APPROPRIATE ALTERNATIVE FUELS FOR IMPROVING AIR QUALITY, CASE STUDY: BIODIESEL

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APPROPRIATE ALTERNATIVE FUELS FOR IMPROVING AIR QUALITY, CASE STUDY : BIODIESEL

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ABSTRACT

The objectives of this research are to study the emission factors of biodiesels for diesel vehicles, to study the difference of traffic emissions between biodiesel and diesel. The study was based on secondary data. The emission factors of HC, CO, NO_X and PM were collected under the categories of seven biodiesels : soy biodiesel (SB), yellow grease biodiesel (YB), palm biodiesel (PB), coconut biodiesel (CB), rapeseed biodiesel (RB), used cooking oil biodiesel (UB) and tallow biodiesel (TB). The traffic data in 2005 on Intharaphithak Road, Ladprao Road and Dindaeng Road, Bangkok, Thailand, were collected for calculating the total emission rates from biodiesel and diesel oil in diesel vehicles. The results of total emission rates from biodiesel B20 and diesel oil were applied to estimate the emissions in nine scenarios based on the various proportions of light duty diesel vehicles (LDDV) and heavy duty diesel vehicles (HDDV) on the three roads.

The emission reduction of biodiesel is greater at higher blend. RB is the best biodiesel in reducing emissions from both diesel vehicles. UB is also effective to reduce HC, CO, NO_X and PM, but it's at B20 use in HDDV increases NO_X. The use of PB and CB are effective on emission reduction in LDDV. The emission reduction of YB in HDDV is better than the use of TB. But the emission of SB is higher than diesel oil and other biodiesels. From scenarios, the emission reduction of biodiesel B20 is effective when it is used in 100% of both diesel vehicles. The use of RB can reduce emissions better than diesel oil in a range of 76-90%. The use of UB is able to reduce HC, CO and PM about 10-80% but increases NO_X when used in 100% HDDV travelling on road. The use of PB or CB in 100% LDDV and YB in 100% HDDV on roads are effective to reduce emissions.

Although RB is the best method of emission reduction, it has to be imported. So, UB is recommended as an appropriate fuel for improving air quality in Thailand because it promotes the recycling of used cooking oil as a replacement of use as a secondary cooking oil, together with an increase of revenue and energy stability in the country.

KEY WORDS : BIODIESEL/EMISSION FACTOR/EMISSION RATE/SCENARIOS

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บทคัดย่อ

การศึกษานี้มีวัตถุประสงค์เพื่อศึกษาค่าการปลดปล่อยมลสารจากการใช้ไบโอดีเซลในยานยนต์ดีเซล, ศึกษาความแตกต่างของอัตราการระบายมลสารจากไบโอดีเซลกับดีเซลโดยการรวบรวมข้อมูลทุติยภูมิของค่าปริมาณมลสารของไฮโดรคาร์บอน (HC), คาร์บอนมอนอกไซด์ (CO), ออกไซด์ของไนโตรเจน (NO_X) และอนุภาคมลสาร (PM) จากไบโอดีเซล 7 ชนิด ได้แก่ soy biodiesel (SB), yellow grease biodiesel (YB), palm biodiesel (PB), coconut biodiesel (CB), rapeseed biodiesel (RB), used cooking oil biodiesel (UB), tallow biodiesel (TB) และข้อมูลจราจร ปี พ.ศ. 2548 ของถนนอินทรพิทักษ์, ถนนลาดพร้าวและถนนดินแดง ใช้เป็นข้อมูลพื้นฐานในการหาอัตราการระบายมลสารทั้งหมดจากยานยนต์ดีเซล ปริมาณการระบายสารมลพิษที่ปล่อยออกมาจากการจราจรถูกประมาณภายใต้ Scenario 9 แบบ โดยการใช้ไบโอดีเซลที่อัตราส่วน 20 และน้ำมันดีเซลกับการจราจรที่รถดีเซลเล็กและดีเซลใหญ่ใช้ไบโอดีเซลและน้ำมันดีเซลที่สัดส่วนต่างๆ

ไบโอดีเซลส่วนใหญ่จะมีอัตราการระบายมลสารลดลงเมื่ออัตราส่วนผสมของไบโอดีเซลสูงขึ้น โดยที่การใช้ RB มีประสิทธิภาพในการลดอัตราการระบายมลสารดีที่สุดในยานยนต์ทั้งสองประเภท รองลงมาคือ UB แต่ยังมีปัญหาการระบาย NO_X สูงที่อัตราส่วน 20% เมื่อใช้ในยานยนต์ดีเซลใหญ่ 100% สำหรับ PB และ CB มีประสิทธิภาพในการลดอัตราการระบายมลสารในยานยนต์ดีเซลเล็กได้ดี ในขณะที่ YB จะมีประสิทธิภาพในการลดการระบายมลสารในยานยนต์ดีเซลใหญ่ดีกว่าการใช้ TB แต่ SB มีการระบายมลสารสูงกว่าน้ำมันดีเซลและไบโอดีเซลชนิดอื่นๆและค่าการระบายมลสารในอัตราส่วนต่างๆ ผันแปรมาก สำหรับ Scenario ของการนำไบโอดีเซลที่อัตราส่วน 20 มาใช้บนถนน 100 % ในยานยนต์ทั้งสองประเภท จะมีประสิทธิภาพในการปรับปรุงปัญหาคุณภาพอากาศมากที่สุด โดยเฉพาะเมื่อใช้ RB พบว่ามีการระบายมลสารต่ำกว่าน้ำมันดีเซลถึง 76-90% ในขณะที่ UB ลดอัตราการระบายมลสารของ HC, CO และPM ได้ดีประมาณ 10-80% ขณะเดียวกันกลับมีปัญหาการเพิ่ม NO_X เมื่อนำมาใช้กับยานยนต์ดีเซลใหญ่ 100% สำหรับ การใช้ PB และ CB ในยานยนต์ดีเซลเล็ก 100% หรือ การใช้ YB ในยานยนต์ดีเซลใหญ่ 100% มีประสิทธิภาพในการลดอัตราการระบายมลสารได้มากกว่าน้ำมันดีเซล

แม้ว่า RB จะมีประสิทธิภาพดีที่สุดในการลดการระบายมลสาร แต่ในปัจจุบันการใช้ RB ยังต้องนำเข้าจากต่างประเทศ ดังนั้น การใช้ UB น่าจะมีความเหมาะสมต่อการปรับปรุงคุณภาพอากาศของประเทศไทยในขณะนี้ เนื่องจากมีการสนับสนุนให้มีการนำน้ำมันประกอบอาหารที่ใช้แล้วมาใช้เป็นวัตถุดิบผลิตไบโอดีเซล ซึ่งเป็นการลดการนำน้ำมันใช้แล้วกลับมาใช้และยังเพิ่มรายได้และความมั่นคงทางพลังงานให้กับประเทศ

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LIST OF ABBREVIATION AND SYMBOLS

HDDV	=	Heavy duty diesel vehicle
LDDV	=	Light duty diesel vehicle
HC	=	Hydrocarbon
CO	=	Carbon monoxide
NO_X	=	Oxide of Nitrogen
PM	=	Particulate matter
SB	=	Soy biodiesel
YB	=	Yellow grease biodiesel
PB	=	Palm biodiesel
CB	=	Coconut biodiesel
RB	=	Rapeseed biodiesel
UB	=	Used cooking oil biodiesel
TB	=	Tallow biodiesel
B	=	Blend of biodiesel mixes in diesel oil
In-R	=	Intharaphithak Road
Lp-R	=	Ladprao Road
Dd-R	=	Dindaeng Road

CHAPTER I
INTRODUCTION

1.1 Background and Significance

In the present, air pollution is a major important problem in an urban area due to human activity such as road transportation. Furthermore the major source of these problems was the road traffic that released air pollutants to atmosphere. In other words, it began from lifestyle and human activities in urban that depended on the traveling by vehicle used fossil fuel. The problem of petroleum oil in the world is limit resource and it is decreasing due to high consumption. These problems brought to energy and economic crisis in the world, especially countries importing petroleum oil, need to spend high revenue for energy consumption. So, these countries turn to new alternative fuels for replacing diesel oil and alleviated environmental problems. Therefore number of researches on property and capability of performance of alternative fuels for using in diesel engine were conducted in many countries.

In Thailand, the interest in using alternative fuels started when the petroleum fuels in the world were decreasing and the economic crisis happened in 1997. Since then, cost of petroleum oil in the country had increased. According to the consumption of diesel fuel in the country, it increased to 337,500 barrel/day in 1997 higher than that of 1996 about 11.6 %. Crude oils were imported from Middle East 633,600 barrel/day, Far East 109,200 barrel/day and other sources 45,700 barrel/day, totally cost 469,214 million baht (PTT Public Company Limited, B.E. 2549). So, these reasons brought to the support of alternative fuels that produced in the country from oily plants. Use of the alternative fuels also maintained the finance in the country. In addition to the consideration of environmental problems, the use of alternative fuels gives less negative impact to environment than that of petroleum fuel (Klanarong Srirod *et.al*, B.E. 2546).

There are alternative fuels many types such as alcohol fuel, called gasohol used in petrol engine and oily animal or oily plant fuel, called biodiesel used in diesel engine (Energy Commissioner of the House of Representative, B.E. 2545). Biodiesel is extracted from all oily plants. However, the selection of oily plants is based on their property or appropriate of their cultivation. Therefore in Thailand, the most cultivate of oily plant was palm and the second most was coconut (Office of Agricultural Economics, B..E. 2549).

For Thailand, the government promoted the studies on property, efficiency and energy of biodiesel. Therefore Energy Commissioner of the House of Representative cooperated with government and public department to conduct a study quantity, type and property of oily plants in the country. The specific gravity and heating value of oily plant and diesel oil are not different, but the viscosity of oily plant is higher than diesel oily (Figure 1.1).

An important problem in diesel engine is its incompleted combustion which emits high level of air pollutants. So, the study of biodiesel is conducted on both their properties and air pollutions. Therefore, many countries had undertaken researches on biodiesel such as United State Environmental Protection Agency that analyzed emission factor of biodiesel from heavy duty diesel vehicle and applied to emission database of biodiesel (United State Environmental Protection Agency, 2002). The emission factors of biodiesel indicate the decrease of hydrocarbon, carbon monoxide and particulate matter, except oxide of nitrogen (Figure 1.2). Oxide of nitrogen reacts with oxygen in the air and change to nitrogen dioxide in atmosphere.

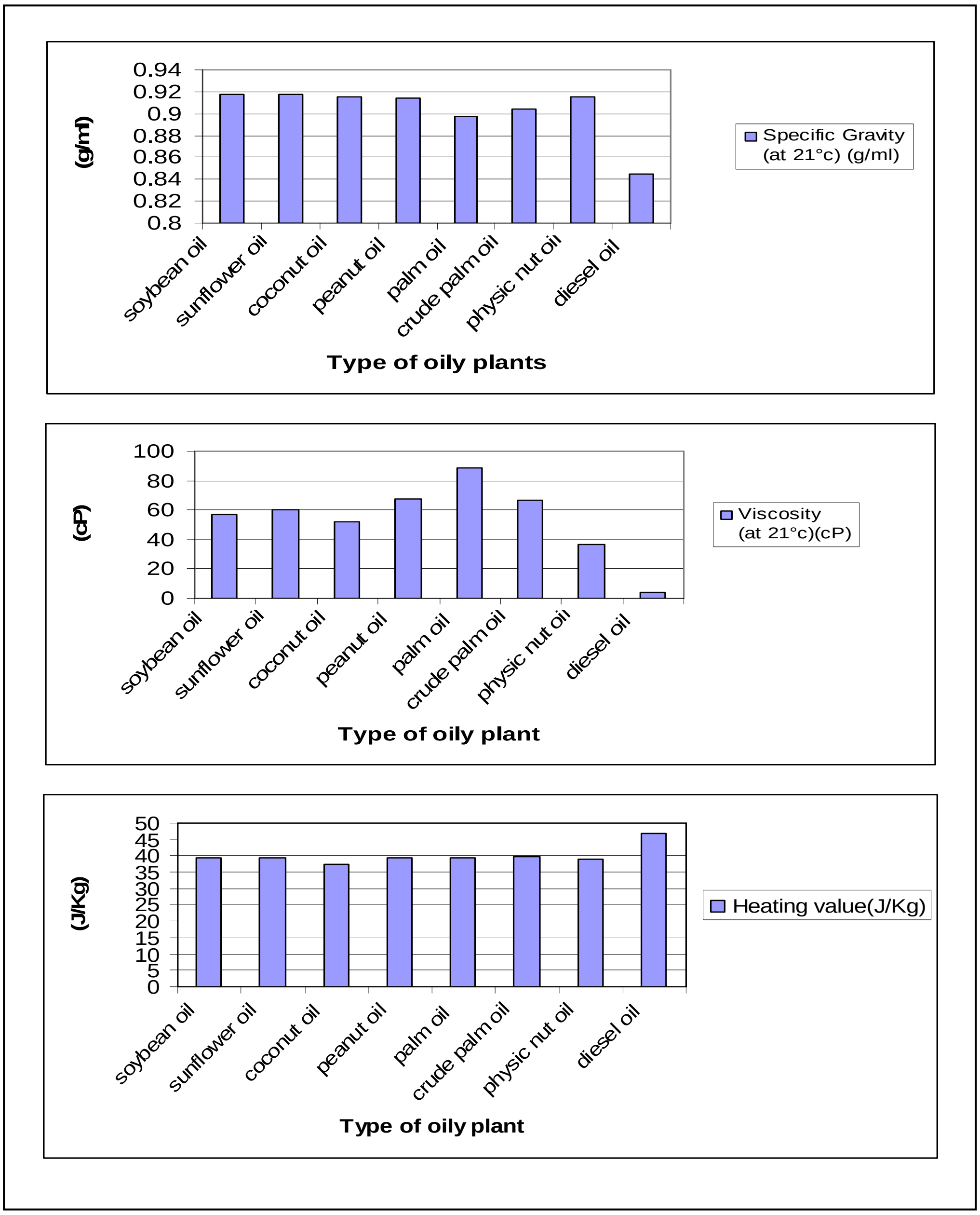

Figure 1.1 Properties of oily plants and diesel oil

Remark: Viscosity of Physic nut (at 38° C)

Source: Modified from Energy Commissioner of the House of Representative, B.E. 2545

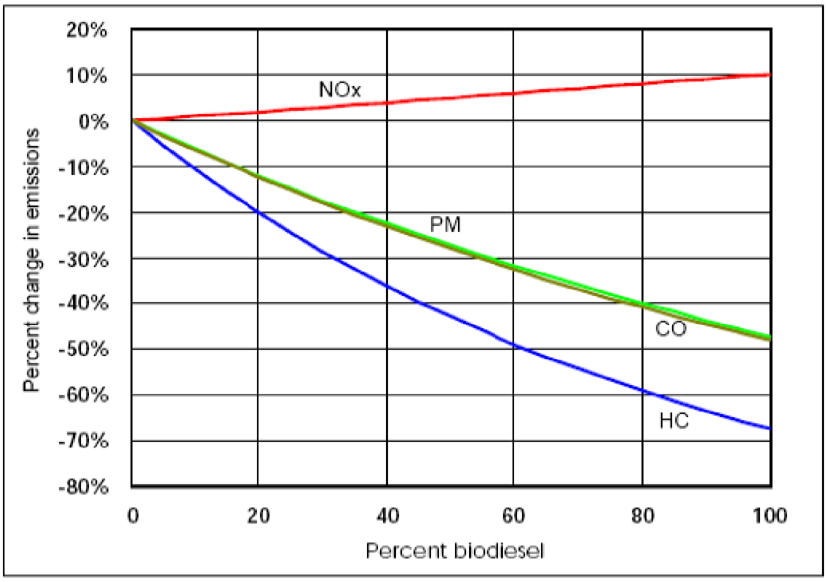

Figure 1.2 Percentage of change in emissions of biodiesels from heavy duty diesel vehicle

Source: United State Environmental Protection Agency, 2002

However, few researches on biodiesel related to air pollution problems in Thailand had been conducted, for example Mongkol Jhumpamee (B.E. 2547) studied exhaust pollutants of biodiesel from light duty diesel vehicle. Niroj Agkarapanyawich (B.E. 2548) studied efficiency and emission factor of biodiesel blends from light duty diesel vehicle. Regarding to these researches, the studies were undertaken in laboratory only. So, we are interesting in the prediction of emissions from biodiesel when we use them with diesel vehicle traveling on roads and how much the benefit obtained on air pollution alleviation. The traffic jam brought about air pollution in urban such as Bangkok. In 1991-2001, vehicles in Bangkok were 24 % of total vehicle in the country and these numbers composed of petrol vehicles 15.30%, diesel vehicle 7.72% and others 0.98% (Pollution Control Department, 2004). Furthermore, comparison of emissions releasing from petrol and diesel (Table 1.1), the emissions in diesel vehicle are higher than that of petrol vehicle. Heavy duty diesel vehicle released high carbon monoxide and hydrocarbon, while light duty diesel vehicle released higher oxide of nitrogen than petrol vehicle (Pollution Control Department, B.E. 2543).

Table 1.1 Emission factors from vehicles

Emission factors (g/km)	Types of vehicle		
	Heavy duty diesel vehicle	Light duty diesel vehicle	Petrol vehicle
Oxide of Nitrogen	28.478	4.116	1.460
Carbon monoxide	11.887	2.177	5.745
Hydrocarbon	3.074	0.984	1.535
Particulate matter	1.855	0.398	-

Source: Modified from Pollution Control Department, B.E. 2543

If we compare the emission tested by Pollution Control Department laboratory (Table 1.2) and standard of exhaust pollutants from a new light duty diesel vehicle, level 6 and a new diesel vehicle, level 7 (Table 1.3), it is found that the emissions of diesel vehicles exceeded the standard used for new vehicle.

Table 1.2 Summary of diesel vehicles emission tested by PCD laboratory

Type	Injection System	Vehicles tested	Test Mode	Driving Cycle	Emissions (g/km)					Efficiency (km/l)
					THC	NO_x	CO	CO_2	PM	
LDDV	DI	228	Cold	NYBC	0.105	1.224	0.562	261.072	0.090	10.787
LDDV	IDI	375	Cold	NYBC	0.065	1.020	0.502	270.000	0.085	10.116
HDDV	DI	176	Hot	TISI	4.189	17.427	30.239	1671.548	4.633	1.628

Remark: LDDV is Light Duty Diesel Vehicle, HDDV is Heavy Duty Diesel Vehicle
DI is Direct Injection, IDI is Indirect Injection, NYBC is New Bus Cycles,
TISI is Thai Industrial Standard Institute

Source: Pollution Control Department, 2004

Table 1.3 Standard of exhaust pollutants from a new light duty diesel vehicle, level six and a new diesel vehicle, level seven

Type of fuel	Reference Weight (RW) (kg)	CO (g/km)	HC (g/km)	NO_X (g/km)	HC + NO_X (g/km)	PM (g/km)
Petrol	RW ≤ 2,500	2.3	0.20	0.15	-	-
Diesel		0.64	-	0.5	0.56	0.05
Don't exceed six seats for vehicle and Don't exceed 2,500 kg for full load of weight						
Type of fuel	**Reference Weight (RW) (kg)**	**CO (g/km)**	**HC (g/km)**	**NO_X (g/km)**	**HC + NO_X (g/km)**	**PM (g/km)**
Petrol	RW ≤ 1,305	2.3	0.2	0.15	-	-
	1,305 ≤ RW ≤ 1,760	4.17	0.25	0.18	-	-
	RW ≥ 1,760	5.22	0.29	0.21	-	-
Diesel	RW ≤ 1,305	0.64	-	0.50	0.56	0.05
	1,305 ≤ RW ≤ 1,760	0.80	-	0.65	0.72	0.07
	RW ≥ 1,760	0.95	-	0.78	0.86	0.10
Don't exceed six seats for vehicle, modify from truck, Don't exceed 2,500 kg for full load of weight or ride outer public road and small truck						

Source: Pollution Control Department, B.E 2548

As mentioned earlier, it can be seen that diesel vehicle released more and higher emissions than that of biodiesel such as carbon monoxide, hydrocarbon and particulate matter. So, this research is interested in the study of applying types of biodiesel to vehicle fleet traveling on roads so as to find whether the difference between diesel and biodiesel on exhausted emissions.

1.2 Conceptual Framework

Diesel using for combustion in diesel engine bring traffic air pollution in high level and one way for air pollution mitigation is biodiesel. In order to study the emissions from diesel and biodiesel used in diesel vehicle, the factors such as the emission factors and traffic data are needed to be known so as to calculate the total emissions from both fuels.

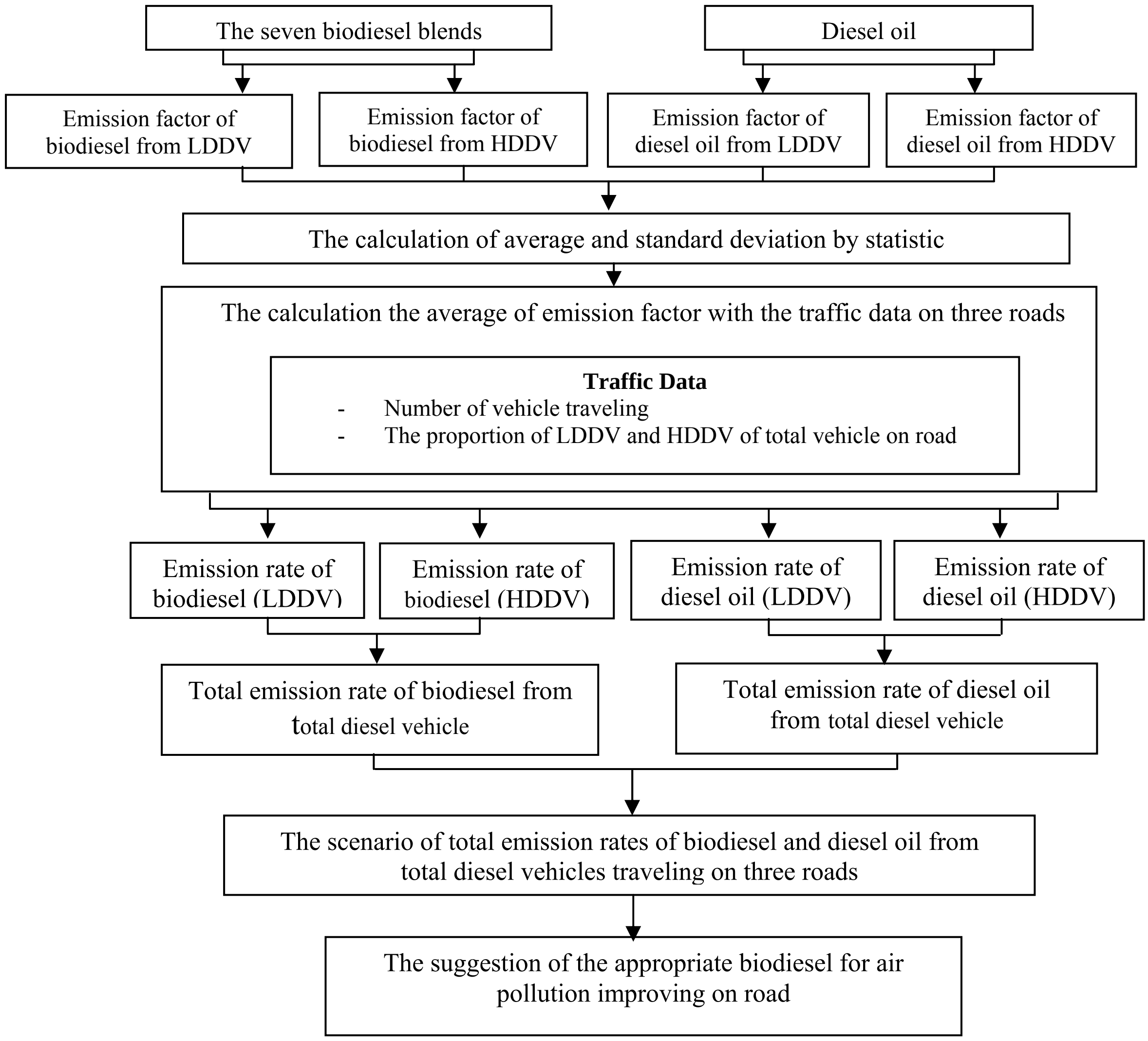

Figure 1.3 Conceptual Framework

1.3 Research Objectives

1) To study emission factor of biodiesels for diesel vehicle.
1) To estimate traffic emissions from biodiesel and diesel oil.
2) To suggest the use of biodiesel for air pollution mitigation.

1.4 Scope of the Study

(1) Types of biodiesel

This research cover seven biodiesel;

1. Soy biodiesel
2. Yellow grease biodiesel
3. Palm biodiesel
4. Coconut biodiesel
5. Rapeseed biodiesel
6. Used cooking oil biodiesel
7. Tallow biodiesel

(2) Types of pollutant

The pollutants of interest in this research are carbon monoxide, hydrocarbon, oxide of nitrogen and particulate matter.

(3) Types of vehicle

Diesel vehicles are categorized into two types;

- Heavy duty diesel vehicle (HDDV) : truck and bus.
- Light duty diesel vehicle (LDDV) : pickup and van.

(4) Traffic data

The traffic data used in this study are;

- Volume of traffic
- The proportion of LDDV and HDDV on vehicle fleet

(5) Study area

Traffic emissions are studied from vehicle fleet traveling along the roads of Intharaphithak Road, Ladprao Road and Dindaeng Road.

1.5 Definition

- **Biodiesel** is defined as an oily plant, animal oil or used cooking oil which is produced from transesterification reaction that this natural oil will be reacted with alcohol (methanol and ethanol) and catalyzed by acid or base. The results are ester (ethyl-ester or methyl-ester) called biodiesel or ester biodiesel.
- **Heavy duty diesel vehicle (HDDV)** is defined as a vehicle which has weight more than 6.5 tons and run by diesel fuel, for this research HDDV is truck and bus.
- **Light duty diesel vehicle (LDDV)** is defined as a vehicle which has weight less than 6.5 tons and run by diesel fuel, for this research LDDV is pickup and van.

1.6 Expected Outcome

The study from this research gives knowledge on both positive and negative impacts of using biodiesel on air quality. The finding in this study is a guildline to mitigate air pollution near roadside location and also useful on the basis of socio – economic issue.

CHAPTER II
LITERATURE REVIEWS

2.1 Fuel from vegetable oil

There are two type of fuel oil, the first type is fossil or petroleum oil that draws from underground and thoughts the extraction process under conditions of high pressure and high temperature for getting liquid petroleum gas, petrol, kerosene, diesel oil, bunker oil and etc. These products have many benefits for use in engines or industries. Therefore petroleum oil is a limit resource. Geologist forecasted that if we did not explore a new source of the petroleum accumulation, it will be run through in next 10 – 20 years. But this forecast was ignore with fuel consumption that rise up continually. So, it urges to seek new energy source such as the fuel from oily plant and oily animal for make instead of fossil oil (Energy Commissioner of the House of Representative, B.E. 2545). These oils have a lot of benefit. It is a material used in many processes such as raw material for production of paint, medicine, cosmetic or plastic and it is an alternative fuel oil in the present.

The vegetable oil can be extracted directly from oily plant i.e. peanut, soy bean, coconut and palm oil or from other plants that give starch and sugar i.e. cassava, corn, sugarcane, millet, tailings sugar or straw rice also (Energy Commissioner of the House of Representative, B.E. 2545). In general, there are two types of oily plant and oily animal for use in engine. They are the consumption oil such as soybean oil, coconut oil, palm oil, sesame oil or lard, and the non-consumption oil because of toxic mixture such as physic nut oil and castor oil. These oily plants can be changed to methyl-ester or ethyl-ester that call biodiesel by transesterification process and used instead of fossil oil. However biodiesel is a good fuel to keep environment and a renewable resource because they are produced by cultivation continuously.

2.2 Definition of biodiesel

Biodiesel is a good fuel oil which can be used in all diesel engines because it has chemical properties nearly the same as diesel oil. Therefore raw material for produce biodiesel is vegetable oil or animal oil and then bring through transesterification process that vegetable oil reacts with alcohol (methanol or ethanol) and has fast process and a lot of products by catalyst (acid or base). The last process gets output as ester (biodiesel) and glycerol. Biodiesel has negative impact on the environment less than diesel oil from petroleum oil because the quantity of oxygen in biodiesel is very high and will get a complete combustion that release low carbon monoxide, low carbon deposit and no sulfur dioxide (Klanarong Srirod *et.al*., B.E. 2546).

2.3 Biodiesel Types

Biodiesel has three types separated under their properties (The College of Kaset and Kanchanaburi Technology, B.E. 2549).

(1) Straight Vegetable Oil or Animal oil

This biodiesel type is a pure vegetable oil (i.e. coconut oil, palm oil, peanut oil or soybean oil) or pure animal oil from adipose (i.e. lard). We can take pure oil instantly or add some chemical mixture before use it in diesel engine also. Therefore, oil will be warmed before use because it has higher viscosity than diesel oil. This property of biodiesel cause the problem to engine such as oil changes to wax in cool air condition and give a difficult engine start or non complete combustion due to oil flow to combustion chamber very slow. So, these biodiesel get trouble when it is used directly in engine.

(2) Hybrid or Kero Mix

This biodiesel is mixture oil between vegetable oil /animal oil and kerosine, diesel oil or the other oils for giving chemical properties similar to diesel oil. For example coco-diesel is coconut oil mixes with kerosine. However, kerosine has high cost and it brings to non complete combustion also.

(3) Ester biodiesel

This biodiesel come from chemical process is transesterification reaction that vegetable oil or animal oil reacts with alcohol (methanol or ethanol) and catalyst by acid or base (Figure 2.1). The output of this reaction gives methyl/ethyl ester (biodiesel) which can be used directly in diesel engine as well. In addition, it is a real term of biodiesel as same as the international countries call biodiesel such as Germany, United State, Malaysia, etc. According to an interview on the difference between methanol and ethanol for biodiesel production with researcher from Department of Alternative Energy Development and Efficiency (DEDE) in Science day 23 September B.E. 2548 at Impact Muang Thong Thani, he said “Methanol and Ethanol are similar efficiency but the cost of the two alcohols is the main consideration for biodiesel production”. According to Renewable Energy Institute of Thailand Foundation (2000) gave definition of alcohol types (methanol and ethanol) as:

Methanol (Methyl alcohol : CH_3OH) comes from natural gas and chemical process. This alcohol can not be eaten because it is highly toxic to human health.

Ethanol (Ethyl alcohol : C_2H_5OH) comes from plant waste fermentation which changes starch to sugar and sugar to alcohol, respectively. It gives benefits for alcoholic production i.e. wine, beer, etc.

Vegetable oil or animal oil that has triglyceride + Methanol or Ethanol → Methyl ester or Ethyl ester (Biodiesel) + Glycerol

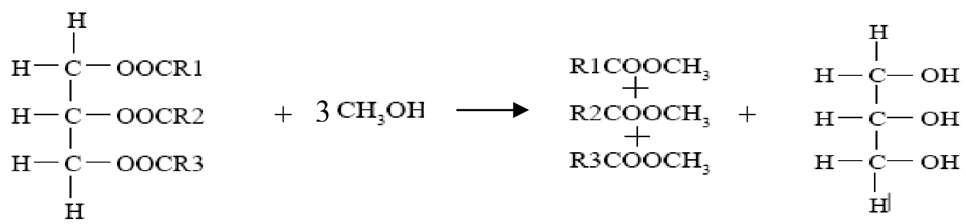

Figure 2.1 Transesterification reaction

Source: Energy Commissioner of the House of Representative, B.E. 2545

The proportion of alcohol and triglyceride at 3 : 1 that make a balance of process and make high product. The transesterification reaction gives major product as biodiesel and minor product as glycerin (Klanarong Srirod *et.al*, B.E. 2546). In addition, we can use biodiesel at 100 percent or other blends in diesel engine. Therefore biodiesel has oxygen component more than diesel oil (Figure 2.2) and bring to complete combustion and emit lower pollution than diesel oil too.

$RCOOCH_3$	$C_{16}H_{34}$
Biodiesel	Diesel oil

Figure 2.2 Structure of biodiesel and diesel oil

2.4 Raw material for biodiesel production

The vegetable oil and animal oil are raw materials for producing biodiesel and all types of oily plant can be extracted to biodiesel. The oily plant was selected under the chemical property of vegetable oil and quantity of oily plant cultivation in each area such as palm and coconut is favor to cultivate in Thailand, palm is favor in Malaysia, soybean is favor in the United State and rapeseed/sunflower is favor in European countries (Energy Commissioner of the House of Representative, B.E. 2545).

2.5 Quantity of oily plant production in foreign countries and Thailand

In the present, foreign countries are interesting in alternative fuel, especially biodiesel. They operate biodiesel production for use with some districts that have air pollution problem includes the widespread of neat biodiesel production by industries also. For Europe and the United State, biodiesel is used and sell regularly in the countries. Therefore, biodiesel was accepted to use in industries of automobile production and commercial fuel oil due to its high quality.

For 15 years ago, 28 countries studied and developed the process of biodiesel production. The eight countries had a lot of biodiesel production in the world. Those countries are Austria, Czech Republic, France, Germany, Republic of Niguaragua, Sweden and the United State. The view of biodiesel material 2002, rapeseed had the highest quantity in the World about 84% of all oily plant, sunflower seed 13%, soybean 1%, palm 1% and other oily plant about 1% (Klanarong Srirod *et.al*, B.E. 2546) as illustrated in Figure 2.3.

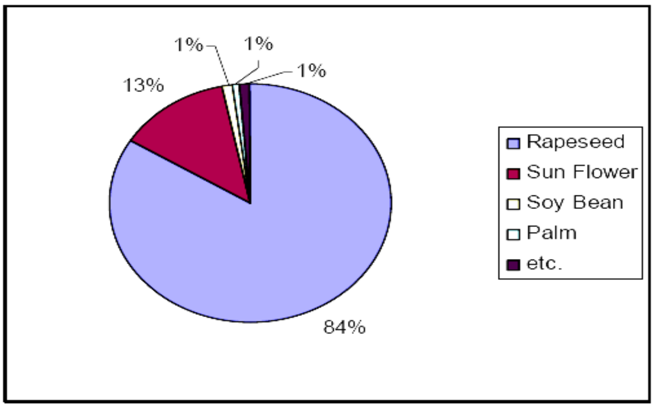

Figure 2.3 Proportion of oily plant in the world for biodiesel production

Many countries in European Union use a lot of rapeseed oil and sunflower seed oil for produce biodiesel and they have a share of production in 2000 about 1.27 million-ton (Energy Commissioner of the House of Representative, B.E. 2545). The United State produced biodiesel to three million gallons and the biodiesel production in Australia accommodates over 12 million gallons per year (Biodiesel Industries Inc, 2005).

The United States have soybean oil and used cooking oil as a major materials and minor materials are flaxseed oil and tallow oil. The industries of biodiesel production in developed countries have two types that were batch wise production and continuous production.

The countries in European Union had oily plant about 12.146 million-ton in 1995. These oily plants were rapeseed about 6.464 million-ton, sunflower seed about 3.87 million-ton, soybean about 1.012 million-ton and other oily plants about 0.8 million-ton (Figure 2.4) (Energy Commissioner of the House of Representative, B.E. 2545).

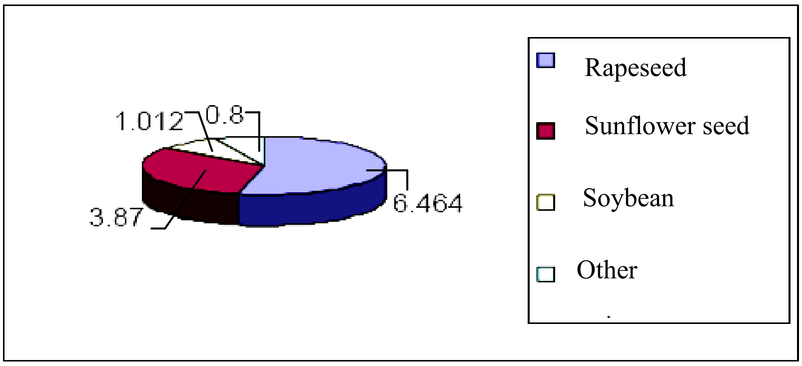

Figure 2.4 Quantity of oily plants in Europe 1995

Remark: Unit is million-ton

Thailand has seven types of oily plant that are soybean, palm, peanut, coconut, peanut, castor oil and sesame. Palm is the most of oily plant product in 2004 about 5.2 million-ton and coconut about 1.5 million-ton respectively (Office of Agriculture Economics, B.E. 2549). Table 2.1 shows the quantity of oily plant production in Thailand during 1997-2004.

Table 2.1 Quantity of oily plant production of Thailand during 1997 – 2004

Unit: Thousand-ton

Years	**Quantity of oily plants production**					
	Palm	**coconut**	**soybean**	**peanut**	**Castor oil**	**Sesame**
1997	2,578	2,064	1,475	538	6	35
1998	2,523	2,005	1,370	559	7	36
1999	3,413	2,110	1,404	563	7	37
2000	3,343	1,400	1,344	532	9	39
2001	4,097	1,396	1,103	432	9	39
2002	4,001	1,418	1,093	448	10	40
2003	4,903	1,432	936	296	10	40
2004	5,182	1,499	998	281	10	41

Source: Office of Agriculture Economics, B.E. 2549

In addition to the six oily plants from above, Thailand has other materials for biodiesel production such as physic nut oil, lard and used cooking oil. Although palm trees are cultivated a lot in Thailand but they gain 3.36 % only when compares with the quantity of palm cultivation in the world 2004 (Table 2.2) (Office of Agriculture Economics, B.E. 2549) or 2 % from data record of CORPODIB in Columbia

(Corporation for the Industrial Development of Biotechnology and Clean Production, 2004) (Figure 2.5).

Table 2.2 Quantity production of palm from countries in 2002 – 2004

Unit: Thousand-ton

Countries	Quantity production of palm cultivation			
	2002	2003	2004	% of 2004
Malaysia	59,546	66,775	68,050	44.14
Indonesia	46,400	49,750	55,000	35.68
Nigeria	8,500	8,600	8,600	5.58
Thailand	4,001	4,903	5,182	3.36
Columbia	2,600	2,633	3,000	1.95
Republic of Ecuador	1,506	1,450	1,480	0.96
Republic of Cote d'ivorie (Ivory Coast)	1,400	1,400	1,400	0.91
Cameroon	1,150	1,200	1,200	0.78
Papua New Guinea	1,178	1,161	1,200	0.78
Congo	1,150	1,150	1,150	0.75
Other countries	7,762	7,913	7,899	5.12
Total of quantity production all the world	135,193	146,935	154,161	100

Source: Modify from Office of Agriculture Economics, B.E. 2549

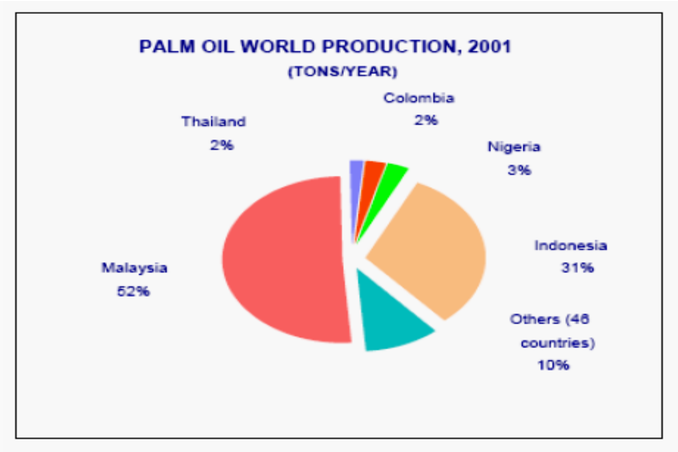

Figure 2.5 Quantity of palm in the world

Source: Corporation for the Industrial Development of Biotechnology and Clean Production, 2004

2.6 The properties of oily plant for biodiesel production

The Energy Commissioner of the House of Representative (B.E. 2545) explained properties of vegetable oil and properties of biodiesel (Table 2.3), therefore as:

- For vegetable oil using in diesel engine, it has high heating value about 83 – 85 % of diesel oil.
- The vegetable oil and animal oil have viscosity higher than diesel oil. If the temperature of these oils is decrease, viscosity of them will get higher and then transform to wax i.e. palm oil has suitable temperature at 24 - 26 ° C, but it will transform to 36% wax at 20 ° C include obstacle for fuel flow and combustion process, especially in winter season or cold air.
- The vegetable oil has poor evaporation of properties. So, oil flows very sticky when it is input into combust chamber. In addition it will remain carbon black in engine higher than diesel oil using.

