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OIL PALM BIOMASS AS A SUSTAINABLE ENERGY SOURCE: A MALAYSIAN CASE STUDY

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ABSTRACT

The latest scientific data confirmed that the earth's climate is rapidly changing. Therefore, it has been widely accepted worldwide that global warming is by far the greatest threat and challenge in the new millennium. The main factor that causes global warming is the release of greenhouse gases to the environment. In order to reduce the emission of these greenhouse gases and to promote sustainable development, renewable energy is the perfect solution to achieve both targets. Besides, latest report has shown that the world, including Malaysia can no longer turn away from renewable energy as fossil fuel reserves can only last for the next 30 to 40 years. On the other hand, presently million of hectares of land in Malaysia is occupied with oil palm plantation generating huge quantities of biomass. In this context, biomass from the oil palm industries appears to be a very promising alternative as a source of raw materials including renewable energy in Malaysia. Thus, this paper aims to presents the current scenario of biomass in Malaysia covering the availability of feedstock as well as current and possible utilization of oil palm biomass. This paper will also discuss some ongoing projects in Malaysia related to the utilization of oil palm biomass as a source of renewable energy. Based on the findings presented, it is definitely clear that Malaysia has position herself in the right path to utilize biomass as a source of renewable energy and this can act as an example to other countries in the world that has huge biomass feedstock.

Keywords: oil palm biomass, alternative energy, cellulose feedstock

INTRODUCTION

Generally, it is accepted worldwide that climate change is currently the most pressing global environmental problem facing humanity. Scientific data showed that hundreds of millions of people could lose their lives if the average global temperatures increase by more than 2°C. In addition, up to one million species of animals and plants are currently at the threat of extinction [1]. Many environmental problems, for instance flooding, hurricanes as well as droughts will and has occured because of the alleviation of earth's temperature. Other detrimental effects of global warming include increment in sea level and subsequently submerging of lowlands, deltas and island as well as changing of weather pattern [2].

The Fourth Assessment Report (AR4) which was released on 17 December 2007 of the United Nation Intergovernmental Panel on Climate Change (IPCC) concluded that the observed warming over the last 50 years is likely due to the increase of greenhouse gas emission such as carbon dioxide, methane and nitrous oxide [3, 4]. According to AR4, the global increment in carbon dioxide concentration is primarily due to the use of fossil fuel, while those of methane and nitrous oxide are because of agriculture activities [3]. Nevertheless, carbon dioxide has been identified as the main culprit due to its huge emission and therefore, utilization of fossil fuel as a source of energy for heat, electricity and transportation fuel have been identified as the primary cause of global warming. Thus, in order to reduce the emission of the greenhouse gases and to promote greater energy

efficiency, substitution of fossil fuel with renewable energy should be part of the climate change solution as long as the renewable energy is truly developed in a sustainable way. There are currently many sources of renewable energy such as solar, wind, geothermal and biomass. However, in a country that has a significant amount of agricultural activities such as Malaysia, biomass can be a very promising alternative source of renewable energy. In fact, the government of Malaysia has embarked on this ideology by drafting the 5th fuel policy that states "To supplement the conventional energy supply, new sources such as renewable energy will be encouraged and biomass such as oil palm, wood waste as well as rice husk will be used on the wider basis" [5].

Figure 1 shows the energy demand in Malaysia that indicates a rapid increase in demand. For the year 2030, the energy demand is expected to be almost 100 Mtoe (million tonne of oil equivalent) [6]. In order to meet the increasing demand of energy and to reduce the emission of carbon dioxide while ensuring energy security, Malaysia needs to have an effective and sustainable source of energy. Table 1 shows that based on 2005 data, about 93% of Malaysia energy consumption depended heavily on fossil fuels (natural gas, coal, diesel and oil) and only 0.5% of the energy came from renewable sources such as biomass (excluding hydropower) [7]. If this trend was to continue on, Malaysia would suffer from lack of energy security as the Malaysia fossil fuel reserves is predicted to last only for another 30 to 40 years [2]. Beyond that, Malaysia will become a net importer of fossil fuel, mainly oil and gas. Therefore, it is inevitable that the Malaysian government has to start looking for reliable source of renewable energy urgently. The need for an urgent source of renewable energy is further supported by the current increasing price of fossil fuel mainly petroleum. With the price of crude oil at US$ 121.91 per barrel in July 2008, the Malaysian government needs to spend a lot on subsidy to keep the cost of energy, mainly transportation fuel low [8]. In 2007 alone, Malaysia's fuel subsidies cost the country about RM40 billion [9].

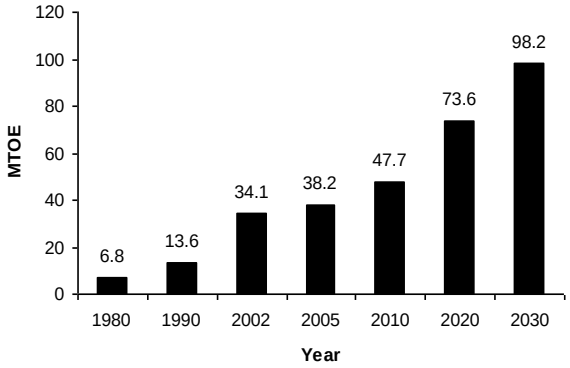

Figure 1: Energy demand in Malaysia [6].

Table 1: Malaysia's energy mix in the year of 2005 [7].

