Biomassa-upstream stuurgroep

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Palm oil production for oil and biomass: the solution for sustainable oil production and certifiably sustainable biomass production?

In the bio-based economy the availability of biomass as feedstock for energy and products will partly depend on the residues from the agro-food chain. In this paper the concept of increasing the sustainability of the palm oil value chain will be elaborated with the aim to produce a certifiable sustainable biomass. It is shown that a combined utilisation of both the appreciated edible oil and biomass residues will result in a more sustainable value chain. This means that it should be environmentally sound, economically viable and socially acceptable.

1. Rationale and question

In the palm oil production chain large quantities of biomass by-products (up to almost 5x the oil production) are produced which are hardly used for adding value to the production chain. The current palm oil production system is generally seen as unsustainable because of detrimental effects on biodiversity such as loss of virgin forests and greenhouse gas emissions associated with current waste disposal methods. The use of by-products for energy and green chemicals offers perspectives for designing a "certified" sustainable food oil production chain that fits well in the development of a bio-based economy.

The major topics for discussion of sustainable palm oil production so far, have concentrated on the issues of rain forest loss, soil fertility and reproduction, biodiversity, pest and water management and the emission of greenhouse gasses. Utilising the available energy that can be derived from the biomass by-products has been recognised and in many cases residues from oil production are used to provide the energy required to run the plant operation.

Improvements taking into account the entire value chain have however not been addressed until recently. This paper will look at opportunities to exploit the abundantly available biomass wastes (shells, fibre, press cake, empty fruit bunches, palm fronts, etc.) as renewable resources for new products and energy that enhance the sustainability of the palm oil production chain.

How much of the different biomass residues are available for alternative use?

2. Approach

Firstly the potential utilisation of palm oil by-products as a sustainable biomass source was assessed by analysing the gross availability of by-products. Subsequently, factors were determined that have to be considered to determine the possible net biomass availability. The following steps were taken:

First the overall production of end-products and by-products was quantified giving a gross biomass production picture (Chapter 3).
Then the current practical and proposed uses of the (by-)products were listed, together with a short discussion on the utilisation rate and efficiency of the use (Chapter 4).
Potential constraints reported in the literature to making by-products available for energy and other uses were listed (Chapter 5).
A short discussion was given on the possibility of increasing the sustainability of the palm oil production by optimal by-product utilisation for energy and other purposes (Chapter 6).

3. Products and by-products in the palm oil production chain

In table 3.1 a list is given of the main by-products generated each year on palm oil plantations (field by-products) and at the mill. Figures show that the potential amount of biomass is very large with an estimated 30 to 50 million tons at the mill and 70 to 80 million tons in the field. These figures are conservative dry weight estimates. Most of this material is found in Malaysia which accounts for almost 50% of world palm oil production and in Indonesia which accounts for almost 1/3 of world palm oil production.

Table 3.1

List of products, by-products and nutrient contents in the oil palm production chain at field and mill level in 2002.

Product Acronym	Where, when available?	DM, per ton of CPO	H_2O	N	P	K	Mg	Ca	Worldwide production x1000 tons DM/ yr #
			-- % --	------------------- % DM				-----------------	
Crude Palm Oil (CPO)	Mill	1	-	-	-	-	-	-	25.000
Kernel oil (KO)	Mill	0.10-0.15	-	-	-	-	-	-	2.500
Oil Palm Fronds (OPF)	Field	1.65-2.0		0.73	0.06	1.29	0.17	0.35	41.500
Roots	Field, every 20/30 years	0.87		0.32	0.03	0.80	0.08	0.05	22.000
Trunks	Field, every 20/30 years	0.4-0.67	50	0.56	0.05	1.62	0.15	0.31	10-17.000
Empty Fruit Bunch (EFB)	Mill	0.32-0.42	58	0.80	0.06	0.24	0.18	-	8-10.000
Fibre	Mill	0.32-0.5	17	2.30	0.01	0.20	0.04	-	8-12.000
Shells	Mill	0.13-0.4	20	-	-	-	-	-	3-10.000
Palm Oil Mill Effluent (POME)	Mill	0.35-1.0	>70	0.11*	0.005*	0.02*	0.02*	-	9-25.000
Palm Kernel Cake (PKC)	Mill	0.06	33	2	0.70	2	0.30	0.25	1.500
Products	Mill	1,1							28.000
Field by-products	Field	2.9-3.5							70-80.000
Mill by-products	Mill	1,2-2.3							30-50.000

- = not found; * on % of water basis.

dry matter (DM) calculated based on total palm oil production of 25 million ton crude palm oil (CPO) (Oil world annual, 2002).

