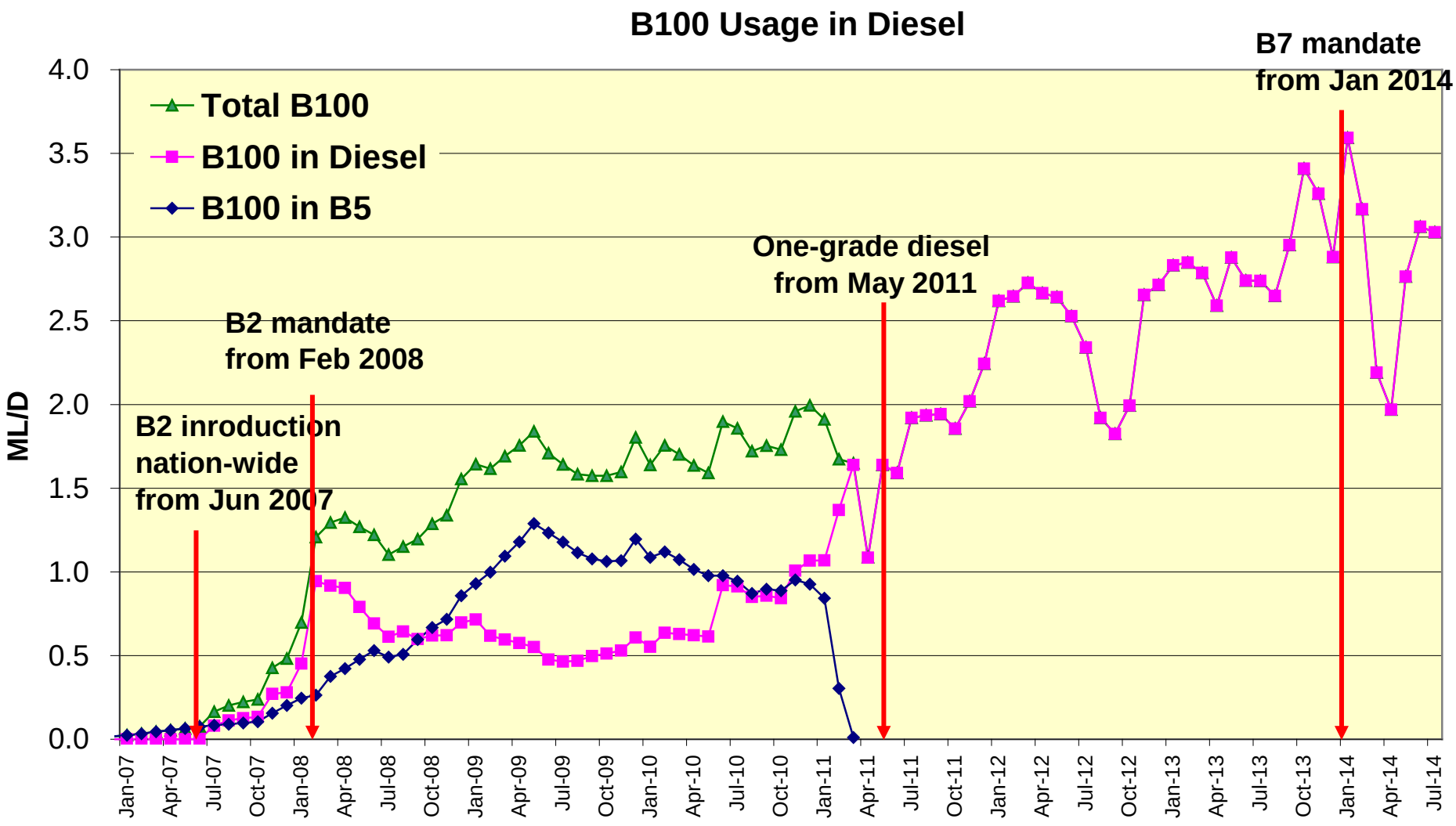
Biodiesel	2.76 ML/day	7.20 ML/day	AEDP Target 2021

May 2014

Source: Department of Energy Business

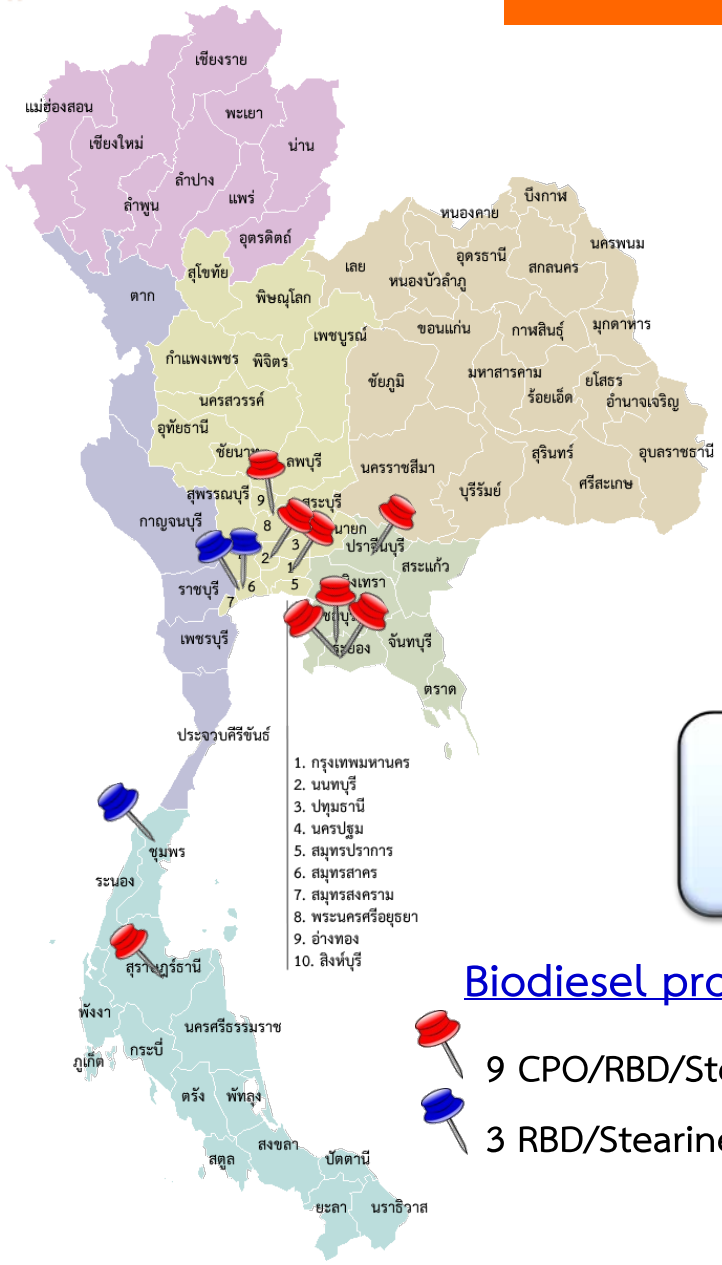
Biodiesel consumption policy





http://www.dede.go.th/dede/images/stories/Biodiesel/B100_demand_for_Diesel_Jan_12.xls
http://www.doeb.go.th/info/data/datadistribution/biodieselB100.pdf

