APPENDICES

APPENDIX A

Specifications of Thai biodiesel standards

A-1 Biodiesel standards for agricultural engines (Community biodiesel)

Property	Unit	Limits		Test Method
		Min	Max	
Density at 15 ^{o}C	kg/m^{3}	860	900	ASTM D 1298
Viscosity at 40 ^{o}C	cSt	1.9	8.0	ASTM D 445
Flash point	^{o}C	120	-	ASTM D 93
Sulphur	%wt	-	0.0015	ASTM D 2622
Cetane number	-	47	-	ASTM D 613
Sulphated ash	%wt	-	0.02	ASTM D 874
Water and sediment	%wt	-	0.2	ASTM D 2709
Copper Strip Corrosion	-	-	No.3	ASTM D 130
Acid value	mg KOH/g	-	0.50	ASTM D 664
Free glycerin	%wt	-	0.2	ASTM D 6584
Total glycerin	%wt	-	1.5	ASTM D 6584
Color			Purple	Test by eyes
Additive	To follow the permission of the Director General of the Department of Energy Business			

Source: Department of Energy Business (2006)

A-2 Biodiesel standards for methyl ester (Community biodiesel)

Property	Unit	Limits		Test Method
		Min	Max	
Density at 15 ^{o}C	kg/m^{3}	860	900	ASTM D 1298
Viscosity at 40 ^{o}C	cSt	1.9	8.0	ASTM D 445
Flash point	^{o}C	120	-	ASTM D 93
Sulphur	%wt	-	0.0015	ASTM D 2622
Cetane number	-	47	-	ASTM D 613
Sulphated ash	%wt	-	0.02	ASTM D 874
Water and sediment	%wt	-	0.2	ASTM D 2709
Copper Strip Corrosion	-	-	No.3	ASTM D 130
Acid value	mg KOH/g	-	0.50	ASTM D 664
Free glycerin	%wt	-	0.2	ASTM D 6584
Total glycerin	%wt	-	1.5	ASTM D 6584
Color			Purple	Test by eyes
Additive	To follow the permission of the Director General of the Department of Energy Business			

Source: Department of Energy Business (2009)

APPENDIX B

Community biodiesel descriptions

B-1 Community biodiesel descriptions in agricultural engine

No.	Code	Model/ Consultant	Production yield (L)	Waste water treatment	Remark
1	UMO	DEDE	100	Waste water treatment tank	-
2	SAM	The Royal Thai Naval Dockyard	100	Waste water treatment station	-
3	SAN	The Royal Thai Naval Dockyard	100	Waste water storage tank	

[a]DEDE; Department of Alternative Energy Development and Efficiency, Ministry of Energy

B-2 Community biodiesel descriptions in high speed diesel engine

No.	Code	Model	Production yield (L)	Waste water treatment	Remark
1	UOL	DEDE	100	Waste water treatment tank	-
2	UPO	DEDE	100	Waste water treatment tank	
3	CPO	DEDE	100	Waste water treatment tank	

[a]DEDE; Department of Alternative Energy Development and Efficiency, Ministry of Energy

B-3 Community biodiesel production process descriptions of agricultural engine

No.	Code	Feed stock	Filter	Starter (oil:alcohol:catalyst)	Mixing time (min)	Setting time (min)	Wash (time)	Water (L) and separated time(min)	Production time (hr/production cycle)
1	UMO	Used palm oil	Yes	20 L Methanol (MeOH) + 1 kg Potassiumhydroxide (KOH) (5:1:50)	60	1,440	>4	100 L, 30 min	-
2	SAM	Mixed used oil	Yes	20 L MeOH+1.4 kg KOH (5:1:70)	90	3	3	75 L, 45 min	6
3	SAN	palm oil	Yes	20 L MeOH+1.4 kg KOH (5:1:70)	90	3	3	75 L, 45 min	6

B-4 Community biodiesel production process descriptions of high speed engine

No.	Code	Feed stock	Filter	Starter (oil:alcohol:catalyst)	Mixing time (min)	Setting time (min)	Wash (time)	Water (L) and separated time(min)	Production time (hr/production cycle)
1	UOL	Mixed used oil	Yes	20 L MeOH+1.4 kg KOH (5:1:70)	90	3	3	75 L, 45 min	6
2	UPO	used palm oil	Yes	20 L MeOH+1.4 kg KOH (5:1:70)	90	3	3	75 L, 45 min	6
3	CPO	palm oil	Yes	20 L MeOH+1.4 kg KOH (5:1:70)	90	3	3	75 L, 45 min	6

APPENDIX C

Engine performance determination

C-1 Calculation of brake specific fuel consumption (BSFC) and thermal efficiency

To calculate the brake specific fuel consumption (BSFC) and thermal efficiency of agricultural diesel engine which is fueled with test fuel, the brake power output of the engine must be calculated.