Source	Percentage, %
Gas	72.5
Coal	16.5
Hydropower	6.2
Diesel	3.2
Oil	0.8
Biomass	0.5
Others	0.3

As the world second largest producer and exporter of palm oil in 2006 [10], Malaysia's palm oil industry leaves behind huge amount of biomass from its plantation and milling activity, way much larger as compared to other types of biomass. The biomass from the oil palm industry has the potential to be converted to commercial products such as animal food, fertilizer and absorbent. It can also be converted to biofuel such as bioethanol or can be used to generate electricity. Thus, this paper aims to presents the current scenario of biomass in Malaysia ranging from the availability of feedstock, current and possible utilization of oil palm biomass in reducing CO_2 emission. Besides, various palm oil utilization projects that have been launched by the Malaysian government, mainly on the generation of power and electricity from oil palm biomass will also be discussed as well. In short, this paper presents Malaysia's commitment and active role to utilize oil palm biomass including as a source of renewable energy to reduce green house gas emission and ultimately, global warming.

AVAILABILITY OF OIL PALM BIOMASS IN MALAYSIA

Oil palm, or also known as *Elaeis guineensis* is the most important species in the *Elaeis* genius which belongs to the family of palmae [11]. It is indigenous to West Africa but is now planted in all tropical areas of the world. Moreover, it has become the most important industrial crops especially in certain South East Asia countries like Malaysia, Indonesia and Thailand. The oil palm fruit is reddish in color and about the size of a large plum, but it grows in large bunches. One bunch usually weighs between 10 to 40 kilograms. Each fruit consists of a single seed (the palm kernel) and surrounded by a soft oily pulp. Oil is extracted from both the pulp of the fruit which can be made into edible oil and the kernel which is used mainly for soap manufacture [12].

Palm oil has now become the world largest source of edible oil with 38.5 million tonnes or 25% of the world total edible oils and fats production as shown in Figure 2 [13]. Thus, oil palm has now become a major economic crop which triggered the expansion of plantation area in Malaysia and Indonesia. In the year of 2006, Malaysia is the second largest producer of palm oil with 15.88 million tonnes or 43% of the total world supply as shown in Figure 3 [10]. Indonesia is the world largest producer of palm oil with 15.9 million tones of oil or 44% of the total world supply. In 2007, productive oil palm plantations in Malaysia were 4.3 million hectares, a 3.4% increase from the year 2006 which stood at 4.2 million hectares [14]. Figure 4 shows the evolution of oil palm plantation area from 1975 to 2006 [15]. The increase in plantation area of oil palm in Malaysia is mainly because of growing global demand for edible oil especially palm oil.

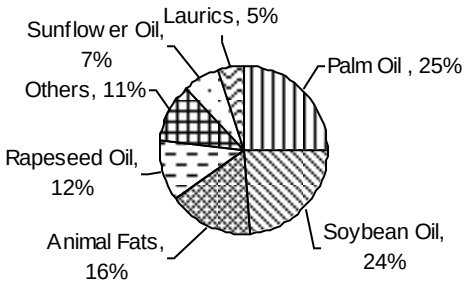

Figure 2: World's oils production in 2007 [13].

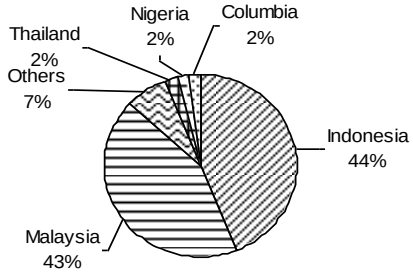

Figure 3: World Producers of Oil Palm in 2006 [10].

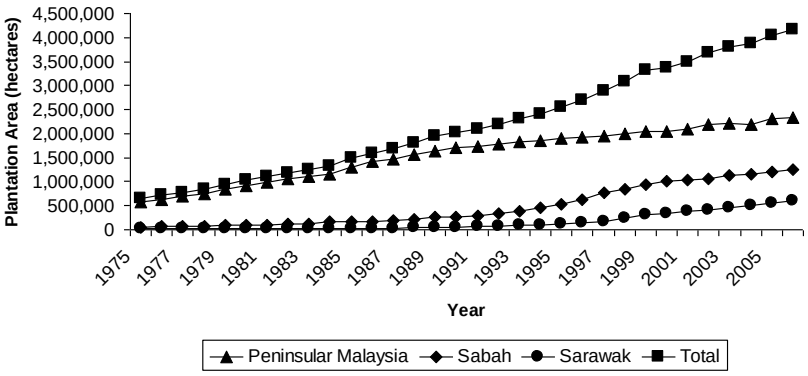

Figure 4: Plantation Area of Oil palm in Malaysia From 1975 to 2006 [15].

With the growth of palm oil production in Malaysia, the amount of residues generated also shows a corresponding increase. One hectare of oil palm plantation can produce about 50 to 70 tonnes of biomass residues [16]. Therefore, the oil palm industry is currently producing the largest amount of biomass in Malaysia with 85.5% out of more than 70 million tonnes as shown in Figure 5 [17]. Other types of biomass generated in Malaysia are from the wood and sugarcane industry, municipal solid waste and others. In the year 2005, about 55.73 million tonnes of oil palm biomass was recorded [18]. The type of biomass produced from the oil palm industry included empty fruit bunches (EFB), fiber, shell, wet shell, palm kernel, fronds and trunks. The amount of each type of biomass component is shown in Table 2 [18-20]. Due to the huge amount of biomass generated yearly, Malaysia has the potential to utilize the biomass efficiently and effectively to other value added products. Currently, there are already various technologies available to convert oil palm biomass to various types of value added products will be presented in the subsequent section. On the other hand, oil palm biomass also has a very good potential to be converted into renewable energy sources considering the calorific value of each component shown in Table 2. Based on simple calculation, oil palm biomass has a total energy potential of about 15.81 Mtoe (million tonne of oil equivalent). Taking an efficiency of 50%, the energy generated from oil palm biomass may reach almost 8 Mtoe. In the year 2006, Malaysia energy demand is 40.4 Mtoe (million tonne of oil equivalent) [21]. This means that oil palm biomass can provide almost 20% of the total energy demand of Malaysia. If all the 8 Mtoe energy produced by oil palm biomass is converted into energy replacing petroleum crude oil, Malaysia can save up to about RM 7.5 billion per year. Therefore, this clearly shows the potential of oil palm biomass as one of the

