Opportunities and challenges in the development of a viable Malaysian palm oil biomass industry

Dr. Ronald Zwart

Abstract
The palm oil industry has brought great economic benefits to Malaysia. The current production of 19 million metric tons (Mmtons) of crude palm oil (CPO) adds 8% to the country’s gross national income (GNI). In addition, the oil palm estates produce an estimated 80 Mmtons of dry weight biomass. This includes trunks, fronds, empty fruit bunches and other biomass fractions. These resources present attractive raw materials for the newly emerging and potentially profitable renewable energy and biobased chemicals markets. The perennial nature of the oil palm biomass supply base and the available volumes are strong assets to tap into these new markets. This paper describes the potential of the biomass markets and highlights some of the answers to the challenges these markets currently present to the oil palm biomass industry.

Key words
Oil palm biomass, bioenergy, biobased economy, biomass markets.

1. Oil palm biomass
Oil palm plantations in Malaysia cover close to 5 million hectares (Mha). With the plantations in Indonesia and other parts of the world the total oil palm acreage reached more than 16 Mha in 2011. The plantations yield crude palm oil (CPO), palm kernel oil (PKO) and palm kernel cake (PKC) as the products that have been of prime interest. These are a traditional ingredient for a wide variety of food, feed and non-food products. In Malaysia, CPO production in 2011 reached 18.91 million metric tons (Mmtons), 2.39 Mmtons for PKC and 2.15 Mmtons for PKO. Apart from these, a number of other biomass fractions are produced from the oil palm trees. For Malaysia, the actual volume for each of these fractions are shown in Table 1. The total volume in dry weight tons amounts to an estimated 80 Mmtons. Given the fact that the trees have an average life span of some 25 years, this volume is produced every year (the OPT yield included in Table 1 has been corrected for this fact). Part of these biomass flows are already collected with the harvesting of the crude palm oil at the palm oil mill. This is true for the EFB, PKS, MF and POME. This saves transport costs when these materials are included in a supply chain for the production of e.g. bioenergy. In contrast, OPT and OPF will have to collected from the field, or processed on site.

Email: Ronald Zwart (ronald.zwart@dovregroup.com)

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While production has focused on CPO and PKO as commercially the most important products, the other biomass fractions mentioned also do have many different applications. This ranges from fuel for the local palm mill boiler (PKS, EFB) to mulching and fertilizer agent (EFB, OPF, OPT) to the production of packaging and building materials (OPT, EFB and others). Some of these uses have a critical function: returning OPF and EFB to the plantations is essential to maintain the soil’s required conditions. PKS and EFB can be essential as a fuel for local and remote palm mills. Still, significant amounts of biomass have been left idle or can be mobilized by improving the efficiency of its current uses.

Table 1: Annual oil palm biomass production base

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<thead>
<tr>
<th>Oil Palm Biomass Fraction</th>
<th>Yield*</th>
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<tbody>
<tr>
<td>EFB - Empty fruit bunches</td>
<td>6.7</td>
</tr>
<tr>
<td>PKS - Palm kernel shells</td>
<td>4.0</td>
</tr>
<tr>
<td>OPF – Oil Palm Fronds</td>
<td>47.7</td>
</tr>
<tr>
<td>OPT – Oil Palm Trunks</td>
<td>13.0</td>
</tr>
<tr>
<td>MF – Mesocarp Fiber</td>
<td>7.1</td>
</tr>
<tr>
<td>POME – Palm Oil Mill Effluent</td>
<td>3.0</td>
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* in dry weight million metric tons per year (dwMmtons/yr)

2. The biomass markets

Biomass is the collective name for all organic matter derived from plants and other living organisms that has not been fossilized into carbon materials like oil or coal. Examples include agricultural products and residues like palm kernel shells or straw, forest residues and municipal solid waste.

Biomass has attracted increasing interest in recent years as an alternative feedstock for the production of energy, chemicals and other biobased products. In particular the use of biomass for the production of biofuels and bioenergy in the form of electricity and heat has ignited the development of an entirely new market.

2.1. Bioenergy

The production of bioenergy is driven by two arguments. The first is the ambition to reduce the emission of greenhouse gases. The second is to secure the production of energy to meet up with growing demand.

