

Lappeenranta University of Technology
Faculty of Technology, LUT Energy
Research Report 1

SUSTAINABILITY OF PALM OIL PRODUCTION AND OPPORTUNITIES FOR FINNISH TECHNOLOGY AND KNOW-HOW TRANSFER

Virgilio Panapanaan
Tuomas Helin
Marjukka Kujanpää
Risto Soukka
Jussi Heinimö
Lassi Linnanen

2009

ISBN 978-952-214-737-0
ISBN 978-952-214-758-5(PDF)
ISSN 1798-1328

Copyright © Lappeenranta University of Technology, 2009

PUBLISHER

Lappeenranta University of Technology
Skinnarilankatu 34, P.O. Box 20, FI-53851 Lappeenranta, Finland
Tel. +358 5 621 11, fax. +358 5 621 2350

This publication is available in PDF format on the Internet at www.doria.fi/lutpub



Photos:

1. Oil palm plantation by: Rhett A. Butler, mongabay.com
2. Oil palm fruit by: Rhett A. Butler, mongabay.com
3. Wastewater aerobic treatment tank: Mika Horttanainen, LUT
4. Improved and modern dryer: Mika Horttanainen, LUT

ABSTRACT

Virgilio Panapanaan, Tuomas Helin, Marjukka Kujanpää, Risto Soukka, Jussi Heinimö and Lassi Linnanen

Sustainability of palm oil production and opportunities for Finnish technology and know-how transfer

Lappeenranta University of Technology
Institute of Energy Technology
Research Report 1
March 2009

95 pages, 18 figures, 14 tables

Keywords: palm oil, bio-diesel, CDM projects, carbon footprint, greenhouse gas balance, life cycle assessment

The global demand for palm oil is growing, thus prompting an increase in the global production particularly in Malaysia and Indonesia. Such increasing demand for palm oil is due to palm oil's relatively cheap price and versatile advantage both in edible and non-edible applications. Along with the increasing demand for palm oil, particularly for the production of biofuel, is a heated debate on its sustainability. Ecological degradation, climate change and social issues are among the main sustainability issues pressing the whole palm oil industry today.

Clean Development Mechanism (CDM) projects fulfilling the imperatives of the Kyoto Protocol are starting to gain momentum in Malaysia as reflected by the increasing registration of CDM projects in the palm oil mills. Most CDM projects in palm oil mills are on waste-to-energy, co-composting, and methane recovery with the latter being the most common.

The study on greenhouse gases (GHG) in the milling process points that biogas collection and energy utilisation has the greatest positive effect on GHG balance. On the other hand, empty fruit bunches (EFB) end-use as energy and high energy efficiency of the mill have the least effect on GHG balance of the mill. The range of direct GHG emissions from the palm oil mill is from 2.5 to 27 gCO₂e/MJ_{CPO}, while the range of GHG emissions with all indirect and avoided emissions included is from -9 to 29 gCO₂e/MJ_{CPO}. Comparing this GHG balance result with that of the EU RES-Directive suggests a further check on the values and emissions consideration of the latter.

FOREWORD

Most industrialised countries have committed to significantly decrease greenhouse gas (GHG) emissions as a response to the challenge of climate change. The EU, as an example, aims to decrease its GHG emissions by 20% from the level of 1990 by the year 2020. One means of attaining this goal is by increasing the share of transport biofuels to 10%. Thus, the markets of transport biofuels in the EU is expected to develop rapidly for the next 15 years. The European Commission has estimated that approximately 80% of the biofuels demand by 2020 can be produced within the Union and the rest will be imported.

Palm oil is becoming a more important raw material for transport biofuels. Compared to other oil plants cultivated in Europe, palm oil has several advantages such as remarkably higher annual oil yield and lower production costs. Along with the rapidly increasing interest on palm oil use for transport fuels, serious concern about the sustainability of palm oil production has also increased and has stirred up new debates. The increasing palm oil production can result to some negative impacts as destruction of forests, emergence of social problems and pollution of the environment. On the other hand, expanding of palm oil production increases the export revenues of palm oil-producing countries and creates new jobs in rural areas.

This report presents an updated information and state-of-the-art of the palm oil industry covering production, trends and development, supply chain, stakeholders, and sustainability issues. The first part (Part I) of this report provides a robust overview of the palm oil industry, while the second part (Part II) reviews the clean development mechanisms (CDM) projects in Malaysia as the world's leading palm oil producer and exporter. The third part (PART III) is a study on GHG emissions and balance in a palm oil mill using a carbon footprinting methodology. Such GHG study using carbon footprinting provides a rational technical approach in calculating the GHG emissions balance and in generating some scenarios for potential emissions reduction. The information and data in Part I and Part II are basically based on desktop research googled from Internet pages or excerpted from latest annual reports, journals, magazines, news clips and conference proceedings. On the other hand, the study on GHG balance is based on best publicly available inventory data gathered from multiple scientific articles on several palm oil mills.

The study was carried out from June to December 2008 as a part of the project, Global Forest Energy Resources, Certification of Supply and Markets for Energy Technology, coordinated by the Finnish Forest Research Institute (METLA). The research project was a part of the ClimBus Technology Programme of the Finnish Funding Agency for Technology and Innovation (TEKES). The authors are grateful to TEKES and Neste Oil Oyj for the financial support to this research.

Lappeenranta, March 2009

Virgilio Panapanaan
Risto Soukka

Tuomas Helin
Jussi Heinimö

Marjukka Kujanpää
Lassi Linnanen

Executive Summary

The global demand for palm oil is growing, thus prompting an increase in production in Malaysia and Indonesia. Such increasing demand for palm oil is due to palm oil's relatively cheap price (compare to other vegetable oils) and versatile advantage both in edible and non-edible applications. The increasing demand for palm oil is also ascribed to the increasing demand for biofuel as an alternative source of energy particularly in Europe having a mandated biofuel utilisation target. The growth in palm oil consumption has resulted in palm oil dominating the current global oil market.

In Malaysia, major players and stakeholders in the palm oil industry form a complex network. Various organisations are busy looking after their own interests in the business and in the supply chain. Leading palm oil industry organisations are considered as active forces in keeping themselves well-represented in high level national decision-making and development programs. Although private ownerships dominate the upstream and downstream production of palm oil, the Malaysian government plays a significant role in the development of palm oil industry in the country.

The production of palm oil is not without problems or challenges. The whole industry is partly blamed as a culprit for loss of forest cover and forested areas (deforestation), loss of biodiversity, endangering wild animals and species, soil, air and water pollution, chemical contamination, as well as for land disputes and social problems in Malaysia (also in Indonesia). At the milling factories, the problems of waste and pollution particularly of the palm oil mill effluents (POME) are also of growing concern.

There are good existing laws and regulations in Malaysia that cover palm oil being a prime agricultural commodity. Policies are typically more of combining different applicable instruments to regulate palm oil production and the industry as a whole. The National Biofuel Policy in Malaysia is an example of new policy decided upon through multi-stakeholder consultation. The Roundtable on Sustainable Palm Oil (RSPO) and Kyoto Protocol are new platforms in forwarding new policy measures to ensure the sustainability of palm oil.

The growth and modernisation of palm oil industry in Malaysia is not without the influence of various research and development efforts of different scientific organisations. The contribution of research to support the development of capacities, technologies and innovations is very much evident by the roles being played by both public and private research institutions.

Overall, palm oil industry is expected to expand and grow more in the near future just as the increasing demands in EU countries, China, India and United States for vegetable oils and fats are expected to rise. The increasing demands for palm oil either for food or for fuels is now a heated debate not only within the industry but also in general public at large. Important issues such as price, ecological degradation and climate change, and technical production innovations remain at the centre point of the palm oil dynamics at present and in the near future.

Clean Development Mechanism (CDM) projects fulfilling the imperatives of the Kyoto Protocol have started to gain momentum in Malaysia in the recent past. The increasing registration of CDM projects in the palm oil mills is a reflection of increasing interests of various market players in the industry. The three main areas of CDM projects are on waste-to-energy, methane recovery and co-composting, with methane recovery being the most common project area. So far, CDM projects are claimed to have boosted the palm oil sustainability in Malaysia. Other than combating global warming, CDM in palm oil mills can significantly reduce pollution, increase the efficiency of waste management system, and provide benefits resulting from new available technologies that are normally part of a CDM project.

Greenhouse gas (GHG) emissions are one key sustainability issue related to palm oil production. POME treatment in open anaerobic ponds is the main source of direct GHG emissions. Minor indirect GHG emissions are derived from raw materials, product and co-product's transport. Significant avoided emissions can be achieved if the system outputs such as; fibres, shells, empty fruit bunches (EFB) and biogas are utilised to replace fossil energy outside the mill.

Biogas collection and energy utilisation has the greatest effect on GHG balance. The extraction efficiency of crude palm oil is the second most important factor, while EFB end-use as energy and high energy efficiency have the least effect on GHG balance of the mill. The range of direct GHG emissions from the milling phase in hydrotreated diesel production from palm oil is from 2.5 to 27gCO₂e/MJ_{fuel}, while the range of GHG emissions with all indirect and avoided emissions included is from -9 to 29gCO₂e/MJ_{fuel}. The best GHG balances are obtained with biogas collection and energy utilisation, good material balance, EFB end-use as energy, and high energy efficiency. Excess shells and fibres have to be delivered and used in the national energy production system to reach the best case scenario.

The result of the carbon footprinting study suggests that the GHG savings values proposed for the RES Directive needs further revision because the RES typical values represent only the direct emissions of a palm oil mill while indirect and avoided emissions are excluded, which contravenes the principles of the carbon footprint calculation. Furthermore, the RES default values address the uncertainties in life cycle assessment in an unconventional manner. A more scientific approach is to evaluate the uncertainties of each product chain during the life cycle assessment process and communicate the results as a range of GHG balance. Calculating the emission savings for renewable fuel use with general values can lead to miscalculation and does not promote the implementation of technological improvements leading to continuous improvement.

Emission savings can be realised from the processing phase of palm oil with the identified improvements in technologies and practices. From this perspective, potential Finnish technologies and know-how (e.g. digestion, energy conversion and oily wastewater technologies) can be harnessed for process improvement. Although it does not fully address other environmental and social issues, GHG emissions reduction from palm oil milling is one step towards sustainable palm oil production.

Table of Contents

PART 1: OVERVIEW OF THE PALM OIL INDUSTRY.....	10
1. INTRODUCTION	10
1.1 GENERAL.....	10
1.2 SHORT BIOLOGY OF OIL PALM PLANT.....	10
1.3 BRIEF HISTORICAL AND UPDATED PALM OIL PRODUCTION DATA	12
2. PALM OIL PRODUCTS UTILISATION AND DEMAND.....	14
2.1 GLOBAL CONSUMPTION OF PALM OIL	14
2.2 PALM OIL FOR BIOFUEL: ALTERNATIVE CHEAPER SOURCE OF ENERGY	16
3. PALM OIL PRODUCTION PROCESS	18
3.1 GENERAL DESCRIPTION OF PALM OIL PROCESSING	18
3.2 THE PALM OIL PROCESS FLOW	19
4. MAJOR PLAYERS IN THE PALM OIL INDUSTRY	23
4.1 UPSTREAM PRODUCERS	23
4.2 DOWNSTREAM PRODUCERS.....	24
4.3 EXPORTERS AND IMPORTERS OF PALM OIL	25
4.4 INDUSTRY ORGANISATIONS.....	27
4.5 GOVERNMENT AGENCIES	29
4.6 OTHER PLAYERS.....	30
4.7 CUSTOMERS.....	31
5. ISSUES AND IMPACTS OF PALM OIL PRODUCTION.....	32
5.1 ECOLOGICAL ISSUES AND IMPACTS.....	32
5.2 SOCIO-ECONOMIC ISSUES AND IMPACTS	34
5.3 WASTE AND POLLUTION FROM PALM OIL PRODUCTION AND MANAGEMENT.....	35
5.4 ECOLOGICAL CULTIVATION OF PALM OIL.....	38
6. SUSTAINABILITY AND THE ROUNDTABLE ON SUSTAINABLE PALM OIL	40
7. POLICY ISSUES.....	43
8. RESEARCH ON PALM OIL	46
9. PALM OIL INDUSTRY - FORECAST AND FUTURE	48
PART II. CDM PROJECTS IN PALM OIL INDUSTRY.....	50
10. THE CLEAN DEVELOPMENT MECHANISM (CDM).....	50
11. CDM IN MALAYSIA	52
12. RECENT AND ON-GOING CDM PROJECTS ON PALM OIL.....	54
13. ELIGIBLE AREAS FOR CDM PROJECT	59
13.1 USE OF PALM OIL WASTE FOR THE PRODUCTION OF THERMAL ENERGY	59
13.2 METHANE RECOVERY WITH ENERGY PRODUCTION	59
13.3 CO-COMPOSTING OF POME AND EFB	60
14. ORGANISATION OF THE CDM PROJECTS IN MALAYSIA	61
PART III. GREENHOUSE GAS BALANCE IN PALM OIL MILLING.....	62
15. GHG BALANCE AND CARBON FOOTPRINTING	62
16. STUDY UNIT: PALM OIL PRODUCTION (MILLING) PROCESS	65

17. PRINCIPLES IN CARBON FOOTPRINT CALCULATION	67
18. METHODOLOGICAL CONSIDERATIONS IN CARBON FOOTPRINTING	70
18.1 GOAL AND SCOPE DEFINITION	70
18.2 FUNCTIONAL UNIT	70
18.3 SYSTEM BOUNDARY	71
18.4 ALLOCATION PROCEDURES	72
18.5 DATA SOURCES AND QUALITY	73
18.6 MATERIAL BALANCE OF PALM OIL MILLING PROCESS	73
18.7 DIRECT, INDIRECT AND AVOIDED EMISSIONS	75
18.8 SCENARIO SETTING	75
18.9 KEY ASSUMPTIONS IN THE GHG BALANCE CALCULATION	78
19. CARBON FOOTPRINT RESULTS.....	82
19.1 GHG BALANCE SCENARIOS	82
19.2 INTERPRETATIONS AND ANALYSIS	84
19.3 EMISSION SAVINGS CALCULATIONS AND RES-DIRECTIVE.....	85
20. TECHNOLOGICAL CONSIDERATIONS	86
21. SUMMARY AND CONCLUSION.....	87
REFERENCES	90

List of Figures

Figure 1.1	Oil palm tree
Figure 1.2	Oil palm fresh fruit bunch and the structure of the palm fruit
Figure 1.3	Indonesia and Malaysia's palm oil production
Figure 1.4	World palm oil productions 2006
Figure 2.1	Growth in industrial used of palm oil
Figure 2.2	Industrial use of palm oil in Malaysia
Figure 2.3	Palm oil global consumption in 2006/07
Figure 3.1	Palm oil process flow chart
Figure 5.1	Sources of waste from palm oil milling
Figure 11.1	Register of CDM project by host countries
Figure 11.2	CERs issued by host countries
Figure 15.1	The supply chain of NExBTL-diesel
Figure 15.2	Material chain for diesel production (NBD PO) from palm oil
Figure 18.1	The system boundary of the GHG balance study
Figure 18.2	Average inputs and outputs of the palm oil mill
Figure 18.3	Different scenarios for palm oil mill
Figure 18.4	System expansions adopted in bio energy production and in EFB mulching
Figure 19.1	Scenarios (in graphical form) for GHG balance of palm oil mill with economic allocation

List of Tables

Table 4.1	Malaysian palm oil exports to major importing countries worldwide
Table 4.2	Major palm oil importing companies from the leading countries
Table 4.3	Palm oil industry organisations
Table 12.1	List of CDM projects in Malaysia (and some from Indonesia)
Table 15.1	Fossil greenhouse gas emission during palm oil product chain of NExBTL-diesel
Table 18.1	Economic allocation of emissions between crude palm oil and palm kernel.
Table 18.2	Lowest, average and highest values for the relevant inventory data for palm oil mills per tonne of FFB
Table 18.3	Best and worst scenario for palm oil mill material balance
Table 18.4	Steam and electricity consumption of palm oil mills with 80%, average and 120% energy consumption
Table 18.5	The applied higher heating values, moisture contents and lower heating values of EFB, fibres, methane and shells
Table 18.6	The nutrient composition of EFB
Table 18.7	The equivalent mass of chemical fertilisers and CO ₂ emission from production
Table 19.1	Scenarios for GHG balance of palm oil mill in kgCO _e /tCPO
Table 19.2	Scenarios for GHG balance of palm oil mill in gCO _e /MJ _{NExBTL} with economic allocation

Appendices

Appendix 1	Profiles of some leading plantation and processing companies in Malaysia
Appendix 2	RSPO principles and criteria for sustainable palm oil production
Appendix 3	Sample: Clean Development Mechanism (CDM) methane to energy project in a palm oil mill
Appendix 4	Palm oil mill process flow and descriptions of unit processes
Appendix 5	Process flow chart from LCA tool GaBi 4.3
Appendix 6	Data on market value of crude palm oil and palm kernel
Appendix 7	All inventory data
Appendix 8	Summary of the relevant calculations behind RES directive; and GHG savings for hydrotreated vegetable oil from palm oil

PART 1: OVERVIEW OF THE PALM OIL INDUSTRY

1. Introduction

1.1 General

Palm oil is one of the fastest growing sectors in global vegetable oil market with Malaysia and Indonesia leading the production and export to date. Currently, the emerging growing demand for palm oil is due to its relatively cheap price (compare to other vegetable oils) and versatile advantage both in edible and non-edible industrial applications. In terms of supply, it will be factored by continued yield improvement in Malaysia and increase in palm oil plantation areas in Indonesia (Carter *et al.*, 2007).

One important development in the palm oil industry is the increasing production of biofuel from palm oil as well as the development of new biofuel markets like in the European Union (EU). As such, biofuel from palm oil are taking on significant global importance as many countries seek to substitute the soaring price of conventional oil and also cut greenhouse gas (GHG) emissions. With high petroleum prices, palm oil as an alternative source of fuel puts the palm oil industry in big global business (Smith, 2006). For Malaysia and Indonesia, being the leading producers and exporters of palm oil, catering to the local and global demands for biofuel means increase in production and expansion to new markets. Undoubtedly, the growing palm oil industry has been an important source of foreign exchange and employment in countries like Malaysia and Indonesia.

However, with such notable growth, the palm oil industry is now charged partly as a culprit for loss of forest covers (deforestation), loss of biodiversity, endangering wild animals and species, as well as land disputes and social problems in plantation areas in Malaysia, Indonesia and elsewhere. With all such consequences and impacts highlighted in the media, the palm oil industry is currently under heavy scrutiny putting the producers, mill owners and operators, governments, NGOs and communities in a big battle of varying interests.

While the increasing trend on global demand for palm oil continues and with economic benefits being weighed against the intensifying environmental and social problems, the palm oil industry is now getting redressed through the lens of sustainable development. Improved methods of palm oil production along with new and efficient technologies, sound environmental and social policy measures, and greater stakeholders' engagement are among the new line of approaches to sustainable palm oil.

1.2 Short biology of oil palm plant

Palm trees may grow up to 60 feet and more in height (Figure 1.1). The trunks of young and adult plants are wrapped in fronds which give them a rough appearance. The older trees have smoother trunks apart from the marks left by the fronds which have withered and fallen off.



Figure 1.1 Oil palm tree¹

Oil palm is a monoecious plant that bears both male and female flowers on the same tree. Each tree produces compact bunches of fruitlets weighing about 10 to 25 kg with 1000 to 3000 fruitlets per bunch. Each fruitlet is spherical or elongated in shape. Generally, the fruitlet is dark purple (almost black) and the colour turns to orange red when ripe. Each fruitlet consists of a hard kernel (seed) inside a shell (endocarp) which is surrounded by fleshy mesocarp (MPOC, 2008). A normal oil palm tree starts bearing fruits 30 months after planting and continues to be productive for about 20 to 30 years. Each ripe bunch is commonly known as Fresh Fruit Bunch (FFB) as shown in Figure 1.2.



Figure 1.2 Oil palm fresh fruit bunch and the structure of the palm fruit²

¹ Photograph courtesy of Rhett A. Butler, mongabay.com.

² Photographs courtesy of Rhett A. Butler, mongabay.com

1.3 Brief historical and updated palm oil production data

Palm oil is made from the fruit of the oil palm tree (*Elaeis guineensis*). It originated from West Africa where it has been used as a source of oil and vitamins. Nowadays, oil palm plantations can be found in tropical countries. The oil palm tree was introduced in South East Asia, in 1848 in Indonesia, and 1875 in Malaysia. In early 19th century, Nigeria was the leading exporter until 1934 but Malaysia's production has grown fast that in 1966 it has become the leading palm oil exporter until 1971, thus replacing Nigeria completely (Teoh, 2002).

The relatively high yields and low risks from planting oil palms in Malaysia helped the industry to grow quickly. This rapid expansion came not only because of growing confidence in the oil palm but also because of the grave post-war problems of the rubber industry. The oil palm was seen as a useful means of diversification to avoid dependence on rubber. The pace of new planting slowed during the worldwide slump of the 1930s, but by 1938 Malaysia had nearly 30,000 hectares and Indonesia (in Sumatra) more than 90,000 hectares under cultivation (Hartley, 1988; Creutzberg, 1975; and Lim, 1967).

After 1960, the Malaysian government and the estate sector launched several systematic Tenera-breeding efforts, in which high-yielding oil palm trees parents were selected and bred through which increasingly productive planting materials were generated. Since then, the new breeds not only yielded more fruits but also produced a type of fruit that was ideally suited to the new screw presses which have become widely used in Malaysia from the mid-1960s (Anwar, 1981).

In terms of production, in 2006, Malaysia and Indonesia produced about 31.78 million tonnes of palm oil (Figure 1.3) accounting about 87% of world palm oil production (Figure 1.4).

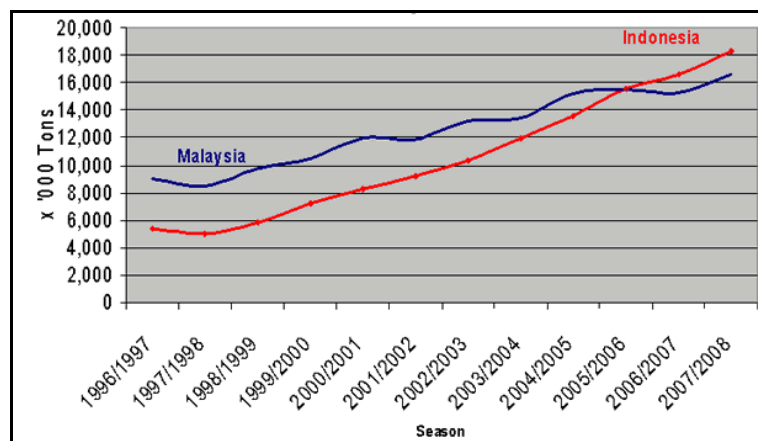


Figure 1.3 Indonesia and Malaysia's palm oil production (USDA, 2007)

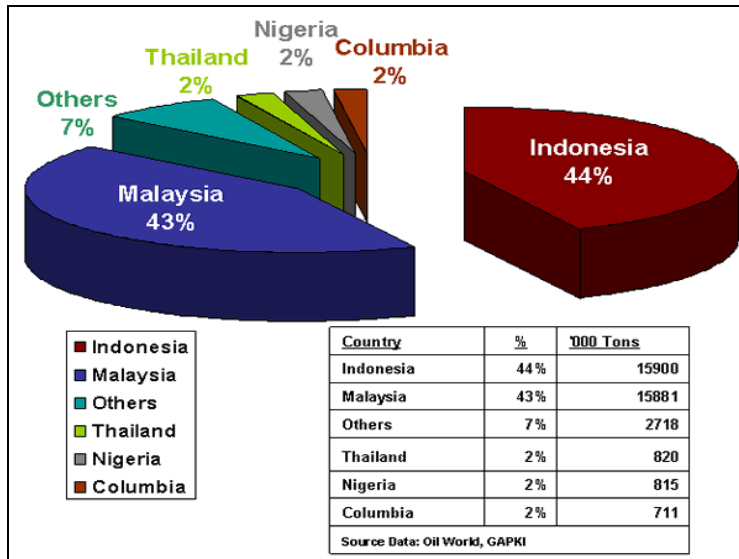


Figure 1.4 World palm oil productions 2006 (USDA, 2007)

In 2006, Indonesia has produced palm oil a little more than Malaysia. The above figures provide a hint that Indonesia has overhauled Malaysia in terms of mature areas, but that the average yield of crude palm oil (CPO) per harvested hectare remained higher in Malaysia. One reason for the difference between Malaysian and Indonesian yield trends is the relatively younger age of Indonesian palm trees as a result of the more rapid growth in its planted areas. With a greater prevalence of young oil palm trees, average reported yields are biased downwards (Carter *et. al*, 2007). However, for 2008/2009 crop year, it was predicted to see a further increase in palm oil production in matured oil palm areas (Flexnews, 2008). Palm oil production for the year 2008 both in Malaysia and Indonesia was forecasted to be about 36.10 million tonnes which is about 86% of the world total production of about 42.21 million tonnes (Basiron, 2008a).

The increasing trend of palm oil production, despite the negative environmental and social impacts (discussed in Section 5), is due to the increasing global imports (e.g. huge imports of the EU, India and China), relatively low price and specific functional properties of palm oil. Basiron (2008a) asserted that the rapid rise of palm oil to its current position as the world's leading vegetable oil by production and trade volume is because of lower price and cheaper production cost of palm oil compare to other alternative vegetable oils.

2. Palm oil products utilisation and demand

2.1 Global consumption of palm oil

Palm oil is an important and versatile raw material for both food and non-food industries, accounting for more than 28 million tonnes of the world's annual 95 million tonnes of vegetable oil (RSPO, 2006). Palm oil is used in various food products, such as cooking and frying oils, margarine, frying fats, shortenings, vanaspati (vegetable ghee), non-dairy creamer, ice cream, cookies, crackers, cake mixes, icing, instant noodles, biscuits, etc. (MPOC, 1996). Several blends have been developed to produce solid fats with a zero content of trans-fatty acids (Berger, 1996). Non-food uses of palm oil and palm kernel oil are either directly or through the oleochemical route. Direct applications include the use of crude palm oil (CPO) as a diesel fuel substitute, drilling mud, soaps and epoxidised palm oil products (EPOP), polyols, polyurethanes and polyacrylates (Salmiah, 2000). Research results have shown that crude palm oil can be used directly as a fuel for cars with suitably modified engines. In drilling for oil, palm oil has been found to be a non-toxic alternative to diesel as a base for drilling mud (Teoh, 2002). Palm oil is also used for non-food products important applications such as diesel, engine lubricants, base for cosmetics, etc. (Butler, 2006).

The industrial use of palm oil has continued to grow dramatically as shown in Figure 2.1. While the rapid growth in the industrial use of palm oil before 2003/2004 was due to the expansion of the oleo-chemical industry in Southeast Asia, recent increase were linked to the rise in petroleum prices beginning in 2003/2004. Palm oil is increasingly used as a fuel, especially in the EU. Food use still dominated the overall use of palm oil at 74% of production for 2004/2005, but this was down from 83% of production in 2000/2001. The annual change in food use since 2000/2001 has averaged 7% while the change in industrial use has been a more robust 18% (USDA, 2005).

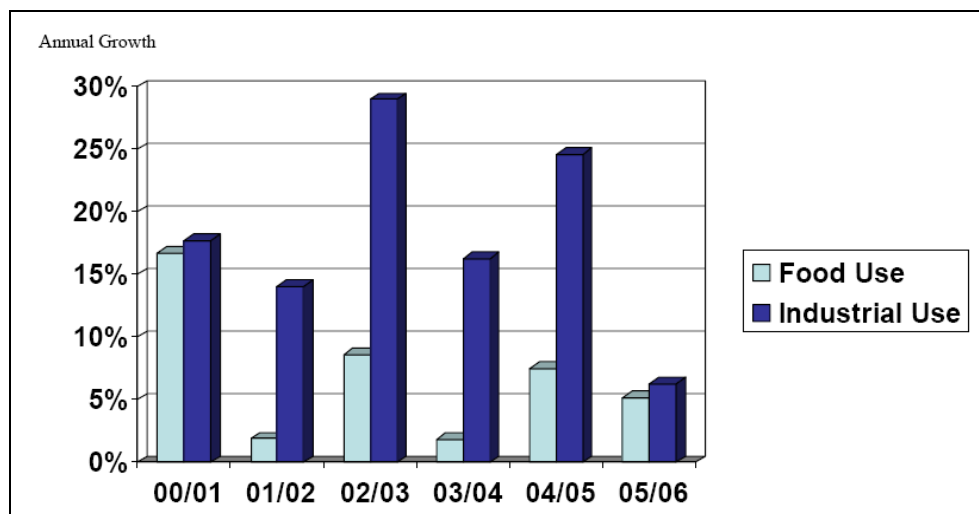


Figure 2.1 Growth in industrial used of palm oil (USDA, 2005)

Malaysia's industrial use of palm oil in 2005/2006 was forecasted at 1.9 million tonnes, up 8% from the previous year (Figure 2.2) and supported by the country's efforts to promote palm oil as an alternative fuel source. In its National Biofuel Policy, released in March 2006, Malaysia set the platform for development of the biodiesel industry ensuring greater use of palm oil for the transport and industrial sector in the country. In addition, Malaysia saw the export opportunities for its biodiesel to the EU due to the existing strong demand and the mandated requirements for biofuel use. The European Commission has set a goal of 5.75% of the total fuel used for transportation to be biofuels by 2010 (USDA, 2006).

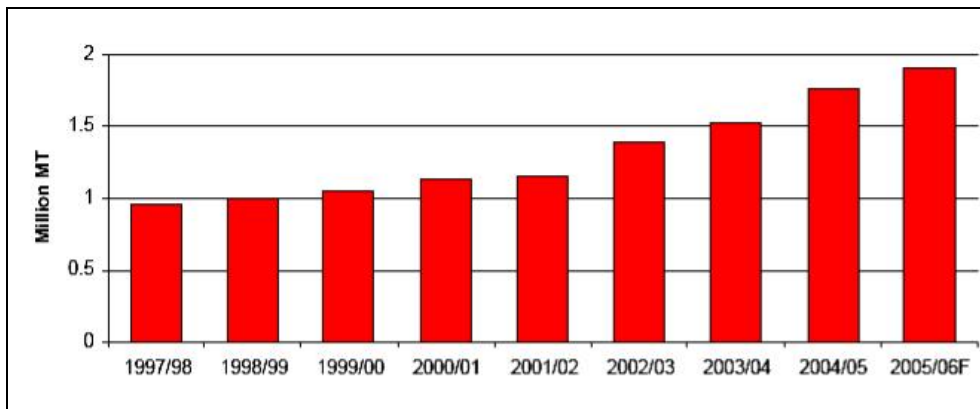


Figure 2.2 Industrial use of palm oil in Malaysia (USDA, 2006)

Global palm oil consumption was forecasted to reach a record of 37.3 million tonnes in 2006/2007 (Figure 2.3). Since 2001/2002, palm oil consumption has increased to 13.2 million tonnes, compared to an 8.7 million tonnes increase in soybean oil consumption. The strong growth in palm oil consumption since 2000 has resulted in palm oil being the dominant oil in the global market. As soybean oil prices began to rise in 2001/2002, the spread between palm oil and soybean oil began to widen, increasing the competitiveness of palm oil in the world market. This lower price, compared to other major oils, primarily soybean oil, has given palm oil a competitive advantage in large oil consuming countries like India and China (USDA, 2006).

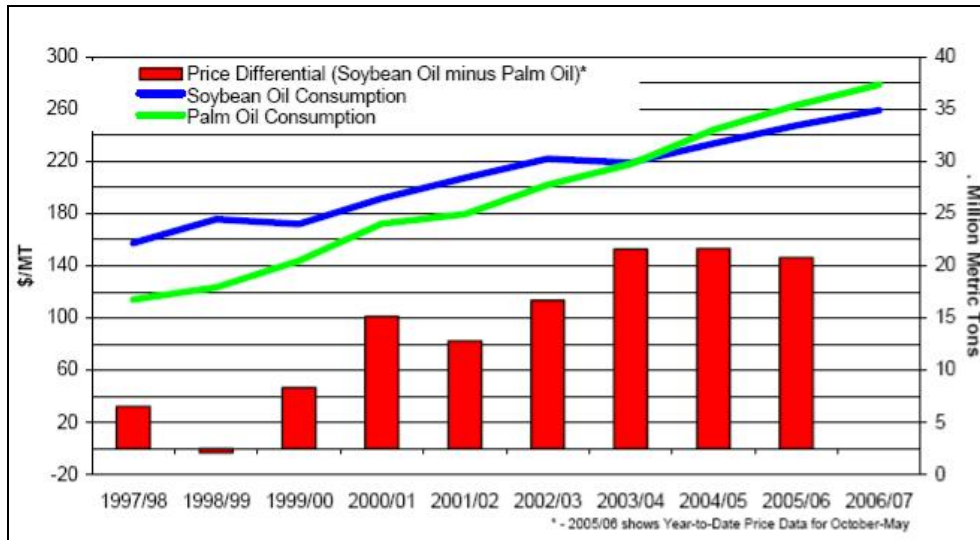


Figure 2.3 Palm oil global consumption in 2006/07 (USDA, 2006)

The trend of strong growth in palm oil consumption continued in 2006/07, as food use and industrial use were forecasted to increase 4.5% (1.2 million tonnes) and 8.9% (7.1 million tonnes), respectively. The larger food consumption forecast was driven primarily by increased palm oil demand in China and India. This trend is expected to be the same in the near future but with greater increase in the use of palm oil for biofuel production. Growth in industrial use will continue as Malaysia, China and the EU-25 expand their palm oil biofuel programs.

2.2 Palm oil for biofuel: alternative cheaper source of energy

With crude oil prices soaring, vegetable oils are the new sources of energy. Palm oil, compare to other vegetable oil (e.g. soybean, rapeseed) is a cheaper raw material for biodiesel and is the most abundantly produced vegetable oil in the world (Ramachandran, 2005). As such, biofuel from palm oil is taking on a global importance as many countries seek to substitute the soaring price of conventional oil and also cut greenhouse gas emissions³. Although palm oil is still mostly used in the manufacture of food products, it is now increasingly used as an ingredient in biodiesel and as a fuel to be burned in power stations to produce electricity. Expectedly, more palm oil will be going to biofuel production (Butler, 2008a). Many analysts believe that biodiesel usage has the potential to become the biggest component of growth in vegetable oils. European governments are trying to promote the use of biofuel, notably biodiesel derived from vegetable oils and ethanol that can be produced from grains, sugar or biomass, to cut greenhouse gas emissions from fossil fuels (Ramachandran, 2005). As such, the EU became the second largest importer of palm oil in 2004 just behind China, almost exclusively on the basis of its use as a fuel. Industrial use of palm oil in the EU in 2004/2005 was estimated at 1.3 million tonnes, with about 1 million of that for fuel. This fuel was mostly used for generating electricity in power plants rather than in automobiles or trucks.