major source of energy in Malaysia. Its renewable nature makes it even a more important energy source.

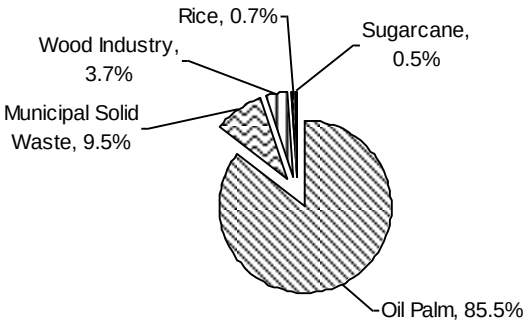

Figure 5: Biomass produced from different industry in Malaysia [17].

Table 2: Oil Palm Biomass Collected in 2005 and Their Energy Potential [18-20].

Biomass Component	Quantity Available (million tonnes)	Calorific Value (kJ/kg) [20]	Potential Energy Generated (Mtoe)
Empty fruit brunches	17.00 [18]	18838	7.65
Fiber	9.60	19068	4.37
Shell	5.92	20108	2.84
Fronds & Trunks	21.10 [19]	-	-
Palm kernel	2.11 [20]	18900	0.95
Total	55.73	-	15.81

POTENTIAL UTILIZATION OF OIL PALM BIOMASS

Due to the huge quantities of biomass generated from the oil palm industry, it will be a waste if the biomass is not properly utilized. In the coming section, the possible utilization of oil palm biomass will be presented. Basically, oil palm biomass can be converted to a wide range of value added products that can be clustered into three main categories namely bio-based value added products, bio-fuel and as direct fuel for power generation.

Bio-based Value Added Products. One of the possible utilization of empty fruit brunches (EFB) is to produce bioplastic or also known as polyhydroxyalkanoates (PHA) or polylactate (PLA). Currently there is a joint research and development in Malaysia by University Putra Malaysia, Felda Palm Industries Sdn. Bhd. and Kyushu Institute of Technology for the production of bioplastic using oil palm biomass. [17]. Bioplastic have similar characteristic as petroleum-derived plastic and can be used for the production of foil, moulds, tins, cups, bottles and other packaging materials [22]. However, the advantage of bioplastic is that it is 100% biodegradable and able to be recycled, composted or burned without producing toxic by-products. Sugar is obtained from EFB and this sugar serves as carbon source for the bacterial during fermentation. At the beginning of the process, EFB is loaded together with

the bioplastic producer *Ralstonia eutropha* into the bioreactor that contained water and nutrient. Under conditions of limiting nutrient such as nitrogen, sulfur and phosphorous and excess carbon (EFB), PHA is produced by *Ralstonia eutropha* [17]. In the fermentation process, EFB will be consumed directly as food by *Ralstonia eutropha*. Cellulose and starch are released from EFB and then the enzymes in the bacterial are used to break the cellulose and starch into organic acid (such as lactic acid) and then the organic acid can be polymerized and converted into bioplastics [23, 24]. In the bioplastic industry, cost for raw material (corn and potato) and the natural producer (*Ralstonia eutropha*) usually constitute 40 to 50 % of the total production. Therefore EFB can be a cheap carbon source for the bioplastic industry, thus reducing the total manufacturing cost [17].

Besides, EFB can also be incinerated for its ash which serves as a very good fertilizer or soil conditioner. This is because EFB itself contain certain macro and micro nutrients that are required for plant growth. In fact, incinerating EFB to obtain its ash is currently the common practice in many pall oil mills as this can offset the increasing cost of inorganic fertilizers. In some oil palm mills, the EFB is not incinerated, but mulch and directly thrown back to the oil palm plantations [25]. Since EFB belongs to the category of fibrous crop residues or also known as lignocellulosic residues, therefore EFB can also be converted into pulp [26]. Pulp produced from EFB is now being commercialized in Malaysia. In the year 2003, the world's first oil palm-based pulp and paper mill located in the East Malaysian (Sabah) was set up by Forest Research Institute Malaysia (FRIM) and Borneo Advanced Sdn. Bhd. (a pulp and paper manufacturer in Malaysia). EFB is converted into pulp using the caustics soda technology developed by FRIM. This new development is expected to reduce Malaysia's reliance on imported pulp and paper products considering the large availability of EFB throughout Malaysia as every 5 tonnes of EFB could produce a tonne of pulp [27].

