Investing in sustainable palm oil production

Ex-ante impact assessment of investments in a palm oil mill in Palembang, Indonesia

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Ex-ante impact assessment of investments in a palm oil mill in Palembang, Indonesia

Yuca Waarts
Kor Zwart (Alterra)

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Contents

Preface

Recycling palm oil mill effluent, decreasing greenhouse gas emissions and improving smallholder livelihoods are three important topics in debates on sustainable palm oil production. In Indonesia, Zebra Special Products BV has invested in various new technologies within palm-oil milling to address these issues. Lately, a methane capture and usage system has been realised which is expected to improve the environmental sustainability of their palm oil production. This investment was co-financed by the Global Sustainable Biomass Fund of the Netherlands Ministry of Economic Affairs. Furthermore, additional investments have been made in increasing the palm oil-processing capacity of the mill, which is expected to improve the socio-economic sustainability of the smallholder producers who supply fresh fruit bunch to the mill as well as the economic sustainability of the mill itself.

In this study, an ex-ante impact assessment is presented on the sustainability of the investments made. This study was commissioned by Zebra bv, and supported by NL Agency from the Netherlands Ministry of Economic Affairs. We hope that the information in this study will be used in debates on sustainable palm oil production and that it may promote investments in sustainable palm oil development by both industry and policymakers.

L.C. van Staalduinen MSc
Managing Director LEI Wageningen UR

Abbreviations

AGNL	Agency NL of the Netherlands Ministry of Economic Affairs
BOD	Biological oxygen demand
CER	Carbon Emission Reduction units
CH4	Methane
CHP	Combined heat and power
CDM	Clean Development Mechanism
CO_2	Carbon dioxide
CO_2eqs	CO_2 equivalents
COD	Chemical oxygen demand
CPO	Crude palm oil
EFB	Empty fruit bunch
FFB	Fresh fruit bunch
GHG	Greenhouse gas
GRI	Global reporting initiative
H2	Hydrogen
H_2S	Hydrogen sulphide
Ha	Hectare
H-PO	Hydrogenated palm oil
IDR	Indonesian Rupiah
IPCC	Intergovernmental Panel on Climate Change
JRC	Joint Research Centre of the European Commission
Kg	Kilogram
LCA	Life cycle analysis
MJ	Mega joule
N	Nitrogen
NH_3	Ammonia
POME	Palm oil mill effluent
RED	Renewable energy directive
RSPO	Roundtable on Sustainable Palm Oil
SO_2	Sulphur dioxide
UNFCCC	The United Nations Framework Convention on Climate Change
VFA	Volatile fatty acids
Zebra BV	Zebra Special Products BV

Summary

S.1 Key findings

Investing in technologies to capture methane emissions from palm oil effluent (POME) to be used in power generation, replacing fossil fuels, is expected to lead to the following results:

1. An 80% reduction of greenhouse gas emissions (GHG) emissions during crude palm oil (CPO) extraction, both for the UNFCCC and the BioGrace tools.
2. The total reduction using the UNFCCC tool is over 9,000 tonnes of carbon dioxide (CO_2) at 100,000 tonnes of FFB processed. Using the BioGrace tool the reduction is almost 17,000 tonnes of CO_2.
3. Utilisation of POME methane may replace over 207 tonnes of diesel annually (at 100,000 tonnes of FFB processed). This may lead to cost-savings of EUR186,701.
4. Methane capture also leads to a reduction of odour emission, especially H_2S (hydrogen sulphide).
5. Flaring of biogas, non-scrubbed for H_2S, leads to local emissions of SO_2 (sulphur dioxide).
6. A positive economic return ('economic value retained') because of the investment.

Zebra BV and PalmPro tackle the second most important contributor of GHG emissions in the palm oil supply chain by implementing these new technologies. As they do not produce fresh fruit bunches themselves, tackling land use change, the most important contributor to GHG emissions, is not in their direct sphere of influence. Even though PalmPro already applies POME sludge to their oil palm plantation of 5 ha, it could further improve its environmental performance by applying POME effluent to irrigate a larger acreage of palm trees after methane capture. This would lead to an additional reduction of GHG emission from fossil fuel due to a lower need for fertiliser N (nitrogen), which is the biggest contributor to air, water, and soil pollution in FFB production.

Investing in almost doubling the capacity of the PalmPro mill is expected to lead to the following results:

1. A positive economic return ('economic value retained') because of the investment.
2. Paying out a premium of IDR100 per kilogram of FFB to FFB suppliers for at least three years after the investment was made, of which 90% is expected to end up at smallholder FFB producer level. This would lead to an extra annual income per smallholder producer of about IDR2.7m (EUR214), which is a substantial increase of 8.4%. Middlemen would also profit from the price premium (IDR10 per kg of FFB).
3. An annual increase in income for all 1,600 smallholders who supply to PalmPro mill and the middlemen combined, of at least IDR4.3bn (EUR342,000). This which appears to be a substantial financial injection into the region in which the PalmPro mill operates.
4. An increase in the proportion of the budget spend on local supply companies as the increase of costs for sourcing FFB far outweighs the decrease in costs for sourcing diesel.