³ <http://www.global-greenhouse-warming.com/palm-oil-biofuel.html>

This new biofuel market is expected to dramatically increase global demand for palm oil and Malaysia and Indonesia are the countries expected to supply the demand (Friends of the Earth, 2005). As such, in 2005, the Malaysian Government invested 120 million Malaysian Ringgit (444 million US Dollars in 2005 average exchange rate) in three joint-venture biodiesel plants through the Malaysian Palm Oil Board (MPOB). The plants were expected to produce 180,000 tonnes of biodiesel every year. At the same time, the Malaysian Industrial Development Authority (MIDA) has approved nine biodiesel plant licenses, mostly in Peninsular Malaysia. The investors included those from Italy and Singapore. As an initial deal, the German train operator, Prignitzer Eisenbahn Arriva AG is working with MPOB on the use of oil palm biodiesel to run trains in Germany. About 35 tonnes of Malaysian palm biodiesel have been shipped to the German company in 2005. According to reports, the trial run in September 2005 had been promising and Prignitzer had ordered 100 tonnes more palm biodiesel from Malaysia (POIC, 2008).

Currently, biodiesel and ULSD blend are the most favoured fuel in Europe. Today, over 70% of new vehicles registered in Europe are diesel-powered. According to Palm Oil Industrial Cluster (POIC), the key to the success of palm oil in biodiesel industry is technology and quality. Malaysia has the first integrated biodiesel plant in the world that is able to produce biodiesel and phytonutrients from crude palm oil. Malaysian Government has announced that it will accord the pioneer status or high technology status to biodiesel companies, which provides a 70% and 100% tax waiver for five years. To compete globally, Malaysian biodiesel is to be produced as high quality cost-competitive products with economies of scale in operations and a large market. For example, Malaysian Envo oil is a high quality biodiesel from palm oil which is a blend of 95% fossil diesel and 5% palm oil (POIC, 2008). This Malaysian Envo oil is not the equivalent of the internationally accepted biodiesel (methyl ester). Malaysian officials said that the combustion grade of palm diesel from the country is on par with winter-grade methyl ester produced from rapeseed, the top source of biofuel in Europe (Ramachandran, 2005). Many markets like South Korea, the United States and EU do not allow the use of direct vegetable oil into diesel engines. For instance, the EU standard on biodiesel (EN 14214) requires a minimum content of 96.5% methyl ester and no more than 0.2% triglycerides (POIC, 2008).

The increasing production of quality biodiesel in Malaysia owing to the biofuel mandate is setting a standard for Indonesia. According to Derom Bangun, chairman of the Indonesian Palm Oil Producers Association, "Indonesia will soon move from the experimental stage in biodiesel to full-fledged manufacturing of quality biodiesel. Many investors are seriously considering to set up biodiesel manufacturing plants in Indonesia and this is an indication of the trend for new demand for palm oil" (Ramachandran, 2005).

The increasing utilisation of palm oil for biofuel production is not without criticisms, and debates about the sustainability of palm oil as a source of energy have been heated up not only in Malaysia and Indonesia but also worldwide. The main issues of debate are on the ecological impacts caused by producing palm oil and on the greenhouse gas emissions by deforestation or by utilisation of palm oil as biofuel. Ecological or environmental impacts of palm oil production are discussed in Section 5, while sustainability issues are discussed in Section 6.

3. Palm oil production process

3.1 General description of palm oil processing

This section on general processing description is excerpted from the FAO Agricultural Services Bulletin 148 (FAO, 2002) supplemented by some additional information from other relevant sources.

Research and development work in many disciplines - biochemistry, chemical and mechanical engineering - and the establishment of plantations, which provided the opportunity for large-scale fully mechanised processing, resulted in the evolution of a sequence of processing steps designed to extract, from a harvested oil palm bunch, a high yield of a product of acceptable quality for the international edible oil trade. The oil extraction process, in summary, involves the harvesting of FFB from the plantations, sterilising and threshing of the FFB to free the palm fruit, crushing the fruit and pressing out the CPO. The crude oil is further treated to purify and dry it for eventual storage and export.

Large-scale plants, featuring all stages required to produce palm oil to international standards, are generally handling from 3 to 60 tonnes of FFB/hr. The large installations have mechanical handling systems (bucket and screw conveyers, pumps and pipelines) and operate continuously, depending on the availability of FFB. Boilers, fuelled by fibre and shell, produce superheated steam, used to generate electricity through turbine generators. The lower pressure steam from the turbine is used for heating purposes throughout the factory. Most processing operations are automatically controlled and routine sampling and analysis by process control laboratories ensure smooth, efficient operation. Although such large installations are capital intensive, extraction rates of 19-21% palm oil per bunch can be achieved from good quality such as Tenera variety.

Conversion of CPO to refined oil involves removal of the products of hydrolysis and oxidation, colour and flavour. After refining, the oil may be separated (fractionated) into liquid and solid phases by thermo-mechanical means (controlled cooling, crystallisation, and filtering), and the liquid fraction (olein) is used extensively as a liquid cooking oil in tropical climates, competing successfully with the more expensive groundnut, corn, and sunflower oils.

Extraction of oil from the palm kernels is generally separated from palm oil extraction, and often carried out in mills that process other oilseeds (such as groundnuts, rapeseed, cottonseed, shea nuts or copra). The stages in this process comprise grinding the kernels into small particles, heating (cooking), and extracting the oil using an oilseed expeller or petroleum-derived solvent. The oil then requires clarification in a filter press or by sedimentation. Extraction is a well-established industry, with large numbers of international manufacturers able to offer equipment that can process from 10 kg to several tonnes per hour.

Palm oil processors of all sizes go through these unit operational stages. They differ in the level of mechanisation of each unit operation and the interconnecting materials transfer mechanisms that make the system batch or continuous. The scale of operations differs at the level

of process and product quality control that may be achieved by the method of mechanisation adopted.

3.2 The palm oil process flow

The palm oil production process starts after the FFB are harvested and the fruits are separated from the bunches. The first step in processing is at the mill where the CPO is extracted from the fruit. The streamlined steps in oil extraction are shown in Figure 3.1 while the detailed process flowchart is shown in Appendix 4. The following processes are merely described and do not discuss the different handling techniques, problems and its effects associated in each process (e.g. bruising of fruits during harvesting, contamination, rancidity, etc).

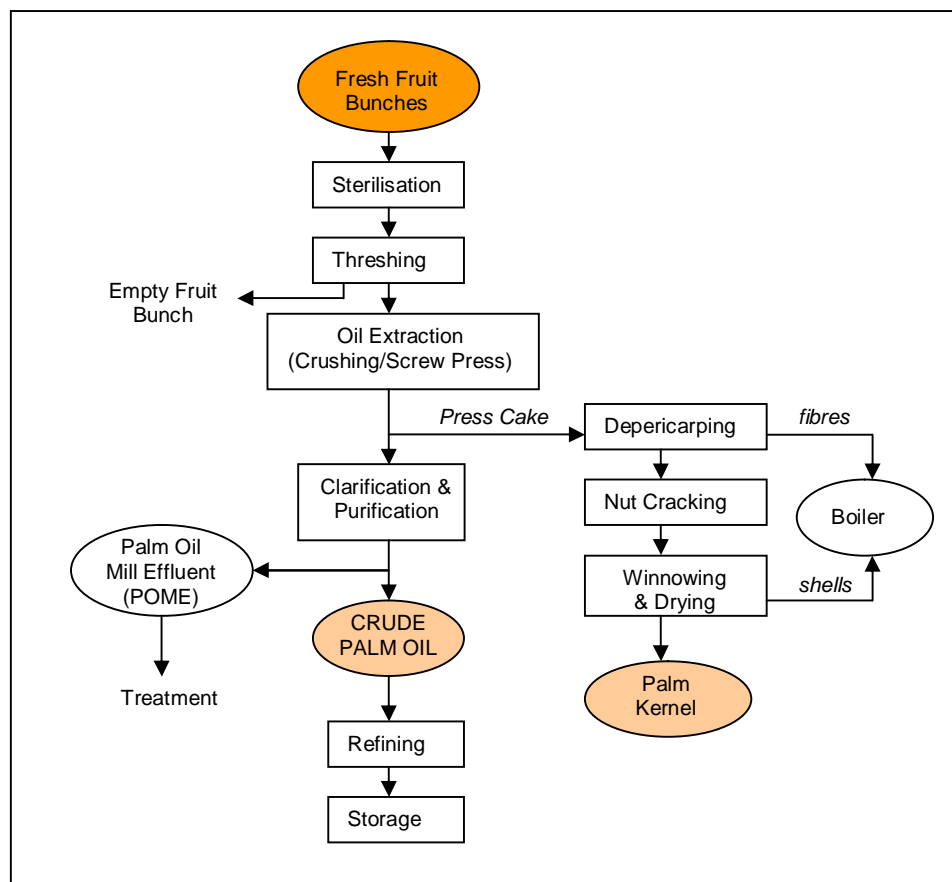


Figure 3.1 Palm oil process flow chart (adapted from FAO, 2002)

3.2.1 Harvesting

As fruit ripen, FFB are harvested using chisels or hooked knives attached to long poles. Each tree must be visited every 10-15 days as bunches ripen throughout the year. Harvesting involves the cutting of the bunch from the tree and allowing it to fall to the ground by gravity. These fruit bunches (each bunch weighing about 25 kg) are then collected, put in containers and transported by trucks to the factories (Poku, 2002). FFB arriving in the factory are weighed accordingly.

3.2.2 Threshing (removal of fruits from the bunches)

The FFB consists of fruits embedded in spikelets growing on a main stem. Manual threshing is achieved by cutting the fruit-laden spikelets from the bunch stem with an axe or machete and then separating the fruits from the spikelets by hand. Children and the elderly in the village earn income as casual labourers performing this activity at the factory site. In a mechanised system, a rotating drum or fixed drum equipped with rotary beater bars detach the fruits from the bunches, leaving the spikelets on the stem (Poku, 2002).

3.2.3 Sterilisation of bunches

Sterilisation or cooking means the use of high temperature wet-heat treatment of loose fruits. Cooking normally uses hot water while sterilisation uses pressurised steam. Cooking typically destroys oil-splitting enzymes and arrests hydrolysis and autoxidation, weakens the fruit stem and makes it easy to remove the fruits from bunches, helps to solidify proteins in which the oil-bearing cells are microscopically dispersed, weakens the pulp structure, softening it and making it easier to detach the fibrous material and its contents during the digestion process, breaks down gums and resins.

3.2.4 Crushing process

In this process, the palm fruits will be passed through shredder and pressing machine to separate oil from fibre and seeds.

3.2.5 Digestion of the fruit

Digestion is the process of releasing the palm oil in the fruit through the rupture or breaking down of the oil-bearing cells. The digester commonly used consists of a steam-heated cylindrical vessel fitted with a central rotating shaft carrying a number of beater (stirring) arms. Through the action of the rotating beater arms the fruit is pounded. Pounding, or digesting the fruit at high temperature, helps to reduce the viscosity of the oil, destroys the fruits' outer covering (exocarp), and completes the disruption of the oil cells already begun in the sterilisation phase (Poku, 2002).

3.2.6 Extracting the palm oil

There are two distinct methods of extracting oil from the digested material. One system uses mechanical presses and is called the "dry" method. The other called the "wet" method uses hot water to leach out the oil.

In the “dry” method, the objective of the extraction is to squeeze the oil out of a mixture of oil, moisture, fibre and nuts by applying mechanical pressure on the digested mash. There are a large number of different types of presses but the principle of operation is basically the same. The presses may be designed for batch (small amounts of material operated upon for a time period) or continuous operations (Poku, 2002).

A unique feature of the oil palm is that it produces two types of oil - palm oil from the flesh of the fruit, and palm kernel oil from the seed or kernel. For every 10 tonnes of palm oil, about 1 ton of palm kernel oil is also obtained. Several processing operations are used to produce the finished palm oil that meets the users' requirements. The first step in processing is at the mill, where CPO is extracted from the fruit (Poku, 2002).

3.2.7 Kernel recovery

The residue from the press consists of a mixture of fibres and palm nuts which are then sorted. The sorted fibres are covered and allowed to heat by own internal exothermic reactions for about two or three days. The fibres are then pressed in spindle press to recover a second grade (technical) oil that is used normally in soap-making. The nuts are usually dried and sold to other operators who process them into palm kernel oil.

Large-scale mills use the recovered fibres and nutshells to fire the steam boilers. The superheated steam is then used to drive turbines to generate electricity for the mill. For this reason it makes economic sense to recover the fibres and to shell the palm nuts. In the large-scale kernel recovery process, the nuts contained in the press cake are separated from the fibres in a depericarper. They are then dried and cracked in centrifugal crackers to release the kernels. The kernels are normally separated from the shells using a combination of winnowing and hydrocycloning. The kernels are then dried in silos to a moisture content of about 7% before packing (FAO, 2002).

3.2.8 Refining process

After the process of extraction, CPO goes through a refining process to become refined oil. The refined oil will undergo a fat segregation process to get refined palm oil. Finally, the refined palm olein which is a part of fractionation process will be used in related industries (Poku, 2002).

3.2.9 Oil storage

Palm oil is stored in large steel tanks at 31 to 40°C to keep it in liquid form during bulk transport. The tank headspace is often flushed with CO₂ to prevent oxidation. Higher temperatures are used during filling and draining tanks. Maximum storage time is about 6 months at 31°C (Poku, 2002).

3.2.10 Packing process

Having passed through production process and inspection under standard quality control system, all refined oils will be stored in a stock tank ready for delivery. It will be partly transported to modern packaging plants of the company under the sanitary and safety standard before

supplying to customers in the form of refined palm olein from pericarp contained in various types of packaging availability as PET bottle, tin, and soft pack (CPOI, 2008).

3.2.11 Delivery

The products will be stringently inspected before loading, and then delivery to customers by using either high standard tanker trucks for mass consumption as industrial usages or different types of truck which suite for each customer size. For export market, the products will be supply as bulk shipment by using vessel with loading capacity either 1,000 tonnes or 2,000 tonnes upon requests (CPOI, 2008).

The entire production processes from harvesting of fruits bunches to oil extraction and from refinery to supply chains involve various resources and technologies at different points and associated with different environmental and social issues.

4. Major players in the palm oil industry

Teoh (2002) prepared a comprehensive compilation about the major players and actors in the palm oil industry and the supply chain. Most of the information provided by Teoh (2002) are excerpted in this section and complimented with recent updates on facts and figures from other sources such as the Malaysian Palm Oil Council, Malaysian Palm Oil Association, and Palm Oil Refiners Association of Malaysia. According Teoh (2002), the major players in the palm oil industry in Malaysia are grouped into following categories:

- Upstream producers - essentially involved in the cultivation of oil palm, production of FFB and processing them into crude palm oil and palm kernel oil;
- Downstream producers - palm oil refiners, palm kernel crushers, manufacturers of palm-based edible products and specialty oils and fats;
- Exporters and importers of palm oil;
- Customers - institutional buyers and retail customers and investors;
- Industry organisations representing the interests of the upstream and downstream producers;
- Government agencies associated with the oil palm industry, particularly with respect to research, development and regulatory functions; and
- Other players who have interest and/or stake in the oil palm industry (NGOs, unions, etc).

4.1 Upstream producers

Included in this category are the plantation companies and private estates, producers under the government schemes, and the smallholders. Most of the 4.17 million hectares (area planted by the end of 2006) of oil palm planted in Malaysia are under private ownership, majority of which are by plantation companies (MPOC, 2006a). The private sector has been the main driver for growth in the development and production of palm oil for more than two decades already as reflected by the increased plantation areas. The sizes of plantation companies vary considerably from a few hundred hectares to more than 100,000 hectares (Teoh, 2002). As such, ownership of planted area by 2006 MPOC data stands to 60% for private estates (2.50 million hectares), 30% for government/state schemes (1.25 million hectares), and 10% for smallholders (0.41 million hectares) (MPOC, 2006a). The profiles of some selected leading private plantation (also processing and exporting) companies are presented in Appendix 1.

The main producer under the government schemes is the Federal Land Development Authority (FELDA)⁴. FELDA has played the most significant role in the development of oil palm in Malaysia. It is the main agency (established in 1956) for land development with the socio-economic mandate of developing forest land for resettlement. From its establishment until the mid-1980s, FELDA's primary activity was the development of agriculture-based settlements, planted with plantation crops, initially with rubber and subsequently with other crops, particularly oil palm from primary forests and logged over forest land.

⁴ <http://www.felda.net.my>

In mid 1980s, FELDA changed its focus to commercial development management of plantations on a commercial basis. The 1980s saw rapid expansion in the area developed of oil but there had been no significant new land developments by FELDA in the last decade and the major activity has been replanting of the older schemes in Peninsular Malaysia. Accordingly, FELDA Group consists of FELDA which is responsible for the management of the settlers' schemes and FELDA Holdings Sdn Bhd which is the corporate arm for the group. FELDA is also responsible for settler activities, which include community development and new economic activities to enhance settlers' income and education (Teoh, 2002).

FELDA Holdings Sdn Bhd is the holding company for about 36 fully-owned and associate companies which are divided into the Plantations Group, Palm Industries Group and Enterprises Group. Through these companies, FELDA is involved in most aspects of the palm oil supply chain. It manages more than 250 plantations covering a total area of more than 354,000 hectares, the produce of which are processed in 72 palm oil mills, 6 kernel crushing plants, 7 palm oil refineries (to produce cooking oil) and 2 margarine plants. It also has refinery operations in Egypt and China. FELDA is involved in the production of palm-based oleochemicals through a joint venture with Proctor & Gamble. Various subsidiary companies provide support service to the core businesses. The group produces its own planting materials, fertilisers and other agricultural inputs. Additionally, the group has its own research, agricultural engineering and construction services, as well as transportation and bulking installations. At the end of the chain, FELDA has companies for trading and marketing of its products. With the vertical integration of its activities, FELDA is essentially an upstream and downstream producer (Teoh, 2002).

Other organisations contributing to the production of palm oil under the government schemes are FELCRA Berhad, Rubber Smallholders Development Authority (RSDA), Sabah Land Development Board (SLDB) and Sarawak Land Rehabilitation and Consolidation Authority (SALCRA). These organisations account for little or not very significant share in terms of total planted oil palm area in Malaysia.

While FELDA manages schemes for what is known as organised smallholders, individual smallholders account for about 320,818 hectares of oil palm or 9.5% of the total planted area (Teoh, 2002). Under the RISDA Act 1972, a smallholder is defined as the owner of legal occupier of any land that is 40.5 (or less) hectares in area. The interests of individual smallholders are represented by the National Association of Smallholders (NASH).

4.2 Downstream producers

Downstream producers can broadly be grouped under plantation-based companies, FELDA, independent manufacturing companies and subsidiaries or associates of multinational companies. Plantation companies are involved in the downstream processing activities as kernel crushing, palm oil refining, palm-based products processing (e.g. for shortening, vanaspati, margarine, dough fat), and manufacturing of cooking oils, specialty fats and oleochemicals. Besides being the largest upstream producer, FELDA is a major player in downstream processing, operating seven palm oil refineries, six kernel crushing plants and two margarine plants (Teoh, 2002).

By 2002, the Malaysia Palm Oil Directory have listed 44 companies involved in palm kernel crushing, majority of them are SME scale operators who supply their crude palm kernel oil (CPKO) to the refining companies or oleochemical producers (Teoh, 2002). Currently, there are more than 50 refineries in operation in Malaysia. Majority of the operating refineries are, in one way or another, associated with oil palm plantation and milling sectors, or both. Some of the refineries have also tied up with manufacturers of specialty products and oleochemicals. Today, the palm oil refining industry is one among the most important manufacturing sectors in Malaysia⁵.

The largest players in refinery are PGEO Edible Oils Sdn Bhd., Ngo Chew Hong Oils & Fats (M) Sdn Bhd, and Pan-Century Edible Oils Sdn Berhad. PGEO Edible Oils is an associate company of PPB Oil Palms Berhad while Ngo Chew Hong is an independent refiner which is also a major manufacturer of palm-based oils and fats. Pan-Century is the subsidiary company of the Birla Group of India (MPOPC, 2002).

Major producers of bulk and retail pack cooking oil and palm oil-based products such as shortening, vanaspati (vegetable ghee), margarine are plantation-based companies such as FELDA Marketing Services Sdn Bhd, Golden Hope Plantations Berhad, PPB Oil Palms Berhad, Sime Darby Berhad and United Plantations Berhad. Other independent manufacturers such as Kuok Oils & Grains Pte Ltd., Federal Flour Mills Berhad, Lam Soon (M) Berhad, Intercontinental Specialty Fats Berhad, Ngo Chew Hong Oils & Fats (M) Sdn Bhd, and Yee Lee Oils Corporation are in the same business. Among multinationals, Unilever and Cargill are involved in the edible oil products sector through Unilever (M) Holdings Sdn Bhd and Cargill Palm Products Sdn Bhd, respectively.

Among producers of specialty fats, IOI Corporation Berhad is set to be the major player following its acquisition of Loders Croklaan BV. Other producers include PPB Oil Palms Berhad, Sime Darby Berhad, United Plantations Berhad, Intercontinental Specialty Fats Berhad, Southern Edible Oil Industries (M) Sdn Bhd and Cargill Specialty Oil & Fats Sdn Bhd (Teoh, 2002).

The largest and most integrated producer of oleochemicals in Malaysia is Palmco Holdings Berhad, a subsidiary of IOI Corporation Berhad. Multinationals have a presence in the oleochemical sector through associate or subsidiary companies such as Akzo & Nobel Oleochemical Sdn Bhd, Cognis Oleochemicals Sdn Bhd (joint venture company between Cognis Oleochemicals of Germany and Golden Hope Plantations Berhad), FPG Oleochemicals Sdn Bhd (Proctor & Gamble's joint venture with FELDA) and Uniqema (Malaysia) Sdn Bhd. Other local major producers are Palm-Oleo Sdn Berhad, a subsidiary of Kuala Lumpur Kepong Berhad and Southern Acids (M) Berhad (Teoh, 2002).

4.3 Exporters and importers of palm oil

China, the EU, Pakistan, United States, India, Japan and Bangladesh are the major importers of Malaysian oil. These countries altogether accounted for 65.3% or 9.41 million tonnes of the total export volume. Table 4.1 shows the different shares of Malaysian palm oil export to these major importing countries (MPOC, 2006a).

⁵ <http://www.poram.org.my>

Table 4.1 Malaysian palm oil exports to major importing countries worldwide (tonnes)

Region/countries	Jan-Dec 2005	Jan-Dec 2006	Change (vol)	Change (%)
China and HK	3,072,604	3,643,123	570,519	18.6
EU	2,282,682	2,599,282	317,600	13.9
India	635,049	561,779	-73,270	-11.5
Pakistan	957,043	968,406	11,363	1.2
US	558,492	684,651	126,159	22.6
North East	848,450	880,326	31,875	3.8
ASEAN	801,309	971,622	170,313	21.3
Bangladesh	510,473	438,152	-72,321	-14.2
Egypt	608,835	211,686	-397,149	-65.2
UAE	264,004	302,738	38,734	14.7
Iran	213,438	245,716	32,278	15.1
South Africa	232,151	261,261	29,110	12.5
Total Exports	13,445,511	14,423,168	977,657	7.3

(Source: MPOB, 2006). Note: North East refers to Japan, South Korea and Taiwan).

Noticeably, China remains as the leading largest importer taking as much as 3.64 million tonnes or 25.3% of Malaysian palm oil during the year 2006. The EU and Pakistan were following with an import of 2.6 and 0.97 million tonnes, respectively (MPOC, 2006a). In general, plantation companies involved in downstream production and manufacturing companies of palm-based products are also exporters of palm oil products. Table 4.2 presents the main companies from the leading importing countries.

Table 4.2: Major palm oil importing companies from the leading countries

Country	Company
China	China National Cereals Oils and Foodstuffs Import & Export Corporation, Shandong; Universal Seeds and Oil Products Company, Beijing
Netherlands	Algemene Oliehandel (AOH), Utrecht; Bergia-Frites B.V., Roermond; Cargill B.V. Hardingsdivisie, Roermond; Karishamns B.V., Koog Ann de Zaan; Loders Croklaan, B.V., Wormerveer; Mead Johnson B.V., Nymegan; Noba Vetveredeling, B.V., Zwaneburg; Remia C.V., ZG den Dolder; romi-Smilfood B.V., Vzaardingen; Soctek Nederland B.V., Zaandam; Unichema Chemie B.V., Gouda; Unimills B.V., Zwyndrecht; Zaanlandse Oileraffinaderji B.V., Zaandam
United Kingdom	Hampshire Commodities Ltd, Hampshire; Matthews Food plc, West Yorkshire; Nutrition International, N. Yorks.
Germany	Henry Lamonte GmbH, Bremen
Spain	Sociedad Iberica de Moituracion S.A., Madrid
Portugal	Africunha-Imp./Exp., LDA, Loures; Gexpo-Gestao de Exp., LDA, Estoril; Mercadafrica-Com. De Exe.E.Imp., LDA, Lisboa; Mundafrica-Com. Prod. Alimentares LDA, Lisboa.
Italy	Via Gardizza snc., Ravenna
Greece	Pavlos N Pettas SA, Patras Achaia
Pakistan	M/S ACP Oil Mills (Pvt) Ltd., Islamabad; M/S Agro Processors & Atmospheric Gases (Pvt) Ltd., Karachi
USA	Corporacion Bonanza CA; ENIG Associates Inc; Impex Trading Corp; Liberty Enterprise Inc; Penta Manufacturing Company Inc; Seaboard Trading & Shipping; Sumitomo Corporation of America
India	Ahmed Oomerbhoy, Mumbai; Hindustan Lever Ltd., M/S Dipak Vegetable Oil Industries Ltd., Gujarat; Pudumjee Agro Industries Ltd, Mumbai.
Japan	Fuji Oil Co Ltd., Osaka; Riken Nosan Kako Co. Ltd., Fukuoka

4.4 Industry organisations

The diverse interests of upstream and downstream producers of palm oil and palm-based products and their derivatives are formally represented by a number of industry organisations classified in Table 4.3.

Table 4.3 Palm oil industry organisations

Sector	Organisation
Plantations	Malaysian Palm Oil Association (MPOA)
	East Malaysia Planters Association (EMPA)
Planters	The Incorporated Society of Planters (ISP)
Independent palm oil millers	Palm Oil Millers Association (POMA)
Palm oil refiners	Palm Oil Refiners Association of Malaysia (PORAM)
Edible oil manufacturers	Malaysian Edible Oil Manufacturers' Assn (MEOMA)
Oleochemical manufacturers	Malaysian Oleochemical Manufacturers Group (MOMG)
Palm oil promotion	Malaysian Palm Oil Promotion Council (MPOPC)

4.4.1 Plantation owners' organisations

The earliest industry organisations include the United Planting Association of Malaysia (UPAM), Rubber Growers' Association (RGA) and the Malaysian Estate Owners' Association (MEOA). With the rapid expansion of the oil palm industry in the 1960s, the Malaysian Oil Palm Growers' Council (MOPGC) was established to represent the plantation companies. With the passage of time and changes in the structure of the industry, there was much overlap in the roles and functions of the four organisations. A rationalisation exercise in 1999 saw the merger of the four major industry organisations into a single body now called the Malaysian Palm Oil Association (MPOA).

The mandate of MPOA is to represent the industry as a single voice and meet the complex needs of the plantation industry more effectively. Any individual or company who owns a minimum of 40 hectares of a plantation crop is eligible to be a member of MPOA. MPOA represents the industry in several government and statutory bodies and related industry organisations. Its key representations include membership on the Board of the Malaysian Palm Oil Board (MPOB) and Chairman of the Board of Trustees of the Malaysian Palm Oil Promotion Council (MPOPC). MPOA also has a voice in international organisations on oils and fats such as the National Institute of Oilseed Products (NIOP), International Association of Seed Crushers (IASC), FOSFA International Oils and Fats Committee and the ASEAN Vegetable Oils Club (AVOC).

Prior to 1999, the interests of plantation companies in Sabah and Sarawak are mainly represented by the East Malaysia Planters' Association (EMPA). During the exercise on the rationalisation of industry organisations, EMPA resolved to remain as an independent body to serve the needs of East Malaysia-domiciled plantation companies. With the establishment of branch offices of MPOA in Sabah and Sarawak, several plantation companies have become members of the new pan-Malaysian organisation (Teoh, 2002).

4.4.2 Planters organisations

While MPOA and EMPA serve the interests of plantation companies, the Incorporated Society of Planters (ISP) represents the interests of the planters - the estate executives at the management level. Established in 1919, the ISP has more than 4000 members, 600 of whom are overseas members from 37 countries. From its inception, ISP has placed priority on technical support for its members through education and publications. The Society conducts examinations and awards professional qualifications from diploma to post-graduate levels; the latter being the Masters of Science in Plantation Management that is jointly conducted with Universiti Putra Malaysia. Over the years, ISP has been organising workshops, seminars, training courses and conferences, at national and international levels on various aspects on research, cultivation and management of plantation crops. The ISP organises the International Planters Conference every three years (Teoh, 2002). The organisation has a monthly publication called the Planter, which is considered as the main vehicle for disseminating information to its members.

4.4.3 Processors and downstream producers

Other producers along the supply chain have their own organisations to represent their interests in various government and industry bodies and committees. The Malaysian Palm Oil Millers Association (POMA) was formed in 1985 to represent the interests of the operators of independent palm oil mills that do not own oil palm plantations. It also serves as a mediator to settle disputes among members or between members and suppliers of FFB.

The Palm Oil Refiners Association of Malaysia (PORAM) takes care of the interests of the member companies involved in the palm oil refining and processing industry. Formed in 1975, PORAM primarily represent a voice to the Government and the trade in all matters affecting the industry. Being a trade association, PORAM is a voluntary, non-profit organisation of competing and related business units in the Malaysian palm oil refining industry. Most refiners in Malaysia are members of PORAM. Membership includes subsidiary companies of plantation companies, subsidiaries of multinational corporations like Cargill and the Birla Group of India and independent refinery companies. PORAM works closely with the Malaysian Palm Oil Association (MPOA), Malaysian Edible Oil Manufacturers' Association (MEOMA), the Malaysia Oleochemical Manufacturers Group (MOMG), and the Palm Oil Millers Association (POMA). PORAM is also a founding member of the ASEAN Vegetable Oils Club (AVOC) and served as the Secretariat for AVOC since its inception in 1994 to 2007.

The Malayan Edible Oils Manufacturers' Association (MEOMA) covers a wider range of industries, its members business activities range from palm oil milling, kernel crushing, palm oil refining, production and packaging of cooking oil for the retail consumer, and oleochemicals. Several members are involved in the production coconut oil and coconut oil cakes while others offer services such as broking and insurance. In view of the varied activities, many MEOMA members are also affiliated with other industry organisations such as POMA, PORAM, MOMG and MPOA.

The Malaysian Oleochemical Manufacturers Group (MOMG) is a product group of the Chemical Industries Council of Malaysia (CICM). MOMG consists of members who are involved in the production of basic oleochemicals namely fatty acids, methyl esters, glycerine and fatty

alcohols in Peninsular Malaysia. MOMG membership consists of local oleochemical manufactures and several joint-venture companies with multinational corporations.

The above palm oil producers' organisations are essentially trade associations to represent the interests of their respective members. All of them are represented on the Board of MPOB and the Board of Trustees of MPOPC (except MOMG). They are also members of MPOPC's Palm Oil Task Force on the Environment.

4.4.4 Palm oil promotion

The Malaysian Palm Oil Promotion Council (MPOPC) was formed in 1990 to replace the Palm Oil Promotion Fund that was set up to address the anti-tropical oil campaign in USA in the 1980s. The mandate of MPOPC is to spearhead the promotional and marketing activities of Malaysian palm oil. MPOPC is an industry-funded organisation and its activities are focused on marketing communications, technical marketing and market promotion locally and in several key edible oil consuming countries.

4.5 Government agencies

4.5.1 Malaysian Palm Oil Board (MPOB)

Prior to the year 2000, public sector research and development efforts on palm oil were spearheaded by the Palm Oil Research Institute of Malaysia (PORIM) that was established in 1979. The regulatory and licensing functions of the industry were the responsibility of the Palm Oil Registration and Licensing Authority (PORLA). By Act 582 of the Parliament of Malaysia, the Malaysian Palm Oil Board (MPOB) was established in May 2000 to take over the functions of the two preceding organisations.

MPOB is the premier government agency entrusted to serve the country's palm oil industry. Its main role is to promote and develop national objectives, policies and priorities for the wellbeing of the Malaysian palm oil industry. It was incorporated by an Act of Parliament (Act 582) and established on 01 May 2000, taking over, through a merger, the functions of the Palm Oil Research Institute of Malaysia (PORIM) and the Palm Oil Registration and Licensing Authority (PORLA). Each of these respective organisations has been involved in the palm oil industry for more than 20 years and it was to render more effective services as well as to give greater national and international focus to the industry that MPOB was instituted.

The MPOB has been playing an active role in developing new technologies which have contributed to the advancement of the Malaysian palm oil industry. In leading the industry, MPOB provides and promotes strong scientific and technological support through its commitment to R&D, the commercialisation of its research findings and the transfer of knowledge and innovation. It also plays a significant role in matters relating to registration, licensing and enforcement. MPOB has continued to provide leadership and has developed strong research expertise in various areas. Remarkable counts of more than 340 technologies including new products and services have been launched for commercialisation and adoption by the industry. This has contributed towards accelerating the development of the industry and provided opportunities for investments in oil palm-

related business. To date, MPOB continues to contribute to the palm oil industry's well-being and future growth⁶.

4.5.2 Regulatory agencies on the environment

The implementation of environmental legislation and regulations is mandated by the Department of Environment Malaysia (DOE), the Natural Resources and Environmental Board (NREB) of Sarawak and the Environment Conservation Department (ECD) of Sabah. These three organisations perform broadly similar functions wherein their key activities include environmental assessment monitoring and review and enforcement of environmental regulations and orders as prescribed under their respective legislation. Orders for prescribed activities pertaining to development of oil palm plantations are quite uniform for Peninsular Malaysia, Sabah and Sarawak.

4.6 Other players

Environmental non-governmental organisations (NGOs) and organisations associated with the social bottom line have roles, albeit indirect, in the palm oil industry and supply chain. Although NGOs such as the Malaysian Nature Society (MNS) have a strong interest and role in the conservation of natural resources (forests and biodiversity), apparently only WWF-Malaysia is actively working on the linkage between forest conservation and the development of oil palm plantations. It is part of the WWF's Global Forest Conversion Initiative that has been taken to promote sustainable palm oil and soybean production globally. Recently, WWF-Malaysia has been working with the plantation owners on the development of best management practices with respect to forest conservation and restoration, especially in areas where there is conflict between conservation and development such as the flood prone areas of the Lower Kinabatangan in Sabah.