4. Practical and proposed uses of palm oil by-products

In table 4.1 a list is given of current and potential uses of palm oil by-products. The list shows that currently most by-products are used (disposed off) within the system for mulching / fertiliser and for energy production at the mill. Currently only part of the total by-products is used a fuel feedstock in plant operations. Especially the EFB is barely used and creates problems for its disposal since open field/pile burning is often no longer allowed. Palm oil mill effluent is also hardly used and creates an accumulating problem at the oil production mills.

Literature clearly shows that biomass utilisation is not optimised and that there is a demand for other uses. This is illustrated by the list is of relevant articles from one journal dealing with potential alternative uses for palm oil by-products (annex 2).

Table 4
1 List of practical and some proposed uses of palm oil (by)-products.

Product Acronym	World-wide production x1000 tons DM/ yr #	Prod/ha /yr	Composition	Current or *possible* uses	Remarks
OPF	41,638	5,70	crude fibre 45%; protein 5.8%	Mulch, pulp, fibre, feed	Distributed over plantation
Roots	21,954	3,01	-	Mulch	too much available at once, uprooting disturbs soil
Trunks	16,907	2,32	-	Mulch, fibre board	too much available at once, often at remote sites of plantation
EFB	8,075	1,11	45-50% cellulose; 25-35% hemicellulose and 25-35% lignin (Deraman 1993).	Mulch, fuel, bunch ash, *fibre board, pulp, paper*	EFB less well suited as fuel than fibre or shell and does accumulate often
Fibre	8,075	1,11	65% cellulose; 19% lignin (Sreekala et al., 1997)	Fuel for mill, *fibre board*	
Shells	3,281	0,45	-	Fuel for mill, activated carbon, briquette, *particle board*	Silicate forms scale when burned
POME	8,832	1,21	95-96% (w/v) water; 0.6-0.7% (v/v) oil; 4-5% (w/v) total solids including 2-4% suspended solids	Methane production, fertilizer, feed, *soap*	Methane emission, river pollution are a problem when not managed properly.
PKC	1,514	0,21	8.3% oil, 17.5% crude fibre, 14.5-19.6 % protein	Feed, fertilizer	Feed potential not fully used

Total palm oil production was 25,235 million ton on 7,3 million ha giving an average palm oil yield of 3,457 ton per ha in 2002 (Oil world annual, 2002) and www.gpfeeds.co.uk/analysis/palmkern.htm

It is hard to get quantified data on the current use of by-products and especially on the efficiency of such use. In the following paragraphs we will discuss the issue of current utilisation rate and efficiency of such uses.

Utilisation rate:
In table 4.2 a list is given of by-products and their utilisation rate in Malaysia (Gurmit, 1999). The table shows quite a high utilisation for field by-products (80 to 95%) as mulch and for shells and fibre as fuel for the mills (90%). For POME and EFB the utilisation rates are much lower (35 to 65 %). Apparently the material is not easily used for energy production and benefits of returning the material to the field as mulch / fertiliser are considered too low to offset the cost. Accordingly literature indicates that these products often form environmental problems producing methane and polluting waterways. A large number of initiatives are underway to find ways of mitigating this problem. In Yeoh (2004) it is estimated that in Malaysia methane emission from open of POME ponds amount to 225.000 tons (1999), which is equivalent to 5,17 million tons of CO_2, or 3.6% of the estimated total emissions in Malaysia. Empty fruit bunches are less attractive as a boiler fuel and are therefore generally not used for energy.

Table 4.2
Level of utilisation of oil palm biomass residues in Malaysia (1998).