The increase in demand for FFB from PalmPro mill is not expected to lead to new plantations as sufficient feedstock will be available when the mill operates in full capacity.

Based on the information from the literature, an increase of IDR90 per kg of FFB would also be a substantial improvement in the income for other Indonesian smallholder FFB producers. However, an increase in the FFB price is not the only factor influencing smallholder farmer incomes. Within the production system, for instance, great improvements can be made with regard to increasing productivity per hectare. Furthermore, challenges in access to capital, access to high quality inputs, access to information and extension, land disputes, land tenure, and unproductive plantation periods, as well as CPO and FFB price volatility, are also factors that influence the incomes of smallholder farmers. Looking at the costs of all these options, increasing the FFB price is a relatively easy way of improving the incomes of smallholder farmers (ceteris paribus) while addressing the other challenges can be very costly and time consuming.

One note needs to be placed here: when other mills would also invest in increasing their processing capacity, this could have a negative impact on nature and the environment. Smallholder farmers could namely react by increasing the productivity of their plantation, but they could also expand oil palm production areas by establishing new plantations. Such an expansion could lead to deforestation, the degradation of natural habitat, loss of biodiversity and environmental problems.

S.2 Recommendations

LEI recommends to PalmPro to evaluate the actual technology impact on GHG emissions, air and water quality and, when applicable, nutrient savings. Furthermore, we recommend PalmPro to communicate the information in this report to palm oil businesses and other stakeholders, as it may be an inspiration for other palm oil mills to make similar investments which can benefit the mill as well as the environment. Furthermore, the information in this report could also feed debates on sustainable palm oil production, and inform organisations such as UNFCCC, the organisations developing the Biograce tool, governments, NGOs and knowledge institutes.

LEI also recommends to PalmPro to evaluate which share of the price premium will end up at the smallholder level, as they intend to do, when the price premiums are paid out, because that would clarify whether their assumptions hold true. Another evaluation can be conducted on how both the technology investment related to methane capture and usage and the premium price impact on the livelihoods of the smallholder farmers, their families, the middlemen, workers and other community members. Such information would be of use to other actors operating in palm oil mill production (companies, governments, NGOs, farmers etc.) as well as knowledge institutes.

S.3 Methodology

This study follows and ex-ante impact assessment approach in which indicator values are compared between 'before investment' and 'after investment' situations for two investments, based on data provided by Zebra Special Products BV and models and parameters from credible sources. Based on principles and criteria from Cramer et al. (2007) and the system boundaries of the investments, the ex-ante impact assessments in this study address the following six research questions:

1. To what extent will greenhouse gas emissions be reduced as a result of the technology investment related to methane capture and usage?
2. To what extent will air quality be improved as a result of the technology investment related to methane capture and usage?
3. To what extent will water quality be improved as a result of the technology investment related to methane capture and usage?
4. To what extent will nutrient use improve as a result of the technology investment related to methane capture and usage?
5. To what extent will local prosperity improve as a result of the technology and mill capacity increase investments?
6. How can the sustainability results of the investments be related to the wider sustainability endeavours in the palm oil value chain?

1 Introduction

1.1 Investing in sustainable palm oil production

Indonesia, the world's leading producer of palm oil (Rist et al., 2010), has increased its palm oil production in the last decades and is expected to continue to do so in the coming seasons (USDA, 2012, Teoh, 2010). Key sustainability challenges in palm oil production are deforestation, biodiversity loss, land conflicts, climate change and poverty reduction (Teoh, 2010). Part of these environmental and socio-economic sustainability challenges can be addressed by investing in cleaner technologies, and increasing the price to be paid out to smallholder FFB suppliers.

Zebra Special Products BV (Zebra BV) has developed a technology through which palm oil mill effluent (POME) is converted into biogas with a 90% conversion efficiency. They have also developed and tested a biological gas scrubbing system to clean biogas from harmful sulphuric acid and a system to mix the clean gas into a standard diesel generator. Through a combination of these technologies, methane emissions are captured from POME and can be used in power generation, replacing fossil fuels. In 2010, Zebra BV has invested in this approach at its PalmPro mill in Palembang, Indonesia, co-financed by the Global Sustainable Biomass Fund.