Table 2.3 Properties of vegetable oils and diesel oil

Types of oil	Properties of oil		
	Specific gravity (at 21 ° C) (g/ml)	Viscosity (at 21 ° C) (cP)	Heating value (KJ/Kg)
Soybean	0.918	57.2	39,350
Sunflower	0.918	60.0	39,490
Coconut	0.915	51.9	37,540
Peanut	0.914	67.1	39,470
Palm	0.898	88.6	39,550
Palm seed	0.904	66.3	39,720
Physic nut seed	0.915	36.9 *	39,000
Diesel oil	0.845	3.8	46,800

Remark: * at 38 ° C

Source: Energy Commissioner of the House of Representative, B.E. 2545

However, the comparison on the quality of material types for biodiesel production in the World indicated that vegetable oil has higher quality than animal oil and used cooking oil, especially rapeseed oil was the best quality, sunflower seed oil, soybean and palm oil respectively. Otherwise, Figure 2.6 point that the sustainable raw material oil is used cooking oil, tallow and rapeseed oil respectively. Therefore, sustainable vegetable oil depends on quantity of raw material for support to biodiesel production process.

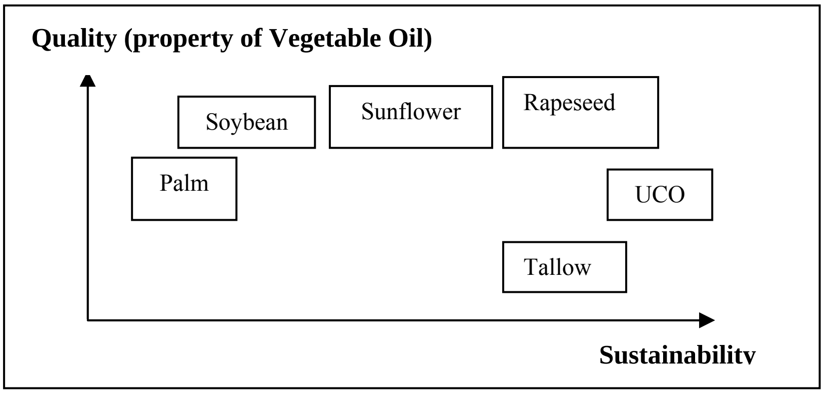

Figure 2.6 Quality of material for biodiesel production

Remark: UCO is used cooking oil

Source: Beer *et.al.*, 2002

2.7 The properties of biodiesel

After vegetable oil is transformed through transesterification process and become to be biodiesel (methyl/ethyl ester), their viscosity are similar to diesel oil but flash point is higher than diesel oil. It is indirect benefit safety for fuel transportation. Biodiesel also has high cetane number that makes it easy to start engine (Energy Commissioner of the House of Representative, B.E. 2545). In addition to a study conducted in Australia, properties of biodiesel from vegetables oil such as canola, palm, soybean and sunflower had properties similar to diesel oil (Beer T *et.al.*, 2002) (Table 2.4).

Table 2.4 Properties of biodiesels

Properties	Biodiesel types						
	Diesel oil	**Canola**	**Biodiesel (FAMAE)**	**Palm oil methyl ester**	**Soy methyl ester**	**Sunflower Methyl ester**	**Tallow methyl ester**
Density (Kg/L) at 15.5 ° C	0.835	0.922	0.88	0.88	0.884	0.880	0.877
Gross calorific value (MJ/L)	38.3	36.9	33.3	37.8	39.8	38.1	39.9
Viscosity (mm^2/s at 37.8 ° C)	3.86	37	4.7	5.7	4.08	4.6	4.1
Cetane number	51-58	-	> 40	62	46	49	58

Remark: FAMAE (Fatty Acid Mono Alkyl Ester)

2.8 The production of biodiesel in the world and Thailand

2.8.1 Biodiesel production in the world

Many countries in the world confront with the energy crisis and environmental problems such as global warming from greenhouse effect gas. So, they will search new fuel which brings about sustainable energy and least impacts to environmental to replace the use of petroleum oil.

The European group which are Germany, France, Italy, England, Austria, East Europe include other counties are United State and Australia also have many industries of biodiesel production for support biodiesel using in the future. The Germany people have the most of biodiesel production in all countries. They can produce biodiesel about 1 million-ton/year. Furthermore, they use biodiesel blends 100% in diesel vehicle and use in fireplace of their house (Energy Commissioner of the House of Representative, B.E. 2545) (Figure 2.7). In addition, the countries in Europe have corporate to design a policy name "Common Agricultural Policy: 1992" for support vegetable oil farm for produce biodiesel i.e. rapeseed and sunflower seed.

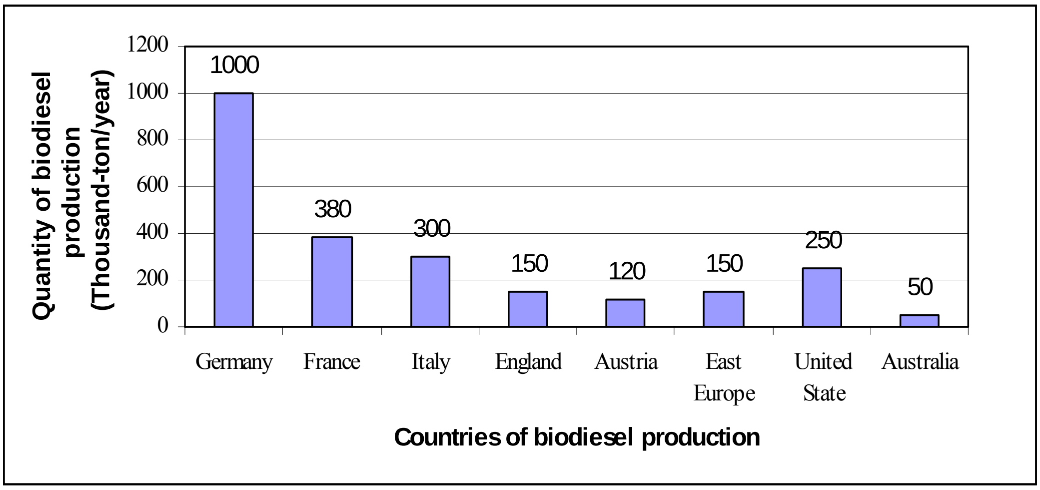

Figure 2.7 Quantity of biodiesel production of countries 2002

Source: Modify from Energy Commissioner of the House of Representative, B.E. 2545

In order to promote lush quality of biodiesel standard, European group set standard for biodiesel in 2002 known as DIN EN 14214 (Table 2.5). In addition to The United State and other countries in Europe corporate created universal standard of biodiesel for used and control biodiesel quality in their countries (Table 2.6).

Table 2.5 DIN EN 14214 Standard of biodiesel quality in Europe

Properties of biodiesel	Unit	Standard		Testing method
		Minimum	Maximum	
Ester content	%w	96.5	-	Pr EN 14103
Density at 15 ° C	Kg/m^3	860	900	EN ISO 3675
Viscosity at 40 ° C	mm/s	3.5	5.0	EN ISO 12185
Flash point	° C	120	-	EN ISO 3104
Sulphur	mg/Kg	-	-	-
Carbon remain at 10% of distillat.	%w	-	0.3	ISO/CD 3679
Cetane number	-	51.0	-	EN ISO 5165
Ash	% w	-	0.02	ISO 3987
Water	mg/Kg	-	500	EN ISO 12937
Contaminate substance	mg/Kg	-	24	EN 12662
Copper corrosion (3 cm, at 50 ° C)	Criteria test	1	-	EN ISO 2160
Stable value at 110 ° C	hour	6.0	-	Pr EN 14112
Acid	mg KOH/g	-	0.5	Pr EN 14104
Iodine	-	-	120	Pr EN 14111
Ester content of Linolenic type	%w	-	12	Pr EN 14103
Ester content of unsaturated type (≥ 4 double bonds)	%w	-	1	-
Methanol	%w	-	0.2	Pr EN 14110
Monoglyceride	%w	-	0.6	Pr EN 14105
Diglyceride	%w	-	0.2	Pr EN 14105
Triglyceride	%w	-	0.2	Pr EN 14105

Source: Energy Commissioner of the House of Representative, B.E. 2545

Table 2.6 Standard of biodiesel quality in countries

Properties of biodiesel	Countries						
	Austria	**Czech Republic**	**France**	**Germany**	**Italy**	**Sweden**	**U.S.A**
Standard/Specification	ON C1191	CSN 65 6507	Journal Official	DIN V51606	-	155436	ASTM PS121-99
Date	July 1997	Sep. 1998	Sep. 1997	Sep. 1997	April 1997	Nov. 1996	July 1999
Application	FAME	RME	VOME	FAME	VOME	VOME	FAMAE
Density at 15 ° C (g/cm^3)	0.85-0.89	0.87-0.89	0.87-0.90	0.88-0.90	0.86-0.90	0.87-0.90	-
Viscosity at 40 ° C (mm^2/s)	3.5-5.0	3.5-5.0	3.5-5.0	3.5-5.0	3.5-5.0	3.5-5.0	1.9-6.0
Distillation 95% ° C	-	-	≤ 360	-	≤ 360	-	-
Flashpoint ° C	≤100	≤100	≤100	≤100	≤100	≤100	≤100
CFPP ° C	0/ -15	-5	-	0/-10/-20	-	-5	-
Pour point ° C	-	-	≤ -10	-	≤0/≤-15	-	-
Sulphur % mass	≤0.02	≤0.02	-	≤0.01	≤0.01	≤0.001	≤0.05
100% CCR % mass	≤0.05	≤0.05	-	≤0.05	-	-	≤0.05
10% distresid. % mass	-	-	≤0.3	-	≤0.5	-	-
Sulfated ash % mass	≤0.02	≤0.02	-	≤0.03	-	-	≤0.02
(Oxid) Ash % mass	-	-	-	-	≤0.01	≤0.01	-
Water (mg/Kg)	-	≤500	≤200	≤300	≤700	≤300	≤0.05%
Total contamination (mg/Kg)	-	≤24	-	≤20	-	≤20	-
Cu-corrosion 3h/50 ° C	-	1	-	1	-	-	≤No.3
Cetane number	-	≥49	≥48	≥49	≥49	≥48	≥40
Natural number mgKOH/g	≤0.8	≤0.5	≤0.5	≤0.5	≤0.5	≤0.6	≤0.8
Methanol %mass	≤0.2	-	≤0.1	≤0.3	≤0.2	≤0.2	-
Ester content %mass	-	-	≥96.5	-	≥98	≥98	-
Monoglyceride %mass	-	-	≤0.8	≤0.8	≤0.8	≤0.8	-
Diglyceride %mass	-	-	≤0.2	≤0.4	≤0.2	≤0.1	-
Triglyceride %mass	-	-	≤0.2	≤0.4	≤0.1	≤0.1	-
Free glycerol %mass	≤0.02	≤0.02	≤0.02	≤0.02	≤0.05	≤0.02	≤0.02
Total glycerol	≤0.24	≤0.24	≤0.25	≤0.25	-	-	≤0.24
Iodine number	≤120	-	≤115	≤115	-	≤125	-
C18:3 and high unsaturated acids %mass	≤15	-	-	-	-	-	-
Phosphor mg/Kg	≤20	≤20	≤10	≤10	≤10	≤10	-
Alkalinity mg/Kg	-	≤10	≤5	≤5	-	≤10	-

Source: Beer *et.al*, 2002

Foreign countries are interesting in the pollutant releasing from biodiesel such as the use of biodiesel in diesel vehicle. In Germany, a study showed that emission releasing from biodiesel has pollutants less than that of diesel oil, except oxide of nitrogen (Table 2.7).

Table 2.7 Emissions of rapeseed biodiesel use in diesel engine

Types of pollution	% emission of diesel oil
Carbon monoxide	about the same
Hydrocarbon	40% lower than diesel oil
Oxide of nitrogen	15% higher than diesel oil
Particulate matter	40% lower than diesel oil
Cancer substance	50% lower than diesel oil

Source: modify from Energy Commissioner of the House of Representative, B.E 2545

2.8.2 Biodiesel production in Thailand

Thailand is interesting in alternative fuel. The development of biodiesel has been initiated by the government departments who support the experiment and researches of biodiesel using in the country. Therefore they have many projects for develop and make people to understand the use of biodiesel such as the project of machine modeling of biodiesel production for used in pilot communities in amphor Sriprachan, Suphanburi province and amphor Nahwa, Nakornpanom province, supported by Department of Alternative Energy Development and Efficiency (DEDE). The biodiesel from used palm oil, lard and used cooking oil from pork rind were used in minibus in Changmai province by cooperation of DEDE, Changmai municipal, Sahakorn nakornlanna CO. LTD, PTT Public Company Limited, the Bangchak Petroleum Public Company Limited, Department of Energy Business, Pollution Control Department, Royal Thai Navy Dockyard, Department of Industrial Works, Ministry of Public Health, Prince of Songkla University, Society of Automotive Engineer Thailand and the Thai Automotive Industry Association. This project was implemented in two phases;

1) The biodiesel blend 2% was used by 1,000 minibuses.
2) The use of biodiesel blends 20% and 50% in minibus and fifteen diesel vehicles was monitored for air pollution and test of engine efficiency.

Surat Thani province has abundant of palm oil and coconut oil to produce biodiesel. The use and production of biodiesel from oily plant in Thailand has begun since in 2000 by the King of Thailand who began the use of palm oil replaced diesel oil. Therefore the King had kindness and supported the study and research to improve the diesel engine. His excellent approach interpolated by the energy conservation and energy cycle of policy by DEDE.

In addition to overview of biodiesel production management combines with suitable of raw material types and cultivation method, capacities of soil quality in the area, suitable of technology for production which highs efficiency, lows cost and no effects on engine, the quantity control of raw material for prevents biodiesel lacking include the worker training for increases potential of worker practice.

Furthermore, the strategy of biodiesel supporting and development was announced since 18 January 2005. This strategy explained about the potential of palm oil about a production and commercial that higher than other vegetables oil because of low capital, low cost and varies benefit for the consumption. In other words, some factories of palm extract could be produced total palm oil 10.81 million-ton/year and the remained quantity of palm oil in each year produced biodiesel to 500,000 liter/day, include the prediction of palm cultivation in 2008 will increase about 10 million farms and the target of this strategy will produce biodiesel up to 720 million-liter/year in 2011 (Department of Alternative Energy Development and Efficiency, B.E. 2549).

2.9 An advantage and disadvantage of biodiesel

Biodiesel has been promoted to substitute diesel oil following the King of Thailand's opinion. It has many advantages but disadvantage together.

2.9.1 The advantage of biodiesel

(1) The benefit of biodiesel for engine performance

1. The institute and technology of PTT Public Company Limited conducted experiments with biodiesel blend 1 – 2 %. It was found that the use of biodiesel increase lubrication of diesel oil. Biodiesel is a clean fuel and good to

environment due to the easy decompose in nature, especially when it contaminates in runoff and ground water.

2. The components of biodiesel have higher oxygen content than diesel oil about 10%. It is stable for spreads and mixes with oil that increase ratio of oxygen volume in oil as well. So, biodiesel promotes the completed combustion, so it releases pollutants less than diesel oil.

3. Although biodiesel has heating value lower than diesel oil about 10% but it still has capacity and efficiency like diesel oil because biodiesel dose not impact with engine working and has complete combustion.

(2) The benefit of biodiesel on economic

1. The use of biodiesel will increase the revenue in country and decrease number of unemployment in rural because they are important labor for cultivate oily plant and produce biodiesel.

2. The use of biodiesel will decrease an expenditure of crude oil importing because the country spent about 300,000 million baht for import fuel oil every year.

3. The use of biodiesel brings a balance of currency and energy in the country.

(3) The benefit of the use of biodiesel on the environment

1. Biodiesel was used to improve air pollution problem as well. Therefore, National Biodiesel Board and U.S Environmental Protection Agency of United State conducted a test on biodiesel at various blends in diesel engine and they found that the use of biodiesel blend 20 and 100 decreased pollutant. In addition, Royal Thai Navy Dockyard tested biodiesel with engine 145 horse power. The results showed that biodiesel decrease black smoke more than 40 %.

2. Biodiesel releases gases of global warming less than diesel oil. It releases carbon monoxide and hydrocarbon very low and it dose not releases sulfur dioxide which is a major pollutant for acid rain. In addition, biodiesel has a few aromatic chemical which is carcinogen substance.

3. The use of biodiesel will protect organism in water and soil when it discharges into the area because biodiesel is a clean fuel oil and it can be decomposed very fast in environment.

4. Biodiesel has a flash point lower than diesel oil relative with safety transportation fuel.

5. Used cooking oil has dioxin compound while it can be produced to biodiesel which is better to use it as biodiesel than to reuse it as cooking oil again. So, it can reduce a return of the second cooking oil.

2.9.2 The disadvantage of biodiesel

Biodiesel is not suitable to use with old vehicle. It increases oxide of nitrogen in air also because it has high oxygen that release a lot of nitrogen oxide, that later transfer to nitrogen dioxide from chemical reaction in air. Therefore this gas brings to global warming effect and has impact on human health.

2.10 Emission Factor

2.10.1 Definition of Emission Factor

Environmental software and services (2007) defines an emission factor that it is the amount of pollutant generated (unit is g/km) from a single vehicle of the given category in the given speed range. This is then converted to the required emission unit of g/m per segment by correcting for the number of vehicle and their distribution, segment length, and average speed. Optional corrections for colds start trips and road type can be applied.

Environmental Health & Safety, Atlanta (2002) defines an emission factor as a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant. The factors facilitate the estimation of emissions from various sources of air pollution. In most cases, these factors are simply averages of all available data of acceptable quality, and are generally assumed to be representative of long-term averages for all facilities in the source category. Emission factor uses for emission estimation.

The general equation for emission estimation is:

$$E = A \times EF \times (1-ER/100)$$

where:

E = emissions, A = activity rate, EF = emission factor, and ER= overall emission reduction efficiency, %.

Emission factors and emission inventories have long been fundamental tools for air quality management. Emission estimates are important for developing emission control strategies, determining applicability of permitting and control programs, ascertaining the effects of sources and appropriate mitigation strategies, and a number of other related applications by an array of users, including federal, state, and local agencies, consultants, and industry. Data from source-specific emission tests or continuous emission monitors are usually preferred for estimating a source's emissions because those data provide the best representation of the tested source's emissions. However, test data from individual sources are not always available and, even then, they may not reflect the variability of actual emissions over time. Thus, emission factors are frequently the best or only method available for estimating emissions, in spite of their limitations.

2.10.2 The use of emission factor

Emission factors may be appropriate to use in a number of situations such as making source-specific emission estimates for area inventories. These inventories have many purposes including ambient dispersion modeling and analysis, control strategy development, and in screening sources for compliance investigations. The use of emission factor may also be appropriate in some permitting applications, such as in applicability determinations and in establishing operating permit fees (Environmental Health & Safety, Atlanta, 2002).

2.11 Pollution from the combustion process of fuel oil

2.11.1 Emission system (Napaporn and Sangsan Panich, B.E. 2544)

(1) Emission sources

Emission sources are the first part of system that emit and disperse pollution to atmosphere. According to types and quantities of pollutant come from many sources that depend on types of source and those sources have an equipment of pollution control or not.

(2) Atmosphere

An atmosphere is a pathway of pollutants from some sources to receptor and the air is a medium for disperse pollutant to the target by a meteorology (temperature, wind speed, wind line and etc.) and topography (a valley, a mountain, artificial human made and etc.).

(3) Receptors

Receptors are everything obtained effect that decline or hazardous with them who are organic (human, plant or animal) and inorganic (clothing, building, residence and etc.). The levels of these impacts depend on a concentration of emission and exposure time of human.

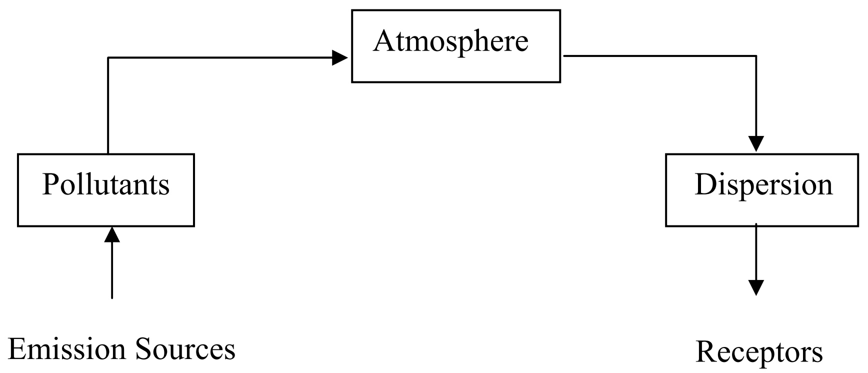

Figure 2.8 Air Pollution System

Source : Napaporn and Sangsan Panich, B.E. 2544

2.11.2 Air Pollutants

As economic in the country grows rapid because the social changes from agricultural base to industrial base. The big cities are changed to business cities where have thrive, a good facilities and high density of population. These things bring about a demand of traveling and transportation which make a bad situation i.e. the traffic jam. The traffic causes air pollution problem with all activities of vehicles on roads such as speed of vehicle slow down and behavior driving that will stop and run vehicle often. These problems are due to the use of fossil fuel and incomplete combustion that is a major source of emissions to atmosphere i.e. carbon monoxide, oxide of nitrogen, hydrocarbon, particulate, sulfur dioxide, black smoke and white smoke.

For diesel vehicle, a major of pollutants releasing are carbon monoxide, oxide of nitrogen, particulate and hydrocarbon.

(1) Carbon monoxide: CO

Carbon monoxide is a colorless gas, odorless and has weight slightly less than air. When we inhale this gas into our lung, it catches with hemoglobin of red blood better than oxygen 200 to 250 times and it is called carboxyhemoglobin (CoHb). Blood will decrease efficiency for transport oxygen from lung to all tissues in body. Generally, quantity of CoHb in blood depends on the quantity of inspiration include carbon monoxide concentration and exposure time. Furthermore, the human symptom is acute or chronic will depend on a respond and sensitivity of each person (Napaporn and Sangsan Panich, B.E. 2544).

The releasing of carbon monoxide from vehicle occurs from improper ratio of the air and fuel that bring to incomplete combustion. In addition carbon monoxide can be changed to carbon dioxide that is one of greenhouse effect gas too. (Green World Foundation, B.E. 2535).

(2) Nitrogen dioxide: NO_2

Oxide of nitrogen is composed of nitrous oxide, nitric oxide, dinitrogen oxide, nitrogen dioxide, dinitrogen tetroxide and dinitrogen pentroxide. In the basic of air pollution, we mean NO and NO_2 only because they are natural gas in atmosphere and important with all organisms (Napaporn and Sangsan Panich, B.E. 2544).

Nitric oxide is colorless gas and dissolves little in water. Nitrogen dioxide is a gas at normal temperature. These gases come from a natural such as thunderbolt, flash of lightning, volcano explosion, a few of microorganism reaction in soil and specially is human action i.e. fuel burning, industrial, a making of nitric acid and sulfur, metal dipping and explode material. The activities of human such as a driving or industries are produced this gas more than natural. Nitric oxide will react with ozone in the air and turn to be nitrogen dioxide and oxygen that can backward reaction.

$$NO + O_3 \longleftrightarrow NO_2 + O_2$$

For the impact to human health, nitrogen dioxide will be harmful to our lung more than nitric oxide. The human get odor of nitrogen dioxide at concentration of 230 $\mu g/m^3$ and people's sensitive fast when atmosphere has high humidity. An asthma patient has symptoms when expose to this gas at 190 $\mu g/m^3$ (Wongpan Limpasaeni *et.al*., B.E. 2543).

The vehicles release high oxide of nitrogen. It comes from complete combustion process which nitrogen oxide will react with oxygen in the air and become to nitrogen dioxide. So, while we try to decrease carbon monoxide by complete combustion but it promotes the production of high nitrogen dioxide (Green World Foundation, B.E. 2535).

(3) Black smoke

The major sources of black smoke are diesel vehicle more than petrol vehicle about 40%. Black smoke comes from incomplete combustion that carbon particle will agglomerate to be black smoke. (Poonporn Sangbangpla, B.E. 2537).

(4) Hydrocarbons: HC

This study concerns the hydrocarbons in the form of gas in atmosphere and hydrocarbon compounds. There are three types as aliphatic, alicyclic and aromatic that depend on atom arrange and chemical property. It can be divided into saturated and unsaturated (Wongpan Limpasaeni *et.al*., B.E. 2543).

Hydrocarbons in vehicle exhaust come from incomplete combustion process like carbon monoxide. The incomplete combustion causes from partition combustion of cylinder block where a wall of this partition will be cooled until oil spray cannot burn. Diesel vehicle releases hydrocarbon less than petrol vehicle due to high volume of air and high temperature in combustion chamber. Otherwise, type of vehicle four strokes uses liquid-gas will release hydrocarbons more than petrol vehicle too (Green World Foundation, B.E. 2535).

(5) Particulate matter

Particulate matter is substances as solid, liquid and semi solid or semi gas. Therefore, these particulate has diameter of 0.0002 – 500 micron and it disperses in atmosphere i.e. smoke, soot, dust, ash or carbon (Chikao Kanaoka and Wiwat Tantapanichakul, B.E. 2528).

- Fine dust has a diameter less than 100 micron.
- Coarse dust has a diameter more than 100 micron.
- Fume or smoke has a diameter about 0.001 – 1 micron. It comes from condensation, sublimation or chemical reaction.
- Mist has a diameter about 0.1 – 10 micron that composes liquid particulate from condensation and sublimation (Institute for Innovation and Development of Learning Process, 2006).

2.12 Air quality in Bangkok

Air pollution is important problem in an urban. Bangkok is a big city and people has variable lifestyle depends on a traveling. The air quality concerns five pollutants which are particulate matter less than 10 micron (24 hours average), carbon monoxide (maximum 8 hours average), ozone (maximum 1 hour average), sulfur dioxide (24 hours average) and nitrogen dioxide (maximum 1 hour average). Air quality index is divided into five levels as good, medium, impact health, strength impact health and hazardous. The result of air quality index in Bangkok is medium level 55.2% and impact health 44.8% but the trend shows an increase of air pollution during 2002 – 2004 (Pollution Control Department, B.E. 2548) (Figure 2.9).

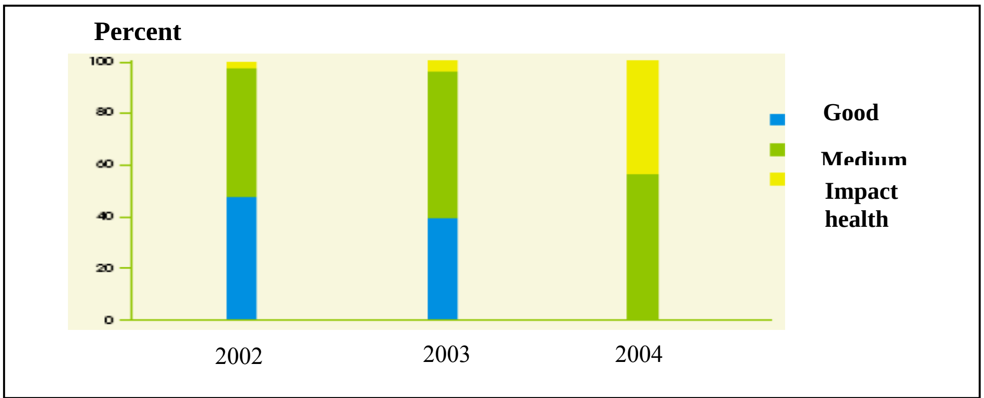

Figure 2.9 Air quality index in Bangkok

Source: Pollution Control Department, B.E. 2548

An air quality in Bangkok is poor due to a lot of pollution releasing from a traveling, especially the traffic jams. Furthermore, this problem will be checked from monitoring air quality on a roadside in Bangkok by Pollution Control Department (Pollution Control Department, B.E. 2548) who installs seven ambient monitoring stations on roadside :

- Ministry of Science and Technology on Rama VI Road
- Department of Land Transport on Pahonyothin Road
- Chulalongkorn Hospital on Rama IV Road
- July 22nd Circle on Yoawaraj Road
- The Thonburi electricity Substation on Intharapitak Road
- The Chokchai Metropolitan Police Station on Ladprao Road
- The Dindaeng Community Domestic on Dindaeng Road

From results of monitoring on roadside (Pollution Control Department, B.E 2548), many pollutants exceed the air quality standard of Thailand such as particulate matter less than 10 micron, carbon monoxide, ozone and nitrogen dioxide (Table 2.8) due to high concentrate of pollutants releasing and high density of vehicles on road include a surface road for support them is narrow. These factors bring to the traffic jam and release high pollution.

Table 2.8 Air quality at roadside site in Bangkok 2005

Pollutants	Values range	Percentile 95	Standard	Number of exceed standard/ measurement (%)	1 year Average
TSP (24 hr average)(μg/m^3)	0.01 – 0.77	0.38	0.33	53/631 (8.4)	0.18
PM10 (24 hr average)(μg/m^3)	21.5 – 224.8	135.2	120	243/2.282 (10.6)	78.5
Pb (1month average) (μg/m^3)	0.02 – 0.31	0.22	1.5	0/104 (0)	0.10
CO (1 hr average) (ppm)	0 - 151	4.5	30	0/55.940 (0)	1.7
CO (8 hr average) (ppm)	0 – 10.6	4.1	9	44/56.647 (0.08)	1.7
O_3 (1 hr average) (ppb)	0 – 143.0	45.0	100	12/24.977 (0.05)	12.4
SO_2 (1 hr average) (ppb)	0 – 66.0	17.0	300	0/24.615 (0)	7.0
SO_2 (8 hr average) (ppb)	0.4 -23.6	12.8	120	0/1.069 (0)	7.0
NO_2 (8 hr average) (ppb)	0 – 172.0	77.0	170	1/24.895 (0.004)	34.7

Source: Pollution Control Department, B.E. 2548

According to a report of developing integrated emission strategies for existing land transport diesel program 2004 conducted by Pollution Control Department (Pollution Control Department, 2004), during 1991 – 2001 there were in-used vehicles in Bangkok about 24% of the country. Diesel vehicles in Bangkok are compared of 52 %micro bus, 21% pickup and van, 21 % bus and 17 % truck, respectively (Table 2.9).

Table 2.9 Number of in-use vehicle by type in Thailand 1991 and 2001

Type	1991	2001	% of overall fleet	% growth rate	% in Bangkok
Private Cars	669,920	1,767,704	15.4	10.0	61
Micro Bus	409,694	316,053	2.7	NC	52
Pickup & Van	731,619	2,439,413	21.2	12.8	21
Taxi	14,338	53,022	0.5	14.0	100
Tuk Tuk	15,171	15,627	0.1	NS	46
Motorcycle	3,947,017	6,257,156	54.4	4.7	13
Bus	89,193	95,750	0.8	1.0	21
Truck	334,724	465,639	4.1	3.3	17
Other	94,968	86,830	0.8	NC	14
Total	6,306,644	11,497,194	100	6.2	24

Source: Pollution Control Department, 2004

However, Table 2.10 shows a difference of PM_{10} between diesel vehicle and gasoline vehicle which diesel vehicle releases PM_{10} 89% but gasoline released 11% only. Diesel vehicle releases other pollutants very high also i.e. carbon monoxide, oxide of nitrogen and hydrocarbons as seen in Table 1.2. So, diesel vehicle is one of important source of air pollution in Bangkok and a way to improve air pollution problem from traffic is to use clean fuel that will emit pollution less than petroleum fuel.

Table 2.10 Quantity of particulate matter less than 10 micron from vehicles in Bangkok 2000

Vehicle Types		PM_{10} (%)
Diesel vehicles	Light duty trucks	31
	City buses	30
	City trucks	23
	Long haul trucks and buses	5
	Total	89
Gasoline vehicles	Motorcycles	10
	Passenger cars	1
	Total	11

Source: Pollution Control Department, 2004

2.13 Related Researches

The selection of biodiesel uses in diesel vehicle will concern about emission. Therefore we will study biodiesel about a process, properties, component and performance. For biodiesel production process, Phanida Siribangkerdphol (B.E 2544) studied about a modification of vegetable oil and animal oil to biodiesel by transesterification process that used methyl or ethyl alcohol reacting with acid or base as a catalyst for change this oil to ester (methyl ester or ethyl ester). Biodiesel has properties similar to diesel oil. Biodiesel, as know worldwide, produced by that reaction.

Regarding to raw material, biodiesel has different property due to types of raw material. Pitsamai Jenwanichpanjakul (B.E 2544) reviewed the properties of vegetable oil types in Thailand (Table 2.11) and it was found that Thailand had many raw materials for the production of biodiesel, such as peanut oil, physic nut oil, coconut oil, palm oil and ester of palm. In addition, Pitsamai compared peanut oil with diesel oil in seven horsepower Yanma engine which did not modify engine. This result showed that peanut oil had high viscosity, difficult to start engine and had a problem of interrupt running at low speed. These problems led to incomplete combustion and emitted high pollution too. The performance of peanut oil and diesel oil were similar when engine run in short time, but peanut oil impaired the engine which cause carbon deposited on a piston more than diesel oil and many sediments in a fuel tank. Pitsamai solved this problem by mixed 40 % peanut oil and 60 % kerosene, and 50 % peanut oil and 50 % diesel oil for reducing a viscosity. This modification could solve problems. In addition, she studied fatty acid methyl ester from palm biodiesel for using in diesel engine and compared it. According to the result of that test, it was found that palm biodiesel had viscosity similar to diesel oil but cetane number higher than diesel oil, and the power of engine was not different from diesel oil.

Table 2.11 The comparison of fuel consumption from five fuel oils

Types of fuel oil	Maximum break – horse power of engine	Fuel Comsumption (l/hr)	Specific Fuel Comsumption (l/break-horsepower-hr)
1. Diesel oil	5.98	2.09	0.3495
2. Peanut oil (crude type)	5.85	1.93	0.3299
3. Peanut oil (crude type) 40% in kerosene	5.22	1.77	0.3391
4. Peanut oil (crude type) 50% in diesel oil	5.31	1.91	0.3597
5. Palm ester or palm biodiesel	5.98	1.97	0.3294

Source: Pitsamai, B.E 2544

An appropriate selection of oily plant beyond property study, we will study component and an enough quantity of raw material too. Report of Office of Agriculture Economics indicated that oily plant produced in Thailand during 1995 – 2001, palm was the most of oily plant cultivation. So, we don’t lack raw material if we use palm for produce biodiesel. Somnerk Jaroonjitsatien (B.E 2545) studied a suitable of quantity of oily plant in Thailand and it was found that coconut and palm were interesting for biodiesel production due to a large cultivation area and a lot of production. His research tested fuel mixture between diesel oil : palm oil at 90:10, 85:15 and diesel oil : palm oil : kerosine at 75:20:5 in 8.5 horsepower of agricultural engine 1000 hours. The result found that fuel oil mixed 85:15 could be use in engine as well and had performance similar to diesel oil. Somnerk suggested that palm oil should kept in suitable area and should use it as a minor component when mix it with diesel oil because palm oil had high acidity that will destroy a piston ring. In addition, Vicha Muntamkal (B.E 2545) studied efficiency of palm biodiesel at various blends in diesel engine that palm biodiesel was produced by methyl alcohol 20% and soda 0.31% mixed with palm oil. The result found that palm biodiesel blend 20:80 has efficiency of the fuel consumption similar to diesel oil.

For above researches, we can conclude that palm is a most of oily plant cultivation in Thailand and it has properties similar to diesel oil. However, it will better, if we produce palm oil as palm biodiesel by transesterification process that get high quality of fuel and its friendly to the environmental due to its purification and lower emission than diesel oil. For a few researches undertaken in Thailand about emission from the using of biodiesel. Bunchai Tuntikornkul (B.E 2546) studied a decreasing of black smoke from used biodiesel blends 5, 10 and 20 by added catalytic converter and studied fuel consumption of biodiesel. The result of research showed that this application decreased black smoke 20 -30%, especially blends 10and 20. Biodiesel three blends have consume fuel not different to diesel oil. Mongkol Jampamee (B.E 2547) studied exhaust pollutants from three biodiesel were stererin palm ethyl ester (stererin palm biodiesel) blends 2%, 5%, 20% and 100% , rapeseed methyl ester (rapeseed biodiesel) blends 2%, 5%, 20% and 100% and used cooking oil blends 20%,30% and 40%. He tested these biodiesels in pickup. Emission factors of HC, CO, NO_X and PM from 2% of stererin palm ethyl ester and rapeseed methyl ester do not different but at blend 5% could slightly decrease HC and PM. In the application of biodiesel, while a blend of biodiesel is high up, it could decrease HC, CO and PM as well, except NO_X should increase about 7%. According to comparison on types of biodiesel, stererin palm ethyl ester can decrease HC, CO and NO_X better than rapeseed methyl ester because it has smaller alkyl chain, so it promotes complete combustion but PM will be higher than diesel oil. The used cooking oil could be decreased PM and HC as well when the proportion of biodiesel mixing high up, except NO_X. Therefore, he studied about the properties of these fuels oil and he found that their physical and chemical properties were not different, except viscosity was slightly higher than diesel oil and heating value less than diesel oil.

Niroj Ukarapanyawit (B.E 2548) studied two biodiesels of palm methyl ester and rapeseed methyl ester blends 2%, 5%, 20% and 100% in pickup and tested performance and emission of biodiesel. The result show that palm methyl ester could decrease pollutants as same as rapeseed methyl ester when proportion of biodiesel high up. The study was concluded that

- Biodiesel 2% decreased black smoke about 10%.
- Biodiesel 5% decreased particulate matter about 10% and black smoke about 20%.
- Biodiesel 20% decreased hydrocarbon and carbon monoxide about 10 – 20 %, black smoke about 20% but increased oxide of nitrogen 10%.
- Biodiesel 100% decreased hydrocarbon, carbon monoxide and particulate matter about 20 - 40 %, black smoke about 60% but increased oxide of nitrogen 20%.

A research conducted by Korbitz (1999) on emissions from 1 kg biodiesel. The study showed the reduction of sulfur dioxide about 99%, carbon monoxide 20%, hydrocarbon 32%, smoke 50% and particulate 39%. Biodiesel is a natural fuel product, so it will be decomposed about 90% in three weeks in proper conditions and carbon monoxide from this process should be used in photochemical process. This process did not increased gas of greenhouse effect phenomena like diesel oil. The Energy Commissioner of the House of Representative (B.E 2545) reported the benefits of there of biodiesel for reducing air pollution in countries as follow :

The use of B2 (biodiesel 2 % : diesel oil 98 %) is regulated in Minnisota state of The United State 2005.

B5 (biodiesel 5 % : diesel oil 95 %) had generally sold in France.

The use of B20 (biodiesel 20 % : diesel oil 80 %) is regulated in the United State by Alternative Motor Fuel Act 1988 (AMFA). It was used with 147 diesel vehicle of government and strictly used with diesel engine in special area where high concentrated pollution i.e. a school bus, a bus, a ship or a machine in the mine.

B40 (biodiesel 40 % : diesel oil 60 %) had generally used in buses in France.

B100 (biodiesel 100 %) had been used in Germany and Austria. Therefore, automobile production company guarantees the use of biodiesel B100 in vehicle.

Prakash (1998) reviewed the previous work on biodiesel's use as a transportation fuel in diesel vehicle. He concluded that the use of biodiesel in diesel vehicle had been actively investigated in Europe and North America during the last decade. The ability of biodiesel in reducing certain emission was recognized by many investigators. Therefore, many researchers used various raw materials for producing biodiesel.

For heavy duty diesel vehicle, Tom Beer *et.al.* (2002) studied emission of all trucks in Australia. They found that it could decrease carbon monoxide about 41 – 51%.

Baldassarri *et.al.* (2004) compared emission of rapeseed biodiesel B20 and diesel oil with EURO II bus. The result indicated that the emissions of the total hydrocarbons, carbon monoxide, carbon dioxide, oxide of nitrogen and particulate matter releasing from rapeseed biodiesel were better than diesel oil.

Schumacher *et.al.* (no date) studied biodiesel B20 and B100 with a truck and a pickup. The use of biodiesel decreases carbon monoxide and hydrocarbon about 40%, particulate matter 25 – 50% and reduce hydrocarbon compound in environment as well, but biodiesel increases oxide of nitrogen in the air about 12%.

Graboski *et.al.* (1999) studied the emissions (oxide of nitrogen and particulate matter) of biodiesel using with Detroit Diesel Corporation series 60 1991 (1991 DDC series 60). The result indicated that biodiesel could decrease particulate matter but the emission of oxide of nitrogen increases because it has oxygen and cetane number higher than diesel oil. In addition the emission of biodiesels production from methyl alcohol or ethyl alcohol was not different.

For light duty diesel vehicle, Durbin *et.al*. (2001) compared emission of diesel oil (California Specification Reformulated Diesel: CARB) and biodiesels from soy biodiesel B20 which collected emission factors data from world energy biodiesel and yellow grease biodiesel B20 with a pickup and a van. The result of this research found that yellow grease biodiesel B20 can decrease hydrocarbon in range of 21 – 66% but it increases oxide of nitrogen. The view of soy biodiesel B20 has particulate matter higher than diesel oil but other pollutants less than diesel oil. In addition to comparison of biodiesel emission, they found that the van emitted oxide of nitrogen higher than the pickup. According to the age of in-used vehicle, the emissions of carbon monoxide and hydrocarbon increases when the age of vehicle is older.

CHAPTER III
MATERIALS AND METHODS

The study collected the secondary data of emission factors of seven biodiesels during 1993 – 2003 and the traffic data of 2005 through the method of analysis process.