Biomass	Quantity produced (Million tons)	Quantity utilised (Million tons)	utilised (%)	Method of utilisation
Pruned fronds	27.20	25.83	95	Mulch
Trunks and fronds at replanting	1.38	1.10	80	Mulch
Fibre	3.56	3.20	90	Fuel
Shell	2.41	2.17	90	Fuel
POME	1.43	0.50	35	Nutrient source & organic fertiliser
EFB	3.38	2.20	65	Mulch & bunch ash
Total	39.36	35.00		

Level of utilisation = 89%. Source: Gurmit (1999)

For other countries utilisation rates should be lower than in Malaysia which has the most advanced palm oil production system.

Efficiency of utilisation:
Table 4.1 and 4.2 do not give an indication of the efficiency of the use for energy or as fertiliser / mulch. Again, it is hard to find quantified data here. Husain et al (2003) found that the palm oil industry is one of those rare industries where very little attempt is made to save energy. The energy balance in a typical palm oil mill is far from optimum and there is considerable scope for improvement. Currently most mills operate low pressure boilers generating steam for operating. In Malaysia increasingly mills are implementing high pressure boiler systems generating electricity and steam for operation of the mill and delivery to the grid.

Still, some data can be found for energy production potential in Malaysia. Hashim (2005) estimates that for 1999 the annual palm oil mill residues amount to 18 million tons of biomass sufficient for generating 3197 GWh and 31.5 million tons of POME with a generation potential of for 1587 GWh. This estimate is low compared to Yeoh (2004) who estimated that 2250 GWh electricity can be generated from POME through biogas production (55C) followed by electricity generation (for 1999 data).

Based on the data from Hashim (2005) the total electricity generating capacity from mill residues is at least 5000 GWh. Field residues amount to 2x the amount of biomass at mill level (roots excluded). This means that in Malaysia the electric production potential is 15000 GWh. As Malaysia account sfor only 50% of the world palm oil production world wide some 30000 GWh can be produced from Palm oil residues.

Menon (http://www.ptm.org.my/biogen) compared the gains from utilising EFB as mulch in fields (nutrient value minus logistics costs) and the gains when used for electricity generation. The returns for electricity generation are 3.5 times higher. Indeed, a number of initiatives exist mainly in Malaysia to produce electricity from palm oil by-products for delivery to the grid. It must be remarked that electricity production through combustion generates ash which contains most of the P and K and some other nutrients that can still be recycled to the plantation.

The examples above are based on electricity delivery to the grid. Still, many mills are too isolated to be able to provide electricity to the grid and other by-product outlets should also be considered such as charcoal, pyrolysis oil, HTU oil, paper pulp, fibre board, etc. Other mills, especially in poorer developing countries will be too small to warrant investments in conversions systems. How many there are and which options do and do not apply is not known.

For the efficiency of recycling of field and mill residues little data could be found. Obviously recycling of POME and EFB is very limited. The effectiveness of recycling field residues was not specifically looked at.

5. Constraints to making palm oil by-products available for energy and other uses

Constraints on the use of by-products are derived from the contribution that the utilisation has on increasing the sustainability of the palm oil production chain and the world in general. This means that it should be environmentally sound, economically viable and socially acceptable.

The "Round table on sustainable palm oil" (www.sustainable-palmoil.org) is probably the best source of information on discussions surrounding the sustainability of Palm Oil production. In the table 5.1 members and other relevant groups involved the sustainability discussion are listed.

Indeed the issue of sustainability is a serious topic which has been recognised by producers in Malaysia (as illustrated by the citation below):

"Malaysian palm oil producers will have to be ready to adapt to other changes given EU moves to adopt policies on labelling, genetic modification and environmental issues linked to product acceptance"

Malaysian Palm Oil Promotion Council News Bulletin Volume 13, issue 1/6, 2003. (http://www.mpopc.org.my/pol/pol1603.pdf)

Table 5.1
Organisations involved in discussions on the sustainability of oil palm production at national and international level Roundtable on Sustainable Palm Oil