Among the social organisations, the National Union of Plantation Workers (NUPW), the All Malayan Estates Staff Union (AMESU), the Malaysian Agricultural Producers' Association (MAPA) and the National Association of Smallholders (NASH) are of particular relevance to the plantation industry. NUPW is the largest workers' union in the country while AMESU represents the interests of clerical, medical and technical staff and non-clerical staff employed in plantations. MAPA, on the other hand is the largest employers' trade union that negotiates collective wage agreements with the NUPW and AMESU. Additionally, MAPA assists its members in labour and industrial relations and represents them in labour disputes and court cases.

Established in 1975, NASH aims to promote the socio-economic well-being of smallholders by fostering inter-agency and inter-organisational activities in order to mobilise available resources with the ultimate aim of enhancing overall productivity, income, and quality of life. Major functions of NASH include; research and development projects in collaboration with Ministries and research agencies, advocacy programme for smallholders, networking of smallholders groups in every state and sub-groups in 150 regions, capacity-building, development of strategic alliances with Government and private sectors, cooperative development and income generating activities (Teoh, 2002).

⁶ <http://www.mpob.gov.my>

4.7 Customers

Customers of Malaysian palm oil and finished palm-based products are important players at the end of the supply chain. Traditionally, customers are seen as the end users of palm oil, be they institutional buyers or retail purchasers. At present, purchasing policies and decisions are based largely on price, quality and delivery with minimal considerations given to environmental aspects. However, with growing awareness on the need for sourcing raw materials and products that have been produced in a sustainable manner, it is envisaged that institutional buyers and importers may incorporate environmental and social considerations into their purchasing policies. For example, Migros, the largest supermarket chain in Switzerland announced in January 2002 its commitment to source all its palm oil from plantations that have not been established at the expense of tropical forests⁷.

Although not involved in the physical product, investors and fund managers can exert significant influence on the supply chain through their shareholding in plantation companies. Institutional investors are usually the substantial shareholders in listed plantation companies, the most significant being the National Equity Corporation (Permodalan Nasional Berhad or PNB) and the Employees Provident Fund (EPF) Board. Both organisations were established with social bottom line responsibilities.

PNB was established as a fully-owned subsidiary of Yayasan Pelaburan Bumiputra (Bumiputra Investment Foundation) in 1978 as the main vehicle to implement the Government's New Economic Policy (NEP) introduced in 1970 to restructure the Malaysian society. One of the key thrusts of the NEP is to increase the share of the Bumiputra (indigenous) community in the Malaysian companies. The savings of individual Bumiputras are mobilised through investment in a number of unit trust funds launched by PNB, the first being the Amanah Saham Nasional Scheme in April, 1981. These trust funds have investments in a wide range of companies listed on the KLSE and have substantial holdings in many plantation companies which are held a nominee company, Amanah Raya Nominees (Tempatan) Sdn Bhd (Teoh, 2002).

EPF was established in October 1951 as a social security organisation to provide retirement benefits for its members through management of a provident fund. Contribution to the fund is mandatory for all employers and employees at the current rate of 23% of the employees' salary, with the employer contributing 12% and the employee at 11% of the monthly salary. Members are entitled to withdraw one-third of the total contributions plus accumulated dividends upon reaching the age of 50 years and the balance at age 55 (Teoh, 2002).

⁷ <http://www.panda.org>

5. Issues and impacts of palm oil production

5.1 Ecological issues and impacts

Production of palm oil has been claimed for some causes of ecological problems including deforestation, loss of biodiversity or wildlife species, destruction of habitat (both for people, animals and wildlife), soil, air, and water pollution and toxic chemical contamination (CMZ, 2008). The following discussion takes into account these claims about the ecological problems ascribed to palm oil cultivation and production. The present discussion is more of general observations based on reports by different groups and that the cited information can not be taken as absolute facts or truths as interests and perspectives on ecology and sustainability normally vary among different interest groups.

As traditionally practiced in Southeast Asia, oil palm cultivation is responsible for widespread deforestation (forest loss) particularly in leading palm oil producing countries as Malaysia and Indonesia (Butler, 2007a; Oh, 2004). Although the role of oil palm in such forest loss is arguably not well documented, available industry data provide some insights. According to the Malaysian Palm Oil Association (MPOA), 66% of all estates have been converted from rubber and cacao and the rest were established in logged forests (MPOA, 2003). According to the Indonesian Palm Oil Research Institute (IOPRI), only 3% of all oil palm plantations are established in primary forests as opposed to 63% in secondary forest and bush (IOPRI, 2003). These figures imply that in the years leading up to the end of 2002, some 3.26 million hectares of forest were cleared in Malaysia and Indonesia. So, according to industry data, 48% of all currently productive oil palm plantations involved forest conversion.

The above observations are generally consistent with those given in other sources (Casson, 2003), however, it should be noted that the industry estimates may not fully reflect the reality. Casson (2003), for example, noted that the Malaysian government and industry claim that most of Malaysia's oil palm plantations have replaced rubber, coconut and cacao plantations. The total area planted with these crops declined by 431,000 hectares, 249,500 hectares and 160,700 hectares, respectively in the 1990-2002 period, or 842,000 hectares in total. On the other hand, the oil palm area increased by 1.6 million hectares. This implies that some 758,000 hectares of forest has been converted to oil palm plantation (Casson, 2003). Therefore, 47% of all oil palm plantation expansion involved deforestation. Based on similar calculations, 87% of Malaysia's deforestation from 1985-2000 can be attributed to oil palm expansion⁸. The continuous expansion of oil palm plantation therefore means continuous clearing of tropical forest areas maybe not much anymore in Malaysia but expectedly more in Indonesia and elsewhere in Southeast Asia. According to WWF's report in 2005, clearance of tropical forests for oil palm plantations has caused some negative effects. The removal or destruction of significant areas of forest has resulted in ecological instability to the natural habitat of the forests (WWF, 2005).

Chhabara (2008) supported the clarification of impacts of deforestation by putting forward two major specific problems associated with the expansion of oil palm plantation. These are the destruction of biodiversity-rainforests and peatlands and destruction of wildlife (e.g. orangutans)

⁸ Calculation based on statistics on land use changes in Second Malaysian Plan and Third Agricultural Policy.

habitats in general (CSPI, 2005). First, biodiversity-rich rainforests and peatlands - critical stores of carbon - are being destroyed to make way for oil palm plantations in Malaysia and Indonesia. A 2007 United Nations Environment Programme report says that palm oil plantations are the leading cause of rainforest destruction in Indonesia and Malaysia. Degradation and burning of peatland areas alone said to be responsible for 4% of global greenhouse gas emissions - from an area making up less than 0.1% of the world's surface. Second, according to the Centre of Science in the Public Interest (CSPI), palm oil producers are destroying orangutan and other wildlife habitats by clearing rainforests particularly in Malaysia and Indonesia (CSPI, 2005).

Another ecological problem is the erosion of top soils with the rains as a result of clearing of lands for oil palm plantations. Furthermore, oil palm takes enormous amounts of nutrients from the soil, and combined together with erosion, this means that the land can be useless for other plants (native or agricultural) after the oil palm plantation is abandoned (ACF, 2008).

As in the case with most crops of only one species cultivation (monoculture), oil palm is also to be protected from pests. As such, pesticides and herbicides are required to maintain the plantation. Fertiliser is also used to meet the nutrient needs of the palms. Fertilisers and pesticides drift into the rivers with the rains, with the potential to pollute both river and other local marine environments (ACF, 2008). In this situation, the impacts of agrochemicals are not only to environment but also to people directly involved in using toxic chemicals in the plantations. In addition to the risk of contamination through skin contact or inhalation, pesticides can also enter and impact the quality of domestic water supplies in the run-off from plantations in areas with high rainfall (Down to Earth, 2004).

While it is important to take into account those ecological impacts (actual and potential), it can be asserted that those impacts change or improve over time. This is so because of the changes that took place in the past and even the on-going development as pressed by NGOs and media. In Malaysia, the palm oil industry leaders and even the government have acknowledged those ecological problems associated with palm oil both in the past and at present. They have been putting efforts to address and possibly rectify those ecological problems, for example, through agreements and existing laws on the protection and conservation of ecology, habitats and species. When the industry saw a surge in planted area from the 1990s, the government in Malaysia has started to intensify laws on the preservation of the environment, and such laws included the Protection of Wildlife Act 1972 (Basiron, 2007). In the recent past, by subscribing to the Roundtable on Sustainable Palm Oil (RSPO), some producers have started to adopt the guidelines for environmentally sustainable palm oil production. Another concrete example is the government's ban on the establishment of palm oil plantations in natural forests areas and peatlands (Butler, 2007b). To date, Malaysian oil palm cultivation takes place only over previously logged land, and mainly on land converted from rubber, cocoa and coconut cultivation. Additionally, the government has stopped the opening of new forest land for agriculture since the 1990s (MPOC, 2007a). Other initiatives recently forwarded by the Malaysian government, producers and owners include among others; comprehensive review of environmental impacts of oil palm plantations, creation of riparian reserves along rivers and oxbow lakes, establishment of wildlife corridors, and promotion of biological pest control measures (Basiron, 2007).

5.2 Socio-economic issues and impacts

The increased demand for palm oil has led to social conflicts and problems other than the environmental problems discussed in the previous section. The social impacts presented in this section are either characteristic of both Malaysia and Indonesia or for any developing country producing palm oil in general. However, since the development of a more organised cultivation and production of palm oil in Malaysia and as a response to accusations and negative criticisms of several NGOs on the industry's social performance, there have been some changes and improvements in the social aspects of palm oil production.

Looking far back on the early development of palm oil industry in Malaysia, some social problems have stemmed out from the conversion of forest to palm oil plantations which were ramified into different consequences in the lives, culture and relationships local people and communities. Glastra *et al.* (2002) put it that oil palm caused social conflicts, destruction of indigenous cultural values, and loss of traditional tribal lands. As reported, plantation developments have caused some land conflicts during the earlier part of Malaysia's palm oil plantation development notably in the 1960's to 1970s.

Today, the social issues that beset the palm oil industry pertain more about the quality of life and working conditions of workers and labourers in plantations and mill factories. Sensitive issues on wages, compensations and migrant workers (from Indonesia) are among the main problems and subjects of debates and campaigns. It is rather difficult to obtain some concrete and unbiased information about these social issues in palm oil plantations but accounts of some reports (typically by journalists and NGOs) provide some insights about those sensitive issues. Although such accounts of journalists and NGOs may contain some biases, some interesting accounts are taken here to provide some perspectives to the issues. For example, in the account of Arun Bhattacharjee for the Asia Times Online (2003), he reported that although the Seventh Malaysia Plan (1996-2000) recognised the social imbalance in plantation wages, which is 80 percent less than the basic poverty-level wages in the country, policy planners decided that the private business houses that ran plantations deal with the issue. The apparent lack of government attention to the welfare of the workers was mostly influenced by the presence of immigrant labour in this sector. Bhattacharjee (2003) furthered that the reasons for the abject status of the plantation workers in Malaysia are political as stated by the National Union of Plantation Workers (NUPW). According to the account of NUPW official, the plantation labour force, whether in earlier rubber estates or in palm-oil estates, was originally composed of south Indians brought as indentured labour. Gradually the character of the workforce changed, with Indonesian and immigrant Bangladeshis comprising nearly 40 percent of the labour force in certain areas. The NUPW official furthered that the present representative character of plantation workers made the issue less sensitive to the ruling coalition led by the Malay-dominated United Malay National Organisation (UMNO) and the Chinese-predominant Malaysian Chinese Association (MCA). That left only the Malaysian Indian Congress (MIC) to champion the cause of the oil-palm estate workers. With less clout and resources, MIC has so far failed to improve the conditions of workers in palm-oil estates where big corporate names are involved (Bhattacharjee, 2003). Given such report and given to the lack of and access to the responses of the Malaysian government and plantation companies, this paper is not in a position to comment about these issues.

Another related report by Down to Earth (2004) was regarding some migrant Indonesian workers who were claimed as vulnerable to exploitation and forced labour in Malaysian palm oil plantations. As reported, many Indonesians who wanted to work in Malaysia have to go through recruitment agencies that charged them extortionate processing and training fees. They were therefore become severely indebted even before they start working in Malaysia. They were required to sign contracts with little or no power to negotiate their terms. Many migrants ended up accepting whatever they were offered even if it was different from the work they were promised. Neither Malaysia nor Indonesia has ratified international conventions intended to protect migrant worker rights (Down to Earth, 2004). Whether this claim is true or not, or whether this case is still existent in the current plantation systems is another matter of inquiry and therefore a new line for further research.

There is not much documents available to dig for these social issues or even if such documents exist, it is fairly difficult to judge the credibility and truthfulness of the claims about the plight of the workers in different palm oil plantations in Malaysia (and even Indonesia). Conducting actual plantation visits, interviews and observations could help this information dilemma, yet it is a limitation of this research. Nevertheless, based on the aforementioned accounts, it is hard to dismiss the claim that social problems exist in oil palm plantations. While it is true that social conflicts and other social problems pose some challenges, there have been some improvements attained and continuously being pursued by various actors in the industry (Basiron, 2007; MPOC, 2007a). This is to say that the social conditions in palm oil estate plantations in Malaysia have been getting better and even continuously improving towards more socially-responsible estates. Social problems related to palm oil cultivation, similar to other crops (e.g. eucalyptus in Thailand, sugar and soybean in South America) are part of the industry's challenges. However, Basiron (2007) pointed out that it should also be acknowledged that oil palm production contributes to uplifting the quality of life of many Malaysians and helped alleviate poverty among landless farmers through participation in the FELDA schemes. Pride (2006) wrote that FELDA has been very active in providing support for the socio-economic development of the many rural Malaysians whose livelihood depends on palm oil. Various infrastructure facilities such as housing, roads, rural clinics, rural schools, educational loan funds, transport systems among others, have been built and upgraded through the years. Well-organised and well-managed over a long period of time, plantations are the established centres of economic and social life of entire communities in the rural heartlands of Malaysia today. Steadily increasing in economic importance, palm oil industry has been contributing to the expansion of the country's agricultural sector and currently employs more than half a million people directly and more than an equal number of dependents indirectly. Palm oil is also a vital source of export earnings, an international trading commodity, as well as an indispensable resource for the country's burgeoning oleochemicals, food and manufacturing industries (MPOC, 2006b). To date, oil palm plantations and oil productions provide a strong pillar in Malaysian economy. The contributions of palm oil (along with rubber) to the Malaysian economy range from 5 to 8 % of the country's GDP (Basiron, 2008b).

5.3 Waste and pollution from palm oil production and management

The two main wastes resulting from palm oil production in a mill are the solid and liquid wastes. Solid wastes typically consist of palm kernel shells (PKS), mesocarp fruit fibres (MF) and empty fruit bunches (EFB). The liquid waste generated from the extraction of palm oil of wet

process comes mainly from oil room after separator or decanter. This liquid waste combined with the wastes from steriliser condensate and cooling water is called palm oil mill effluent (POME) (ADB, 2006). Figure 5.1 shows the different point sources of waste in palm oil milling.

Air emission from the oil palm mills are from the boilers and incinerators and are mainly gases with particulates such as tar and soot droplets of 20-100 microns and a dust load of about 3000 to 4000 mg/nm. Incomplete combustion of the boiler and incinerator produce dark smoke resulting from burning a mixture of solid waste fuels such as shells, fibres and sometimes EFB. These boiler fly ashes are also wastes and pose problems of disposal.

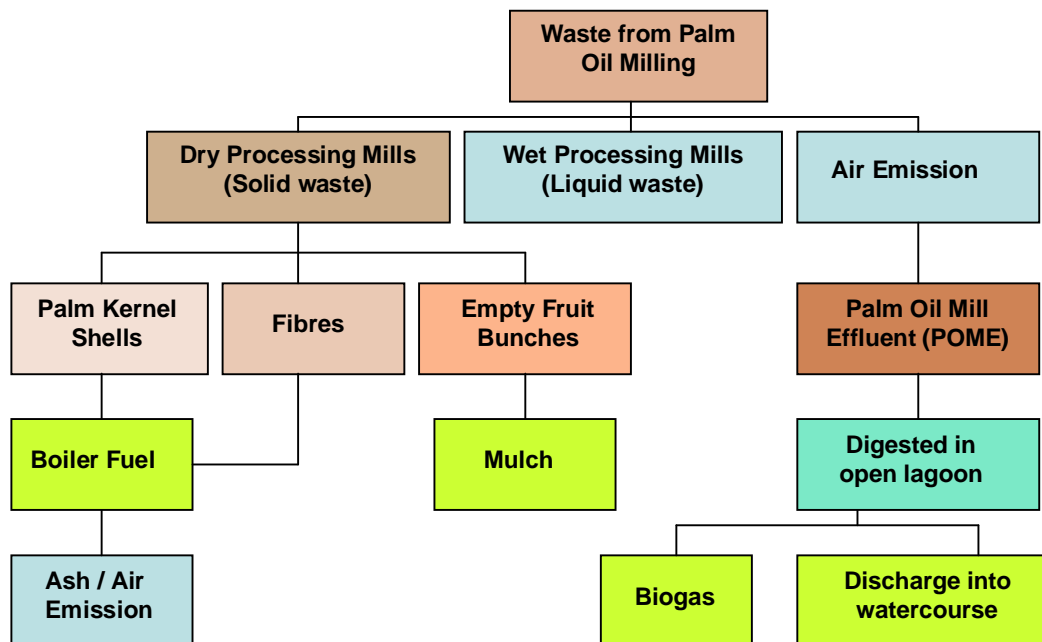


Figure 5.1 Sources of waste from palm oil milling (redrawn from ADB, 2006)

From the palm oil mills, according to the Asian Development Bank (ADB) study, the impacts of palm oil processing activities to the environment are in the following (ADB, 2006):

- Biogas generated from the anaerobic digestion escapes into the atmosphere and such biogas contains about 65% methane, which is one of the most potent greenhouse gases;
- The incineration of EFB emits particulates into the surrounding atmosphere; and
- Indiscriminate dumping of EFB causes additional methane emission into the atmosphere.

In terms of water pollution, illegal disposal of POME into waterways creates some problems related to killing of life-forms in the water (Ahmad *et al.*, 2003; Shirkie and Ji, 1983). However, because of the strict current regulation and stringent standard on effluent discharge imposed by the Malaysian Department of Environment, nowadays, it is difficult to find a case of direct POME disposal into water bodies in Malaysia. Even if such illegal practice exists, it is a

limitation of this paper not to find a report about illegal discharges of POME. Nevertheless, to illustrate the impact of illegal POME disposal and the pollution it causes, the article of Shirkie and Ji (1983) provides a good picture of such environmental crime. Shirkie and Ji (1983) reported that large amount of wastewater from palm oil mills were released during the 1970s that most of the major river basins along the west coast of Malaysia were affected. According to the report, the waterways received not only the suspended and dissolved wastes, but also acidic phenol compounds. The result was a stink that discouraged people from using the water to drink, wash clothes or utensils or bathe. Since such incidence, however, the Government of Malaysia enacted legislation in 1977 to regulate pollution from palm oil industry. Until then, few palm oil factories had any means of controlling their waste discharges. To date, water pollution due to POME is under the control and regulation set by the Malaysian Department of Environment.

In terms of waste management, the demand is generally driven by the government first and then by the private sector. The government is typically responsible for policies and regulations that establish standards for enforcement of waste management practices. The private sector is responsible for productive use of technologies (ADB, 2006). The Malaysian experience in effluent control in the palm oil industry demonstrates that a set of well designed environmental policies can be very effective in controlling industrial pollution. The Malaysian government's efforts to reduce the effluent from palm oil industry have been implemented through a licensing system, which mainly consists of effluent standards and effluent charges. Progressively, stringent effluent standards were stated in the government's environmental quality regulations (Igwe and Onyegbado, 2007).

Solid wastes, mainly PKS and MF are used for in-house energy generation. PKS are used as a source of fuel for the boilers. The fibres recovered from the nut/fibre separation stage are good combustible materials and can be used as fuel to the boiler. The fibres constitute the bulk of materials used to fire large boilers for generating superheated steam to drive turbines for electrical power generation.

Unfortunately, the shells contain silicates that form scales in the boilers. Also, when too much shells are fed into the furnace, it limits the amount of shells that can be utilised in the boilers. Residual shell is disposed of as gravel for plantation roads maintenance. The application of shells for road hardening has no impact to environment.

EFB are partly dried in the sun and later used as fuel, if not incinerated or applied to the fields. An economic use of EFB is to return them to the plantation as a mulch to enhance moisture retention and organic matter in the soil. On the other hand, the ash recovered from the incinerated EFB can also be sold or used as fertiliser in the palm plantations (ADB, 2006).

Boiler ash is recycled as fertiliser and factory floor cleaning agent. The potash in the ashes reacts with the oil to form a weak potash soap that is washed away with water. In the bid to achieve a zero discharge of the palm oil mill, boiler fly ash have been used to reduce the biochemical oxygen demand (BOD), total suspended solid (TSS), colour and other contaminants from POME before discharge. According to Igwe and Onyegbado (2007), boiler fly ash has also been used in the removal of heavy metals from other industrial effluents.

Liquid waste treatment involves anaerobic fermentation followed by aerobic fermentation in large ponds until the effluent quality is suitable for discharge. As observed in some mills, the

treated effluent can be used in the farm as manure and source of water for irrigation. The sludge accumulating in the fermentation ponds is periodically removed and transferred to the land.

5.4 Ecological cultivation of palm oil

Understanding the ecological and socio-economic impacts and the pollution associated with of palm oil production as discussed in the previous sections can be a little biased as one may draw a one-sided view of the impacts. Providing a view on the ecological and sustainable production of palm oil would give a balance in understanding that good practices and techniques have also been developed for a better and improved oil palm cultivation and oil production in Malaysia. This section takes into account such development in improving palm oil production towards a more environmentally and socially-acceptable business. The accounts of impacts some years ago do not necessarily be the same as today since improvements and new sustainable practices have been proliferating in many oil palm plantations all over Malaysia.

A quick look on FAO's modern oil palm cultivation course handbook suggests that modern oil palm cultivation needs a modern grower who understands oil palm plant and its oil products and production system in totality (FAO, 1990). That is to say that understanding all the processes from nursery to planting, to growing management, to harvesting and to oil production in the mill includes a series of different processes and requirements. Accounting for all these processes would be impossible in this section, but an overview may suffice for the purpose of getting a picture of modern and improved oil palm cultivation particularly in Malaysia. For this purpose, the paper of Basiron (2007) of the Malaysian Palm Oil Council provided an account on ecological and sustainable palm oil production. Accordingly, Basiron (2007) emphasised that in Malaysia, oil palm thrives best in such tropical climate which is marked by all-year round temperatures ranging from 25 to 33 degrees centigrade and evenly distributed rainfall of 2000 mm per year. Not many countries have similarly ideal temperatures and rainfall patterns. The commercial variety of oil palm, *Elaeis guineensis*, thrives best in Malaysia. From the earliest days of cultivation, experiments have been carried out to produce hybrid strains of oil palm that give higher yields of oil. The industry's breeding and selection work since 1960's has contributed to improvements in yield. The progress in breeding to enhance the yield has meant that the viability of oil palm cultivation continues to improve, and such progress has stimulated expansion of cultivation (Basiron, 2007).

During the 1960s and 1970s, estate-based plantation scheme of oil palm cultivation and palm oil production was adopted as industrial strategy. Such estate plantation scheme has evolved and developed in the past and still considered as the model of today's plantation system. In many cases, the estate owners operate mills where the harvested fruits are processed for oil extraction. Small farmers with varying sizes of oil palm holdings also produce fruits which are then sold through dealers who send the fruits to nearby mills. Estates usually have access to contiguous land area, often in excess of 2000 hectares at each location. This allows economies of scale to prevail and ensures that the management team is employed at an optimum level. It is pertinent to note that growth of the palm oil industry has led to a significant social phenomenon of rural communities relying on plantations as source of employment and income (Basiron, 2007).

A typical estate of 2000 hectares would employ a manager (usually a university graduate), three assistant managers and nine field staff. Manual workers are employed to carry out field duties, including weeding, applying fertilisers and harvesting. When operated in a corporate

environmental, the plantations are deemed to be professionally managed by Board Directors, managers, financial experts, advisors and inspectors. They are backed by research expertise relating to agronomic, social and water management right from land preparation and efficient planting techniques, better nursery management, to prevention of soil erosion, and to harvesting methods (Basiron, 2007).

Modern palm oil cultivation is characterised by different technologies use at different phases of cultivation. Advancement in the technology is normally directed at increasing yield and reducing costs. In most cases, adequate and balanced fertilisation is essential to realise the palm's genetic growth and yield potentials. Many years of fertiliser trial research have provided better knowledge of fertiliser application in terms of type and quantities of fertilisers. Improved knowledge of soil and water management as well as better seed-quality development has enabled the palm to sustain a consistent pattern of high yield throughout its economic life of 25-30 years (Basiron, 2007). To date, ecological and sustainable way of cultivating palm oil has been in many estate plantations while many plantation-owners are continuously striving to better improve the environmental, social and economic performance of palm oil industry. Hence, an offshoot to the continuing need to produce palm oil sustainably has led to the establishment of the Roundtable on the Sustainable Palm oil (RSPO) which is discussed in the following section.

6. Sustainability and the Roundtable on Sustainable Palm Oil

The increasing global attention and concerns about the various environmental and social impacts of palm oil production has raised the issue of sustainability. This is highlighted by the recent criticisms and accusations to the industry over health, environmental and social issues associated with palm oil production in developing countries particularly in Malaysia and Indonesia (Oh, 2004). These include allegations that oil palm cultivation had led to deforestation, pollution and social conflicts among other things as discussed in Section 5. Industry players have often characterised these issues as anti-palm oil smear campaigns but it is clear that they cannot afford to ignore the fact that others are watching closely the practices of the industry (Oh, 2004). However, with the growing palm oil demand and consumption worldwide, large-scale palm oil production is now saddled with the very fundamental question of "compatibility with sustainable development". Oh (2004) pointed clearly about the concerns that further expansion and larger scale of production cannot go on for long if oil palm is grown purely to fatten the economic bottom line without taking into account the long term needs of society and environment. The key word is sustainability.

Addressing the sustainability challenges has led to various initiatives within the industry as well as in the global supply chain. As such, the Malaysian Palm Oil Council (MPOC) put into action various sustainability initiatives, social programmes and product development in Malaysia and around the world (MPOC, 2007b). Although, MPOC and palm oil industrial players in Malaysia claim that they have addressed sustainability issues and have done a lot of improvements for several years already, they agree that there are still more to improve. As stated by the Chairman of MPOC in the Annual Report 2006, "Malaysia has long struck a balance between economic needs and preservation of the environment. Its palm oil industry has been working hard to provide sustainable supply of edible oil by enhancing the production without stressing the environment" (MPOC, 2006a). Despite all the efforts, the claims and allegations from different interest groups and NGOs abound (e.g. WWF, Friends of the Earth) which brings the point that sustainability is indeed a never-ending process.

Efforts to address palm oil sustainability are continuing problem-solving activities seeking to find better ways and solutions to the problems associated with palm oil production. Recently, an initiative by the industry players at global level was formed to tackle sustainability in a more practical way, which was the formation of Roundtable on Sustainable Palm Oil (RSPO). The Roundtable was established in 2002 as a result of informal cooperation between what is claimed to be the world's leading manufacturers of high value-added speciality vegetable fats, AAK; a leading Malaysian oil-palm cultivator called Golden Hope Plantations Berhad; Switzerland's largest supermarket chain and largest employer Migros; the Malaysian Palm Oil Association; the UK supermarket chain Sainsbury's; and one of the world's biggest global manufacturers of cosmetics, food and homecare products, Unilever. A preparatory meeting was held in London on 20 September 2002 and this was followed by a meeting in Gland, Switzerland, on 17 December 2002. These businesses constituted themselves as an organising committee to organise the first

Roundtable meeting and to prepare the foundation for the organisational and governance structure for the formation of the RSPO⁹.

The inaugural meeting of the Roundtable took place in Kuala Lumpur, Malaysia on 21-22 August 2003 and was attended by 200 participants from 16 countries. The key output from the meeting was the adoption of a statement of intent, a non-legally binding expression of support for the Roundtable process. As of 31 August 2004, forty seven businesses and organisations had signed the statement of intent. On 8 April 2004, the RSPO was formally established under Article 60 of the Swiss Civil Code with a governance structure that aims to ensure fair representation of all stakeholders throughout the supply chain. The base of the association is in Zurich, Switzerland, while the secretariat is currently based in Kuala Lumpur. There is also a liaison office in Jakarta, Indonesia¹⁰.

RSPO is the first non-profit organisation that aims to produce sustainable palm oil worldwide. Members of the RSPO and participants in its activities include plantation companies, manufacturers of palm oil products, environmental NGOs and social NGOs. RSPO defines sustainable palm oil production as a legal, economically viable, environmentally appropriate and socially beneficial management and operations (Tan *et al.*, 2007). The mission of RSPO is set to advance the production, procurement and use of sustainable oil-palm products through the development, implementation and verification of credible global standards and, the engagement of stakeholders along the supply chain¹¹.

RSPO is an association created by businesses and organisations carrying out their activities in and around the entire supply chain for palm oil to promote the growth and use of sustainable palm oil through co-operation within the supply chain and open dialogue with its stakeholders. In particular, the RSPO has declared its intention to work on the following tasks:

- Research and develop definitions and criteria for the sustainable production and use of palm oil;
- Undertake practical projects designed to facilitate implementation of sustainable best practices;
- Develop solutions to practical problems related to the adoption and verification of best practices for plantation establishment and management, procurement, trade and logistics;
- Acquire financial resources from private and public funds to finance projects under the auspices of the RSPO; and
- Communicate the Roundtable's work to all stakeholders and to a broader public.

In 2005, RSPO endorsed the "Principles and Criteria for Sustainable Palm Oil Production" as the best approach to sustainable palm oil production in the light of current knowledge. Members of RSPO were expected to support each other in good faith applying the principles and criteria to as great extent as possible. Additionally, members from various sectors of RSPO were encouraged to actively promote the use of sustainable palm oil. Sustainable palm oil production is comprised of

⁹ <http://www.rspo.com>

¹⁰ *Ibid.*

¹¹ *Ibid.*

legal, economically viable, environmentally appropriate and socially beneficial management and operations. This is delivered through the application of the said set of principles and criteria. The public release version of the RSPO Principles and Criteria for Sustainable Palm Oil Production is copied in Appendix 2. Since then, pilot implementation and evaluation of these criteria has been an on-going activity (RSPO, 2005).

Malaysia has been an active member of RSPO with government agencies and private companies like MPOA, FELDA, Golden Hope Plantation Bhd and United Plantation Bhd taking important roles and positions in the organisation. In fact, MPOA and Golden Hope were among the founding members of RSPO in 2004 while MPOA and FELDA are current Executive Board members of RSPO. As of 2007, there were 152 regular members of RSPO comprising oil palm growers, palm oil processors and traders, consumer goods manufacturers, retailers, banks and investors, environment NGOs and social NGOs. With huge support from those in palm oil industries, this RSPO's initiative on principles and criteria is hopefully a progressive step towards sustainable palm oil production (Tan *et al.*, 2007).

7. Policy issues

The increasing importance of palm oil in supporting the economy as well as the issues associated with it in terms production, trade, impacts and sustainability are not without the effect of policy measures and instruments that guide decisions of different actors and players in the palm oil industry both in the past and in the present. Thus, policy development related to palm oil can be well understood in a historical economic development of the country.

Taking a bit back to the earlier part of Malaysia's economic development, the account of Simeh and Ahmad (2001) points clearly that policies on country's economic development was importantly linked to the success of palm oil (referred as "golden crop" during that time) production. According to Simeh and Ahmad (2001), the emergence of palm oil during the early 1960s could not have come at a better time to assist the country in alleviating poverty, especially in the rural areas. During that period, social resentment as a result of high disparity of income between the rural (mainly consisted of ethnic Malays) and urban (mainly consisted of the ethnic Chinese) led to the bloody racial riots in 1969 (Noor, 1997). Such racial riot prompted the government to formulate the New Economic Policy, NEP (1970-1990) with the overriding objective of achieving national integration and unity. The integration and unity was to be realised through a two-pronged strategy of reducing and eradication of poverty and a restructuring of the Malaysian society to correct economic imbalances and eliminate the identification of race with economic function. It was during that era that rural and agricultural development policies were focused on increasing emphasis to provide employment and income earning opportunities to the rural poor. The government through its agencies such as the Federal Land Development Authority (FELDA) opened up extensive new lands for re-settlement of the landless rural people. The development of these land schemes, which mainly consisted of organised oil palm and rubber smallholdings, marked the beginning of the key role played by palm oil in the crop and export diversification and poverty alleviation programs of Malaysia (Simeh and Ahmad, 2001; FELDA, 1996).

Earlier in the development, Malaysia's crop diversification policy and programs were initiated against the backdrop of the Korean War rubber boom wherein Malaysian commercial agriculture in the 1950s was synonymous with rubber (Sekhar, 2000). During those days, there were already some 1.5 million hectares of rubber in the country whose expansion was spearheaded by the expanding world automobile and transport industry. The advent of the synthetic rubber, which was cheaper, had negatively affected the development of Malaysian rubber. The ready supply of this cheaper substitute led to the fall of rubber prices resulting in drastic reductions in incomes of those involved in rubber. Malaysia's foreign exchange and the general economy also suffered. The need to diversify the country's agricultural base was pressing and a crop diversification policy was inevitable to find better economic alternatives to rubber - and palm oil was the prime crop choice for the diversification program (Jaafar, 1994). Hence, large tracts of rubber lands were converted to oil palm plantations over the next three decades (Sekhar, 2000). Coupled with intensified new land development policies, in particular for FELDA, state agencies and the private sector, oil palm areas expanded from a mere 55,000 hectares in 1960 to 1 million hectares in 1980, only over a span of two decades. Oil palm planted areas later profoundly doubled to 2 million hectares in 1990.

Concomitant with the increase in oil palm plantation areas are the increase in production, exports, and palm oil products for about four decades now. This was boosted by the palm oil export diversification policy and programs created at that time. It was noted that the success of palm oil export diversification program was accompanied by initiatives in penetrating and deepening of markets, R&D and a conducive regulatory framework. This was done through strong institutional support of the government. Three main institutions were involved to implement these policy objectives. They were the Palm Oil Registration and Licensing Authority (PORLA), Palm Oil Research Institute of Malaysia (PORIM) and Malaysian Palm Oil Promotion Council (MPOPC) (Simeh and Ahmad, 2001).