1. Calculation the brake power (BP, kW) of engine which is equal to the force it exerts multiplied by its velocity using equation C1 and C2. In rotational systems, power is related to the torque (τ) and angular velocity (ω). The magnitude of torque depends on the force (F) applied and the length of the lever arm connecting the axis to the point of force application (r) which the length of the lever arm vector of test [76].

$$BP = \tau \times \omega \quad \text{(C1)}$$

or

$$BP = \tau \times \frac{2\pi N}{60} \quad \text{(C2)}$$

Where $\tau\ (Nm) = r \times F$; r is the lever arm vector of test engine which is 0.24 meter for agricultural diesel engine, 0.25 meter in high speed diesel engine and F is the magnitude of the force applied which obtained from load applied.

N = engine speed (rpm)

2. Calculation the BSFC (kg/kWh) of fuel efficiency within a shaft reciprocating using equation 3 and thermal efficiency using equation C3.

$$\text{BSFC} = \frac{\text{mf}}{\text{BP}} \quad \text{(C3)}$$

Where mf = fuel consumption (kg/h) and BP is brake power as is defined above.

3. Calculation the thermal efficiency (TE, %) which is the efficiency and completeness of combustion of the fuel usually perform as the ratio of the output or work done by the working substance in the cylinder in a given time to the input or heat energy of the fuel supplied during the same time [77], however; this study use the equation C4 which is the inverse of BSFC and heating value as below.

$$\text{TE} = \frac{3{,}600}{\text{BSFC} \times \text{HHV}} \times 100 \quad \text{(C4)}$$

Sample calculation of BSFC and TE

Fuel sample: UMO-1

Load = 5.1 kg, r = 0.24 m and Speed (N) = 1,794 rpm

1. To calculated the BP (kW) which that of calculated Torque was 12 Nm

$$\text{BP} = 12 \times \frac{2\pi \times 1{,}794}{60}$$

$$= 2.3 \text{ kW}$$

2. To calculated the BSFC (kg/kWh) which that of fuel flow rate was 0.861 kg/h

$$\text{BSFC} = \frac{0.861}{2.3}$$

= 0.38 kg/kWh

3. To calculated the TE (kg/kWh) which that of heating value was 38,348 kJ/kg fuel flow rate was 0.873 kg/h

$$TE = \frac{3{,}600}{0.38 \times 38{,}348} \times 100$$

= 25%

C-2 Engine performance data of tested fuel from agricultural diesel engine

Tested fuel	Load (kg)	Speed (rpm)	Torque (Nm)	Brake power (kW)	Fuel flow rate (kg/h)	Brake specific fuel consumption (kg/kWh)	Thermal efficiency (%)
UMO	5.1	1,794	12	2.3	0.861	0.38	25
	4.9	1,799	12	2.2	0.838	0.99	24
	5.0	1,806	12	2.2	0.797	0.36	26
SAM	5.7	1,807	13	2.5	0.958	0.38	24
	5.7	1,800	13	2.5	0.943	0.37	25
	5.5	1,797	13	2.4	0.953	0.39	24
SAN	5.2	1,801	12	2.3	0.856	0.37	26
	5.2	1,799	12	2.3	0.854	0.37	27
	5.4	1,798	13	2.4	0.859	0.36	28
DIE	5.9	1,805	14	2.6	0.736	0.28	29
	5.9	1,806	14	2.6	0.750	0.28	29
	5.9	1,805	14	2.6	0.771	0.30	27

C-2 Engine performance data of test fuel (Continued)

Test fuel	Load (kg)	Speed (rpm)	Torque (Nm)	Brake power (kW)	Fuel flow rate (kg/h)	Brake specific fuel consumption (kg/kWh)	Thermal efficiency (%)
PTT	5.8	1,804	14	2.6	0.787	0.30	28
B5	5.8	1,805	14	2.6	0.783	0.30	28
	5.8	1,805	14	2.6	0.785	0.30	28

C-3 Engine performance data of test fuel from high speed diesel engine

Tested fuel	Load (kg)	Speed (rpm)	Torque (Nm)	Brake power (kW)	Fuel flow rate (kg/h)	Brake specific fuel consumption (kg/kWh)	Thermal efficiency (%)
UOL	9.9	1,500	23	3.7	2.930	0.79	10
	9.7	1,500	23	3.6	2.966	0.82	10
	9.7	1,500	23	3.6	2.877	0.80	10
UPO	11.3	1,500	27	3.7	2.664	0.63	12
	11.1	1,500	26	3.6	2.539	0.61	13
	10.9	1,500	26	3.6	2.611	0.64	12
CPO	9.5	1,500	22	4.2	2.664	0.77	10
	11.4	1,500	22.	4.1	2.539	0.78	10
	11.6	1,500	22	4.0	2.611	0.80	10

DIE100	11.4	1,500	27	4.2	2.464	0.58	13
	11.4	1,500	27	4.2	2.448	0.58	13
	11.6	1,500	27	4.3	2.481	0.57	13
PTT	11.6	1,500	27	4.2	2.587	0.60	12
B3	11.3	1,500	27	4.2	2.520	0.60	12
	11.7	1,500	27	4.3	2.520	0.58	12

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List of Conferences

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