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# ECONOMIC IMPACTS OF BIODIESEL DEVELOPMENT PROGRAM IN MALAYSIA

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*ABSTRACT*

Concerns over finite supply of fossil fuel, geopolitical uncertainties, and the 2007-2008 episodes of rapid fossil fuel price increase has stimulated interests in biofuel. Increasing energy demand and budgetary constraints are additional factors that prompted governments to promote investments in biofuel. Blending biofuel with petrol or diesel can help ease pressure on diminishing fossil fuel supplies and ensure greater energy security and avoiding heavy reliance on imported oil. The objective of this study is to quantify the potential economic impacts of the Malaysian biodiesel program instituted under National Biofuel Policy. In this study, we found that the 500,0000 tonnes per annum biodiesel program would have overall positive impact on the economy. For each dollar of demand created by the biodiesel industry on other sectors of the economy, total output would increase by 2.84 times while the output multiplier of petroleum fuel is 1.61. The whole economy is positively affected by the creation of this industry. Sectors with large benefits are "manufacture of oil of fats", "oil palm estates", and "manufacture of industrial chemical and other chemicals". In addition, the "wholesale and retail sector" also stands to benefit quite considerably from the existence of this industry.

Keywords: biodiesel, input-output analysis, economic impact.

## INTRODUCTION

Due to concerns over finite supply of fossil fuel, geopolitical uncertainties and the environment, global interest in biofuels is gradually increasing. Presently, worldwide production and consumption of biofuel is still small a fraction of total energy balance. In 2006, fossil-based fuels comprised 79 percent of world final energy consumption; the remaining, 3 percent is from nuclear and 18 percent renewables. Of the 18 percent, biofuels only comprised 0.3 percent (REN21 2008). In the same year, world production of ethanol fuel and biodiesel were only 39 billion liters and six billion liters, respectively (REN21 2008). World largest producer and consumer of ethanol fuel are the United States and Brazil; while the EU is the single largest consumer and producer of biodiesel. In spite of the small proportion, average renewable energy production capacity, especially solar PV and biodiesel, is growing rapidly. It is expected that as fossil fuel supply diminish, coupled with worldwide pressure on all countries to reduce GHG emissions, demands for biofuels will continue to expand. The main beneficiary of biofuel is the transportation sector.

The main raw material input for biofuel production is its biomass feedstock. Past literatures indicated that feedstock comprised at least 70 to 80 percent of the cost component (for example, Stiefelmeyer *et al*. 2006 and Ye 2005). The choice of feedstock in any region or country depends on their relative cost, reliability and consistency of supply. Malaysia, with its abundant supply of palm oil, has natural comparative advantage in using palm oil as feedstock for the production of biodiesel. At the same time, expansion into biodiesel production enables the palm oil industry to expand into a new value added market and allows the industry to draw down its increasing stock. On this line of reasoning, and rising concerns over increasing fuel subsidy and fuel import expenditures, the National Biofuel Policy was announced on August 10, 2005 by Malaysian government. Among the proposals in the policy is to produce B5 blend biodiesel (comprising 5% processed palm oil with 95% petroleum diesel) for the domestic market. With national diesel consumption at approximately 10 million tonnes per year, it was estimated that the B5 blend would create 500,000 tonnes additional demand for palm oil, thus drawing close to 30% of 2006–2009 average palm oil stock (Table 1). In addition, the program would generate employment and additional tax revenue for the government and allow savings in terms of fuel subsidy.

To implement this plan, the Malaysian Biodiesel Industry Act 2007 was gazetted on July 26, 2007. This act allows for mandatory use of biodiesel. Interim implementation of the act started in February 2009 where B5 biodiesel utilization is directed to government vehicles, specifically MINDEF and DBKL. Full implementation was initially set at February 2010 but was postponed to June 2011. For the interim implementation, petroleum depot used for blending and distribution of biodiesel shipments is the Klang Valley Distribution Terminal (or KVDT) situated along the South Klang Valley Expressway.

The objective of this paper is to estimate the economy wide impact of the Malaysian biodiesel program. This is essential since sectoral partial analysis might under- or over-estimate the economic benefits of the Biodiesel Act. This paper proceeds as follows. The next section presents a brief overview of biodiesel industry in Malaysia. This is followed by a discussion on the methodology and sources of data. Discussions in the final two sections centre on research results and conclusion.