Biodiesel Production



Raw material	Registration	
	factory	Capacity (ML/day)
CPO/RBDPO/Stearin	9	4.06
RBDPO/Stearine	3	0.90
รวม	11	4.96

Source - Department of Energy Business, Feb 2014

Current biodiesel production capacity is 4.96 ML/day

Biodiesel production factory

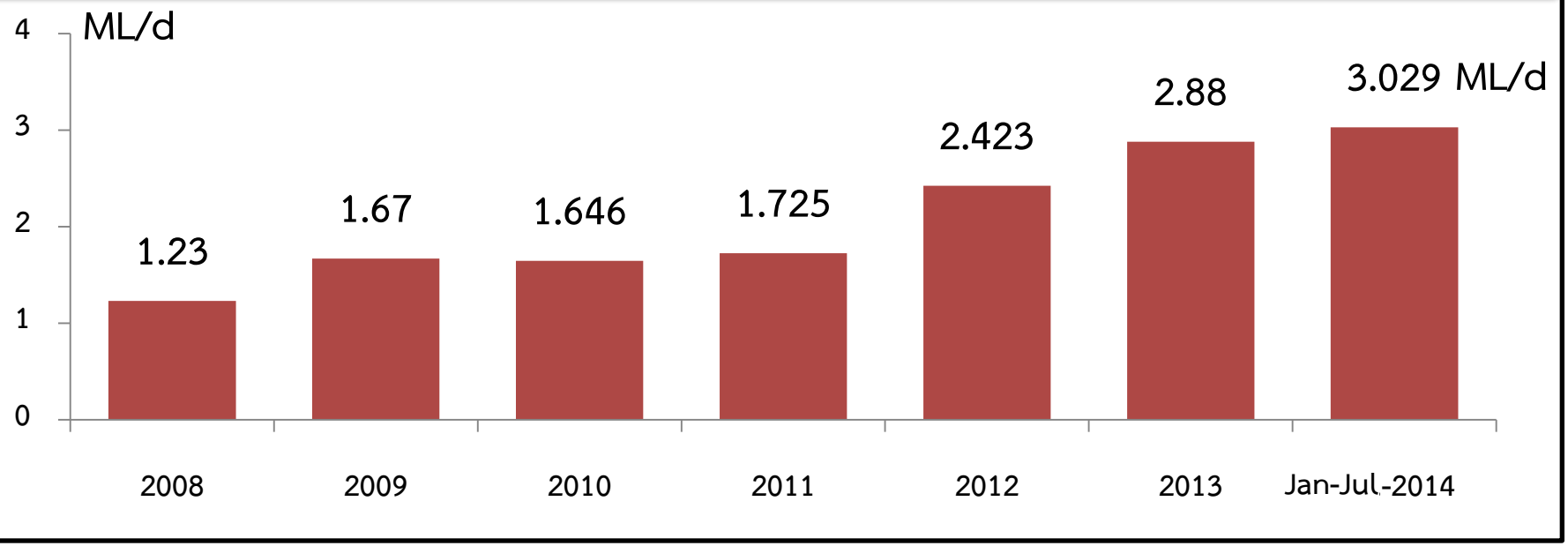
9 CPO/RBD/Stearine

3 RBD/Stearine

Biodiesel Consumption

Thailand has mandated 7% biodiesel (B7) blend for every liters of diesel sold in 2014

Average daily usage of biodiesel (B100)



Source - Department of Energy Business

- Mar - May 2014, biodiesel blending % was reduced according to the palm oil situation.
- All involving parties keep monitoring on CPO supply and adjusting biodiesel blending % correspondingly to avoid foot supply interference