Similar to EFB, frond of the oil palm tress is also categorized as fibrous crop residues, allowing it to be converted to pulp. Oil palm frond basically consists of petiole and leaflets [28]. Production of pulp using oil palm frond is still at research stage. Research shows that the morphologically structure of the frond fibers are comparable to those of hardwood. This findings was made after examining the physical and chemical characteristics (including their response to chemical pulping such as sulfite, soda-sulfite and soda process) of the fiber strands from the frond of oil palm trees. Therefore, the frond pulp might be used as reinforcement component in newsprint production using softwood thermomechanical fibers (a kind of pulp produced via mechanical process) [26]. In addition, oil palm fronds can also go through further processing and can be used as a roughage source for ruminants such as castles and goats. The main processing step is to chop the whole oil palm fronds into pieces and then it can be utilized as ruminants feed directly or conserved as silage by mixing with other ingredients in proper rations. The suitability of oil palm fronds as a roughage source is base on the chemical analysis and metabolizable energy value of oil-palm fronds [28]. Recently, Malaysian Agricultural Research and Development Institute (MARDI) has developed a new product known as oil palm frond based ruminant pellet. The pelleted and cubed feeds based on oil palm fronds can be used as complete or balance diets for fattening beef cattle as well as for intensive dairying in Malaysia and abroad [29].

Palm fibers on the other hand can be used as fillers in thermoplastics and thermoset composites. These composites have wide applications in furniture and automobile components. Progress in this area of research finally reached to the commercialization stage when PROTON (Malaysian national carmaker) entered into agreement with PORIM (Palm Oil Research Institute of Malaysia) to develop the thermoplastic and thermoset composites and used it in PROTON car [30].

In addition, oil palm biomass or the ash derived from it can be converted into adsorbents for toxic gas and heavy metal removal. Some researches have conducted the study

on utilizing oil palm ash (OPA) as an absorbent for removing pollutants gasses such as sulfur dioxides and nitrogen oxides. The OPA is produced after the combustion of oil palm fiber and shell as boiler fuel to produce steam for palm oil mill consumption. The OPA was found to contain high amount of silica, calcium, potasium and alumina that can be utilize to synthesize active compounds that is responsible for the sorption of the pollutants gasses into the absorbent [31, 32]. Apart from that, it was also reported that charcoal derived from oil palm shell can be coated with chitosan and can be used effectively to remove heavy metal especially chromium from industrial wastewater. This is due to the presence of some functional group such as carboxylic, hydroxyl and lactone in oil palm shell that has a high affinity towards metal ions [33]. However, the application of the oil palm biomass as adsorbents is still in the research stage and not being commercialized yet.

Energy Related Products. Although oil palm biomass can be converted to various value added products, nevertheless, its potential as a source of renewable energy seems to be more promising, considering the current state of energy crisis with the price of crude petroleum hitting record high every other day. Apart from that, its utilization as a source of energy will bring other environmental benefit like reduction in CO_2 emissions. In the following section, the possible utilization of biomass into renewable energy will be presented. It can generally be categorized into two main sections, the oil palm biomass directly be used as a fuel or initially converted to bio-fuel (intermediate product).

Electrical power generation activity and emission from vehicles are the main contributors of greenhouse gas emission primarily carbon dioxide (CO_2). Greenhouse gas emission in APEC (Asia-Pacific Economic Cooperation) economics within Asia is expected to grow rapidly, with forecast showing 3-5% growth in annual CO_2 emission [34]. Figure 6 shows that CO_2 emission increased significantly after the year of 2000 [35]. For the year of 2004, the total emission of CO_2 already reached close to 50000 thousand metric tones. Therefore, it is necessary to explore and find the alternative in order to reduce and stabilize the concentration of CO_2 in the atmosphere. This problem can be overcome since oil palm biomass can be used as alternative fuel in the power generation meanwhile bio-ethanol and bio-methanol can be used as vehicles fuel.

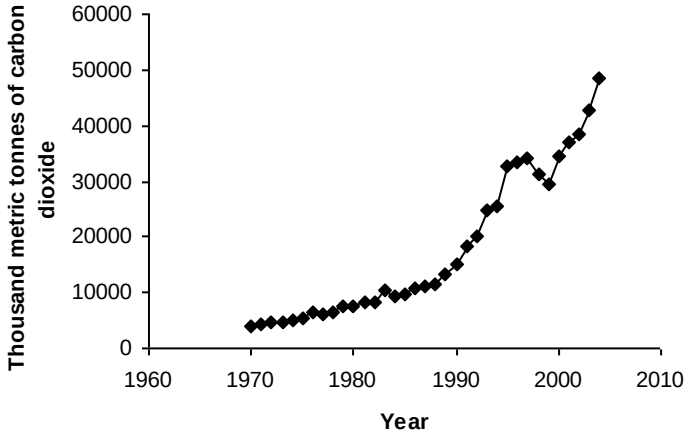

Figure 6: CO_2 Emission in Malaysia from 1974 to 2004 [35].

Research shows that if bio-fuels like bio-ethanol and bio-methanol are blended with conventional diesel or bio-diesel can help to reduce the lifecycle of CO_2 emission by almost

80% compared to petroleum diesel [34]. In year 2004, the CO_2 emission from liquid fuels is 197,620 thousand metric tonnes [35], therefore by using bio-fuels can reduce the emission of CO_2 by 158,096 thousand metric tonnes which is 3.3% of the total CO_2 emission of Malaysia in 2004. This is quite a significant decrease. In addition, with the replacement of diesel with biogas such as methane in electricity generation would reduce up to 1,040 thousand metric tonnes of CO_2 being released into atmosphere [34].