To date, palm oil industry is still expanding and at the same time, more than ever, has become a top industry where policy and decision makers (not only locally but also globally) are wrestling because of the current problems associated with palm oil of palm oil production, such as deforestation, lost of biodiversity, pollution and social problems.

Since palm oil industry has modernised and increased production, accompanying effective pollution measures and policies were also advanced. In Malaysia, the Environmental Quality Act of 1974 (amended in 1997) and Environmental Quality (Clean Air) Regulations of 1978 are the principal regulations to prevent, abate and control pollution (Idris, 2003). According to Teoh (2002), regulations that are directly applicable to the oil palm industry include the following under these Acts. As cited, the Environmental Quality Act stipulates detailed conditions with the license to use or operate a premise for palm oil processing. These include compliance to stringent standards for discharge of treated effluents to water courses or for land application. On the other hand, Environmental Quality (Clean Air) Regulations 1978 stipulates the conditions pertaining to open burning and emission standards for smoke and particulate emissions into the atmosphere (Teoh, 2002). The question of how effective the implementation of those policies and regulations is another point of discussion but hinting on Brian Dyer (2008)¹², he argued that there is a strong legislative framework that many companies in the industry must abide by.

In view of the functioning Malaysian market, economic instruments are also being used although often still in combination with command-and-control regulations. Economic instruments such as pollution charges, pricing policy, favourable terms of investment for environmental technology, market creation, as well as ecological compensation fees, are being introduced (UNEP, 2000). For example, the "polluter pays principle" was adopted in Malaysia to assess the amount of fee to operate the palm oil mill premises. The amount of effluent-related fee payable to the Government was linked to the BOD load of the effluent discharged either onto land, watercourse or both (Idris, 2003). Likewise, all oil palm planters, including smallholders pay a windfall tax that took effect on 1st July 2008. Plantation Industries and Commodities Minister, Datuk Peter Chin said that smallholders pay via palm oil millers (Business Times, 2008).

In terms of biofuel policy, the formulation of the Malaysian National Biofuel Policy in 2006 was a way to ensure a healthy development of the biofuel industry in line with the Five Fuels Diversification Policy. As such, the National Biofuel Policy was envisioned to use environmentally-friendly, sustainable and viable sources of energy to reduce the dependency on depleting fossil

¹² *Managing director of LONSUM, a company that grows and processes palm products in Indonesia. In: Biodiversity and Oil Palm, Ecology and Policy. April 10, 2008.*

fuels; and to enhance prosperity and well-being of all stakeholders in the agriculture and commodity-based industries through stable and remunerative prices. Having that as a framework, the policy is underpinned by five strategic thrusts: (1) biofuel for transport, (2) biofuel for industry, (3) biofuel technologies, (4) biofuel for export, and (5) biofuel for cleaner environment. With the National Biofuel Policy gearing now for short and medium term implementation since 2006, various incentives and benefits were expected on the other end. For example, biodiesel projects can be eligible to be considered for pioneer status or investment tax allowance under the promotion of Investment Act 1986. Similarly, mitigation of the effects of petroleum price escalation, savings in foreign exchange, achievement of socio-economic safety are among the cited benefits that can be derived due to the implementation of such national biofuel policy (MPIC, 2006). Evaluation of the effectiveness of this biofuel policy is still not emphasised in many discussions probably because there is still little, if not at all done, local research in this area.

Since the demand for palm oil is increasing, policies and regulations are geared towards more cultivation of palm oil plants in a manner that is less damaging to the environment, as exemplified by the RSPO. Similarly, the next phase of the Kyoto Protocol currently being negotiated and reducing emissions from deforestation and processing of palm oil plays an important role in crafting policies towards emission trading and clean development mechanisms (CDM). In this connection, public and private policies for palm oil are also strongly directed and promoted towards sustainability (e.g. ecological criteria, certification for agriculture and forestry, clean technologies) as well as equity and social cohesion.

8. Research on palm oil

Research activities related to palm oil conducted by different organisations and institutions in Malaysia have been intensifying since palm oil has become a prime commodity of the country. Scientific, applied, business, socio-economics, and market research on palm and palm oil dominate the mainstream prints and on-line media. Based on Agricultural Science and Technology Indicators (ASTI, 2005) country briefs on Malaysia, the government, universities and various private institutions are very active in conducting research on palm, palm oil and its industrial development. As mentioned earlier in Section 4.5, the leading governmental agency in the frontier of palm and palm oil research is the Malaysian Palm Oil Board (MPOB). MPOB has been playing an active role in developing new technologies which have contributed to the advancement of the Malaysian oil palm industry. In leading the industry, MPOB provides and promotes strong scientific and technological support through its commitment to R&D, the commercialisation of its research findings and the transfer of knowledge and innovation¹³.

The Forest Research Institute of Malaysia (FRIM) and Malaysian Agricultural Research and Development Institute (MARDI) are the active institutes doing different research on palm oil. FRIM is a leading institution in tropical forestry research in Malaysia. FRIM became a statutory body governed by the Malaysia Forestry Research and Development Board under the Ministry of Primary Industries in 1985 and then in 2004, it became a statutory body governed under Ministry of Natural Resources and Environment. FRIM promotes sustainable management and optimal use of forest resources by generating knowledge and technology through research, development and application¹⁴. On the other hand, MARDI is another statutory body that undertakes research and development in food and tropical agriculture. MARDI's R&D efforts for over more than two decades have contributed to the development of new crop varieties/clones (including oil palm) and animal breeds and their husbandry practices. New techniques have also been developed by MARDI to better manage the environment and agricultural resources in particular, the soil, water and genetic resources¹⁵. SIRIM Berhad is another wholly-owned company of the Malaysian Government under the Minister of Finance Incorporated. It focuses on discovering and developing new technologies to enable industries move up the value chain and aims to expand in solving technical problems, thus helping industries to reinvent their products and business. SIRIM also aims to promote the development of new sources for SMEs to tap and collaborate with SIRIM in the quest for growth in the manufacturing, technology and services sectors. The latest research on palm at SIRIM Berhad was on life cycle assessment (LCA) of palm oil¹⁶

Various universities in Malaysia are also busy and have their share of research on palm oil. Notable among these are the faculties of agriculture, forestry and biotechnology of the University Putra Malaysia (UPM), University of Malaysia Sarawak (UNIMAS), and University Kebangsaan Malaysia (UKM). Oftentimes, these universities cooperate with companies and other private sectors to do more technical and applied research related to palm oil cultivation, management and technological advancements.

¹³ <http://www.mpob.gov.my>

¹⁴ <http://www.frim.gov.my>

¹⁵ <http://www.mardi.gov.my>

¹⁶ <http://www.sirim.my>

The private sectors are also contributing in the R&D by conducting research which are mainly on palm oil plantation and milling issues. Leading the research frontiers among the private sectors is the Palm Oil Research Institute of Malaysia (PORIM). Established in 1979, PORIM is funded mainly from research tax from palm oil millers. PORIM is typically involved in scientific and managerial research contributing to the success of oil palm which include the significant genetic improvements and production of high quality planting materials, the development and application of finely-tuned agronomic practices, the appropriate scale and efficient organisation of oil palm plantations and the continuous research and development and good infrastructural support provided in the country (POIC, 2008). Other private research entities on palm oil are the Applied Agricultural Research Sdn Bhd of the Dow AgroScience; Golden Hope Research of Golden Hope Plantation Berhad; and Research and Advisory Services of the Estet Pekebun Kecil Sdn Bhd. (ASTI, 2005).

9. Palm oil industry - forecast and future

Carter *et al.* (2007) forecast that the future palm oil supply depends on the ability to mechanise, the potential for improving yields and the scope for expanding the oil palm areas in Malaysia and Indonesia, since ultimately they will determine the palm oil supply for decades to come. Although palm oil area growth in Malaysia has been slowing, particularly in Peninsular Malaysia, further expansion in area in the Malaysian Sabah and Sarawak provinces on the island of Borneo are expected to increase. By contrast, the area planted with oil palm in Indonesia has been growing fast in the past few years and has the potential to continue expanding particularly in Kalimantan province in Borneo.

Translating oil palm areas into palm oil production volumes requires a forecast of future palm oil yields. For this forecast, Carter *et al.* (2007) provide a picture of what can be expected in terms of palm oil production. As yields are much more volatile in Indonesia than in Malaysia, the clear trend in Malaysian yields were used to estimate the yield forecasts for both producers. Based on calculation, Malaysian palm oil yields have been increasing by almost 0.03 tonnes (i.e. almost 30 kg) per year. This trend for Malaysia was used and assumed that Indonesia will be able to increase yields from their current level at this rate. Thus, the forecast with a continuation of the past trends in the growth in yields, the global production of palm oil, with plantings responding to high prices, would be expected to increase by 20 million tonnes from the level in 2005 to almost 54 million tonnes by 2012, with the two main players continuing to account for 88% of the world output (Carter *et al.*, 2007).

According to Chin Fah Kui, Minister of Plantation Enterprise and Commodities, Malaysia sees bright future in palm oil industry. With the world's growing consumption of oils and fats even expected to rise from the current level of 90 million tonnes to 169 million tonnes by 2020, palm oil can surely contribute to this growth in the world consumption of vegetable oils, particularly so on account of consumers' increasing acceptance in terms of its quality, versatility and nutritional value as well as health characteristics (Xinhua, 2006).

Smith (2006) cited that Malaysia and Indonesia have announced a joint commitment to each produce 6 million tonnes of crude palm oil per year to feed the production of fuel and biodiesel. The Malaysian National Biofuel Policy mandate is expected to encourage the increase in production of quality biofuel to satisfy the global demands. According to Basiron (2008a), biofuel and biodiesel demands are changing the dynamics of the palm oil industry. EU is now the major user of vegetable oils for fuels and is expected to remain so in the medium term due to its increased target for biofuel usage. Therefore, the higher demand for vegetable oil for biodiesel in Europe has contributed to increased supply pressure. Given the scenario in Europe and in the US, it would be difficult for their domestic vegetable oils to provide the raw materials needed. Therefore, the palm oil has to play the role in filling the supply gap for food and other applications (Basiron, 2008a). This scenario of increasing oil demand for food and for fuels is now a heating debate not only within the industry but in general public at large. In such food versus fuel debates, the main issues would be politically sensitive and economically challenging. Issues such as price, climate change, and technical production innovations are among the factors that are at the centre of the dynamics of palm oil industry today and in the near future.

The issue of sustainability will be never go away from the palm oil industry. The establishment of Roundtable for Sustainable palm Oil (RSPO) is expected to steer the industry towards a more sustainable palm oil production. As such, RSPO is expected to connect more stakeholders such as growers, processors, investors, traders, retailers and NGOs together into the Roundtable in order to ensure a more sustainable and responsible palm oil production.

PART II. CDM PROJECTS IN PALM OIL INDUSTRY

10. The Clean Development Mechanism (CDM)

The central feature of the Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC) is its requirement that countries limit or reduce their greenhouse gas emissions (GHG). By setting such targets, emission reductions took on economic value. To help countries meet their emission targets, and to encourage the private sector and developing countries to contribute to emission reduction efforts, negotiators of the Protocol included three market-based mechanisms - Emissions Trading, the Clean Development Mechanism (CDM) and Joint Implementation (UNFCCC, 2008). Having UNFCCC as the main source of information, this brief note on CDM is excerpted from the UNFCCC's document on Kyoto Protocol Mechanisms¹⁷.

CDM allows emission-reduction (or emission removal) projects in developing countries to earn Certified Emission Reduction (CERs) credits, each equivalent to one tonne of CO₂. These CERs can be traded and sold, and used by industrialised countries to meet a part of their emission reduction targets under the Kyoto Protocol. CDM enables industrialised countries with emissions reductions commitments to efficiently reach their targets in an economically efficient way. The incentive to invest in projects is created by the different costs of carbon abatement - an industrialised country seeking to reduce emissions domestically is likely to face substantially higher costs, compared to investment in CDM projects to abate emissions overseas. By providing investment incentives, the CDM acts as an aid to project finance in host countries, encouraging sustainable development through the adoption of cleaner energy sources, or more efficient industrial processes.

The CDM is a project-based financing mechanism, whereby eligible Annex 1 countries¹⁸ may purchase carbon credits generated by projects hosted in developing non-Annex 1 countries¹⁹. Such Annex 1 countries may be purchasing carbon credits to fulfil compliance requirements, or for speculation, as is the case for US companies. Projects hosted in non-Annex 1 countries such as; Asia, South Africa and South America, may be developed unilaterally or bilaterally with investment or support from companies and Governments in Annex 1 countries, as long as the project helps the host country meet its own goals for sustainable development, and does not divert Overseas Development Aid away from the country. Although the first "Commitment Period" of the Kyoto Protocol does not start until 2008, under the CDM, projects can generate emission credits (CERs) from 2000 onwards.

CDM projects can be designed using established guidelines, or if none exist for the project type, guidelines can be established specifically for the project. These guidelines are referred to as a methodology, and must be approved by the CDM Executive Board (EB). Methodologies are split into three main categories (TFS Green, 2008):

¹⁷ <http://www.unfccc.int>

¹⁸ Annex 1 is an Annex in the United Nations Framework Convention on Climate Change. The Annex 1 countries are those which committed themselves as a group to reducing their emissions of the six greenhouse gases by at least 5% below 1990 levels over the period between 2008 and 2012. Specific targets vary from country to country.

¹⁹ Non-Annex 1 countries are developing countries, and they have no emission reduction targets.

- *Small-scale*: Includes renewable, energy efficiency and other project. Projects in this category must be less than 15MW in the case of energy generation to qualify as "small-scale".
- *Non-small-scale methodologies and consolidated methodologies, which combine several different approaches*: This category spans project types such as renewable energy, incineration of industrial chemical waste streams such as HFC₂₃ and N₂O, methane reduction activities such as landfill and animal waste management, and other types such as energy efficiency.
- *Forestry*: Afforestation/Reforestation, typically remediation of degraded land. Methodologies for avoided deforestation are currently under discussion.

11. CDM in Malaysia

By July 2007, a total of 36 CDM projects (companies' projects committed to reduce greenhouse gas emissions) have been given Letters of Approval by the Ministry of Natural Resources and Environment (MNRE) of Malaysia (Figure 11.1). Out of 36 projects, 16 projects are registered with CDM Executive Board (CDM EB) in Germany and two projects have been issued with Certified Emission Reductions (CERs). Malaysia has registered 16 CDM projects with 1,856,430 of average annual reductions (Figure 11.2) and has currently issued 386,960 of CERs (Leong, 2007).

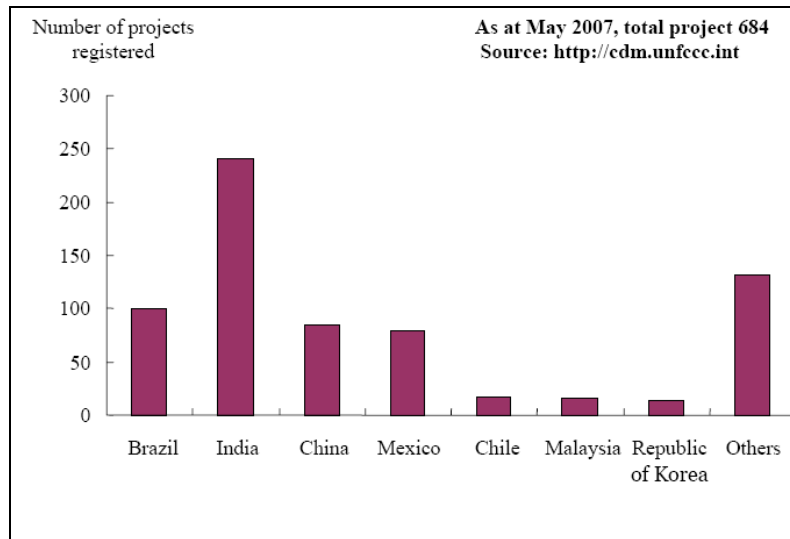


Figure 11.1 Register of CDM project by host countries

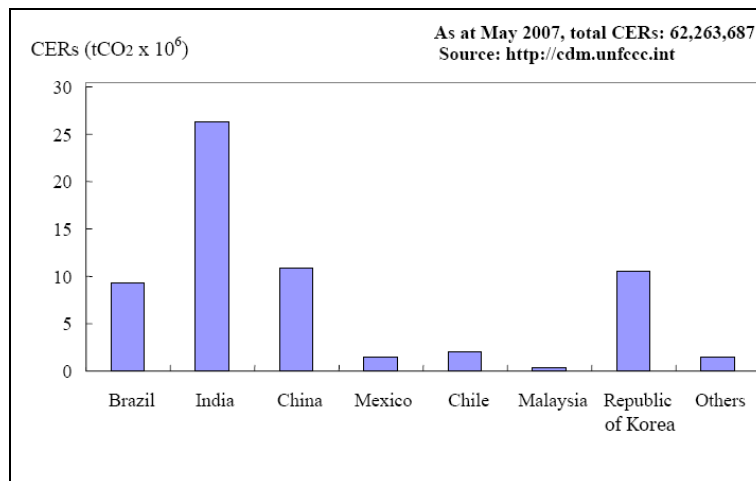


Figure 11.2 CERs issued by host countries

Palm oil plantation owners in Malaysia are slowly coming to grip with the opportunities that are achievable when initiating CDM project activities in the mills. With CDM projects, sustainable development in palm oil has started to gain significance. Projects under CDM that are managed efficiently with innovative activities and technologies are considered with strong additionality. Additionality is an important requirement for a successful registration of a CDM project. For example, the waste (both solid and liquid) generated from palm mill could be efficiently managed by adopting innovative waste management technologies.

Even though oil palm millers in Malaysia were apprehensive in the beginning with regard to CDM, they gradually realised the potential of CDM projects in the mills that could lead to a more sustainable palm oil production. Recent projects and the increasing registration of new projects attest to the gaining momentum of CDM in Malaysia. Specific opportunities that could find favour with the developers of CDM projects in a palm oil mill can be in any of the following types:

- Composting that could help in the management of both EFB and POME, thus enabling the mills to achieve zero waste management while at the same time producing organic compost that could successfully substitute chemical fertiliser in the plantations, albeit partially, thus giving rise to substantial savings and a sustainable business model.
- Biogas capture from POME and destruction. Project developers in this regard would be well advised to note that flaring of biogas is not seen sustainable under Gold Standard²⁰. CDM projects under this type may become essential in the future in order to ensure premium carbon credits for project developers.
- Biomass to energy production is another CDM project type that seems to find favour with groups that have other project activities adjacent to a mill, thus displacing fossil fuel based energy.

There are many opportunities that prevail in palm oil milling sector for a successful implementation of a CDM project in a manner that is fully sustainable and with a sound financial returns (Krishnamurthy, 2008). According to Leong (2007), CDM projects have been touted as good initiatives to boost sustainable development for Malaysia's palm oil industry. Besides combating global warming, palm oil mills can also gain competitive advantages with CDM implementations by increasing the efficiency of their waste management, benefitting from the transfer of technology, reducing cost and gaining additional revenue stream from sales of CERs.

²⁰ The Gold Standard is a Swiss-based non-profit foundation (<http://www.cdmgoldstandard.org>).

12. Recent and on-going CDM projects on palm oil

Malaysia is a party to the UNFCCC and has ratified the Kyoto Protocol. Malaysia has been following the negotiations and development of climate change issues very closely due to the numerous implications that can and will arise from the agreements achieved. As a developing country, Malaysia has no quantitative commitments under the Kyoto Protocol at present. To respond to the Kyoto Protocol, particularly to the CDM component, various activities such as seminars and roundtable discussions have been conducted by government organisations, NGOs, and industrial and professional associations. These activities were initiated individually by each stakeholder and/or through collaboration between them. Various stakeholders hold different points of views about CDM, however, they share the same view of the CDM objectives - to reduce GHG emissions and to create sustainable development (CDM Malaysia, 2008a).

There is a growing interest among palm oil mill owners in Malaysia, especially the big major companies, for CDM projects because the palm oil industry has high potential for POME treatment and biomass utilisation. However, most of local companies are carefully and cautiously observing developments and curious about any successful practices in CDM projects and how much carbon credits would be gained (Pacific Consultant, 2008).

In Malaysia, several CDM projects on palm oil sector are successfully implemented. Notably, the Biomass Energy Plant Lumut was the first Malaysian project registered at the UNFCCC as a CDM project (Rao, 2006). CDM projects in Malaysia are listed and briefly described in Table 12.1 (with some inclusions from Indonesia). A concrete example of CDM methane to energy project is shown in Appendix 3.

Table 12.1 List of CMD projects in Malaysia (and some from Indonesia).

Host Party	Register Date	Project Name	Project Type	Description
Malaysia	24 Feb 06	Biomass Energy Plant-Lumut	Methane recovery and utilisation	Project to generate biogas from palm oil mill effluent. The biogas was aimed at displacing fossil fuels.
Malaysia	07 Apr 06	Replacement of fossil fuel by PKS biomass in the production of Portland cement.	Biomass	The replacement of fossil fuel by palm kernel shell biomass in the cement manufacturing process.
Malaysia	23 Apr 06	Sahabat Empty Fruit Bunch Biomass Project	Biomass	The project was about using waste EFB for electricity and steam generation. It involved the construction of a 7.5 MW turbine generator equipped with auxiliary facilities.
Malaysia	10 Jun 06	LDEO Biomass Steam and Power Plant in Malaysia	Biomass	This project was aimed at using EFB as fuel for a modern high efficient biomass - fired cogeneration system to supply steam and electricity.
Malaysia	10 Jun 06	SEO Biomass Steam and Power Plant in Malaysia	Biomass	This project was aimed at using EFB as fuel for a modern high efficient biomass - fired cogeneration system to supply steam and electricity.
Malaysia	21 Jul 06	Seguntor Bioenergy 11.5MW EFB Power Plant	Biomass	The purpose of the project activity was to utilise EFB as the primary biomass fuel for power generation.
Malaysia	21 Jul 06	Kina Biopower 11.5MW EFB Power Plant (the Project) (Version 02)	Biomass	The purpose of the project activity was to utilise EFB as the primary biomass fuel for power generation.
Malaysia	02 Sep 06	Bentong Biomass Energy Plant in Malaysia	Biomass	This project was aimed at using EFB as the fuel for a modern high efficient biomass - fired cogeneration system to supply steam.
Malaysia	02 Sep 06	Johor Bundled Biomass Steam Plant in Malaysia	Biomass	This project was aimed at using EFB as fuel for a modern highly efficient biomass -fired steam system to supply steam to three different industrial plants in Johor.
Malaysia	04 Sep 06	ENCO Biomass Energy Plant in Malaysia	Biomass	This project was aimed at using EFB as fuel for a modern efficient biomass -fired steam system to supply steam to an industrial plant in Kulim, Kedah.
Malaysia	24 Sep 06	Jendarata Steam and Power Plant	Biomass	The project was aimed at replacing the existing low efficient biomass fired, fire-tube boilers with a more efficient, water-tube biomass reciprocating grade boiler in the palm oil mill.
Malaysia	20 May 07	Landfill gas utilisation at Seelong Sanitary Landfill	Biomass	A project to transform biomass waste to energy. Installation of a biomass-fired cogeneration system to supply steam and electricity to a palm oil refinery.

Note: Details of these projects with their respective project codes are available at UNFCCC Project List for the years 2006, 2007 and 2008 (<http://cdm.unfccc.int/Projects>).

Table 12.1 List of CMD projects (continuation)

Host Party	Register Date	Project Name	Project Type	Description
Malaysia	04 Nov 07	Co-composting of EFB and POME - MG BioGreen Sdn.Bhd (MGBG)	Co-composting and methane recovery	The project was aimed to divert the EFB and POME to a controlled aerobic composting plant that will prevent the emissions of methane. The organic material and wastewater were converted into compost and used as soil conditioner in the plantation and as partial substitute to chemical fertiliser.
Malaysia	08 Nov 07	Methane recovery and utilisation project at United Plantations Berhad, Jendarata Palm Oil Mill	Methane recovery and utilisation	The project activity focused on the installation of a closed continuous-flow stirred tank reactor (CSTR) anaerobic digester plant for the treatment of palm oil mill effluent.
Malaysia	14 Dec 07	Golden Hope Composting Project - 5 projects	Landfill gas extraction	The project was aimed to combust collected methane from a landfill to generate electricity.
Malaysia	21 Dec 07	Biomass thermal energy plant - Hartalega Sdn.Bhd	Biomass	The project was aimed at replacing the conventional boilers (8 units) by three biomass boilers, and at sourcing biomass residues from surroundings palm oil mills that have abundant waste from their operation.
Malaysia	19 Mar 08	Methane recovery and utilisation project at TSH Kunak Oil Palm Mill	Methane recovery and utilisation	The project was aimed to install a closed continuous-flow stirred tank reactor (CSTR) anaerobic digester plant for the treatment of POME.
Malaysia	01 May 08	Inno-Malsa - Palm Oil Mill Waste Recycle Scheme	Co-composting	This project featured two main technologies employed in the project activity: in-vessel biomass composting and wastewater pre-treatment.
Malaysia	20 May 08	Construction and operation of two 11.5MW biomass power plants in Kuching and Mukah, Sarawak	Biomass	The project involved the construction and operation of two 11.5MW biomass power plants in Sarawak. The power plants are to be fuelled using EFB obtained from palm oil industries as the feedstock.
Malaysia	15 Jan 08	Co-composting with AVC POME Treatment System for Mewah Palm Oil Mill - 4 projects	Co-composting and utilisation	The project was aimed at reducing the methane emission from the anaerobic digestion of POME by avoiding the current anaerobic wastewater treatment method by using an "AVC" sludge dewatering system.
Malaysia	Requesting registration	Methane recovery for on-site utilisation project at Desa Kim Loong Palm Oil Mill, Sook, Keningau, Sabah, Malaysia	Methane recovery and utilisation	The project activity aims to reduce the methane emissions from the treatment of POME. The existing open anaerobic tanks will be enclosed and installed with a biogas capture and collection system for utilisation for on-site heat and power generation.

Note: Details of these projects with their respective project codes are available at UNFCCC Project List for the years 2006, 2007 and 2008 (<http://cdm.unfccc.int/Projects>).

Table 12.1 List of CMD projects (continuation)

Host Party	Register Date	Project Name	Project Type	Description
Malaysia	Requesting registration	Avoidance of methane production in POME treatment through Boustead Biotherm Palmass Technology	Co-composting and utilisation	This project aims to eliminate the methane emission generated from the anaerobic treatment of the POME by an aerobic co-composting technique using a technology where the composting process is optimised to remove moisture and to prevent the emission of methane from POME.
Malaysia	Status unknown	Bumibiopower Biomass Power Plant Project	Biomass	The project activity is to generate electricity utilising biomass as fuel, and to develop an enhanced approach to waste-disposal in the palm oil industry.
Malaysia	Status unknown	Methane recovery and utilisation project at United Plantations Berhad	Methane recovery and utilisation	The project activity contributes to GHG emission reductions by recovering the methane gas generated from the anaerobic digestion process, as well as utilising the biogas generated to displace fossil fuels for boilers and/or thermal heaters.
Indonesia	18 Mar 08	Pelita Agung Agrindustri Biomass Cogeneration Plant*	Biomass	This project was on renewable energy initiatives covering construction of (a) co-generation plant powered using biomass generated by its upstream milling activities and (b) biogas extraction project to treat the complex' effluent, diverting from traditional method of relying on fossil fuel.
Indonesia	20 Mar 08	Nubika Jaya Biogas Extraction for Bio-Hydrogen Production	Methane recovery and utilisation	The project was aimed at capturing methane from the complex industrial waste-water generated from the palm fruit milling. It also aimed to convert the recovered methane to hydrogen as feedstock for the hydrogenation process in the newly constructed oleo-chemical facility.
Indonesia	Requesting registration	PAA Biogas Extraction Project for Heat Generation	Methane recovery and utilisation	This is an integrated palm oil processing facility consisting of a palm oil mill, a kernel crushing plant, and currently developing a palm oil refinery and a biodiesel plant. The project is on methane recovery and utilisation for energy.

Note: Details of these projects with their respective project codes are available at UNFCCC Project List for the years 2006, 2007 and 2008 (<http://cdm.unfccc.int/Projects>).

The above-listed on-going (probably with some finished already) projects in Malaysia are mostly small-scale methane recovery from palm oil mill effluents. Those projects recover methane caused by the decay of biogenic matter in the effluent stream of an existing palm oil processing mill by introducing methane recovery and combustion to the existing anaerobic effluent treatment system (lagoons) (TÜV SÜD, 2008).

13. Eligible areas for CDM project

Palm oil mills are large generators of organic wastes that are often improperly managed or under-valorised. For every tonne of FFB processed, about 20% of CPO is produced leaving major waste streams. For an average mill capacity of approximately 200,000 tonnes per year, the proper management of waste is a key factor towards sustainability.

If mesocarp fibres (MF) and palm kernel shells (PKS) are often burned on-site in inefficient boilers for the production of process steam and electricity, the other waste streams end up being dumped in the plantation while POME is treated in anaerobic lagoons. Both activities result in the uncontrolled released of large quantities of methane into the atmosphere. With all the potential areas for improvement (as identified in Section 2), typical projects that are potentially eligible as CDM project include; waste to thermal energy, methane recovery, and co-composting (Kyoto Energy, 2008).

13.1 Use of palm oil waste for the production of thermal energy

EFB and PKS are wastes generated by the palm oil milling process at the rate of 23% and 7% respectively from processed FFB. PKS generated during the palm oil mill are commonly used as a boiler fuel while EFB are left to decay naturally in the plantation. Since the ban imposed by the Malaysian government in 2000 on open-air burning particularly in the palm oil industry, mills are facing the challenge to dispose large amounts of waste. Nowadays, a common practice consists of stock piling waste in the mill premises and eventually transport these waste to the plantation sites to decay. EFB biomass residues are abundant and are combustible in the boiler. However, the fuel characteristics of EFB are poor (low calorific value, high moisture, formation of clinkers), co-combustion of PKS or other biomass might be required to improve the combustion process. EFB is characterised by a low homogeneity and high moisture content that entails technical sophistication in a project. The production of energy from EFB requires specific technological development which is not well developed yet in Malaysia. However, according to Finpro (2001), at least a Malaysian company Szetech Engineering Sdn. Bhd manufactures equipment for pre-treatment of EFB prior to conventional boiler combustion. The major problems are linked to the poor fuel characteristics of this biomass residue causing unstable combustion.

On the other hand, PKS is another waste generated by the palm oil industry that is also used as a boiler fuel at the mills. The challenge that PKS poses is on identification of some efficiency measures to the current system and from that identify possible technological options that could improve the processing of PKS. For example, considering the high calorific value of the PKS the use of the excess shells as fuel for generating power or electricity in gasification plants for villagers or palm oil mills could possibly be an option for an optimum and efficient waste utilisation.

13.2 Methane recovery with energy production

POME is characterised by a very high organic matter contents derived from the organic fractions of the palm oil production process with an average BOD and COD level of 25,000 and 55,000 mg/L, respectively. POME is ranked among the strongest industrial wastewater in terms of

organic matter contents in the world, and the most significant because of its large volume generated from the palm oil industry.

Typically, POME is treated in open lagoons before discharge. The anaerobic decay of organic matter inside the lagoons is accompanied by the production of biogas containing methane, usually released in the atmosphere in an uncontrolled manner. The challenge for improvement in this respect is to improve the collection efficiency, treatment and utilisation of methane for energy.

13.3 Co-composting of POME and EFB

Green waste composting facility is the treatment component of an agricultural management system for the biological stabilisation of organic waste material from palm oil mills (i.e. EFB, boiler ash, and palm oil mill effluent and decanter sludge). The main objective is to reduce the pollution potential of organic agricultural waste to surface and ground water. The challenge in this area is to find efficient technological options for better and more efficient composting facilities and biogas collection and utilisation technologies (e.g. for combustion, grid energy).

14. Organisation of the CDM projects in Malaysia

Since the ratification of the Kyoto Protocol, Malaysia has been working on the implementation of the CDM. The entire institutional setup for evaluating CDM project applications at the national level is in place since 2003. The following institutions are the main players involved in CDM project implementation and evaluation in Malaysia:

The Ministry of Natural Resources and Environment which has been appointed as the Designated National Authority (DNA) to be the official focal point for CDM with the main task of evaluating CDM projects.

On 31st May 2002, the National Steering Committee on Climate Change (NSCCC)²¹ agreed on the establishment of a two-tiered organisation for CDM implementation in Malaysia, thus establishing the national institutional arrangement for the CDM. The two-tiered institutional CDM set up is composed of:

- The National Committee on CDM (NCCDM) - Review and evaluate CDM project proposals as requested by the DNA and assist DNA in other CDM policy issues for which they seek advice; and
- Two Technical Committees (The technical committee on energy and the technical committee on forestry) - Carry out technical and financial evaluation of the CDM project proposals using the recommendations provided by the Secretariat resulting from their first evaluation of the projects.

Pusat Tenaga Malaysia (PTM) was appointed as the Secretariat to the Technical Committee on Energy, while the Forest Research Institute Malaysia (FRIM) was appointed as the Secretariat to the Technical Committee on Forestry. The main roles of PTM and FRIM as CDM Secretariats are to assist the Technical Committees in evaluating CDM proposals, to provide policy inputs on CDM to the Government, to conduct CDM outreach activities, and to provide guidelines and advisory services to potential local and foreign CDM investors in the respective sectors (CDM Malaysia, 2008b).

²¹ The NSCCC is to formulate and implement climate change policies including mitigation of GHG emissions and adaptation to climate change.

PART III. GREENHOUSE GAS BALANCE IN PALM OIL MILLING

15. GHG balance and carbon footprinting

One of the key sustainability requirements for renewable transport fuel usage is the realisation of GHG emission savings. The EU directive proposal on the promotion of the use of energy from renewable sources (RES Directive) stated that GHG reduction has to be at least 35% compare to the use of fossil transport fuels (European Union, 2008). In palm oil production, GHG emissions typically arise from the raw material cultivation, processing and transport. The end-use of renewable transport fuel is considered free from CO₂ emissions.

Carbon footprint calculation is the methodology for calculating the GHG emissions of a product chain based on the principles of life cycle assessment (LCA). An earlier carbon footprint study by Nikander (2008) evaluated the GHG emissions of the NExBTL-diesel product chain with the three different raw materials: animal fats, palm oil and rape seed oil. From the said study, the supply chain of NExBTL-diesel was drawn as in Figure 15.1 while the results of the carbon footprint calculation for palm oil product chain are presented in Table 15.1.