Step towards increased biodiesel utilization

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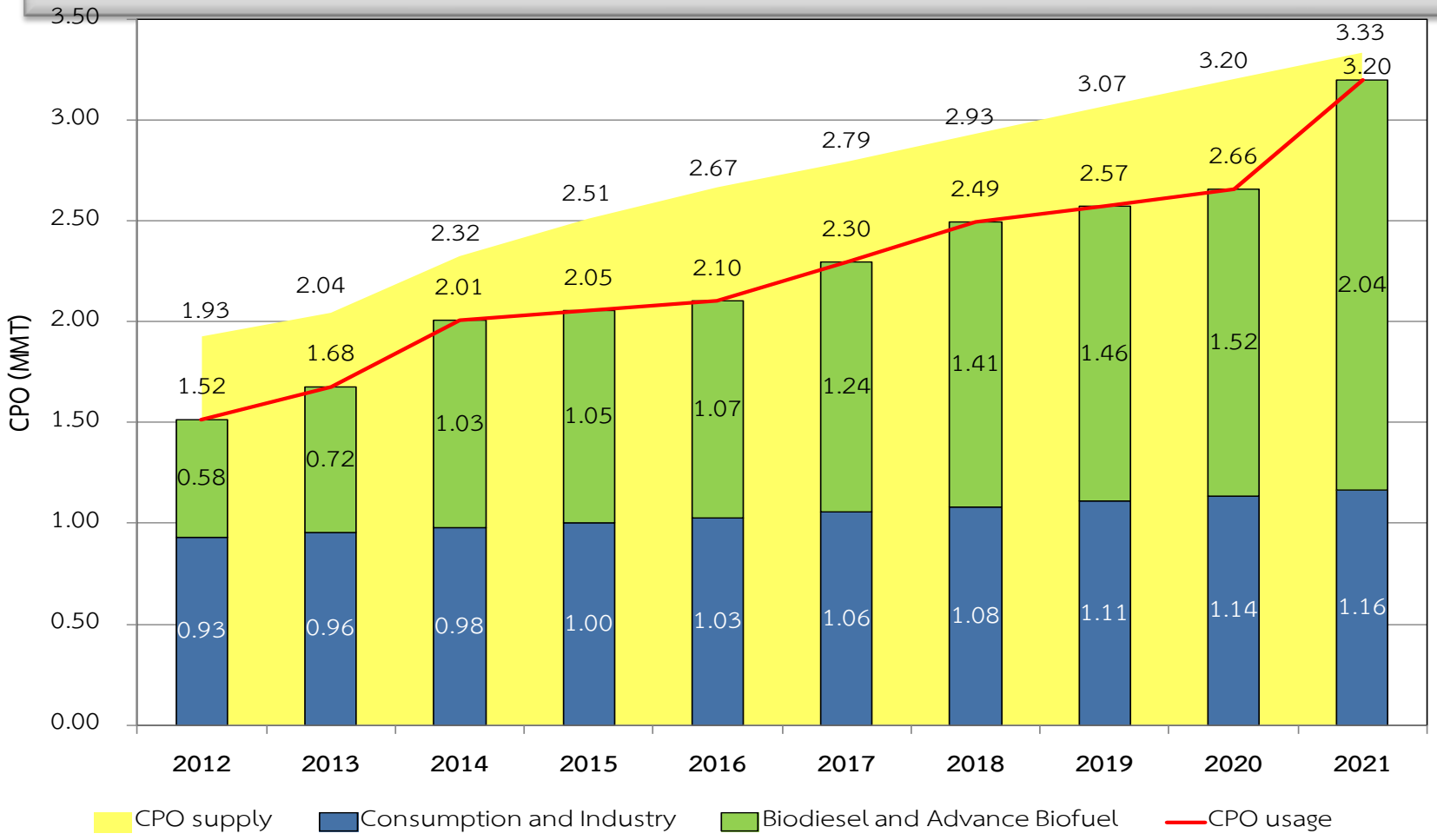
Supply and Demand Plan

Demand of Palm oil (2012 – 2021)



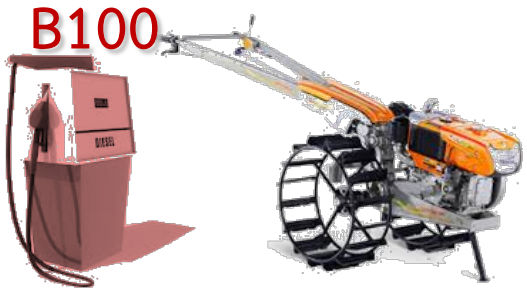
Balance between domestic supply and biofuel demand.

Future Trend of Biodiesel Using

Mandatory B10

Mandatory B7 + B20 for Bus and Truck

Mandatory B7+ B100 for Agricultural Machinery



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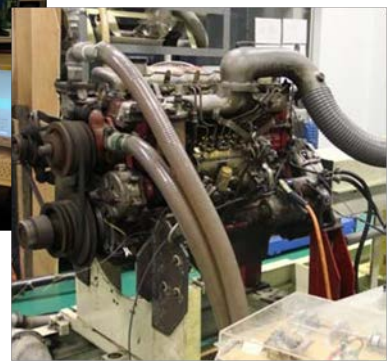
B20 in Fishery Project (2013)

- 20 fishery boats participated (20 4-cylinder & 20 6 cylinder)
- Using B20 for 500 hours over 1-7 months depending on usage (as is)
- T-test statistical interview with boat owners after 500 hours usage
  - No significantly different from diesel (B5) usage at 95% confident interval
- Lube oil sampling showed no significant degradation over 500 hours
- Engine dyno test before and after 500 hours
  - Power/torque, SFC (specific fuel consumption) and emissions (HC, CO, NOx, smoke) showed no significant deterioration



B20 in HD Truck Project (2014)

- Thailand has ~1 million HD (heavy-duty) trucks with ~0.6 million trucks over 15 years old age
- 20 HD (heavy duty, 6-cylinder) cement-carrying truck of 200-350HP trucks ran with B20 for 30,000 km each (4 HD trucks on diesel)
  - B20: 12 HINOs, 7 ISUZUs, 1 Mitsubishi
  - Diesel: 2 HINOs, 2 ISUZUs
- Tailpipe emissions of B20 showed higher HC and NOx but lower PM than diesel; whereas, no significant difference in fuel consumption (liter/km-ton)

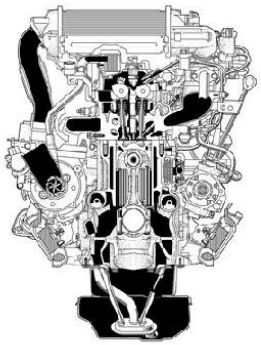
PTT-Toyota tests on engine/vehicle with BHD blends

These reports are partially summarized from

Collaborative R&D project on BHD(Bio-Hydrogenated Diesel) for Diesel Vehicle

【Engine】

Euro4 Hilux 3.0L
Turbo charger Common rail
Direct Injection Intercooler



【Fuel】

① B0(Diesel)
② B5
③ BHD5+5%PME
④ BHD20+5%PME
⑤ BHD20
⑥ BHD100

- Power ?
- Emission ?
- Other ?

SUMMARY

① Overall Engine Performance Screening

Comparison with B0(Diesel)

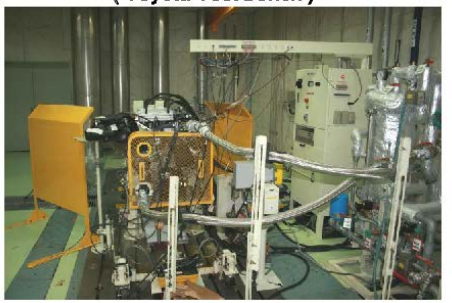
1. BHD(*) give better smoke(PM) emission.
2. Up to 20% blending BHD(*) give no significant difference in output power.