Directly As Fuel. Oil palm biomass such as EFB, mesocarp fiber (MF) and palm kernel shell (PKS) can be used to produce steam for processing activities and for generating electricity [36]. However, due to their characteristic, some of these fuel resources have to be pretreated before they can be burned in the boiler. Some pretreatment process that is required for the effective use of the biomass is such as using a shedding machine to reduce the size of EFB and drying to reduce the moisture content. In Malaysia, there are currently more than 300 palm oil mill operating with self generated electricity from oil palm biomass. The electricity generated is not only for their internal consumption (crude palm oil extraction) but also sufficient for surrounding remote areas [37]. The system required for generating electricity from biomass consists of a combustion system (boiler and furnace), steam turbine and generator [38]. Many projects on using biomass to generate electricity have been or will be launched in Malaysia. Up to the year 2004, under Small Renewable Energy Power Programme (SREP), 62 projects have been approved and out of these projects, 25 of them used oil palm biomass as fuel source [37]. This indicates that Malaysia is focusing on using oil palm biomass as energy source to generate electricity.

Besides, a cement company in Malaysia had seriously embarked on the alternative fuel to partially replace fossil fuels in the cement manufacturing. The company used PKS as fuel in the boiler and they claimed that this can reduce the emission of CO_2 by 366.26 thousand metric tonnes in the year of 2006 [39]. Therefore, if all the industries in Malaysia can replace the fossil fuel with oil palm biomass to generate energy, then the emission of CO_2 of Malaysia will decrease significantly. Malaysia can achieve the vision to be the well developed country without paying the price to destroy the environment.

Biofuel. Synthetic bio-fuels are synthetic hydrocarbons or mixture of synthetic hydrocarbons from biomass. Oil palm biomass can be used to make fuels as an alternative to partially replace the fossil fuels. There are 5 types of bio-fuels that can be produced through oil palm biomass which include bio-ethanol, bio-methanol, bio-briquettes, hydrogen gas and pyrolysis oil.

Bio-ethanol is made by fermenting any biomass high in carbohydrate content (starches, sugar or celluloses) through a process similar to brewing. Oil palm biomass especially EFB is rich in sugar and lignocellulose content. Research shows that after the production of xylose from EFB through acid hydrolysis, the EFB residue can be further utilized for the production of second generation ethanol [40]. Bio-ethanol is mostly used as a fuel additive to cut down a vehicle's carbon monoxide and other smog-causing emission. Flexible-fuel vehicles which run on mixtures of gasoline and up to 85% of ethanol made of these biomasses are now available in Brazil, US and European market [41, 42]. Apart from bio-ethanol, bio-methanol can also be produced from biomass. Bio-methanol is most suitable the application in spark ignition engines due to its high octane rating [43]. There are a number of methods to convert biomass to bio-methanol, but the most likely approach is gasification. Gasification involves vaporizing the biomass at high temperatures and then removing the impurities from the hot gas and passing it through a catalyst which converts it into bio-methanol [41]. The demand of bio-ethanol and bio-methanol as alternative fuel in Malaysia is still low since most of the vehicles in Malaysia are still running on petrol.

Therefore there is currently no large scale production of bio-ethanol and bio-methanol in Malaysia.

Converting palm biomass into a uniform and solid fuel through briquetting process appears to be another attractive solution in fully utilizing the oil palm biomass. Oil palm biomass such as EFB and palm kernel expeller (PKE, a by product of the crushing and expelling of oil from palm kernel) can be densified into briquettes at high temperature and pressure using screw extrusion technology. Oil palm briquettes can be used for household and industrial heating unit operation such as boiler. It is not only a renewable source of energy which helps to reduce the carbon content in the atmosphere (through zero carbon emission) but its usage is also qualified for carbon credit due to its potential in supporting Kyoto Protocol and mitigating global warming [44]. Research shows that briquettes made from 100% pulverized EFB exhibited good burning properties. However, in order to produce good quality briquettes from EFB fiber and PKE, it was recommended to blend with sawdust. Generally, converting oil palm biomass into briquettes will increase its energy content while reducing the moisture content by at least 5% and 38% respectively compared to its raw materials [20]. Advantages of using palm briquettes include low cost, available all year around, high calorific value, longer burning duration and most importantly more environmental friendly [45]. Therefore, palm biomass briquettes can become important renewable energy fuel source in the future.

The gasification of biomass can also generate hydrogen gas which can be potentially be used either as a gaseous fuel for power generation or as a feedstock for the synthesis of clean transportation fuels. Components of the oil palm biomass that can be used for gasification are EFB, oil palm fiber, oil palm shell, palm tree trunks and fronds [46, 47]. The latest gasification technology to convert oil palm biomass into hydrogen gas is via supercritical water technology. Oil palm biomass is the perfect candidate as feedstock for the gasification process to produce hydrogen gas. This is due to its high energy and moisture content which is an integral requirement for reactions in supercritical water reaction. The insignificant amount of trace minerals in the biomass composition is an added advantage for the reaction [46]. However, the production of hydrogen from biomass in Malaysia is still at the early stage of research.

Pyrolysis oil is a kind of tar that can be extracted from dried biomass and is currently under the investigation as a substitute for petroleum [48]. EFB and oil palm shell can be converted into pyrolysis oil via rotating cone pyrolysis technology [49, 50]. Pyrolysis oil derived from biomass (EFB) is rich in carbon and can be refined in ways similar to crude petroleum. The chemical compositions of pyrolysis oil vary according to the pyrolysis methods and process condition [50]. This pyrolysis oil can serve as a potential feedstock for the production of fuels and chemicals in petroleum refineries. It has the potential to replace up to 60% of transportation fuels [51]. With the co-operation between Malaysian based Genting Sanyen Bhd and BTG Biomass Technology Group BV, the first pyrolysis plant in Malaysia has been completed [49]. This is a breakthrough step in Malaysia for the utilization of oil palm biomass as a source of pyrolytic oil.