Reducing greenhouse gas emissions

Reduction of greenhouse gas emissions appeared on the international agenda in the 1990s when awareness was growing about the role of gaseous molecules like CO₂, NOx and methane in causing climate change. The use of fossil fuels like coal to produce electricity and oil to drive our cars are major contributors to increasing levels of these greenhouse gases. In the EU, this is the most important argument behind the introduction of renewable energy initiatives and the ambitious target to use at least 20% renewable energy in 2020. The EU consumed almost 1,800 Mtoe of energy in 2007 and is expected to remain at that level in 2030. Thus, the 20% target implies a replacement of fossil fuels with renewable alternatives.

Security of energy supply

While the EU energy market is about replacing fossil resources with renewable ones, the Asian situation is very different. According to the IEA, the Asian continent is expected to roughly double its demand for energy in the next 20 years. For China and India, spectacular increases are expected from 1,970 to 3,827 and from 595 Mtoe to 1,287, respectively. Similarly, energy demand in Malaysia will grow from 73 to 118 Mtoe. The ASEAN group of countries will go from 513 to 903 Mtoe. These stunning figures imply that renewable energy sources, including biomass, will be needed in addition to fossil fuels to meet the increasing demand for energy. It will be part of the portfolio to secure energy supply. The use of biomass to meet additional demand has very different market dynamics compared to energy replacement. Also, renewable energy suffers from a lack of appreciation in the market. Customers show little appetite to pay more for renewable energy, rendering biomass use for the reduction of greenhouse gas emissions with a low economic value. This value difference could change when e.g. the price of CO₂-emission rights recovers.
2.1.1. Biofuels

The EU target of 20% renewable energy in 2020 includes an obligatory mandate of 10% biofuels. This created a biofuels market of approximately 36 million ton of oil equivalents (Mtoe)\(^5\). Despite strong headwinds from unfavorable economics and continued concerns and uncertainties about the sustainability performance of these fuels, the market has been growing steadily. The 2010 biofuels use in the EU reached 12.6 Mtoe. This figure is more than a doubling of the use in 2006 (5.9). However, the market has been growing slower than anticipated. The 2010 use represented a blending percentage of 4.25%, which is 1.5 points below the intermediate 2010 target that was set at 5.75%.\(^6\) Still, this example shows that clear regulatory mandates can be a powerful tool to create a bioenergy market.

Similar blending mandates are in place in other countries. Malaysia e.g. has a B5 blending mandate for palm oil derived biodiesel. Full implementation of the mandate would yield an annual market of 500,000 tons, but actual consumption figures are much lower (2-4,000 metric tons)\(^7\). This is explained by the recent implementation of the B5 mandate (started in mid 2011) and the subsidized fuel prices at the pump. The government therefore has to pay for the additional production costs of biodiesel. This is an unattractive situation with the current high feedstock (CPO) prices. Malaysia did invest significantly in biodiesel production facilities to develop a new export product. However, production is almost at a standstill (15,000 metric tons in 2011) compared to the installed capacity (2.6 Mmtons). Export markets are not developing due to several reasons, including high feedstock prices, existing trade tariff structures, sustainability concerns and technical specifications. The latter two arguments specifically affect access to the EU market. Biodiesel production facilities standing idle can be retrofitted into biobased chemicals producing units to obtain a return on investment and generate more economically attractive products.

2.1.2. Bio-electricity and heat

The EU mandate of 20% renewable energy in 2020 also creates a substantial market for solid biomass products for the production of electricity and heat. The current portfolio of renewable energy production resources shows a 67% share of biomass versus 2%, 7.7% and 19% of solar, wind and hydro, respectively (Figure 1)\(^8\). Under the assumption that these shares remain constant, the biomass market for energy in the EU will grow from 112 Mtoe today to a potential 240 Mtoe in 2020.