3.1 The study of emission factor from seven biodiesel blends in diesel vehicle.

3.1.1 The several emission factors (g/km) of HC, CO, NO_X and PM from diesel oils and seven biodiesel blends in light duty diesel vehicle and heavy duty diesel vehicle (Table 3.1) were collected as a secondary data from literature review (see in Appendix A). Therefore, we divided them into three groups of biodiesel from the emission data :

(1) A group of biodiesel using in LDDV and HDDV which were Soy biodiesel, Yellow grease biodiesel, Rapeseed biodiesel and Used cooking oil biodiesel.

(2) A group of biodiesel using only in LDDV which were Palm biodiesel and Coconut biodiesel.

(3) A group of biodiesel using only in HDDV which were Tallow biodiesel.

3.1.2 These emission factors (g/km) of HC, CO, NO_X and PM were analyzed to obtain the average of emission factor for LDDV and HDDV and standard deviation by statistic program (SPSS for window) because the one type of biodiesel had various emission factor in each blend.

3.1.3 The results of the average of emission factors (g/km) were used in next section for studies the difference of emissions emitted from vehicle fleet traveling on roads using biodiesels and diesels.

Table 3.1 The seven biodiesels blends of diesel vehicles

Type of Biodiesels	Blends	Type of Vehicles	
		Light Duty Vehicle	Heavy Duty Vehicle
1. Soy Biodiesel	10 : 90	-	√
	20 : 80	√	√
	30 : 70	-	√
	40 : 60	-	√
	100	-	√
2. Yellow Grease Biodiesel	20 : 80	√	√
	100	√	-
3. Palm Biodiesel	2 : 98	√	-
	5 : 95	√	-
	20 : 80	√	-
	100	√	-
4. Coconut Biodiesel	20 : 80	√	-
5. Rapeseed Biodiesel	2 : 98	√	-
	5 : 95	√	-
	20 : 80	√	√
	100	√	√
6. Used Cooking Oil Biodiesel	20 : 80	√	√
	30 : 70	√	-
	35 : 65	-	√
	40 : 60	√	-
7. Tallow Biodiesel	20 : 80	-	√
	35 : 65	-	√
	100	-	√

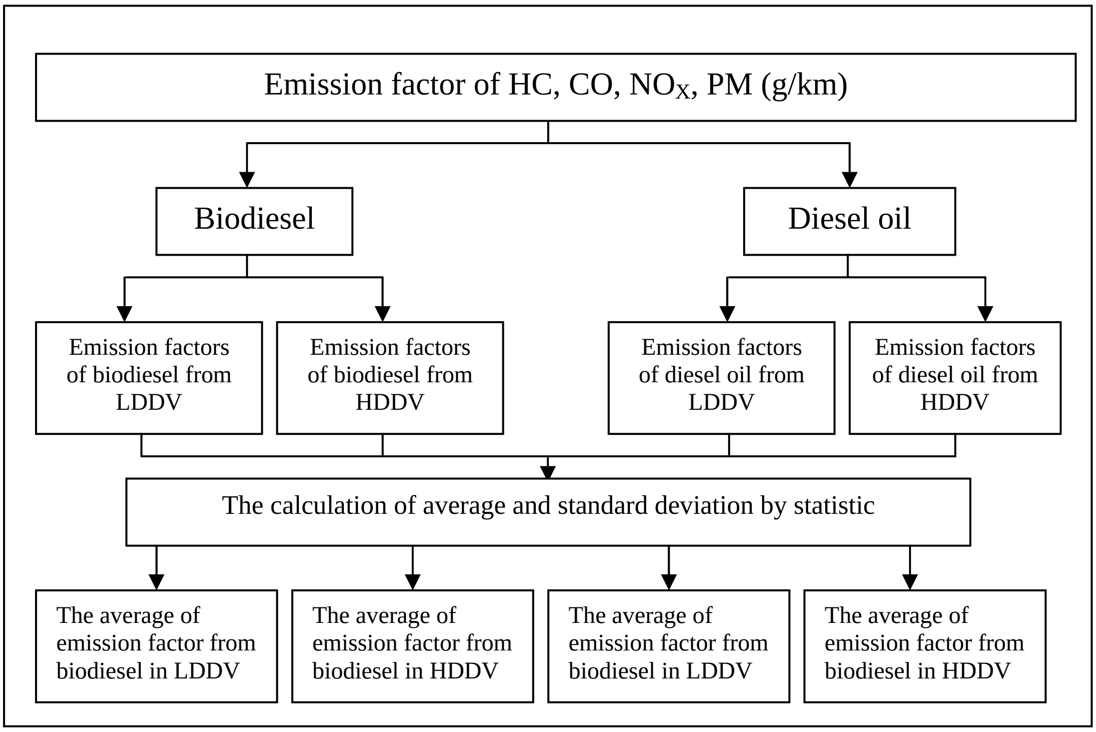

Figure 3.1 The method to obtain the average of emission factor

3.2 The study of the difference of emissions emitted from vehicle fleet traveling on roads using biodiesels and diesels

This section studies the difference of emission factors between the blends of each biodiesel type, biodiesel types and biodiesel types with diesel oil.

3.2.1 The number of LDDV and HDDV of total flow 24 hours for one year on road

The 2005 traffic data were collected for the traffic flow, ratio of LDDV and HDDV of total flow and speed from Intharaphithak Road, Ladprao Road and Dindaeng Road. These data were observed by Traffic and Transportation Department, BMA. The three roads were chosen because these roads had air monitoring stations that locate next to high polluted area. However, the traffic data were available during 07.00 am – 19.00 pm only and types of diesel vehicle traveling on roads were Pickup, Van, Truck, Bus, Minibus and petrol vehicle were car and a three-wheeled vehicle passenger.

3.2.1.1 The calculation of the number of LDDV and HDDV of total flow 24 hours for one year on three roads.

(1) The traffic volume observed by Traffic and Transportation Department had daytime data between 07.00 am – 19.00 pm only. So, the night time data between 19.00 pm – 07.00 am were estimated as the following.

<u>The calculation of traffic volume during 19.00 pm – 07.00 am</u>

= (The number of vehicle traveling during 07.00 am – 19.00 pm) x 1/3

when 1/3 was the correction factor for estimating the number of vehicle traveling during the night time which in a previous study it was found that the number of vehicle traveling on roads in Bangkok is one third of the number during the day time. (Mutchimwong, 2005)

The traffic volume at 24 hours

= (Traffic volume during 07.00 am – 19.00 pm) +

(Traffic volume during 19.00 pm – 07.00 am)

(2) The observed traffic data consist diesel vehicle (light duty diesel vehicle and heavy duty diesel vehicle) and petrol vehicle (car and three-wheeled vehicle passenger), but not included the number of motorcycle. The number of motorcycle, therefore estimate from the vehicle registered in 2005 by Department of Land Transport.

The motorcycle volume on roads 24 hour

$$= \frac{(MC_R) \text{ x (The number of vehicle traveling on road)}}{\text{The number of vehicle}_R}$$

when MC_R = The record of registered motorcycle

The number of vehicle traveling on road

= Diesel vehicle (Light duty diesel vehicle and Heavy duty diesel vehicle) + Petrol vehicle (car + three-wheeled vehicle passenger) on road observed by Traffic and Transportation Department

The number of vehicle_R

= The registered of Diesel vehicle (Light duty diesel vehicle and Heavy duty diesel vehicle) + Petrol vehicle (car + three-wheeled vehicle passenger) in Bangkok recorded by Department of Land Transport

(3) The number of LDDV and HDDV in a day was obtained by multiplied the fraction of LDDV and HDDV to the total volume of vehicle traveling on that road in a day.

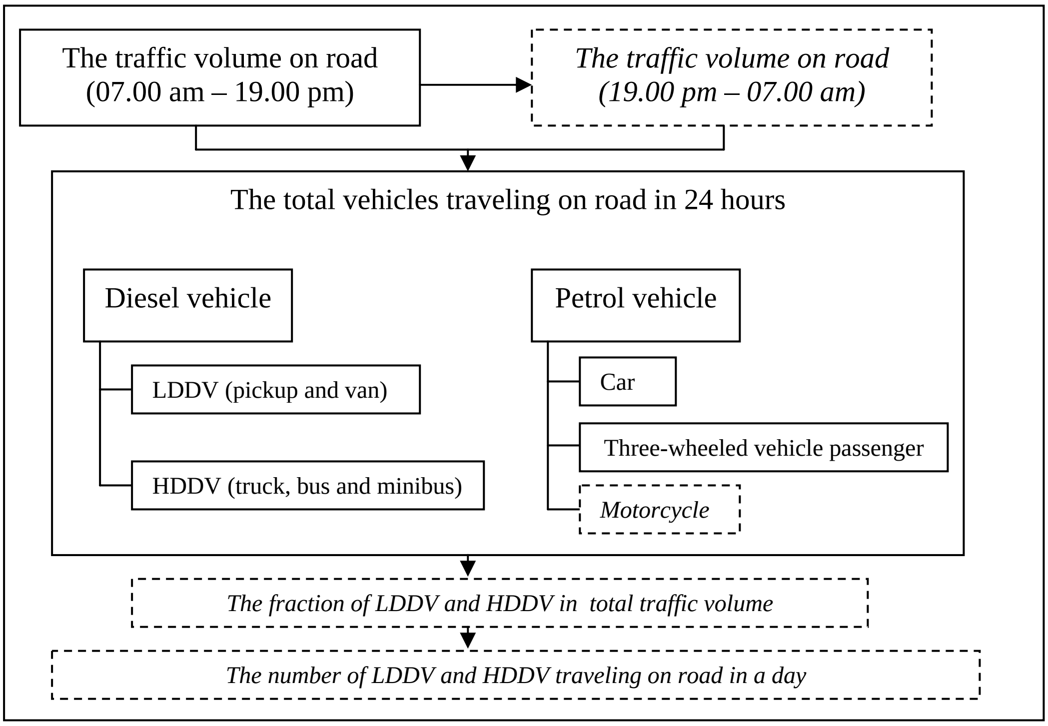

Figure 3.2 The calculation of the number of LDDV and HDDV of total flow 24 hours for one year on three roads.

Remark : *An italic was obtain from the estimation*

3.2.2 The emission rate (ton/km-y) of biodiesel and diesel oil from LDDV and HDDV on road

The calculation of the daily flow of LDDV and HDDV and the average of emission factors (g/km) from seven biodiesel blends were conducted to estimate the emission rate in ton/km-y and % emission change compares with HC, CO, NO_X and PM emission of biodiesel and diesel oil from LDDV and HDDV on the three roads.

$$= \left(\frac{\text{(The average of emission factor from each biodiesel) (g/km)} \times \text{(The daily number of LDDV and HDDV)}}{1{,}000{,}000} \right) \times 365$$

when 1 tons = 1,000,000 g

1 year = 365 days

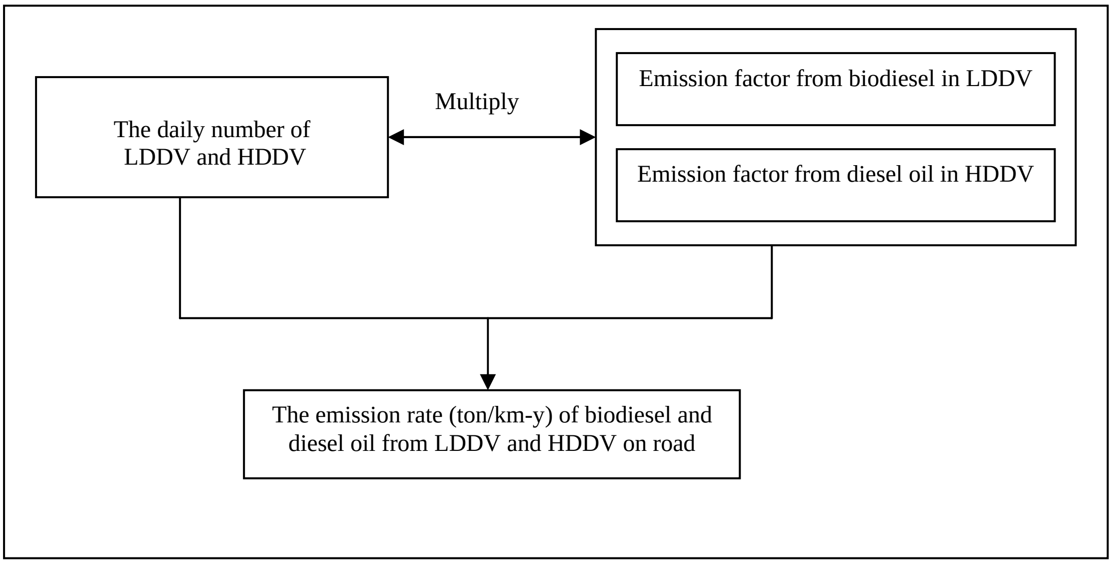

Figure 3.3 The emission rate of biodiesel and diesel oil from LDDV and HDDV on road

3.3 The difference of emissions emitted from vehicle fleet using biodiesels B20 and diesel oil

This section was focused on seven biodiesel B20 only for the comparison of emission reduction between seven biodiesel B20 and diesel oil.

3.4 Scenarios on emission reduction of diesel vehicle traveling on roads

The application of biodiesel B20 for emissions reduction under scenarios is shown in Table 3.2, 3.3 and 3.4.

Table 3.2 The scenarios of biodiesel used in both diesel vehicles

Scenario	The proportion of diesel vehicle types in the total flow on roads			
	Biodiesel		Diesel oil	
	LDDV	HDDV	LDDV	HDDV
(100-100)	100	100	0	0
(100-75)	100	75	0	25
(75-100)	75	100	25	0
(100-50)	100	50	0	50
(50-100)	50	100	50	0
(100-0)	100	0	0	100
(50-50)	50	50	50	50
(0-100)	0	100	100	0
(25-25)	25	25	75	75

Table 3.3 The scenarios of biodiesel used in LDDV only

Scenario	The proportion of diesel vehicle types in the total flow on roads			
	Biodiesel		Diesel oil	
	LDDV	HDDV	LDDV	HDDV
(100-0)	100	0	0	100
(75-0)	75	0	25	100
(50-0)	50	0	50	100
(25-0)	25	0	75	100

Table 3.4 The scenarios of biodiesel used in HDDV only

Scenario	The proportion of diesel vehicle types in the total flow on roads			
	Biodiesel		Diesel oil	
	LDDV	HDDV	LDDV	HDDV
(0-100)	0	100	100	0
(0-75)	0	75	100	25
(0-50)	0	50	100	50
(0-25)	0	25	100	75

CHAPTER IV
RESULTS AND DISCUSSIONS

4.1 Emission factors from seven biodiesels

The result of emission factors were averaged from seven biodiesels (Soy biodiesel, Yellow grease biodiesel, Palm biodiesel, Coconut biodiesel, Rapeseed biodiesel, Used cooking oil biodiesel and Tallow biodiesel). The different trademark gave different emission factors, although the same trademark of biodiesel but different year also gave the different emissions factors. For example, the use of Soy biodiesel in pickup Ford F350 1983 exhausts release hydrocarbon, carbon monoxide and particulate matter less than that of pickup Ford F350 1993, except nitrogen oxide that higher than Ford F350 1993 (Table 1A in Appendix). It was found that the quantity of exhaust emissions does not depend on how new the model but emissions depends on efficiency of technology production. For this reason, many diesel vehicles traveling on roads give various emission factors. So, we average all emission factors to get the emission factors of each biodiesel at various blends (Table 1A in Appendix A). The averages of emission factors in this section were used as a primary data for the study in the next section.

In addition, the limit of secondary data is based on the difference of HC, CO, NO_X and PM emission factors from seven biodiesels, measurement method, the source of biodiesel production, technology vehicles. So, the average of some emission factors in this study had a high standard deviation.

The consideration of emission factors from seven biodiesel blends in light duty diesel vehicles and heavy duty diesel vehicles gives a trend of emission factors change in seven biodiesel blends, seven biodiesel blend 20 and the comparison of emission factors from seven biodiesel blends against regular diesel oil in diesel vehicles are shown in the next section of the difference of emissions emitted from vehicle fleet using biodiesels and diesels.

4.1.1 Emission factors of seven biodiesel blends used in light duty diesel vehicles (LDDV) and heavy duty diesel vehicles (HDDV)

4.1.1.1 Emission factors of Soy biodiesel blends

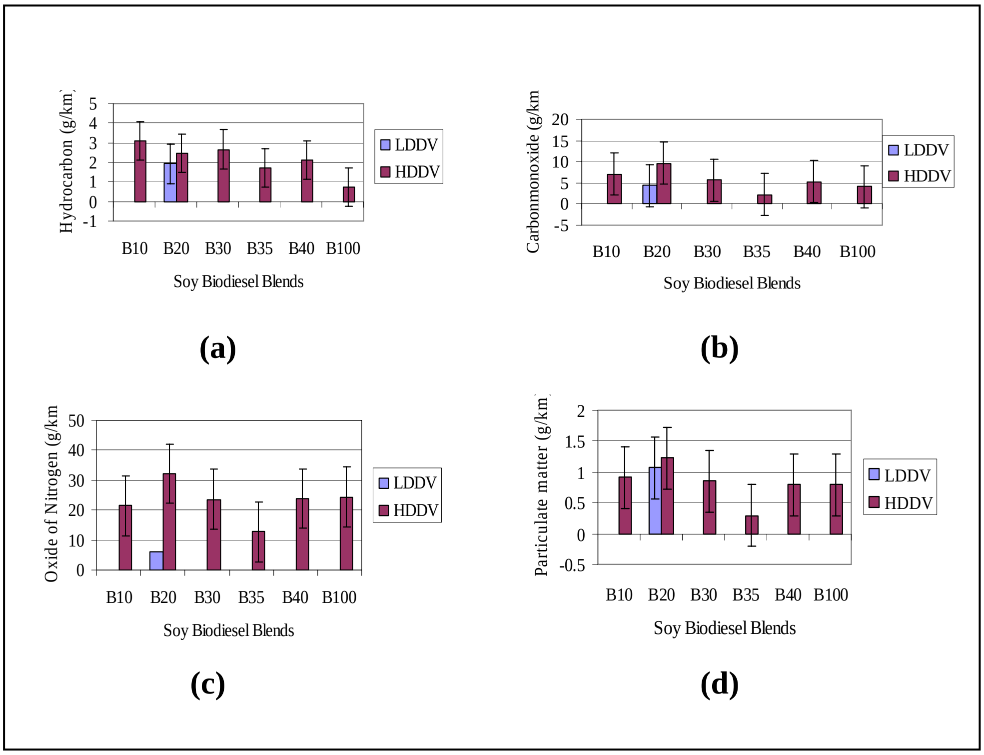

Figure 4.1 Emission factors of Soy biodiesel blends

Remark : B is biodiesel blend

For the secondary data of emission factors from Soy biodiesel for LDDV and HDDV at blends 10, 20, 30, 35, 40 and 100 had been compared (Figure 4.1). The average of emission factors of Soy biodiesel B20 in LDDV releases HC, CO, NO_x and PM less than in HDDV because the higher combustion rate, the longer cycle of complete combustion and higher loading weight. These factors bring to high emissions of all pollutants in HDDV. In addition, the use of Soy biodiesel B20 in both diesel vehicles releases CO, NO_x and PM more than other blends because the different of vehicle technology that CO and NO_x emissions of some models of vehicles are higher than other vehicles such as HDDV 6V-71N-77 MUI model (Table 1A in Appendix). Amongst, Soy biodiesels blends 10, 20, 30, 35, 40 and 100 used in HDDV, biodiesel B35 could be the most efficiency blend for decrease HC, NO_x and PM, and B100 could be the most efficiency blend in decreasing HC.

However, more future works should be conducted in order to confirm this conclusion. The pattern of emission change is unsystematically because the availability of emission factors of Soy biodiesel blends were limited.

4.1.1.2 Emission factors of Yellow grease biodiesel blends

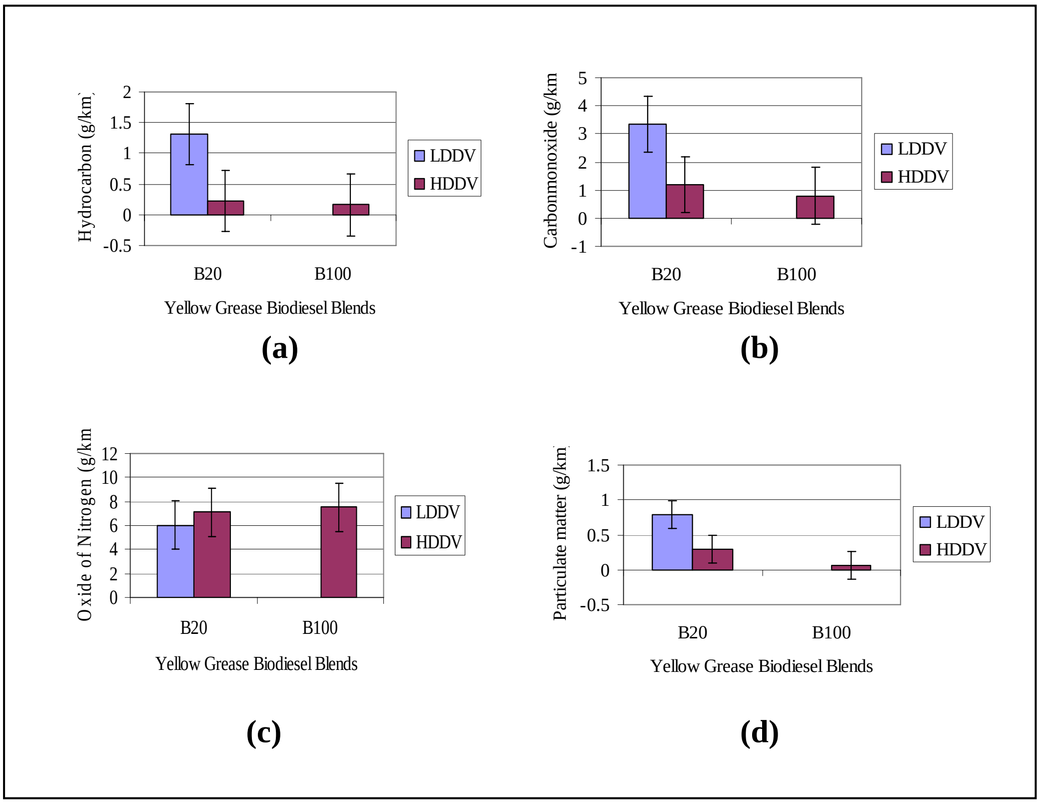

Figure 4.2 Emission factors of Yellow grease biodiesel blends

Remark : B is biodiesel blend

Figure 4.2 shows the average of emission factors from Yellow grease biodiesel B20 for LDDV and HDDV, and B100 for HDDV. The emission of LDDV emits HC, CO and PM higher than in HDDV. But NO_x emission of the both diesel vehicles is opposites from the other pollutants. It shows higher emission factor when the blend is higher. So, the use of Yellow grease biodiesel in HDDV will reduce HC, CO and PM emission. Furthermore, the comparison of emission factors from B100 releases less HC, CO and PM than blend 20, except oxide of nitrogen because Yellow grease biodiesel contains high oxygen which promotes the complete combustion. At the same time engines will be over heated and bring to the increasing of NO_x. However, the trend of emission factors (HC, CO and PM) indicates that they will decrease when the blend of Yellow grease biodiesels gets higher.

4.1.1.3 Emission factors of Palm biodiesel blends

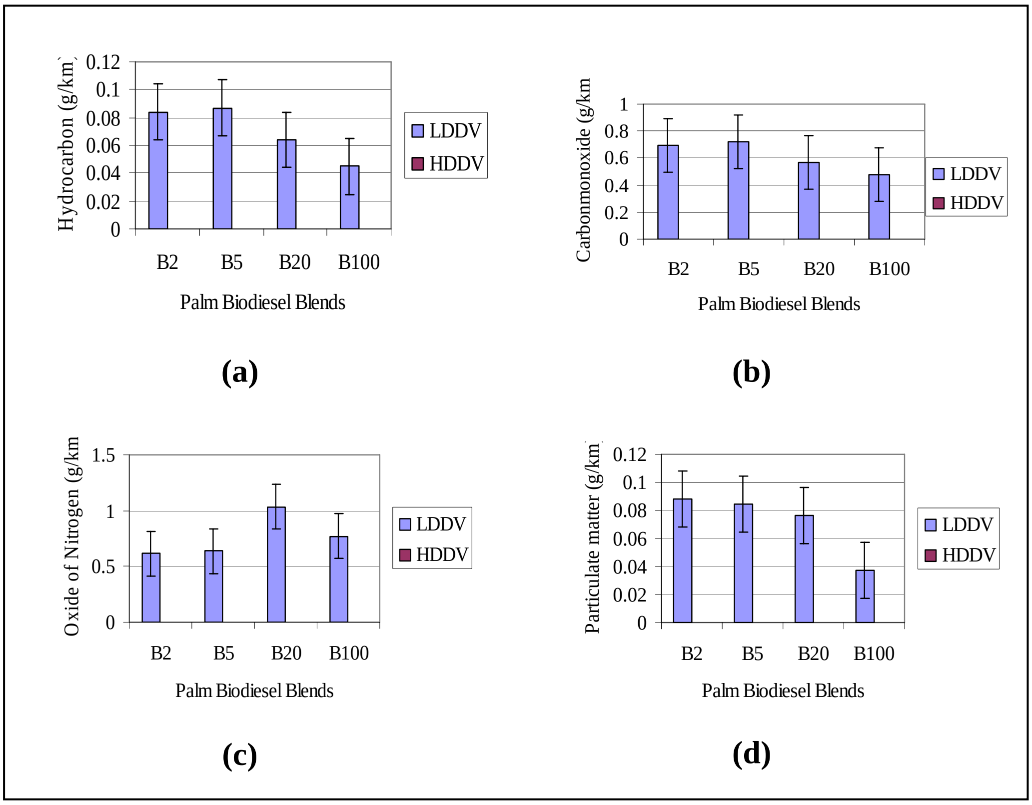

Figure 4.3 Emission factors of Palm biodiesel blends

Remark : B is biodiesel blend

The emission factors of Palm biodiesel blends 2, 5, 20 and 100 were found to be used only in LDDV in Thailand whilst them were no formal evidences such as research paper to exhibit that it was used in the other countries. The results show that the emission from Palm biodiesel B100 gave HC, CO and PM lower than other blends, except NO_x from B20 is higher than the others. Furthermore, the trends show that HC, CO and PM emission rate reduce when Palm biodiesels get higher blends. Trend of NO_x emission increases when Palm biodiesel get higher blends. It should be notice that B20 emit the highest NO_x.

So, it can be concluded that the reduction of HC, CO and PM get higher when we use higher blend. Due to the more oxygen content in Palm biodiesel than in diesel oil. So, it promotes the complete combustion in engine and give low pollution.

4.1.1.4 Emission factors of Coconut biodiesel blends

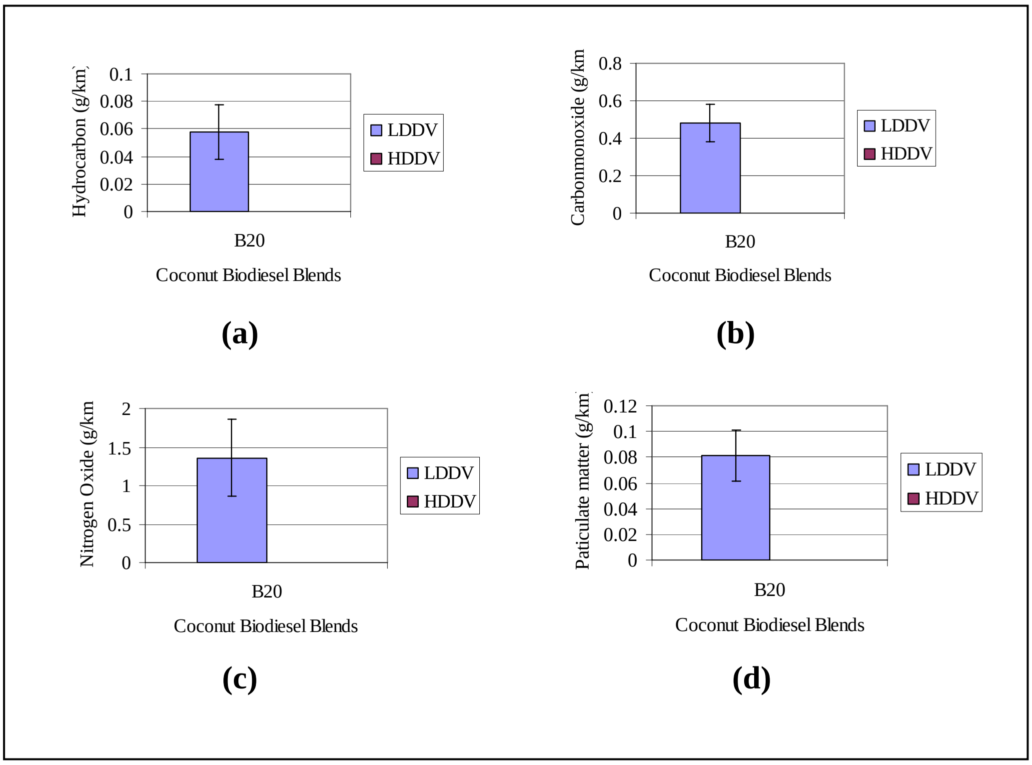

Figure 4.4 Emission factors of Coconut biodiesel blends

Remark : B is biodiesel blend

Due to the limit of data of Coconut biodiesel, only the blend 20 is in available. For the emission factors of Coconut biodiesel blend 20 is used in light duty diesel vehicles (Figure 4.4). The data of emission factor of this biodiesel is not enough to give the discussion because there was only one research conducted by Pollution Control Department.

4.1.1.5 Emission factors of Rapeseed biodiesel blends

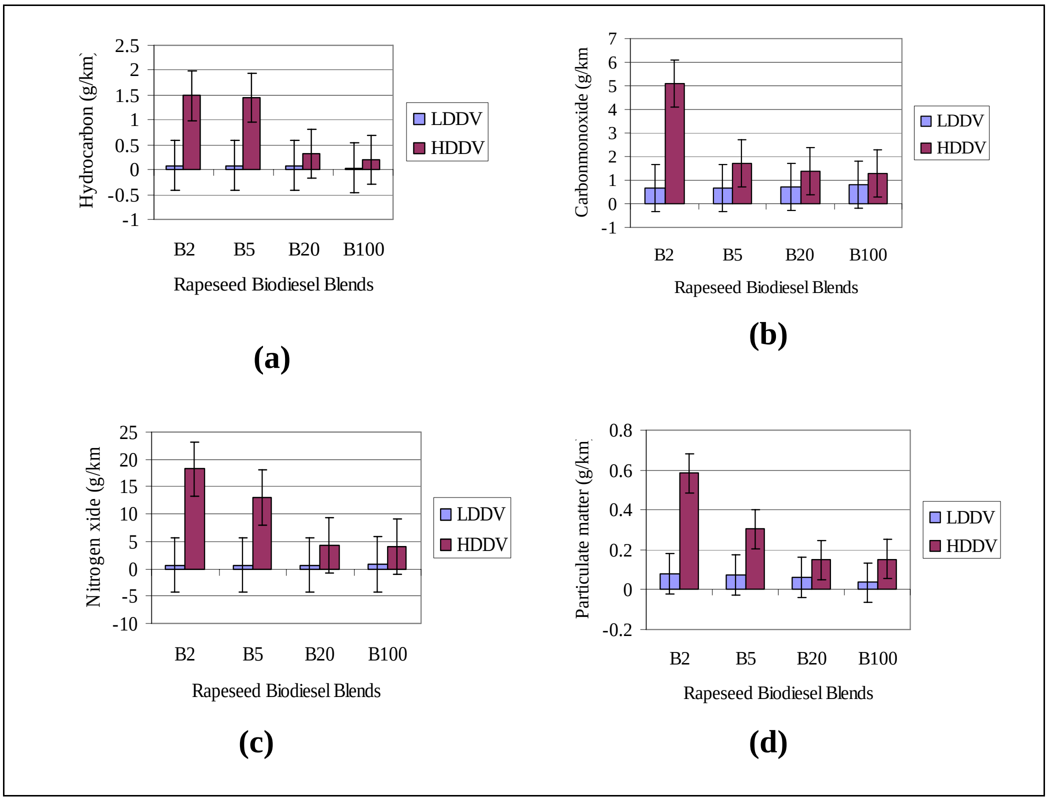

Figure 4.5 Emission factors of Rapeseed biodiesel blends

Remark : B is biodiesel blend

For the emission factors of rapeseed biodiesel blends 2, 5, 20 and 100 from LDDV and HDDV is shown in Figure 4.5. The use of Rapeseed biodiesel for LDDV releases HC, CO, NO_x and PM less than those in HDDV. LDDV that used Rapeseed biodiesel emit less HC and PM obviously when biodiesel blends getting higher, except B100 is slightly increases CO and NO_x but it has a similar emission rate.

In addition, the use of Rapeseed biodiesel in HDDV decreases HC, CO, NO_x when biodiesel blends get higher similar to the use in LDDV but PM emission is slightly increases in B100 when it was compared to other blends.

4.1.1.6 Emission factors of Used cooking oil biodiesel blends

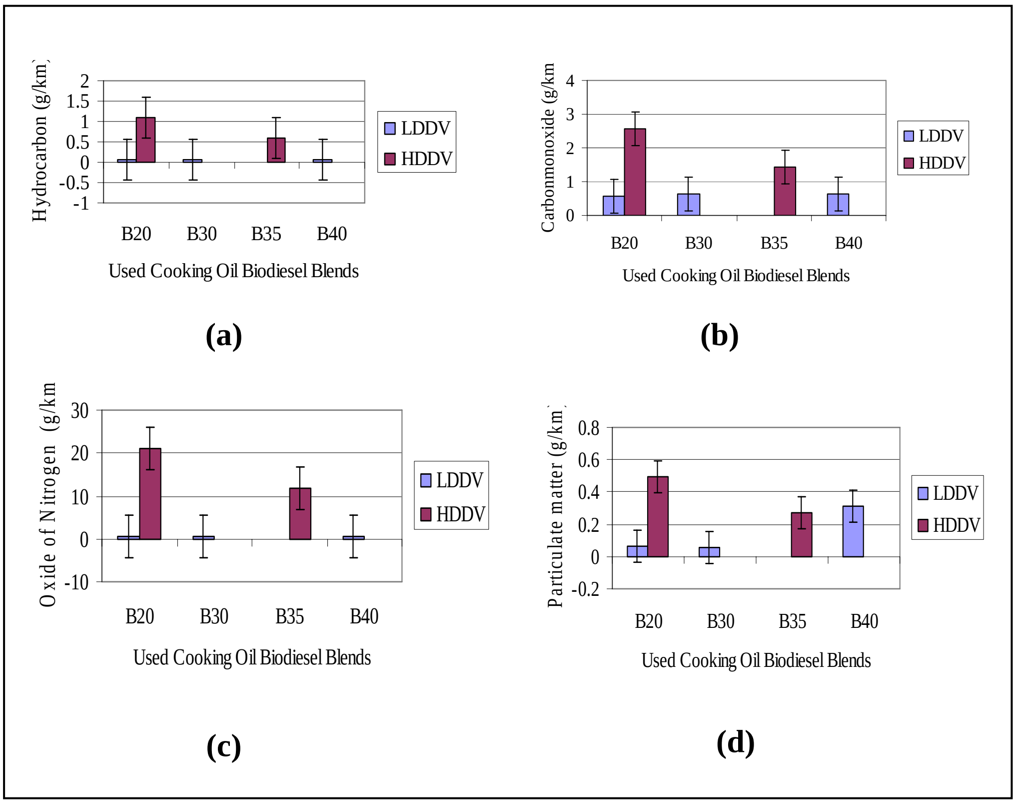

Figure 4.6 Emission factors of Used cooking oil biodiesel blends

Remark : B is biodiesel blend

The emission factors of Used cooking oil biodiesel blend of 20, 30 and 40 were used in LDDV, B20 and B35 in HDDV (Figure 4.6). The emission factors of Used cooking oil biodiesels B20 for LDDV release HC, CO, NO_x and PM less than HDDV. However, if we consider the trend of all emission factors, it was found that emission factors in LDDV slightly increases when the blend of Used cooking oil biodiesels is increased.

4.1.1.7 Emission factors of Tallow biodiesel blends

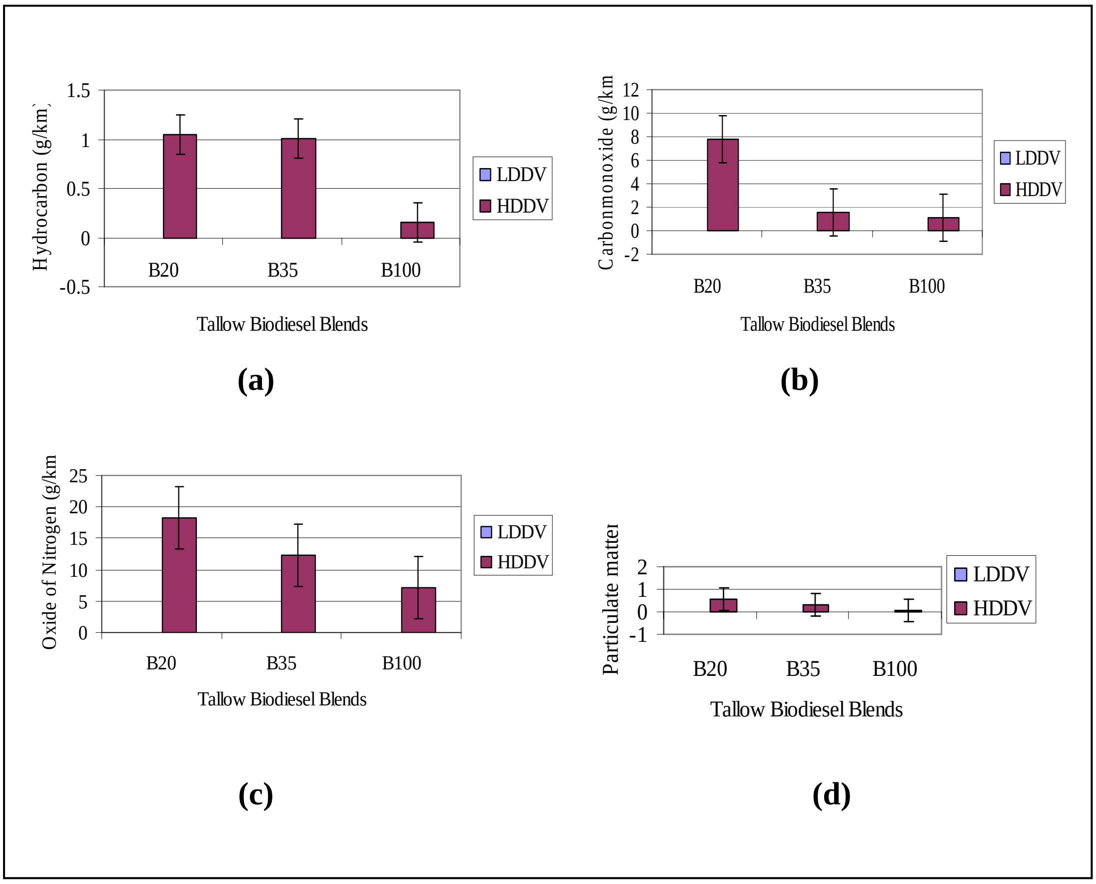

Figure 4.7 Emission factors of Tallow biodiesel blends

Remark : B is biodiesel blend

The emission factors of Tallow biodiesel blends 20, 35 and 100 used only in heavy duty diesel vehicles because it is difficult to produce by extraction process (Department of the Environment and Water Resources, 2006). So, there were a few researches on the use of this biodiesel. For this reason, Tallow biodiesel is rarely used in diesel vehicle. The results show that the emission factors from Tallow biodiesel blend 100 has the lowest HC, CO, NO_x and PM emissions when compares with other blends. Figure 4.7 shows that when the blends get to higher number, the emissions are lower.