Engine durability test result “OK” → Reliability “PASS”

(PTT Test bench)

High Speed Durability Pattern
"Long trip & High way driving customer"

(Toyota Test bench)



Composite Durability Pattern
"Short trip & city driving customer"

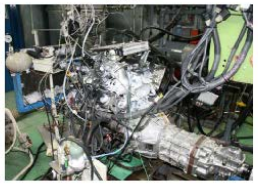
*BHD=BHD20(60%NormalBHD+40%IsoBHD)+5%PME

http://www3.pttplc.com/Files/RTI/62_110040_T.pdf

TOYOTA

Tested fuel

【Reference】 B5(PME)
【Target】 BHD20+5%PME BHD20=60%NormalBHD+40%IsoBHD



- Output power/torque
- Blow by gas flow
- Fuel consumption
- Oil deterioration & consumption

- Parts appearance & Inspection

TOYOTA

SUMMARY ② Engine Reliability

1. Overall results show existing Euro4 engine is compatible with BHD(*)
   - Performance - Wear - Appearance
2. No difference in performance, oil deterioration from durability test.

*BHD =BHD20(60%NormalBHD+40%IsoBHD)+5%PME

TOYOTA

To evaluate test fuels on vehicle durability for 100,000 km.

Vehicle : Toyota VIGO 4WD, C-Cab, 3.0L, Euro 4
Engine Oil : CI-4/SL,10W-30
Fuel : B5(PME), BHD20+5%PME, BHD20

TOYOTA

SUMMARY ③ Vehicle Evaluation

1) Driving 100,000km by higher blending ratio (Up to 20%BHD*) with existing TOYOTA Hilux (Euro4 specification) without any negative result.

2) Better PM emission performance.

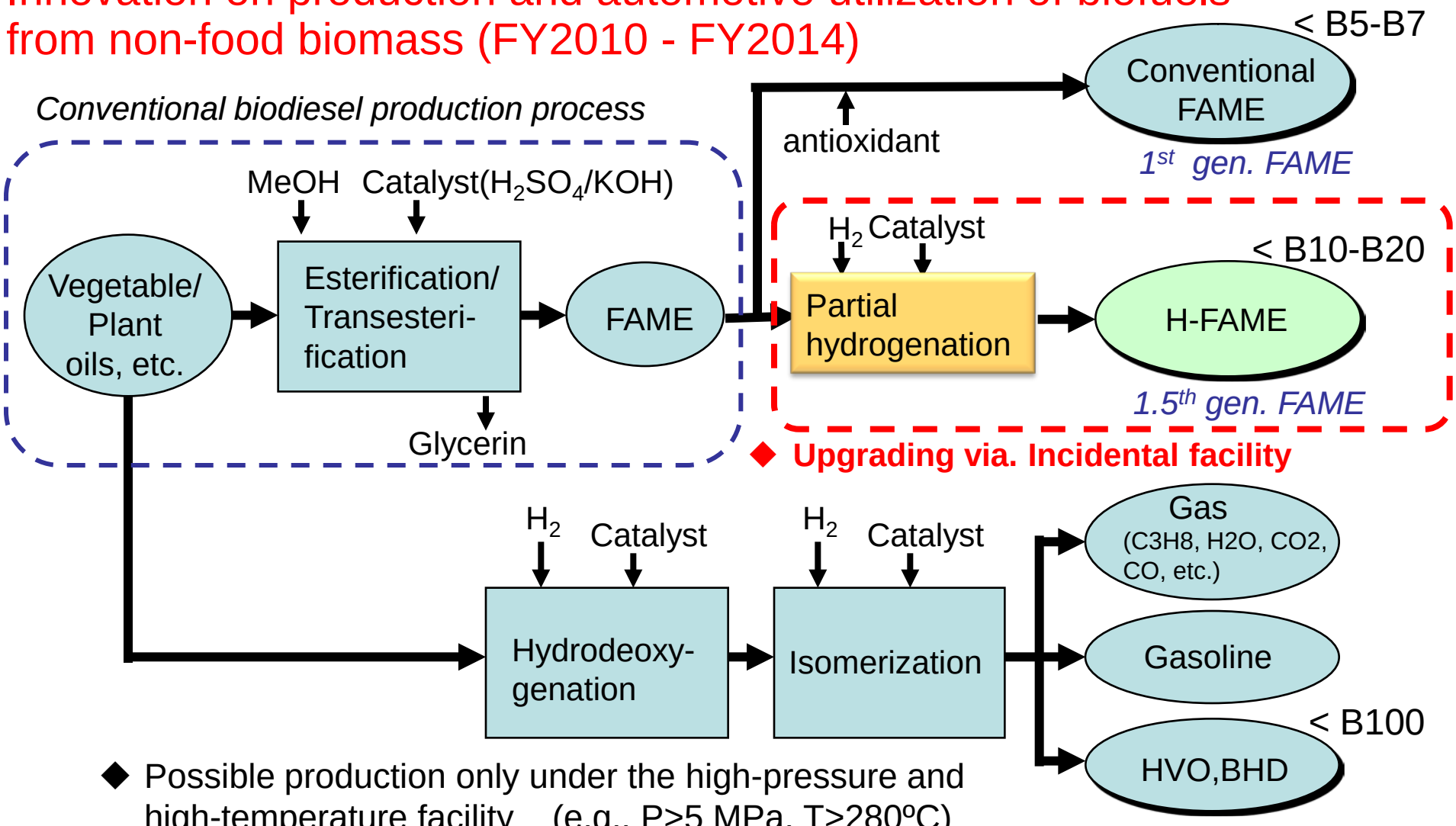
3) All test fuels do not affect on full load power, acceleration, fuel consumption and used oil analysis result from durability test.

*BHD =BHD20(60%NormalBHD+40%IsoBHD)+5%PME

http://www3.pttplc.com/Files/RTI/62_110040_T.pdf

H-FAME Technology

Innovation on production and automotive utilization of biofuels from non-food biomass (FY2010 - FY2014)



- Possible production only under the high-pressure and high-temperature facility (e.g., P>5 MPa, T>280ºC)
- Petroleum refineries could afford to produce this 2nd gen. biodiesel.