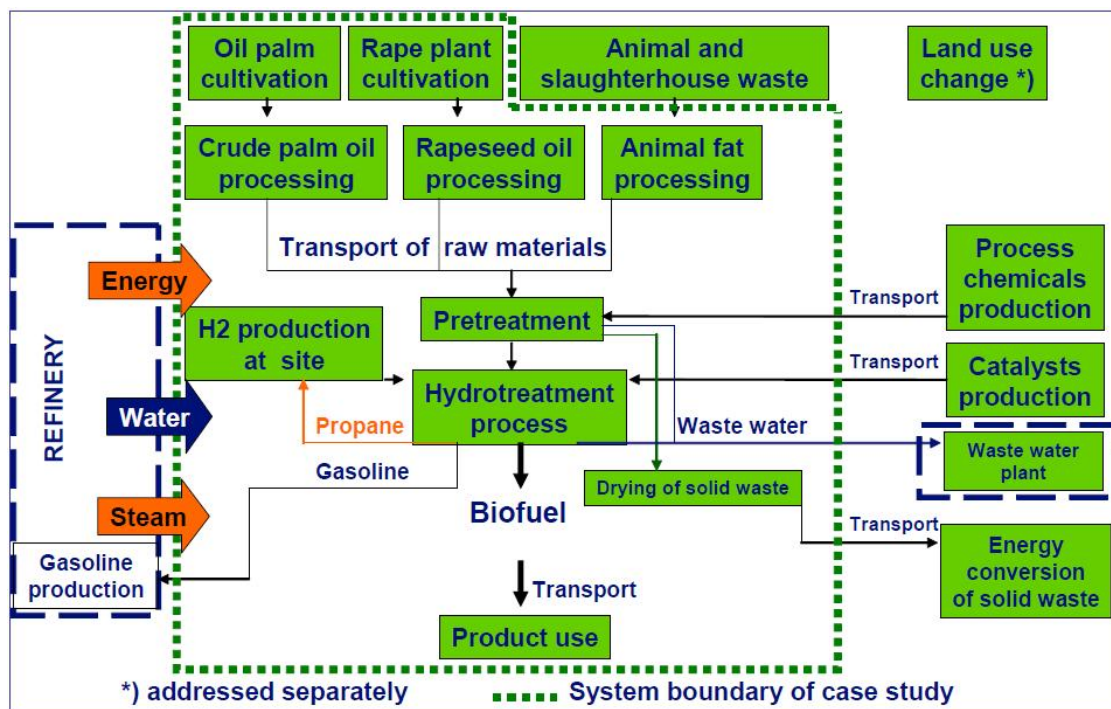


Figure 15.1. The supply chain of NExBTL-diesel (Nikander, 2008)

Table 15.1. Fossil greenhouse gas emissions during palm oil product chain of NExBTL-diesel. Allocation by mass between crude palm oil and kernel (Nikander, 2008)

Product chain phase	Palm oil not allocated		Palm oil allocated	
	Fossil CO ₂ e [gCO ₂ e/MJ _{biofuel}]		Fossil CO ₂ e [gCO ₂ e/MJ _{biofuel}]	
Raw material cultivation	8,72	18%	6,54	19%
Raw material processing	26,36	54%	19,77	58%
Raw material transport	2,37	5%	2,37	7%
Biofuel production	10,47	22%	5,04	15%
Product transport	0,66	1%	0,66	2%
Product use	0,00	0%	0,00	0%
Land use change	0,00	0%	0,00	0%
Total	48,58	100%	34,38	100%

(The carbon intensity of fossil fuel is 83.8 gCO₂/MJ_{fossil fuel}.)

Based on Nikander's (2008) study, the fossil CO₂ emission from palm oil mill is 19.77 gCO₂e/MJ_{biofuel}, if emissions are allocated by mass. The production of NExBTL-diesel meets the EU requirement of 35 % greenhouse gas reduction with palm oil. With the results of the study, the GHG reduction is:

$$\begin{aligned}
 \text{Reduction (no allocation)} &= 1 - \frac{\text{biofuel}}{\text{fossil.fuel}} = 1 - \frac{48,58 \text{ gCO}_2\text{e} / \text{MJ}_{\text{biofuel}}}{83,8 \text{ gCO}_2\text{e} / \text{MJ}_{\text{fossil.fuel}}} = 42 \% \\
 \text{Reduction (allocation)} &= 1 - \frac{\text{biofuel}}{\text{fossil.fuel}} = 1 - \frac{34,4 \text{ gCO}_2\text{e} / \text{MJ}_{\text{biofuel}}}{83,8 \text{ gCO}_2\text{e} / \text{MJ}_{\text{fossil.fuel}}} = 59 \%.
 \end{aligned}$$

A more detailed study on the material flow chain of palm oil-based diesel production was conducted by Smith (2007) as shown in Figure 15.2. Briefly, the material flow starts where palm oil is cultivated in oil palm plantations, the harvested fresh fruit bunches delivered to crude palm oil mill where the crude palm oil (CPO) is extracted and finally CPO delivered to a refinery where NExBTL-diesel is produced through hydrotreatment process. The crude palm kernel oil (PKO) is not used in NExBTL-production (Neste Oil, 2008). The carbon footprint study carried out by

Nikander (2008) stated that over 50% of life cycle GHG emissions from the palm oil material chain arise from the raw material processing in palm oil mill.

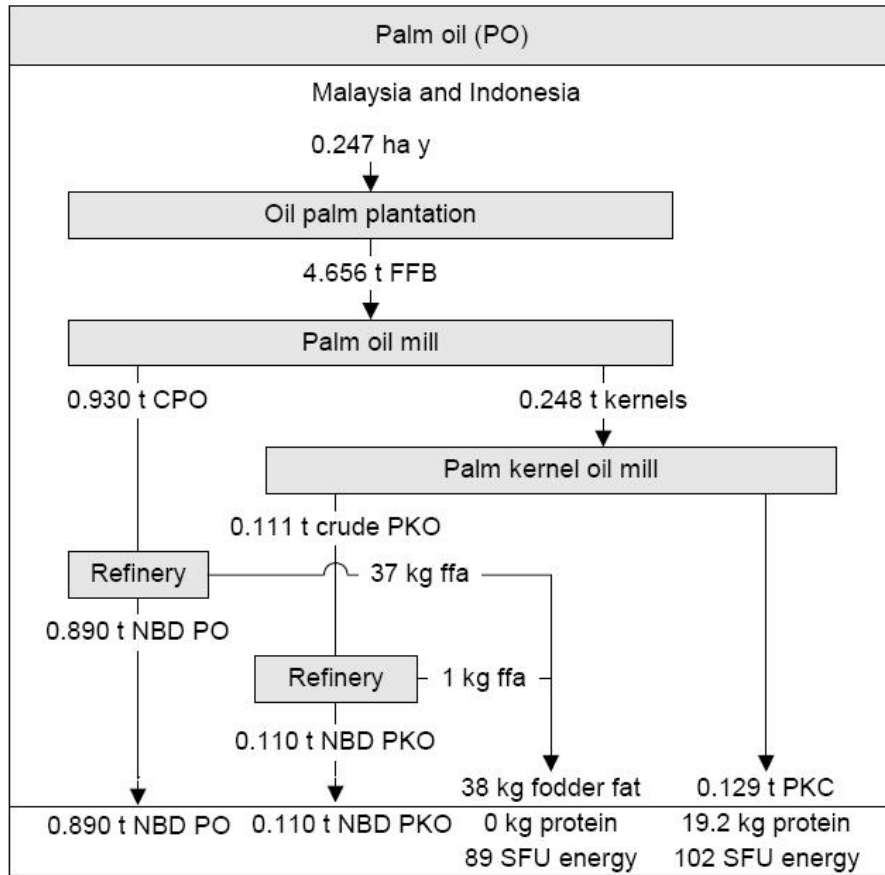


Figure 15.2. Material chain for renewable diesel production (NBD PO) from palm oil (Schmidt, 2007)

Since palm oil is used as the main raw material for NExBTL-diesel, there is a need to focus on this product chain. To identify further life cycle GHG reduction potential for palm oil-based diesel, this raw material processing phase needs to be studied. It is the phase where the CPO is extracted from the fruit bunches in a mill close to the oil palm plantation. Various studies on CPO milling point to the high methane emission from the palm oil mill effluent (POME) treatment and the possibilities for GHG reductions exist in mill co-product end-use as well (Schmidt, 2007 and Yusoff *et al.*, 2007).

Building from the aforementioned studies, this part of the report is a further study conducted to identify and quantify the key aspects that have impact on GHG emissions of a typical palm oil mill and to study the potential GHG emission reductions from CPO milling using different technological improvements. The other objective of this study was to compare the results achieved and methods applied in GHG balance calculation to the GHG values proposed in the RES Directive of the European Union. Furthermore, the study was aimed at evaluating the possibility for Finnish technology-transfer relevant to palm oil process improvement and GHG emission reduction.

16. Study unit: palm oil production (milling) process

Based on the illustration and discussion in Section 3, the palm oil extraction process can be summed up into the following processes:

- sterilisation of the FFB;
- separation of fruit from empty fruit bunch = stripping or threshing;
- digestion of the fruit;
- separation of the oil from solid material, with pressure or hot water;
- clarifying, purifying and drying the CPO;
- palm oil mill effluent (POME) collection to sludge pits and biological treatment;
- fibre, shell and kernel separation from the press dry cake;
- electricity and steam generation from fibre and shell; and
- crude palm oil and kernel delivery to customers

Detailed description of the unit processes of a large scale palm oil mill can also be found in Appendix 4.

According to several inventory studies, the main material inputs for a palm oil mill are FFB from plantations and water for the process and steam generation. Although there are occasions when the power from the grid and diesel as boiler start-up fuel are needed, the mill can still be considered over self-sufficient on energy. Electricity and steam for the mill is produced from fibres and shells, co-products of the CPO extraction process (Subramaniam *et al.*, 2008; Schmidt, 2007; and Yusoff *et al.*, 2007).

The process outputs from palm oil milling are CPO, palm kernels, fibres, shells, EFB and POME. The valuable outputs of a mill are CPO and palm kernel, which are sold to subsequent processors. Shells and fibres are considered valuable co-products because these are readily used as fuel in electricity and steam production in the mill. EFB can be treated as solid waste or as co-product which can be used for mulching or for energy generation. POME is wastewater with high organic content and is therefore best treated by anaerobic treatment. The high methane production potential of POME is problematic for the environment if released to atmosphere, but can be considered as a major possibility for biogas production if collected.

The process outputs with adverse environmental impacts are the treated wastewater, methane from POME treatment and the flue gases from the boiler. Methane is a greenhouse gas with high global warming potential (GWP = 25) and its release from anaerobic ponds is a major issue in palm oil production. Fibres and shells are used as biofuel in the mill boiler, hence, the flue gases can be considered CO₂-neutral. The problem with using biomass is the high concentration of particulate matter in the flue gases (Yusoff, 2007).

POME treatment in anaerobic ponds is the source of direct GHG emissions. The high amount of methane formed in anaerobic digestion has a major negative impact on GHG balance. Carbon dioxide from POME treatment and from burning of co-products in energy production can be considered CO₂-neutral. The FFB have annual crop yield and the carbon stored in products and co-products are released to atmosphere within a year. Therefore, the carbon balance in the

atmosphere is neutral. GHG emissions are also derived from raw material, product and co-product transport.

17. Principles in carbon footprint calculation

Carbon footprinting is a relatively new methodology for carbon balance calculation and also an emerging new field of research. The demand to calculate carbon footprints for products and services has increased recently, since the global interest in the climate change has increased. Carbon footprint calculation is a tool for many businesses to market their green products as well as for policy-makers and the general public to obtain information on the effect of different goods and services on climate change.

Carbon footprint calculation is based on life cycle assessment (LCA) methodology, however, it is limited to solely address the impact category of global warming. LCA methodology is based on international standards, ISO 14040 and ISO 14044, which offer the basis for carbon footprint calculations as well. However, there is a need to establish own standards for carbon footprint calculation since LCA standards leave room for various interpretations when used as the basis for carbon footprint assessment. A consistent method to calculate carbon footprint does not exist yet. It is important to specify the common principles for carbon footprint calculation so the carbon footprints of different products and services can be considered comparable. There is a high probability that LCA practitioners address the yet undefined questions for their own advantage in the calculations. For example, issues such as the time scale of the calculation, inclusion of avoided emissions in the calculation, omission of capital goods, carbon sequestration in products and end-use are still open to subjective interpretation.

BSI Standards Solutions has published a publicly available *"Specification for the Assessment of the Life Cycle Green House Gas Emissions of Goods and Services"*, abbreviated as PAS 2050:2008 (BSI, 2008). The specification and guidance documents are aimed to unify the carbon footprint assessment methods in order to allow better comparison between different goods and services. It is the latest non-industry specific guidance for carbon footprint calculation and another step towards international carbon footprint standardisation. PAS 2050 builds on existing LCA methods established through ISO 14040 and ISO 14044 by specifying requirements for the assessment of the life cycle GHG emissions of goods and services. Some principles given in PAS 2050 differ from the ISO 14040 series and the relevant principles are discussed here.

Allocation of emissions between multiple products is to be carried out, if inputs and outputs of a unit process cannot be divided into sub-processes or if expanding product system is impossible. The allocation of emissions is to be performed in relation to mass or energy content according to the ISO 14040 series. PAS 2050, on the other hand, instructs the use of economic allocation if allocation procedures cannot be avoided. The allocation in relation to mass or energy is easier to measure and to validate. The disadvantage of mass or energy allocation is that it does not divide the emissions based on the rationale for the activity. Trade is the ground for the majority of modern day activities, not the output of mass or energy. Economic allocation is based on the assumption that the valuable good or service output is the reason for the activity and emissions are allocated according to the revenue of products. However, due to fluctuation in the market prices of goods, uncertainties exist in the use of economic allocation. The use of average economic values of the products may lead to some misinterpretations. This matter has to be properly understood and explained if economic allocation is to be used.

According to ISO 14044, the applied inventory data can be from direct measurement on site or they can be obtained or calculated from other sources. In PAS 2050, the data is divided into two classes - primary and secondary activity data. Direct data collected or measured from site is referred as primary activity data and the indirectly obtained or calculated data as secondary activity data. PAS 2050 stipulates conditions for the use of primary and secondary activity data. Primary data is required for the activities owned by the organisation conducting carbon footprint calculations, and for upstream activities if less than 10% of the GHG emission of the life cycle of the product is bound from own activities. However, some exceptions to the rule are given in the PAS 2050. Secondary data has to be from reliable sources.

PAS 2050 declares the use of common Product Category Rules (PCR) in the system boundary setting, if available for the product. The list of existing PCRs can be found at www.environdec.com. There was a limited number of PCRs available in autumn 2008.

The effect of biogenetic CO₂ is considered neutral to global warming in PAS 2050. No GHG balance calculation is required between the carbon sequestration in the raw material biomass growth and biogenetic CO₂ release. The possible difference is addressed by calculating the carbon storage in the products and carbon sequestration in the end-use in landfill.

As stated in ISO 14044, sensitivity analysis is the procedure to determine how changes in data and methodological choices affect the results of the LCA. If great variance exists in multiple variables, for example, process inputs and outputs or optional processing technologies, a sensitivity analysis between each scenario can be carried out.

Direct, indirect and avoided emissions

According to Miner and Perez-Garcia (2007), Confederation of European Paper Industries (CEPI, 2007) and PAS 2050, the GHG emissions can be divided into three classes: direct, indirect and avoided emissions. On the other hand, the GHG protocol divides emissions to direct and indirect only (GHG Protocol, 2008).

Direct emissions are emissions that occur from sources owned or controlled by the operator, and therefore the company has the most control over these emissions. Emissions associated with fuel consumption at the production site, management of mill wastes and secondary manufacturing operations are considered as direct emissions (Miner and Perez-Garcia, 2007). Sometimes secondary manufacturing is not controlled by the operator, so these emissions are considered indirect. Direct emissions are at the primary focus nowadays. They are currently regulated in many countries and jurisdictions, and are likely to be regulated even more in the future, hence, it is advisable for a company to identify these emissions accordingly.

Indirect emissions are emissions that occur from sources that are not owned or controlled by the operator, but they occur as a result of the industry's activities. Emissions associated with purchased power and methane from landfills are considered as indirect emissions. Transportation can be considered as direct or indirect, depending on the ownership of the transport capacity (Miner and Perez-Garcia, 2007).

GHG emissions could be avoided by substituting waste streams for virgin materials in the production of energy (energy substitution) or materials (material substitution) outside the studied system boundary. Emissions can be avoided by using less GHG emitting practices instead of GHG intensive practices to produce energy. A good example is the situation where fossil fuels are replaced with biofuels, or the energy content of waste is utilised in waste incineration and the energy from the waste replaces fossil-based energy. In addition, emissions can be avoided by material substitution or by changes in the end-of-life treatment.

18. Methodological considerations in carbon footprinting

This gate-to-gate carbon footprint study in palm oil milling phase was conducted with the LCA methodology. The sole impact class of global warming was included. The study was based on secondary scientific data and the calculations carried out with a LCA tool called GaBi 4.3.

18.1 Goal and scope definition

The goal of the study was to calculate the range of GHG balance of a large scale palm oil milling, according to the commonly accepted carbon footprint assessment principles. The range of GHG emission levels in palm oil milling were calculated with four different technological solutions, thus making up to a total of 24 scenarios. The variables were energy consumption and material balance of a palm oil mill and the end-use options of the co-products such as POME, shells, fibres and EFB. The obtained results were then compared to the values given in RES directive proposal.

The carbon footprint study was carried out in accordance with LCA standards, ISO 14040 and ISO 14044 and the British publicly available specification PAS 2050. The results of this study can be used later on to identify the best practices to reduce the GHG emission levels in palm oil milling. Results can also be used to set sustainability requirements for crude palm oil providers in the renewable diesel production chain. Additionally, this study was carried out to widen the understanding and promote the transparency in the calculations behind emission savings values.

18.2 Functional unit

The functional unit of the final results of the study is Mega Joule (MJ) of NExBTL-diesel (brand name for HVO-diesel of Neste Oil). This functional unit allows the comparison to the results of other renewable fuel studies. However, the inventory data of palm oil mill was gathered based on metric tonne of FFB and the emissions calculated based on metric tonne of CPO. The conversion of tonne of CPO to MJ of biofuel is based on the figures given out by Neste Oil in the carbon footprint study of NExBTL-product chain by Nikander (2008).

18.3 System boundary

The system boundary of this GHG balance study is presented in Figure 18.1.

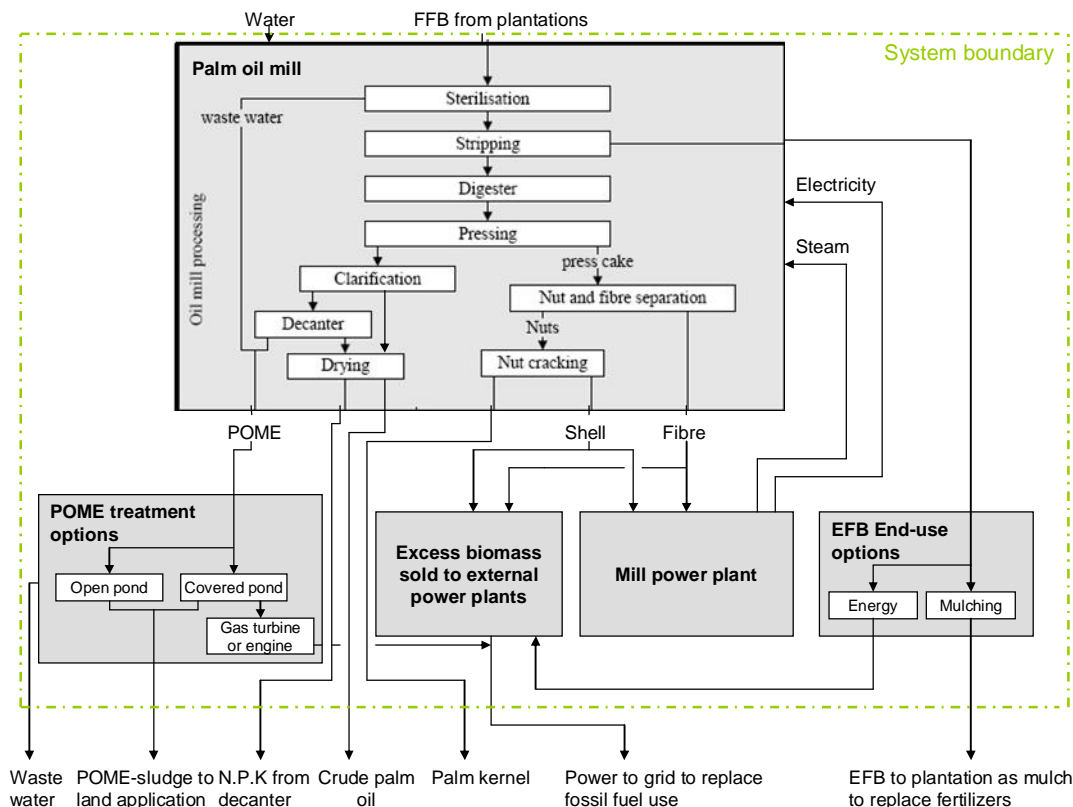


Figure 18.1. The system boundary of GHG balance study.

The palm oil mill processing is handled as one unit process since the unit process specific (sterilisation, stripping, etc.) inputs and outputs were not available. FFB, water, electricity and steam are the main inputs for the palm oil mill unit process. Data on water consumption is omitted because it has no direct effect on GHG balance. The relevant outputs are POME, nutrients from decanter, CPO, kernels, shells, fibres and EFB. The output of nutrients from decanter was assumed to be 0 kg, because the use of decanter in water processing is not a common practice (Schmidt, 2007).

For POME treatment unit process, the input is obviously the wastewater with high organic content. POME is traditionally discharged to open pond for anaerobic treatment. The outputs from the POME treatment are methane and carbon dioxide to air, solid POME sludge and wastewater. The wastewater release is irrelevant to GHG balance and is therefore omitted. The POME sludge is put back to the oil palm plantations and is therefore omitted in this gate-to-gate study. If the biogas containing methane and CO₂ is collected, it can be used as renewable fuel for a gas turbine or engine.

Mill power plant generates steam and electricity for the mill from fibres and shells, the co-products of the oil mill unit process. Although the power plant uses fuel oil as start-up fuel, the steam generation from fibres and shells are considered CO₂-neutral.

EFB are traditionally used as mulching material in the oil palm plantations. The energy conversion is another possibility to consider for EFB because it can be used as biofuel in energy production similar to excess fibres and shells. The biomass can be burned in the premises of the mill and the excess power can be fed to the national power grid (if accessible). The fuel can be delivered to a third party power plant in case that no national power grid is accessible.

The flow sheet used in GHG balance calculations using LCA tool GaBi 4.3 is presented in Appendix 5. Additionally, PAS 2050 proposes the use of common Product Category Rules (PCR) in setting the system boundary, if available for the product. The list of existing PCRs can be found at www.environdec.com. There is no PCR available for palm oil and therefore such common system boundary was not applied.

18.4 Allocation procedures

The valuable outputs of a palm oil mill are CPO and palm kernels. The GHG emissions were allocated between the two products with economic allocation. The latest British carbon footprint specification document (PAS 2050:2008) suggests the use of economic allocation, if the inputs and outputs cannot be divided into sub-processes or if expanding product system is impossible. The results are communicated both with economic allocation and without allocation procedures in Section 19. Information on monthly average prices of CPO and palm kernels were collected from the years 2007 and 2008, which were available in MPOB website (MPOB, 2008).

Since there is fluctuation in the market prices of raw materials, some uncertainties exist in the use of economic allocation. The use of average economic values of the products may lead into some misinterpretations. To reduce the uncertainty, the use of monthly market value ratio of CPO to palm kernel was applied in the economic allocation. Although the prices fluctuated heavily during the two year period (2007/2008), the relative monthly market value between the two products remained constant. The monthly market value of CPO was 1.72 times higher than the value of palm kernel in 2007 and 1.64 times higher in 2008, on average. The average of the relative market value of CPO was 1.68 times the value of palm kernel in the two year period, with an acceptably small standard deviation of 5%. The factor 1.68 was used in the economic allocation. The full data and explanation of the calculation method is presented in Appendix 6. The allocation of emissions between the two flows is presented in Table 18.1.

Table 18.1. Economic allocation of emissions between crude palm oil and palm kernel.

	Mill output [kg/t FFB]	Share of mass	Relative market value [€,kg/€,kgPK]	Relative value [€]	Share of revenue
CPO	200	74 %	1.68	336	83 %
Palm kernel	70	26 %	1	70	17 %
<i>Total</i>	<i>270</i>	<i>100 %</i>	<i>n/a</i>	<i>406</i>	<i>100 %</i>

Note: A total of 83 % of the emissions of the milling phase was credited to CPO.

18.5 Data sources and quality

This study utilised the best available secondary data. There are several published academic articles and inventory reports available on palm oil mills (Subramaniam *et al.*, 2008; Nikander, 2008; RTFO, 2008; Schmidt, 2007; Yusoff *et al.*, 2007; and Gheewala *et al.*, 2004). Majority of these inventory reports are based on direct measurements on site and therefore considered as the best available secondary data. The peer review requirement for such published articles assures the quality of the data.

The GHG emission data on transport and Malaysian power grid mix was based on the life cycle tool GaBi 4.3 database. Since this study is not a case study but is aimed to find the range of GHG balance of a large scale palm oil milling, the average data from the studies mentioned above were applied as listed in Appendix 7. The range of relevant inventory data on carbon intensity of palm oil mills was studied.

18.6 Material balance of palm oil milling process

In this study, the focus was set on large scale palm oil mills because those mills were the only vendors with enough CPO production capacity catering for the European diesel refineries. Large scale crude palm oil mills have a capacity of up to 100 tonnes of FFB/h (Subramaniam *et al.*, 2008). A detailed description of the unit processes of a large scale palm oil mill is shown in Appendix 4. It is assumed that the vendors for renewable diesel refineries are at the technological level described in Appendix 4.

Inventory data for palm oil mills was based on seven scientific articles on 17 large scale palm oil mills. The data was converted to uniform unit of metric tonne of FFB, analysed, and ruled out unacceptable data. The full inventory data from the earlier studies can be found in Appendix 7. Average, lowest and highest accepted values for relevant inputs and outputs of the mill are presented in Table 18.2. The water consumption, amount of boiler ash, capital goods, volume of wastewater and minor chemical consumption in POME treatment were omitted as irrelevant variables to carbon footprint calculation.

Table 18.2. Lowest, average and highest values for the relevant inventory data for palm oil mills per tonne of FFB. Source: (Subramaniam *et al.*, 2008; Nikander 2008; RTFO 2008; Schmidt, 2007; Yusoff *et al.*, 2007, and Gheewala *et al.*, 2004)

Per tonne FFB			
INPUTS	Lowest	Average	Highest
FFB [kg]	1000	1000	1000
Electricity [MJ]	58	65	75
Steam [MJ]	1100	1400	1700
Diesel for Mill[L]	0.24	0,48	0.96
Diesel for Vehicles [L]	0.03	0.37	0.73
OUTPUTS			
CPO [kg]	190	200	210
EFB [kg]	220	240	300
Fibre [kg]	120	140	160
Shell [kg]	50	70	80
Palm kernels [kg]	50	70	80
POME [kg]	500	590	700
CH ₄ [kg] / POME [t]	12,36	13	13,05
CH ₄ [kg]	6,2	7,7	9,4

The values represent the inputs and outputs of the milling process, not the flows at the system boundary. These are further clarified in the process flow chart in Figure 18.2.

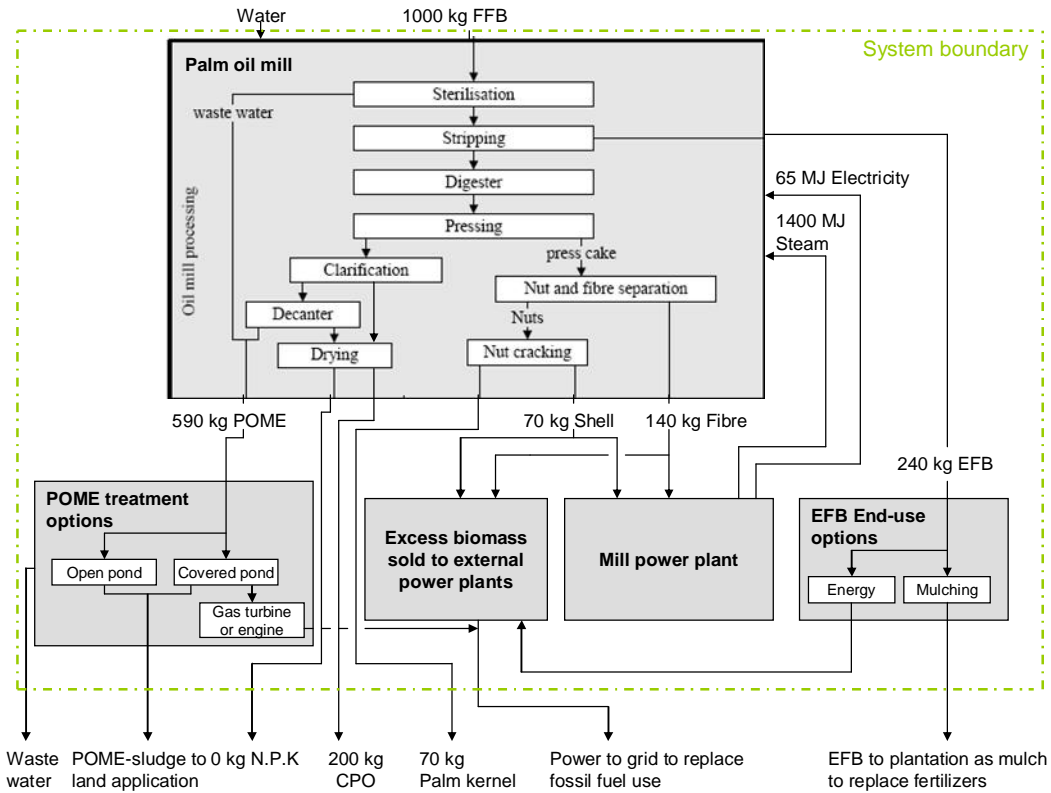


Figure 18.2. Average inputs and outputs of the palm oil mill

POME is discharged from the milling process to wastewater treatment, traditionally to anaerobic digestion in open ponds. Both open and covered ponds were studied. Some palm oil mills extract a considerable share of the solids from POME with a decanter prior to treatment. The decanter cake can then be mixed with inorganic fertilisers. However, the use of this technology is not a common practice (Schmidt, 2008). Hence, the fertiliser (NPK) output is considered as 0kg for a typical palm oil mill. The outputs of wastewater and POME sludge to land application were omitted as irrelevant variables to GHG emissions of the milling phase.

The fibre and shell co-products are fed to the mill power plant for steam and electricity generation. In many mills, there is an oversupply of these biofuels however varying in amount depending on the energy efficiency of the milling process. According to Schmidt (2008), it is common to feed all the fibres and shells to the boiler and release the excess steam into the air. However, according to inventory study conducted by Subramaniam (2008), the excess fibres and shells are sold as fuel in all 12 palm oil mills studied. This option offered by Subramaniam (2008) was considered in this study.

EFB are traditionally used as mulching material in the oil palm plantations. However, the use of EFB for energy generation is increasing as prompted by the proliferation of CDM projects on EFB biofuel use. Given the usefulness of EFB, both end-use options for EFB were considered in this study.

18.7 Direct, indirect and avoided emissions

GHG emissions are divided into three classes: direct, indirect and avoided emissions.

POME treatment in anaerobic ponds is the source of direct methane emissions in palm oil mills. Direct carbon dioxide release from POME treatment and from burning of co-products in energy production is biogenic and can be considered CO₂-neutral.

The indirect GHG emissions are derived from raw material, product and co-product transport. The raw materials and product transport are outside the system boundary of this gate-to-gate study, as they are included separately in carbon footprint studies of cultivation and fuel transport phases of renewable diesel product chain. The fibres, shells and EFB transported to third party power plant are calculated as indirect emission in this study.

Avoided GHG emissions are achieved when the system outputs replace fossil energy use outside the system boundary. Avoided emissions can be achieved when biogas, fibres, shells or EFB are provided to third party as a source of energy. Avoided emissions are achieved in chemical fertiliser production when EFB is used in mulching.

18.8 Scenario setting

There are various possibilities for the end-use of co-products of a palm oil mill and therefore a scenario analysis for the combination of different variables was applied. The four major variables that have an effect on GHG balance of a palm oil mill are:

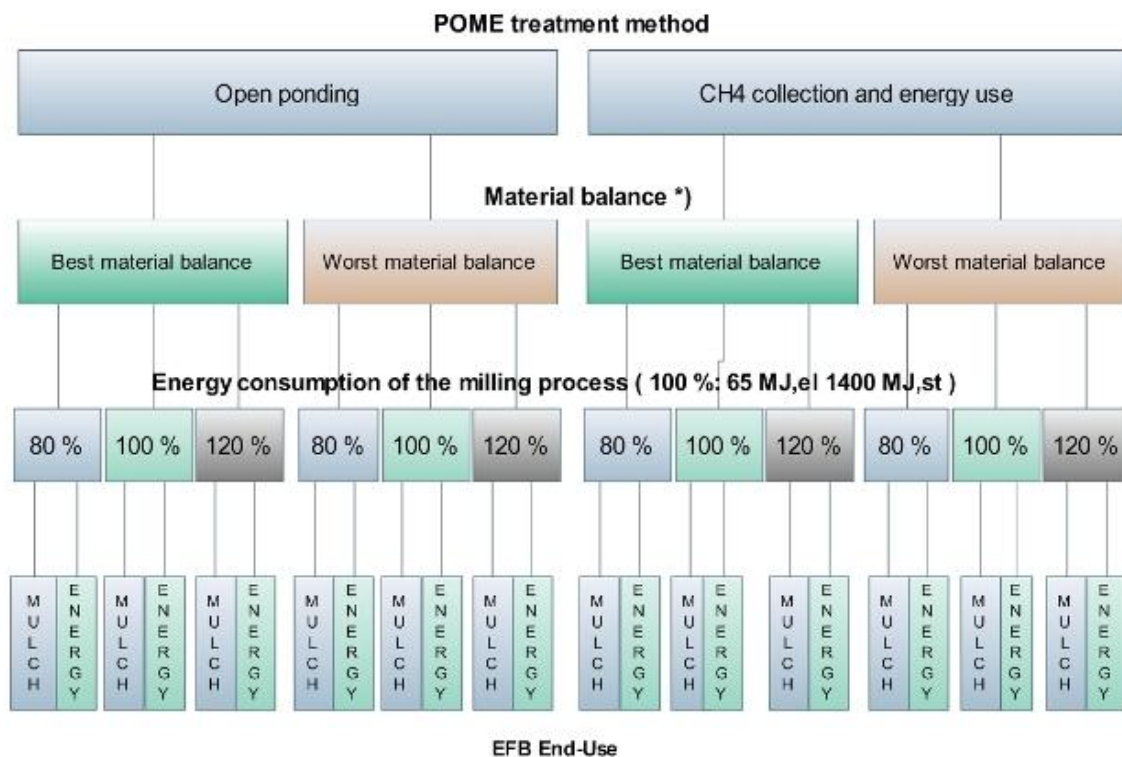
- POME biogas collection or release to atmosphere;
- The end-use of EFB as mulch or as energy;
- Energy consumption of the milling process; and
- Material efficiency of the milling process.