4.1.2 Emission factors of B20 from seven biodiesel used in light duty diesel vehicles (LDDV) and heavy duty diesel vehicles (HDDV)

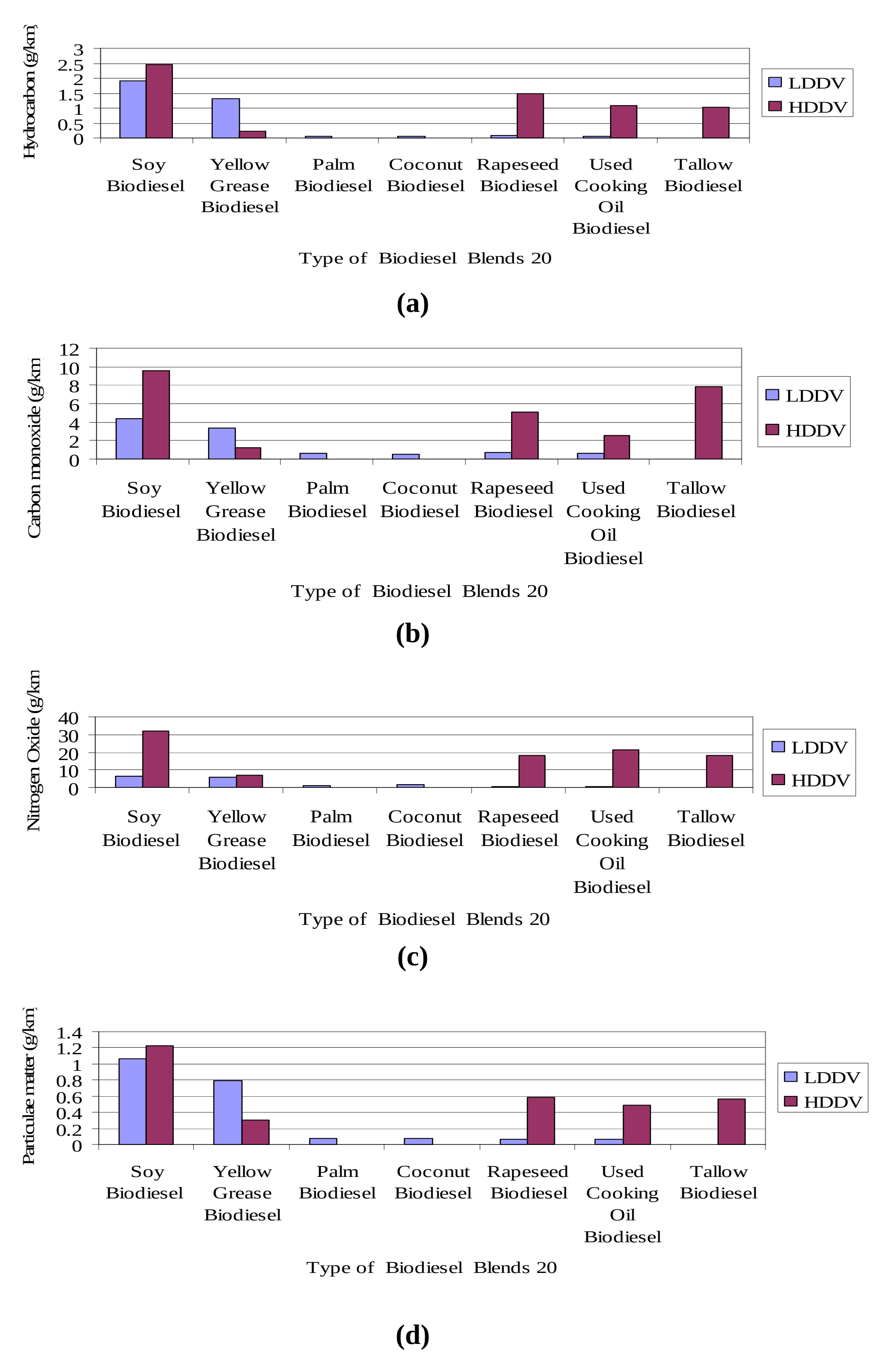

Figure 4.8 Emission factors of B 20 from seven biodiesels

Figure 4.8 (a) shows the HC emissions factor of seven biodiesels blend 20 in LDDV and HDDV. The results of emission factors show that the use of Soy biodiesel, Rapeseed biodiesel and Used cooking oil biodiesel reduces HC in LDDV better than in HDDV. But HC emission in LDDV used Yellow grease biodiesel is higher than HDDV about 0.8 g/km. The ranking of efficiency of HC emission reduction regarding to type of biodiesel is Coconut biodiesel, Used cooking oil biodiesel, Palm biodiesel, Rapeseed biodiesel, Yellow grease biodiesel and Soy biodiesel respectively. The lowest HC emission in HDDV occurred when Yellow grease biodiesel was used but higher when it was changed to Soy biodiesel, Rapeseed biodiesel, Used cooking oil biodiesel and Tallow biodiesel.

Figure 4.8 (b) shows the trend of CO emissions. The use of Soy biodiesel, Rapeseed biodiesel and Used cooking oil in LDDV emit CO less than when it was used in HDDV. The order of biodiesel from good to fair in CO reduction in LDDV is Coconut biodiesel, Palm biodiesel, Used cooking oil biodiesel, Rapeseed biodiesel respectively. The results indicate that the use of Yellow grease biodiesel in HDDV emit the lowest CO emission.

Figure 4.8 (c) shows the emissions of NO_x. The use of Soy biodiesel, Rapeseed biodiesel, Used cooking oil biodiesel and Yellow grease biodiesel can reduce NO_x better in LDDV than in HDDV. The use of Palm biodiesel and Coconut biodiesel only in LDDV decreases NO_x as well. The best biodiesel that releases NO_x very low is Yellow grease biodiesel.

Figure 4.8 (d) shows PM emission. The best biodiesel for decreasing PM is Used cooking oil biodiesel and Rapeseed biodiesel. For Palm biodiesel and Coconut biodiesel, they can reduce PM as well but they have emission factors only for LDDV. Yellow grease biodiesel is the best in PM reduction in HDDV.

From the results, it can be concluded that the use of Soy biodiesel in LDDV and HDDV emit highest level of all pollutants. Yellow grease biodiesel emit the lowest pollutants when it was used in HDDV. On the contrary, it released higher pollutant when it was used in LDDV. The use of Coconut biodiesel and Palm biodiesel in LDDV releases all pollutants very low, that especially HC and CO. The emissions of all pollutants from Rapeseed biodiesel and Used cooking oil biodiesel are very low in the both diesel vehicle.

4.1.3 The comparison of emission factors from seven biodiesel blends against regular diesel oil

4.1.3.1 The comparison of emission factors from biodiesel blends against diesel oil used in light duty diesel vehicles (LDDV)

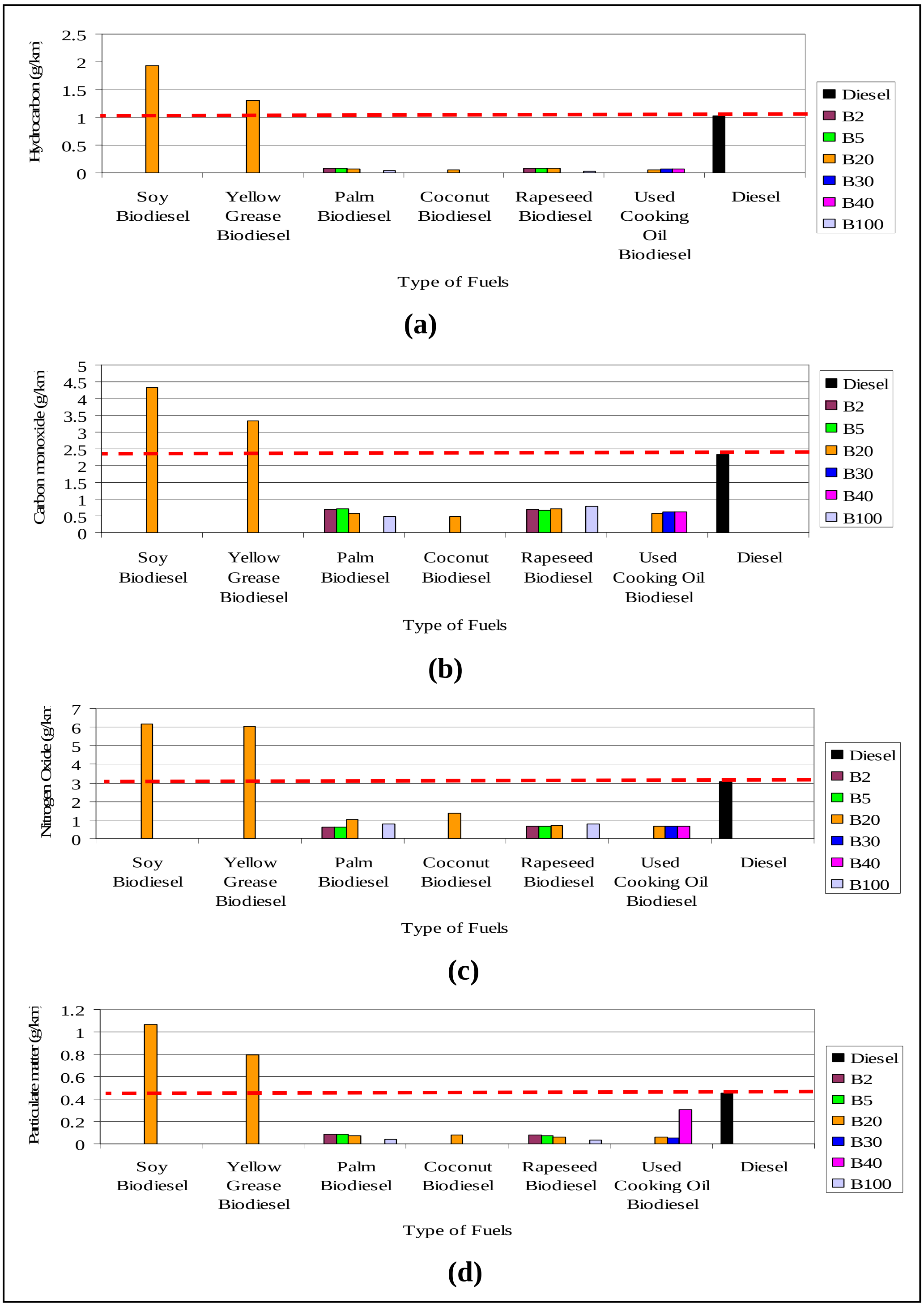

Figure 4.9 The comparison of emission factors from seven biodiesels blends and diesel oil used in light duty diesel vehicles

As shown in Figures 4.9 (a) – (d), the emission factors of HC, CO, NO_x and PM from Soy biodiesel and Yellow grease biodiesel are much higher than that of diesel oil. While the use of Coconut biodiesel, Palm biodiesel and Rapeseed biodiesel releases HC, CO, NO_x and PM less than diesel oil.

So, the use of Coconut biodiesel, Palm biodiesel, Rapeseed biodiesel and Used cooking oil biodiesel emit pollutants (HC, CO, NO_x, PM) less than diesel oil. The use of Soy biodiesel and Yellow grease biodiesel is not suitable for using in LDDV due to the emission factor of pollutants is higher than that of diesel oil. However, the use of biodiesel blends in LDDV seems to be one of the most appropriate for improving air pollution in each area.

4.1.3.2 The comparison of emission factors from biodiesel blends against

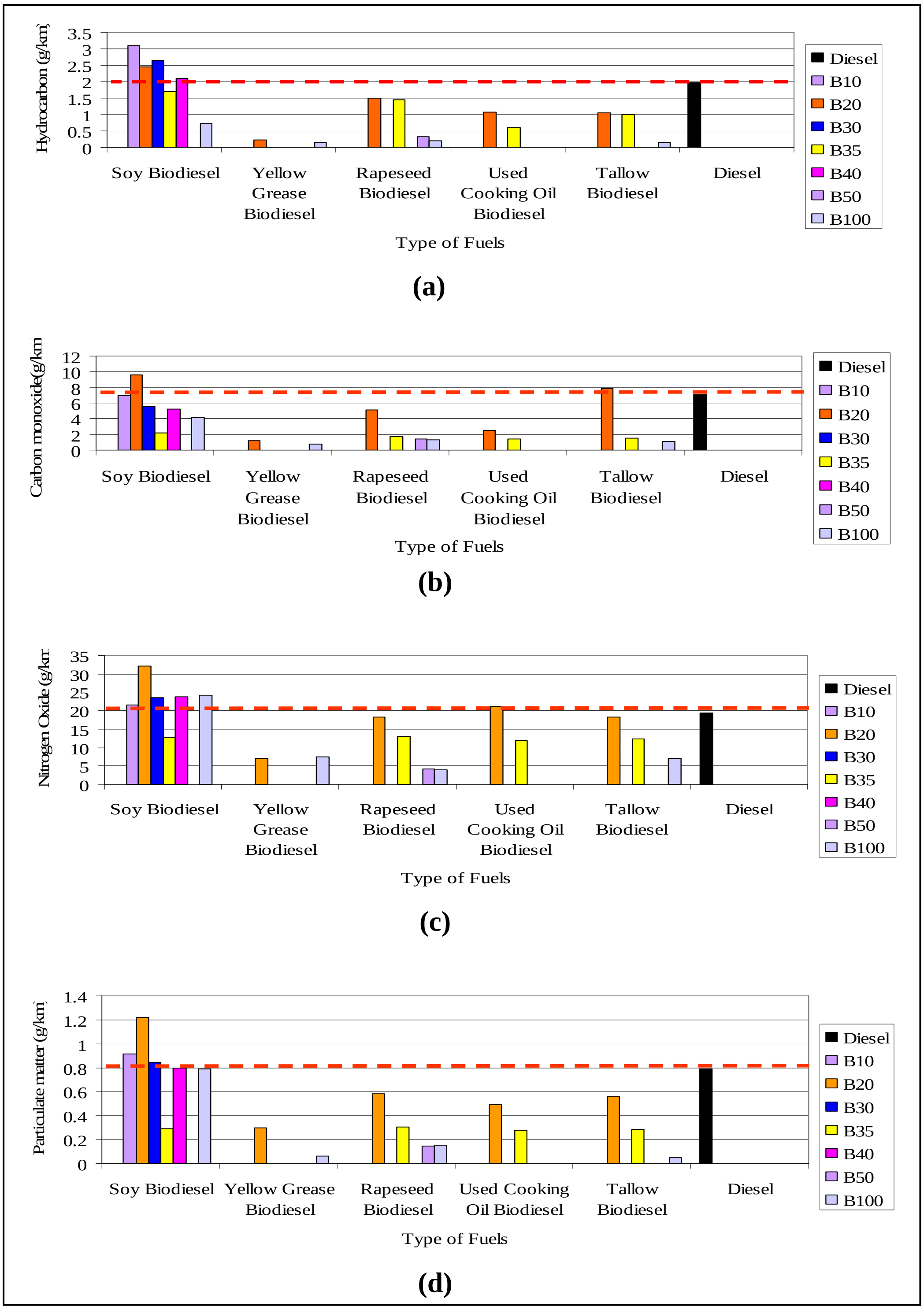

Figure 4.10 The comparison of emission factors from seven biodiesel blends and diesel used in heavy duty diesel vehicles

Figures 4.10 (a) – (d) show the emission factor of HC, CO, NO_x and PM from biodiesel blends used in HDDV. The emissions from Soy biodiesel are higher than diesel oil. While the Yellow grease biodiesel, Rapeseed biodiesel, Used cooking oil biodiesel and Tallow biodiesels with HDDV releases all pollutants less than diesel oil, except the emission of NO_x from B20 of used cooking oil biodiesel and emission of CO from B20 of Tallow biodiesel which are slightly higher than the emission of diesel oil.

From the results shown in this section, it can be concluded that the appropriate biodiesels for decrease all pollutants when they are used in LDDV and HDDV are Rapeseed biodiesel and Used cooking oil biodiesel.

The effective biodiesels for decreasing pollutants when they are used in LDDV are Palm biodiesel, Coconut biodiesel, Rapeseed biodiesel and Used cooking oil biodiesel.

The effective biodiesels for emission reduction when they are used in HDDV are Yellow grease biodiesel, Rapeseed biodiesel, Used cooking oil biodiesel and Tallow biodiesel.

4.2 The difference of emissions emitted from vehicle fleet using biodiesels and diesels

The section presents the results of the difference of emissions released from vehicle fleet using biodiesels and diesels. The results in this section are based on the 2005 traffic data and the emission factors regarding to the calculation in Section 4.1. The pollutants of HC, CO, NO_x and PM emitted from traffic on Intharaphithak, Ladprao and Dindaeng Roads were estimated as the emission rate as weight of ton per distance of a kilometer in duration of a year (in unit of ton/km-y). The values of emission rates of each biodiesel blend at a road are different due to the traffic conditions of each road but the percentage of change comparing to the ordinary diesel is the same.

In addition the emissions from biodiesel were compared to the emission from diesel oil and present as the percentage of change. This factor was used for determining the success of emission reduction owing to the application of the biodiesel in different blends on road of ordinary diesel oil.

The explanation in this section concentrates on the percentage of change so as to give an overview of the effects of the application of biodiesel oil in types and blends on vehicle exhaust emission.

4.2.1 Light Duty Diesel Vehicles (LDDV)

Due to the limits of research data conducted in this field, the emission factors of biodiesel that are available for applying to the light duty diesel vehicles (LDDV) are of which one blend of Soy biodiesel, one blend of Yellow grease biodiesel, four blends of Palm biodiesel, one blend of Coconut biodiesel, four blends of Rapeseed biodiesel, three blends of Used cooking oil biodiesel.

Table 4.1 Emissions and percentage of change of biodiesel and diesel oil emitted from light duty diesel vehicles (LDDV) on Intharaphithak Road (In-R), ladprao Road (Lp-R) and Dindaeng Road (Dd-R)

Unit : ton/km-y

Types of Biodiesel	Blend	Emissions and % Change of fuel from LDDV															
		HC			**% HC change com-pared to diesel oil**	**CO**			**% CO change com-pared to diesel oil**	**NOx**			**% NO_x change com-pared to diesel oil**	**PM**			**% PM change com-pared to diesel oil**
		In-R	Lp-R	Dd-R		In-R	Lp-R	Dd-R		In-R	Lp-R	Dd-R		In-R	Lp-R	Dd-R	
1. SB	B 20	14.8688	10.3995	18.4494	86.6	33.4010	23.3612	41.4442	86.0	47.7378	33.3886	59.2333	100.8	8.2365	5.7607	10.2199	136.8
2. YB	B 20	10.0951	7.0607	12.5260	26.7	25.7120	17.9834	31.9037	43.2	46.5809	32.5795	57.7979	95.9	6.1079	4.2720	7.5788	75.6
3. PB	B 2	0.6478	0.4530	0.8038	-91.9	5.3444	3.7380	6.6314	-70.2	4.7583	3.3280	5.9041	-80.0	0.6786	0.4746	0.8420	-80.5
	B 5	0.6709	0.4692	0.8325	-91.6	5.5527	3.8836	6.8898	-69.1	4.9357	3.4521	6.1242	-79.2	0.6555	0.4584	0.8133	-81.2
	B 20	0.4935	0.3452	0.6124	-93.8	4.3881	3.0691	5.4448	-75.6	7.9820	5.5827	9.9041	-66.4	0.5861	0.4099	0.7272	-83.2
	B100	0.3470	0.2427	0.4306	-95.6	3.6940	2.5837	4.5836	-79.4	5.9305	4.1479	7.3587	-75.1	0.2853	0.1995	0.3540	-91.8
4. CB	B 20	0.4473	0.3128	0.5550	-94.4	3.7095	2.5944	4.6027	-79.3	10.4421	7.3034	12.9567	-56.1	0.6246	0.4369	0.7751	-82.0
5. RB	B 2	0.6555	0.4584	0.8133	-91.8	5.3213	3.7218	6.6027	-70.4	5.2056	3.6409	6.4592	-78.1	0.6092	0.4261	0.7559	-82.5
	B 5	0.6632	0.4638	0.8229	-91.7	5.2287	3.6571	6.4879	-70.9	5.1670	3.6139	6.4113	-78.3	0.5784	0.4045	0.7176	-83.4
	B 20	0.6169	0.4315	0.7655	-92.3	5.4370	3.8027	6.7462	-69.7	5.3984	3.7757	6.6984	-77.3	0.4858	0.3398	0.6028	-86.0
	B100	0.2622	0.1833	0.3253	-96.7	6.1079	4.2720	7.5788	-66.0	6.1928	4.3313	7.6840	-74.0	0.2776	0.1941	0.3444	-92.0
6. UB	B 20	0.4550	0.3182	0.5645	-94.3	4.4730	3.1285	5.5501	-75.1	5.0976	3.5654	6.3252	-78.6	0.4781	0.3344	0.5932	-86.3
	B 30	0.5244	0.3667	0.6507	-93.4	4.7737	3.3388	5.9233	-73.4	5.1285	3.5869	6.3635	-78.4	0.4318	0.3020	0.5358	-87.6
	B 40	0.4858	0.3398	0.6028	-93.9	4.8354	3.3820	5.9998	-73.1	5.1285	3.5869	6.3635	-78.4	2.3907	1.6721	2.9664	-31.3
7. Diesel	-	7.9665	5.5719	9.8849	-	17.9537	12.5571	22.2771	-	23.7763	16.6296	29.5018	-	3.4781	2.4326	4.3157	-

Remark: SB (Soy biodiesel), YB (Yellow grease biodiesel), PB (Palm biodiesel), CB (Coconut biodiesel), RB (Rapeseed biodiesel)
UB (Used cooking oil biodiesel)
+ = higher in percentage of change, **-** = lower in percentage of change

The results (Table 4.1) show that the use of Soy biodiesel and Yellow grease biodiesel releases more emissions of target air pollutants than those of the diesel oil. This implies that these two biodiesels are not suitable for reducing HC, CO, NO_x and PM emitted from LDDV.

The results indicate that the use of biodiesels produced from Palm biodiesel, Coconut biodiesel, Rapeseed biodiesel and Used cooking oil biodiesel in various blends in LDDV emits the levels of all pollutants a lot lower than the emissions from LDDV using the diesel oil in a roughly range of 56.1 – 96.7 % reduction.

The use of Palm biodiesel in higher blend seems to give more benefit in reducing HC, CO and PM emissions in LDDV due to the increase of percentage in emission reduction, for instance, the percentage of HC emission reduction comparing to those of diesel oil increases from 91.9% in B2 to 95.6% in B100. However, it should be remarked that the reduction rate is quite low, when the blend of Palm biodiesel increase from B20 to B100, the reduction rate increases from 93.8% to 95.6% in HC emission, 75.6% to 79.4% in CO emission, and 83.2% to 91.8% in PM. For NO_x reduction, the results show the opposite trend against the others. The reduction rate decreases (80.0% to 75.1%) when the blend increase but unsystematically as shown at B20 to B100. So, the use of Palm biodiesel in LDDV should be aware when one wants to apply higher blend of Palm biodiesel to an area where the level of NO_x is more concern than CO, HC and PM due to the less effective in NO_x reduction at higher blend.

The use of Coconut biodiesel B20 in LDDV seems to be a good choice for HC and CO emissions reduction similarly to Palm, Rapeseed and Used cooking oil biodiesels at the same blend. This kind of biodiesel is less effective in PM reduction than those three biodiesels. Additionally when comparing to those three biodiesels, the biodiesel of B20 from coconut is the least effective biodiesel in NO_x reduction in LDDV.

The results show that the Rapeseed biodiesel is also one of a good alternative fuel in the case that the emission reduction is in need. This kind of biodiesel gives over 90% HC emission reduction in LDDV which its reduction rate of HC emission increases as the blend increases. The trend of PM emission reduction in higher blend is similar to that of HC emission but less percentage of reduction in range 60 -80%. When the Rapeseed biodiesel was used at higher blend it yields a lower percentage of emission reduction for CO (70.2% at B2 to 66.0% at B100) and NO_x (78.1% at B2 – 84.0% at B100).

For the Used cooking oil biodiesel, it shows to be the most effective in emission reduction in this study when it was applied to LDDV but the application in higher blend reduces the percentage of emission reduction i.e. for CO 75.1% at B20 to 73.1% at B40 or for PM 86.3% at B20 to 31.3% at B40.

4.2.2 Heavy Duty Diesel Vehicles (HDDV)

The emission factors of biodiesel that are available for applying to the Heavy Duty Diesel Vehicles (HDDV) are of which six blends of Soy biodiesel, two blend of Yellow Grease biodiesel, four blends of Rapeseed biodiesel, two blends of Used cooking oil biodiesel and three blends of Tallow biodiesel.

Table 4.2 Emissions and percentage of change of biodiesel and diesel oil emitted from heavy duty diesel vehicles (HDDV) on Intharaphithak Road (In-R), ladprao Road (Lp-R) and Dindaeng Road (Dd-R)

Unit : ton/km-y

Types of Biodiesel	Blend	Emissions and % Change of fuel from HDDV															
		HC			% HC change com-pared to diesel oil	CO			% CO change com-pared to diesel oil	NO_x			% NO_x change com-pared to diesel oil	PM			% PM change com-pared to diesel oil
		In-R	Lp-R	Dd-R		In-R	Lp-R	Dd-R		In-R	Lp-R	Dd-R		In-R	Lp-R	Dd-R	
1. SB	B 10	10.1832	7.1461	6.3383	56.6	23.1174	16.2226	14.3888	-1.0	70.8051	49.6875	44.0708	10.5	3.0078	2.1107	1.8721	15.4
	B 20	8.1077	5.6896	5.0464	24.7	31.6303	22.1966	19.6875	35.5	106.1517	74.4920	66.0714	65.6	4.0291	2.8274	2.5078	54.6
	B 30	8.7303	6.1265	5.4340	34.3	18.4293	12.9328	11.4708	-21.1	77.5951	54.4524	48.2970	21.1	2.7970	1.9628	1.7409	7.3
	B 35	5.6302	3.9510	3.5044	-13.4	7.1951	5.0492	4.47844	-69.2	42.0871	29.5346	26.1960	-34.4	0.9619	0.6750	0.5987	-63.1
	B 40	6.9546	4.8804	4.3287	6.9	17.2960	12.1375	10.7654	-25.9	78.5637	55.1321	48.8999	22.6	2.6191	1.8379	1.6302	0.5
	B 100	2.4214	1.6992	1.5071	-62.8	13.5798	9.5296	8.4524	-41.9	80.0989	56.2094	49.8555	25.0	2.6092	1.8310	1.6240	0.1
2. YB	B 20	0.7247	0.5086	0.4511	-88.9	3.9533	2.7742	2.4606	-83.1	23.4238	16.4376	14.5795	-63.5	0.9883	0.6935	0.6151	-62.1
	B 100	0.5271	0.3699	0.3280	-91.9	2.6355	1.8495	1.64045	-88.7	24.8075	17.4086	15.4407	-61.3	0.1976	0.1387	0.1230	-92.4
3. RB	B 2	4.9186	3.4516	3.0615	-24.4	16.7623	11.7629	10.4333	-28.2	60.1771	42.2293	37.4557	-6.1	1.9206	1.3478	1.1954	-26.3
	B 5	4.7737	3.3499	2.9712	-26.6	5.6236	3.9464	3.5003	-75.9	43.0754	30.2282	26.8112	-32.8	1.0015	0.7028	0.6233	-61.6
	B 20	1.0575	0.7421	0.6582	-83.7	4.5332	3.1811	2.8215	-80.6	14.0641	9.8695	8.7538	-78.1	0.4908	0.3444	0.3055	-81.2
	B 100	0.6556	0.4600	0.4080	-89.9	4.2334	2.9708	2.6349	-81.9	13.3492	9.3678	8.3089	-79.2	0.5040	0.3537	0.3137	-80.7
4. UB	B 20	3.5580	2.4968	2.2146	-45.3	8.4338	5.9184	5.2494	-63.9	69.5796	48.8275	43.3080	8.5	1.6241	1.1397	1.0109	-37.7
	B 35	1.9832	1.3917	1.2344	-69.5	4.7012	3.2990	2.9261	-79.9	38.8387	27.2551	24.1741	-39.4	0.9026	0.6334	0.5618	-65.4
5. TB	B 20	3.4328	2.4090	2.1366	-47.2	25.7991	18.1045	16.0580	10.5	59.9432	42.0652	37.3101	-6.5	1.8482	1.2969	1.1503	-29.1
	B 35	3.3109	2.3234	2.0608	-49.1	5.0998	3.5788	3.1742	-78.2	40.5881	28.4827	25.2630	-36.7	0.9422	0.6612	0.5864	-63.8
	B 100	0.4941	0.3467	0.3075	-92.4	3.6239	2.5431	2.2556	-84.5	23.4567	16.4607	14.6000	-63.4	0.1647	0.1155	0.1025	-93.7
6. Diesel	-	6.5033	4.5637	4.0478	-	23.3513	16.3868	14.5344	-	64.1041	44.9851	39.8999	-	2.6059	1.8287	1.6220	-

Remark: SB (Soy biodiesel), YB (Yellow grease biodiesel), RB (Rapeseed biodiesel), UB (Used cooking oil biodiesel), TB (Tallow biodiesel)

+ = higher in percentage of change, **-** = lower in percentage of change

Table 4.2 shows that the percentages of emission reduction against the blends of Soy biodiesel are varied and unsystematically. So, it cannot give the conclusion about the application of Soy biodiesel in HDDV.

The results indicate that generally the use of biodiesels produced from Yellow grease biodiesel, Rapeseed biodiesel, Used cooking oil biodiesel and Tallow biodiesel in various blends in HDDV emits the levels of all pollutants less than the emissions from HDDV using the diesel oil.

The use of Yellow grease biodiesel in higher blend seems to give more benefit in reducing HC, CO and PM emissions in HDDV, for instance, the percentage of HC emission reduction comparing to those of diesel oil increases from 88.9% in B20 to 91.9% in B100. However it should be remarked that the reduction rate is not much different except the percentage of PM which reduce from 62.1% in B20 to 92.4% in B100. For NO_x reduction, the results show the opposite trend against the others as the same results occurred when it was applied in LDDV.

The Rapeseed biodiesel seems to be more effective on emission reduction of all target pollutants when the higher blend is applied in HDDV. The reduction of NO_x also increases when the blend applied is higher (6.1% in B2 to 79.2% in B100). It should be noticed that the use of very high blend of Rapeseed biodiesel in HDDV gives more emission reduction rate than a very low blend whereas the use of high or low blend in LDDV seem to cause less effects on the emission change. For example, HC emission reduces about 91.8% in B2 and about 96.7% in B100 when the Rapeseed biodiesel was applied in LDDV, while HC emission reduces about 24.4% in B2 and about 89.9% in B100 when it was used in HDDV.

The blend of the Used cooking oil biodiesel and Tallow biodiesel seems to be an important factor in emission reduction in HDDV as well as in Rapeseed biodiesel. The use of very high blend of the Used cooking oil biodiesel and Tallow biodiesel in HDDV gives more emission reduction rate than a very low blend.

4.2.3 The biodiesels applicable to both LDDV and HDDV

Based on the results mentioned in previous sections, it can be concluded the biodiesels which are use of both LDDV and HDDV are Soy biodiesel B20, Yellow grease biodiesel B20, Rapeseed biodiesel B2, B5, B20, B100 and Used cooking oil biodiesel B20.

Soy biodiesel and Yellow grease biodiesel are also available to both LDDV and HDDV. But the use of Soy biodiesel in both type of vehicle emits more pollutants than the use of diesel oil, while Yellow grease biodiesel is worse than diesel oil when this biodiesel is applied in LDDV and better in HDDV.

Rapeseed biodiesel and Used cooking oil biodiesel are also available to both LDDV and HDDV, especially emissions reduction in two types of diesel vehicle in Rapeseed biodiesel. It has a trend of emissions reduction changes to increase familiar both LDDV and HDDV when the blend applied is higher. Use cooking oil biodiesel reduces emission in LDDV more than in HDDV that increases NO_x higher than 8.5% of diesel oil.

Palm biodiesel, Coconut biodiesel and Tallow biodiesel have emission data only in LDDV or HDDV. So they are not the first choice for applicable in air pollution mitigation in this study.

4.3 The difference of emissions emitted from vehicle fleet using biodiesels B20 and diesel oil

This section focuses on the comparison between the emissions released from biodiesels B20 and diesel oil. The blend of B20 is of interest because biodiesel was mostly produced in the blend of B20 and it also easies for uses in diesel vehicle which does not modifies engine. So, the availability of data based on B20 was found in nearly all types of biodiesel. The comparison amongst the biodiesel B20 in types available can give clearer view for determining the types of which give more positive impacts on air quality.

4.3.1 Light Duty Diesel Vehicles (LDDV)

Table 4.3 shows that the use of Soy biodiesel B20 and Yellow grease biodiesel B20 in LDDV traveling on the three roads gives the emissions of HC, CO, NO_x and PM more than those of diesel oil. Especially, Soy biodiesel is very poor on NO_x and PM emission reduction, around 101% and 137% over than diesel oil respectively. Hence, these two biodiesel are not a good choice if air quality along the roadside is concerned.

Table 4.3 Emissions of B 20 from light duty diesel vehicles (LDDV) on Intharaphithak Roads (In-R), ladprao Road (Lp-R) and Dindaeng Road (Dd-R)

Unit : ton/km-y

Type of Biodiesels	Emissions of B20 and % Change of fuel from LDDV															
	HC			% HC change com-pared to diesel oil	CO			% CO change com-pared to diesel oil	NO_x			% NO_x change com-pared to diesel oil	PM			% PM change com-pared to diesel oil
	In-R	Lp-R	Dd-R		In-R	Lp-R	Dd-R		In-R	Lp-R	Dd-R		In-R	Lp-R	Dd-R	
1. SB	14.8688	10.3995	18.4494	86.6	33.4010	23.3612	41.4442	86.0	47.7378	33.3886	59.2333	100.8	8.2365	5.7607	10.2199	136.8
2. YB	10.0951	7.0607	12.5260	26.7	25.7120	17.9834	31.9037	43.2	46.5809	32.5795	57.7979	95.9	6.1079	4.2720	7.5788	75.6
3. PB	0.4935	0.3452	0.6124	-93.8	4.3881	3.0691	5.4448	-75.6	7.9820	5.5827	9.9041	-66.4	0.5861	0.4099	0.7272	-83.2
4. CB	0.4473	0.3128	0.5550	-94.4	3.7095	2.5944	4.6027	-79.3	10.4421	7.3034	12.9567	-56.1	0.6246	0.4369	0.7751	-82.0
5. RB	0.6169	0.4315	0.7655	-92.3	5.4370	3.8027	6.7462	-69.7	5.3984	3.7757	6.6984	-77.3	0.4858	0.3398	0.6028	-86.0
6. UB	0.4550	0.3182	0.5645	-94.3	4.4730	3.1285	5.5501	-75.1	5.0976	3.5654	6.3252	-78.6	0.4781	0.3344	0.5932	-86.3
7. Diesel	7.9665	5.5719	9.8849	-	17.9537	12.5571	22.2771	-	23.7763	16.6296	29.5018	-	3.4781	2.4326	4.3157	-

Remark: SB (Soy biodiesel), YB (Yellow grease biodiesel), PB (Palm biodiesel), CB (Coconut biodiesel), RB (Rapeseed biodiesel)

UB (Used cooking oil biodiesel)

The results indicate that biodiesels B20 produced from Palm biodiesel, Coconut biodiesel, Rapeseed biodiesel and Used cooking oil biodiesel release the emission of HC, CO, NO_x and PM less than the ordinary diesel oil. The use of these biodiesels B20 in LDDV reduces the emission more than diesel oil in the range of 92% - 94% for HC, 70% - 79% for CO, 56% - 79% for NO_x, and 82% - 86% for PM. The Coconut biodiesel B20 is the best for HC and CO reduction in LDDV. Used of cooking oil biodiesel B20 should be recommended for NO_x and PM reduction in LDDV due to its greatest effectiveness. However, the use of the Rapeseed biodiesel B20 seems to be interesting due to its high score in emission reduction of all pollutants even though it does not reach the highest place comparing with the other biodiesels B20.

4.3.2 Heavy Duty Diesel Vehicles (HDDV)

The use of Soy biodiesel B20 in HDDV also emits HC, CO, NO_x and PM more that those of diesel oil (Table 4.4). Whereas the Yellow grease biodiesel B20 releases less emission of all target pollutants than those of diesel oil. The use of the Yellow grease biodiesel B20 in HDDV is also better in emission reduction than the use of the Used cooking oil biodiesel B20 in HDDV, while the opposite results occur when they are used in LDDV. The similar manner as the Yellow grease biodiesel B20 also found in the application of Rapeseed biodiesel B20 in HDDV with a fair better of later biodiesel than former one in NO_x and PM emission reduction.

Table 4.4 Emissions of B 20 from heavy duty diesel vehicles (HDDV) on Intharaphithak Road (In-R), ladprao Road (Lp-R) and Dindaeng Road (Dd-R)

Unit : ton/km-y

Type of Biodiesels	**Emissions of B20 and % Change of fuel from HDDV**															
	HC			**% HC change com-pared to diesel oil**	**CO**			**% CO change Com-pared to diesel oil**	**NO_x**			**% NO_x change Com-pared to diesel oil**	**PM**			**% PM change com-pared to diesel oil**
	In-R	Lp-R	Dd-R		In-R	Lp-R	Dd-R		In-R	Lp-R	Dd-R		In-R	Lp-R	Dd-R	
1.SB	8.1077	5.6896	5.0464	24.7	31.6303	22.1966	19.6875	35.5	106.1517	74.4920	66.0714	65.6	4.0291	2.8274	2.5078	54.6
2. YB	0.7247	0.5086	0.4511	-88.9	3.9533	2.7742	2.4606	-83.1	23.4238	16.4376	14.5795	-63.5	0.9883	0.6935	0.6151	-62.1
3. RB	1.0575	0.7421	0.6582	-83.7	4.5332	3.1811	2.8215	-80.6	14.0641	9.8695	8.7538	-78.1	0.4908	0.3444	0.3055	-81.2
4. UB	3.5580	2.4968	2.2146	-45.3	8.4338	5.9184	5.2494	-63.9	69.5796	48.8275	43.3080	8.5	1.6241	1.1397	1.0109	-37.7
5. TB	3.4328	2.4090	2.1366	-47.2	25.7991	18.1045	16.0580	10.5	59.9432	42.0652	37.3101	-6.5	1.8482	1.2969	1.1503	-29.1
6. Diesel	6.5033	4.5637	4.0478	-	23.3513	16.3868	14.5344	-	64.1041	44.9851	39.8999	-	2.6059	1.8287	1.6220	-

Remark: SB (Soy biodiesel), YB (Yellow grease biodiesel), RB (Rapeseed biodiesel), UB (Used cooking oil biodiesel), TB (Tallow biodiesel)

The results imply that the application of Used cooking oil biodiesel B20 in HDDV is not suitable when NO_x reduction is in concern due to the more NO_x emission than that of the diesel oil around 8.5%. The application of Tallow biodiesel B20 in HDDV gives more CO emission than that of diesel oil approximately 11%. Although it produces less emission of HC, NO_x and PM than those of diesel oil, its effectiveness is much less than the Yellow grease and Rapeseed biodiesels under the same blend.

4.3.3 The biodiesels B20 applicable to both LDDV and HDDV

Regarding to previous sections the biodiesels of B20 are common in any type of biodiesel. So, B20 was used for formulating the scenarios of emission reduction in next section.

Soy biodiesel B20 is a poor of emissions reduction because of all pollutants obvious higher than diesel oil.

B20 of Yellow grease biodiesel and Used cooking oil biodiesel opposite emission reduction in two diesel vehicles that Used cooking oil biodiesel high increases for emissions reduction when applied in LDDV while it releases higher NO_x in HDDV than diesel oil about 8.5%. The use of Yellow grease biodiesel is higher all pollutants reduction than diesel oil but it increases emissions reduction for use in HDDV as well in range 62 – 89%.

Rapeseed biodiesel B20 has constant values of the all pollutants decreasing is high nearly in both LDDV and HDDV and it reduces emissions more than uses in that diesel oil too.

4.4 Scenarios on emission reduction of diesel vehicle traveling on roads in the use of biodiesels

This section presents scenarios based on the assumptions that nine patterns of various percentages of LDDV and HDDV traveling on road use biodiesel while the rest use diesel oil as usual (see details in Appendix Table 1C, 2C, 3C). The scenarios on emission reduction were formulated under the application of biodiesel B20.

Scenarios were divided into three groups of emission factor as followed :

- The first group of biodiesel used in LDDV and HDDV applied under nine scenarios is Soy biodiesel, Yellow grease biodiesel, Rapeseed biodiesel and Used cooking oil biodiesel.
- The second group of biodiesels used only in LDDV applied under four scenarios is Palm biodiesel and Coconut biodiesel.
- The third group of biodiesels used only in HDDV applied under four scenarios is Tallow biodiesel.