Advantages of H-FAME

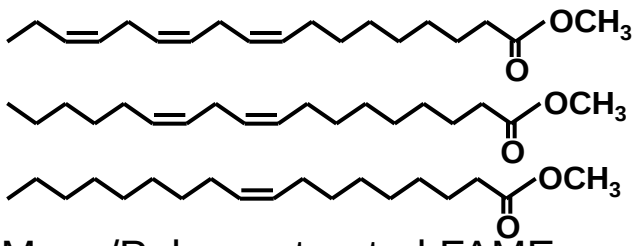
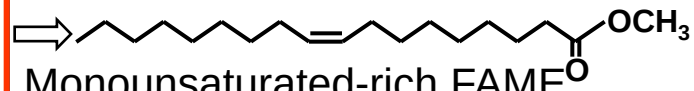
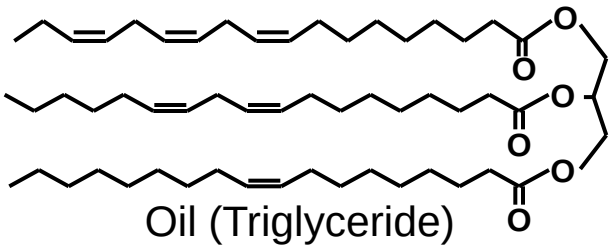
Advantages of H-FAME:

- **H-FAME is intrinsically stable for oxidation: meets with the FAME standards (>10 h), and less amounts of peroxides.**
- **Very lower cost-up for H-FAME compared with HVO, BHD: no need of the high-pressure and high temperature facilities (i.e., P<0.5MPa, T<100-130°C), and less amounts of H2 necessary compared with HVO, BHD.**
- **Detoxification of the phorbol ester in Jatropha FAME.**
- **Higher combustibility (increase in Cetane number).**
- **Decrease in the high-boiling point fractions of FAME, i.e., T95=380°C for Rapeseed FAME into T95=360°C.**
- **Possible high concentration use more than B10.**
- **Make ease the removal of saturated monoglyceride, etc.**

Issues of H-FAME:

- **Need of the hydrogen supply system, i.e., on-site and package-type hydrogenation production unit, H2 delivery systems, etc.**

Comparison between the H-FAME and HVO (BHD)

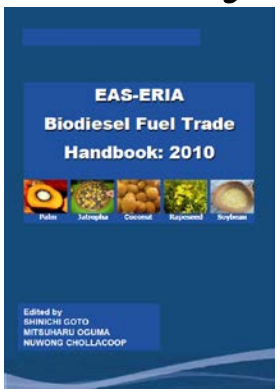
	H-FAME (1.5th gen. FAME)	HVO (2nd gen. biofuel)
Reaction	 Mono/Polyunsaturated FAME  Monounsaturated-rich FAME	 Oil (Triglyceride)  Hydrocarbons
Hydrogen consumption	Partial hydrogenation : $3H_2$	Hydrogenolysis/hydrogenation: $18H_2$ Decarboxylation: $9H_2$
Oxidation Stability	Relatively high	High
Reaction Conditions	Low pressure (atmospheric~0.5MPa) Low temperature (80~130ºC)	High pressure (>5MPa) High temperature (>280ºC)
Catalysts	Ni catalysts, Noble metal catalysts, etc.(sulfur-tolerant ones)	Water (steam)-tolerant NiMo catalysts, CoMo catalysts, etc.
Further processing	None	Isomerization for conditioning cold flow property and cetane number
Location of processing facility	Local Community~ Refinery (small ~ large plants)	Petroleum refinery (Neat ~ Coprocessing)

H-FAME meets with the FAME standards

Items	Units	EU EN14214:2003	Japan JIS K2390:2008	EAS-ERIA BDF Standard (EEBS):2008	WWFC March, 2009	TISR's PP Product BDF
Ester content	mass%	96.5 min.	96.5 min.	96.5 min.	96.5 min.	99.7
Density	kg/m3	860-900	860-900	860-900	Report	876
Viscosity	mm2/s	3.50-5.00	3.50-5.00	2.00-5.00	2.0-5.0	5.0
Flashpoint	deg. C	120 min.	120 min.	100 min.	100 min.	186
Sulfur content	mass%	0.0010 max.	0.0010 max.	0.0010 max.	0.0010 max.	0.00025
Distillation, T90	deg. C	-	-	-	-	-
Carbon residue (100%) or Carbon residue (10%)	mass%	- 0.30 max.	- 0.3 max.	0.05 max. 0.3 max.	0.05 max. -	 0.14
Cetane number		51.0 min.	51.0 min.	51.0 min.	51.0 min.	57
Sulfated ash	mass%	0.02 max.	0.02 max.	0.02 max.	0.005 max.	<0.001
Ash content	mass%	-	-	-	0.001 max.	-
Water content	mg/kg	500 max.	500 max.	500 max.	500 max.	385
Water and sediment	vol%	-	-	-	0.05 max.	-
Total contamination	mg/kg	24 max.	24 max.			8.3
Copper corrosion		Class-1	Class-1			Class-1a
Corrosion: Ferrous		-	-	-	light rusting. Max	-
Acid value	mgKOH/g	0.50 max.	0.50 max.	0.50 max.	0.5 max.	0.16
Oxidation stability	hrs.	6.0 min.	(**)	10.0 min. (****)	10 min.	15.1
Iodine value		120 max.	120 max.	Reported (***)	130 max.	70.5
Methyl Linolenate	mass%	12.0 max.	12.0 max.	12.0 max.	12.0 max.	0
Polyunsaturated FAME (more than 4 double bonds)	mass%	1 max.	N.D.	N.D. (***)	1 max.	N.D.
Methanol content	mass%	0.20 max.	0.20 max.	0.20 max.	0.20 max.	<0.01
Monoglyceride content	mass%	0.80 max.	0.80 max.	0.80 max.	0.80 max.	0.54
Diglyceride content	mass%	0.20 max.	0.20 max.	0.20 max.	0.20 max.	0.20
Triglyceride content	mass%	0.20 max.	0.20 max.	0.20 max.	0.20 max.	0.06
Free glycerol content	mass%	0.02 max.	0.02 max.	0.02 max.	0.02 max.	0
Total glycerol content	mass%	0.25 max.	0.25 max.	0.25 max.	0.25 max.	0.17
Na+K	mg/kg	5.0 max.	5.0 max.	5.0 max.	5 max.	<3
Ca+Mg	mg/kg	5.0 max.	5.0 max.	5.0 max.	5 max.	<2
Phosphorous content	mg/kg	10.0 max.	10.0 max.	10.0 max.	4 max.	<1
Trace metals		-	-	-	no addition	-

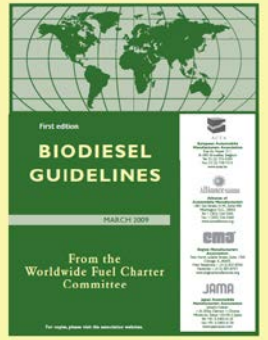
Demands for high quality BDF

Mid-term target



◆*EAS-ERIA BDF standard, (EEBS):2008*

Final target

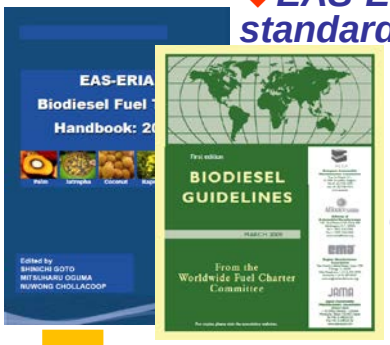


◆*WWFC Guideline BDF quality*

(*) Equivalent to diesel oil
(**) Meet diesel oil specification
(***) Need data check and further discussion
(****) Need more data & discussion from 6 to 10 hrs.