## CURRENT STATUS OF BIODIESEL INDUSTRY

### *Feedstock*

Feedstock for biodiesel in Malaysia is palm oil (either in the form of crude palm oil or processed palm oil).[i] Palm oil could be simply mixed with fossil diesel to produce biodiesel. However, to meet international specification, the production of biodiesel must go through transesterification process to create a palm oil methyl ester with glycerine as a by-product.

As of 2009, a total of 91 licenses were issued with total capacity amounting to 10,193,630 tonnes per annum. However, the number of plants in operation in 2010 is only 10% of the number of license issued. In 2006, only four plants were in operation producing 54,981 tonnes of biodiesel (Table 2). In 2007, the number of plants in operation increased to 11 and production increased to 129,715 tonnes. In 2009, nine plants were in operation producing a total of 222,217 tonnes of methyl ester. Up to the first quarter of 2010, the number of firms in operation dropped to six, producing only 4,602 tonnes of methyl ester biodiesel.

### *Biodiesel production process*

The process of chemically converting palm oil (or any vegetable oil) to biodiesel is transesterification. The purpose of transesterification is to alter the viscosity of palm oil into the proper level suitable for diesel engines.[ii] Catalysts for the chemical process are generally sodium methoxide and/or sodium hydroxide. When the process is complete catalyst used for the process can be recovered and glycerin is seperated as by-product.[iii] With proper facility, the glycerin can be further refined to produce pharmaceutical grade glycerine.[iv] Figure 1 shows the transesterification stages.

## METHODOLOGY

### *Input-output analysis*

There are numerous biofuel impact studies done outside Malaysia. However, these studies do not focus on palm biodiesel. Some examples are Althoff *et al*. (2003) , Bowman (2003), Chang (1994), FAPRI (2000), Hill et al. (2006), Biljana *et al*. (2007), Peterson *et al*. (2006), Steinhurst *et al.* (2005), Stiefelmeyer *et al.* (2006), Ye (2006), and Urbanchuk (2006). In Malaysia, several studies that touched on economic impacts of palm biodiesel are restricted to direct impact based on *guesstimate* without proper justification on the magnitude of impacts. Some examples are Puah and Choo (2008), PTM (2005), and Ahmad Zairin Ismail (2003). None of these studies had explicitly examined the potential impact of the Malaysian biodiesel program. One reason that may have led to this is the unavailability of data related to palm biodiesel. In this section, we present the methodology for estimating the direct and indirect impact of biodiesel production based on input-output analysis.

Wassily Leontief developed the Input-output (I-O) framework in the 1930s (Miller and Blair 2009). In this framework, the structure of an economy is analyzed in terms of interrelationships between production sectors. Given an $n$-sector economy with inter-sectoral transaction matrix **Z** and sectoral total output vector **X**, the direct input requirement matrix **A** is given by

$$\mathbf{A} = \mathbf{Z}(\hat{\mathbf{X}})^{-1}$$

The implied assumption of I-O framework is that the production process in each economic sector is characterized by linear relationship between the amount of input required and the final output. The input-output relationship is described by the following equation.

$$(1) \qquad \mathbf{X} = \mathbf{AX} + \mathbf{Y}$$

In equation (1), **Y** is final demand vector, **X** is a vector of total output with elements $x_i$, $i = 1, \ldots, n$. Elements of matrix **A** indicate the direct input requirement of sector *j* from sector *i* for producing one ringgit's worth of output (henceforth, the ringgit is dropped). Equaton (1) implies that gross output for any given sector equals the sum of sales to sectoral intermediate demand and final demand. Solving equation (1) for total output yields equation (2) below.

$$(2) \qquad \mathbf{X} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{Y}$$

In equation (2), **I** is an identity matrix and $(\mathbf{I} - \mathbf{A})^{-1}$ is the total requirement matrix, or more popularly known as the Leontif inverse matrix. Equation (2) can be expressed as in terms of change as $\Delta\mathbf{X} = (\mathbf{I} - \mathbf{A})^{-1}\Delta\mathbf{Y}$. Expanded to an infinite series, equation (2) can be written as:

$$(3) \qquad \mathbf{X} = (\mathbf{I} + \mathbf{A} + \mathbf{A}^2 + \mathbf{A}^3 + \mathbf{A}^4 + \ldots)\mathbf{Y}$$

The first term on the right hand side of equation (3) represents the initial effect of increase in final demand. **AY** is the direct increase in output requirements in order to allow the industry to meet the demand vector **Y** (the effect is sometimes called the first round effect or direct effect). Sectors or industries supplying inputs to the industry receiving the initial order must also purchase inputs in order to meet their increased demand. These are the indirect effects and are given by the sum of the rest of terms in equation (3). They are the value of inputs purchased by the backward-linked industries in additional rounds of spending.