Biogas from POME treatment is traditionally released into the air. GHG reductions and a source of biofuel can be obtained with the collection of biogas and consequent energy use. The direct GHG emissions are reduced by collection and avoided emissions achieved with the energy utilisation.

EFB are traditionally used as mulching material in oil palm plantation but using it for energy is becoming popular. The avoided emissions related to chemical fertiliser replacement in mulching is calculated, as well as the avoided emissions in energy use. The Malaysian government has set targets to increase the share of renewable energy in the nation wide power supply mix and has set various incentives to promote the energy use of biomass, such as EFB (Carlos *et al.*, 2007).

The lower energy consumption (or improved energy efficiency) of the milling process has indirect impact on GHG emissions. If the energy demand of the mill is smaller, less fibres and shells are needed inside the system boundary. This excess energy can be sold to third party as energy or fuel and avoided emissions are achieved. The current incentives set by Malaysian government for biofuels support this market, and a recent inventory study confirms that such practice is widespread (Carlos *et al.*, 2007; and Subramaniam, 2008).

Material efficiency has complex effects on the GHG balance of a mill. The more CPO is extracted from a unit of FFB, the less GHG are released per unit of CPO. If less degradable organic material is directed to open ponds, the methane emission is smaller. This is a factor of both the volume of POME from process and the concentration of degradable organic material. On the other hand, more energy can be obtained with biogas collection system, if the degradable organic material load is higher. Furthermore, the more fibres, shells and EFB are obtained from a unit of FFB, the higher the energy use potential and subsequent avoided emission. With limited knowledge on the process, an assumption is made that the differences in the material balances of the mills are attributed to different compositions of FFB. The other assumption is that, the mills with less efficient product and co-product extraction rates lose this material into POME, as there are no other significant waste streams reported. With the four variables, 24 different scenarios were created as presented in Figure 18.3.



*) The range of the material inputs and outputs of the mill. Best and worst material balances are defined in Table 18.3.

Figure 18.3. Different scenarios for palm oil mill

The POME is treated either in an open pond or in a covered pond with methane collection. The relationship between inputs and outputs vary across mills. As such, the range of variation is presented in Table 18.2. The best and the worst scenarios for the material balance of the mill were defined, which are presented in Table 18.3. The average electricity and steam consumptions of the milling process are 65 MJ_{el} and 1400 MJ_{st}, respectively. The effect on GHG balance of a 20% lower or a 20% higher energy consumption was set as one variable, communicated in numbers in Table 18.4. The EFB end-use options are either mulching or energy conversion. This adds up to a total of 24 scenarios for palm oil mill GHG balance.

Table 18.3. Best and worst scenario for palm oil mill material balance

Per tonne FFB		
INPUTS	Worst	Best
FFB [kg]	1000	1000
Diesel for Mill[L]	0.48	0.48
OUTPUTS		
CPO [kg]	190	210
EFB [kg]	220	300
Fibre [kg]	120	160
Shell [kg]	50	80
Palm kernels [kg]	50	80
POME [kg]	700	500
CH ₄ [kg] / POME [t]	13	13
CH ₄ [kg]	9,1	6,5

Table 18.4. Steam and electricity consumption of palm oil mills with 80 %, average and 120 % energy consumption

Energy consumption	80%	100%	120%	Unit
Electricity consumption	52	65	78	MJ/t _{FFB}
Steam consumption	1120	1400	1680	MJ/t _{FFB}

As presented in Table 18.3, the material balance is considered to be the best for GHG balance when the yield of CPO and energy co-products, fibres, shells and EFB are at highest and the amount of POME is at lowest possible. In the worst considered material balance, POME output is high and CPO and energy co-product is low.

18.9 Key assumptions in the GHG balance calculation

A number of assumptions were made in this carbon footprint calculation. These were as follows:

The methane formation was assumed to be constant at 13kg per tonne of POME. This is the widely used assumption in literature, which somewhat represents the situation when a fraction of biogas is 65% methane and 35% is CO₂. However, the volume of biogas formed and the fraction of methane in biogas varies significantly with different techniques and circumstances. A baseline study on methane emission from POME treatment by Yacob *et al.* (2005) concluded that the fraction of methane in biogas varies and average methane formation is lower (12.4 kgCH₄/t POME) than generally assumed. The widely used assumption of 13kg per tonne was applied.

When methane is collected and burned, not all of it is converted into energy and CO₂. Based on a CDM project reported by Schmidt (2007), the collection percentage of biogas is 92.2%, and 8.4% of the collected methane does not react in the gas turbine or engine. The efficiency of

methane combustion seems rather low, but is applied to LCA model as no other source was found. The fuel-to-electricity ratio of a gas turbine or engine was assumed to be 0.25. These numbers were applied in the POME treatment.

The heating values of co-products burned were obtained from biomass characterisation and previous studies conducted by Finpro and VTT in year 2001 (Finpro, 2001; and Taipale, 2001). The applied average higher heating value, moisture and lower heating value of all the fuels are presented in Table 18.5.

Table 18.5. The applied higher heating values, moisture contents and lower heating values of EFB, fibres, methane and shells

	HHV [MJ/kg]	Moisture [%]	LHV [MJ/kg]
EFB	19.4	60	5.5
Fibre	18.2	40	9.9
Shell	19.3	10	17.1
Methane			50

The fuel-to-energy efficiencies of typical combined heat and power (CHP) plants of palm oil mills vary from 51 to 72% according to Hussein (Schmidt, 2007). The efficiencies reported are much lower than what is achievable with best available technology. Bio-CHP plants in Finland reach fuel-to-energy efficiencies of above 80%. The power plant efficiency was assumed to be 65% in this study for a large scale and modern palm oil mill.

According to Schmidt (2007), the shells and fibres are fed to the boiler in a mass ratio of 35% and 65%, respectively. This is due to the high silicate content of the shell. This assumption was applied to the model. On the other hand, the CH₄ and N₂O emissions from solid biomass boilers were assumed to be negligible.

The co-products sold to third party power plants were assumed to be used in electricity generation. The applied fuel-to-power ratio for power generation was 0.17. The biofuel was assumed to be delivered to a distance of 100 km using an old 22 tonne-truck. The emissions were calculated based on the inventory data of a truck with 28 - 32 tonnes total cap. / 22 tonnes payload/ 1980s' from the GaBi 4.3 database.

Two system expansions were adopted for evaluating the avoided emissions achieved in EFB mulching and co-product bioenergy use in electricity production. System expansion 1 was for the avoided emissions from national power mix and system expansion 2 was for the avoided emissions from the chemical fertiliser production (Figure 18.4).

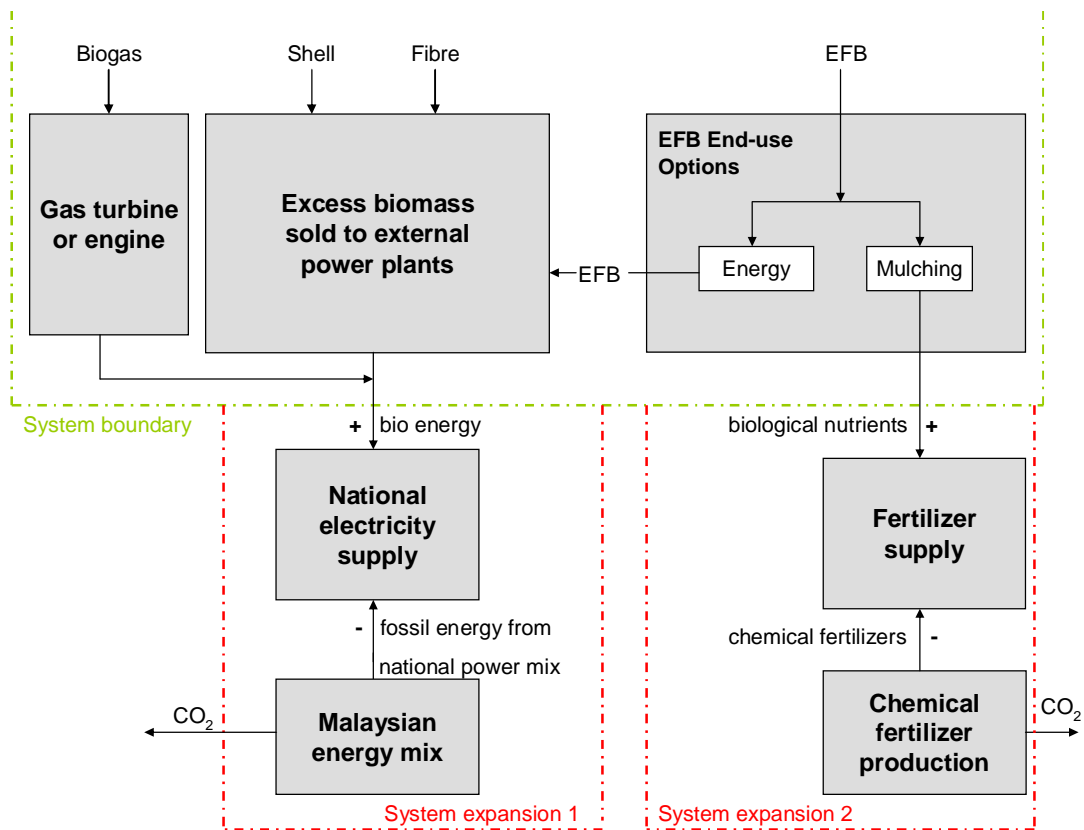


Figure 18.4. System expansions adopted in bioenergy production and in EFB mulching

If EFB are used as mulching materials, it is assumed that these replace the use of chemical fertilisers. The nutrient composition of EFB adopted from Schmidt (2007) is presented in Table 18.6.

Table 18.6. The nutrient composition of EFB (Schmidt 2007)

	Nutrient content of EFB
N content	3.2 kgN/t EFB
P content	0.38 kgP/t EFB
K content	9.6 kgK/t EFB

The equivalent mass of chemical fertilisers and the fossil CO₂ emission from the production is presented in Table 18.7(Schmidt, 2007).

Table 18.7. The equivalent mass of chemical fertilisers and CO₂ emission from production (Schmidt, 2007)

	Equivalent chemical fertilisers	CO ₂ emission factors
N content 3.2 kgN/t EFB	30% Urea: 0.84 kgN / t EFB 70% Ammonium sulphate: 2.36 kgN / t EFB	3.29 kgCO ₂ eq / kg N 2.68 kgCO ₂ eq / kg N
P content 0.38 kgP/t EFB	0.89 kgP ₂ O ₅ / t EFB	2.46 kgCO ₂ eq / kg P ₂ O ₅
K content 9.6 kgK/t EFB	11.6 kgK ₂ O/t EFB	0.50 kgCO ₂ eq / kg K ₂ O

The possible GHG emissions from POME sludge land application in plantations is omitted from this study because those are included in the GHG balance studies of the cultivation phase.

The results of the GHG balance calculations were converted from metric tonne of CPO to MJ of renewable diesel, NExBTL. The conversion was carried out based on the figures given out by Neste Oil which was based on LCA study conducted by Nikander (2008). According to the study, 1.19 kg of CPO is needed for 1 kg of NExBTL and the energy content of NExBTL is 44.2 MJ/kg (Nikander, 2008).

19. Carbon footprint results

19.1 GHG Balance scenarios

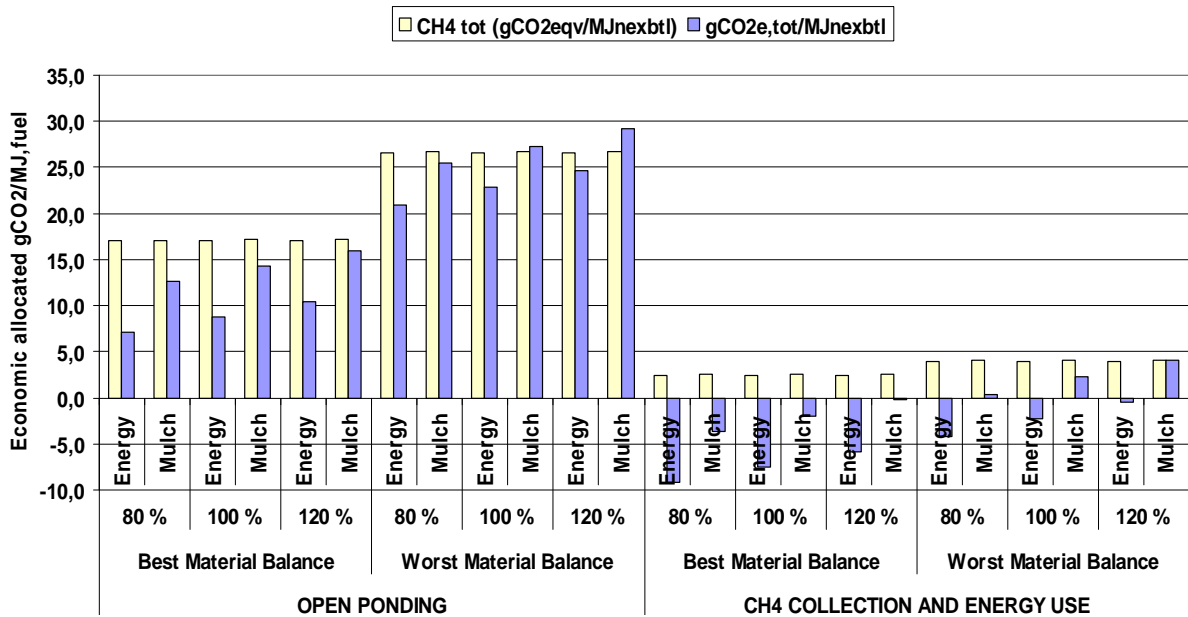
The GHG balances for 24 different scenarios are presented in Table 19.1 and in Table 19.2, respectively.

Table 19.1. Scenarios for GHG balance of palm oil mill in kgCO₂e/tCPO.

POME treatment	OPEN PONDING											
Material balance of mill	Best Material Balance						Worst Material Balance					
Energy consumption	80 %		100 %		120 %		80 %		100 %		120 %	
EFB End-use	Energy	Mulch	Energy	Mulch	Energy	Mulch	Energy	Mulch	Energy	Mulch	Energy	Mulch
Scenario number	1	2	3	4	5	6	7	8	9	10	11	12
CH4 Pond&Turbine	30,9	30,9	30,9	30,9	30,9	30,9	47,9	47,9	47,9	47,9	47,9	47,9
Avoided CH4	-0,4	-0,2	-0,3	-0,1	-0,2	0	-0,3	0	-0,2	0	-0,1	0,1
CH4 tot (CO₂eqv)	762,5	767,5	765	770	767,5	772,5	1190	1197,5	1192,5	1197,5	1195	1200
CO ₂ (biotic)	2560	1517	2561	1518	2562	1520	2050	1205	2051	1206	2053	1208
CO ₂ Boiler	8	8	8	8	8	8	8,9	8,9	8,9	8,9	8,9	8,9
CO ₂ Transport	17,4	3,2	15	2,6	14,2	1	12	1	10	0	8,4	0
Avoided in El. Prod	-471	-194	-396	-118	-320	-42,9	-271	-45	-187	38	-104	120
Foss CO₂ tot	-446,1	-203	-372,3	-129,3	-298,5	-55,5	-250	-53	-168	28,6	-87	110
kgCO₂e, tot /tCPO	316	565	393	641	469	717	940	1145	1025	1226	1108	1310
gCO₂e,tot/MJnnextl	8,5	15,2	10,6	17,2	12,6	19,3	25,3	30,8	27,6	33,0	29,8	35,3
With economic allocation:												
kgCO₂e, tot /tCPO	262	467	325	530	388	593	778	947	848	1015	917	1084
gCO₂e,tot/MJnnextl	7	13	9	14	10	16	21	26	23	27	25	29
POME treatment	CH ₄ COLLECTION AND ENERGY USE											
Material balance of mill	Best Material Balance						Worst Material Balance					
Energy consumption	80 %		100 %		120 %		80 %		100 %		120 %	
EFB End-use	Energy	Mulch	Energy	Mulch	Energy	Mulch	Energy	Mulch	Energy	Mulch	Energy	Mulch
Scenario number	13	14	15	16	17	18	19	20	21	22	23	24
CH4 Pond&Turbine	4,8	4,8	4,8	4,8	4,8	4,8	7,4	7,4	7,4	7,4	7,4	7,4
Avoided CH4	-0,5	-0,2	-0,4	-0,2	-0,4	-0,1	-0,4	-0,1	-0,3	0	-0,2	0
CH4 tot (CO₂eqv)	107,5	115	110	115	110	117,5	175	182,5	177,5	185	180	185
CO ₂ (biotic)	2632	1589	2633	1590	2634	1592	2161	1316	2163	1317	2164	1319
CO ₂ Boiler	8	8	8	8	8	8	8,9	8,9	8,9	8,9	8,9	8,9
CO ₂ Transport	17,5	4	16	2,5	14	1	12	1,2	10	0	8	0
Avoided in El. Prod	-545	-267	-470	-192	-395	-116,6	-385	-160	-301	-76	-220	8
Foss CO₂ tot	-520	-276	-446	-203	-372	-129	-364	-167	-282	-85	-200	0
kgCO₂e, tot /tCPO	-413	-161	-336	-88	-262	-12	-189	16	-105	100	-20	185
gCO₂e,tot/MJnnextl	-11,1	-4,3	-9,0	-2,4	-7,1	-0,3	-5,1	0,4	-2,8	2,7	-0,5	5,0
With economic allocation:												
kgCO₂e, tot /tCPO	-341	-133	-278	-73	-217	-10	-156	13	-86	83	-17	153
gCO₂e,tot/MJnnextl	-9	-4	-7	-2	-6	0	-4	0	-2	2	0	4

Table 19.2. Scenarios for GHG balance of palm oil mill in gCO_e/MJ_{NEXBTL} with economic allocation.

POME treatment	OPEN PONDING											
Material balance of mill	Best Material Balance						Worst Material Balance					
Energy consumption	80 %		100 %		120 %		80 %		100 %		120 %	
EFB End-use	Energy	Mulch	Energy	Mulch	Energy	Mulch	Energy	Mulch	Energy	Mulch	Energy	Mulch
Scenario number	1	2	3	4	5	6	7	8	9	10	11	12
CH4 tot (gCO ₂ eqv/MJ _{nexbtl})	17,0	17,1	17,0	17,2	17,1	17,2	26,5	26,7	26,6	26,7	26,6	26,7
Fossil CO ₂ -balance (gCO ₂ /MJ)	-9,9	-4,5	-8,3	-2,9	-6,7	-1,2	-5,6	-1,2	-3,7	0,6	-1,9	2,5
gCO_{2e,tot}/MJ_{nexbtl}	7	13	9	14	10	16	21	26	23	27	25	29
POME treatment	CH4 COLLECTION AND ENERGY USE											
Material balance of mill	Best Material Balance						Worst Material Balance					
Energy consumption	80 %		100 %		120 %		80 %		100 %		120 %	
EFB End-use	Energy	Mulch	Energy	Mulch	Energy	Mulch	Energy	Mulch	Energy	Mulch	Energy	Mulch
Scenario number	13	14	15	16	17	18	19	20	21	22	23	24
CH4 tot (gCO ₂ eqv/MJ _{nexbtl})	2,4	2,6	2,5	2,6	2,5	2,6	3,9	4,1	4,0	4,1	4,0	4,1
Fossil CO ₂ -balance (gCO ₂ /MJ)	-11,6	-6,1	-9,9	-4,5	-8,3	-2,9	-8,1	-3,7	-6,3	-1,9	-4,5	0,0
gCO_{2e,tot}/MJ_{nexbtl}	-9	-4	-7	-2	-6	0	-4	0	-2	2	0	4



Note: The light yellow bar represents the direct emission from POME treatment and the blue bar the total GHG balance with direct, indirect and avoided emissions included.

Figure 19.1. Scenarios (in graphical form) for GHG balance of palm oil mill with economic allocation.

The range of GHG balance for palm oil mill can vary from 9 to 35gCO_{2e}/MJ_{fuel} without methane collection and from -11 to 5gCO_{2e}/MJ_{fuel} with methane collection. With economic allocation between CPO and palm kernel, the palm oil milling phase contributes to 7 to 30gCO_{2e}/MJ_{fuel} of NEXBTL-diesel life cycle carbon footprint without methane collection and from -9 to 4gCO_{2e}/MJ_{fuel} with methane collection.

19.2 Interpretations and analysis

When analysing only the direct GHG emissions from the mill, methane collection obviously has the strongest effect on the mill GHG balance as graphically shown in Figure 19.1. Direct greenhouse gas emissions of the mill go down from 17 - 27gCO₂e/MJ_{fuel} to 2.5 - 4gCO₂e/MJ_{fuel} with methane collection and energy use, depending on the mill's material balance. The material balance is the second important factor in the direct GHG emissions. The less degradable organic material load to POME treatment per mass unit of CPO produced, the smaller the direct emissions are. The degradable organic material load can be roughly estimated by the amount of POME treated, if the degradable organic material concentration is assumed to be constant. If only the direct GHG emissions are considered, the range of GHG balance of palm oil milling is from 2.5 to 27gCO₂e/MJ_{fuel}.

With all indirect and avoided emissions included, the range of the GHG balance of the mill is between -9 to 29 gCO₂e/MJ_{fuel} as shown in Figure 19.1. The best GHG balance of -9 gCO₂e/MJ_{fuel} is achieved in scenario number 13, when methane is collected, with the best possible material balance, with low mill energy consumption and with the use of EFB in energy production. The worst GHG balance of 29 gCO₂e/MJ_{fuel} is in scenario number 12, when methane is released to the air, the material balance is worst possible, the mill has high energy consumption and the EFB are used in mulching.

Of the four variables studied, methane collection or release in POME treatment has the greatest effect on GHG balance by far as seen in Figure 19.1. With methane collection the GHG balance is 21 gCO₂e/MJ_{fuel} lower than without collection, on average. The material balance is the second greatest factor, especially when the methane is not collected as there is a lot of POME fed to the treatment. The effect of material balance on GHG balance is 9 gCO₂e/MJ_{fuel} on average. The EFB end-use as energy is better for GHG balance than mulching, but the difference is small, 5 gCO₂e/MJ_{fuel} on average. The energy efficiency or energy consumption of the mill has the smallest effect on GHG balance. The difference in GHG balance is 3.5 gCO₂e/MJ_{fuel} between a palm oil mill with an energy consumption of 20% below average and one with 20% above average.

The results confirm the assumption that methane collection and energy conversion are the most important factors in GHG emissions, as the GHG balance is at or below zero in all except two scenarios when methane is collected. On the other hand, GHG balance of below 10 gCO₂e/MJ_{fuel} is achievable in mills with no methane collection. This is the case when the extraction rate of CPO is high, 0.21 kg/kg_{FFB}, formation of POME is low, 0.5 kg/kg_{FFB}, and the EFB is used in energy conversion to replace fossil fuel use.

The biofuel use of excess co-products play an important role in the GHG balance of a palm oil mill. The avoided emissions related to biogas, shell, fibre and EFB utilisation for energy production is an important issue but not given due consideration in many palm oil mill related literature. The reason for this might be that there is no infrastructure or markets for the delivery of renewable fuels or energy. It is assumed that the palm oil mills are not connected to the national power grid and therefore electricity distribution is impossible. However, this situation is changing in

Malaysia since the government started to promote the access to the existing grid for renewable energy producers (Carlos *et al.*, 2007).

The scenario analysis confirms that there is a great variation in the GHG balance of palm oil mills, depending on the material and energy efficiency of the mill and the technology applied for POME treatment and co-products end-use.

19.3 Emission savings calculations and RES-directive

EU has set goals on renewable energy use and has and in January 2008 published a directive proposal on the promotion of the use of energy from renewable sources, known as RES directive. The proposal was accepted in December 2009 as directive. Default values are given for renewable fuel GHG calculations in the Annex VII of the RES-directive. According to the calculations behind these GHG savings values, the typical value represents the actual carbon footprint results calculated by European Commission Joint Research Centre (JRC). The main points behind the calculations are presented in Appendix 8, provided by JRC. The palm oil mill phase has been calculated to have a GHG balance of $23.22\text{gCO}_2\text{e/MJ}_{\text{fuel}}$ without methane collection, and $0\text{gCO}_2\text{e/MJ}_{\text{fuel}}$ with methane collection. Allocation by energy is applied. (JRC, 2008) These values calculated by JRC are within the range of GHG balance of this study.

The numbers behind the typical value calculations by JRC, however, reveal that the GHG balance is calculated only on the basis of direct emissions from POME treatment. The emission of CO_2 and N_2O is assumed zero and the CH_4 emission is $0.93\text{ g/MJ}_{\text{fuel}}$, which adds up to $23.22\text{ gCO}_2\text{eq/MJ}_{\text{fuel}}$, as presented in Appendix 8 (JRC, 2008). This reveals that no avoided or indirect emissions have been included in the calculations. Recent specifications from PAS 2050 and even from the old ISO 14040 series support the inclusion of all the three types of emission in carbon footprint calculations.

As stated before, the typical values in RES-directive represents the actual carbon footprint results calculated by JRC. The default values, however, have been calculated with an extra 40% given to the GHG emissions bound from the processing phase, which palm oil mill represent in this product system. It seems that this method has been applied to avoid underestimating the emissions but it has no scientific grounds. First, it only addresses the uncertainties in the processing phase and assumes no uncertainties to the cultivation and transport phases, which in fact have greater uncertainties than emissions arising from industrial processes. Second, it addresses the uncertainties in an unconventional manner. The uncertainties can be properly assessed during the carbon footprint study and the range of GHG balance should be communicated in the results.

Calculating the emission savings for renewable fuel use with one general value can lead to miscalculations and does not promote the implementation of technological improvements in renewable fuel production. Proper carbon footprint assessments for each fuel provider narrows the uncertainties, increases understanding of the whole product chain and subsequently encourages the implementation of technological improvements, thus allowing continuous improvement.

20. Technological Considerations

The utilisation of methane for energy is the most promising technology to implement in order to reduce GHG emission from the milling process. This can be achieved by covering the anaerobic pond with suitable plastic sheets or bags to collect the biogas, or by treating the POME in a digestion tank. According to Yacob *et al.* (2007), plastic-covered anaerobic ponds have higher conversion rates of biodegradable organics to methane in wastewater treatment than digestion tanks. The high energy content of biogas can be converted to energy in a gas engine or turbine. The gas engine is preferable because it has a high fuel-to-electricity efficiency of above 0.33, less need for process control during the operation, and the gas does not need to be pre-treated (General Electric, 2008). In relation to this, technology and know-how on efficient digestion and energy conversion are available in Finland. For example, MK-Protech Oy and Preseco Oy provide technology and expertise in digestion and energy conversion technologies. According to MK-Protech, the combined biogas production from a mixture of POME, sludge and biomass with high load anaerobic digestion could be considered as one option.

The technologies applied in wastewater pre-treatment and palm oil extraction highly affect the essential material balance of the mill. The extraction efficiency of CPO from other liquids that go to wastewater is essential. Residual palm oil in wastewater can be collected and redirected back to palm oil clarification with the use of rotary brush strainers in the pre-treatment of wastewater. The biodegradable organic load of the POME can be reduced with a decanter prior to treatment. Some oil mills extract the nutrient rich solids with a decanter, and the separated cake can then be mixed with inorganic fertilisers. However, the use of this technology is not a common practice in Malaysian mills (Schmidt, 2007). Leading technologies and know-how on pre-treatment of oily wastewater are available in Finland with Mzymes Ltd. and Lamor Corporation in front of the business.

In terms of GHG balance, the efficient end-use of EFB is for energy conversion. There is large bioenergy potential in EFB although the energy production from EFB is not without technological problem due to its high alkaline content. According to Finpro (2001), at least a Malaysian company, Szetech Engineering Sdn. Bhd. manufactures equipment for pre-treatment of EFB that enable combustion in conventional boiler.

Although there are high potential yet unused biomass resources in crude palm oil production and the policies that support biofuel use exist in Malaysia, the infrastructure is still lacking on the distribution of the energy (Subramaniam, 2008). The development of the power grid and the biofuel distribution chains can be considered essential for the full exploitation of the bioenergy potential related to from palm oil production.

According to Schmidt (2007), ashes from burning of fibres and shells are traditionally used as road materials in plantation. The mineral and nutrient rich ash could be considered as recyclable that can be put back to plantation to replace chemical fertiliser use. Finnish companies, FA Forest and Naturansa provide technology for ash pre-treatment and recycling. The possible impurities in boiler ash, such as metals, may restrict the use in food production chain. This issue has to be properly studied before the ash recycling can be implemented.

21. Summary and Conclusion

The global demand for palm oil is currently increasing, thus prompting an increase in production worldwide particularly in Malaysia and Indonesia. Such increasing demand for palm oil is mainly due to palm oil's relatively cheap price (compare to other vegetable oil) and versatile advantage in edible and non-edible applications. In terms of global supply, Malaysia and Indonesia are expected to continue leading the supply of palm oil to as much as 88% of the total world palm oil production. This current trend of strong growth in palm oil consumption is also due to the increased demand in China, Europe and India. In the EU alone, growth in industrial use has increased due the promotion of biofuel utilisation programs. Such emergence of new biofuel market in the EU is seen in Malaysia as a good export opportunity and therefore expected to grow in the near future.

Major players and stakeholders in the palm oil industry are as diverse as its supply chain, ranging from large upstream to different sizes downstream producers as well as other parties who have interest in palm oil. It can be said that various organisations are well in place to look after the interests of every players in the supply chain. Although private ownerships dominate the upstream and downstream production of palm oil, the government schemes with FELDA on the lead, play the most significant role in the development of palm oil plantation in Malaysia. Similarly, other government agencies, with MPOB on the lead, play important roles in promoting and developing national objectives, policies and priorities for the well-being of the Malaysian palm oil industry. The leading palm oil industry organisations such as the MPOA, MPOC, PORAM, MEOMA, POMA and MOMG, are strong forces in keeping themselves well represented in high level national decision-making and development programs related to palm oil.

The production of palm oil is not without problems and challenges. The palm oil industry is partly blamed for the loss of forest cover and forested areas (deforestation), loss of biodiversity, endangering wild animals and species, soil, air and water pollution, chemical contamination, as well as increasing land disputes and social problems in Malaysia (also in Indonesia). At the milling factories, the problems of waste and pollution are also of growing concern. Most of these problems were pronounced in the early stage of development of oil palm plantations and production in Malaysia. With time and continuous search for solutions to these problems, modern improvements and technological advancements as well as sustainable strategies have been continuously developed for a better quality of life of many Malaysians working in the palm oil industry.

In terms of policy, countries like Malaysia and Indonesia have well-established laws and regulations that encompass palm oil being a prime agricultural commodity. Policy and regulations are seen to be more of combining different applicable instruments that facilitate market mechanisms to steer the whole palm oil industry. A concrete National Biofuel Policy in Malaysia is an example of new policy decided upon through multi-stakeholder consultation with government's moderate control yet with good incentives and benefits offer for the palm oil businesses. Likewise, the RSPO and Kyoto Protocol Kyoto are considered good platforms in forwarding new policies that can reduce, if not totally eliminate, the negative impacts of palm oil production.

The growth and modernisation of palm oil industry in Malaysia is not without the influence of various research and development efforts of different scientific organisations. The contribution of research supporting the development of capacities, technology and innovations is very much evident by the roles being played by both public and private research institutions.

Along with the increasing demand for palm oil either for food or for fuels is a heated debate on its sustainability. In such food versus fuel debate, the main issues would be politically sensitive and economically challenging. At present, important issues such as price, ecological degradation and global climate change remain at the centre of palm oil sustainability and dynamics, and will probably remain in the near future. The issue of sustainability is expected to gain even more attention particularly in the EU.

CDM projects aimed at fulfilling the imperatives of the Kyoto Protocol are starting to gain momentum in Malaysia. The increasing registration of CDM projects in the palm oil mills is a reflection of increasing interests of various market players in the industry. The three main areas of CDM projects are on waste-to-energy, methane recovery and co-composting, with methane recovery being the most common project area. So far, CDM projects are claimed to have been boosting palm oil sustainability in Malaysia. Other than combating global warming, CDM in palm oil mills can significantly reduce pollution, increase the efficiency of their waste management system, and provide benefit from new available efficient technologies that are normally part of a CDM project.

With carbon footprinting, it is shown that there can be significant differences in the GHG balances of palm oil mills, depending on material and energy balance of the mill and the applied technologies for co-products end-use. GHG emission reduction potentials exist in the POME, fibres, shells and EFB end-use. The biogas collection and energy utilisation were shown to be the most important activity for improving the GHG balance of the mill. Increasing the CPO extraction efficiency and reducing the biodegradable organic load discharged to POME treatment is important for better GHG balance as well. Avoided emissions can be achieved with energy conversion of EFB and with improvements in the energy efficiency of the mill. Material balance, energy efficiency and the end-use of EFB as biomass have an equal effect on GHG balance as biogas collection and energy use from POME treatment alone.

The range of direct GHG emissions from milling phase in hydrotreated diesel production from palm oil is from 2.5 to 27gCO₂e/MJ_{fuel}. With all indirect and avoided emissions included, the range of GHG emissions is from -9 to 29gCO₂e/MJ_{fuel}. The best GHG balances are obtained with biogas collection and energy utilisation, good material balance, EFB end-use as energy and a high energy efficiency of a mill. Excess shells and fibres have to be delivered and used in national energy production system to reach the best case scenario.

The side streams of palm oil production have great bioenergy potential. Methane from POME treatment, fibres, shells and EFB are the main renewable energy sources from palm oil processing. The development of infrastructure for fuel or power delivery is the key issue, as the incentives set by Malaysian government have opened markets for bioenergy. The bioenergy use of co-products leads to GHG emission reductions in the national energy production.

The GHG savings values proposed for RES directive need further revision. This is so because the RES typical values represent only the direct emissions of a palm oil mill while indirect and avoided emissions are excluded, which is against the carbon footprint calculation principles. Moreover, the RES default values address the uncertainties in life cycle assessment in an unconventional manner. The default values are calculated with an extra 40% GHG emission added to only the processing phase of each renewable fuel production chain, while assuming no uncertainties to the cultivation and transport phases. A more scientific approach is to evaluate the uncertainties of each product chain during the life cycle assessment process and communicate the results as a range of greenhouse gas balance. Calculating the emission savings for renewable fuel use with general values can lead to miscalculations and does not promote the implementation of technological improvements leading to continuous improvement.