Figure 7 displays the details of each process. Basically all conversion technologies that have been mentioned above are being practiced in Malaysia either in commercial sector or some technologies like gasification using supercritical water is still in research stage to improve the performance. This shows that Malaysia is well positioned to take advantage of her enormous output of biomass from oil palm biomass.

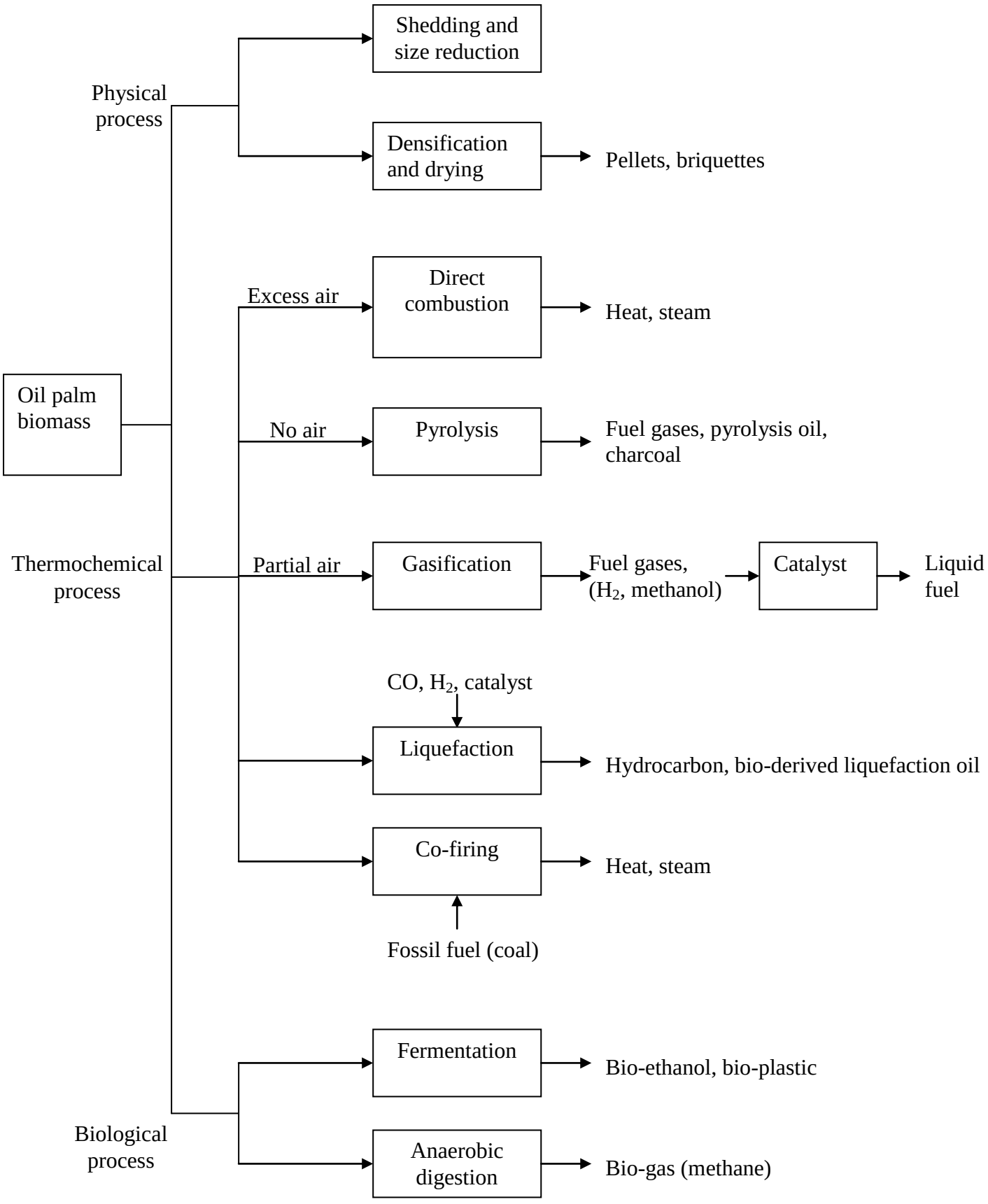

Figure 7: Oil Palm Biomass Conversion Technologies.

PROJECTS RELATED TO THE UTILIZATION OF OIL PALM BIOMASS IN MALAYSIA.

Due to the fact that Malaysia will exhaust its oil and gas reserves in the future, Malaysia has intensified its research on renewable energy sources especially on the utilization of oil palm biomass. The use of renewable energy sources is a vital element in providing a long-term solution to Malaysia's energy needs for promoting sustainable development. Presently in Malaysia, many programs and projects regarding to the utilization of oil palm biomass have been launched or in the planning stage.

Small Renewable Energy Power Program (SREP). Malaysia government announced the launching of SREP on 11th May 2001 [52]. The launch of the program is among the steps taken by the government to encourage the utilization of renewable energy in power generation. This is in line with the government's decision to intensify the development of renewable energy as the fifth fuel resource under the country's Fuel Diversification Policy stipulated in the objectives of the Third Outline Perspective plan for 2001-2010 and the Eight Malaysia Plan (2001-2005).