One biomass product that has entered the market is industrial wood pellets. These are made of compressed wood fiber and can be used for co-firing in coal-fired power utilities or as a standalone fuel in dedicated biomass boilers. The demand for industrial wood pellets has grown from 3.4 in 2008 to 5.0 Mmtons in 2010. Projections for future use in 2020 range anywhere between 20 to 90 Mmtons. This large uncertainty margin is due to the present market specifics. First, the use of wood pellets is economically non-competitive with its fossil counterpart coal. With the current price settings (H1-2012) the production of electricity from wood pellets costs 92 €/MWh versus 39 €/MWh for coal. Also, existing regulatory and policy measures to promote the use wood pellets have been fragmented, subject to change and without long term running times. This made investors shy and utility operators reluctant to pursue to increase production of bioenergy. To improve this situation many countries consider or have started to implement Feed-in-Tariffs (to compensate for the additional costs to produce electricity from renewable sources compared to the cost of the use of fossil fuels).

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\(5\) Mtoe: Metric tons of oil equivalents

\(6\) Setting: 5.75% target

\(7\) Malaysia: Data from 2011

\(8\) Figure 1: Relative share of EU renewable energy sources
Table 2: Comparison of EU wood pellets specifications with PKS

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<tr>
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<th>EU industrial wood pellets specs</th>
<th>PKS properties</th>
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<tr>
<td>Moisture (weight %)</td>
<td>≤ 10</td>
<td>12 - 18</td>
</tr>
<tr>
<td>Net cal value (GJ/ton)</td>
<td>≥ 16.5</td>
<td>17 - 19</td>
</tr>
<tr>
<td>Ash content (weight % dm)</td>
<td>≤ 1.0 – 3.0</td>
<td>2 - 8</td>
</tr>
<tr>
<td>Chloride (weight % dm)</td>
<td>≤ 0.03 – 0.10</td>
<td>0.1</td>
</tr>
<tr>
<td>Sulphur (weight % dm)</td>
<td>≤ 0.05 – 0.40</td>
<td>0.1 – 0.5</td>
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Here, governments will carry the financial burden of the compensation cost. Apart from countries in the EU, Malaysia, the Philippines and most recently Japan have also introduced this incentive measure. Alternatively, introduction of an obligation to produce or deliver a minimum share of renewable electricity (comparable to the biofuels blending mandate) would involve the market place to finance the additional costs. Also, this would create an incentive to find cheaper ways to meet the obligation.

An upcoming challenge faced by the EU power utilities is to source the necessary volumes of biomass raw materials to meet their bioenergy targets. Resources in the EU are limited and the industry has been looking at North-America for supply. In fact, industrial wood pellets imports into the EU have doubled in only two years time to 3.4 Mmtons in 2011. This has led entrepreneurs in other countries, including Malaysia, to develop pelletizing facilities to serve the EU market. However, strict product specifications, transport costs and sustainability requirements are among the factors that have made it difficult thus far to enter the EU market. The EU technical specifications are largely based on the use of soft wood materials. Low ash content of 1-2% is among the most critical parameters. Of the different oil palm biomass resources, PKS qualifies best with similar energy content compared to wood pellets and relatively low ash (2-8%; see also Table 2).

Ash and other fuel properties also impact the use of oil palm biomass in the local boilers and domestic markets. To improve its use as a fuel, torrefaction can be applied. This is a method to modify the biomass into 'coal-like' material under high temperature and low oxygen conditions. The resulting product is a more homogenous fuel with higher energy content. Alternatively, pre-treatment technologies for oil palm biomass are being developed to improve the fuel characteristics of the biomass, e.g. by removing the minerals. This biorefining concept holds tremendous promise for the full capitalization of biomass as a raw material for the production of fuel, chemicals, minerals and other components that are contained within a single biomass source. The Oil Palm Biomass Center (OPBC) is a public-private partnership of Malaysian and international companies, academic institutions and the government to accelerate the development of biorefining technologies to improve the economic benefits and sustainability footprint of the entire oil palm biomass production chain. OPBC was launched under the 1 Malaysia Biomass Alternative Strategy (1MBAS), which is coordinated by the Palm Oil and Rubber NKEA.