***Methods for estimating the total impact of a new sector***

The latest publicly available Malaysian IO table is for the year 2000 with 94 sectors. In IO framework, there are two approaches to estimating the impacts of a new industry. One is the complete inclusion approach; the other is the final demand approach (Miller and Blair 2009).

The complete inclusion approach requires that the new sector must first be created and included in the IO table by estimating the technical coefficients of the new industry. Technical coefficients of a new sector can be estimated either by the full survey method or non-survey method. In the final demand approach, the impact of a new industry is indirectly estimated from the impacts on output generated by additional demand of the new sector on the economy. For this study, the final demand approach is utilized to examine the economic impact of Malaysian biodiesel program.

## RESULTS AND DISCUSSION

To operationalize the final demand approach, input requirements for 100,000 tonnes per annum plant were identified and their associated costs estimated. The costs are then extrapolated to 500,000 tonnes per annum production. These costs estimates were compiled from four biodiesel processing.[v] Figure 2 shows the input requirements of producing 500,000 tonnes of methyl ester biodiesel. Figure 3 shows the same information but from the expenditure perspective. The expenditures were calculated based on the following sets of parameters.[vi]

- Exchange rates: USD1.00 = RM3.50 and 1SGD = RM2.10
- Crude palm oil price: RM2,500.00 per tonne.
- Methyl ester biodiesel price: RM2,600 per tonne.
- Glycerin price is RM70 per tonne.
- Capacity of processing plant: 100,000 tonnes per year.

Based on the input requirements and costs presented in Figure 2 and Figure 3, we simulated a full implementation scenario for Klang Valley, Putrajaya and Cyberjaya. In this scenario, we assumed annual methyl ester biodiesel production of 500,000 tonnes. After the production process, methyl esters are transported to the KVDT for blending and subsequent distribution to petrol stations in Klang Valley, Putrajaya and Cyberjaya.[vii] For the purpose of estimation, we utilized the Leontief inverse matrix found in Table 18 of Input-output Table Malaysia 2000.[viii] Final demand entries were follows.

1. Crude palm oil feedstock requirements resulted in higher demand on output of Sector 16 (manufacture oils and fats) by RM1,250 million. The "manufacture oils and fats" sector includes manufacture of crude and refined palm oil and palm kernel oil, manufacture of coconut oil and other vegetable and animal oils and fats.
2. Requirements for hot water (RM0.18 million), steam (RM10.65 million) and electricity (RM1.96 million) were entered as final demand increase in Sector 66 (electricity and gas). The total final demand increase amounted to RM12.79 million. The sector includes production, collection and distribution of electricity, and production of gas, steam and hot water supply.
3. Chemical inputs, comprising methanol (RM80.50 million), citric acid (RM1.92 million), hydrochloric acid solution (RM4.50 million), and sodium hydroxide solution (RM0.75 million), and sodium methoxide (RM31.50 million) were entered as final demand increase in Sector 37 (manufacture of industrial chemical). The total increase in annual demand for basic chemicals amounted to RM119.17 million.
4. In our discussions with plant managers, we found that it is typical for Malaysian biodiesel processors to obtain two months working capital financing from financial institutions. As such, we included two months working capital financing cost (RM15 million) as additional demand for output of Sector 73 (Banks: Monetary intermediation).
5. To approximate the increase in demand for transport service for transporting methyl ester to KVDT, we assumed an average distance of 250 km for the transportation of methyl ester to KVDT using 32,000-liter fuel tanker. Fuel consumption for transporting methyl ester to the blending facility was calculated based on average 6mpg (2.123km/liter) fuel consumption. Total number of truckloads is 177,756 and total fuel consumption is 2,090,796 liter. Total fuel consumption at average per liter diesel cost of RM1.60 per liter is RM3,763,433 per year. As such, this creates additional minimum final demand of RM3.76 million on transportation services (Sector 71).