Emission savings can be realised from the palm oil processing with the identified improvements in technologies and practices. Several CDM projects affirm that the implementation of these improvements has already begun and Finnish technology and know-how (e.g. digestion, energy conversion, and oily wastewater technology) can be harnessed for such improvement. Although it does not address other environmental and social issues, the GHG emission reduction from palm oil milling is one step towards sustainable palm oil production.

References

- Agricultural Science and Technology Indicators (ASTI). 2005. ASTI country brief on Malaysia. Available at: <http://www.asti.cgiar.org/profiles/malaysia.aspx>
- Ahmad, A.L., Ismail, S. and Bhatia, S. 2003. Water recycling from palm oil mill effluent (POME) using membrane technology. *Desalination* 157 (2003), Elsevier Science B.V. pp. 87-95.
- Anwar, M. 1981. Current and prospective situations of the oil palm/palm oil industry. Palm Oil Research Institute of Malaysia, Occasional Paper No. 1. Kuala Lumpur.
- Asian Development Bank, ADB. 2006. Technology overview- palm oil waste management-Appendix VII. Available at: <http://www.adb.org/Documents/Reports/Consultant/36557-INO/36557-INO-TACR-AppendixVII.pdf>
- Australian Conservation Foundation, ACF. 2008. Oil palm in PNG. Available at: http://www.acfonline.org.au/default.asp?section_id=96&c=303922
- Bhattacharjee, A. 2003. The price of Malaysia palm oil expansion. *The Asia Times Online*. May 3, 2003.
- Basiron, Y. 2008a. Malaysian palm oil: dynamics and prospects. A plenary presentation at the Malaysia-India Palm Oil Trade Fair and Seminar, Mumbai, India.
- Basiron, Y. 2008b. Creating fine balance for development, food, security and environmental sustainability. *Palm Oil Blog*. Available at: <http://www.ceopalmoil.com/>
- Basiron, Y. 2007. Palm oil production through sustainable plantations. *European Journal of Lipid Science and Technology* 109. Wiley InterScience, Weinheim. pp 289-295.
- Berger, K.G. 1996. Food uses of palm oil. MPOPC Palm Oil Information Series, Kuala Lumpur, p25.
- BSI British Standards. 2008. Specification for the assessment of the life cycle greenhouse gas emissions of goods and services, PAS 2050:2008. ICS 13.020.40. ISBN 978 0 580 50978 0. Available at: <http://www.bsigroup.com/en/Standards-and-Publications/Industry-Sectors/Energy/PAS-2050/>
- Business Times, 2008. Malaysian palm oil growers to pay windfall tax. *Business Times* (June 6, 2008). Available at: <http://www.btimes.com.my>.
- Butler, R.A. 2008a. Falling palm oil prices makes palm biodiesel viable, may offer target for NGOs. Commentary at *Mongabay.com* (September 10, 2008).
- Butler, R.A. 2008b. The social impact of oil palm in Borneo. *The impact of oil palm in Borneo*. Available at: http://www.mongabay.com/borneo/borneo_oil_palm.html
- Butler, R.A. 2007a. Eco-friendly palm oil could help alleviate poverty in Indonesia palm oil is not a failure as a biofuel. Available at: http://news.mongabay.com/2007/0403-oil_palm.html
- Butler, R.A. 2007b. Palm oil doesn't have to be bad for the environment. *Mongabay News*, April 4, 2007. Available at: http://news.mongabay.com/2007/0404-oil_palm.html
- Butler, R.A. 2006. Why is palm oil replacing tropical rainforests? Why are biofuels fuelling deforestation? *Mongabay*, April 25, 2006. Available at: <http://news.mongabay.com>.

- Carlos, R. and Khang, D. 2007. Characterization of biomass energy projects in Southeast Asia. *Biomass and bioenergy*. Volume 32, Issue 6, June 2008, 525-532pp.
- Carter, C., W. Finley, J. Fry, D. Jackson and L. Willis. 2007. Palm oil markets and future supply. *In: European Journal of Lipid Science and Technology 109 (2007)*. Wiley InterScience, Weinheim. 307-314pp.
- Casson, A. 2003. Oil palm, soybeans and critical habitat loss. Paper prepared for WWF Forest Conservation Initiative, Switzerland. 1-21pp.
- Centre for Science in the Public Interest (CSPI). 2005. Cruel oil: How palm oil harms health, rainforest and wildlife. Washington DC. 1-40pp.
- Chhabara, R. 2008. Ethical sourcing: palm oil - a palm for the soul. Special Report, Ethical Corporations, July 7, 2008, 1-7pp.
- Cheyenne Mountain Zoo (CMZ). 2008. Association of Zoos Aquariums. Protecting orangutans by promoting certified sustainable palm oil and product labelling. Available at: <http://www.cmzoo.org/docs/PalmoilEducationHandout.pdf>
- Chumporn Palm Oil Industry, *CPOI*. 2008. Processing chart. Available at: <http://www.cpi-th.com/eng/products-process.html>.
- Clean Development Mechanism (CDM) Malaysia. 2008a. CDM in energy sector, CDM in Malaysia. Available at: <http://cdm.eib.org.my/subindex.php?menu=7>
- Clean Development Mechanism (CDM) Malaysia. 2008b. CDM in energy sector; Institutional framework. Available at: <http://cdm.eib.org.my/subindex.php?menu=7&submenu=33>
- Confederation of European Paper Industries (CEPI). 2007. Framework for the development of Carbon Footprints for paper and board products. ENV-148-07. September 2007. Available at: <http://www.cepi.org/DocShare/Common/GetFile.asp?PortalSource=1166&DocID=13681&mfd=off&pdoc=1>
- Creutzberg, P. 1975. Indonesian export crops, 1816-1940. *Changing economy in Indonesia*, Vol. 1. Nijhoff, the Hague.
- Dennis R. A. 2000. Review of fire projects in Indonesia, 1992- 1998. Bogor, Indonesia: Center for International Forestry Research. 1999.
- Down to Earth. 2004. Sustainable palm oil: mission impossible? Down to Earth No. 63, November 2004.
- European Union. 2008. Proposal for a directive on the promotion of the use of energy from renewable sources (RES-directive proposal). Available at: http://ec.europa.eu/energy/climate_actions/doc/2008_res_directive_en.pdf .
- FAO. 2002. Small scale palm oil processing in Africa. *FAO Agricultural Services Bulletin* 148. 1- 56pp.
- FAO. 1990. The oil palm. Better farming series # 3(24). *FAO Economic and Social Development Series*.
- FELDA. 1996. FELDA Annual Report 1996, FELDA Publication, Kuala Lumpur.
- Finpro. 2001. Bio Asia II, loppuraportti, Thaimaa ja Malesia.
- Flexnews. 2008. Global palm oil output forecast to reach record levels in 2007/2008. Flexnews, May 29, 2008. Available at: <http://www.flex-news-food.com/pages/16803/Global/Palm-Oil/global-palm-oil-output-forecast-reach-record-levels-20072008.html>
- Friends of the Earth. 2005. Greasy palms. The social and ecological impacts of large-scale oil palm plantation development in Southeast Asia. Available at: http://www.foe.co.uk/resource/reports/greasy_palms_impacts.pdf.

- General Electric. 2008. General Electric's Jenbacher gas engines. Available at: http://www.ge-energy.com/prod_serv/products/recip_engines/en/index.htm
- Gheewala, S. Pleanjai, S., and Garivait, S. 2004. Environmental evaluation of biodiesel production from palm oil in a life cycle perspective. The joint international conference on "Sustainable energy and environment (SEE)". 1-3 December 2004, Hua Hin, Thailand.
- GHG Protocol. 2008. The greenhouse gas protocol: A corporate accounting and reporting standard (Revised Edition). World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD). Washington, DC. Available at: <http://www.ghgprotocol.org/standard/index.htm>
- Glastra, R., Wakker E. and Richert W. 2002. Oil palm plantations and deforestation in Indonesia. What role do Europe and Germany play? Frankfurt: World Wide Fund for Nature- Germany. Available at: www.panda.org/downloads/forests/oilpalmindonesia.pdf.
- Hartley, C. W. S. 1988. The oil palm (*Elaeis guineensis* Jacq.). Third edition. London
- Idris, Z. 2003. Effluent related fee in the palm oil industry of Malaysia. Document submitted to ESCAP Virtual Conference. Available at: http://www.unescap.org/drrpad/vc/conference/bg_my_14_erf.htm
- Igwe, J.C. Onyegbado, C.C. 2007. A review of palm oil mill effluent water treatment. *Global Journal of Environmental Research*, 1(2):.IDOSI Publications. pp 54-62. Available at: [http://www.idosi.org/gjer/gjer1\(2\)07/4.pdf](http://www.idosi.org/gjer/gjer1(2)07/4.pdf)
- Indonesian Palm Oil Research Institute, *IOPRI*. 2003. Medan. The remaining 34% is planted on other vegetation types. Information Board, Medan, Indonesia.
- Jaafar, M. 1994. The Malaysian palm oil - A dynamic industry. *In: Selected Readings on Palm Oil and its Uses*. PORIM Publication, Bangi, Selangor, Malaysia.
- Joint Research Centre (JRC). 2008. Background material for RES-directive development. Notification in written form: Updated figures communicated - Update on Data on pathways for RES Directive. European Commission.
- Krishnamurthy P. 2008. CDM in the oil palm sector. Available at: http://www.kyotoenergy.net/content.php?langue=english&cle_menus=1177773419
- Kyoto Energy. 2008. CDM opportunities in the palm oil industry. Available at: <http://www.kyotoenergy.net/cdm%20palm%20oil%20industry.html>
- Leong, J. 2007. AES AgriVerde and Foong Lee Sawiminyak partners to advance Malaysia in greenhouse gas offset project. Press Release (20 July 2007). AES AgriVerde and Foong Lee Sawiminyak Sdn Bhd. Kuala Lumpur, Malaysia.
- Lim, C.Y. 1967. Economic development of modern Malaya. Kuala Lumpur, Malaysia.
- Ma, A.N. 2002. Carbon credit from palm: Biomass, biogas and bio diesel. MPOB: Palm Oil Engineering Bulletin. 24-26pp.
- Malaysian Palm Oil Association (MPOA). 2003. Sustainable palm oil: Malaysian Palm Oil Association Perspective. Malaysian Palm Oil Association. Presentation at the Palm Oil Roundtable, Kuala Lumpur, August 21-22, 2003.
- Malaysian Palm Oil Council (MPOC). 2008. The palm oil. Available at: http://www.mpoc.org.my/main_palmoil_01.asp
- Malaysia Palm Oil Council (MPOC). 2007a. Sustainable palm oil - for profit, people and the planet. Available at: <http://www.malaysiapalmoil.org/life/practices.asp>

Malaysian Palm Oil Council (MPOC). 2007b. Malaysia Palm Oil Industry calls for closer ties with EU on sustainability. Press Release in Brussels, Belgium (9 March 2007).

Malaysian Palm Oil Council (MPOC). 2006a. Malaysian Palm Oil Council Annual Report 2006.

Malaysian Palm Oil Council (MPOC). 2006b. Building a better world through your business with Malaysian palm oil. Available at: <http://www.americanpalmoil.com/pdf/enviromental/businesswithpalmoil.pdf>

Malaysian Palm Oil Promotion Council (MPOPC). 1996. Palm oil - a guide for users. MPOPC Palm Oil Information Series, Kuala Lumpur, p47.

Miner, R. and Perez-Garcia J. 2007. The greenhouse gas and carbon profile of the global forest products industry. Special report no. 07-02. Research Triangle Park, N.C.: National Council for Air and Steam Improvement, Inc. (NCASI). United States. 32p. Available at: <http://www.ncasi.org/publications/detail.aspx?id=2952>

Ministry of Plantation Industries and Commodities (MPIC). 2006. The national biofuel policy of Malaysia.

Malaysian Palm Oil Board (MPOB). 2008. MPOB economic and industry development. Available at: http://econ.mpob.gov.my/economy/EID_web.htm

Neste Oil. 2008. NExBTL diesel, raw materials. Available at: <http://www.nesteoil.com/>

Nikander, S. 2008. Greenhouse gas and energy intensity of product chain: case transport fuel. Master's thesis. Helsinki University of Technology, Finland.

Noor, M. 1997. Inter-industry linkages and the unbalanced growth approach to economic development: with special reference to the Malaysian economy. Unpublished Ph.D. thesis, University of Hull, UK.

Oh, E. 2004. Sustainable palm oil production. *In: The Star Online*, Bizweek (November 20, 2004). 1-4pp.

Oravainen, K. 2002. Characterisation of some Asian biomass fuels for heat and power production. VTT Processes. 6th Asia-Pacific International Symposium on Combustion and Energy Utilization.

Pacific Consultant. 2008. POME treatment co-benefits CDM, Malaysia. Available at: http://gec.jp/gec/en/Activities/cdm-fs/2007/2007PCKK_eMalaysia_rep.pdf

Palm Oil Industrial Cluster (POIC). 2008. Malaysian palm oil biodiesel export market. Available at: www.etawau.com.

Poku, K. 2002. Small-scale palm oil processing in Africa, FAO Agriculture Services Bulletin 148. ISBN 92-5-104859-2. Available at: <http://www.fao.org/docrep/005/Y4355E/y4355e00.HTM>

Pride, D. 2006. Oil palm land schemes alleviating rural poverty. Palm Oil Truth Foundation. Available at: <http://www.palmoiltruthfoundation.com>

Rao, T. 2006. Successful CDM projects in Malaysia. Latest News (12 October 2006), Danish Management Group. Kuala Lumpur Malaysia.

Ramachandran, H. 2005. Biodiesel set to ignite palm oil's prospects Press Release for Business Times. National Economic Action Council, Malaysia. September 2005.

Roundtable for Sustainable Palm Oil (RSPO). 2006. About sustainable palm oil. Available at: http://www.rspo.org/About_Sustainable_Palm_Oil.aspx#

Roundtable for Sustainable Palm Oil (RSPO). 2005. RSPO's principles and criteria for sustainable palm oil production. Public release version 3 (22 September 2005). 1-6pp.

- RTFO. 2008. United Kingdom's renewable transport fuel obligation (RTFO): carbon and sustainability reporting within the renewable transport fuel obligation, requirements and guidance draft. Government recommendation to RTFO Administrator. London. Available at: www.dft.gov.uk/roads/RTFO
- Salmiah, A. 2000. Non-food uses of palm oil and palm kernel oil. MPOPC Palm Oil Information Series, Kuala Lumpur. p24.
- Schmidt, J. 2007. Life cycle assessment of rapeseed oil and palm oil. Ph.D. thesis, Part 3. Ålborg University, Denmark.
- Sekhar, B.C. 2000. The Malaysian plantation sector: rubber, oil palm - the new millennium equation. Paper presented at the Eminent Person Lecture, Academy of Science Malaysia, Kuala Lumpur.
- Shirkie, R. and Ji, S.C. 1983. Oil upon the waters: palm oil wastes in Malaysia. IDRC Publication, Ottawa Canada.
- Simeh, A. and Ahmad, T.M.A.T. 2001. The case study on the Malaysian palm oil. Paper presented to the regional workshop on commodity export diversification and poverty reduction in South and Southeast Asia, held in Bangkok, Thailand, April 3-5, 2001. UNCTAD/ESCAP.
- Subramaniam, V. Ngan, M. May, C. and Sulaiman, N. 2008. Environmental performance of the milling process of Malaysian palm oil using the life cycle assessment approach. *American Journal of Environmental Sciences* 4(4): 310-315, 2008. ISSN 1553-345X.
- Smith, G. 2006. Palm oil: deforestation diesel. Wren Media and the New Agriculturalist. Available at: <http://www.new-ag.info/06-6/focuson/focuson6.html>
- Taipale, R. 2001. Kirjallisuusyhteenveto kaukoidän polttoaineista. VTT Energia.
- Tan, K.T., et al. 2007. Palm oil: Addressing issues and towards sustainable development, *Renew Sustain Energy Review* (2007), doi:10.1016/j.rser.2007.10.001.
- Teoh, C.H. 2002. The palm oil industry in Malaysia - from seed to frying pan. A report prepared for WWF-Switzerland. Selangor, Malaysia. 1-59pp.
- TFS Green. 2008. Clean Development Mechanism and CDM introduction. Available at: <http://www.tfsgreen.com/global-markets/clean-development-mechanism/#CDM2>
- TÜV SÜD Industrie Service GmbH. 2008. UNFCCC completed and on-going projects. Available at: http://www.netinform.net/KE/Wegweiser/Ebene1_Projekte.aspx?Ebene1_ID=26&mode=2
- UNEP (2000). Global environment outlook 2000. Earthscan, London.
- United Nations Framework Convention on Climate Change (UNFCCC). 2008. About clean development mechanism (CDM). Available at: <http://cdm.unfccc.int/about/index.html>
- United Nations Framework Convention on Climate Change (UNFCCC). 2007. The Kyoto Protocol mechanisms. International emissions trading clean development mechanism joint implementation. Climate Change Secretariat, UNFCCC, Bonn, Germany. Available at: <http://unfccc.int/resource/docs/publications/mechanisms.pdf>
- United States Department of Agriculture (USDA). 2007. Indonesia: palm oil production prospects continue to grow. Available at: http://www.pecad.fas.usda.gov/highlights/2007/12/Indonesia_palmoil/
- United States Department of Agriculture (USDA). 2006. Palm oil continues to dominate global consumption in 2006/07. Oilseeds: World markets and trade. Circular Series FOP 6-06, Foreign Agricultural Series. Available at: <http://www.fas.usda.gov/oilseeds/circular/2006/06-06/Junecov.pdf>

United States Department of Agriculture (USDA). 2006. Malaysia's industrial use of palm oil strengthens in 2005/06. Oilseeds: World markets and trade. Circular Series FOP 4-06, Foreign Agricultural Series. Available at: <http://www.fas.usda.gov/oilseeds/circular/2006/06-04/Aprcov.pdf>

United States Department of Agriculture (USDA). 2005. Growth in industrial uses of palm oil exceeds food uses. Oilseeds: World markets and trade. Circular Series FOP 9-05, Foreign Agricultural Series. Available at: <http://www.fas.usda.gov/oilseeds/circular/2005/05-09/sepcov.pdf>

United States Department of Agriculture (USDA). 2003. World palm oil import. Oil seeds: World markets and trade. Available at: <http://www.fas.usda.gov/oilseeds/circular/2005/05>

World Wildlife Fund (WWF). 2005. Agricultural and environment: Palm oil and air pollution. Available at: <http://www.panda.org/> (downloaded 5th June 2007).

Xinhua, 2006. Malaysia sees bright future in palm oil industry. People Daily Online (English), Updated: 08:22, August 11, 2006.

Yacob, S. Hassan, M. Shirai, Y. Wakisaka, M, and Subash, S. 2005. Baseline study of methane emission from anaerobic ponds of palm oil mill effluent treatment. Science of the Total Environment 366 (2006) 187-196.

Yusoff, S. and Hansen, S. 2007. Feasibility study of performing a life cycle assessment on crude palm oil production in Malaysia. University of Malaya. International Journal of Life Cycle Assessment 12 (1) 50 - 58, 2007.

APPENDIX 1

PROFILES OF SOME LEADING PLANTATION AND PROCESSING COMPANIES IN MALAYSIA

1. Asiatic Development Berhad

Contact:
10th floor, Wisma Genting
Jalan Sultan Ismail
50250 Kuala Lumpur, Malaysia
Tel : +60 3 2333 6441
Fax : +60 3 2164 1032
Homepage: www.asiatic.com.my

Asiatic was incorporated as a private limited company on 29 September 1977, and commenced operations in 1980 as the plantation arm of Genting Berhad. In August 1982, Asiatic gained listing on the Kuala Lumpur Stock Exchange (KLSE). The principal activities of Asiatic Group include plantation and property development. Our mission is to become a leader in the plantation industry and enhance return on the Company land bank through property development activities. As at 30 June 2004, Asiatic owns 71,078 hectares of land, 80% of which is planted with oil palm. Asiatic also owns 6 oil mills, with a total milling capacity of 255 metric tonnes per hour. Asiatic has ventured into property development since 1993. The Group's main development areas are strategically located in Johor, Melaka and Kedah.

2. Boustead Estates Agency Sendirian Berhad (BEASB)

Contact:
Boustead Plantations Berhad
28th floor, Menara Boustead, No 69, Jalan Raja Chulan
50200 Kuala Lumpur, Malaysia
Tel : + 60 3 2145 2121
Fax : + 60 3 2141 1690

Plantation ownership and management is a core business for Boustead Plantations Berhad. The Division's main activities include planting and processing of oil palm, rubber, forestry and also oil bulking installations operation. The Group's plantation holdings are managed by Boustead Estates Agency Sendirian Berhad (BEASB), a wholly owned subsidiary of Boustead Holdings Berhad.

BEASB is one of the leading estate management agencies in the region and provides a complete package of services to effectively and efficiently manage an estate and plantation company. BEASB presently manages a total land area of about 116,000 hectares.

Through its associated company, Applied Agricultural Resources Sendirian Berhad (AARSB), BEASB offers research-backed agronomic services involving all aspects of field management practices and factors which affect crop productivity and long term soil fertility in the plantations. AARSB's consultancy service also undertakes to carry out soil suitability and crop feasibility evaluations for new investments in plantations. AARSB is also one of the eminent suppliers of oil palm planting material in the region.

The Group has been actively investing in Sarawak through joint ventures with the Land Custody & Development Authority. To position itself in the region, the Group has invested in Indonesia through joint venture projects in Sumatra Barat and Selatan. Management of the Group's investment in Indonesia is undertaken through Boustead-Anwarsyukur Estate Agency Sdn Bhd (BASEA), a wholly-owned subsidiary of BEASB. BASEA also provides a complete package of management services for clients.

3. Golden Hope Plantations Berhad

Contact:

*Golden Hope Plantations Berhad
9-16th floors, Menara PNB, No 201-A, Jalan Tun Razak
50400 Kuala Lumpur, Malaysia
Tel : +60 3 3120 2311 Fax : +60 3 3120 1197
Homepage: www.goldenhope.com*

Golden Hope Plantations Berhad is a leading Malaysian corporation listed in the Kuala Lumpur Stock Exchange with over 17,000 shareholders and over 20,000 employees. Strong foundation in the plantation sector since 1903, the Group has developed into a diversified conglomerate involved in four dynamic business sectors: 1) Agribusiness, 2) Property, 3) Industries and 4) International Business.

The Group's principal activities are the production and sale of edible oils and fats. Other activities include cultivation, processing and sale of palm oil, palm kernel, fresh fruit bunches and rubber; manufacturing of latex concentrate, trading and marketing of fruit juices; development and construction of residential, commercial and industrial property and sale of developed land; production and sale of oil palm seeds and seedlings, biodiesel, rubber footwear and technical products, coconut-based food products, fruit juices and puree; production of Vitamin E; provision of research services and agricultural and computer consultancy services and investment holding. Operations are carried out in Malaysia, Europe, South Africa and Asia.

Golden Hope Plantations Berhad's plantations principally include palm oil-based crops, as well as rubber, guava, and other crops in total planted area of approximately 169,307 hectares. As of June 30, 2005, the company also operated 24 palm oil mills. In addition, it involves in processing and marketing oils and fats products that are primarily used in food industries, such as food supplements and oleo-chemicals. These products include oils and customised blends for confectionary and bakery applications, retail packed cooking oil, and fats. Further, the company involves in the property development business activities, which include development and sale of township, administrative buildings, and supermarkets. It also operates in the Netherlands, Vietnam, Bangladesh, Indonesia, the People's Republic of China, Germany, and South Africa. Golden Hope was established in 1844 as Harrison and Crossfield and changed its name to Golden Hope Plantations Berhad in 1990. The company is based in Kuala Lumpur, Malaysia. As of November 27, 2007, Golden Hope Plantations Bhd is a subsidiary of Synergy Drive Bhd.

4. Hap Seng Consolidated Berhad

Contact:

*Hap Seng Consolidated Berhad
Locked Bag No 5
91109 Lahad Datu, Sabah
Malaysia
Tel : +60 89 617677/821595
Fax : +60 89 618128*

Hap Seng Consolidated Berhad is a public-listed company listed in the main board of the Bursa Saham Malaysia with an annual turnover of RM1.2 billion in 2005. The Group's principal activities are the ownership and operation of oil palm plantations; manufacturing and trading of agricultural fertilisers, agro-chemicals, building materials and general plantation supplies; trading in heavy equipment, motor vehicles and spares, servicing of heavy equipment and motor vehicles, and investment holding; fabrication and sales of commercial trailers and tankers; leasing, hire purchase financing and licensed money lending, and packing, marketing and wholesale trading of edible oils and food. In 2005, trading accounted for 76% of its revenues while plantation and processing, 24%.

5. IJM Plantations Berhad (IJMP)

Contact:

*IJM Plantations Berhad
Wisma IJM Plantations, Lot 1, Jalan Bandar Utama
Mile 6, Jalan Utara, Mail Bag 8, BQ3933
90009 Sandakan, Sabah, Malaysia
Tel : + 60 (89) 667721
Fax : + 60 (89) 667728
www.ijm.com*

IJM Plantations Berhad (IJMP) is an associate of IJM Corporation Berhad and it assumed Rahman Hydraulic Listing Status in June, 2003. IJMP ventured into oil palm cultivation in 1986, having its 1st land bank being the 4,000 ha Desa Talisai Estate in Sandakan. Over the years, expansion has been rapid and the group plantation land bank had burgeoned to over 29,559 hectares as of 31 December 2003. IJMP comprises of 12 estates in Sabah, 3 palm oil mills, and a palm kernel crushing plant. The group achieved record revenue of RM 202.02 million in 2003 compared to RM 96.8 million in 2002 which has marked a significant increase of 109% against the previous year.

6. IOI Corporation Berhad

Contact:

*IOI Group (Malaysia/Netherlands)
Level 8, Two IOI Square , IOI Resort
62502 Putrajaya, Malaysia
Tel : +60 3 8947 8668
Fax : +60 3 8943 2899
Homepage: www.ioigroup.com*

IOI a Malaysia business conglomerates. Within a relatively short span of 30 years, the IOI Group has firmly established itself as a leader in its core business areas of Plantations, Property Development & Investment, and Manufacturing. From an oil palm plantation entity, the IOI Group has transformed itself to become a leading integrated palm oil player in the country.

Moreover through the acquisition of Loders Croklaan, IOI is now a strong global player with a strategic focus on growth in the area of palm based oil products. It is one of the largest plantation groups in Malaysia with a sizeable plantation holding of over 160,000 hectares. Annual production of CPO is in excess of 800,000 tonnes. To gain further leverage as a key palm oil producer, IOI has also ventured into downstream value-added palm oil based manufacturing activities such as palm oil refining, palm kernel extraction, oleochemicals and specialty fats and oils.

IOI Edible Oils' palm oil refinery in Sabah is a manufacturer of various quality processed palm oil products. It has its own jetty and bulking installation facilities for direct shipments of palm oil products. It is the first palm oil refinery in Sabah to obtain certification for ISO 9001.

Through IOI Oleochemical Industries Berhad, the Group operates one of the most established and largest oleo chemical production facilities in Malaysia, producing a wide range of oleo chemical products for food and non-food industrial applications. It is the largest fatty acid producer in Asia.

Loders Croklaan is one of the world's leading suppliers of specialty fats and oils to the food sector with a long standing tradition of quality and innovation. It has pioneered products and applications in its core snack ingredients business. It is also in the development of the potentially high growth area of lipid nutrition.

7. Kuala Lumpur Kepong Berhad (KLK)

Contact:
Wisma Taiko, No 1 Jalan SP Seenivasagam
30000 Ipoh, Perak Darul Ridzuan, Malaysia
Tel : + 60 5 241 7844
Fax : + 60 5 255 5466
www.klk.com.my

Kuala Lumpur Kepong Berhad (KLK) is a Malaysian multinational company involved in plantation, manufacturing, retailing and property development. Plantation remains KLK's core business. The Group also expanded downstream into resource-based manufacturing, in particular oleochemicals, cocoa processing and rubber processing.

Through Crabtree & Evelyn, a worldwide brand, the Group is involved in the manufacture and retail of personal care products, toiletries, home fragrances and fine foods. Capitalizing on the strategic location of its land bank in Malaysia, KLK has also ventured into property development. KLK is amongst the top plantation companies in Malaysia, with a land bank in excess of 145 687 hectares, located in Peninsular Malaysia (64, 750 hectares), Sabah (40,468 hectares) and Indonesia (40,468 hectares). Oil palm is the predominant crop with an annual production of 1.9 million tonnes of Fresh Fruit Bunches (FFB) and which is expected to increase rapidly in the years ahead as the vast new plantings in Sabah and Indonesia are progressively brought into harvesting. Processing of the crop is carried out in KLK's own mills and refineries into crude palm oil, RBD palm olein and stearin, and kernel oil and cake.

The declining rubber area in Peninsular Malaysia, in favour of oil palm, has been made up to an extent by the new rubber area from KLK's plantations in Indonesia. This will enable KLK to maintain a steady yearly production of about 25,000 tonnes of premium SIR/SMR grades and latex concentrate, meeting with the ISO 9002 standards.

8. Kulim (Malaysia) Berhad

Contact:
Kulim (Malaysia) Berhad
KB 705, 80990 Johor Bahru
Johor Darul Takzim
Malaysia
Tel : +60 7 861 1611
Fax : +60 7 861 1701

Kulim (Malaysia) Berhad is a public listed company. It was incorporated on 2 July 1975 and was listed on the Kuala Lumpur Stock Exchange (KLSE) main board on 14 November 1975. Its core business is in the palm oil industry encompassing cultivation of oil palm, palm oil milling and refinery as well as the manufacture of oleochemicals. The Group manages 105,000 ha of palm oil plantations and 95% of its planted area lies in Malaysia, Papua New Guinea and Indonesia. This area includes Kulim's acquisition of 90% equity in New Britain Palm Oil Limited (NBPOL), which is one of the largest plantations groups operating in Papua New Guinea.

9. Kumpulan Guthrie Group

Contact:

*Kumpulan Guthrie Berhad
Wisma Guthrie, Jln Gelenggang
Damansara Heights, 50490 Kuala Lumpur
Malaysia
Tel : + 60 (3) 2094 1644
Fax : + 60 (3) 2094 3445
Homepage: www.guthrie.com.my*

Kumpulan Guthrie Group history dates back to 1821, when the company was first established in Singapore. The Group made its first foray into Indonesia in 1995 to develop an oil palm plantation in Sumatra. In the year 2000, the Group won a bid to purchase interests in companies involved in oil palm cultivation which were spread over seven provinces in Indonesia. Currently, the Group has interests in plantations in both Malaysia (106,000 hectares) and Indonesia (200,000 hectares) and other core businesses include property development, manufacturing, and trading operations.

10. PPB Oil Palms Berhad

Contact:

*PPB Oil Palms Berhad
15th floor Wisma Jerneh
38 Jalan Sultan Ismail
50250 Kuala Lumpur
Malaysia
Tel : + 60 3 2144 1503
Fax : + 60 3 2141 3960*

PPB Oil Palms Berhad is a plantation group principally engaged in oil palm cultivation and milling of fresh fruit bunches. The Group currently owns and operates 13 plantations totalling 142,000 hectares and 8 palm oil mills in East Malaysia and Indonesia. The Group's goal is to remain profitable, stay competitive and achieve sustainable growth with appropriate strategies to maintain an equitable balance between commercial success and environmental considerations.

Accordingly the Group adheres to the principles of sustainable agriculture in the management of its plantations operations. In all greenfield development, the Group has a policy of clearing only suitable logged-over forests for planting oil palms. Other aspects that relate positively to environmental conservation are prescribed in its Agriculture Manual to ensure that its estates adopt the best management practices.

11. Sime Plantations Sdn Bhd

Contact:

*Sime Plantations Sdn Bhd
1st floor, Wisma Consplant, No 2, Jalan SS16/4
47500 Subang Jaya, Selangor Darul Ehsan, Malaysia
Tel : + 60 (3) 5631 7133/8088
Fax : + 60 (3) 5631 7588
Homepage: www.simenet.com*

Sime Plantations Sdn Bhd is one of the core business units in Sime Darby Berhad. Sime major business activities comprise Plantations, Commodity Trading, Refining and Food Business with operations in Malaysia, Singapore, Thailand and Indonesia.

- Plantations: Responsible for managing over 80,000 hectares of oil palm estates in Peninsular Malaysia, Sabah and Kalimantan, as well as operating 8 mills in these areas to extract CPO. Marketing activities of CPB' s CPO is handled internally via Commodities Trading Malaysia.
- Oils and Fats: Responsible for managing the edible oil refining and trading operations in Malaysia (Kempas Edible Oil), Singapore (Sime Darby Edible Products) and Thailand (Morakot Industries).
- Food: Responsible for the aeroponics vegetable farm business in Malaysia, the sale and marketing of vegetable oils (palm olein, soya bean, olive, etc) and the agri-bio business such as cover crop seeds, rat baits and oil palm harvesting poles. Other activities include business development and R&D into non-aeroponic food crops, aquaculture and processed foods.

12. TH Plantations Sdn Bhd (THP)

Contact:

*TH Plantations Sdn Bhd
26th floor, Menara TH Selborn
Jalan Tun Razak
50400 Kuala Lumpur
Malaysia
Tel : + 60 3 2681 0700
Fax : + 60 3 2681 0511
Homepage: www.thplantations.com*

TH Plantations Sdn Bhd was incorporated under the Company Act 1965 as a private limited company on 28th August 1972 under the name of Perbadanan Ladang-Ladang Tabung Haji Sdn Bhd (PLLTH). The company name was subsequently changed to its present name i.e. TH Plantations Sdn Bhd on 15th September 1997. Started with the paid capital of 50 millions, the company expanded rapidly and has become an active oil palm contributor in Malaysia's oil palm industry.

TH Plantations' core business comprises of two, which are the cultivation of oil palm and production of crude palm oil (CPO) and palm kernel. The company owns oil palm plantations totalling 138,208 hectares in Malaysia (which includes Peninsular, Sabah and Sarawak) and Indonesia. TH Plantations Sdn Bhd also acts as the managing agent for TH's oil palm operations in Malaysia, teak plantations operations in Sabah and overseas operations i.e. PT Multigambut Industry. The appointment of TH Plantations Sdn Bhd as a managing agent is to streamline and standardise plantation practices, financial and administrative policies for TH Plantation's Group of Companies.