EAS: East Asia Summit ; ERIA: Economic Research Institute for ASEAN and East Asia ; WWFC: World Wide Fuel Charter

Automotive compatibility of Jatropha H-FAME



◆*EAS-ERIA BDF standard, (EEBS):2008*

◆*WWFC Guideline BDF quality*

MOU ceremony on “Innovation on New Non-Food Biodiesel Project” (2012.7.30) @Bangkok

On-road test (50,000km) 2012.11.1-2013.5.31

ISUZU ISUZU TECHNICAL CENTER OF ASIA CO.,LTD Page 1 / 19

TEST REPORT	PROJ. NAME : Jatropha bio-diesel B10 Durability	TEST PLAN NO. Q1201-12-028	TEST REPORT NO. Q1204-13-066
	PROJ. CODE B1295 CLIENT MTEC	JOB ORDER SHEET NO.	

Title : JATROPHA BIO-DIESEL B10 ON ROAD DURABILITY 50,000 KM

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☐ IMCT	
☐ ISUZU	
☑ OTHERS : MTEC	All
- Dr.Nuwong	
- Dr.Manida	

Index	Page
Test report	1
Test progressive	2~4
F/C and LOC Data	5 ~ 6
Emission data	7 ~ 9
Max Power and Torque data	10
Dynamic performance data	11
Engine oil analysis result	12 ~ 16
Reference for oil analysis	17 ~ 19

1. Purpose

To evaluate the effect of using high-quality biodiesel blend B10 (Extracted from non-food biomass) By on road durability test 50,000 km (course -3CZ)

2. Period

1 Nov '12 ~ 30 Jun '13

3. Attendants

ITA Incharge(VEX) : Kraiwuth Simarat, Nuttapol Yiemkhantithavon, Thongpon Adulsiripong

4. Test Vehicle (As shown in below figure)

No.	Test vehicle	VIN	Engine No.	Load condition
1	TFR EXT 4x2 Lo-ride	MP1TFR86JCT100042	HR7547	2700 kg

5. Test Condition & Test Route

Test weight = Shown as above

Fuel usage : Jatropha Bio-diesel B10

Test Route : -3CZ Course (Apporximately : A = 51.2%, Course B = 46.1%, Course C = 2.7%)

Running distance : 600 km/day for Course A, 630 km/day for Course B, 280 km/day for Course C, Running test on daytime and repeat until accumulated distance reaching 50,000 km (See in figure)

The vehicle was measured power /Torque/Emission at every 25,000 km and lube oil was sampling at every 10,000 km as see in figure

6. Test Summary

After running test (Accumulate distance about 50,000 km),We can summary result that are shown as below and details please find as attached :

Item	Result
Average Speed	61.88 km/h
Average Fuel consumption	14.09 km/L
Average LOC	15,734 km/L

Engine Driveability : We have not found abnormal phenomenon of driveability and dynamic performance while on road validation same as general diesel used.

Leakage / Damage : We not found oil leak and damaged on engine till test finished.

Dynamic performance Test : There were no significant difference between initial and final result.

Max power & torque measurement : There were no significant difference between initial and final result.

Emission test : All emission data have complied with Euro3 emission standard

Engine Oil Analysis Result : All wear conditions and wear tests appear in normal working range. Fuel dilutes have oil condition test indicate that the oil is slightly degraded.(Please refer to engine oil analysis result by Focus Lab)

Conclusion

We can accept the Jatropha bio-diesel B10 to using on ISUZU diesel engine same as general diesel used

ATTORY	①TEST DIVISION	②VEHICLE TYPE	③VEHICLE STAGE	④TYPE OF WORK	APPROVE	CHECK	ISSUE
	☐Validation&RideHandling	☑LCV	☐Prototype	☑General Evaluation	Y.Hayashi 25-Jul-2013	Anuwat 24 Jul 13	S.Kraiwuth 24 Jul '13
	☑Durability&Stress	☐LD	☐Trial	☐Problem Investigation			
	☐Powertrain&C/D Task Force	☐MD	☑Production	☐C/M Evaluation			
	☐NV/Brake/Elec ☐Other	☐HD&BUS		☐CR ☐Other	Y.Hayashi	K.Anuwat	S.Kraiwuth

FM-12-04 (Rev01) ITA Validation & Experiment Department

We can accept the jatropha bio-diesel B10 using on ISUZU diesel engine same as general diesel used

Lessons learned & Experiences shared

- Quality assurance of biodiesel in actual market
- BDF blends and based diesel specification
- Contamination prevention

Quality Assurance of BDF

- Thailand (by Department of Energy Business, DOEB) has issued separate standards for
  - Neat biodiesel (B100) for both industrial grade (blended with diesel for multiple cylinder engine) and community grade (strictly used with agricultural engine)
  - Blended diesel at biodiesel ratio of currently 7% (B7) and adjustable depending on palm oil supply
- B100 producers must comply to B100 specification when selling to oil retailers for blending; whereas, oil retailers are randomly audited by DOEB against diesel specification
- Penalty given to those who fails to meet specification (Fuel Act 2000)*
- With mandate of B7 since 1 Jan 2014, need to modify some diesel specifications
  - Add "Oxidation stability" > 35 hrs

*http://www.doeb.go.th/knowledge/complain_instruction.htm

Quality Inspection

- DOEB encourages fuel station to take part in quality assurance program

- Both DOEB (by law) and fuel companies perform quality check at fuel

http://www.doeb.go.th/activity/56/feb56/238.jpg
http://www.benzowner.net/forum/showthread.php?t=32843

Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY

BDF Specification (2014)