Table 3 shows the output impact of biodiesel transestrification industry on the economy. The existence of a biodiesel processing industry resulted in RM1,400.72 million additional annual demand on the economy, and resulted in additional output of RM3,973.13 million. The implied output multiplier of this 2.84; i.e., about 76 percent larger than that of petroleum sector which has an output multiplier of 1.61. The figure is also nearly as large as that of Sector 16 (manufacture of oils and fats) which has the largest output multiplier of about 2.96.

Table 4 shows the distribution of total impact for the first three rounds. As shown in the table, relative to the "petroleum sector" (Sector 42), the biodiesel sector goes through more rounds of production before the full impact of increased final demand is realized. The "petroleum sector" (Sector 42) only needs to through the initial, first round and second round of multiplier effect before realizing 98 percent of its full impact compared to 81 percent for the biodiesel sector. This implies that the biodiesel sector is made up of more backward-linked industries in the supply-chain.

Table 5 shows five sectors that received the largest percentage increase from the base line as a result of the new sector are. The sectors are Sector 16 (the manufacture of oils and fats), Sector 3 (oil palm estate), Sector 37 (Manufacture industries chemic.), Sector 42 (petrol and coal industries), and Sector 66 (electricity & gas). In terms of magnitude of increase, ordering of the first four are the same. The fifth was replaced by "wholesale and retail". The first four sectors comprised 88 percent of the total impact.

The impact of biodiesel processing on other agriculture sectors that are not related to palm oil is very small. As shown in the table, output of Sector 1 (Agriculture other), Sector 2 (Rubber planting), Sector 4 (coconut), Sector 5 (tea estates), Sector 6 (Livestock breeding etc.), Sector 7 (Forestry & logging), and Sector 8 (Fishing) increased by less than one percent. In value terms, the combined effect is only about RM16.7 million. The same situation is also true for food-manufacturing sectors (Sector 17–Sector 24). Their combined increased is only about 5 million.

## CONCLUSION

Biofuel has several advantages over its fossil counterpart. Biofuel comes from a renewable resource while fossil fuel from a finite resource. The feedstock can be grown easily and are thus reliable in supply. Biofuel crops absorb the carbon dioxide in the air. In addition, biofuels emit less green house gas during the final use stage. Blending biofuel with petrol fuel helps to ease pressure on fossil fuel supplies, thus ensuring greater energy security and avoiding heavy reliance on imported oil. Biofuel is biodegradable and far less toxic than fossil fuels. An additional advantage of biofuel over fossil fuel is the additional demand for fuel crop will help to boost the agricultural industries.

In this study, we have shown that a 500,0000 tonnes biodiesel industry would have positive impact on the economy. For each dollar of demand for methyl ester biodiesel, total output would increase by 2.84 times. While the whole economy is positively affected by the creation of this industry, several stands out more than others. Sectors that benefits are manufacture of oil of fats, oil palm estates, manufacture of industrial chemical and other chemicals, and petrol and coal industries. In addition, the wholesale and retail sector and the electricity sectors also benefit quite considerably from the existence of this industry. Due to the positive environmental and economic impacts of biodiesel, the full implementation of the program must be implemented as soon as possible. Several options could be taken to hasten the implementation.

(1) Switching from subsidizing petrol fuel to subsidizing biofuel.
(2) Supplementing biodiesel palm oil feedstock with other environmentally less demanding feedstock (for example used cooking oil from fast-food restaurants or non-food competing renewable feedstock such as jatropha).
(3) Reducing the bio-content of biodiesel, for example from the current B5 to B2.

**Endnotes**

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[i] While CPO (crude palm oil) is cheaper than PPO (processed palm oil), additional treatment is required if the choice of feedstock is crude palm oil.

[ii] Source: http://www.biodiesel.com/index.php/biodiesel/history_of_biodiesel_fuel (last visited: Sept. 25, 2010) and Jitputti et al. (2004).

[iii] Industry sources reveal that the yield loss during refining ranged between 2% to 10% depending on the technology used and accuracy of reporting.

[iv] We are grateful to Sime Darby Biodiesel Sdn Bhd and Global Biodiesel Sdn Bhd for giving us a tour of their facilities and demonstrating the process of producing methyl ester biodiesel.

[v] The cost estimates are average values and after harmonizing with information from other sources. They do not represent actual cost of production of any individual plants we visited.

[vi] These costs were estimated in 2007. Current market condition may change part or all of the cost components.