4.4.1 Scenarios on HC emission reduction

Table 4.5 Application of biodiesels B20 for reducing HC emissions

Unit: ton/km-y

Fuel	Scenario	Roads					
		In-R		Lp-R		Dd-R	
		emission	% change BD relative to D	emission	% change BD relative to D	emission	% change BD relative to D
Diesel	Diesel oil	14.470	0.0	10.136	0.0	13.993	0.0
Yellow grease biodiesel	YB20(100-100)	10.820	-25.2	7.569	-25.320	12.977	-6.859
	YB20(100-75)	12.265	-15.2	8.583	-15.318	13.876	-0.405
	YB20(75-100)	10.288	-28.9	7.197	-28.992	12.317	-11.598
	YB20(100-50)	13.709	-5.3	9.597	-5.316	14.776	+6.049
	YB20(50-100)	9.756	-32.6	6.825	-32.664	11.657	-16.337
	YB20(100-0)	16.598	+14.7	11.624	+14.688	16.574	+18.956
	YB20(50-50)	12.645	-12.6	8.853	-12.660	13.455	-3.429
	YB20(0-100)	8.691	-39.9	6.081	-40.008	10.336	-25.815
	YB20(25-25)	13.557	-6.3	9.497	-6.330	13.694	-1.715
Rapeseed biodiesel	RB20(100-100)	1.674	- 88.4	1.174	-88.421	1.424	-89.781
	RB20(100-75)	3.036	-79.0	2.219	-78.995	2.271	-83.699
	RB20(75-100)	3.512	-75.7	2.459	-75.742	3.704	-73.418
	RB20(100-50)	4.397	-69.6	3.084	-69.569	3.119	-77.617
	RB20(50-100)	5.349	-63.0	3.744	-63.062	5.983	-57.055
	RB20(100-0)	7.120	-50.8	4.995	-50.716	4.813	-65.453
	RB20(50-50)	8.072	-44.2	5.655	-44.210	7.678	-44.891
	RB20(0-100)	9.024	-37.6	6.314	-37.704	10.543	-24.328
	RB20(25-25)	11.217	-22.1	7.895	-22.105	10.806	-22.445
Used cooking oil biodiesel	UB20(100-100)	4.013	-72.3	2.815	-72.226	2.779	-80.053
	UB20(100-75)	4.749	-67.2	3.332	-67.128	3.238	-76.763
	UB20(75-100)	5.891	-59.3	4.129	-59.267	5.109	-63.329
	UB20(100-50)	5.486	-62.1	3.849	-62.030	3.696	-73.474
	UB20(50-100)	7.769	-46.3	5.442	-46.309	7.439	-46.605
	UB20(100-0)	6.958	-51.9	4.882	-51.834	4.612	-66.895
	UB20(50-50)	9.241	-36.1	6.475	-36.113	8.356	-40.026
	UB20(0-100)	11.525	-20.4	8.069	-20.392	12.100	-13.157
	UB20(25-25)	11.856	-18.1	8.306	-18.056	11.144	-20.013
Palm biodiesel	PB20(100-0)	6.997	-51.7	4.909	-51.568	4.660	-66.552
	PB20(75-0)	8.865	-38.7	6.216	-38.676	6.978	-49.914
	PB20(50-0)	10.733	-25.8	7.522	-25.784	9.297	-33.276
	PB20(25-0)	12.602	-12.9	8.829	-12.892	11.615	-16.638
Coconut biodiesel	CB20(100-0)	6.951	-52.0	4.877	-51.887	4.603	-66.964
	CB20(75-0)	8.830	-39.0	6.191	-38.915	6.935	-50.223
	CB20(50-0)	10.710	-26.0	7.506	-25.944	9.268	-33.482
	CB20(25-0)	12.590	-13.0	8.821	-12.972	11.600	-16.741
Tallow biodiesel	TB20(0-100)	11.399	-21.2	7.981	-21.259	12.022	-13.717
	TB20(0-75)	11.034	-23.8	8.520	-15.944	12.499	-10.288
	TB20(0-50)	10.668	-26.3	9.058	-10.629	12.977	-6.858
	TB20(0-25)	10.30	-28.8	9.597	-5.315	13.455	-3.429

Table 4.5 show the results of the first group of biodiesel used in both LDDV and HDDV. The results show that the use of Yellow grease biodiesel in 100% of LDDV and HDDV reduces HC emissions on Intharaphithak Road, Ladprao Road and Dindaeng Road from 14.5 to 10.8, 10.1 to 7.6 and 14.0 to 13 ton/km-y respectively. It can be concluded that the application of Yellow grease biodiesel under all scenarios to diesel vehicles traveling on roads for HC reduction is less than 25%. The results show that the use of Yellow grease biodiesel in LDDV alone (0% in HDDV) releases total HC emission larger than the total HC emission emitted from the use of diesel oil in

both LDDV and HDDV (15% increase at YB20(100-0)). For instance, HC emission on Intraphithak Road increases from 14.5 to 16.6 ton/km-y.

The results show that the more percentage of diesel vehicles using Rapeseed biodiesel, the more HC reduction in diesel vehicle emissions. The results indicates that if ones need to reduce HC emission higher than diesel oil 50%, the scenarios that meet this requirement are RB20(100-100), RB20(100-75), RB20(75-100), RB20(100-50) and RB20(100-0). It seems to show that the application of Rapeseed biodiesel gives the most benefit to HC emission reduction in diesel vehicle traveling on roads. For example HC emission on Intharaphithak Road reduce to around 88.4% at RB20 (100-100).

The application of Used cooking oil biodiesel in a similar manner gives less HC emission reduction than the use of Rapeseed biodiesel. For example, the use of RB20 (100-100) and UB20 (100-100) reduces HC emission less than that of diesel oil about 88.4% and 72.3% respectively. The scenarios that reduce HC emission more than 50 % of diesel oil emission are UB20 (100-100), UB20 (100-75), UB20 (75-100), UB20 (100-50) and UB20 (100-0). The Used cooking oil biodiesel seems to be the second best after Rapeseed biodiesel for reducing HC emission in diesel vehicle.

The second group of biodiesel that used only in LDDV was applied under four scenarios. The application of Palm biodiesel and Coconut biodiesel in 100% LDDV or less can reduce HC emission from diesel vehicle traveling on road about 13-67% less than the use of diesel oil. The more percentage of LDDV using of Palm biodiesel, the more HC emission reduction.

The third group of biodiesel that used only in HDDV was applied under four scenarios. The use of Tallow biodiesel in 100% HDDV or less also reduces HC emission from diesel vehicle traveling on road but in a relatively low range of about 21-29%. Surprisingly the more percentage of HDDV using the Tallow biodiesel has lower HC emission reduction.

4.4.2 Scenarios on CO emission reduction

Table 4.6 Application of B20 biodiesels for reducing CO emissions

Unit: ton/km-y

Fuel	Scenario	Road					
		In-R		Lp-R		Dd-R	
		emission	% change BD relative to D	emission	% change BD relative to D	emission	% change BD relative to D
Diesel	Diesel oil	41.3	0.0	29	0.0	36.8	0.0
Yellow grease biodiesel	YB20(100-100)	29.6655	-28.18	20.758	-28.283	14.987	-59.288
	YB20(100-75)	34.515	-16.439	24.161	-16.525	18.005	-51.088
	YB20(75-100)	27.7259	-32.875	19.401	-32.970	17.425	-52.666
	YB20(100-50)	39.3645	-4.6983	27.564	-4.768	21.024	-42.888
	YB20(50-100)	25.7863	-37.571	18.045	-37.657	19.862	-46.043
	YB20(100-0)	49.0634	18.7831	34.370	+18.748	27.061	-26.489
	YB20(50-50)	35.4853	-14.09	24.851	-14.141	25.899	-29.644
	YB20(0-100)	21.9071	-46.963	15.331	-47.031	24.738	-32.799
	YB20(25-25)	38.3952	-7.0449	26.897	-7.071	36.200	-1.662
Rapeseed biodiesel	RB20(100-100)	9.970	-75.9	6.984	-75.871	3.587	-90.255
	RB20(100-75)	14.675	-64.5	10.285	-64.456	6.515	-82.301
	RB20(75-100)	13.099	-68.3	9.173	-68.309	8.965	-75.646
	RB20(100-50)	19.379	-53.1	13.587	-53.058	9.444	-74.346
	RB20(50-100)	16.229	-60.7	11.361	-60.748	14.343	-61.037
	RB20(100-0)	28.788	-30.3	20.190	-28.625	15.300	-58.437
	RB20(50-50)	25.638	-37.9	17.964	-37.935	20.199	-45.128
	RB20(0-100)	22.467	-45.6	15.738	-45.625	25.099	-31.818
	RB20(25-25)	33.471	-19.0	23.454	-18.968	30.001	-18.502
Used cooking oil biodiesel	UB20(100-100)	12.907	-68.8	9.047	-68.743	5.814	-84.206
	UB20(100-75)	16.636	-59.7	11.664	-59.701	8.135	-77.900
	UB20(75-100)	16.277	-60.6	11.404	-60.599	11.242	-69.460
	UB20(100-50)	20.366	-50.7	14.281	-50.659	10.457	-71.594
	UB20(50-100)	19.647	-52.4	13.761	-52.455	16.670	-54.714
	UB20(100-0)	27.824	-32.6	19.515	-32.576	15.099	-58.983
	UB20(50-50)	27.106	-34.4	18.995	-34.372	21.313	-42.103
	UB20(0-100)	26.388	-36.1	18.476	-36.168	27.527	-25.223
	UB20(25-25)	34.206	-17.2	23.970	-17.186	30.309	-17.666
Palm biodiesel	PB20(100-0)	27.740	-32.8	19.456	-24.585	15.147	-58.853
	PB20(75-0)	31.131	-24.6	21.828	-24.585	20.563	-44.140
	PB20(50-0)	34.522	-16.4	24.200	-16.39	25.979	-29.426
	PB20(25-0)	37.914	-8.2	26.572	-8.195	32.603	-11.431
Coconut biodiesel	CB20(100-0)	27.061	-34.5	18.981	-34.420	15.089	-59.009
	CB20(75-0)	30.622	-25.9	21.472	-25.815	20.520	-44.257
	CB20(50-0)	34.183	-17.2	23.963	-17.210	25.951	-29.504
	CB20(25-0)	37.444	-8.6	26.453	-8.605	32.393	-12.003
Tallow biodiesel	TB20(0-100)	43.753	+5.9	29.373	+5.935	38.335	+4.139
	TB20(0-75)	43.141	+4.4	29.803	+.451	37.954	+3.104
	TB20(0-50)	42.529	+3.0	30.232	+1.484	37.573	+2.069
	TB20(0-25)	41.917	+1.5	30.662	+5.935	37.192	+1.035

The application of first group of biodiesels for decreased CO emission, shows that Rapeseed biodiesel applied in diesel vehicle traveling on road (LDDV and HDDV in combination) under all scenarios is better than the use of the other biodiesels (as shown in Table 4.6). The results show that the use of Rapeseed biodiesel in 100% LDDV and 100% HDDV on three Road releases total CO emission less than the total CO emission emitted from the use of diesel oil in combination of LDDV and HDDV about 76 -90%. The scenarios that emit CO less than diesel oil 50% are RB20 (100-100), RB20 (100-75), RB20 (75-100), RB20 (100-50), and RB20 (50-100). The application of Used cooking oil biodiesel in a similar manner to gives CO emission less than the use of diesel oil is constantly the values of emission reduction on three roads in range 69 -84% of UB (100 -100). But Yellow grease biodiesel differences CO emission reduction from other biodiesels because it can be reduced better CO emission with 100% HDDV traveling on roads than used100% LDDV only (increases 19% of YB(100-0) and reduces 47% of YB(0-100)) (see in Table 4.7).

The application of second group found that Palm biodiesel and Coconut biodiesel in LDDV can reduce CO emission from diesel vehicle traveling on road up to 40%. The more percentage of LDDV using the Palm biodiesel or Coconut biodiesel, the more CO emission reduction.

The scenario of Tallow biodiesel using in HDDV increases CO emission over than that of diesel vehicle traveling on road and the more percentage of HDDV using the Tallow biodiesel the more CO emit. For example the scenario TB20 (0-100) and TB20 (0-25) emit CO more than diesel oil about 6% and 2% in Intraphithak Road respectively. Hence Tallow biodiesel should not be applied to HDDV traveling on the road that CO level is very near to or over than the CO-ambient air standard.

4.4.3 Scenarios on NO_x emission reduction

Table 4.7 Application of B20 biodiesels for reducing NO_x emissions

Unit: ton/km-y

Fuel	Scenario	Road					
		In-R		Lp-R		Dd-R	
		emission	% change BD relative to D	emission	% change BD relative to D	emission	% change BD relative to D
Diesel	Diesel oil	87.9	0.0	61.6	0.0	69.4	0.0
Yellow grease biodiesel	YB20(100-100)	70.005	-20.3	49.017	-20.446	72.378	+4.288
	YB20(100-75)	80.175	-8.8	56.154	-8.863	78.708	+13.409
	YB20(75-100)	64.304	-26.8	45.030	-26.917	65.304	-5.905
	YB20(100-50)	90.345	+2.8	63.291	+2.721	85.038	+22.530
	YB20(50-100)	58.602	-33.3	41.042	-33.389	58.229	-16.098
	YB20(100-0)	110.685	+26.0	77.565	+25.887	97.698	+40.771
	YB20(50-50)	78.943	-10.2	55.316	-10.223	70.890	+2.144
	YB20(0-100)	47.200	-46.3	33.067	-46.332	44.081	-36.484
	YB20(25-25)	83.412	-5.1	58.465	-5.111	70.146	+1.072
Rapeseed biodiesel	RB20(100-100)	19.463	-77.9	13.645	-77.854	15.452	-77.735
	RB20(100-75)	31.973	-63.6	22.424	-63.606	23.239	-66.516
	RB20(75-100)	24.057	-72.6	16.859	-72.638	21.153	-69.521
	RB20(100-50)	44.483	-49.4	31.203	-49.358	31.025	-55.296
	RB20(50-100)	28.652	-67.4	20.072	-67.423	26.854	-61.306
	RB20(100-0)	69.503	-20.9	48.761	-20.862	46.598	-32.857
	RB20(50-50)	53.672	-38.9	37.630	-38.927	42.427	-38.867
	RB20(0-100)	37.841	-56.9	26.499	-56.992	38.256	-44.878
	RB20(25-25)	70.776	-19.5	49.622	-19.463	55.914	-19.434
Used cooking oil biodiesel	UB20(100-100)	74.677	-15.0	52.393	-14.967	49.633	-28.484
	UB20(100-75)	73.308	-16.6	51.432	-16.526	48.781	-29.712
	UB20(75-100)	79.347	-9.7	55.659	-9.666	55.427	-20.136
	UB20(100-50)	71.940	-18.1	50.472	-18.085	47.929	-30.940
	UB20(50-100)	84.017	-4.4	58.925	-4.365	61.222	-11.787
	UB20(100-0)	69.202	-21.3	48.551	-21.203	46.225	-33.395
	UB20(50-50)	81.279	-7.5	57.004	-7.483	59.518	-14.242
	UB20(0-100)	93.356	+6.2	65.457	+6.236	72.810	+4.911
	UB20(25-25)	84.580	-3.8	59.309	-3.742	64.460	-7.121
Palm biodiesel	PB20(100-0)	72.086	-18.0	50.568	-17.929	49.804	-28.23
	PB20(75-0)	76.035	-13.5	53.330	-13.447	54.704	-21.18
	PB20(50-0)	79.983	-9.0	56.091	-8.964	59.03	-14.12
	PB20(25-0)	83.932	-4.5	58.853	-4.482	64.502	-7.06
Coconut biodiesel	CB20(100-0)	74.546	-15.2	52.289	-15.136	52.857	-23.840
	CB20(75-0)	77.880	-11.4	54.620	-11.352	56.993	-17.880
	CB20(50-0)	81.213	-7.6	56.952	-7.568	61.129	-11.920
	CB20(25-0)	84.547	-3.8	59.283	-3.784	65.266	-5.960
Tallow biodiesel	TB20(0-100)	83.720	-4.7	58.695	-4.739	66.812	-3.732
	TB20(0-75)	84.760	-3.6	59.425	-3.554	67.459	-2.799
	TB20(0-50)	85.800	-2.4	60.155	-2.370	68.107	-1.866
	TB20(0-25)	86.840	-1.2	60.885	-1.185	68.754	-0.933

The scenarios show unsystematic pattern on percentage of NO_x emission change when they are compared to the emission of NO_x emitted from the diesel oil. Thus the application of Yellow grease biodiesel in both types of diesel vehicle is impractical for reducing NO_x emission.

The diesel vehicles using Rapeseed biodiesel show the most NO_x reduction in comparing to emissions from other biodiesels. To reduce NO_x emission more than 50% NO_x emission of diesel oil, the application of Rapeseed biodiesel in diesel vehicle should be followed the scenarios of RB20 (100-100), RB20 (100-75), RB20

(75-100), RB20 (50-100) and RB20 (0-100). It seems to show that the application of Rapeseed biodiesel gives the most benefit to NO_x emission reduction in diesel vehicle traveling on roads.

The application of Used cooking oil biodiesel is not recommended in HDDV only because it yields higher NO_x than that of the diesel oil. When it was applied to both two types of diesel vehicle, the benefits from application in LDDV will compensate the negative impact in HDDV. The benefits from the use of Used cooking oil biodiesel for NO_x emission reduction in diesel vehicles are generally lower than that of the Rapeseed biodiesel.

The application of Palm biodiesel and Coconut biodiesel in LDDV under four scenarios can reduce NO_x emission from diesel vehicle traveling on road up to 10%. The more percentage of LDDV using from Palm biodiesel or Coconut biodiesel less NO_x emission. For the use of Tallow biodiesel only in HDDV also reduces NO_x emission as a similar pattern as Palm biodiesel and Coconut biodiesel but the percentage of NO_x reduction is less than 5%.

4.4.4 Scenarios on PM emission reduction

Table 4.8 Application of B20 biodiesels for reducing PM emissions

Unit: ton/km-y

Fuel	Scenario	Road					
		In-R		Lp-R		Dd-R	
		emission	% change BD relative to D	emission	% change BD relative to D	emission	% change BD relative to D
Diesel	Diesel oil	6.1	0.0	4.3	0.0	5.9	0.0
Yellow grease biodiesel	YB20(100-100)	7.096	+16.6	4.966	+16.525	8.194	+37.999
	YB20(100-75)	7.501	+23.3	5.249	+23.184	8.446	+42.238
	YB20(75-100)	6.439	+5.8	4.506	+5.734	7.378	+24.260
	YB20(100-50)	7.905	+29.9	5.533	+29.844	8.697	+46.477
	YB20(50-100)	5.781	-5.0	4.046	-5.056	6.562	+10.521
	YB20(100-0)	8.714	+43.2	6.101	+43.163	9.201	+54.955
	YB20(50-50)	6.590	+8.3	4.613	+8.262	7.066	+18.999
	YB20(0-100)	4.5	-26.6	3.126	-26.638	4.931	-16.957
	YB20(25-25)	6.337	+4.2	4.437	+4.131	6.502	+9.500
Rapeseed biodiesel	RB20(100-100)	0.977	-83.9	0.684	-83.942	0.908	-84.701
	RB20(100-75)	1.506	-75.3	1.055	-75.235	1.238	-79.158
	RB20(75-100)	1.725	-71.7	1.208	-71.664	1.837	-69.069
	RB20(100-50)	2.034	-66.6	1.426	-66.527	1.567	-73.616
	RB20(50-100)	2.473	-59.4	1.731	-59.386	2.765	-53.436
	RB20(100-0)	3.092	-49.2	2.169	-49.112	2.225	-62.530
	RB20(50-50)	3.530	-42.0	2.473	-41.971	3.423	-42.351
	RB20(0-100)	3.969	-34.8	2.777	-34.830	4.621	-22.171
	RB20(25-25)	4.807	-21.0	3.367	-20.986	4.680	-21.175
Used cooking oil biodiesel	UB20(100-100)	2.102	-65.4	1.474	-65.406	1.604	-72.982
	UB20(100-75)	2.348	-61.4	1.646	-61.364	1.757	-70.410
	UB20(75-100)	2.852	-53.1	1.999	-53.096	2.535	-57.310
	UB20(100-50)	2.593	-57.4	1.819	-57.322	1.910	-67.837
	UB20(50-100)	3.602	-40.8	2.523	-40.786	3.465	-41.637
	UB20(100-0)	3.084	-49.3	2.163	-49.239	2.215	-62.691
	UB20(50-50)	4.093	-32.7	2.868	-32.703	3.771	-36.491
	UB20(0-100)	5.102	-16.1	3.572	-16.167	5.327	-10.291
	UB20(25-25)	5.089	-16.4	3.565	-16.351	4.854	-18.246
Palm biodiesel	PB20(100-0)	3.192	-47.5	2.239	-47.467	2.349	-60.435
	PB20(75-0)	3.915	-35.7	2.744	-35.600	3.246	-45.326
	PB20(50-0)	4.638	-23.8	3.250	-23.733	4.143	-30.217
	PB20(25-0)	5.361	-11.9	3.756	-11.867	5.041	-15.109
Coconut biodiesel	CB20(100-0)	3.231	-46.9	2.266	-46.834	2.397	-59.629
	CB20(75-0)	3.944	-35.2	2.765	-35.125	3.282	-44.722
	CB20(50-0)	4.657	-23.5	3.264	-23.417	4.167	-29.815
	CB20(25-0)	5.371	-11.7	3.762	-11.708	5.053	-14.907
Tallow biodiesel	TB20(0-100)	5.326	-12.5	3.730	-12.478	5.466	-7.943
	TB20(0-75)	5.516	-9.3	3.863	-9.359	5.584	-5.957
	TB20(0-50)	5.705	-6.2	3.996	-6.239	5.702	-3.971
	TB20(0-25)	5.895	-3.1	4.128	-3.120	5.820	-1.986

The nine scenarios of biodiesel used in LDDV and HDDV show that PM emissions from Yellow grease biodiesel are likely higher than PM emitted from the diesel oil. Thus the application of Yellow grease biodiesel in diesel vehicles should be avoided in the area where PM level is in concern.

The diesel vehicles using Rapeseed biodiesel show the most PM reduction in comparing to emissions from other biodiesels. To reduce PM emission more than 50% of NO_x emitted from vehicle used diesel oil, the application of Rapeseed biodiesel in diesel vehicle should be followed the scenarios of RB20 (100-100), RB20 (100-75), RB20 (75-100), RB20 (100-50) and RB20 (50-100). It seems to show that the application of Rapeseed biodiesel gives the most benefit to PM emission reduction in diesel vehicle traveling on three roads. The application of Used cooking oil biodiesel similar a manner to Rapeseed biodiesel but gives slightly more PM emission than the use of Rapeseed biodiesel.

For the group of biodiesel used in only each of diesel vehicle, the application of Palm biodiesel and Coconut biodiesel in LDDV can reduce PM emission from diesel vehicle traveling on road up to 50%. The more percentage of LDDV using from Palm biodiesel or Coconut biodiesel lows PM emission. The use of Tallow biodiesel in HDDV also reduces PM emission as a similar pattern as Palm biodiesel and Coconut biodiesel but the percentage of PM reduction is less than 15%.

4.5 Appropriate biodiesel for applying to the scheme on emission reduction in diesel vehicle on roads

The findings from the previous section point that not any kind of biodiesel can reduce all target pollutants to the lowest level. For example, Palm biodiesel, Coconut biodiesel and Tallow biodiesel are only available to use in one type of diesel vehicle (LDDV or HDDV). So their effectiveness in emission reduction is relatively lower than the other biodiesels which are available to use in both type of diesel vehicle (LDDV and HDDV). For Tallow biodiesel, it was found that it should not be applied to HDDV traveling on the road that CO level is very near to or over than the CO-ambient air standard (6% increase at TB20 (0-100) and 1.5% increase at TB20 (0-25)). For the emission reduction of Yellow grease biodiesel as well when uses in HDDV more than LDDV ((+18% CO emission of YB(100-0) and 47% CO emission of YB (0-100) on Intharaphithak Road),(+26% NO_x emission of YB(100-0) and -46%

NO_x emission of YB(0-100) on Ladprao Road),(+19% HC emission of YB(100-0) and -26% PM emission of YB(0-100) on Dingdaeng Road)). So, the applications of Yellow grease biodiesel suitable to concern in a road of air pollution problem.

From the results, it can be concluded that the application of Rapeseed biodiesel gives the most benefit to HC, CO, NO_x and PM emission reduction in diesel vehicle traveling on three roads (in Table 4.10 shows 88% HC reduction, 76% CO reduction, 78% NO_x reduction and 84% PM reduction at RB20 (100-100)). The use of Rapeseed biodiesel also reduce large amount of CO (90.3% reduction at RB20 (100-100) in Dindaeng Road also.

The Used cooking oil biodiesel seems to be the second position of Rapeseed biodiesel for reducing HC, CO and PM emissions in diesel vehicle traveling on road (from Table 4.9 is 72% HC reduction, 69% CO reduction, and 65% PM reduction at UB20(100-100)). The application of Used cooking oil biodiesel is not recommended in HDDV alone because it yields higher NO_x than that of the diesel oil (5 - 6% increase at UB20 (0-100)) on Intharaphithak Road and Ladprao road.

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Table 4.9 The emission reduction of biodiesel using in both LDDV and HDDV

Types of Pollutants	An appropriate of the use of biodiesels reduction with LDDV and HDDV on roads					
	Intharaphithak Road		Ladprao Road		Dindaeng Road	
	Biodiesel B20	Emission (min - max)	Biodiesel B20	Emission (min - max)	Biodiesel B20	Emission (min - max)
HC	RB	-22 of RB(25-25)	RB	-22 of RB(25-25)	RB	-23 RB of (25-25)
		-88 of RB(100-100)		-88 of RB(100-100)		-80 RB of (100-100)
	UB	-18 of UB(25-25)	UB	-18 of UB(25-25)	UB	-13 UB of (0-100)
		-72 of UB(100-100)		-72 of UB(100-100)		-80 UB of (100-100)
	YB	+15 of YB(100-0)	YB	+15 of YB(100-0)	YB	+19 YB of (100-0)
		-40 of YB(0-100)		-40 of YB(0-100)		-26 YB of (0-100)
CO	RB	-19 of RB(25-25)	RB	-18 of RB(25-25)	RB	-19 RB of (25-25)
		-76 of RB(100-100)		-76 of RB(100-100)		-90 RB of (100-100)
	UB	-17 of UB(25-25)	UB	-17 of UB (25-25)	UB	-18 UB of (25-25)
		-69 of UB(100-100)		-69 of UB(100-100)		-84 UB of (100-100)
	YB	+18 of YB(100-0)	YB	+19 of YB(100-0)	YB	-2 YB of (25-25)
		-47 of YB(0-100)		-47 of YB(0-100)		-59 YB of (100-100)
NO_X	RB	-20 of RB(25-25)	RB	-20 of RB(25-25)	RB	-19 RB of (25-25)
		-78 of RB(100-100)		-78 of RB(100-100)		-78 RB of (100-100)
	YB	+26 of YB(100-0)	YB	+26 of YB(100-0)	YB	+41 YB of (100-0)
		-46 of YB(0-100)		-46 of YB(0-100)		-37 YB of (0-100)
	UB	+6 of UB(0-100)	UB	+6 of UB(0-100)	UB	+5 UB of (0-100)
		-21 of UB(100-0)		-21 of UB(100-0)		-33 UB of (100-0)
PM	RB	-21 of RB(25-25)	RB	-21 of RB(25-25)	RB	-21 RB of (25-25)
		-84 of RB(100-100)		-84 of RB(100-100)		-84 RB of (100-100)
	UB	-16 of UB(0-100)	UB	-16 of UB (0-100)	UB	-10 UB of (0-100)
		-65 of UB(100-100)		-65 of UB(100-100)		-73 UB of (100-100)
	YB	+43 of YB(100-0)	YB	+43 of YB(100-0)	YB	+55 YB of (100-0)
		-27 of YB(0-100)		-27 of YB(0-100)		-17 YB of (0-100)

Remark : YB = Yellow grease biodiesel
RB = Rapeseed biodiesel
UB = Used cooking oil biodiesel

The criteria of the appropriate biodiesel for applying to the scheme on emission reduction in diesel vehicle on roads is type of biodiesel and proportion of biodiesel using in both diesel vehicle that influence to the effective of emission reduction.

Although, Palm biodiesel and Coconut biodiesel are effective for decreasing emission on road but they are not chosen for the study in this section because these two biodiesels have supporting data only in LDDV.

So, Rapeseed biodiesel, Used cooking oil biodiesel and Yellow grease biodiesel which have emission data support in both diesel vehicles (LDDV and HDDV) are chosen for the consideration of the appropriate biodiesel using on road.

Rapeseed biodiesel is a good alternative fuel for improving of air pollution on three roads. The emissions rates of Rapeseed biodiesel are constants and have highs emission reduction of HC, CO, NO_X and PM, especially the use of Rapeseed biodiesel 100% in LDDV and HDDV. The used of Yellow grease biodiesel is good in HC, CO, NO_X and PM reduction when it was used in HDDV only.

The emission reduction on HC, CO, NO_x and PM of Used cooking oil biodiesel in two diesel vehicles at 100% proportion is high when apply on three roads, except when applied only in HDDV (scenario (0 - 100)) due to higher NO_x emission than diesel oil.

According to the level of pollutant that exceeds ambient air standard, air pollution problem in Bangkok is PM (see Appendix at Table 1D and Figure 1D). Whilst, CO and NO_X are under the standard. Unfortunately, standard for HC has not included into the standard. Hence the use of Rapeseed biodiesel that greatest in PM reduction should be the first choice and following by Used cooking oil biodiesel for reducing PM levels in the area near to the roads in Bangkok. Because these biodiesels can reduce PM emission in both types of diesel vehicle.

These results conform the providing of biodiesel following the strategic plan of biodiesel using blend 2% in Bangkok, suburban of Bangkok and south of Thailand

2006 - 2007 to use in all diesel vehicles in country in 2010. The strategic plan explained the enough of raw material in two sections (import vegetable oil and production in country i.e. palm oil or used cooking oil) for biodiesel production (Department of Alternative Energy Development and Efficiency, 2004).

CHAPTER V
CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

1. The study on emission factors of seven biodiesels for diesel vehicle was devided into three groups of emission factor : The first group of biodiesel used in both LDDV and HDDV were Rapeseed biodiesel and Used cooking oil biodiesel but Yellow grease biodiesel is effectives when it was used in HDDV only.

The second group which their emission factor are used only in LDDV were Palm biodiesel, Coconut biodiesel.

The third group which its emission factor were used only in HDDV was Tallow biodiesel.

Soy biodiesel blends was found in general that its emissions of all pollutants are higher than that of diesel oil.

2. The estimation of traffic emissions from the use of biodiesel and diesel was found that the use of Rapeseed biodiesel and Used cooking oil biodiesel are appropriate fuel for decreasing air pollution problem from both diesel vehicles. The application of Used cooking oil biodiesel blend 20 in HDDV was not recommend in the area that NO_X is concerned. The use of Palm biodiesel and Coconut biodiesel in LDDV can reduce all pollutants.

3. The suggestion on the use of biodiesel for air pollution mitigation from scenarios on emission reduction was based on biodiesels B20. The appropriate biodiesel using on road depend on the types of biodiesel and the proportion of biodiesel using in both diesel vehicles that influence the effective of emission reduction. The result of the proportion of biodiesel using in diesel vehicle on road

show the emission reduction of biodiesel is effective when it is used in 100% of both diesel vehicles traveling on road and the trend of emission reduction decreases when the % proportion of biodiesel using in diesel vehicles traveling on road is lower.

Yellow grease biodiesel is not appropriate for use to improve air pollution on road because it is effective in emission reduction only when applied to HDDV.

Rapeseed biodiesel give high emission reduction with all pollutants in all scenarios. But it is needed to be imported.

This study suggest the Used cooking oil biodiesel as an appropriate alternative fuel for improving air pollution because it gives emission lower than diesel oil and the effectiveness in emission reduction similar to Rapeseed biodiesel. However, the use of Used cooking oil biodiesel at blend 20 should be avoided in 100% HDDV. In addition, Used cooking oil biodiesel is also appropriates and available in the country whilst the Rapeseed biodiesel has to be imported. In Changmai province, there was pilot project of biodiesel producing from the waste of pork rind oil and applied to use in minibus traveling on road. So, the application of Used cooking oil biodiesel gives benefits in reducing the use of secondary cooking oil that harmful to consumer health. In addition, it gives the socio – economic benefits to the country in the ways that it reduces the fossil fuel consumption, maintains of the finance and the stability of energy in country. Due to the biodiesel’s cheaper price, it saves the expedition of consumer and the government.

5.2 RECOMMENDATIONS

1. Due to the limit of data on emission factors, which some biodiesel are available only for LDDV (Palm biodiesel and Coconut biodiesel) or HDDV (Tallow biodiesel) and the availability was only in some blends, not cover all blends, hence more researches should be conducted more data are available.

2. This research focus on the changes of emissions due to the application of biodiesel instead of diesel oil in diesel vehicle. The research dose not covers the study on the change of the level of air pollutants (concentration). Hence more researches on the issue of concentration of air pollutants should be undertaken in the future by taking the emission rates of pollutants from diesel vehicle on roads which are found in this research, in combination with emission rate from petrol vehicle on the same roads. The data of diesel vehicle's emission rate and petrol vehicle's emission rate will be the input data of an air quality model for predicting air quality in the area of interest.

3. Due to the limited data of Palm biodiesel's emission factor which was applied in LDDV only. But it is very interesting biodiesel because it is the most of oily plants grown in the country. So, the future research should focus on the study on the emission factors of Palm biodiesel in LDDV and HDDV, including the study on the comparison of emission reduction between the use of Palm biodiesel and Used cooking oil biodiesel in order to get scientific evidences to support the determination on which biodiesels are more appropriate to promote their use in the country and improving air quality as well.

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APPENDIX

Table 1A The emission factors from biodiesel and diesel oil in LDDV

Types of fuel	Name of researcher	Blends	Types of diesel vehicle	Emission factors (g/km)			
				HC	CO	NO_X	PM
1. Soy biodiesel	Durbin, 2001	20% SoyGold Biodiesel	1983 Ford F350 pick-up	*2.058*	*5.646*	*5.936*	*0.993*
				2.009	5.479	6.293	1.301
			1985 Chevy C-30 pick-up	*0.407*	*2.12*	*6.190*	*0.355*
				0.361	2.156	6.738	0.312
			1987 Chevy C-30 pick-up	*1.121*	*4.173*	*3.360*	*0.507*
				1.373	4.17	3.412	0.578
			1989 Chevy 2500 pick-up	*0.684*	*2.703*	*3.663*	*0.356*
				0.969	3.08	3.706	0.438
			1990 Chevy 2500 pick-up	*0.704*	*3.032*	*4.592*	*0.265*
				0.533	2.745	4.801	0.257
			1990 Ford E350 Van	*0.145*	*1.312*	*14.828*	*0.204*
				0.235	1.317	15.245	0.188
			1993 Ford F350 pick-up	*10.352*	*12.410*	*3.251*	*3.674*
				7.903	11.692	3.223	4.151

Remark : *An italic is Emission factors from diesel oil*

Table 1A The emission factors from biodiesel and diesel oil in LDDV (continued)

Types of fuel	Name of researcher	Blends	Types of diesel vehicle	Emission factors (g/km)			
				HC	CO	NO_X	PM
1. Soy biodiesel	Durbin, 2001	20% World Energy Biodiesel	1983 Ford F350 pick-up	*2.058*	*5.646*	*5.936*	*0.993*
				2.075	5.224	5.997	1.474
			1985 Chevy C-30 pick-up	*0.407*	*2.12*	*6.190*	*0.355*
				0.375	2.145	6.717	0.318
			1987 Chevy C-30 pick-up	*1.121*	*4.173*	*3.360*	*0.507*
				1.220	4.072	3.420	0.587
			1989 Chevy 2500 pick-up	*0.684*	*2.703*	*3.663*	*0.356*
				0.960	2.975	3.853	0.432
			1990 Chevy 2500 pick-up	*0.704*	*3.032*	*4.592*	*0.265*
				0.411	2.676	4.682	0.259
			1990 Ford E350 Van	*0.145*	*1.312*	*14.828*	*0.204*
				0.169	1.296	15.245	0.187
			1993 Ford F350 pick-up	*10.352*	*12.410*	*3.251*	*3.674*
				8.395	11.603	3.323	4.465

Remark : *An italic is Emission factors from diesel oil*

Table 1A The emission factors from biodiesel and diesel oil in LDDV (continued)

Types of fuel	Name of researcher	Blends	Types of diesel vehicle	Emission factors (g/km)			
				HC	CO	NO_X	PM
2. Yellow Grease	Durbin, 2001	20% Oxy-GB-60 Biodiesel	1983 Ford F350 pick-up	*2.058*	*5.646*	*5.936*	*0.993*
				1.480	4.011	6.223	0.926
			1985 Chevy C-30 pick-up	*0.407*	*2.12*	*6.190*	*0.355*
				0.324	1.914	6.40	0.332
			1987 Chevy C-30 pick-up	*1.121*	*4.173*	*3.360*	*0.507*
				0.736	2.930	3.379	0.469
			1989 Chevy 2500 pick-up	*0.684*	*2.703*	*3.663*	*0.356*
				0.774	2.694	3.832	0.413
			1990 Chevy 2500 pick-up	*0.704*	*3.032*	*4.592*	*0.265*
				0.237	1.636	4.816	0.255
			1990 Ford E350 Van	*0.145*	*1.312*	*14.828*	*0.204*
				0.171	1.172	14.091	0.206
			1993 Ford F350 pick-up	*10.352*	*12.410*	*3.251*	*3.674*
				5.443	8.982	3.536	2.946

Remark : *An italic is Emission factors from diesel oil*

Table 1A The emission factors from biodiesel and diesel oil in LDDV (continued)

Types of fuel	Name of researcher	Blends	Types of diesel vehicle	Emission factors (g/km)			
				HC	CO	NO_X	PM
3. Palm biodiesel	Mongkol, B.E. 2547	2%	2003 Toyota D4D 2.5L pickup	*0.052*	*0.056*	*0.481*	*0.075*
				0.046	0.558	0.457	0.073
			2003 Isuzu DMAX 2.5L Pickup	*0.134*	*0.845*	*0.760*	*0.099*
				0.121	0.827	0.777	0.100
	Mongkol, B.E. 2547	5%	2003 Toyota D4D 2.5L pickup	*0.052*	*0.056*	*0.481*	*0.075*
				0.046	0.570	0.462	0.080
			2003 Isuzu DMAX 2.5L Pickup	*0.134*	*0.845*	*0.760*	*0.099*
				0.128	0.870	0.818	0.090
	Mongkol, B.E. 2547	20%	2003 Toyota D4D 2.5L pickup	*0.052*	*0.056*	*0.481*	*0.075*
				0.038	0.451	0.538	0.059
			2003 Isuzu DMAX 2.5L Pickup	*0.134*	*0.845*	*0.760*	*0.099*
				0.102	0.765	0.836	0.086
	Pollution control department, (no date)	20%	(3 ปี) Toyota 2500 pickup	*0.051*	*0.511*	*0.961*	*0.053*
				0.049	0.459	0.963	0.047
			(5 ปี) Toyota 2500 pickup	*0.074*	*0.619*	*1.741*	*0.126*
				0.066	0.602	1.804	0.113
	Mongkol, B.E. 2547	100%	2003 Toyota D4D 2.5L pickup	*0.052*	*0.056*	*0.481*	*0.075*
				0.035	0.440	0.579	0.027
			2003 Isuzu DMAX 2.5L Pickup	*0.134*	*0.845*	*0.760*	*0.099*
				0.054	0.518	0.959	0.046

Remark : *An italic is Emission factors from diesel oil*

Table 1A The emission factors from biodiesel and diesel oil in LDDV (continued)

Types of fuel	Name of researcher	Blends	Types of diesel vehicle	Emission factors (g/km)			
				HC	CO	NO_X	PM
4. Coconut biodiesel	Pollution control department, (no date)	20%	(3 ปี) Toyota 2500 pickup	*0.051*	*0.511*	*0.961*	*0.053*
				0.041	0.404	0.97	0.041
			(5 ปี) Toyota 2500 pickup	*0.074*	*0.619*	*1.741*	*0.126*
				0.075	0.558	1.738	0.121
5. Rapeseed biodiesel	Mongkol, B.E. 2547	2%	2003 Toyota D4D 2.5L pickup	*0.051*	*0.547*	*0.526*	*0.066*
				0.048	0.555	0.520	0.063
			2003 Isuzu DMAX 2.5L Pickup	*0.122*	*0.829*	*0.780*	*0.09*
				0.121	0.824	0.830	0.095
	Mongkol, B.E. 2547	5%	2003 Toyota D4D 2.5L pickup	*0.051*	*0.547*	*0.526*	*0.066*
				0.049	0.567	0.534	0.059
			2003 Isuzu DMAX 2.5L Pickup	*0.122*	*0.829*	*0.780*	*0.09*
				0.123	0.788	0.806	0.091
	Mongkol, B.E. 2547	20%	2003 Toyota D4D 2.5L pickup	*0.051*	*0.547*	*0.526*	*0.066*
				0.043	0.575	0.546	0.047
			2003 Isuzu DMAX 2.5L Pickup	*0.122*	*0.829*	*0.780*	*0.09*
				0.116	0.834	0.844	0.078
	Mongkol, B.E. 2547	100%	2003 Toyota D4D 2.5L pickup	*0.051*	*0.547*	*0.526*	*0.066*
				0.038	0.673	0.588	0.024
			2003 Isuzu DMAX 2.5L Pickup	*0.122*	*0.829*	*0.780*	*0.09*
				0.029	0.911	1.017	0.048

Remark : *An italic is Emission factors from diesel oil*

Table 1A The emission factors from biodiesel and diesel oil in LDDV (continued)