2.2 Chemicals
The global chemicals market averaged 2,400 billion US$ of annual net sales in 2011. Only some 3% of this market currently consists of chemicals produced from biomass (called biobased chemicals). The limited market penetration of biobased chemicals is due to several reasons. First, the chemical industry has not been exposed to regulatory requirements and public demands like the energy market has. Furthermore, availability of feedstock and conversion technologies has
been a challenge, as well as the economic performance. Here, the creation of multidisciplinary consortia (like the OPBC) bringing together the necessary knowledge and resources would be a facilitator to overcome these challenges and to start building successful biomass supply chains.

2.3 Plastics
A similar massive opportunity resides in the plastics market. The total plastics market reached 265 Mmtons in 2010\textsuperscript{10}, while total production capacity for bioplastics (which includes non-biobased biodegradable plastics) stood at approximately 0.72 Mmtons\textsuperscript{11}. That same reference projected this number to rise to 1.7 Mmtons in 2015. Southeast Asia enjoys strong interest from bioplastics manufacturers and the first production facilities have been commissioned in Thailand and Malaysia.

3. Sustainability changes
One particular challenge that deserves a separate chapter in this paper is sustainability. The upcoming of the bioenergy markets has reignited the discussions about the sustainability performance of oil palm derived products. Reignited, because already in the 1990s concerns were developing about the environmental consequences of large scale expansions of oil palm plantations. In response, government and private led initiatives evolved. One outstanding example concerns the Roundtable on Sustainable Palm Oil (RSPO). RSPO was initiated almost 10 years ago by oil palm plantations with their downstream food industry customers and environmental organizations to define and implement responsible management of the plantations for a sustained production of palm oil while preserving the natural treasures that are invaluable to mankind. At that point in time, CPO, PKO and PKC were the only products produced commercially from the oil palm trees and largely for the food industry. Biofuels were basically nonexistent at that time. Now, this situation is increasingly different with outlets in the energy market and with the commercial exploitation of additional biomass fractions (PKS and EFB in particular at this moment in time). Obtaining more economic value from the existing biomass produced per hectare of oil palm plantation is by itself an improvement of the sustainability performance. Still, it cannot overrule or disregard existing sustainability challenges in the fields of \textit{inter alia} biodiversity conservation, plantation management, illegal land use and labour. In fact, it should be an incentive to reinforce the efforts to address these challenges to preserve the present palm oil and biomass supply base for future use. This is a challenge that can only be successfully addressed in collaborations between upstream and downstream players in the entire supply chain that are prepared to recognize their mutual interests to find constructive ways forward.

4. Conclusions
The newly emerging biomass markets present significant economic opportunities for the oil palm industry. It comes with several challenges that are diverse in nature and thus require a wide range of different approaches. Still, many of the challenges relate to parts or involve the entire biomass value chain. Sustainability is an outstanding example here. These challenges can best be addressed by initiatives that bring together the necessary counterparts. RSPO and OPBC are two successful examples of organizing the oil palm supply chain to address specific issues successfully. A third example was recently launched. The Malaysian biomass industry inaugurated the Malaysian Biomass Industries Confederation (MBIC). MBIC was established under the Biomass-SP program. This industry platform has an important role in giving profile to this young industry and in promoting the commercialization, marketing and utilization of high value biomass products applications.

A second opportunity lies in creating collection centers and biomass industry hubs (like POIC, BioXCell) to overcome logistic and technology challenges and costs and to benefit from the co-siting of related and complementing businesses. A third opportunity resides in the creation of facilitative tools that help the oil palm biomass industry in Malaysia to grow. The developments of technical product standards are extremely useful tools to provide guidance for producers and end-users of biomass products to design their facilities and operations. The palm oil industry is very familiar with this and it should be given a follow
up for oil palm biomass products. Product standards can also be extended to sustainability questions, providing a strong reference point or definition for all players in the biomass value chain. Other tools include price references and standardization of trading contracts to facilitate the commercialization of oil palm biomass products.

An exciting road is ahead of the palm oil industry to capitalize the potential of the oil palm biomass for the production of energy and chemicals. With the potential market growth and value it can be a significant contribution to the economy of Malaysia and to a more sustainable world. It will not be easy and requires serious commitment. But together with the other players in the biomass value chains significant strength can be created to make it happen.

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