[vii] "Klang Valley (Malay: Lembah Klang) is an area in Malaysia comprising Kuala Lumpur and its suburbs, and adjoining cities and towns in the state of Selangor. An alternative reference to this would be Kuala Lumpur Metropolitan Area or Greater Kuala Lumpur, though neither of these terms is used locally." (Quoted from http://en.wikipedia.org/wiki/Klang_Valley).

[viii] We utilized the 2000 table for the impact assessment in 2007 under the assumption that the structure of the economy has not significantly change between the two periods.

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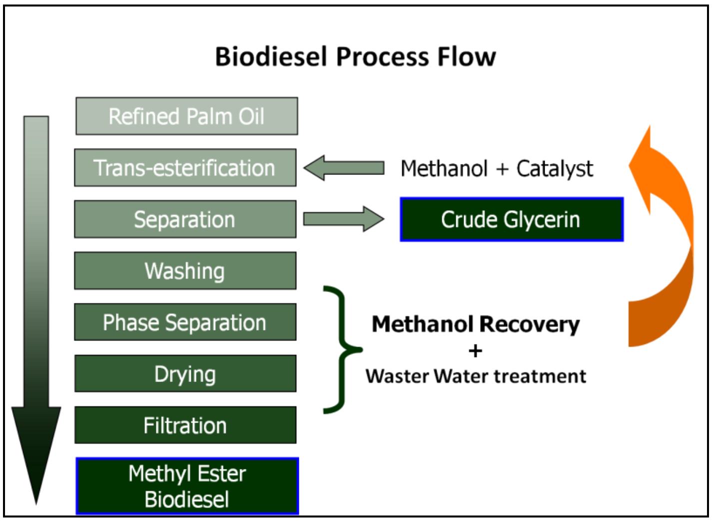
Figure 1 : Biodiesel Production Process