13. United Plantations Berhad

Contact:

*United Plantations Bhd
Jenderate Estate
36009 Teluk Intan
Perak Darul Ridzuan
Malaysia
Tel : +60 5 6411411
Fax : +60 5 6411876
Homepage: www.unitedplantations.com*

United Plantation Berhad is one of the most efficiently managed, eco-friendly and integrated plantation companies in Malaysia and is well known globally for its best agricultural practices and high quality standards. In Malaysia, UP's total Landbanks consist of approximately 40,874 hectares. The main focus is cultivation of oil palms (90%) and coconuts (10%). In Malaysia, United Plantations Berhad operates 6 Palm Oil Mills and the Unitata refinery, a subsidiary that has been cooperating for a number of years, on a joint venture basis, with AarhusKarlshamn AB; a leader in the global speciality fats sector.

With the acquisition of two Indonesian plantation companies in 2006 the total hectareage in Indonesia will be approximately 40,000 hectares which is expected to be developed over the next 10 years. Development is progressing as planned. The company is committed towards sustainability in all aspects of its plantation operations. Firstly, special emphasis is paid on achieving high yields hereby maximising the productivity of its land bank resources e.g. United Plantations average yield of crude palm oil per hectare was 5.3 million tonnes during 2003 compared with the national Malaysia average of 3.75 million tonnes of CPO/ha.

Sources of information for these corporate profiles:

<http://www.etawau.com/OilPalm/PalmOilSuppliersMalaysia.htm>

<http://investing.businessweek.com/research/stocks/private/snapshot.asp?privcapId=875256>

http://www.unitedplantations.com/About/UP_facts.asp

APPENDIX 2

RSPO Principles and Criteria for Sustainable Palm Oil Production (Public release version)

RSPO Principles and Criteria for Sustainable Palm Oil Production Version 3 (22 September 2005)

Principles and Criteria for Sustainable Palm Oil Production

Principle 1: Commitment to transparency

Criterion 1.1 Oil palm growers and millers provide adequate information to other stakeholders on environmental, social and legal issues relevant to RSPO Criteria, in appropriate languages & forms to allow for effective participation in decision making.

Criterion 1.2 Management documents are publicly available, except where this is prevented by commercial confidentiality or where disclosure of information would result in negative environmental or social outcomes

Principle 2: Compliance with applicable laws and regulations

Criterion 2.1 There is compliance with all applicable local, national and ratified international laws and regulations.

Criterion 2.2 The right to use the land can be demonstrated, and is not legitimately contested by local communities with demonstrable rights.

Criterion 2.3 Use of the land for oil palm does not diminish the legal rights, or customary rights, of other users, without their free, prior and informed consent

Principle 3: Commitment to long-term economic and financial viability

Criterion 3.1 There is an implemented management plan that aims to achieve long-term economic and financial viability.

Principle 4: Use of appropriate best practices by growers and millers

Criterion 4.1 Operating procedures are appropriately documented and consistently implemented and monitored.

Criterion 4.2 Practices maintain soil fertility at, or where possible improve soil fertility to, a level that ensures optimal and sustained yield.

Criterion 4.3 Practices minimise and control erosion and degradation of soils.

Criterion 4.4 Practices maintain the quality and availability of surface and ground water.

Criterion 4.5 Pests, diseases, weeds and invasive introduced species are effectively managed using appropriate Integrated Pest Management (IPM) techniques.

Criterion 4.6 Agrochemicals are used in a way that does not endanger health or the environment. There is no prophylactic use, and where agrochemicals are used that are categorised as World Health Organisation Type 1A or 1B, or are listed by the Stockholm or Rotterdam Conventions, growers are actively seeking to identify alternatives, and this is documented.

Criterion 4.7 An occupational health and safety plan is documented, effectively communicated and implemented.

Criterion 4.8 All staff, workers, smallholders and contractors are appropriately trained.

Principle 5: Environmental responsibility and conservation of natural resources and biodiversity

Criterion 5.1 Aspects of plantation and mill management that have environmental impacts are identified, and plans to mitigate the negative impacts and promote the positive ones are made, implemented and monitored, to demonstrate continuous improvement.

Criterion 5.2 The status of rare, threatened or endangered species and high conservation value habitats, if any, that exist in the plantation or that could be affected by plantation or mill management, shall be identified and their conservation taken into account in management plans and operations.

Criterion 5.3 Waste is reduced, recycled, re-used and disposed of in an environmentally and socially responsible manner.

Criterion 5.4 Efficiency of energy use and use of renewable energy is maximised.

Criterion 5.5 Use of fire for waste disposal and for preparing land for replanting is avoided except in specific situations, as identified in the ASEAN guidelines or other regional best practice.

Criterion 5.6 Plans to reduce pollution and emissions, including greenhouse gases, are developed, implemented and monitored.

Principle 6: Responsible consideration of employees and of individuals and communities affected by growers and mills

Criterion 6.1 Aspects of plantation and mill management that have social impacts are identified in a participatory way, and plans to mitigate the negative impacts and promote the positive ones are made, implemented and monitored, to demonstrate continuous improvement.

Criterion 6.2 There are open and transparent methods for communication and consultation between growers and/or millers, local communities and other affected or interested parties.

Criterion 6.3 There is a mutually agreed and documented system for dealing with complaints and grievances, which is implemented and accepted by all parties.

Criterion 6.4 Any negotiations concerning compensation for loss of legal or customary rights are dealt with through a documented system that enables indigenous peoples, local communities and other stakeholders to express their views through their own representative institutions.

Criterion 6.5 Pay and conditions for employees and for employees of contractors always meet at least legal or industry minimum standards and are sufficient to meet basic needs of personnel and to provide some discretionary income.

Criterion 6.6 The employer respects the right of all personnel to form and join trade unions of their choice and to bargain collectively. Where the right to freedom of association and collective bargaining are restricted under law, the employer facilitates parallel means of independent and free association and bargaining for all such personnel.

Criterion 6.7 Child labour is not used. Children are not exposed to hazardous working conditions. Work by children is acceptable on family farms, under adult supervision, and when not interfering with education programmes.

Criterion 6.8 The employer shall not engage in or support discrimination based on race, caste, national origin, religion, disability, gender, sexual orientation, union membership, political affiliation, or age.

Criterion 6.9 A policy to prevent sexual harassment and all other forms of violence against women and to protect their reproductive rights is developed and applied.

Criterion 6.10 Growers and millers deal fairly and transparently with smallholders and other local businesses.

Criterion 6.11 Growers and millers contribute to local sustainable development wherever appropriate.

Principle 7: Responsible development of new plantings

Criterion 7.1 A comprehensive and participatory independent social and environmental impact assessment is undertaken prior to establishing new plantings or operations, or expanding existing ones, and the results incorporated into planning, management and operations.

Criterion 7.2 Soil surveys and topographic information are used for site planning in the establishment of new plantings, and the results are incorporated into plans and operations.

Criterion 7.3 New plantings since November 2005 (which is the expected date of adoption of these criteria by the RSPO membership), have not replaced primary forest or any area containing one or more High Conservation Values.

Criterion 7.4 Extensive planting on steep terrain, and/or on marginal and fragile soils, is avoided.

Criterion 7.5 No new plantings are established on local peoples' land without their free, prior and informed consent, dealt with through a documented system that enables indigenous peoples, local communities and other stakeholders to express their views through their own representative institutions.

Criterion 7.6 Local people are compensated for any agreed land acquisitions and relinquishment of rights, subject to their free, prior and informed consent and negotiated agreements.

Criterion 7.7 Use of fire in the preparation of new plantings is avoided other than in specific situations, as identified in the ASEAN guidelines or other regional best practice.

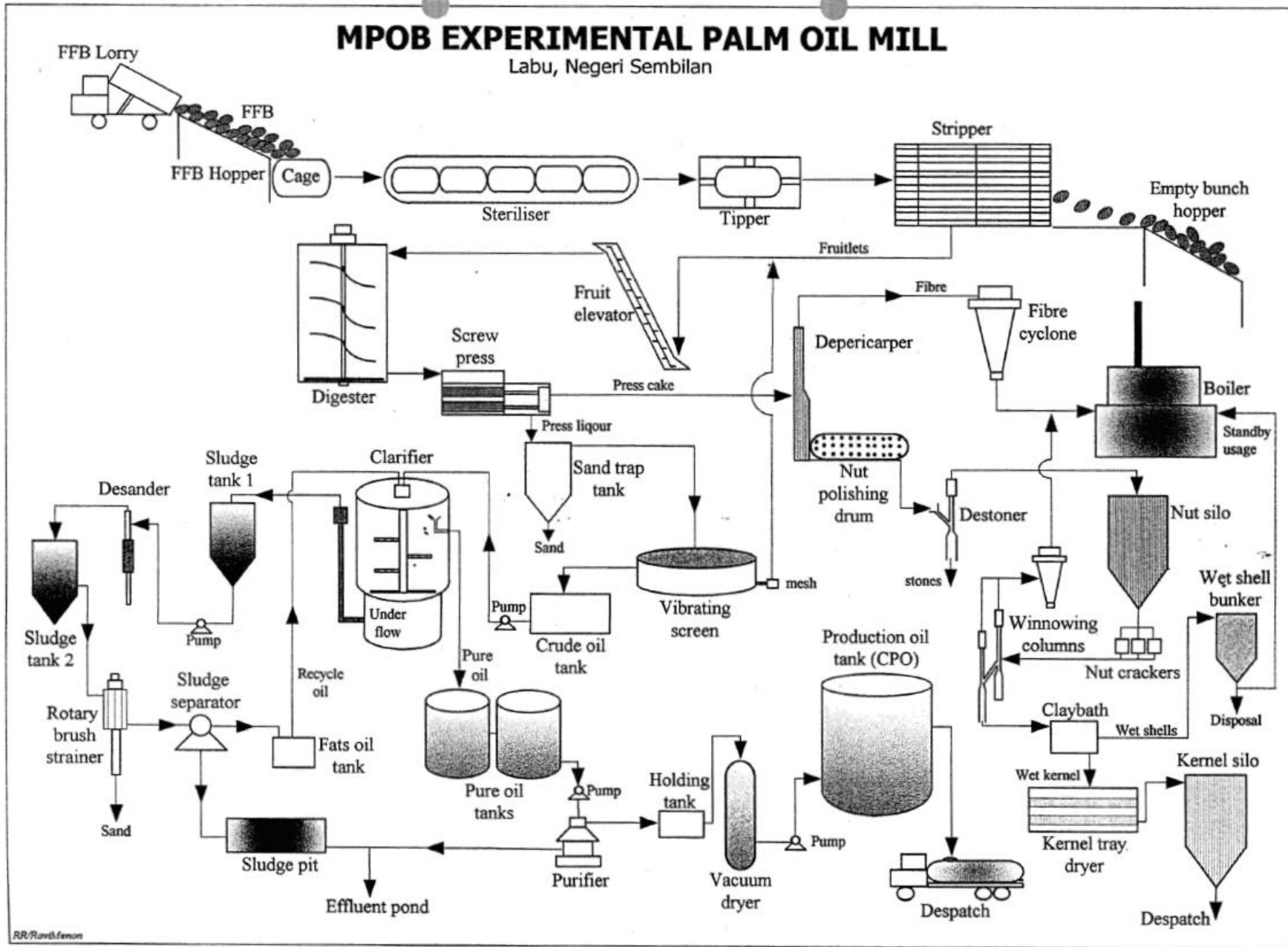
Principle 8: Commitment to continuous improvement in key areas of activity

Criterion 8.1 Growers and millers regularly monitor and review their activities and develop and implement action plans that allow demonstrable continuous improvement in key operations

APPENDIX 3

Sample: Clean Development Mechanism (CDM) Methane to Energy Project in a Palm Oil Mill
 Published by Webmaster on 2007/3/20 (<http://www.ecoideal.com.my>)

Clean Development Mechanism (CDM) Methane to Energy Project in a Palm Oil Mill Kim Loong Methane Recovery for Onsite Utilisation Project at Kota Tinggi, Johor, Malaysia	
Project Type	CDM (Clean Development Mechanism)
Category of Project Activity	Waste management measures which contribute to the avoidance of greenhouse gas emissions, especially through energy recovery from waste, if possible with waste heat utilisation
Project Location	Johor
Current Project Status	The Project Design Document (PDD) was validated by TUV.
<p>Introduction</p> <p>Malaysia is the largest producer and exporter of palm oil in the world today. In the year 2003 alone, Malaysia exported 12 248 000 million tonnes of palm oil. There are approximately 370 palm oil mills in operation in Malaysia and an additional 40 mills currently in their planning stages or under construction. Most, (approximately 85%) use anaerobic ponds to process their waste. There is such a large potential for developing biogas projects to reduce methane emissions and to increase the use of biomass for energy purposes.</p> <p>In line with Vision 2020 (to become a developed nation), Malaysia has implemented a 5th fuel act, where under this act, renewable energy plays a major role in the countries development. By the year 2008, Malaysia is set to have reached their target of renewable energies occupying a minimum of 5% of the total market demand. With this online, the project will continue to proactively develop the palm oil industry through increased efficiency of Palm Oil Mill Effluent (POME) utilisation, thus resulting in reduced green house gases (GHG).</p> <p>Each and every CDM project is unique, from the project design to the application of even the simplest methodology. Some of the projects submitted for validation may be very efficient in reducing emissions and score well in terms of economic, social and environmental benefits, but may still not qualify as CDM projects¹. Once the project is approved, the Certified Emission Reductions (CERs) will be sold to Annex 1 countries² (price per tCO₂e).</p>	
<p>Project Description</p> <p>The purpose of the project is to reduce methane emissions from wastewater treatment by closing the current open tank in the mill and installing a methane collection system to capture the methane (biogas) from the Palm Oil Mill Effluent (POME). The biogas will be used in a boiler to produce steam for direct application (heat as energy source) and the surplus shall be used for electricity generation (using a steam turbine) for the present plant's own consumption and also the newly integrated ones.</p> <p>Energy (steam and electricity) at the palm oil mill is generated by biomass-based fuels, namely palm kernel shells (PKS) and palm fibre. The electricity generated from methane will replace partly this biomass-based fuel and also diesel when energy from the biomass-based fuel is insufficient with additional demands from the integrated plants. Therefore, this project will not contribute to further GHG emissions but reduce them when diesel is replaced.</p> <p>Biomass fuels, especially PKS, when replaced by biogas, may be exported and used as biofuel in industries. PKS is easily transported and handled because of its low moisture content and high heating value. This will contribute to further use of biomass as fuel in Malaysia.</p>	
<p>¹ United Nations Environment Programme (UNEP). (2005). [Online]. Available: http://www.cd4cdm.org/ [2005, November 18]</p> <p>² Annex 1 countries: These are the 36 industrialised countries and economies in transition listed in Annex 1 of the UNFCCC). Their responsibilities under the Convention are various, and include a non-binding commitment to reducing their GHG emissions to 1990 levels by the year 2000.</p>	



From Oravainen 2002, VTT Processes: original RR/Kosh/Ravi Menon

APPENDIX 4 (2/2)

FFB

Fresh fruit bunch, which is harvested from oil palm trees at the plantation.

FFB Lorry/Trailer

Vehicles used for transporting the fresh fruit bunch from the plantation to the mill.

FFB Hopper

A sliding platform made of mild steel where the vehicles unload the fresh fruit bunches.

Cage

To transport the fruit bunches from the hopper to the steriliser.

Steriliser

A cylindrical vessel used to cook fresh fruit bunches using pressurized steam, in order to sterilise the fruits and to soften and detach the fruits from the whole bunch. Sterilisation prevents the rise of free fatty acid (FFA) in the fruits.

Tipper

A rotating device that tips the FFB cage at 180 degree to transfer the sterilised bunches to the stripper.

Stripper

A rotary drum in which the lifting bars pick up the bunches and throw them down a few times to detach the fruits from the bunch and they pass through the perforations of the stripper to a bottom conveyor.

Empty bunch hopper

A sliding platform that collects and feed empty fruit bunches to lorries that transport them for mulching in the field.

Fruit elevator

A chain elevator with buckets to transfer the fruitlets to horizontal conveyor that feed into the digesters.

Digester

A steam heated vertical tank with a motorized central shaft fitted with 5 pairs of stirring arms, which causes the fruitlets to rupture the oil bearing cells and condition the fruits to subsequent pressing operation

Screw press

Two screws revolving in opposite directions to compress the digested mash to squeeze out the oil.

Sand trap tank

To remove sand and other sediments.

Vibrating screen

To remove all fibrous material from crude oil and recycle them to the digester.

Crude oil tank

To collect the crude oil after screening as a buffer tank, with provision for steam heating.

Clarifier

Separates the pure oil and sludge (underflow) from the diluted crude oil, using specific gravity separation.

Sludge tank

To store the sludge from clarifier.

Desander

To remove sand from the oil.

Rotary brush strainer

To impart shear force to sludge so that oil separates out in separation.

Sludge separator/centrifuge

Recovers the oil from the sludge

Sludge pit

Collects the sludge from separator to this ground concrete tank.

Effluent pond

Wastewater ponds for biological digestion.

Fats oil tank

Recycled oil is collected to this storage tank.

Pure oil tank

Pure oil from clarifier is collected to this storage tank.

Purifier

Pure oil is purified further, dirt suspended sediments and moisture is removed.

Holding tank

Pure oil is transferred from purifier and stored to this tank.

Vacuum dryer

Pure oil moisture evaporates at low pressure in this vacuum chamber.

Production oil tank

Crude palm oil is stored in this tank before dispatch to buyers.

Depericarper

Separates the fibre and the nut from press cake, using pneumatic separation principle.

Fibre cyclone

The separated fibre is discharged through this cyclone to boiler fuel conveyor.

Nut polishing drum

This is a rotary drum which receives the nuts from de-pericarp column. The mutual rubbing action removes the fibre attached on the nut before cracking.

Destoner

Removes stones or any other heavy particles from nuts after nut polishing drum.

Nut silo

A vertical steam heating tank that holds the polished nuts before going to nut cracker.

Nut cracker

Cracks the nut to shell and kernel.

Winnowing columns

Shells and dust are drawn to the boiler using pneumatic separation (winnowing).

Claybath

Koalin solution having a specific gravity of 1.185 causes the shell to separate from kernel.

Kernel tray dryer

Wet kernels are dried to remove moisture to meet required specification before storage.

Kernel bulk silo

A vertical tank where the dried kernels are stored before dispatch to buyers.

Boiler

Fibre and shell are fed into the boiler as fuel to produce steam that runs the turbine coupled to alternator. The electricity generated is used to operate all the motors in the mill. The low pressure steam from the back pressure turbine (3 bar) is used for process heating.

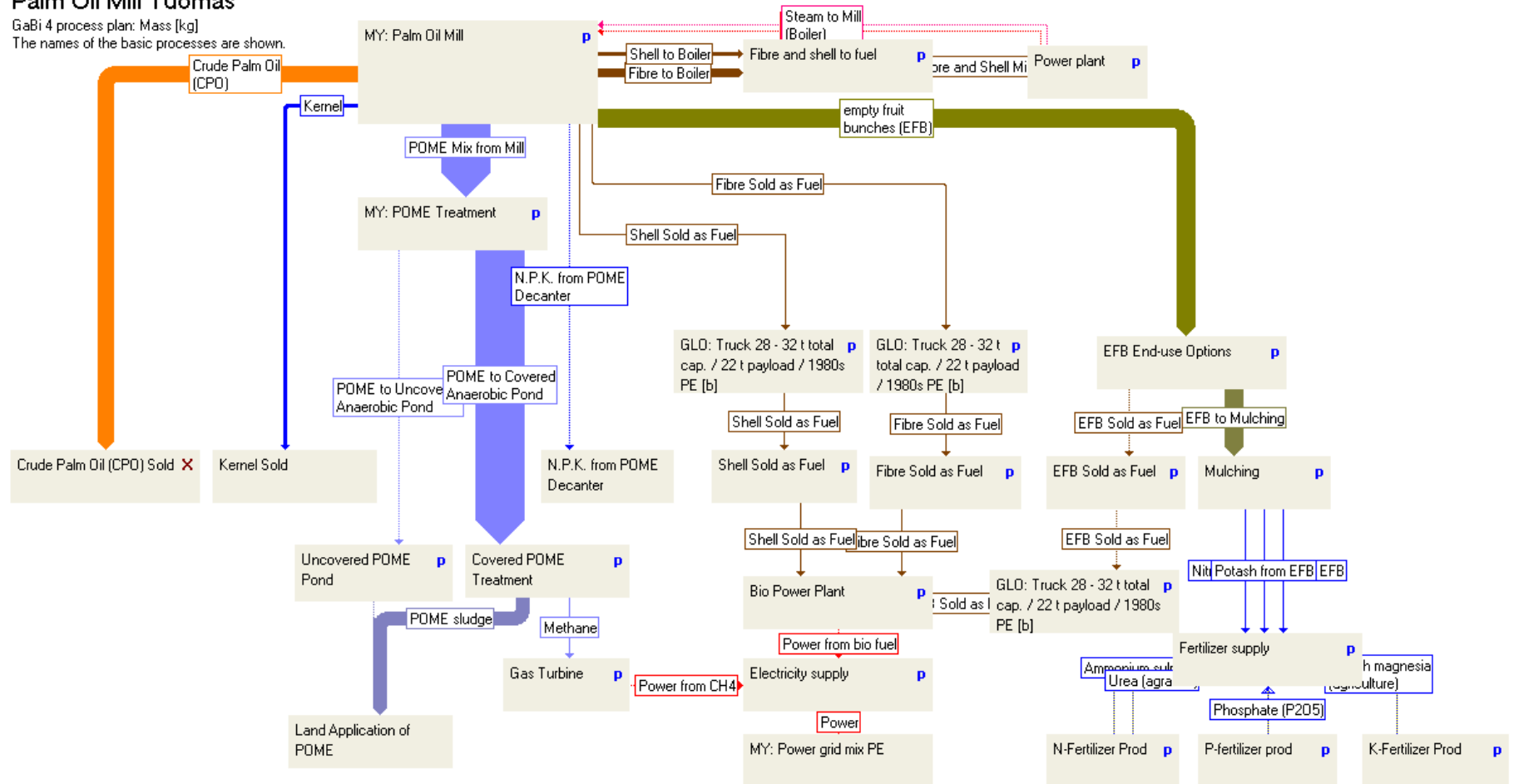
From Oravainen 2002, VTT Processes: original RR/Kosh/Ravi Menon

APPENDIX 5

Process flow chart from LCA tool GaBi 4.3

Palm Oil Mill Tuomas

GaBi 4 process plan: Mass [kg]
The names of the basic processes are shown.



APPENDIX 6

Data on market value of crude palm oil and palm kernel

ECONOMIC VALUE OF CRUDE PALM OIL (RM/TONNE)

Months	North		South		Central		E.Coast	
	2007	2008	2007	2008	2007	2008	2007	2008
January	1 914,50	3 210,00	1 934,00	3 230,00	1 937,50	3 210,00	1 918,00	3 111,50
February	1 912,00	3 520,50	1 931,00	3 515,00	1 931,00	3 511,50	1 901,00	3 350,00
March	1 941,50	3 668,00	1 969,50	3 693,50	1 958,00	3 707,50	1 926,00	3 673,00
April	2 179,00	3 411,50	2 226,00	3 442,00	2 206,50	3 399,00	2 050,00	3 270,00
May	2 449,00	3 482,50	2 480,00	3 513,00	2 472,50	3 540,00	2 345,00	3 361,50
June	2 533,00	3 587,00	2 617,00	3 607,50	2 627,00	3 581,00	2 533,00	3 505,00
July	2 607,50	3 397,00	2 643,00	3 482,00	2 634,50	3 463,00	2 585,00	3 095,50
August	2 521,00	2 655,50	2 546,00	2 693,00	2 536,00	2 649,50	2 527,50	2 591,50
September	2 563,00	2 306,00	2 592,00	2 361,00	NT	2 343,50	2 531,00	2 262,00
October	2 729,50	1 698,00	2 781,00	1 772,00	2 776,00	1 743,50	2 665,00	1 728,50
November	2 926,50		2 978,50		2 955,00		2 923,00	
December	2 919,00		2 943,00		2 923,50		2 874,00	
Average	2 453,00	3 134,50	2 582,50	3 057,00	2 508,50	3 007,00	2 406,50	2 718,00

ECONOMIC VALUE OF PALM KERNEL (RM/TONNE)

Months	North		South		Central		E.Coast	
	2007	2008	2007	2008	2007	2008	2007	2008
January	1 079,00	2 005,50	1 096,00	1 977,00	1 098,00	2 007,50	1 084,50	1 991,50
February	1 088,50	2 065,00	1 093,50	2 064,50	1 092,50	2 082,50	1 074,03	2 057,00
March	1 103,50	1 985,00	1 119,00	2 052,50	1 110,50	2 062,00	1 103,50	2 034,50
April	1 233,00	1 917,00	1 237,50	1 929,50	1 243,00	1 933,50	1 234,00	1 902,50
May	1 338,00	2 007,50	1 321,00	2 015,00	1 348,50	2 022,00	1 305,00	1 992,50
June	1 507,50	2 034,50	1 517,00	2 075,00	1 524,50	2 065,50	1 520,50	2 055,50
July	1 532,00	1 838,00	1 543,00	1 868,50	1 549,50	1 857,50	1 543,00	1 837,50
August	1 502,50	1 464,00	1 515,00	1 502,50	1 509,00	1 481,00	1 509,50	1 471,50
September	1 563,00	1 417,00	1 569,50	1 441,00	1 588,50	1 455,00	1 572,00	1 424,00
October	1 663,00	1 186,50	1 672,00	1 144,00	1 683,50	1 136,50	1 673,00	1 095,50
November	1 677,00		1 696,00		1 698,00		1 691,50	
December	1 755,00		1 745,50		1 750,50		1 730,00	
Average	1 422,50	1 788,00	1 485,50	1 790,00	1 448,50	1 894,00	1 438,34	1 788,00

CRUDE PALM OIL MARKET VALUE TO PALM KERNEL MARKET VALUE

Months	North		South		Central		E.Coast	
	2007	2008	2007	2008	2007	2008	2007	2008
	Relative monthly economic value [$\$/_{CPO}$ / $\$/_{palm\ kernel}$]							
January	1,77	1,60	1,76	1,63	1,76	1,60	1,77	1,56
February	1,76	1,70	1,77	1,70	1,77	1,69	1,77	1,63
March	1,76	1,85	1,76	1,80	1,76	1,80	1,75	1,81
April	1,77	1,78	1,80	1,78	1,78	1,76	1,66	1,72
May	1,83	1,73	1,88	1,74	1,83	1,75	1,80	1,69
June	1,68	1,76	1,73	1,74	1,72	1,73	1,67	1,71
July	1,70	1,85	1,71	1,86	1,70	1,86	1,68	1,68
August	1,68	1,81	1,68	1,79	1,68	1,79	1,67	1,76
September	1,64	1,63	1,65	1,64		1,61	1,61	1,59
October	1,64	1,43	1,66	1,55	1,65	1,53	1,59	1,58
November	1,75		1,76		1,74		1,73	
December	1,66		1,69		1,67		1,66	
Average	1,72	1,75	1,74	1,71	1,73	1,59	1,67	1,52
	2007	2008	2007-08					
Average	1,72	1,64	1,68					
Std. Dev	0,06	0,10	0,08					
Std. Dev %	4 %	6 %	5 %					

The relative market value of crude palm oil to market value of palm kernel oil was calculated for each month and each area of Malaysia separately. The data was gathered from MPOB web pages for years 2007 and 2008, http://econ.mpob.gov.my/economy/EID_web.htm. The average ratio of market value in year 2007 was 1.72 and for year 2008 1.64. The average 1.68 ± 0.08 market value ratio was applied in the economic allocation.

APPENDIX 7 – All inventory data

The green cells represent the lowest value, red the highest and yellow the suspiciously high or low values omitted from calculations.

per tonne FFB					min	max				
	RTFO	Schmidt	Nikander	Yusoff&Hansen	Gheewala		Shahrakbah	Subramaniam et al. 2008		
INPUTS										
FFB [t]	1	1	1	1	1	1		1	1	1
Electricity [MJ]	29,00	69,09	29,00	64,00	41,06	57,60	0,00	73,45	73,40	72,07
Steam [MJ] or [ton]	1188,00	1622,68	1188,00	1620,00	0,30	0,48	<i>Subram [t]:</i>	0,50	0,65	0,52
Diesel for Mill[L]								0,44	0	0,24
Diesel for Vechiles [L]								0,06	0,03	0,49
OUTPUTS										
CPO [t]	0,21	0,20	0,21	0,20	0,19	0,16		0,20	0,20	0,19
EFB [t]		0,22	0,23	0,23	0,27	0,30		0,23	0,23	0,23
Fibre [t]		0,13	0,13	0,16	0,27	0,33		0,12	0,12	0,12
Shell [t]		0,07	0,07	0,08	0,05	0,07		0,07	0,07	0,07
Palm kernels t]		0,05	0,05	0,07	0,05	0,06		0,08	0,08	0,08
POME [t]	0,53	0,67	0,70	0,50	0,49	0,528		0,60	0,60	0,60
CH4 from POME [m3]	7,98	11,64	12,13	9,10				10,92	10,92	10,91
CO2 from POME [m3]				4,90				5,880	5,880	5,876
CH4 [kg] / POME [t]	10,87	12,42	12,42	13,05			12,36kg/tPOME	13,04	13,05	13,06
per tonne FFB										
Subramaniam et al. 2008 continue										Average
FFB [t]	1	1	1	1	1	1	1	1	1	1
Electricity [MJ]	72,14	74,07	72,01	71,96	71,94	72,06	72,05	71,97	72,01	66,24
Steam [MJ] or [ton]	0,48	0,50	0,50	0,52	0,50	0,45	0,45	0,65	0,47	0,51
Diesel for Mill[L]	0,36	0,55	0,61	0,45	0,42	0,96	0,72	0,93	0,07	0,48
Diesel for Vechiles [L]	0,54	0,16	0,76	0,20	0,25	0,73	0,73	0,14	0,39	0,37
OUTPUTS										
CPO [t]	0,18	0,19	0,21	0,18	0,20	0,21	0,21	0,21	0,19	0,20
EFB [t]	0,23	0,23	0,23	0,23	0,23	0,23	0,23	0,23	0,23	0,24
Fibre [t]	0,12	0,12	0,12	0,10	0,12	0,12	0,12	0,12	0,12	0,12
Shell [t]	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07
Palm kernels t]	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,07	0,07
POME [t]	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,60	0,59
CH4 from POME [m3]	10,92	10,93	10,92	10,91	10,91	10,93	10,93	10,92	10,91	10,93
CO2 from POME [m3]	5,878	5,884	5,880	5,878	5,875	5,884	5,884	5,877	5,876	
CH4 [kg] / POME [t]	13,04	13,07	13,06	13,05	13,04	13,07	13,07	13,05	13,05	12,74

APPENDIX 8 (1/2)

Summary of the relevant calculations behind RES directive greenhouse gas savings for hydrotreated vegetable oil from palm oil (1/2)

Biofuel production pathway	Typical GHG emitted (g CO ₂ eq/MJ)				Default GHG emitted (g CO ₂ eq/MJ)			
	Cultivation	Processing	Transport & distribution	Total	Cultivation	Processing	Transport & distribution	Total
sugar beet ethanol	12	19	2	33	12	26	2	40
wheat ethanol (lignite as process fuel in CHP plant)	23	32	2	57	23	45	2	70
wheat ethanol (natural gas as process fuel in conventional boiler)	23	21	2	46	23	30	2	55
wheat ethanol (natural gas as process fuel in CHP plant)	23	14	2	39	23	19	2	44
wheat ethanol (straw as process fuel in CHP plant)	23	1	2	26	23	1	2	26
corn (maize) ethanol, Community produced (natural gas as process fuel in CHP plant)	20	15	2	37	20	21	2	43
sugar cane ethanol	14	1	9	24	14	1	9	24
rape seed biodiesel	29	16	1	46	29	22	1	52
sunflower biodiesel	18	16	1	35	18	22	1	41
soybean biodiesel	19	18	13	50	19	26	13	58
palm oil biodiesel (process not specified)	14	35	5	54	14	49	5	68
palm oil biodiesel (process with methane capture at oil mill)	14	13	5	32	14	18	5	37
waste vegetable or animal oil biodiesel	0	9	1	10	0	13	1	14
hydrotreated vegetable oil from rape seed	30	10	1	41	30	13	1	44
hydrotreated vegetable oil from sunflower	18	10	1	29	18	13	1	32
hydrotreated vegetable oil (HVO) from palm oil (process not specified)	15	30	5	50	15	42	5	62
hydrotreated vegetable oil from palm oil (process with methane capture at oil mill)	15	7	5	27	15	9	5	29
pure vegetable oil from rape seed	30	4	1	35	30	5	1	36
biogas from municipal organic waste as compressed natural gas	0	14	3	17	0	20	3	23
biogas from wet manure as compressed natural gas	0	8	5	13	0	11	5	16
biogas from dry manure as compressed natural gas	0	8	4	12	0	11	4	15

Source: JRC (European Commission Joint Research Centre) background material for RES directive development. 2008. Written notification: "Updated figures communicated - Update on Data on pathways for RES Directive.xls, worksheet Updated figures communicated"

APPENDIX 8 (2/2)

Summary of the relevant calculations behind RES directive GHG savings for hydrotreated vegetable oil from palm oil

FAME

		Energy consumed (MJx/MJf)				Net GHG emitted (g CO2eq/MJf)			CO2	CH4	N2O
		Total primary			Fossil	Best est.	min	Max	g/MJ	g/MJ	g/MJ
		Best est.	min	Max							
POHY	Hydrotreated vegetable oil (HVO) from palm oil, palm kernel meal taken into account via allocaton by energy										
	Cultivation	0,09				14,70			5,5	0,01	0,030
	Road transport, 20 km	0,00				0,19			0,2	0,00	0,000
	FFB storage	0,04				0,00			0,0	0,00	0,000
	Oil mill	0,83				23,22			0,0	0,93	0,000
	Transport to EU 3)	0,05				3,66			3,6	0,00	0,000
	Oil mill, refining, hydrotreating	0,15				6,69			6,2	0,02	0,000
	Transport to refuelling station 1)	0,01				0,71			0,7	0,00	0,000
	Refuelling station	0,01				0,44			0,4	0,00	0,000
	Total WTT GHG emitted					49,6	44,4	74,2	16,6	0,96	0,030
	Credit for renewable combustion CO2					-70,8			-70,8		
	Total pathway	1,17	1,17	1,18	0,27	-21,2	-26,5	3,3			

Source: JRC (European Commission Joint Research Centre) background material for RES directive development. 2008. Written notification: "Updated figures communicated - Update on Data on pathways for RES Directive.xls, worksheet FAME-HVO, rows 72-83"