MTEC a member of NSTDA

รายละเอียดแนบท้ายประกาศกรมธุรกิจพลังงาน
เรื่อง กำหนดลักษณะและคุณภาพของไบโอดีเซลประเภทเมทิลเอสเตอร์ของกรดไขมัน
พ.ศ. ๒๕๕๖

รายการ	ข้อกำหนด		อัตราสูงต่ำ		วิธีทดสอบ๒/
๑	เมทิลเอสเตอร์ (Methyl Ester,	*ร้อยละโดยน้ำหนัก* *%wt.)*	<	96.5	EN ๑๔๑๐๓
๒	ความหนาแน่น ณ อุณหภูมิ ๑๕ °ซ (Density at 15 °C	*กิโลกรัม/ลูกบาศก์เมตร* *kg/m³)*	> <	860 900	ASTM D ๑๒๙๘
๓	ความหนืด ณ อุณหภูมิ ๔๐ °ซ (Viscosity at 40 °C	*เซนติสโตกส์* *cSt)*	> <	3.5 5.0	ASTM D ๔๔๕
๔	จุดวาบไฟ (Flash Point,	*องศาเซลเซียส* *°C)*	>	120	ASTM D ๙๓
๕	กำมะถัน (Sulphur,	*ร้อยละโดยน้ำหนัก* *%wt.)*	<	0.001	ASTM D ๒๖๒๒
๖	ภากถ่าน จากร้อยละ ๑๐ ของส่วนที่เหลือจากการกลั่น (Carbon Residue, on 10% Distillation Residue	*ร้อยละโดยน้ำหนัก* *%wt.)*	<	0.3	ASTM D ๔๕๓๐
๗	จำนวนซีเทน (Cetane Number)		>	51	ASTM D ๖๑๓
๘	เถ้าซัลเฟต (Sulphated Ash,	*ร้อยละโดยน้ำหนัก* *%wt.)*	<	0.02	ASTM D ๘๗๔
๙	น้ำ (Water	*มิลลิกรัม/กิโลกรัม* *mg/kg)*	<	500	EN ISO ๑๒๙๗๗
๑๐	สิ่งปนเปื้อนทั้งหมด (Total Contamination	*มิลลิกรัม/กิโลกรัม* *mg/kg)*	<	24	EN ๑๒๖๖๒
๑๑	การกัดกร่อนแผ่นทองแดง (Copper Strip Corrosion)		<	No.1	ASTM D ๑๓๐
๑๒	เสถียรภาพต่อการเกิดปฏิกิริยาออกซิเดชัน ณ อุณหภูมิ ๑๑๐ °ซ (Oxidation Stability at 110 °C	*ชั่วโมง* *hr.)*	>	10	EN ๑๔๗๔๐
๑๓	ค่าความเป็นกรด (Acid Value ,	*มิลลิกรัมโปตัสเซียมไฮดรอกไซด์/กรัม* *mg KOH/g)*	<	0.5	ASTM D ๖๖๔

(ต่อ -๒-)

รายการ	ข้อกำหนด		อัตราสูงต่ำ		วิธีทดสอบ๒/
๑๔	ค่าไอโอดีน (Iodine Value ,	*กรัมไอโอดีน/(๑๐๐ กรัม)* *g Iodine / 100g)*	<	120	EN ๑๔๑๑๑
๑๕	กรดลิโนเลนิกเมทิลเอสเตอร์ (Linolenic Acid Methyl Ester ,	*ร้อยละโดยน้ำหนัก* *% wt.)*	<	12	EN ๑๔๑๐๑
๑๖	เมทานอล (Methanol ,	*ร้อยละโดยน้ำหนัก* *% wt.)*	<	0.2	EN ๑๔๑๐๐
๑๗	โมโนกลีเซอไรด์ (Monoglyceride ,	*ร้อยละโดยน้ำหนัก* *% wt.)*	<	0.7	EN ๑๔๑๐๔
๑๘	ไดกลีเซอไรด์ (Diglyceride ,	*ร้อยละโดยน้ำหนัก* *% wt.)*	<	0.2	EN ๑๔๑๐๔
๑๙	ไตรกลีเซอไรด์ (Triglyceride ,	*ร้อยละโดยน้ำหนัก* *% wt.)*	<	0.2	EN ๑๔๑๐๔
๒๐	กลีเซอรีนอิสระ (Free glycerin ,	*ร้อยละโดยน้ำหนัก* *% wt.)*	<	0.02	EN ๑๔๑๐๔
๒๑	กลีเซอรีนทั้งหมด (Total glycerin ,	*ร้อยละโดยน้ำหนัก* *% wt.)*	<	0.25	EN ๑๔๑๐๔
๒๒	โลหะกลุ่ม ๑ (โซเดียมและโปแตสเซียม) (Group I metals (Na +K) ,	*มิลลิกรัม/กิโลกรัม* *mg/kg)*	<	5.0	EN ๑๔๕๓๗
	โลหะกลุ่ม ๒ (แคลเซียมและแมกนีเซียม) (Group II metals (Ca + Mg) ,	*มิลลิกรัม/กิโลกรัม* *mg/kg)*	<	5.0	EN ๑๔๕๓๗
๒๓	ฟอสฟอรัส (Phosphorus ,	*ร้อยละโดยน้ำหนัก* *% wt.)*	<	0.001	EN ๑๔๑๐๗
๒๔	จุดขุ่น (Cloud Point : CP	*องศาเซลเซียส* *°C)*	Reported		
๒๕	จุดอุดตันการไหลที่อุณหภูมิต่ำ Cold Flow Plugging Point : CFPP	*องศาเซลเซียส* *°C)*	Reported		
๒๖	สารเติมแต่ง (ถ้ามี) (Additives , If Any)		Approval from Director-General		

หมายเหตุ ๑/ วิธีทดสอบอาจใช้วิธีอื่นที่เทียบเท่าก็ได้ แต่ในกรณีที่มีข้อโต้แย้งให้ใช้วิธีที่กำหนดในรายละเอียดแนบท้ายนี้
๒/ ให้ผู้ค้าน้ำมันรายงานต่อธนาธิบดีเป็นรายไตรมาส ภายในวันที่ ๑๕ ของเดือนถัดจากเดือนสุดท้ายของไตรมาสนั้น

http://www.ratchakitcha.soc.go.th/DATA/PDF/2556/E/158/15.PDF

Department of Alternative Energy Development and Efficiency
MINISTRY OF ENERGY

Diesel Specification (2014)