Source: Taken from Sime Darby Biodiesel Sdn Bhd company visit presentation slide

Figure 2 : Input requirements and Output of Transestrification

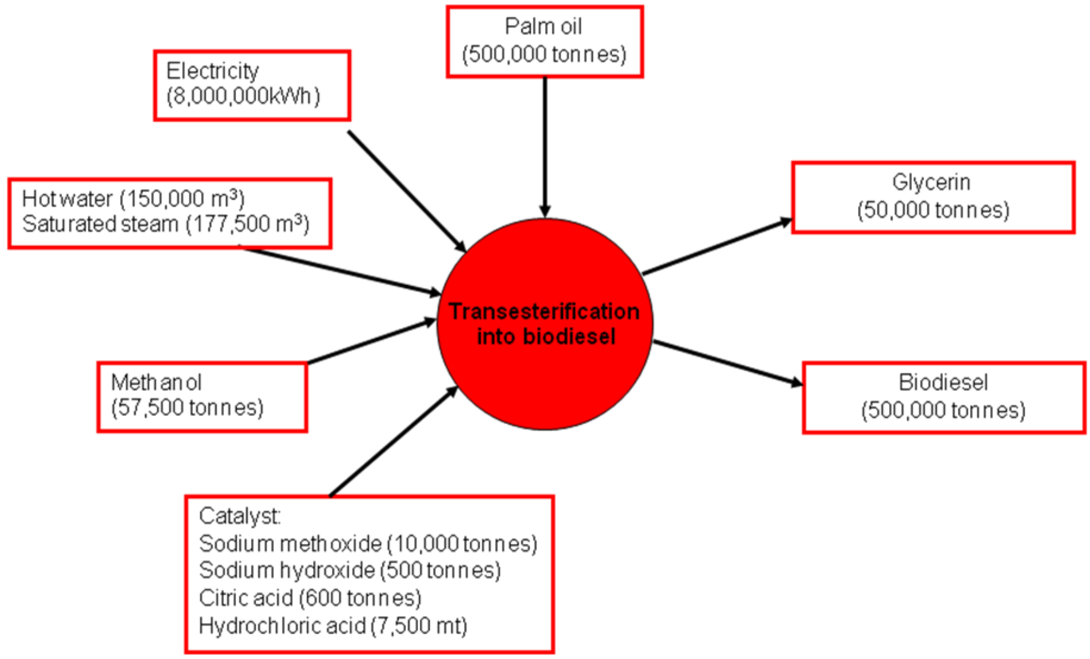



Figure 3 : Input-output of Transesterification in Monetary Terms

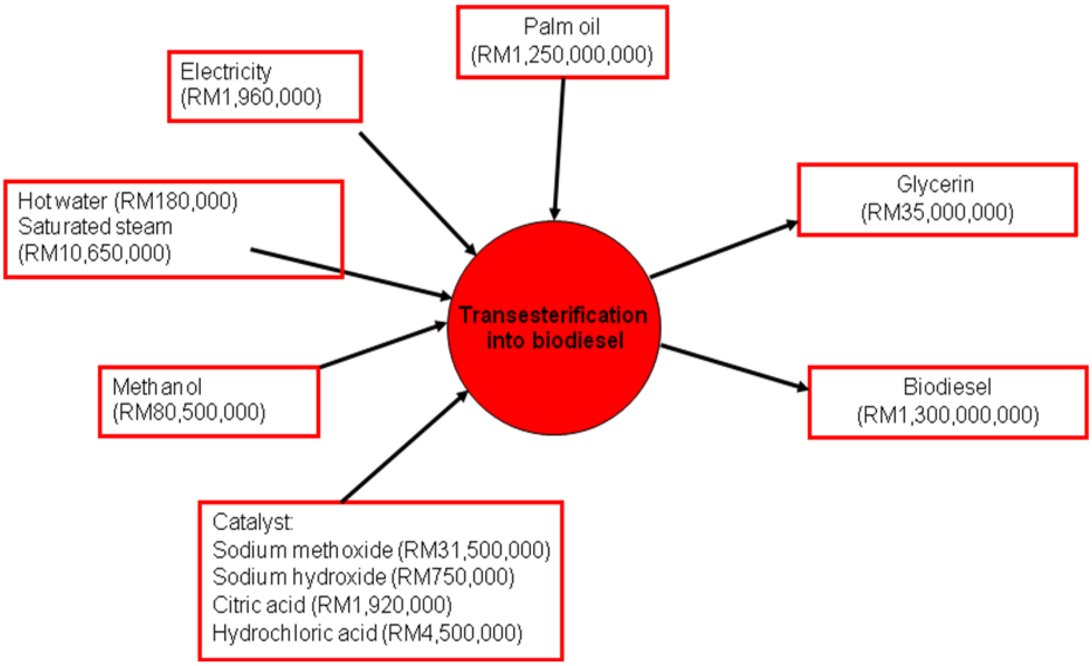


Table 1 : Palm Oil Statistics, 2006-2009

| | 2006 | 2007 | 2008 | 2009 | Average |
|---|---|---|---|---|---|
| Area (hactares) | 4,165,215 | 4,304,914 | 4,487,957 | 4,691,160 | 4,412,312 |
| **Production (tonnes)** | | | | | |
| Crude Palm Oil | 15,880,487 | 15,823,368 | 17,734,441 | 17,564,937 | 16,750,808 |
| Palm Kernel | 4,125,113 | 4,096,990 | 4,577,500 | 4,500,683 | 4,325,072 |
| Crude Palm Kernel Oil | 1,955,634 | 1,907,613 | 2,131,399 | 2,097,096 | 2,022,936 |
| Palm Kernel Cake | 2,200,225 | 2,152,488 | 2,358,732 | 2,312,222 | 2,255,917 |
| Oleochemical Products | 2,099,074 | 2,934,544 | 2,201,939 | 2,168,930 | 2,351,122 |
| **Closing stock (tonnes)** | | | | | |
| Palm oil | 1,506,035 | 1,682,587 | 1,994,710 | 2,238,717 | 1,855,512 |
| Palm Kernel | 161,117 | 170,539 | 142,098 | 129,249 | 150,751 |
| Palm Kernal oil | 362,723 | 268,842 | 349,171 | 305,912 | 321,662 |
| Palm Kernel Cake | 240,336 | 289,357 | 302,278 | 320,008 | 287,995 |

Source : Summarized from MPOB Palm oil Statistics (available at http://www.mpob.gov.my)

Table 2 : Methyl Ester Biodiesel Production, 2006-2010

| Year | Production (tonnes) |
|---|---|
| 2006 (Aug-Dec) | 54,981 |
| 2007 (Jan-Dec) | 129,715 |
| 2008 (Jan-Jul) | 64,298 |
| 2009 (Jan-Dec) | 222,217 |
| 2010 (Jan-Mar) | 4,602 |

Source: MPOB.