Types of fuel	Name of researcher	Blends	Types of diesel vehicle	Emission factors (g/km)			
				HC	CO	NO_X	PM
6. Used cooking oil biodiesel	Mongkol, B.E. 2547	20%	2003 Toyota D4D 2.5L pickup	*0.037*	*0.435*	*0.528*	*0.09*
				0.024	0.421	0.534	0.070
			2003 Isuzu DMAX 2.5L Pickup	*0.122*	*0.853*	*0.754*	*0.06*
				0.094	0.739	0.787	0.054
	Mongkol, B.E. 2547	30%	2003 Toyota D4D 2.5L pickup	*0.037*	*0.435*	*0.528*	*0.09*
				0.035	0.463	0.525	0.061
			2003 Isuzu DMAX 2.5L Pickup	*0.122*	*0.853*	*0.754*	*0.06*
				0.101	0.774	0.805	0.050
	Mongkol, B.E. 2547	40%	2003 Toyota D4D 2.5L pickup	*0.037*	*0.435*	*0.528*	*0.09*
				0.035	0.489	0.526	0.57
			2003 Isuzu DMAX 2.5L Pickup	*0.122*	*0.853*	*0.754*	*0.06*
				0.090	0.764	0.803	0.050

Remark : *An italic is Emission factors from diesel oil*

Table 2A The emission factors from biodiesel and diesel oil in HDDV

Types of fuel	Name of researcher	Blends	Types of diesel vehicle	Emission factors (g/km)			
				HC	CO	NO_X	PM
1. Soy biodiesel	Schumacher, (no date)	10%	1991 6V-92TA DDC 11 Coach	*3.533*	*7.409*	*20.756*	*0.967*
				3.091	7.017	21.492	0.913
	Graboski, 1999	20%	1991 DDC Series 60 Engine	*0.515*	*27.091*	*22.444*	*1.394*
				0.554	23.818	22.704	1.084
	Schumacher, (no date)	20%	1991 6V-92TA DDC 11 Coach	*3.533*	*7.409*	*20.756*	*0.967*
				2.748	6.477	21.884	0.859
	Satish Lele, (no date)	20%	DDC series 50 engine	*0.294*	*7.311*	*22.081*	*0.500*
				0.294	6.771	22.866	0.432
	Fosseen,1994 *	20%	6V-71N-77MUI	*9.863*	*17.616*	*48.872*	*4.073*
				7.017	13.396	50.05	3.975
	Manicom et. al., 1993 *	20%	6V-92TA-91DDECH	*3.533*	*7.409*	*20.756*	*0.967*
				2.748	6.477	21.884	0.859
	Fosseen,1995 *	20%	6V-71N-77MUI	*4.220*	*15.604*	*57.508*	*1.384*
				3.631	15.211	58.293	1.585
	Fosseen, 1994 *	20%	6V-92TA-81/89MUI	*2.061*	*10.599*	*49.363*	*1.315*
				1.766	8.881	51.523	1.276
	Sharp, 1994	20%	6V 92TA DDEC ENGINES	*2.944*	*7.851*	*41.806*	*0.981*
				2.601	6.820	43.818	0.981

Remark : *An italic is Emission factors from diesel oil*

*cited in Prakash, 1998

Table 2A The emission factors from biodiesel and diesel oil in HDDV (continued)

Types of fuel	Name of researcher	Blends	Types of diesel vehicle	Emission factors (g/km)			
				HC	CO	NO_X	PM
1. Soy biodiesel	Prakash,1996 *	20%	6V-92TA-DDC	*2.679*	*6.084*	*26.202*	*1.325*
				2.193	5.594	27.086	1.290
	Stotler, 1995 *	20%	Cummins L-10 87 MUI	*4.367*	*11.433*	*27.676*	*1.521*
				4.024	9.617	28.261	1.374
	Ortech,, 1995 *	20%	Cummins N-14 87 MUI	*2.846*	*10.795*	*31.011*	*1.816*
				2.306	10.402	31.993	1.521
	Marshall, 1995 *	20%	Cummins L-10-92	*1.325*	*7.164*	*24.583*	*0.515*
				1.227	5.986	25.368	0.451
	Starr, 1997 *	20%	DDC Series 60 260 KW	*0.353*	*13.592*	*23.357*	*1.089*
				0.28	11.040	22.424	0.903
	Schumacher, (no date)	30%	1991 6V-92TA DDC 11 Coach	*3.533*	*7.409*	*20.756*	*0.967*
				2.650	5.594	23.553	0.849
	Beer, 2002	20%	Bus 20%	*2.71*	*4.89*	*20.20*	*0.787*
				3.07	3.92	22.94	0.525
	Beer, 2002	35%	Truck 35%	*1.509*	*2.723*	*11.250*	*0.438*
				1.709	2.184	12.775	0.292
	Schumacher, (no date)	40%	1991 6V-92TA DDC 11 Coach	*3.533*	*7.409*	*20.756*	*0.967*
				2.110	5.250	23.847	0.795
	Satish Lele, (no date)	100%	DDC series 50 engine	*0.294*	*7.311*	*22.081*	*0.500*
				0.049	4.514	24.583	0.255
	Satish Lele, (no date)	100%	DDC series 50 engine	*0.294*	*7.311*	*22.081*	*0.500*
				0.098	3.729	24.043	0.147

Remark : *An italic is Emission factors from diesel oil*

* cited in Prakash, 1998

Table 2A The emission factors from biodiesel and diesel oil in HDDV (continued)

Types of fuel	Name of researcher	Blends	Types of diesel vehicle	Emission factors (g/km)			
				HC	CO	NO_X	PM
2. Yellow grease biodiesle	(None), 1993	20 %	cummin L10-280E Truck	*0.3*	*2.9*	*4.3*	*0.23*
				0.22	1.2	7.11	0.03
	(None), 1993	100 %	cummin L10-280E Truck	*0.3*	*2.9*	*4.3*	*0.23*
				0.16	0.8	7.53	0.06
3. Rapeseed biodiesel	(Sharp,1 996 *	20%	Cummins B 5.9 Truck	*1.472*	*7.213*	*21.443*	*0.520*
				1.08	5.594	21.541	0.456
	Beer, 2002	20%	Bus	*1.129*	*6.084*	*21.148*	*0.491*
				2.71	4.89	20.20	0.787
	Baldassarri,2004	20%	BUS EURO II IVECO 8360.46R	*2.6*	*3.06*	*23.48*	*0.545*
				3.947	13.813	34.861	1.710
	Taberski, 1998	20%	1995 emission pickup truck 5.9 L	*3.289*	*12.497*	*34.861*	*1.776*
				0.53	2.288	4.191	0.114
	Taberski, 1998	20%	1998 emission pickup truck 5.9 L	*0.442*	*1.884*	*3.876*	*0.121*
				0.533	1.946	4.828	0.107
	Beer, 2002	35%	Truck	*0.417*	*1.406*	*4.691*	*0.107*
				1.509	2.723	11.250	0.438
	Taberski, 1998	50%	1995 5.9 L pickup truck	*1.449*	*1.707*	*13.075*	*0.304*
				0.53	2.288	4.191	0.114
	Taberski, 1998	50%	1998 5.9 L pickup truck	*0.3*	*1.491*	*4.068*	*0.155*
				0.533	1.946	4.828	0.107
	Taberski, 1998	100%	1995 5.9 L pickup truck	*0.342*	*1.261*	*4.470*	*0.143*
				0.53	2.288	4.191	0.114
	Taberski, 1998	100%	1998 5.9 L pickup truck	*0.201*	*1.493*	*3.673*	*0.162*
				0.533	1.946	4.828	0.107

Remark : *An italic is Emission factors from diesel oil,* * cited in Prakash, 1998

Table 2A The emission factors from biodiesel and diesel oil in HDDV (continued)

Types of fuel	Name of researcher	Blends	Types of diesel vehicle	Emission factors (g/km)			
				HC	CO	NO_X	PM
4. Used cooking oil biodiesel	Beer, 2002	20 %	Bus	*2.71*	*4.89*	*20.20*	*0.787*
				1.07	2.52	21.12	0.493
	Beer, 2002	20%	Bus	*2.71*	*4.89*	*20.20*	*0.787*
				1.09	2.60	21.12	0.493
	Beer, 2002	35 %	Truck	*1.509*	*2.723*	*11.250*	*0.438*
				0.597	1.403	11.764	0.274
	Beer, 2002	35%	Truck	*1.509*	*2.723*	*11.250*	*0.438*
				0.607	1.450	11.814	0.274
5. Tallow biodiesel	Graboski, 1999	20%	1991 DDC Series60Engine	*0.520*	*26.826*	*22.621*	*1.369*
				0.339	24.464	22.130	1.158
	Beer, 2002	20 %	Bus 20%	*2.71*	*4.89*	*20.20*	*0.787*
				2.53	3.03	23.08	0.533
	Beer, 2002	35 %	Truck 35%	*1.509*	*2.723*	*11.250*	*0.438*
				1.409	1.689	12.855	0.297
	Beer, 2002	20 %	Bus 20%	*2.71*	*4.89*	*20.20*	*0.787*
				1.08	2.53	21.16	0.493
	Beer, 2002	35 %	Truck 35%	*1.509*	*2.723*	*11.250*	*0.438*
				0.600	1.407	11.784	0.275
	(None), 1993	20 %	cummin L10-280E	*0.3*	*2.9*	*4.3*	*0.23*
				0.22	1.3	6.41	0.06
	(None), 1993	100 %	cummin L10-280E	*0.3*	*2.9*	*4.3*	*0.23*
				0.15	1.1	7.12	0.05

Remark : *An italic is Emission factors from diesel oil*

Table 3A Averages and standard deviations of emission factors from seven biodiesels blends and diesel oil in diesel vehicles

Type of Biodiesel	Blends	Number data (N)	Type of Vehicle	Average and Standard Deviation of Emission Factors (g/km)			
				HC	CO	NO_x	PM
1. soy biodiesel	10	-	LDDV	-	-	-	-
		1	HDDV	3.091	7.017	21.492	0.913
	20	14	LDDV	1.928 (± 2.707)	4.331 (± 3.348)	6.190 (± 4.046)	1.068 (± 2.707)
		14	HDDV	2.431 (± 1.753)	9.720 (± 5.050)	32.265 (± 12.880)	1.246 (± 0.860)
	30	-	LDDV	-	-	-	-
		1	HDDV	0.049	4.514	24.583	0.255
	35	-	LDDV	-	-	-	-
		1	HDDV	2.110	5.250	23.847	0.795
	40	-	LDDV	-	-	-	-
		1	HDDV	0.098	3.729	24.043	0.147
	100	-	LDDV	-	-	-	-
		2	HDDV	2.390 (0.049-0.098)*	3.052 (3.729-4.514)*	17.858 (24.043-24.583)*	0.409 (0.147-0.255)*
2. yellow grease biodiesel	20	7	LDDV	1.309 (± 1.877)	3.334 (± 2.662)	6.040 (± 3.757)	0.792 (± 0.979)
		1	HDDV	0.220	1.200	7.110	0.300
	100	-	LDDV	-	-	-	-
		1	HDDV	0.160	0.800	7.530	0.060

Remark : * the range of emission factor (minimum - maximum)

Table 3A Averages and standard deviations of emission factors from seven biodiesels blends and diesel oil in diesel vehicles (continued)

Type of Biodiesel	Blends	Number data (N)	Type of Vehicle	Average and Standard Deviation of Emission Factors (g/km)			
				HC	CO	NO_x	PM
3. palm biodiesel	2	2	LDDV	0.084 (0.046-0.121)*	0.693 (0.558-0.827)*	0.617 (0.457-0.777)*	0.088 (0.073-0.100)*
		-	HDDV	-	-	-	-
	5	2	LDDV	0.087 (0.046-0.128)*	0.720 (0.57-0.87)*	0.640 (0.462-0.818)*	0.085 (0.080-0.090)*
		-	HDDV	-	-	-	-
	20	4	LDDV	0.064 (± 0.028)	0.569 (± 0.148)	1.035 (± 0.543)	0.076 (± 0.029)*
		-	HDDV	-	-	-	-
	100	2	LDDV	0.045 (0.035-0.054)*	0.479 (0.440-0.518)*	0.769 (0.579-0.959)*	0.037 (0.027-0.046)*
		-	HDDV	-	-	-	-
4. coconut biodiesel	20	2	LDDV	0.058 (0.041-0.075)*	0.481 (0.404-0.558)*	1.354 (0.97-1.738)*	0.081 (0.041-0.121)*
		-	HDDV	-	-	-	-

Remark : * the range of emission factor (minimum - maximum)

Table 3A Averages and standard deviations of emission factors from seven biodiesels blends and diesel oil in diesel vehicles (continued)

Type of Biodiesel	Blends	Number data (N)	Type of Vehicle	Average and Standard Deviation of Emission Factors (g/km)			
				HC	CO	NO_x	PM
5. rapeseed biodiesel	2	2	LDDV	0.085 (0.048-0.121)*	0.690 (0.555-0.824)*	0.675 (0.520-0.830)*	0.079 (0.063-0.095)*
		-	HDDV	-	-	-	-
	5	2	LDDV	0.086 (0.049-0.123)*	0.678 (0.567-0.788)*	0.670 (0.534-0.806)*	0.075 (0.059-0.091)*
		-	HDDV	-	-	-	-
	20	2	LDDV	0.080 (0.043-0.116)*	0.705 (0.575-0.834)*	0.700 (0.546-0.844)*	0.063 (0.047-0.078)*
		6	HDDV	1.493 (± 1.185)	5.088 (± 4.101)	18.266 (± 11.941)	0.583 (± 0.615)
	35	-	LDDV	-	-	-	-
		1	HDDV	1.449	1.707	13.075	0.304
	50	-	LDDV	-	-	-	-
		2	HDDV	0.321 (0.3-0.342)*	1.376 (1.261-1.491)*	4.269 (4.068-4.470)*	0.149 (0.143-0.155)*
	100	2	LDDV	0.034 (0.038-0.029)*	0.792 (0.673-0.911)*	0.803 (0.588-1.017)*	0.036 (0.024-0.048)*
		2	HDDV	0.199 (0.196-0.201)*	1.285 (1.076-1.493)*	4.052 (3.673-4.430)*	0.153 (0.144-0.162)*

Remark : * the range of emission factor (minimum - maximum)

Table 3A Averages and standard deviations of emission factors from seven biodiesels blends and diesel oil in diesel vehicles

(continued)

Type of Biodiesel	Ratio	Number data (N)	Type of Vehicle	Average and Standard Deviation of Emission Factors (g/km)			
				HC	CO	NO_x	PM
6. used cooking oil biodiesel	20	2	LDDV	0.059 (0.024-0.094)*	0.580 (0.421-0.739)*	0.661 (0.534-0.787)*	0.062 (0.070-0.054)*
		2	HDDV	1.080 (1.07-1.09)*	2.560 (2.52-2.60)*	21.120 (21.120-21.120)*	0.493 (0.493-0.493)*
	30	2	LDDV	0.068 (0.035-0.101)*	0.619 (0.463-0.774)*	0.665 (0.525-0.805)*	0.056 (0.061-0.050)*
		-	HDDV	-	-	-	-
	35	-	LDDV	-	-	-	-
		2	HDDV	0.602 (0.597-0.607)*	1.427 (1.403-1.450)*	11.789 (11.764-11.814)*	0.274 (0.274-0.274)*
	40	2	LDDV	0.063 (0.035-0.090)*	0.627 (0.489-0.764)	0.665 (0.526-0.803)	0.310 (0.57-0.050)
		-	HDDV	-	-	-	-
7. tallow biodiesel	20	-	LDDV	-	-	-	-
		4	HDDV	1.042 (± 1.062)	7.831 (± 11.112)	18.195 (± 7.896)	0.561 (± 0.452)
	35	-	LDDV	-	-	-	-
		2	HDDV	1.005 (0.600-1.409)*	1.548 (1.407-1.689)*	12.320 (11.784-12.855)*	0.286 (0.275-0.297)*
	100	-	LDDV	-	-	-	-
		1	HDDV	0.150	1.100	7.120	0.050

Remark : * the range of emission factor (minimum - maximum)

Table 3A Averages and standard deviations of emission factors from seven biodiesels blends and diesel oil in diesel vehicles (continued)

Type of Biodiesel	Ratio	Number data (N)	Type of Vehicle	Average and Standard Deviation of Emission Factors (g/km)			
				HC	CO	NO_x	PM
8. Diesel	-	47	LDDV	1.033 (± 2.517)	2.328 (± 3.072)	3.083 (± 3.671)	0.451 (± 0.884)
		44	HDDV	1.974 (± 1.777)	7.088 (± 5.846)	19.458 (± 12.719)	0.791 (± 0.688)

Table 1B The result of the traffic data calculation

Roads	Time	Diesel vehicle			Petrol vehicle	Total vehicle
		LDDV	HDDV	Total		
Intharaphithak (Wongwean yai cross)	07.00-19.00	15,884	6,742	22,626	131,223	153,849
	19.00-07.00	5,295	2,247	7,542	43,741	51,283
	24 hour	21,179	8,989	30,168	174,965	205,133
Ladprao (Bangkapi cross)	07.00-19.00	11,079	4,424	15,503	63,666	79,169
	19.00-07.00	3,693	1,475	5,168	21,222	26,390
	24 hour	14,772	5,899	20,671	84,889	105,559
Dindaeng (Prachasongkor cross)	07.00-19.00	19,987	3,965	23,952	116,497	140,449
	19.00-07.00	6,662	1,322	7,984	38,832	46,816
	24 hour	26,649	5,287	31,936	155,329	187,265

Remark : LDDV = pickup and van

HDDV = truck, bus and minibus

Petrol vehicle = car, three wheel vehicle passenger and motorcycle

Table 2B The proportion of diesel vehicles (LDDV and HDDV) registration with total vehicle registration 2005 in Bangkok and Boundary

Region	The proportion of diesel vehicle registration and total vehicle registration	
	LDDV of Total Vehicles	HDDV of Total Vehicles
Bangkok	0.236046	0.023324
Samutprakan	0.30947	0.187224
Patumtani	0.356223	0.119978
Nontaburi	0.324518	0.060907
Nakornpatom	0.253137	0.067822
Samutsakorn	0.148939	0.051645
All country	0.209711	0.034407

Table 3B The proportion of diesel vehicles with total vehicle traveling on road

Roads	The proportion of diesel vehicles with total vehicle traveling on road			
	LDDV		HDDV	
	at day time	at night	at day time	at night
Intharaphithak	0.103	0.103	0.04	0.04
Ladprao	0.14	0.14	0.06	0.06
Dindaeng	0.14	0.14	0.03	0.03

Table 4B The quantity of LDDV and HDDV of total vehicle traveling flow on road 24 hour

Roads	The quantity of diesel vehicle of total vehicle traveling flow on road 24 hour	
	LDDV	HDDV
Intharaphithak	21,129	9,026
Ladprao	14,778	6,334
Dindaeng	26,217	5,618

Table 1C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Intharaphithak Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of HC Emissions	% Change diesel
			% LDDV	% HDDV		
1. Diesel	-	-	0	0	14.470	-
2. Soy Biodiesel	B 10	SB10(0-25)	0	25	15.390	+6.358
		SB10(0-50)	0	50	16.310	+12.716
		SB10(0-75)	0	75	17.230	+19.074
		SB10(0-100)	0	100	18.150	+25.432
	B 20	SB20(25-25)	25	25	9.362	-35.303
		SB20(0-100)	0	100	14.611	+0.976
		SB20(50-50)	50	50	18.723	+29.395
		SB20(100-0)	100	0	22.835	+57.814
		SB20(50-100)	50	100	26.029	+79.882
		SB20(100-50)	100	50	30.141	+108.301
		SB20(75-100)	75	100	31.738	+119.336
		SB20(100-75)	100	75	33.794	+133.545
		SB20(100-100)	100	100	37.447	+158.789
	B 30	SB30(0-25)	0	25	15.027	+3.848
		SB30(0-50)	0	50	15.583	+7.696
		SB30(0-75)	0	75	16.140	+11.543
		SB30(0-100)	0	100	16.697	+15.391
	B 35	SB35(0-100)	0	100	13.597	-6.033
		SB35(0-75)	0	75	13.815	-4.525
		SB35(0-50)	0	50	14.033	-3.017
		SB35(0-25)	0	25	14.252	-1.508
	B40	SB40(0-25)	0	25	14.583	+0.780
		SB40(0-50)	0	50	14.696	+1.560
		SB40(0-75)	0	75	14.808	+2.339
		SB40(0-100)	0	100	14.921	+3.119
	B100	SB100(0-100)	0	100	10.388	-28.209
		SB100(0-75)	0	75	11.409	-21.157
		SB100(0-50)	0	50	12.429	-14.105
		SB100(0-25)	0	25	13.449	-7.052

Table 1C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Intharaphithak Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of HC Emissions	% Change diesel
			% LDDV	% HDDV		
3. Yellow Grease Biodiesel	B20	YB20(0-100)	0	100	8.691	-39.935
		YB20(50-100)	50	100	9.756	-32.580
		YB20(75-100)	75	100	10.288	-28.902
		YB20(100-100)	100	100	10.820	-25.225
		YB20(100-75)	100	75	12.265	-15.241
		YB20(50-50)	50	50	12.645	-12.612
		YB20(25-25)	25	25	13.557	-6.306
		YB20(100-50)	100	50	13.709	-5.257
		YB20(100-0)	100	0	16.598	+14.710
	B100	YB100(0-100)	0	100	8.494	-41.301
		YB100(0-75)	0	75	9.988	-30.976
		YB100(0-50)	0	50	11.482	-20.650
		YB100(0-25)	0	25	12.976	-10.325
4. Palm Biodiesel	B2	PB2(100-0)	100	0	7.151	-50.579
		PB2(75-0)	75	0	8.981	-37.934
		PB2(50-0)	50	0	10.811	-25.290
		PB2(25-0)	25	0	12.640	-12.645
	B5	PB5(100-0)	100	0	7.174	-50.419
		PB5(75-0)	75	0	8.998	-37.815
		PB5(50-0)	50	0	10.822	-25.210
		PB5(25-0)	25	0	12.646	-12.605
	B20	PB20(100-0)	100	0	6.997	-51.645
		PB20(75-0)	75	0	8.865	-38.734
		PB20(50-0)	50	0	10.733	-25.823
		PB20(25-0)	25	0	12.602	-12.911
	B100	PB100(100-0)	100	0	6.850	-52.658
		PB100(75-0)	75	0	8.755	-39.493
		PB100(50-0)	50	0	10.660	-26.329
		PB100(25-0)	25	0	12.565	-13.164
5. Coconut Biodiesel	B20	CB20(100-0)	100	0	6.951	-51.965
		CB20(75-0)	75	0	8.830	-38.974
		CB20(50-0)	50	0	10.710	-25.982
		CB20(25-0)	25	0	12.590	-12.991

Table 1C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Intharaphithak Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of HC Emissions	% Change diesel
			% LDDV	% HDDV		
6. Rapeseed Biodiesel	B2	RB2(100-100)	100	100	5.574	-61.477
		RB2(100-75)	100	75	5.970	-58.739
		RB2(100-50)	100	50	6.367	-56.002
		RB2(100-0)	100	0	7.159	-50.526
		RB2(75-100)	75	100	7.402	-48.846
		RB2(50-100)	50	100	9.230	-36.214
		RB2(50-50)	50	50	10.022	-30.739
		RB2(25-25)	25	25	12.246	-15.369
		RB2(0-100)	0	100	12.885	-10.951
	B5	RB5(100-100)	100	100	5.437	-62.426
		RB5(100-75)	100	75	5.869	-59.437
		RB5(100-50)	100	50	6.302	-56.449
		RB5(100-0)	100	0	7.167	-50.473
		RB5(75-100)	75	100	7.263	-49.808
		RB5(50-100)	50	100	9.089	-37.189
		RB5(50-50)	50	50	9.953	-31.213
		RB5(25-25)	25	25	12.212	-15.606
		RB5(0-100)	0	100	12.740	-11.953
	B20	RB20(100-100)	100	100	1.674	-88.428
		RB20(100-75)	100	75	3.036	-79.019
		RB20(75-100)	75	100	3.512	-75.730
		RB20(100-50)	100	50	4.397	-69.610
		RB20(50-100)	50	100	5.349	-63.032
		RB20(100-0)	100	0	7.120	-50.792
		RB20(50-50)	50	50	8.072	-44.214
		RB20(0-100)	0	100	9.024	-37.635
		RB20(25-25)	25	25	11.271	-22.107
	B100	RB100(100-100)	100	100	0.918	-93.657
		RB100(100-75)	100	75	2.380	-83.554
		RB100(75-100)	75	100	2.844	-80.346
		RB100(100-50)	100	50	3.842	-73.451
		RB100(50-100)	50	100	4.770	-67.035
		RB100(100-0)	100	0	6.766	-53.244
		RB100(50-50)	50	50	7.694	-46.829
		RB100(0-100)	0	100	8.622	-40.413
		RB100(25-25)	25	25	11.082	-23.414

Table 1C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Intharaphithak Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of HC Emissions	% Change diesel
			% LDDV	% HDDV		
7. Used Cooking Oil Biodiesel	B20	UB20(100-100)	100	100	4.013	-72.266
		UB20(100-75)	100	75	4.749	-67.178
		UB20(100-50)	100	50	5.486	-62.089
		UB20(75-100)	75	100	5.891	-59.288
		UB20(100-0)	100	0	6.958	-51.912
		UB20(50-100)	50	100	7.769	-46.310
		UB20(50-50)	50	50	9.241	-36.133
		UB20(0-100)	0	100	11.525	-20.354
		UB20(25-25)	25	25	11.856	-18.067
	B30	UB30(100-0)	100	0	7.028	-51.432
		UB30(75-0)	75	0	8.888	-38.574
		UB30(50-0)	50	0	10.749	-25.716
		UB30(25-0)	25	0	12.609	-12.858
	B35	UB35 (0-100)	0	100	9.950	-31.238
		UB35 (0-75)	0	75	11.080	-23.428
		UB35 (0-50)	0	50	12.210	-15.619
		UB35 (0-25)	0	25	13.340	-7.809
	B40	UB40 (100-0)	100	0	6.989	-51.698
		UB40 (75-0)	75	0	8.859	-38.774
		UB40 (50-0)	50	0	10.730	-25.849
		UB40 (25-0)	25	0	12.600	-12.925
8. Tallow Biodiesel	B20	TB20 (0-25)	0	25	10.302	-28.804
		TB20 (0-50)	0	50	10.668	-26.276
		TB20 (0-75)	0	75	11.034	-23.748
		TB20 (0-100)	0	100	11.399	-21.220
	B35	TB35 (0-100)	0	100	11.278	-22.062
		TB35 (0-25)	0	25	13.672	-5.516
		TB35 (0-50)	0	50	12.874	-11.031
		TB35 (0-75)	0	75	12.076	-16.547
	B100	TB100 (0-100)	0	100	8.461	-41.529
		TB100 (0-75)	0	75	9.963	-31.146
		TB100 (0-50)	0	50	11.465	-20.764
		TB100 (0-25)	0	25	12.968	-10.382

Table 1C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Intharaphithak Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of CO Emissions	% Change diesel
			% LDDV	% HDDV		
1. Diesel	-		0	0	41.305	
2. Soy Biodiesel	B 10	SB10(0-100)	0	100	41.07117	-0.5663
		SB10(0-75)	0	75	41.12965	-0.42472
		SB10(0-50)	0	50	41.18812	-0.28315
		SB10(0-25)	0	25	41.2466	-0.14157
	B 20	SB20(25-25)	25	25	47.23667	+14.36044
		SB20(0-100)	0	100	49.58413	+20.04367
		SB20(50-50)	50	50	53.16826	+28.72087
		SB20(100-0)	100	0	56.75239	+37.39808
		SB20(50-100)	50	100	57.30779	+38.74271
		SB20(100-50)	100	50	60.89191	+47.41991
		SB20(75-100)	75	100	61.16961	+48.09223
		SB20(100-75)	100	75	62.96168	+52.43083
		SB20(100-100)	100	100	65.03144	+57.44175
	B 30	SB30(0-100)	0	100	36.38311	-11.9161
		SB30(0-75)	0	75	37.6136	-8.9371
		SB30(0-50)	0	50	38.84409	-5.95807
		SB30(0-25)	0	25	40.07459	-2.97903
	B 35	SB35(0-100)	0	100	25.1489	-39.1143
		SB35(0-75)	0	75	29.18794	-29.3357
		SB35(0-50)	0	50	33.22699	-19.5571
		SB35(0-25)	0	25	37.26603	-9.77857
	B40	SB40(0-100)	0	100	35.24981	-14.6599
		SB40(0-75)	0	75	36.76362	-10.9949
		SB40(0-50)	0	50	38.27744	-7.32994
		SB40(0-25)	0	25	39.79126	-3.66497
	B100	SB100(0-100)	0	100	31.53362	-23.6568
		SB100(0-75)	0	75	33.97649	-17.7426
		SB100(0-50)	0	50	36.41935	-11.8284
		SB100(0-25)	0	25	38.86221	-5.9142

Table 1C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Intharaphithak Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of CO Emissions	% Change diesel
			% LDDV	% HDDV		
3. Yellow Grease Biodiesel	B20	YB20(100-100)	29.6655	-28.18	29.6655	-28.18
		YB20(100-75)	34.515	-16.439	34.515	-16.439
		YB20(75-100)	27.7259	-32.875	27.7259	-32.875
		YB20(100-50)	39.3645	-4.6983	39.3645	-4.6983
		YB20(50-100)	25.7863	-37.571	25.7863	-37.571
		YB20(100-0)	49.0634	18.7831	49.0634	18.7831
		YB20(50-50)	35.4853	-14.09	35.4853	-14.09
		YB20(0-100)	21.9071	-46.963	21.9071	-46.963
		YB20(25-25)	38.3952	-7.0449	38.3952	-7.0449
	B100	YB100(0-100)	0	100	20.58933	-50.153
		YB100(0-75)	0	75	25.76826	-37.6148
		YB100(0-50)	0	50	30.9472	-25.0765
		YB100(0-25)	0	25	36.12614	-12.5383
4. Palm Biodiesel	B2	PB2(100-0)	100	0	28.69582	-30.5271
		PB2(75-0)	75	0	31.84813	-22.8954
		PB2(50-0)	50	0	35.00045	-15.2636
		PB2(25-0)	25	0	38.15276	-7.63178
	B5	PB5(100-0)	100	0	28.90405	-30.023
		PB5(75-0)	75	0	32.0043	-22.5173
		PB5(50-0)	50	0	35.10456	-15.0115
		PB5(25-0)	25	0	38.20482	-7.50576
	B20	PB20(100-0)	100	0	27.73952	-32.8423
		PB20(75-0)	75	0	31.13091	-24.6318
		PB20(50-0)	50	0	34.5223	-16.4212
		PB20(25-0)	25	0	37.91369	-8.21059
	B100	PB100(100-0)	100	0	27.04543	-34.5227
		PB100(75-0)	75	0	30.61035	-25.8921
		PB100(50-0)	50	0	34.17526	-17.2614
		PB100(25-0)	25	0	37.74017	-8.63069
5. Coconut Biodiesel	B20	CB20(100-0)	100	0	27.06086	-34.4854
		CB20(75-0)	75	0	30.62191	-25.864
		CB20(50-0)	50	0	34.18297	-17.2427
		CB20(25-0)	25	0	37.74402	-8.62135

Table 1C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Intharaphithak Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of CO Emissions	% Change diesel
			% LDDV	% HDDV		
6. Rapeseed Biodiesel	B2	RB2(100-100)	100	100	22.0837	-46.5351
		RB2(100-75)	100	75	23.73095	-42.5471
		RB2(75-100)	75	100	25.2418	-38.8893
		RB2(100-50)	100	50	25.37819	-38.5591
		RB2(50-100)	50	100	28.3999	-31.2436
		RB2(100-0)	100	0	28.67268	-30.5832
		RB2(50-50)	50	50	31.69439	-23.2676
		RB2(0-100)	0	100	34.7161	-15.952
		RB2(25-25)	25	25	36.49974	-11.6338
	B5	RB5(100-100)	100	100	10.85249	-73.726
		RB5(75-100)	75	100	14.03372	-66.0242
		RB5(100-75)	100	75	15.2844	-62.9963
		RB5(50-100)	50	100	17.21496	-58.3224
		RB5(100-50)	100	50	19.71631	-52.2666
		RB5(0-100)	0	100	23.57743	-42.9188
		RB5(50-50)	50	50	26.07878	-36.863
		RB5(100-0)	100	0	28.58014	-30.8072
		RB5(25-25)	25	25	33.69193	-18.4315
	B20	RB20(100-100)	100	100	9.970238	-75.862
		RB20(75-100)	75	100	13.09942	-68.2862
		RB20(100-75)	100	75	14.67477	-64.4722
		RB20(50-100)	50	100	16.2286	-60.7104
		RB20(100-50)	100	50	19.3793	-53.0825
		RB20(0-100)	0	100	22.48695	-45.5589
		RB20(50-50)	50	50	25.63766	-37.931
		RB20(100-0)	100	0	28.78837	-30.3031
		RB20(25-25)	25	25	33.47137	-18.9655
	B100	RB100(100-100)	100	100	10.34139	-74.9634
		RB100(75-100)	75	100	13.30283	-67.7937
		RB100(100-75)	100	75	15.12087	-63.3922
		RB100(50-100)	50	100	16.26427	-60.624
		RB100(100-50)	100	50	19.90035	-51.821
		RB100(0-100)	0	100	22.18715	-46.2847
		RB100(50-50)	50	50	25.82323	-37.4817
		RB100(100-0)	100	0	29.45932	-28.6787
		RB100(25-25)	25	25	33.56416	-18.7408

Table 1C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Intharaphithak Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of CO Emissions	% Change diesel
			% LDDV	% HDDV		
7. Used Cooking Oil Biodiesel	B20	UB20(100-100)	100	100	12.9069	-68.7523
		UB20(75-100)	75	100	16.27708	-60.593
		UB20(100-75)	100	75	16.63627	-59.7234
		UB20(50-100)	50	100	19.64727	-52.4338
		UB20(100-50)	100	50	20.36563	-50.6946
		UB20(0-100)	0	100	26.38763	-36.1153
		UB20(50-50)	50	50	27.10599	-34.3761
		UB20(100-0)	100	0	27.82435	-32.637
		UB20(25-25)	25	25	34.20554	-17.1881
	B30	UB30(100-0)	100	0	28.12513	-31.9088
		UB30(75-0)	75	0	31.42011	-23.9316
		UB30(50-0)	50	0	34.7151	-15.9544
		UB30(25-0)	25	0	38.01009	-7.9772
	B35	UB35(0-100)	0	100	22.65497	-45.1521
		UB35(0-75)	0	75	27.3175	-33.8641
		UB35(0-50)	0	50	31.98003	-22.576
		UB35(0-25)	0	25	36.64255	-11.288
	B40	UB40(100-0)	100	0	28.18682	-31.7594
		UB40(75-0)	75	0	31.46639	-23.8196
		UB40(50-0)	50	0	34.74595	-15.8797
		UB40(25-0)	25	0	38.02551	-7.93986
8. Tallow Biodiesel	B20	TB20(0-25)	0	25	41.917	+1.482
		TB20(0-50)	0	50	42.529	+2.963
		TB20(0-75)	0	75	43.141	+4.445
		TB20(0-100)	0	100	43.753	+5.926
	B35	TB35(0-100)	0	100	23.054	-44.187
		TB35(0-75)	0	75	27.616	-33.140
		TB35(0-50)	0	50	32.179	-22.093
		TB35(0-25)	0	25	36.742	-11.047
	B100	TB100(0-25)	0	25	36.373	-11.940
		TB100(0-100)	0	100	21.578	-47.760
		TB100(0-50)	0	50	31.441	-23.880
		TB100(0-75)	0	75	26.510	-35.820

Table 1C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Intharaphithak Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of NO_x Emissions	% Change diesel
			% LDDV	% HDDV		
1. Diesel	-		0	0	87.881	
2. Soy Biodiesel	B 10	SB10(0-100)	0	100	94.582	+7.625
		SB10(0-75)	0	75	104.663	+19.097
		SB10(0-50)	0	50	114.745	+30.570
		SB10(0-25)	0	25	124.827	+42.042
	B 20	SB20(25-25)	25	25	104.383	+18.778
		SB20(100-0)	100	0	111.842	+27.266
		SB20(50-50)	50	50	120.885	+37.556
		SB20(0-100)	0	100	129.928	+47.846
		SB20(100-50)	100	50	132.866	+51.189
		SB20(50-100)	50	100	141.909	+61.479
		SB20(100-75)	100	75	143.378	+63.151
		SB20(75-100)	75	100	147.899	+68.296
		SB20(100-100)	100	100	153.890	+75.112
	B 30	SB30(0-25)	0	25	91.253	+3.838
		SB30(0-50)	0	50	94.626	+7.676
		SB30(0-75)	0	75	97.999	+11.514
		SB30(0-100)	0	100	101.371	+15.351
	B 35	SB35(0-100)	0	100	65.863	-25.053
		SB35(0-75)	0	75	71.368	-18.790
		SB35(0-50)	0	50	76.872	-12.527
		SB35(0-25)	0	25	82.376	-6.263
	B40	SB40(0-25)	0	25	91.495	+4.113
		SB40(0-50)	0	50	95.110	+8.227
		SB40(0-75)	0	75	98.725	+12.340
		SB40(0-100)	0	100	102.340	+16.454
	B100	SB100(0-25)	0	25	91.879	+4.550
		SB100(0-50)	0	50	95.878	+9.100
		SB100(0-75)	0	75	99.877	+13.650
		SB100(0-100)	0	100	103.875	+18.201

Table 1C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Intharaphithak Road

Types of Biodiesel	**Blend**	**Scenario**	**% vehicles of total flows**		**Total of NO_x Emissions**	**% Change diesel**
			% LDDV	**% HDDV**		
3. Yellow Grease Biodiesel	B20	YB20(0-100)	0	100	47.200	-46.291
		YB20(50-100)	50	100	58.602	-33.316
		YB20(75-100)	75	100	64.304	-26.828
		YB20(100-100)	100	100	70.005	-20.341
		YB20(50-50)	50	50	78.943	-10.170
		YB20(100-75)	100	75	80.175	-8.768
		YB20(25-25)	25	25	83.412	-5.085
		YB20(100-50)	100	50	90.345	+2.804
		YB20(100-0)	100	0	110.685	+25.950
	B100	YB100(0-100)	0	100	48.584	-44.716
		YB100(0-75)	-	75	58.408	-33.537
		YB100(0-50)	0	50	68.232	-22.358
		YB100(0-25)	0	25	78.056	-11.179
4. Palm Biodiesel	B2	PB2(100-0)	100	0	68.863	-21.641
		PB2(75-0)	75	0	73.617	-16.231
		PB2(50-0)	50	0	78.372	-10.820
		PB2(25-0)	25	0	83.126	-5.410
	B5	PB5(100-0)	100	0	69.040	-21.439
		PB5(75-0)	75	0	73.750	-16.079
		PB5(50-0)	50	0	78.460	-10.719
		PB5(25-0)	25	0	83.170	-5.360
	B20	PB20(100-0)	100	0	72.086	-17.973
		PB20(75-0)	75	0	76.035	-13.479
		PB20(50-0)	50	0	79.983	-8.986
		PB20(25-0)	25	0	83.932	-4.493
	B100	PB100(100-0)	100	0	70.035	-20.307
		PB100(75-0)	75	0	74.496	-15.230
		PB100(50-0)	50	0	78.958	-10.153
		PB100(25-0)	25	0	83.419	-5.077
5. Coconut Biodiesel	B20	CB20(100-0)	100	0	74.546	-15.173
		CB20(75-0)	75	0	77.880	-11.380
		CB20(50-0)	50	0	81.213	-7.587
		CB20(25-0)	25	0	84.547	-3.793

Table 1C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Intharaphithak Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of NO_x Emissions	% Change diesel
			% LDDV	% HDDV		
6. Rapeseed Biodiesel	B2	RB2(100-100)	100	100	65.383	-25.600
		RB2(100-75)	100	75	66.365	-24.483
		RB2(100-50)	100	50	67.346	-23.366
		RB2(100-0)	100	0	69.310	-21.132
		RB2(75-100)	75	100	70.025	-20.317
		RB2(50-100)	50	100	74.668	-15.034
		RB2(50-50)	50	50	76.632	-12.800
		RB2(25-25)	25	25	82.256	-6.400
		RB2(0-100)	0	100	83.954	-4.469
	B5	RB5(100-100)	100	100	48.243	-45.104
		RB5(75-100)	75	100	52.895	-39.810
		RB5(100-75)	100	75	53.500	-39.122
		RB5(50-100)	50	100	57.547	-34.517
		RB5(100-50)	100	50	58.757	-33.140
		RB5(0-100)	0	100	66.852	-23.929
		RB5(50-50)	50	50	68.062	-22.552
		RB5(100-0)	100	0	69.271	-21.176
		RB5(25-25)	25	25	77.971	-11.276
	B20	RB20(100-100)	100	100	19.463	-77.853
		RB20(75-100)	75	100	24.057	-72.625
		RB20(50-100)	50	100	28.652	-67.397
		RB20(100-75)	100	75	31.973	-63.618
		RB20(0-100)	0	100	37.841	-56.941
		RB20(100-50)	100	50	44.483	-49.383
		RB20(50-50)	50	50	53.672	-38.927
		RB20(100-0)	100	0	69.503	-20.912
		RB20(25-25)	25	25	70.776	-19.463
	B100	RB100(100-100)	100	100	19.542	-77.763
		RB100(75-100)	75	100	23.938	-72.761
		RB100(50-100)	50	100	28.334	-67.759
		RB100(100-75)	100	75	32.231	-63.324
		RB100(0-100)	0	100	37.126	-57.754
		RB100(100-50)	100	50	44.920	-48.886
		RB100(50-50)	50	50	53.711	-38.881
		RB100(100-0)	100	0	70.297	-20.008
		RB100(25-25)	25	25	70.796	-19.441