INTERNATIONAL	EUROPE
World Wildlife Fund for Nature	Friends of the Earth UK
Friends of the Earth	Friends of the Earth Finland
Greenpeace	Friends of the Earth (Milieudefensie) Netherlands
World Rainforest Movement	Greenpeace Netherlands
Global Forest Coalition	MALAYSIA
Rainforestweb.org	WWF Malaysia
ECA-Watch: campaign on export credit agencies	INDONESIA
Focus on Finance	WWF Indonesia
Forest Trends	Friends of the Earth Indonesia
	Down to Earth

http://www.sustainable-palmoil.org/players/ngos.htm

When reviewing the issues discussed at the Roundtable, by-product utilisation is mostly discussed in the context of waste disposal, energy use and the reduction of emissions of pollutants and greenhouse gasses (methane). This is best illustrated in the most recent discussion paper "RSPO Draft Criteria for Sustainable Palm Oil, November 2004" where the topics are discussed in Principle 4 "Environmental responsibility and conservation of natural resources and biodiversity" (See table 5.2).

Table 5.2
Sustainability issues related to by-products and wastes from palm oil production.

Criterion	Proposed guidance
Criterion 4.3 Waste from the plantation and the mill is reduced, recycled and re-used and any waste produced is disposed of in an environmentally and socially responsible manner.	A policy of minimal wastes and emissions should be promoted through improving the efficiency of resource utilisation (e.g., achieving high extraction efficiency to reduce oil in EFB (empty fruit bunches) and effluent) and recycling wastes as nutrients (e.g., EFB) or converted into value-added products (e.g., through animal feeding programmes). Issues raised for further discussion: The Criteria Working Group should provide guidance and/or refer to existing best practice guidelines on recycling and re-use of nutrients, managing effluent ponds, increasing mill extraction efficiency and appropriate disposal of wastes that cannot be recycled. Guidance should also be provided on appropriate ways for nutrients in EFB and effluent to be returned to smallholders from the mill that processes their fruit. Suggested guidance includes Unilever guidelines, MPOA best practices and ample literature. The term 'socially responsible manner' needs clear definition.
Criterion 4.4 Efficiency of energy use should be maximised whilst minimising fossil fuel use	Develop and implement a strategy to become as close to self-sufficient as possible in terms of fuels, including: maximising fuel burning efficiency; using renewable energy sources wherever possible (e.g., fibre and shell). Large plantations should assess the energy balance of their operations and energy efficiency of their operations. Issues raised for further discussion: The CWG should provide more detailed guidance, e.g., from MPOA guidelines on disposal of waste water and emissions.
Criterion 4.5 Use of fire for waste disposal and for preparing land for replanting is avoided except in exceptional circumstances and should always be consistent with the ASEAN Policy on Zero Burning	Fire should be used only when permitted "Guidelines for the Implementation of the ASEAN policy on zero burning'" and where an assessment has demonstrated that it is the most effective and least environmentally damaging option for minimising the risk of severe pest and disease outbreaks. Issues raised for further discussion: The extent that smallholders can comply with this, especially in Africa, is unclear, at least without extension/training programmes. The term 'exceptional' needs clear definition.
Criterion 4.6 Plans to reduce pollution and emissions, including greenhouse gases, should be developed, implemented and monitored	An assessment of all polluting activities should be conducted, including gaseous emissions, particulate/soot emissions and effluent. A plan should be developed and implemented to reduce the company's pollution and the progress of this plan is regularly monitored. Issues raised for further discussion: The CWG should consider providing a simple checklist of activities that should be addressed.

(See http://www.sustainable-palmoil.org)

We have used the discussions within the "Roundtable on Sustainable Palm Oil" as one of the sources to make an inventory of possible constraints. A short analysis of the possible effects of by-product utilisation is given per subject. The discussion is organised from 3 viewpoints: People, Profit and Planet.

In table 5.3 a listing is given of factors to consider in the evaluation of sustainable use of palm oil by-products.

Table 5.3
Factors that should be considered when utilising palm oil by-products/wastes.