SREP aims to establish small power producers that use clean, renewable fuel sources to generate electricity [53]. Besides, the other objectives of SREP include the reduction of Malaysia's dependency of oil and to reduce the emission of greenhouse gases [5]. The generated electricity can be sold and feed to the national grid through the Distribution Grid System. The renewable energy electricity producers will be given a license for a period of 21 years which will be effective from the date of commissioning of the plant. Under this SREP, utilization of all types of renewable energy including biomass, biogas, municipal waste, solar, mini-hydro and wind are allowed [52]. Under this program, the maximum allowable electricity to be fed to the national grid is 10 MW.

A special committee on renewable energy (SCORE) has been set up under the Ministry of Energy, Water and Communications to coordinate the SREP programs [52]. Table 3 represents the status of SREP projects approved by SCORE in the year 2004. Based on the data, 62 SREP projects have been approved. Out of these projects, 32 projects use biomass as fuel source, of which 25 projects with grid connected capacity of 165.9 MW are generated using oil palm waste [37]. The grid connected capacity generated via oil palm biomass is about 52.8% of the total capacity. This indicates that oil palm biomass is really suitable and attractive to be used as alternative energy source. The other reason why many SREP projects are using oil palm biomass as fuel source is owing to the enormous quantity of this biomass generated in Malaysia through out the year.

Table 3: Status of SREP Projects Approved by SCORE at 2004 [37].

No.	Type	Energy source	Approved application	Grid connected capacity	%
1	Biomass	Oil palm biomass	25	165.9	52.8
		Wood residues	1	6.6	2.1
		Rice husks	2	12.0	3.8
		Municipal solid waste	1	5.0	1.6
		Mix fuel	3	19.2	6.1
2	Landfill gas		5	10.0	3.2
3	Mini-hydro		25	95.4	30.4
4	Wind and solar		0	0.0	0.0
	Total		62	314.1	100

This SREP program is still running in the whole country of Malaysia until now. According to the news dated 3rd June 2008 reported by BERNAMA (Malaysian National News Agency), Tenaga National Bhd (TNB) an electricity generation company announced that it has agreed to purchase the electricity generated by a small renewable energy power project developed by Bell Eco Power Sdn Bhd under SREP program. The estimated value of the renewable energy power purchase agreement was about RM3.1 million per year [54]. The signing of the agreement demonstrates that SREP program is receiving great support from the utilities sector in the country.

In 18th March 2008, TNB has signed a memorandum of understanding (MOU) with Felda Palm Industries Sdn. Bhd. and Japan's J-Power to develop a biomass power plant at Jengka, Pahang. This project is expected to be completed by the end of 2010 and EFB is again used as a fuel source to generate electricity. This biomass plant will be built using 4.6 hectares of land housing an EFB processing plant, EFB storage areas, a biomass boiler firing on EFB fuel, a steam turbine complete with generator unit and other related auxiliaries components. According to TNB, upon completion the plant will have a generation capacity of 10 MW and would be connected to its 11kV grid network that supply electricity to the local surrounding areas [55]. The power plant will be implemented under the SREP launched by Malaysian government in order to promote the utilization of renewable energy in power generation [56].

This biomass project involves the participation of local company and also international company like J-Power in Japan. That means utilization of oil palm biomass to generate electricity in Malaysia is really a potential business that can attract the investment from foreign country.

Biomass Based Power Generation and Co-generation in the Malaysian Palm Oil Industry (Biogen). To further catalyst the development of SREP program, a national project called the biomass-based power generation and cogeneration in the Malaysia palm oil industry project had been implemented by the Malaysian government on October 2002. This project will facilitate the maximum utilization of waste residue from oil palm industry for power generation and thus reducing the emission of greenhouse gases in Malaysia [37]. Besides, this project is also aimed to promote the growth of power generation and cogeneration [57]. In the year 2003, the first full scale model (FSM) project has been developed and renewable energy business facility (REBF) which served as the financial support mechanism for the FSM's development has been established [37].

The strategy of biogen project involves the implementation of barrier-removal activities including the implementation of biomass-based grid connected power generation and combined heat and power (CHP) in Malaysia. The Biogen project is carried out over a 5 year period, representing collaborative efforts by the global community through United Nation Development Program (UNDP) and private organizations. This five year project consists of 2 phases; the first phase in which a 2 years time frame beginning 2003 is given focused on technical assistance activities for the removal of primary barriers that hindered the widespread application of biomass-based power generation and cogeneration using biomass. Phase 2 (subsequent 3 years) involves the implementation of an innovative loan or grant mechanism that would be worked through the Malaysian banking sector [37].

MHES Asia Sdn Bhd was selected as the first FSM project under Biogen with the biomass power plant located in Bahau, Negeri Sembilan having a capacity of 13 MW and EFB is used as fuel. Based on the agreement, the plant will sell 10 MW electricity to TNB for 21 years at the price of RM0.19/kWh [58]. The plant is expected to be completed in 2008 [59].

EC-ASEAN COGEN Programs. The EC-ASEAN COGEN programs are co-generation programs that were economic co-operation initiated by the European Commission (EC) and the Association of South-East Asian Nations (ASEAN), funded by the EC. Three phases of the COGEN programs were successfully implemented in the period of 1991-2004. COGEN phase I which took place between 1991 and 1994 was essentially a technical framework focusing on identifying phase for what was to become of COGEN phase II. COGEN phase II took place in 1995-1998 and the purpose of this phase was both to demonstrate that proven European technologies are available to support biomass-based cogeneration in ASEAN countries as well as to enhance the EU-ASEAN economic co-operation. The third phase of COGEN program (2002-2004) is also known as COGEN 3. It was an enlargement both in terms of new member countries within ASEAN and in terms of expanding the range of fuel to be used. In addition to biomass, cogeneration for coal and gas were also promoted. The objective of COGEN 3 was to promote and create business opportunities for the use of co-generation to generate power and heat using biomass, coal or gas as fuel [60].