Table 1C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Intharaphithak Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of NO_x Emissions	% Change diesel
			% LDDV	% HDDV		
7. Used Cooking Oil Biodiesel	B20	UB20(100-0)	100	0	69.202	-21.255
		UB20(100-50)	100	50	71.940	-18.139
		UB20(100-75)	100	75	73.308	-16.582
		UB20(100-100)	100	100	74.677	-15.024
		UB20(75-100)	75	100	79.347	-9.710
		UB20(50-50)	500	50	81.279	-7.512
		UB20(50-100)	50	100	84.017	-4.397
		UB20(25-25)	25	25	84.580	-3.756
		UB20(0-100)	0	100	93.356	+6.231
	B30	UB30(100-0)	100	0	69.233	-21.220
		UB30(75-0)	75	0	73.895	-15.915
		UB30(50-0)	50	0	78.557	-10.610
		UB30(25-0)	25	0	83.219	-5.305
	B35	UB35(0-100)	00	100	62.615	-28.750
		UB35(0-75)	0	75	68.931	-21.562
		UB35(0-50)	0	50	75.248	-14.375
		UB35(0-25)	0	25	81.564	-7.187
	B40	UB40(100-0)	100	0	69.233	-21.220
		UB40(75-0)	75	0	73.895	-15.915
		UB40(50-0)	50	0	78.557	-10.610
		UB40(25-0)	25	0	83.219	-5.305
8. Tallow Biodiesel	B20	TB20(0-100)	0	100	83.720	-4.735
		TB20(0-75)	0	75	84.760	-3.551
		TB20(0-50)	0	50	85.800	-2.367
		TB20(0-25)	0	25	86.840	-1.184
	B35	TB35(0-100)	0	100	64.364	-26.759
		TB35(0-75)	0	75	70.243	-20.069
		TB35(0-50)	0	50	76.123	-13.380
		TB35(0-25)	0	25	82.002	-6.690
	B100	TB100(0-25)	0	25	77.719	-11.563
		TB100(0-100)	0	100	47.233	-46.253
		TB100(0-50)	0	50	67.557	-23.127
		TB100(0-75)	0	75	57.395	-34.690

Table 1C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Intharaphithak Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of PM Emissions	% Change diesel
			% LDDV	% HDDV		
1. Diesel	-		0	0	6.084	
2. Soy Biodiesel	B 10	SB10(0-25)	0	25	6.185	+1.652
		SB10(0-50)	0	50	6.285	+3.303
		SB10(0-75)	0	75	6.386	+4.955
		SB10(0-100)	0	100	6.486	+6.606
	B 20	SB20(0-100)	0	100	7.507	+23.392
		SB20(25-25)	25	25	7.629	+25.401
		SB20(50-50)	50	50	9.175	+50.801
		SB20(50-100)	50	100	9.886	+62.497
		SB20(100-0)	100	0	10.842	+78.210
		SB20(75-100)	75	100	11.076	+82.050
		SB20(100-50)	100	50	11.554	+89.906
		SB20(100-75)	100	75	11.910	+95.754
		SB20(100-100)	100	100	12.266	+101.602
	B 30	SB30(0-25)	0	25	6.132	+0.785
		SB30(0-50)	0	50	6.180	+1.570
		SB30(0-75)	0	75	6.227	+2.355
		SB30(0-100)	0	100	6.275	+3.141
	B 35	SB35(0-100)	0	100	3.568	-41.356
		SB35(0-75)	0	75	3.979	-34.601
		SB35(0-50)	0	50	4.390	-27.846
		SB35(0-25)	0	25	4.801	-21.091
	B40	SB40(0-25)	0	25	6.087	+0.054
		SB40(0-50)	0	50	6.091	+0.108
		SB40(0-75)	0	75	6.094	+0.162
		SB40(0-100)	0	100	6.097	+0.217
	B100	SB100(0-25)	0	25	6.085	+0.014
		SB100(0-50)	0	50	6.086	+0.027
		SB100(0-75)	0	75	6.087	+0.041
		SB100(0-100)	0	100	6.087	+0.054

Table 1C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Intharaphithak Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of PM Emissions	% Change diesel
			% LDDV	% HDDV		
3. Yellow Grease Biodiesel	B20	YB20(0-100)	0	100	4.466	-26.587
		YB20(50-100)	50	100	5.781	-4.975
		YB20(25-25)	25	25	6.337	+4.159
		YB20(75-100)	75	100	6.439	+5.831
		YB20(50-50)	50	50	6.590	+8.319
		YB20(100-100)	100	100	7.096	+16.637
		YB20(100-75)	100	75	7.501	+23.284
		YB20(100-50)	100	50	7.905	+29.931
		YB20(100-0)	100	0	8.714	+43.225
	B100	YB100(0-100)	0	100	3.676	-39.583
		YB100(0-75)	0	75	4.278	-29.687
		YB100(0-50)	0	50	4.880	-19.792
		YB100(0-25)	0	25	5.482	-9.896
4. Palm Biodiesel	B2	PB2(100-0)	100	0	3.285	-46.013
		PB2(75-0)	75	0	3.984	-34.510
		PB2(50-0)	50	0	4.684	-23.007
		PB2(25-0)	25	0	5.384	-11.503
	B5	PB5(100-0)	100	0	3.261	-46.393
		PB5(75-0)	75	0	3.967	-34.795
		PB5(50-0)	50	0	4.673	-23.197
		PB5(25-0)	25	0	5.378	-11.598
	B20	PB20(100-0)	100	0	3.192	-47.534
		PB20(75-0)	75	0	3.915	-35.651
		PB20(50-0)	50	0	4.638	-23.767
		PB20(25-0)	25	0	5.361	-11.884
	B100	PB100(100-0)	100	0	2.891	-52.478
		PB100(75-0)	75	0	3.689	-39.358
		PB100(50-0)	50	0	4.488	-26.239
		PB100(25-0)	25	0	5.286	-13.119
5. Coconut Biodiesel	B20	CB20(100-0)	100	0	3.231	-46.901
		CB20(75-0)	75	0	3.944	-35.175
		CB20(50-0)	50	0	4.657	-23.450
		CB20(25-0)	25	0	5.371	-11.725

Table 1C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Intharaphithak Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of PM Emissions	% Change diesel
			% LDDV	% HDDV		
6. Rapeseed Biodiesel	B2	RB2(100-100)	100	100	2.530	-58.417
		RB2(100-75)	100	75	2.701	-55.601
		RB2(100-50)	100	50	2.873	-52.786
		RB2(100-0)	100	0	3.215	-47.154
		RB2(75-100)	75	100	3.247	-46.629
		RB2(50-100)	50	100	3.964	-34.840
		RB2(50-50)	50	50	4.307	-29.209
		RB2(25-25)	25	25	5.196	-14.604
		RB2(0-100)	0	100	5.399	-11.263
	B5	RB5(100-100)	100	100	1.580	-74.032
		RB5(100-75)	100	75	1.981	-67.439
		RB5(75-100)	75	100	2.305	-62.116
		RB5(100-50)	100	50	2.382	-60.846
		RB5(50-100)	50	100	3.030	-50.201
		RB5(100-0)	100	0	3.184	-47.661
		RB5(50-50)	50	50	3.832	-37.016
		RB5(0-100)	0	100	4.480	-26.371
		RB5(25-25)	25	25	4.958	-18.508
	B20	RB20(100-100)	100	100	0.977	-83.946
		RB20(100-75)	100	75	1.506	-75.255
		RB20(75-100)	75	100	1.725	-71.650
		RB20(100-50)	100	50	2.034	-66.564
		RB20(50-100)	50	100	2.473	-59.355
		RB20(100-0)	100	0	3.092	-49.182
		RB20(50-50)	50	50	3.530	-41.973
		RB20(0-100)	0	100	3.969	-34.764
		RB20(25-25)	25	25	4.807	-20.986
	B100	RB100(100-100)	100	100	0.782	-87.152
		RB100(100-75)	100	75	1.307	-78.515
		RB100(75-100)	75	100	1.582	-74.001
		RB100(100-50)	100	50	1.833	-69.878
		RB100(50-100)	50	100	2.382	-60.850
		RB100(100-0)	100	0	2.884	-52.605
		RB100(50-50)	50	50	3.433	-43.576
		RB100(0-100)	0	100	3.982	-34.547
		RB100(25-25)	25	25	4.758	-21.788

Table 1C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Intharaphithak Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of PM Emissions	% Change diesel
			% LDDV	% HDDV		
7. Used Cooking Oil Biodiesel	B20	UB20(100-100)	100	100	2.102	-65.445
		UB20(100-75)	100	75	2.348	-61.411
		UB20(100-50)	100	50	2.593	-57.377
		UB20(75-100)	75	100	2.852	-53.118
		UB20(100-0)	100	0	3.084	-49.309
		UB20(50-100)	50	100	3.602	-40.791
		UB20(50-50)	50	50	4.093	-32.723
		UB20(25-25)	25	25	5.089	-16.361
		UB20(0-100)	0	100	5.102	-16.136
	B30	UB30(100-0)	100	0	3.038	-50.069
		UB30(75-0)	75	0	3.799	-37.552
		UB30(50-0)	50	0	4.561	-25.035
		UB30(25-0)	25	0	5.323	-12.517
	B35	UB35(0-100)	0	100	4.381	-27.995
		UB35(0-75)	0	75	4.807	-20.996
		UB35(0-50)	0	50	5.232	-13.998
		UB35(0-25)	0	25	5.658	-6.999
	B40	UB40(100-0)	100	0	4.997	-17.873
		UB40(75-0)	75	0	5.269	-13.405
		UB40(50-0)	50	0	5.540	-8.936
		UB40(25-0)	25	0	5.812	-4.468
8. Tallow Biodiesel	B20	TB20(0-100)	0	100	5.326	-12.454
		TB20(0-75)	0	75	5.516	-9.341
		TB20(0-50)	0	50	5.705	-6.227
		TB20(0-25)	0	25	5.895	-3.114
	B35	TB35(0-100)	0	100	4.420	-27.345
		TB35(0-75)	0	75	4.836	-20.509
		TB35(0-50)	0	50	5.252	-13.673
		TB35(0-25)	0	25	5.668	-6.836
	B100	TB100(0-100)	0	100	3.643	-40.125
		TB100(0-75)	0	75	4.253	-30.093
		TB100(0-50)	0	50	4.863	-20.062
		TB100(0-25)	0	25	5.474	-10.031

Table 2C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Ladprao Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of HC Emissions	% Change diesel
			% LDDV	% HDDV		
1. Diesel	-	-	0	0	10.136	-
2. Soy Biodiesel	B 10	SB10(0-25)	0	25	10.7813	+6.369585
		SB10(0-50)	0	50	11.4269	+12.73917
		SB10(0-75)	0	75	12.0725	+19.10876
		SB10(0-100)	0	100	12.7181	+25.47834
	B 20	SB20(0-100)	0	100	11.262	+11.108
		SB20(25-25)	25	25	11.624	+14.685
		SB20(50-50)	50	50	13.112	+29.369
		SB20(50-100)	50	100	13.675	+34.923
		SB20(75-100)	75	100	14.882	+46.831
		SB20(100-0)	100	0	14.963	+47.630
		SB20(100-50)	100	50	15.526	+53.184
		SB20(100-75)	100	75	15.808	+55.961
		SB20(100-100)	100	100	16.089	+58.738
	B 30	SB30(0-25)	0	25	10.526	+3.855
		SB30(0-50)	0	50	10.917	+7.710
		SB30(0-75)	0	75	11.308	+11.564
		SB30(0-100)	0	100	11.699	+15.419
	B 35	SB35(0-100)	0	100	9.523	-6.045
		SB35(0-75)	0	75	9.676	-4.533
		SB35(0-50)	0	50	9.829	-3.022
		SB35(0-25)	0	25	9.983	-1.511
	B40	SB40(0-25)	0	25	10.215	+0.781
		SB40(0-50)	0	50	10.294	+1.562
		SB40(0-75)	0	75	10.373	+2.344
		SB40(0-100)	0	100	10.452	+3.125
	B100	SB100(0-100)	0	100	7.271	-28.261
		SB100(0-75)	0	75	7.987	-21.196
		SB100(0-50)	0	50	8.703	-14.131
		SB100(0-25)	0	25	9.420	-7.065

Table 2C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Ladprao Road

Types of Biodiesel	**Blend**	**Scenario**	**% vehicles of total flows**		**Total of HC Emissions**	**% Change diesel**
			% LDDV	**% HDDV**		
3. Yellow Grease Biodiesel	B20	YB20(0-100)	0	100	6.081	-40.008
		YB20(50-100)	50	100	6.825	-32.664
		YB20(75-100)	75	100	7.197	-28.992
		YB20(100-100)	100	100	7.569	-25.320
		YB20(100-75)	100	75	8.583	-15.318
		YB20(50-50)	50	50	8.853	-12.660
		YB20(25-25)	25	25	9.494	-6.330
		YB20(100-50)	100	50	9.597	-5.316
		YB20(100-0)	100	0	11.624	14.688
	B100	YB100(0-100)	0	100	5.942	-41.377
		YB100(0-75)	0	75	6.990	-31.032
		YB100(0-50)	0	50	8.039	-20.688
		YB100(0-25)	0	25	9.087	-10.344
4. Palm Biodiesel	B2	PB2(100-0)	100	0	5.017	-50.504
		PB2(75-0)	75	0	6.297	-37.878
		PB2(50-0)	50	0	7.576	-25.252
		PB2(25-0)	25	0	8.856	-12.626
	B5	PB5(100-0)	100	0	5.033	-50.344
		PB5(75-0)	75	0	6.309	-37.758
		PB5(50-0)	50	0	7.584	-25.172
		PB5(25-0)	25	0	8.860	-12.586
	B20	PB20(100-0)	100	0	4.909	-51.568
		PB20(75-0)	75	0	6.216	-38.676
		PB20(50-0)	50	0	7.522	-25.784
		PB20(25-0)	25	0	8.829	-12.892
	B100	PB100(100-0)	100	0	4.806	-52.579
		PB100(75-0)	75	0	6.139	-39.434
		PB100(50-0)	50	0	7.471	-26.290
		PB100(25-0)	25	0	8.803	-13.145
5. Coconut Biodiesel	B20	CB20(100-0)	100	0	4.877	-51.887
		CB20(75-0)	75	0	6.191	-38.915
		CB20(50-0)	50	0	7.506	-25.944
		CB20(25-0)	25	0	8.821	-12.972

Table 2C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Ladprao Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of HC Emissions	% Change diesel
			% LDDV	% HDDV		
6. Rapeseed Biodiesel	B2	RB2(100-100)	100	100	3.910	-61.422
		RB2(100-75)	100	75	4.188	-58.679
		RB2(100-50)	100	50	4.466	-55.936
		RB2(100-0)	100	0	5.022	-50.450
		RB2(75-100)	75	100	5.189	-48.809
		RB2(50-100)	50	100	6.467	-36.197
		RB2(50-50)	50	50	7.023	-30.711
		RB2(25-25)	25	25	8.579	-15.355
		RB2(0-100)	0	100	9.024	-10.971
	B5	RB5(100-100)	100	100	3.814	-62.372
		RB5(100-75)	100	75	4.117	-59.378
		RB5(100-50)	100	50	4.421	-56.385
		RB5(100-0)	100	0	5.028	-50.397
		RB5(75-100)	75	100	5.091	-49.773
		RB5(50-100)	50	100	6.368	-37.174
		RB5(50-50)	50	50	6.975	-31.186
		RB5(25-25)	25	25	8.555	-15.593
		RB5(0-100)	0	100	8.922	-11.975
	B20	RB20(100-100)	100	100	1.174	-88.421
		RB20(100-75)	100	75	2.129	-78.995
		RB20(75-100)	75	100	2.459	-75.742
		RB20(100-50)	100	50	3.084	-69.569
		RB20(50-100)	50	100	3.744	-63.062
		RB20(100-0)	100	0	4.995	-50.716
		RB20(50-50)	50	50	5.655	-44.210
		RB20(0-100)	0	100	6.314	-37.704
		RB20(25-25)	25	25	7.895	-22.105
	B100	RB100(100-100)	100	100	0.643	-93.651
		RB100(100-75)	100	75	1.669	-83.530
		RB100(75-100)	75	100	1.991	-80.360
		RB100(100-50)	100	50	2.695	-73.408
		RB100(50-100)	50	100	3.338	-67.069
		RB100(100-0)	100	0	4.747	-53.164
		RB100(50-50)	50	50	5.390	-46.826
		RB100(0-100)	0	100	6.032	-40.487
		RB100(25-25)	25	25	7.763	-23.413

Table 2C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Ladprao Road

Types of Biodiesel	**Blend**	**Scenario**	**% vehicles of total flows**		**Total of HC Emissions**	**% Change diesel**
			% LDDV	**% HDDV**		
7. Used Cooking Oil Biodiesel	B20	UB20(100-100)	100	100	2.815	-72.226
		UB20(100-75)	100	75	3.332	-67.128
		UB20(100-50)	100	50	3.849	-62.030
		UB20(75-100)	75	100	4.129	-59.267
		UB20(100-0)	100	0	4.882	-51.834
		UB20(50-100)	50	100	5.442	-46.309
		UB20(50-50)	50	50	6.475	-36.113
		UB20(0-100)	0	100	8.069	-20.392
		UB20(25-25)	25	25	8.306	-18.056
	B30	UB30(100-0)	100	0	4.931	-51.355
		UB30(75-0)	75	0	6.232	-38.516
		UB3050-0)	50	0	7.533	-25.678
		UB30(25-0)	25	0	8.834	-12.839
	B35	UB35(0-100)	0	100	6.964	-31.295
		UB35(0-75)	0	75	7.757	-23.471
		UB35(0-50)	0	50	8.550	-15.647
		UB35(0-25)	0	25	9.343	-7.824
	B40	UB40(100-0)	100	0	4.904	-51.621
		UB40(75-0)	75	0	6.212	-38.716
		UB40(50-0)	50	0	7.520	-25.811
		UB40(25-0)	25	0	8.828	-12.905
8. Tallow Biodiesel	B20	TB20(0-100)	0	100	7.981	-21.259
		TB20(0-75)	0	75	8.520	-15.944
		TB20(0-50)	0	50	9.058	-10.629
		TB20(0-25)	0	25	9.597	-5.315
	B35	TB35(0-100)	0	100	7.895	-22.103
		TB35(0-75)	0	75	8.456	-16.577
		TB35(0-50)	0	50	9.016	-11.051
		TB35(0-25)	0	25	9.576	-5.526
	B100	TB100(0-100)	0	100	5.919	-41.605
		TB100(0-75)	0	75	6.973	-31.204
		TB100(0-50)	0	50	8.027	-20.802
		TB100(0-25)	0	25	9.081	-10.401

Table 2C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Ladprao Road

Types of Biodiesel	**Blend**	**Scenario**	**% vehicles of total flows**		**Total of CO Emissions**	**% Change diesel**
			% LDDV	**% HDDV**		
1. Diesel	-	-	0	0	28.944	-
2. Soy Biodiesel	B 10	SB10(0-100)	0	100	28.780	-0.567
		SB10(0-75)	0	75	28.821	-0.425
		SB10(0-50)	0	50	28.862	-0.284
		SB10(0-25)	0	25	28.903	-0.142
	B 20	SB20(25-25)	25	25	33.097	+14.35
		SB20(0-100)	0	100	34.754	+20.073
		SB20(50-50)	50	50	37.251	+28.700
		SB20(100-0)	100	0	39.748	+37.328
		SB20(50-100)	50	100	40.156	+38.737
		SB20(100-50)	100	50	42.653	+47.364
		SB20(75-100)	75	100	42.857	+48.068
		SB20(100-75)	100	75	44.105	+52.382
		SB20(100-100)	100	100	45.558	+57.400
	B 30	SB30(0-100)	0	100	25.490	-6.345
		SB30(0-75)	0	75	26.353	+3.388
		SB30(0-50)	0	50	27.217	-3.075
		SB30(0-25)	0	25	28.080	-34.165
	B 35	SB35(0-100)	0	100	17.606	-39.171
		SB35(0-75)	0	75	20.441	_29.378
		SB35(0-50)	0	50	23.275	-19.585
		SB35(0-25)	0	25	26.110	-9.793
	B40	SB40(0-100)	0	100	24.695	-14.681
		SB40(0-75)	0	75	25.757	-11.011
		SB40(0-50)	0	50	26.819	-7.341
		SB40(0-25)	0	25	27.882	-3.670
	B100	SB100(0-100)	0	100	22.087	-23.691
		SB100(0-75)	0	75	23.801	-17.768
		SB100(0-50)	0	50	25.515	-11.846
		SB100(0-25)	0	25	27.230	-5.923

Table 2C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Ladprao Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of CO Emissions	% Change diesel
			% LDDV	% HDDV		
3. Yellow Grease Biodiesel	B20	YB20(0-100)	0	100	15.331	-47.031
		YB20(50-100)	50	100	18.045	-37.657
		YB20(75-100)	75	100	19.401	-32.970
		YB20(100-100)	100	100	20.758	-28.283
		YB20(100-75)	100	75	24.161	-16.525
		YB20(50-50)	50	50	24.851	-14.141
		YB20(25-25)	25	25	26.897	-7.071
		YB20(100-50)	100	50	27.564	-4.768
		YB20(100-0)	100	0	34.370	+18.748
	B100	YB100(0-100)	0	100	14.407	-50.226
		YB100(0-75)	0	75	18.041	-37.669
		YB100(0-50)	0	50	21.675	-25.113
		YB100(0-25)	0	25	25.310	-12.556
4. Palm Biodiesel	B2	PB2(100-0)	100	0	20.125	-30.470
		PB2(75-0)	75	0	22.330	-22.852
		PB2(50-0)	50	0	24.534	-15.235
		PB2(25-0)	25	0	26.739	-7.492
	B5	PB5(100-0)	100	0	20.270	-29.967
		PB5(75-0)	75	0	22.439	-22.475
		PB5(50-0)	50	0	24.607	-14.983
		PB5(25-0)	25	0	26.776	-7.492
	B20	PB20(100-0)	100	0	19.456	-24.585
		PB20(75-0)	75	0	21.828	-24.585
		PB20(50-0)	50	0	24.200	-16.39
		PB20(25-0)	25	0	26.572	-8.195
	B100	PB100(100-0)	100	0	18.971	-34.458
		PB100(75-0)	75	0	21.464	-25.843
		PB100(50-0)	50	0	23.957	-17.229
		PB100(25-0)	25	0	26.451	-8.614
5. Coconut Biodiesel	B20	CB20(100-0)	100	0	18.981	-34.420
		CB20(75-0)	75	0	21.472	-25.815
		CB20(50-0)	50	0	23.963	-17.210
		CB20(25-0)	25	0	26.453	-8.605

Table 2C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Ladprao Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of CO Emissions	% Change diesel
			% LDDV	% HDDV		
6. Rapeseed Biodiesel	B2	RB2(100-100)	100	100	15.485	-46.501
		RB2(100-75)	100	75	16.641	-42.507
		RB2(75-100)	75	100	17.694	-27.247
		RB2(100-50)	100	50	17.797	-38.513
		RB2(50-100)	50	100	19.902	-31.238
		RB2(100-0)	100	0	20.109	-30.526
		RB2(50-50)	50	50	22.214	-23.250
		RB2(0-100)	0	100	24.320	-15.975
		RB2(25-25)	25	25	25.579	-11.625
	B5	RB5(100-100)	100	100	7.604	-73.730
		RB5(75-100)	75	100	9.829	-66.043
		RB5(100-75)	100	75	10.714	-62.985
		RB5(50-100)	50	100	12.054	-58.356
		RB5(100-50)	100	50	13.824	-52.240
		RB5(0-100)	0	100	16.504	-42.981
		RB5(50-50)	50	50	18.274	-36.865
		RB5(100-0)	100	0	20.044	+30.749
		RB5(25-25)	25	25	23.609	+18.433
	B20	RB20(100-100)	100	100	6.984	-75.871
		RB20(75-100)	75	100	9.173	-68.309
		RB20(100-75)	100	75	10.285	-64.456
		RB20(50-100)	50	100	11.361	-60.748
		RB20(100-50)	100	50	13.587	-53.058
		RB20(0-100)	0	100	15.738	-45.625
		RB20(50-50)	50	50	17.964	-37.935
		RB20(100-0)	100	0	20.190	-28.625
		RB20(25-25)	25	25	23.454	-18.968
	B100	RB100(100-100)	100	100	7.243	-74.976
		RB100(75-100)	75	100	9.314	-67.820
		RB100(100-75)	100	75	10.597	-63.388
		RB100(50-100)	50	100	11.385	-60.664
		RB100(100-50)	100	50	13.951	-51.801
		RB100(0-100)	0	100	15.528	-46.352
		RB100(50-50)	50	50	18.093	-37.488
		RB100(100-0)	100	0	20.659	-32.576
		RB100(25-25)	25	25	23.519	-18.744

Table 2C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Ladprao Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of CO Emissions	% Change diesel
			% LDDV	% HDDV		
7. Used Cooking Oil Biodiesel	B20	UB20(100-100)	100	100	9.047	-68.743
		UB20(75-100)	75	100	11.404	-60.599
		UB20(100-75)	100	75	11.664	-59.701
		UB20(50-100)	50	100	13.761	-52.455
		UB20(100-50)	100	50	14.281	-50.659
		UB20(0-100)	0	100	18.476	-36.168
		UB20(50-50)	50	50	18.995	-34.372
		UB20(100-0)	100	0	19.515	-32.576
		UB20(25-25)	25	25	23.970	-17.186
	B30	UB30(100-0)	100	0	19.726	-31.849
		UB30(75-0)	75	0	22.030	-23.887
		UB3050-0)	50	0	24.335	-15.924
		UB30(25-0)	25	0	26.639	-7.962
	B35	UB35(0-100)	0	100	15.856	-45.217
		UB35(0-75)	0	75	19.128	-33.913
		UB35(0-50)	0	50	22.400	-22.609
		UB35(0-25)	0	25	25.672	-11.304
	B40	UB40(100-0)	100	0	19.769	-31.700
		UB40(75-0)	75	0	22.063	-23.775
		UB40(50-0)	50	0	24.356	-15.850
		UB40(25-0)	25	0	26.650	-7.925
8. Tallow Biodiesel	B20	TB20(0-25)	0	25	29.373	+5.935
		TB20(0-50)	0	50	29.803	+1.484
		TB20(0-75)	0	75	30.232	+.451
		TB20(0-100)	0	100	30.662	+5.935
	B35	TB35(0-100)	0	100	16.136	-44.251
		TB35(0-75)	0	75	19.338	-33.188
		TB35(0-50)	0	50	22.540	-22.125
		TB35(0-25)	0	25	25.742	-11.063
	B100	TB100(0-100)	0	100	15.100	-47.829
		TB100(0-75)	0	75	18.561	-35.872
		TB100(0-50)	0	50	22.022	-23.915
		TB100(0-25)	0	25	25.483	-11.957

Table 2C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Ladprao Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of NO_x Emissions	% Change diesel
			% LDDV	% HDDV		
1. Diesel	-	-	0	0	61.615	-
2. Soy Biodiesel	B 10	SB10(0-25)	0	25	62.790	+1.908
		SB10(0-50)	0	50	63.966	+3.816
		SB10(0-75)	0	75	65.142	+5.724
		SB10(0-100)	0	100	66.317	+7.632
	B 20	SB20(25-25)	25	25	73.181	+18.772
		SB20(100-0)	100	0	78.374	+27.200
		SB20(50-50)	50	50	84.748	+37.545
		SB20(0-100)	0	100	91.122	+47.889
		SB20(100-50)	100	50	93.127	+51.144
		SB20(50-100)	50	100	99.501	+61.489
		SB20(100-75)	100	75	100.504	+63.117
		SB20(75-100)	75	100	103.691	+68.289
		SB20(100-100)	100	100	107.881	+75.089
	B 30	SB30(0-25)	0	25	63.982	+3.841
		SB30(0-50)	0	50	66.348	+7.683
		SB30(0-75)	0	75	68.715	+11.524
		SB30(0-100)	0	100	71.082	+15.365
	B 35	SB35(0-100)	0	100	46.164	-25.076
		SB35(0-75)	0	75	50.027	-18.807
		SB35(0-50)	0	50	53.890	-12.538
		SB35(0-25)	0	25	57.752	-6.269
	B40	SB40(0-25)	0	25	64.151	+4.117
		SB40(0-50)	0	50	66.688	+8.234
		SB40(0-75)	0	75	69.225	+12.351
		SB40(0-100)	0	100	71.762	+16.468
	B100	SB100(0-25)	0	25	64.421	+4.554
		SB100(0-50)	0	50	67.227	+9.108
		SB100(0-75)	0	75	70.033	+13.663
		SB100(0-100)	0	100	72.839	+18.217

Table 2C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Ladprao Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of NO_x Emissions	% Change diesel
			% LDDV	% HDDV		
3. Yellow Grease Biodiesel	B20	YB20(0-100)	0	100	33.067	-46.332
		YB20(50-100)	50	100	41.042	-33.389
		YB20(75-100)	75	100	45.030	-26.917
		YB20(100-100)	100	100	49.017	-20.446
		YB20(50-50)	50	50	55.316	-10.223
		YB20(100-75)	100	75	56.154	-8.863
		YB20(25-25)	25	25	58.465	-5.111
		YB20(100-50)	100	50	63.291	+2.721
		YB20(100-0)	100	0	77.565	+25.887
	B100	YB100(0-100)	0	100	34.038	-44.756
		YB100(0-75)	0	75	40.932	-33.567
		YB100(0-50)	0	50	47.827	-22.378
		YB100(0-25)	0	25	54.721	-11.189
4. Palm Biodiesel	B2	PB2(100-0)	100	0	48.313	-21.588
		PB2(75-0)	75	0	51.639	-16.191
		PB2(50-0)	50	0	54.964	-10.794
		PB2(25-0)	25	0	58.289	-5.397
	B5	PB5(100-0)	100	0	48.437	-21.387
		PB5(75-0)	75	0	51.732	-16.040
		PB5(50-0)	50	0	55.026	-10.693
		PB5(25-0)	25	0	58.320	-5.347
	B20	PB20(100-0)	100	0	50.568	-17.929
		PB20(75-0)	75	0	53.330	-13.447
		PB20(50-0)	50	0	56.091	-8.964
		PB20(25-0)	25	0	58.853	-4.482
	B100	PB100(100-0)	100	0	49.133	-20.258
		PB100(75-0)	75	0	52.254	-15.193
		PB100(50-0)	50	0	55.374	-10.129
		PB100(25-0)	25	0	58.494	-5.064
5. Coconut Biodiesel	B20	CB20(100-0)	100	0	52.289	-15.136
		CB20(75-0)	75	0	54.620	-11.352
		CB20(50-0)	50	0	56.952	-7.568
		CB20(25-0)	25	0	59.283	-3.784

Table 2C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Ladprao Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of NO_x Emissions	% Change diesel
			% LDDV	% HDDV		
6. Rapeseed Biodiesel	B2	RB2(100-100)	100	100	45.870	-25.553
		RB2(100-75)	100	75	46.559	-24.435
		RB2(100-50)	100	50	47.248	-23.317
		RB2(100-0)	100	0	48.626	-21.080
		RB2(75-100)	75	100	49.117	-20.283
		RB2(50-100)	50	100	52.365	-15.013
		RB2(50-50)	50	50	53.743	-12.777
		RB2(25-25)	25	25	57.679	-6.388
		RB2(0-100)	0	100	58.859	-4.473
	B5	RB5(100-100)	100	100	33.842	-45.075
		RB5(75-100)	75	100	37.096	-39.793
		RB5(100-75)	100	75	37.531	-39.087
		RB5(50-100)	50	100	40.350	-34.512
		RB5(100-50)	100	50	41.221	-33.099
		RB5(0-100)	0	100	46.858	-23.950
		RB5(50-50)	50	50	47.728	-22.537
		RB5(100-0)	100	0	48.599	-21.124
		RB5(25-25)	25	25	54.672	-11.269
	B20	RB20(100-100)	100	100	13.645	-77.854
		RB20(75-100)	75	100	16.859	-72.638
		RB20(50-100)	50	100	20.072	-67.423
		RB20(100-75)	100	75	22.424	-63.606
		RB20(0-100)	0	100	26.499	-56.992
		RB20(100-50)	100	50	31.203	-49.358
		RB20(50-50)	50	50	37.630	-38.927
		RB20(100-0)	100	0	48.761	-20.862
		RB20(25-25)	25	25	49.622	-19.463
	B100	RB100(100-100)	100	100	13.699	-77.766
		RB100(75-100)	75	100	16.774	-72.776
		RB100(50-100)	50	100	19.848	-67.786
		RB100(100-75)	100	75	22.604	-63.315
		RB100(0-100)	0	100	25.997	-57.806
		RB100(100-50)	100	50	31.508	-48.863
		RB100(50-50)	50	50	37.657	-38.883
		RB100(100-0)	100	0	49.317	-19.960
		RB100(25-25)	25	25	49.636	-19.442

Table 2C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Ladprao Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of NO_x Emissions	% Change diesel
			% LDDV	% HDDV		
7. Used Cooking Oil Biodiesel	B20	UB20(100-0)	100	0	48.551	-21.203
		UB20(100-50)	100	50	50.472	-18.085
		UB20(100-75)	100	75	51.432	-16.526
		UB20(100-100)	100	100	52.393	-14.967
		UB20(75-100)	75	100	55.659	-9.666
		UB20(50-50)	50	50	57.004	-7.483
		UB20(50-100)	50	100	58.925	-4.365
		UB20(25-25)	25	25	59.309	-3.742
		UB20(0-100)	0	100	65.457	6.236
	B30	UB30(100-0)	100	0	48.572	-21.168
		UB30(75-0)	75	0	51.833	-15.876
		UB3050-0)	50	0	55.093	-10.584
		UB30(25-0)	25	0	58.354	-5.292
	B35	UB35(0-100)	0	100	43.885	-28.776
		UB35(0-7)5	0	75	48.317	-21.582
		UB35(0-50)	0	50	52.750	-14.388
		UB35(0-25)	0	25	57.182	-7.194
	B40	UB40(100-0)	100	0	48.572	-21.168
		UB40(75-0)	75	0	51.833	-15.876
		UB40(50-0)	50	0	55.093	-10.584
		UB40(25-0)	25	0	58.354	-5.292
8. Tallow Biodiesel	B20	TB20(0-100)	0	100	58.695	-4.739
		TB20(0-75)	0	75	59.425	-3.554
		TB20(0-50)	0	50	60.155	-2.370
		TB20(0-25)	0	25	60.885	-1.185
	B35	TB35(0-100)	0	100	45.112	-26.783
		TB35(0-75)	0	75	49.238	-20.087
		TB35(0-50)	0	50	53.364	-13.392
		TB35(0-25)	0	25	57.489	-6.696
	B100	TB100(0-100)	0	100	33.090	-46.295
		TB100(0-75)	0	75	40.221	-34.721
		TB100(0-50)	0	50	47.353	-23.147
		TB100(0-25)	0	25	54.484	-11.574

Table 2C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Ladprao Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of PM Emissions	% Change diesel
			% LDDV	% HDDV		
1. Diesel	-	-	0	0	4.261	-
2. Soy Biodiesel	B 10	SB10(0-25)	0	25	4.332	+1.655
		SB10(0-50)	0	50	4.402	+3.309
		SB10(0-75)	0	75	4.473	+4.964
		SB10(0-100)	0	100	4.543	+6.619
	B 20	SB20(0-100)	0	100	5.260	+23.437
		SB20(25-25)	25	25	5.343	+25.384
		SB20(50-50)	50	50	6.425	+50.768
		SB20(50-100)	50	100	6.924	+62.486
		SB20(100-0)	100	0	7.589	+78.098
		SB20(75-100)	75	100	7.756	+82.011
		SB20(100-50)	100	50	8.089	+89.817
		SB20(100-75)	100	75	8.339	+95.676
		SB20(100-100)	100	100	8.588	+101.535
	B 30	SB30(0-25)	0	25	4.295	+0.787
		SB30(0-50)	0	50	4.328	+1.573
		SB30(0-75)	0	75	4.362	+2.360
		SB30(0-100)	0	100	4.395	+3.147
	B 35	SB35(0-100)	0	100	3.108	-27.072
		SB35(0-75)	0	75	3.396	-20.304
		SB35(0-50)	0	50	3.685	-13.536
		SB35(0-25)	0	25	3.973	-6.768
	B40	SB40(0-25)	0	25	4.264	+0.054
		SB40(0-50)	0	50	4.266	+0.109
		SB40(0-75)	0	75	4.268	+0.163
		SB40(0-100)	0	100	4.271	+0.217
	B100	SB100(0-25)	0	25	4.262	+0.014
		SB100(0-50)	0	50	4.263	+0.027
		SB100(0-75)	0	75	4.263	+0.041
		SB100(0-100)	0	100	4.264	+0.054

Table 2C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Ladprao Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of PM Emissions	% Change diesel
			% LDDV	% HDDV		
3. Yellow Grease Biodiesel	B20	YB20(0-100)	100	100	3.126	-26.638
		YB20(50-100)	50	100	4.046	-5.056
		YB20(25-25)	25	25	4.437	+4.131
		YB20(75-100)	75	100	4.506	+5.734
		YB20(50-50)	50	50	4.613	+8.262
		YB20(100-100)	100	100	4.966	+16.525
		YB20(100-75)	100	75	5.249	+23.184
		YB20(100-50)	100	50	5.533	+29.844
		YB20(100-0)	100	0	6.101	+43.163
	B100	YB100(0-100)	0	100	2.571	-39.658
		YB100(0-75)	0	75	2.994	-29.744
		YB100(0-50)	0	50	3.416	-19.829
		YB100(0-25)	0	25	3.839	-9.915
4. Palm Biodiesel	B2	PB2(100-0)	100	0	2.303	-45.948
		PB2(75-0)	75	0	2.793	-34.461
		PB2(50-0)	50	0	3.282	-22.974
		PB2(25-0)	25	0	3.772	-11.487
	B5	PB5(100-0)	100	0	2.287	-46.327
		PB5(75-0)	75	0	2.781	-34.745
		PB5(50-0)	50	0	3.274	-23.164
		PB5(25-0)	25	0	3.768	-11.582
	B20	PB20(100-0)	100	0	2.239	-47.467
		PB20(75-0)	75	0	2.744	-35.600
		PB20(50-0)	50	0	3.250	-23.733
		PB20(25-0)	25	0	3.756	-11.867
	B100	PB100(100-0)	100	0	2.028	-52.403
		PB100(75-0)	75	0	2.587	-39.302
		PB100(50-0)	50	0	3.145	-26.202
		PB100(25-0)	25	0	3.703	-13.101
5. Coconut Biodiesel	B20	CB20(100-0)	100	0	2.266	-46.834
		CB20(75-0)	75	0	2.765	-35.125
		CB20(50-0)	50	0	3.264	-23.417
		CB20(25-0)	25	0	3.762	-11.708

Table 2C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Ladprao Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of PM Emissions	% Change diesel
			% LDDV	% HDDV		
6. Rapeseed Biodiesel	B2	RB2(100-100)	100	100	1.774	-58.371
		RB2(100-75)	100	75	1.894	-55.550
		RB2(100-50)	100	50	2.014	-52.729
		RB2(100-0)	100	0	2.255	-47.087
		RB2(75-100)	75	100	2.276	-46.600
		RB2(50-100)	50	100	2.777	-34.828
		RB2(50-50)	50	50	3.018	-29.186
		RB2(25-25)	25	25	3.640	-14.593
		RB2(0-100)	0	10	3.781	-11.284
	B5	RB5(100-100)	100	100	1.107	-74.014
		RB5(100-75)	200	75	1.389	-67.409
		RB5(75-100)	75	100	1.614	-62.116
		RB5(100-50)	100	50	1.670	-60.804
		RB5(50-100)	50	100	2.121	-50.217
		RB5(100-0)	100	0	2.233	-47.593
		RB5(50-50)	50	50	2.684	-37.007
		RB5(0-100)	0	100	3.136	-26.421
		RB5(25-25)	25	25	3.473	-18.503
	B20	RB20(100-100)	100	100	0.684	-83.942
		RB20(100-75)	100	75	1.055	-75.235
		RB20(75-100)	75	100	1.208	-71.664
		RB20(100-50)	100	50	1.426	-66.527
		RB20(50-100)	50	100	1.731	-59.386
		RB20(100-0)	100	0	2.169	-49.112
		RB20(50-50)	50	50	2.473	-41.971
		RB20(0-100)	0	100	2.777	-34.830
		RB20(25-25)	25	25	3.367	-20.986
	B100	RB100(100-100)	100	100	0.548	-87.143
		RB100(100-75)	100	75	0.917	-78.489
		RB100(75-100)	75	100	1.108	-74.010
		RB100(100-50)	100	50	1.285	-69.836
		RB100(50-100)	50	100	1.667	-60.878
		RB100(100-0)	100	0	2.023	-52.530
		RB100(50-50)	50	50	2.405	-43.571
		RB100(0-100)	0	100	2.786	-34.613
		RB100(25-25)	25	25	3.333	-21.786