MTEC a member of NSTDA

รายละเอียดแนบท้ายประกาศกรมธุรกิจพลังงาน
เรื่อง กำหนดลักษณะและคุณภาพของน้ำมันดีเซล
พ.ศ. ๒๕๕๖

รายการ	ข้อกำหนด		อัตราสูง/ต่ำ	Diesel HiSp	Diesel LoSp	วิธีทดสอบ[๑/]
๑	ความถ่วงจำเพาะ ณ อุณหภูมิ ๑๕.๖/๑๕.๖ (Specific Gravity at ๑๕.๖/๑๕.๖)	*องศาเซลเซียส* (°C)	>	0.81	-	ASTM D ๔๒๙๘
			<	0.87	0.92	
๒	จำนวนซีเทน (Cetane Number) หรือ		>	50	45	ASTM D ๖๑๓
	ดัชนีซีเทน (Calculated Cetane Index)					ASTM D ๔๗๓๖
๓	ความหนืด (Viscosity,	*เซนติสโตกส์* *cSt*)				ASTM D ๔๔๕
	๓.๑ ณ อุณหภูมิ ๔๐ *องศาเซลเซียส* หรือ (at 40 °C)		>	1.8	-	
			<	4.1	8.0	
	๓.๒ ณ อุณหภูมิ ๕๐ *องศาเซลเซียส* (at 50 °C)		<	-	6.0	
๔	จุดไหลเท (Pour Point,	*องศาเซลเซียส* °C)	<	10	16	ASTM D ๙๗
๕	กำมะถัน (Sulphur,	*ร้อยละโดยน้ำหนัก* %wt.)	<	0.05	1.5	ASTM D ๒๖๒๒
๖	การกัดกร่อนแผ่นทองแดง (Copper Strip Corrosion)		<	No.1	-	ASTM D ๑๓๐
๗	เสถียรภาพต่อการเกิดปฏิกิริยาออกซิเดชัน (Oxidation Stability)					
		กรัม/ลูกบาศก์เมตร g/m³	>	25	-	ASTM D ๒๒๗๔
		ชั่วโมง hr.	<	35	-	EN ๑๕๗๕๑
๘	กากถ่าน จากร้อยละ ๑๐ ของส่วนที่เหลือจากการกลั่น (Carbon Residue, on 10% Distillation Residue	*ร้อยละโดยน้ำหนัก* %wt.)	<	0.3	-	ASTM D ๔๕๓๐
๙	น้ำและตะกอน (Water and Sediment,	*ร้อยละโดยปริมาตร* %vol.)	<	-	0.3	ASTM D ๒๗๐๙
๑๐	น้ำ (Water	มิลลิกรัม/กิโลกรัม mg/kg)	<	300	-	EN ISO ๑๒๙๗๗
๑๑	สิ่งปนเปื้อนทั้งหมด (Total Contamination	มิลลิกรัม/กิโลกรัม mg/kg)	<	24	-	EN ๑๒๖๖๒

รายการ	ข้อกำหนด		อัตราสูง/ต่ำ	Diesel HiSp	Diesel LoSp	วิธีทดสอบ[๑/]
๑๒	เถ้า (Ash,	*ร้อยละโดยน้ำหนัก* %wt.)	<	0.01	0.02	ASTM D ๔๘๒
๑๓	จุดวาบไฟ (Flash Point,	*องศาเซลเซียส* °C)	>	52	52	ASTM D ๙๓
๑๔	การกลั่น (Distillation,	*องศาเซลเซียส* °C)				ASTM D ๘๖
	อุณหภูมิของส่วนที่กลั่นได้โดยปริมาตรในอัตราร้อยละเก้าสิบ (90% Recovered)		<	357	-	
๑๕	โพลีไซคลิก อะโรมาติก ไฮโดรคาร์บอน (Polycyclic Aromatic Hydrocarbon,	*ร้อยละโดยน้ำหนัก* % wt.)	<	11	-	ASTM D ๖๔๒๕
๑๖	สี (Colour)			-		
	๑๖.๑ ชนิดของสี (Hue)			เหลือง	น้ำตาล	
	๑๖.๒ ความเข้มของสี (Intensity)		>	-	4.5	ASTM D ๑๕๐๐
			<	4.0	7.5	
๑๗	ไบโอดีเซลประเภทเมทิลเอสเตอร์ของกรดไขมัน (Methyl Ester of Fatty Acids,	ร้อยละโดยปริมาตร %vol.)	>	6.0	-	EN ๑๔๐๗๘
			<	7	-	
๑๘	คุณสมบัติการหล่อลื่น รอยขีดข่วน (Lubricity , Wear Scar	*ไมโครเมตร* μm)	<	460	-	CEC F – ๐๖ - ๙๖
๑๙	สารเติมแต่ง (ถ้ามี) (Additives , If Any)		Approval from Director-General			

หมายเหตุ ๑/ วิธีทดสอบอาจใช้วิธีอื่นที่เทียบเท่าก็ได้ แต่ในกรณีที่มีข้อโต้แย้งให้ใช้วิธีที่กำหนดในรายละเอียดแนบท้ายนี้

http://www.ratchakitcha.soc.go.th/DATA/PDF/2556/E/158/15.PDF

Contamination Prevention

- Fuel contamination may occur during processing, storage, transportation, dispenser and underground fuel tank so need to be cautious in all steps
- Explicit laws to govern fuel storage, transportation tank, dispenser and underground tank for both safety and contamination prevention
- Additional guideline during flooding*

*http://www.doeb.go.th/knowledge/data/protecttank

Concerns for Taiwanese Biodiesel Market

- Issues of BDF blending (B2) in ULSD promoting microbial growth*
  - Biodiesel is more susceptible to oxidation stability due to bio component
  - Water content as low as 100ppm may be sufficient to allow microbial growth
  - Reduced sulfur (natural bacteria killer) content in ULSD (<10 ppm S)
- Discussion points
  - Technical or logistic issues?
    - Quality according to specification at BDF producer or blending facility
    - Need to check quality at fuel station especially contamination in underground tank storage
  - Even with diesel, already some protocol to follow
    - Diesel fuel microbe infestation analysis, IP-385 and IP-472
    - Biocide may be added for biodiesel blending

* http://www.petrolplaza.com/technology/articles/MiZlbiYxNDg1NCYmMSYxJiY%3D

Thank you

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