Pro	Contra
People	
Local people may benefit from local electricity and bio-gas production	It is possible used locally are now exported increasing demand for (fossil) fuels
Local employment would be positively affected when new biomass based industries could be set up	The available labour is often restricted in Palm oil growing areas
Local economy may profit from lower fossil fuel imports	Will biomass that is based on a controversial palm oil system be considered sustainable?
Environmental pollution problems affecting local people can be mitigated by efficient utilisation of waste biomass	Export of biomass may increase the need for local people to buy other more expensive fuels
Profit	
Additional income per ha due to energy production and other uses of palm oil by-products	Nutrients exported in the biomass have to be replaced at a cost.
The cost of recycling nutrients and can be reduced because digestate from POME biogas production is more concentrated and cheaper to transport to the field	If field by-products are used, returning ash and digestate are essential to prevent depletion of soil and thus productivity of the plantation.
Planet	
Increased revenues per ha will make more money available for good management and make investments to maintain soil fertility more attractive, thus increasing sustainability of the system.	Soil carbon has to be replaced on poor forest soils. Generally rain forests recycle nutrients
Manufacturing of novel wood substitute products from plantation and agro-industrial residues will have a slowing impact on the rate of deforestation	Utilisation of waste for energy instead of recycling can lead to loss of soil fertility and reduce sustainability of the plantation. This can lead a lower yields requiring more production area which increases pressure on virgin forest
Methane emissions from POME and EFB can be greatly reduced	
When by-products are used for energy production nutrients may easier be recycled to the plantation increasing soil fertility and sustainability and productivity of the system	
The need for fire to burn residues at the mill and field will be reduced as the biomass finds profitable uses	

6. Discussion and conclusions

In the Palm Oil value chain there is an overall surplus of by-products and the utilisation rate of these by-products is low, as is especially the case for effluent and empty fruit bunches. For other mill by-products the efficiency of the application can clearly be increased. For field residues the main utilisation now is disposal as mulch and fertiliser. The efficiency and effectiveness of this application could not be determined here. Still this will depend on local conditions and it should be possible to give indications of what recycling or valorisation system will be optimal here.

By-products are considered at best as a nuisance which may lead to environmental problems. As the biobased economy develops and markets for carbon neutral products grow those by-products should be seen as resource. The first effects are becoming clear with delivery of sustainable palm oil waste electricity to the grid in Malaysia.

The primary benefits of external demand for by-products is the solving of problems concerning polluting by-products and increasing the profitability of the production by:

- balanced recycling nutrients and carbon at the field,
- increasing the efficiency of boiler fuel utilisation at the mill
- supplies of surplus energy to local electricity net

novel economic activity and generation of local employment by conversion of biomass residues in value added products

The increased nutrient recycling will increase soil fertility and increase sustainability of palm oil production. Systems that minimise the removal of nutrients and carbon from the system should be preferred. Still not all carbon and nutrients have to be re-cycled. What the optimum is between biomass utilisation and recycling varies according to soil and climate. This is a most relevant research question.

In the case that external demand for by-products of palm oil production materialises, larger amounts of by-products will become available. The palm oil industry will have to weigh the own demand for fuel and the need for recycling of nutrients and soil carbon against the cost of fertiliser and the profits of biomass conversion. It is important to know what are the optimum conditions here in order to design sustainable systems that also produce large quantities of biomass for energy and products.

A very rough guess is that 25 to 50 % of the by-products may be available for energy export (corresponding roughly to 30-60 million tons dry weight biomass). It would be a good development if the by-products from Palm oil production were considered as a potential resource for CO_2 neutral energy and products instead of a waste.

A much more detailed study into the net mass balance and potential biomass production from the palm oil chain and the possibilities of finding added value for these products in a biobased economy is essential for developing economically, socially and environmentally sustainable palm oil systems.

The recognition that utilising by-products for added value is beneficial to the sustainability of palm oil production is essential for certifying the sustainability of the palm oil biomass energy and products.

Multi-stakeholder involvement is required for addressing the sustainability of the food oil supply chain. This would also include outsider (non-food) industries involved in energy and fibre products marketing.

Issues that should be addresses:
More information is needed to determine how much biomass is needed at the mill for plant operations and how efficient this use is,
How much nutrients can be removed from the system without affecting sustainability (nutrient and carbon recycling).
Evaluations are needed of systems that generate energy and products and make it possible to recycle nutrients.
Evaluation of the competitive potential of supplies to the market of energy, products and carbon fixation.
More quantified information is needed on countries outside Malaysia that have similar palm oil waste disposal problems and potentials to utilise these products as a resource.

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