Table 2C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Ladprao Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of PM Emissions	% Change diesel
			% LDDV	% HDDV		
7. Used Cooking Oil Biodiesel	B20	UB20(100-100)	100	100	1.474	-65.406
		UB20(100-75)	100	75	1.646	-61.364
		UB20(100-50)	100	50	1.819	-57.322
		UB20(75-100)	75	100	1.999	-53.096
		UB20(100-0)	100	0	2.163	-49.239
		UB20(50-100)	50	100	2.523	-40.786
		UB20(50-50)	50	50	2.868	-32.703
		UB20(25-25)	25	25	3.565	-16.351
		UB20(0-100)	0	100	3.572	-16.167
	B30	UB30(100-0)	100	0	2.131	-49.998
		UB30(75-0)	75	0	2.663	-37.499
		UB3050-0)	50	0	3.196	-24.999
		UB30(25-0)	25	0	3.729	-12.500
	B35	UB35(0-100)	0	100	3.066	-28.048
		UB35(0-7)5	0	75	3.365	-21.036
		UB35(0-50)	0	50	3.664	-14.024
		UB35(0-25)	0	25	3.963	-7.012
	B40	UB40(100-0)	100	0	3.501	-17.847
		UB40(75-0)	75	0	3.691	-13.386
		UB40(50-0)	50	0	3.881	-8.924
		UB40(25-0)	25	0	4.071	-4.462
8. Tallow Biodiesel	B20	TB20(0-100)	0	100	3.730	-12.478
		TB20(0-75)	0	75	3.863	-9.359
		TB20(0-50)	0	50	3.996	-6.239
		TB20(0-25)	0	25	4.128	-3.120
	B35	TB35(0-100)	0	100	3.094	-27.397
		TB35(0-75)	0	75	3.386	-20.548
		TB35(0-50)	0	50	3.678	-13.699
		TB35(0-25)	0	25	3.970	-6.849
	B100	TB100(0-100)	0	100	2.548	-40.201
		TB100(0-75)	0	75	2.977	-30.151
		TB100(0-50)	0	50	3.405	-20.100
		TB100(0-25)	0	25	3.833	-10.050

Table 3C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Dindaeng road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of HC Emissions	% Change diesel
			% LDDV	% HDDV		
1. Diesel	-	-	0	0	13.933	-
2. Soy Biodiesel	B 10	SB10(0-25)	0	25	14.505	+4.110
		SB10(0-50)	0	50	15.078	+8.220
		SB10(0-75)	0	75	15.651	+12.330
		SB10(0-100)	0	100	16.223	+16.440
	B 20	SB20(0-100)	0	100	14.931	+7.167
		SB20(25-25)	25	25	16.324	+17.159
		SB20(50-50)	50	50	18.714	+34.319
		SB20(50-100)	50	100	19.214	+37.902
		SB20(75-100)	75	100	21.355	+53.270
		SB20(100-0)	100	0	22.497	+61.470
		SB20(100-50)	100	50	22.997	+65.053
		SB20(100-75)	100	75	23.246	+66.845
		SB20(100-100)	100	100	23.496	+68.637
	B 30	SB30(0-25)	0	25	14.279	+2.487
		SB30(0-50)	0	50	14.626	+4.975
		SB30(0-75)	0	75	14.972	+7.462
		SB30(0-100)	0	100	15.319	+9.949
	B 35	SB35(0-100)	0	100	13.389	-3.900
		SB35(0-75)	0	75	13.525	-2.925
		SB35(0-50)	0	50	13.661	-1.950
		SB35(0-25)	0	25	13.797	-0.974
	B40	SB40(0-25)	0	25	14.003	0.504
		SB40(0-50)	0	50	14.073	1.008
		SB40(0-75)	0	75	14.144	1.512
		SB40(0-100)	0	100	14.214	2.016
	B100	SB100(0-100)	0	100	11.392	-18.235
		SB100(0-75)	0	75	12.027	-13.676
		SB100(0-50)	0	50	12.662	-9.118
		SB100(0-25)	0	25	13.298	-4.559

Table 3C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Dindaeng Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of HC Emissions	% Change diesel
			% LDDV	% HDDV		
3. Yellow Grease Biodiesel	B20	YB20(0-100)	0	100	10.336	-25.815
		YB20(50-100)	50	10	11.657	-16.337
		YB20(75-100)	75	100	12.317	-11.598
		YB20(100-100)	100	100	12.977	-6.859
		YB20(50-50)	50	50	13.455	-3.429
		YB20(25-25)	25	25	13.694	-1.715
		YB20(100-75)	100	75	13.876	-0.405
		YB20(100-50)	100	50	14.776	+6.049
		YB20(100-0)	100	0	16.574	+18.956
	B100	YB100(0-100)	0	100	10.213	-26.698
		YB100(0-75)	0	75	11.143	-20.023
		YB100(0-50)	0	50	12.073	-13.349
		YB100(0-25)	0	25	13.003	-6.674
4. Palm Biodiesel	B2	PB2(100-0)	100	0	4.852	-65.178
		PB2(75-0)	75	0	7.122	-48.884
		PB2(50-0)	50	0	9.392	-32.589
		PB2(25-0)	25	0	11.663	-16.295
	B5	PB5(100-0)	100	0	4.880	-64.972
		PB5(75-0)	75	0	7.143	-48.729
		PB5(50-0)	50	0	9.407	-32.486
		PB5(25-0)	25	0	11.670	-16.243
	B20	PB20(100-0)	100	0	4.660	-66.552
		PB20(75-0)	75	0	6.978	-49.914
		PB20(50-0)	50	0	9.297	-33.276
		PB20(25-0)	25	0	11.615	-16.638
	B100	PB100(100-0)	100	0	4.478	-67.857
		PB100(75-0)	75	0	6.842	-50.893
		PB100(50-0)	50	0	9.206	-33.928
		PB100(25-0)	25	0	11.569	-16.964
5. Coconut Biodiesel	B20	CB20(100-0)	100	0	4.603	-66.964
		CB20(75-0)	75	0	6.935	-50.223
		CB20(50-0)	50	0	9.268	-33.482
		CB20(25-0)	25	0	11.600	-16.741

Table 3C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Dindaeng Road

Types of Biodiesel	**Blend**	**Scenario**	**% vehicles of total flows**		**Total of HC Emissions**	**% Change diesel**
			% LDDV	**% HDDV**		
6. Rapeseed Biodiesel	B2	RB2(100-100)	100	100	3.875	-72.189
		RB2(100-75)	100	75	4.121	-70.419
		RB2(100-50)	100	50	4.368	-68.649
		RB2(100-0)	100	0	4.861	-65.110
		RB2(75-100)	75	100	6.143	-55.911
		RB2(50-100)	50	100	8.411	-39.634
		RB2(50-50)	50	50	8.904	-36.094
		RB2(25-25)	25	25	11.418	-18.047
		RB2(0-100)	0	100	12.946	-7.079
	B5	RB5(100-100)	100	100	3.794	-72.768
		RB5(100-75)	100	75	4.063	-70.836
		RB5(100-50)	100	50	4.333	-68.904
		RB5(100-0)	100	0	4.871	-65.041
		RB5(75-100)	75	100	6.060	-56.507
		RB5(50-100)	50	100	8.325	-40.247
		RB5(50-50)	50	50	8.864	-36.384
		RB5(25-25)	25	25	11.398	-18.192
		RB5(0-100)	0	100	12.856	-7.727
	B20	RB20(100-100)	100	100	1.424	-89.781
		RB20(100-75)	100	75	2.271	-83.699
		RB20(100-50)	100	50	3.119	-77.617
		RB20(75-100)	75	100	3.704	-73.418
		RB20(100-0)	100	0	4.813	-65.453
		RB20(50-100)	50	100	5.983	-57.055
		RB20(50-50)	50	50	7.678	-44.891
		RB20(0-100)	0	100	10.543	-24.328
		RB20(25-25)	25	25	10.806	-22.445
	B100	RB100(100-100)	100	100	0.733	-94.736
		RB100(100-75)	100	75	1.643	-88.205
		RB100(100-50)	100	50	2.553	-81.674
		RB100(75-100)	75	100	3.123	-77.583
		RB100(100-0)	100	0	4.373	-68.612
		RB100(50-100)	50	100	5.513	-60.430
		RB100(50-50)	50	50	7.333	-47.368
		RB100(0-100)	0	100	10.293	-26.124
		RB100(25-25)	25	25	10.633	-23.684

Table 3C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Dindaeng Road

Types of Biodiesel	**Blend**	**Scenario Name**	**% vehicles of total flows**		**Total of HC Emissions**	**% Change diesel**
			% LDDV	**% HDDV**		
7. Used Cooking Oil Biodiesel	B20	UB20(100-100)	100	100	2.779	-80.053
		UB20(100-75)	100	75	3.238	-76.763
		UB20(100-50)	100	50	3.696	-73.474
		UB20(100-0)	100	0	4.612	-66.895
		UB20(75-100)	75	100	5.109	-63.329
		UB20(50-100)	50	100	7.439	-46.605
		UB20(50-50)	50	50	8.356	-40.026
		UB20(25-25)	25	25	11.144	-20.013
		UB20(0-100)	0	100	12.100	-13.157
	B30	UB30(100-0)	100	0	4.699	-66.277
		UB30(75-0)	75	0	7.007	-49.708
		UB3050-0)	50	0	9.316	-33.139
		UB30(25-0)	25	0	11.624	-16.569
	B35	UB35(0-100)	0	100	11.119	-20.192
		UB35(0-75)	0	75	11.823	-15.144
		UB35(0-50)	0	50	12.526	-10.096
		UB35(0-25)	0	25	13.229	-5.048
	B40	UB40(100-0)	100	0	4.651	-66.621
		UB40(75-0)	75	0	6.971	-49.965
		UB40(50-0)	50	0	9.292	-33.310
		UB40(25-0)	25	0	11.612	-16.655
8. Tallow Biodiesel	B20	TB20(0-100)	0	100	12.022	-13.717
		TB20(0-75)	0	75	12.499	-10.288
		TB20(0-50)	0	50	12.977	-6.858
		TB20(0-25)	0	25	13.455	-3.429
	B35	TB35(0-100)	0	100	11.946	-14.261
		TB35(0-75)	0	75	12.443	-10.696
		TB35(0-50)	0	50	12.939	-7.131
		TB35(0-25)	0	25	13.436	-3.565
	B100	TB100(0-100)	0	100	10.193	-26.845
		TB100(0-75)	0	75	11.128	-20.134
		TB100(0-50)	0	50	12.063	-13.422
		TB100(0-25)	0	25	12.998	-6.711

Table 3C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Dindaeng Road

Types of Biodiesel	**Blend**	**Scenario**	**% vehicles of total flows**		**Total of CO Emissions**	**% Change diesel**
			% LDDV	**% HDDV**		
1. Diesel	-	-	0	0	36.8116	-
2. Soy Biodiesel	B 10	SB10(0-100)	0	100	36.666	-0.396
		SB10(0-75)	0	75	36.702	-0.297
		SB10(0-50)	0	50	36.739	-0.198
		SB10(0-25)	0	25	36.775	-0.099
	B 20	SB20(100-0)	100	0	32.984	-10.398
		SB20(100-50)	100	50	35.560	-3.399
		SB20(100-75)	100	75	36.849	+0.101
		SB20(50-50)	50	50	37.474	+1.800
		SB20(100-100)	100	100	38.137	+3.601
		SB20(75-100)	75	100	39.094	+6.200
		SB20(50-100)	50	100	40.051	+8.800
		SB20(0-100)	0	100	41.965	+13.999
		SB20(25-25)	25	25	42.892	+16.517
	B 30	SB30(0-100)	0	100	33.748	-8.322
		SB30(0-75)	0	75	34.514	-6.242
		SB30(0-50)	0	50	35.280	-4.161
		SB30(0-25)	0	25	36.046	-2.081
	B 35	SB35(0-100)	0	100	26.756	-27.318
		SB35(0-75)	0	75	29.270	-20.488
		SB35(0-50)	0	50	31.784	-13.659
		SB35(0-25)	0	25	34.298	-6.829
	B40	SB40(0-100)	0	100	33.043	-10.238
		SB40(0-75)	0	75	33.985	-7.679
		SB40(0-50)	0	50	34.927	-5.119
		SB40(0-25)	0	25	35.869	-2.560
	B100	SB100(0-100)	0	100	30.730	-16.522
		SB100(0-75)	0	75	32.250	-12.391
		SB100(0-50)	0	50	33.771	-8.261
		SB100(0-25)	0	25	35.291	-4.130

Table 3C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Dindaeng Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of CO Emissions	% Change diesel
			% LDDV	% HDDV		
3. Yellow Grease Biodiesel	B20	YB20(100-100)	100	100	14.987	-59.288
		YB20(75-100)	75	100	17.425	-52.666
		YB20(100-75)	100	75	18.005	-51.088
		YB20(50-100)	50	100	19.862	-46.043
		YB20(100-50)	100	50	21.024	-42.888
		YB20(0-100)	0	100	24.738	-32.799
		YB20(50-50)	50	50	25.899	-29.644
		YB20(100-0)	100	0	27.061	-26.489
		YB20(25-25)	25	25	36.200	-1.662
	B100	YB100(0-100)	0	100	23.918	-35.027
		YB100(0-75)	0	75	27.141	-26.270
		YB100(0-50)	0	50	30.365	-17.514
		YB100(0-25)	0	25	33.588	-8.757
4. Palm Biodiesel	B2	PB2(100-0)	100	0	15.338	-58.333
		PB2(75-0)	75	0	20.707	-43.750
		PB2(50-0)	50	0	26.075	-29.167
		PB2(25-0)	25	0	32.900	-10.626
	B5	PB5(100-0)	100	0	15.367	-58.255
		PB5(75-0)	75	0	20.728	-43.691
		PB5(50-0)	50	0	26.089	-29.128
		PB5(25-0)	25	0	32.965	-10.450
	B20	PB20(100-0)	100	0	15.147	-58.853
		PB20(75-0)	75	0	20.563	-44.140
		PB20(50-0)	50	0	25.979	-29.426
		PB20(25-0)	25	0	32.603	-11.431
	B100	PB100(100-0)	100	0	14.965	-59.347
		PB100(75-0)	75	0	20.427	-44.510
		PB100(50-0)	50	0	25.888	-29.673
		PB100(25-0)	25	0	32.388	-12.016
5. Coconut Biodiesel	B20	CB20(100-0)	100	0	15.089	-59.009
		CB20(75-0)	75	0	20.520	-44.257
		CB20(50-0)	50	0	25.951	-29.504
		CB20(25-0)	25	0	32.393	-12.003

Table 3C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Dindaeng Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of CO Emissions	% Change diesel
			% LDDV	% HDDV		
6. Rapeseed Biodiesel	B2	RB2(100-100)	100	100	11.247	-69.448
		RB2(100-75)	100	75	12.272	-66.663
		RB2(100-50)	100	50	13.297	-63.877
		RB2(100-0)	100	0	15.348	-58.307
		RB2(75-100)	75	100	16.613	-54.871
		RB2(50-100)	50	100	21.979	-40.294
		RB2(50-50)	50	50	24.029	-34.724
		RB2(25-25)	25	25	31.868	-13.430
		RB2(0-100)	0	100	32.710	-11.141
	B5	RB5(100-100)	100	100	4.323	-88.256
		RB5(100-75)	100	75	7.082	-80.762
		RB5(75-100)	75	100	9.687	-73.685
		RB5(100-50)	100	50	9.840	-73.268
		RB5(50-100)	50	100	15.050	-59.115
		RB5(100-0)	100	0	15.357	-58.281
		RB5(50-50)	50	50	20.567	-44.128
		RB5(0-100)	0	10	25.777	-29.975
		RB5(25-25)	25	25	30.106	-18.217
	B20	RB20(100-100)	100	100	3.587	-90.255
		RB20(100-75)	100	75	6.515	-82.301
		RB20(75-100)	75	100	8.965	-75.646
		RB20(100-50)	100	50	9.444	-74.346
		RB20(50-100)	50	100	14.343	-61.037
		RB20(100-0)	100	0	15.300	-58.437
		RB20(50-50)	50	50	20.199	-45.128
		RB20(0-100)	0	100	25.099	-31.818
		RB20(25-25)	25	25	30.001	-18.502
	B100	RB100(100-100)	100	100	2.960	-91.958
		RB100(100-75)	100	75	5.935	-83.877
		RB100(75-100)	75	100	8.448	-77.050
		RB100(100-50)	100	50	8.910	-75.795
		RB100(50-100)	50	100	13.936	-62.142
		RB100(100-0)	100	0	14.860	-59.633
		RB100(50-50)	50	50	19.886	-45.979
		RB100(0-100)	0	100	24.912	-32.325
		RB100(25-25)	25	25	30.162	-18.063

Table 3C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Dindaeng Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of CO Emissions	% Change diesel
			% LDDV	% HDDV		
7. Used Cooking Oil Biodiesel	B20	UB20(100-100)	100	100	5.814	-84.206
		UB20(100-75)	100	75	8.135	-77.900
		UB20(100-50)	100	50	10.457	-71.594
		UB20(75-100)	75	100	11.242	-69.460
		UB20(100-0)	100	0	15.099	-58.983
		UB20(50-100)	50	100	16.670	-54.714
		UB20(50-50)	50	50	21.313	-42.103
		UB20(0-100)	0	100	27.527	-25.223
		UB20(25-25)	25	25	30.309	-17.666
	B30	UB30(100-0)	100	0	15.185	-58.749
		UB30(75-0)	75	0	20.592	-44.062
		UB3050-0)	50	0	25.998	-29.374
		UB30(25-0)	25	0	32.723	-11.106
	B35	UB35(0-100)	0	100	25.203	-31.534
		UB35(0-7)5	0	75	28.105	-23.651
		UB35(0-50)	0	50	31.007	-15.767
		UB35(0-25)	0	25	33.909	-7.884
	B40	UB40(100-0)	100	0	15.137	-58.879
		UB40(75-0)	75	0	20.556	-44.159
		UB40(50-0)	50	0	25.974	-29.439
		UB40(25-0)	25	0	32.742	-11.054
8. Tallow Biodiesel	B20	TB20(0-25)	0	25	37.192	+1.035
		TB20(0-50)	0	50	37.573	+2.069
		TB20(0-75)	0	75	37.954	+3.104
		TB20(0-100)	0	100	38.335	+4.139
	B35	TB35(0-100)	0	100	25.451	-30.860
		TB35(0-75)	0	75	28.291	-23.145
		TB35(0-50)	0	50	31.131	-15.430
		TB35(0-25)	0	25	33.972	-7.715
	B100	TB100(0-100)	0	100	24.533	-33.356
		TB100(0-75)	0	75	27.602	-25.017
		TB100(0-50)	0	50	30.672	-16.678
		TB100(0-25)	0	25	33.742	-8.339

Table 3C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Dindaeng Road

Types of Biodiesel	**Blend**	**Scenario**	**% vehicles of total flows**		**Total of NO_x Emissions**	**% Change diesel**
			% LDDV	**% HDDV**		
1. Diesel	-	-	0	0	69.402	-
2. Soy Biodiesel	B 10	SB10(0-25)	0	25	70.445	+1.502
		SB10(0-50)	0	50	71.487	+3.005
		SB10(0-75)	0	75	72.530	+4.507
		SB10(0-100)	0	100	73.573	+6.010
	B 20	SB20(25-25)	25	25	83.378	+20.137
		SB20(0-100)	0	100	95.573	+37.710
		SB20(50-50)	50	50	97.353	+40.275
		SB20(100-0)	100	0	99.133	+42.840
		SB20(50-100)	50	100	110.439	+59.130
		SB20(100-50)	100	50	112.219	+61.695
		SB20(75-100)	75	100	117.872	+69.840
		SB20(100-75)	100	75	118.762	+71.122
		SB20(100-100)	100	100	125.305	+80.550
	B 30	SB30(0-25)	0	25	71.501	+3.025
		SB30(0-50)	0	50	73.600	+6.050
		SB30(0-75)	0	75	75.700	+9.074
		SB30(0-100)	0	100	77.799	+12.099
	B 35	SB35(0-100)	0	100	55.698	-19.746
		SB35(0-75)	0	75	59.124	-14.809
		SB35(0-50)	0	50	62.550	-9.873
		SB35(0-25)	0	25	65.976	-4.936
	B40	SB40(0-25)	0	25	71.652	+3.242
		SB40(0-50)	0	50	73.902	+6.484
		SB40(0-75)	0	75	76.152	+9.726
		SB40(0-100)	0	100	78.402	+12.968
	B100	SB100(0-25)	0	25	71.891	+3.586
		SB100(0-50)	0	50	74.380	+7.172
		SB100(0-75)	0	75	76.868	+10.759
		SB100(0-100)	0	100	79.357	+14.345

Table 3C Total emissions and percentage of change e of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Dindaeng Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of NO_x Emissions	% Change diesel
			% LDDV	% HDDV		
3. Yellow Grease Biodiesel	B20	YB20(0-100)	0	100	44.081	-36.484
		YB20(50-100)	50	100	58.229	-16.098
		YB20(75-100)	75	100	65.304	-5.905
		YB20(25-25)	25	25	70.146	+1.072
		YB20(50-50)	50	50	70.890	+2.144
		YB20(100-100)	100	100	72.378	+4.288
		YB20(100-75)	100	75	78.708	+13.409
		YB20(100-50)	100	50	85.038	+22.530
		YB20(100-0)	100	0	97.698	+40.771
	B100	YB100(0-100)	0	100	44.943	-35.243
		YB100(0-75)	0	75	51.057	-26.432
		YB100(0-50)	0	50	57.172	-17.621
		YB100(0-25)	0	25	63.287	-8.811
4. Palm Biodiesel	B2	PB2(100-0)	100	0	45.804	-34.001
		PB2(75-0)	75	0	51.704	-25.501
		PB2(50-0)	50	0	57.603	-17.001
		PB2(25-0)	25	0	63.502	-8.500
	B5	PB5(100-0)	100	0	46.024	-33.684
		PB5(75-0)	75	0	51.869	-25.263
		PB5(50-0)	50	0	57.713	-16.842
		PB5(25-0)	25	0	63.557	-8.421
	B20	PB20(100-0)	100	0	49.804	-28.238
		PB20(75-0)	75	0	54.704	-21.179
		PB20(50-0)	50	0	59.603	-14.119
		PB20(25-0)	25	0	64.502	-7.060
	B100	PB100(100-0)	100	0	47.259	-31.906
		PB100(75-0)	75	0	52.794	-23.929
		PB100(50-0)	50	0	58.330	-15.953
		PB100(25-0)	25	0	63.866	-7.976
5. Coconut Biodiesel	B20	CB20(100-0)	100	0	52.857	-23.840
		CB20(75-0)	75	0	56.993	-17.880
		CB20(50-0)	50	0	61.129	-11.920
		CB20(25-0)	25	0	65.266	-5.960

Table 3C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Dindaeng Road

Types of Biodiesel	**Blend**	**Scenario**	**% vehicles of total flows**		**Total of NO_x Emissions**	**% Change diesel**
			% LDDV	**% HDDV**		
6. Rapeseed Biodiesel	B2	RB2(100-100)	100	100	43.915	-36.724
		RB2(100-75)	100	75	44.526	-35.843
		RB2(100-50)	100	50	45.137	-34.963
		RB2(100-0)	100	0	46.359	-33.202
		RB2(75-100)	75	100	49.676	-28.423
		RB2(50-100)	50	100	55.436	-20.123
		RB2(50-50)	50	50	56.658	-18.362
		RB2(25-25)	25	25	63.030	-9.181
		RB2(0-100)	0	100	66.958	-3.522
	B5	RB5(100-100)	100	100	33.223	-52.130
		RB5(100-75)	100	75	36.495	-47.415
		RB5(75-100)	75	100	38.995	-43.812
		RB5(100-50)	100	50	39.767	-42.700
		RB5(50-100)	50	100	44.768	-35.495
		RB5(100-0)	100	0	46.311	-33.271
		RB5(50-50)	50	50	51.312	-26.065
		RB5(0-100)	50	100	56.313	-18.859
		RB5(25-25)	25	25	60.357	-13.033
	B20	RB20(100-100)	100	100	15.452	-77.735
		RB20(75-100)	75	100	21.153	-69.521
		RB20(100-75)	100	75	23.239	-66.516
		RB20(50-100)	50	100	26.854	-61.306
		RB20(100-50)	100	50	31.025	-55.296
		RB20(0-100)	0	100	38.256	-44.878
		RB20(50-50)	50	50	42.427	-38.867
		RB20(100-0)	100	0	46.598	-32.857
		RB20(25-25)	25	25	55.914	-19.434
	B100	RB100(100-100)	100	100	15.993	-76.956
		RB100(75-100)	75	100	21.447	-69.097
		RB100(100-75)	100	75	23.891	-65.576
		RB100(50-100)	50	100	26.902	-61.238
		RB100(100-50)	100	50	31.789	-54.196
		RB100(0-100)	0	100	37.811	-45.519
		RB100(50-50)	50	50	42.697	-38.478
		RB100(100-0)	100	0	47.584	-31.437
		RB100(25-25)	25	25	56.050	-19.239

Table 3C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Dindaeng Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of NO_x Emissions	% Change diesel
			% LDDV	% HDDV		
7. Used Cooking Oil Biodiesel	B20	UB20(100-0)	100	0	46.225	-33.395
		UB20(100-50)	100	50	47.929	-30.940
		UB20(100-75)	100	75	48.781	-29.712
		UB20(100-100)	100	100	49.633	-28.484
		UB20(75-100)	75	100	55.427	-20.136
		UB20(50-50)	50	50	59.518	-14.242
		UB20(50-100)	50	100	61.222	-11.787
		UB20(25-25)	25	25	64.460	-7.121
		UB20(0-100)	0	100	72.810	+4.911
	B30	UB30(100-0)	100	0	46.264	-33.340
		UB30(75-0)	75	0	52.048	-25.005
		UB3050-0)	50	0	57.833	-16.670
		UB30(25-0)	25	0	63.617	-8.335
	B35	UB35(0-100)	0	100	53.676	-22.659
		UB35(0-75)	0	75	57.607	-16.994
		UB35(0-50)	0	50	61.539	-11.330
		UB35(0-25)	0	25	65.470	-5.665
	B40	UB40(100-0)	100	0	46.264	-33.340
		UB40(75-0)	75	0	52.048	-25.005
		UB40(50-0)	50	0	57.833	-16.670
		UB40(25-0)	25	0	63.617	-8.335
8. Tallow Biodiesel	B20	TB20(0-100)	0	100	66.812	-3.732
		TB20(0-75)	0	75	67.459	-2.799
		TB20(0-50)	0	50	68.107	-1.866
		TB20(0-25)	0	25	68.754	-0.933
	B35	TB35(0-100)	0	100	54.765	-21.090
		TB35(0-75)	0	75	58.424	-15.818
		TB35(0-50)	0	50	62.083	-10.545
		TB35(0-25)	0	25	65.743	-5.273
	B100	TB100(0-100)	0	100	44.102	-36.454
		TB100(0-75)	0	75	50.427	-27.341
		TB100(0-50)	0	50	56.752	-18.227
		TB100(0-25)	0	25	63.077	-9.114

Table 3C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Dindaeng Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of PM Emissions	% Change diesel
			% LDDV	% HDDV		
1. Diesel	-	-	0	0	5.938	-
2. Soy Biodiesel	B 10	SB10(0-25)	0	25	6.000	+1.053
		SB10(0-50)	0	50	6.063	+2.107
		SB10(0-75)	0	75	6.125	+3.160
		SB10(0-100)	0	100	6.188	+4.213
	B 20	SB20(0-100)	0	100	6.824	+14.919
		SB20(25-25)	25	25	7.635	+28.589
		SB20(50-50)	50	50	9.333	+57.177
		SB20(50-100)	50	100	9.776	+64.637
		SB20(75-100)	75	100	11.252	+89.496
		SB20(100-0)	100	0	11.842	+99.436
		SB20(100-50)	100	50	12.285	+106.895
		SB20(100-75)	100	75	12.506	+110.625
		SB20(100-100)	100	100	12.728	+114.355
	B 30	SB30(0-25)	0	25	5.967	+0.501
		SB30(0-50)	0	50	5.997	+1.002
		SB30(0-75)	0	75	6.027	+1.502
		SB30(0-100)	0	100	6.057	+2.003
	B 35	SB35(0-100)	0	100	4.914	-17.233
		SB35(0-75)	0	75	5.170	-12.925
		SB35(0-50)	0	50	5.426	-8.616
		SB35(0-25)	0	25	5.682	-4.308
	B40	SB40(0-25)	0	25	5.940	+0.035
		SB40(0-50)	0	50	5.942	+0.069
		SB40(0-75)	0	75	5.944	+0.104
		SB40(0-100)	0	100	5.946	+0.138
	B100	SB100(0-25)	0	25	5.938	+0.009
		SB100(0-50)	0	50	5.939	+0.017
		SB100(0-75)	0	75	5.939	+0.026
		SB100(0-100)	0	100	5.940	+0.035

Table 3C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Dindaeng Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of PM Emissions	% Change diesel
			% LDDV	% HDDV		
3. Yellow Grease Biodiesel	B20	YB20(0-100)	0	100	4.931	-16.957
		YB20(25-25)	25	25	6.502	+9.500
		YB20(50-100)	50	100	6.562	+10.521
		YB20(50-50)	50	50	7.066	+18.999
		YB20(75-100)	75	100	7.378	+24.260
		YB20(100-100)	100	100	8.194	+37.999
		YB20(100-75)	100	75	8.446	+42.238
		YB20(100-50)	100	50	8.697	+46.477
		YB20(100-0)	100	0	9.201	+54.955
	B100	YB100(0-100)	0	100	4.439	-25.245
		YB100(0-75)	0	75	4.813	-18.934
		YB100(0-50)	0	50	5.188	-12.622
		YB100(0-25)	0	25	5.563	-6.311
4. Palm Biodiesel	B2	PB2(100-0)	100	0	2.464	-58.501
		PB2(75-0)	75	0	3.332	-43.876
		PB2(50-0)	50	0	4.201	-29.251
		PB2(25-0)	25	0	5.069	-14.625
	B5	PB5(100-0)	100	0	2.435	-58.984
		PB5(75-0)	75	0	3.311	-44.238
		PB5(50-0)	50	0	4.187	-29.492
		PB5(25-0)	25	0	5.062	-14.746
	B20	PB20(100-0)	100	0	2.349	-60.435
		PB20(75-0)	75	0	3.246	-45.326
		PB20(50-0)	50	0	4.143	-30.217
		PB20(25-0)	25	0	5.041	-15.109
	B100	PB100(100-0)	100	0	1.976	-66.720
		PB100(75-0)	75	0	2.966	-50.040
		PB100(50-0)	50	0	3.957	-33.360
		PB100(25-0)	25	0	4.947	-16.680
5. Coconut Biodiesel	B20	CB20(100-0)	100	0	2.397	-59.629
		CB20(75-0)	75	0	3.282	-44.722
		CB20(50-0)	50	0	4.167	-29.815
		CB20(25-0)	25	0	5.053	-14.907

Table 3C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Dindaeng Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of PM Emissions	% Change diesel
			% LDDV	% HDDV		
6. Rapeseed Biodiesel	B2	RB2(100-100)	100	100	1.951	-67.135
		RB2(100-75)	100	75	2.058	-65.339
		RB2(100-50)	100	50	2.165	-63.543
		RB2(100-0)	100	0	2.378	-59.951
		RB2(75-100)	75	100	2.841	-52.147
		RB2(50-100)	50	100	3.731	-37.159
		RB2(50-50)	50	50	3.945	-33.567
		RB2(25-25)	25	25	4.941	-16.784
		RB2(0-100)	0	100	5.511	-7.183
	B5	RB5(100-100)	100	100	1.341	-77.414
		RB5(100-75)	100	75	1.591	-73.210
		RB5(100-50)	100	50	1.840	-69.005
		RB5(75-100)	75	100	2.241	-62.265
		RB5(100-0)	100	0	2.340	-60.596
		RB5(50-100)	50	100	3.140	-47.116
		RB5(50-50)	50	50	3.639	-38.707
		RB5(25-25)	25	25	4.789	-19.354
		RB5(0-100)	0	100	4.939	-16.818
	B20	RB20(100-100)	100	100	0.908	-84.701
		RB20(100-75)	100	75	1.238	-79.158
		RB20(100-50)	100	50	1.567	-73.616
		RB20(75-100)	75	100	1.837	-69.069
		RB20(100-0)	100	0	2.225	-62.530
		RB20(50-100)	50	100	2.765	-53.436
		RB20(50-50)	50	50	3.423	-42.351
		RB20(0-100)	0	100	4.621	-22.171
		RB20(25-25)	25	25	4.680	-21.175
	B100	RB100(100-100)	100	100	0.658	-88.914
		RB100(100-75)	100	75	0.985	-83.406
		RB100(100-50)	100	50	1.312	-77.898
		RB100(75-100)	75	100	1.651	-72.194
		RB100(100-0)	100	0	1.966	-66.881
		RB100(50-100)	50	100	2.644	-55.474
		RB100(50-50)	50	50	3.298	-44.457
		RB100(25-25)	25	25	4.618	-22.229
		RB100(0-100)	0	100	4.629	-22.033

Table 3C Total emissions and percentage of change of biodiesel and diesel oil emitted from scenario of total flow (% LDDV and % HDDV) on Dindaeng Road

Types of Biodiesel	Blend	Scenario	% vehicles of total flows		Total of PM Emissions	% Change diesel
			% LDDV	% HDDV		
7. Used Cooking Oil Biodiesel	B20	UB20(100-100)	100	100	1.604	-72.982
		UB20(100-75)	100	75	1.757	-70.410
		UB20(100-50)	100	50	1.910	-67.837
		UB20(100-0)	100	0	2.215	-62.691
		UB20(75-100)	75	100	2.535	-57.310
		UB20(50-100)	50	100	3.465	-41.637
		UB20(50-50)	50	50	3.771	-36.491
		UB20(25-25)	25	25	4.854	-18.246
		UB20(0-100)	0	100	5.327	-10.291
	B30	UB30(100-0)	100	0	2.158	-63.658
		UB30(75-0)	75	0	3.103	-47.744
		UB3050-0)	50	0	4.048	-31.829
		UB30(25-0)	25	0	4.993	-15.915
	B35	UB35(0-100)	0	100	4.878	-17.854
		UB35(0-7)5	0	75	5.143	-13.391
		UB35(0-50)	0	50	5.408	-8.927
		UB35(0-25)	0	25	5.673	-4.464
	B40	UB40(100-0)	100	0	4.588	-22.724
		UB40(75-0)	75	0	4.926	-17.043
		UB40(50-0)	50	0	5.263	-11.362
		UB40(25-0)	25	0	5.600	-5.681
8. Tallow Biodiesel	B20	TB20(0-100)	0	100	5.466	-7.943
		TB20(0-75)	0	75	5.584	-5.957
		TB20(0-50)	0	50	5.702	-3.971
		TB20(0-25)	0	25	5.820	-1.986
	B35	TB35(0-100)	0	100	4.902	-17.440
		TB35(0-75)	0	75	5.161	-13.080
		TB35(0-50)	0	50	5.420	-8.720
		TB35(0-25)	0	25	5.679	-4.360
	B100	TB100(0-100)	0	100	4.418	-25.590
		TB100(0-75)	0	75	4.798	-19.193
		TB100(0-50)	0	50	5.178	-12.795
		TB100(0-25)	0	25	5.558	-6.398

Table 1D Air quality of Bangkok roadside station

Air pollution measurement station	Air Quality of Bangkok roadside from Pollution Control Department 2004											
	SO_2 (ppb) 1 hr		NO_2 (ppb) 1 hr		CO (ppm) 1 hr		O_3 (ppb) 1 hr		PM_{10} (µg/m^3) 24 hr		TSP(µg/m^3) 24 hr	
	Min-Max	**Number time exceed**	**Min-Max**	**Number time exceed**	**Min-Max**	**Number time exceed**	**Min-Max**	**Number time exceed**	**Min-Max**	**Number time exceed**	**Min-Max**	**Number time exceed**
Thonburi Electricity minor (Inthr)	0.0-57	0/7,977	0.0-126.0	0/8,316	0.0-7.6	0/8,343	0.0-143	6/8,339	23.6-153.9	4/361	0.1-0.2	0/53
Chokchai Metropolitan Police (Ladprao Road)	0.0-66	0/8,327	0.0-161.0	0/8,302	0.0-5.0	0/8,349	0.0-122	6/8,324	40.5-160	3/364	0.1-0.2	0/46
Dindaeng Community domestic (Dindaeng Road)	0.0-41	0/8,311	0.0-172.0	0/8,277	0.0-8.0	0/8,301	0.0-79	0/8,314	29.1-185.1	12/354	0.1-0.5	2/31
Standard (Hour)	300		170		30		100		120		0.33	
Standard (Annual)	40		-		-		-		50		0.1	

Source: modified from Pollution Control Department, B.E. 2548

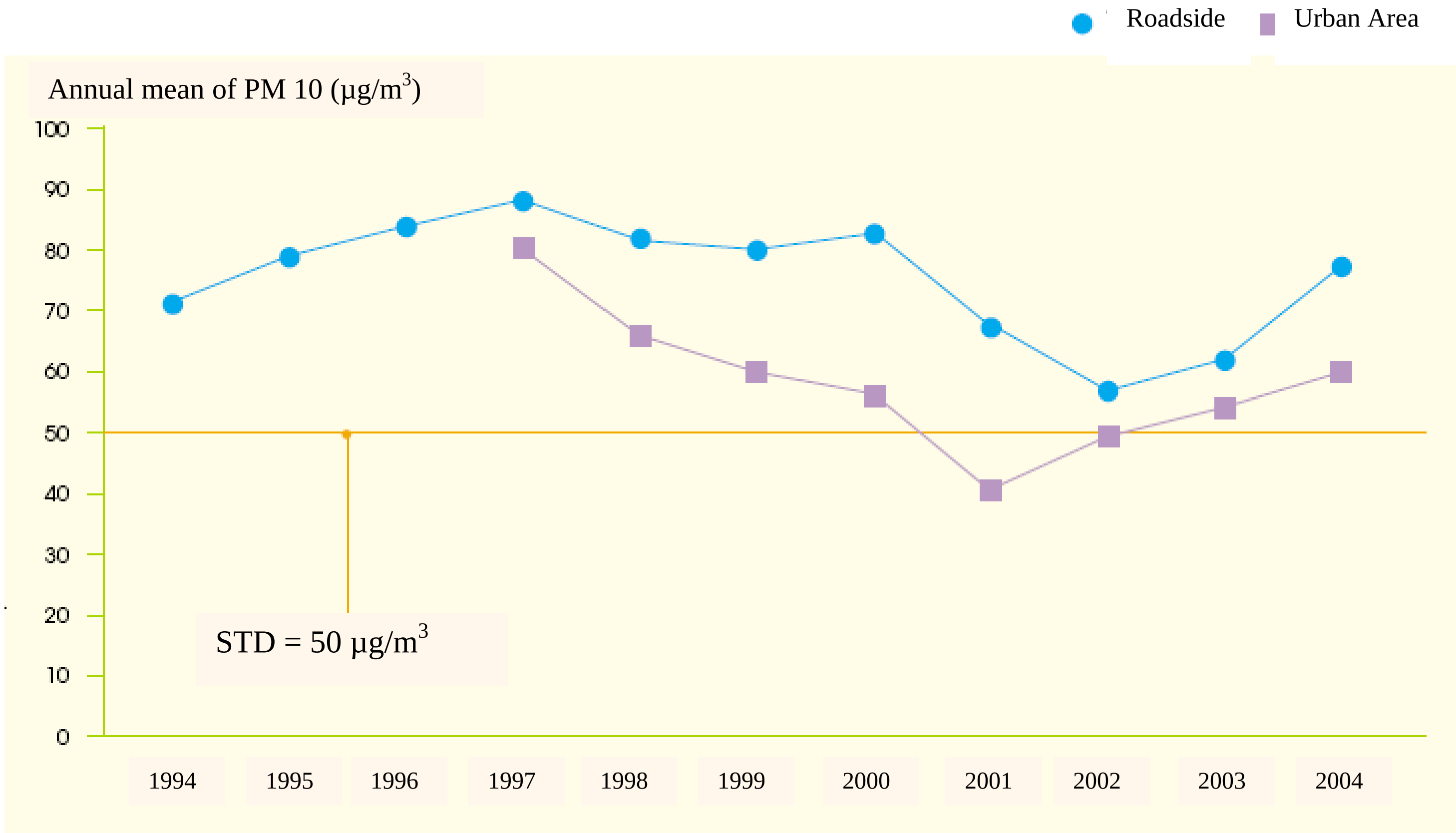

Figure 1D The annual mean of PM10 in Bangkok 1994 -2004

Source : Pollution Control Department, B.E. 2548

BIOGRAPHY

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