Under COGEN 3, 13 full scale demonstration projects (FSDP) had been established. Out of these, 4 projects were launched in Malaysia which include Bumi Biopower Sdn. Bhd. with 6 MW cogeneration plant using EFB and shells as fuel, Kumpulan Guthrie Berhad with 2 MW cogeneration plant using oil plam fibers and shells as fuels, TSH Bio-Energy Sdn. Bhd. with 14 MW cogeneration plant using EFB as fuel source and Kelang Beras Co. Titi Serong Sdn. Bhd. with 1.5 MW rice–fired cogeneration plant [61].

Biomass Energy Plant in Lumut. PGEO Group Sdn. Bhd. (PGSB) is a major edible oils refiner and exporter in Malaysia. In the year of 2005, PGSB has completed the construction of a biomass-fired steam generator plant in Lumut [62]. This project was registered by the Clean Development Mechanism (CDM) Executive Board on 24th February 2006 [63]. The objective of this project is to reduce the amount of steam produced from fuel oil and grid generated power and thus reducing greenhouse gas emission. The project activity will be able to reduce emission in three ways. Firstly is by displacing fuel oil with oil palm biomass which is used to generate 15 tonnes per hour of steam. Secondly and thirdly is by displacing electricity from the national grid by replacing the existing chiller system and generating electric from biomass [63, 64]. From February 2005 until April 2006, the reduction of CO_2 emission is 22,000 CER (certified emission reduction) [65]. The reduction of CO_2 emission is expected to increase to 36,494 tonnes of CO_2 by the year 2011 [64].

The plant obtained its biomass waste from neighboring 16 palm oil mills via fuel purchase agreement. In the plant, EFB, PKS and mesocarp fibers from oil palm are used as the fuel source. This project involves the installation of a modern, high efficiency 30 tonnes per hour capacity, 29 Bar_g biomass-fired cogeneration systems to supply steam and electricity to PGSB palm oil refinery [63]. This project can be said to achieve environmental, social and economical sustainability since it involved the used of sustainable renewable energy source in an efficient manner.

Chubu Biomass Electric Power Plant in Malaysia. Chubu Electric Power in Japan has announced on 2nd August 2006 that the company plans to build two biomass power plants in eastern province of Sabah, Malaysia. These two biomass power plants will use EFB as renewable energy source to generate 10,000 kW using small scale electric power plants [66]. The objective of the company is to seek growth in both power generation businesses for long term and stable profits as well as environmental businesses designed to acquire CO_2 emission credits while maintaining profitability. According to Chubu Electric Power, Malaysia is chosen as the location to develop their biomass power plants because Malaysia is one of the

top producers of palm oil in the world. Therefore, large quantity of oil palm biomass is available in Malaysia. The first power plant has already begun operations in March 2008 after ground breaking ceremony in August 2006. Apart from contributing to the area's local environmental protection by effectively using palm EFB as fuel, the project has also been registered as a CDM (Clean Development Mechanism) project with the UN, and is expected to generate CO_2 emission credits. From the power plants, the reductions of CO_2 emissions are expected to reach nearly 2 million tons by the year 2012 [67].

Bio-ethanol Plant in Malaysia. Japan's Mitsui Engineering & Shipbuilding Co. Ltd (MES) plans to introduce a plant in Malaysia producing bio-ethanol from oil palm biomass. In the year 2006, Mitsui has sent an investment team to visit Malaysia to conduct a feasibility study. If found viable, the company will collaborate with a local partner from the oil palm sector to invest RM 10.8 million in a pilot plant for the commercial production of bio-ethanol. Mitsui plans to build a pilot plant in 2008 and commence testing and trial operation by the year 2010. Oil palm trunks, oil palm fronds, EFB and PKS will be used as feedstocks. According to a spokesman from Mitsui, the company is still on-going to optimize the productivity of bio-ethanol from oil palm biomass [68]. The successful implementation of this project will set a new mile stone in the utilization of bio-ethanol as fuel substitute for petrol-powered vehicles in Malaysia.

CONCLUSION

The energy demand in Malaysia is expected to increase significantly especially after the year 2020 whereas Malaysian energy sector is still dependent on non-renewable fuels such as fossil fuels as energy source. However, these non-renewable fuels reserves are depleting gradually in Malaysia as well as in the world. Therefore, derivation of energy from biomass has been shown to be the most practical solution. Oil palm biomass has great potential to be used to generate energy needed in the country. Malaysia is one of the countries in the world that produce a vast quantity of oil palm biomass annually. Oil palm biomass can be used to produce bio-based commercial products, synthetic bio-fuels and also for power generation. Among all available conversion technologies, gasification has a wide scope of application. Hence, efforts and resources are needed so that this particular technology can be commercialized. Data proves that using oil palm biomass to generate energy can reduce CO_2 emission significantly. Besides, many projects related to the utilization of oil palm biomass as a source of renewable energy have been launched in Malaysia. In addition, foreign country or organization such as Japan and United Nations respectively has taken part in some of the launched biomass projects. This shows that Malaysia has the potential to be one of the major contributors of renewable energy in the world via oil palm biomass.

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