Table 3 : Transesterification sector: Impact on output (selected)

| Sectors | Sector no. | Change in final demand (RM) | Change in output (RM) | Distribution of change (%) | Percent Increase from baseline |
|---|---|---|---|---|---|
| Agriculture other | 1 | 0 | 4,408,024 | 0.111 | 0.064 |
| Rubber planting | 2 | 0 | 660,766 | 0.017 | 0.032 |
| Oil Palm estates | 3 | 0 | 645,799,064 | 16.254 | 6.073 |
| Coconut | 4 | 0 | 35,315 | 0.001 | 0.024 |
| Tea estates | 5 | 0 | 4,829 | 0.000 | 0.018 |
| Livestock breeding etc. | 6 | 0 | 785,237 | 0.020 | 0.012 |
| Forestry & logging | 7 | 0 | 7,447,643 | 0.187 | 0.053 |
| Fishing | 8 | 0 | 3,329,220 | 0.084 | 0.061 |
| Crude petrol, natural gas & coal | 9 | 0 | 64,834,753 | 1.632 | 0.147 |
| | | | | | |
| Manufacture oils and fats | 16 | 1,250,000,000 | 2,506,900,833 | 63.096 | 9.002 |
| Grain mills | 17 | 0 | 909,227 | 0.023 | 0.039 |
| Bakeries | 18 | 0 | 309,719 | 0.008 | 0.018 |
| Manufacture confect. | 19 | 0 | 66,151 | 0.002 | 0.006 |
| Manufacture of ice | 20 | 0 | 90,548 | 0.002 | 0.079 |
| Manufacture other food | 21 | 0 | 2,359,927 | 0.059 | 0.049 |
| Manufacture animal feeds | 22 | 0 | 335,852 | 0.008 | 0.014 |

| | | | | | |
|---|---|---|---|---|---|
| Prod. wine and spirits | 23 | 0 | 530,562 | 0.013 | 0.048 |
| Prod. of soft drinks | 24 | 0 | 437,151 | 0.011 | 0.037 |
| | | | | | |
| Manufacture industries chemic. | 37 | 119,170,000 | 193,052,885 | 4.859 | 1.058 |
| | | | | | |
| Petrol & coal industries | 42 | 0 | 161,170,954 | 4.057 | 0.493 |
| | | | | | |
| Electricity & gas | 66 | 12,790,000 | 48,807,423 | 1.228 | 0.295 |
| | | | | | |
| Wholes.&retail trade | 69 | 0 | 92,884,958 | 2.338 | 0.179 |
| Hotels & restaurants | 70 | 0 | 11,201,499 | 0.282 | 0.052 |
| Transport | 71 | 3763433 | 61,436,705 | 1.546 | 0.173 |
| Communication | 72 | 0 | 8,210,287 | 0.207 | 0.046 |
| Banks | 73 | 15,000,000 | 18,391,133 | 0.463 | 0.076 |
| | | | | | |
| Other public administration | 94 | 0 | 1,193,034 | 0.030 | 0.020 |
| **Total Impact** | | 1,400,723,433 | 3,973,129,767 | | |

Table 4 : Decomposition Of Impact, Biodiesel Vs. Fossil Fuel

| Round | Biodiesel sector | Sector 42 |
|---|---|---|
| Initial (IY) | 35% | 62% |
| Initial+ 1st round (IY+AY) | 64% | 94% |
| Initial + 1st round+2nd round (IY+AY+A$^2$Y) | 81% | 98% |

Table 5 : Decomposition of Impact, Biodiesel vs. Fossil fuel

| Rank | Percent change | Magnitude |
|---|---|---|
| 1 | Sector 16: Manufacture oils and fats (9.0%) | Sector 16: Manufacture oils and fats (2,507 million) |
| 2 | Sector 3: Oil Palm estates (6.1%) | Sector 3: Oil Palm estates (646 million) |
| 3 | Sector 37: Manufacture industrial chemic. (1.1%) | Sector 37: Manufacture industrial chemic. (193 million) |
| 4 | Sector 42: Petrol & coal industries (0.5%) | Sector 42: Petrol & coal industries (161 million) |
| 5 | Sector 66: Electricity & gas (0.3%) | Sector 69: Wholes.&retail trade (93 million) |