Next to investing in technologies, Zebra BV also invested in doubling its processing capacity at the mill, which is expected to lead to higher prices to be paid out to smallholder fresh fruit bunch suppliers. This investment was made between November 2012 and March 2013. From March 2013 onwards, the FFB processing will start; in June 2013, Zebra BV expects the mill to operate in full capacity.

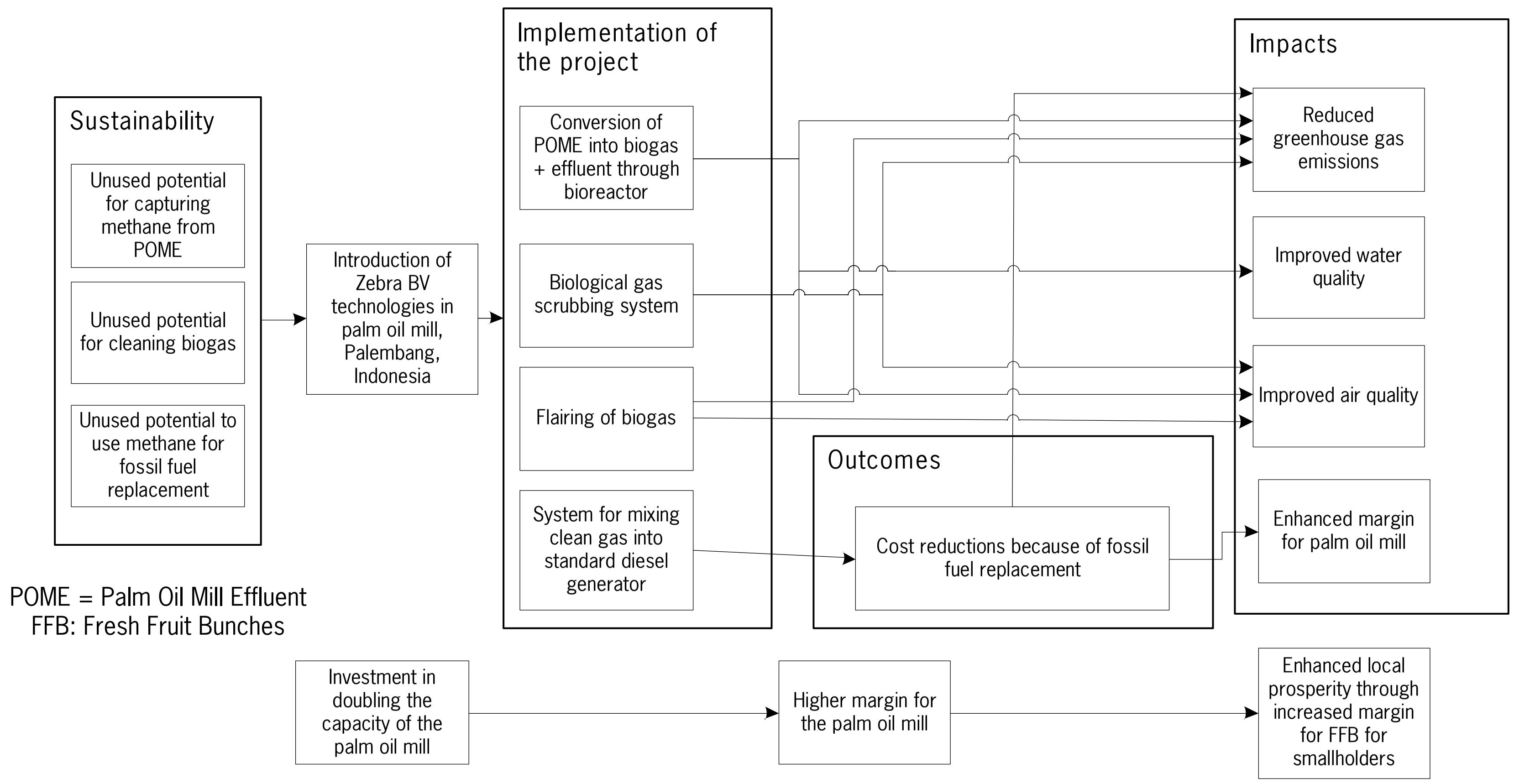
1.2 The impact logic of the intervention

An impact logic is a specific description of an intervention visualising the causal relation between the activities and their expected outcomes and impacts in one diagram. The impact logic in this ex-ante impact assessment describes how Zebra BV expects to create its desired outcome through the implementation of new technologies. In Figure 1.1 you will find the impact logic of the intervention. The flow-diagram starts with the reasons why the project started, which is followed by project activities (implementation of technologies) which lead to expected economic, environmental and social impacts.

As can be seen from the impact logic, the technology investment related to methane capture and usage is expected to improve air and water quality, reduce greenhouse gas emissions and lead to cost reductions through fossil fuel replacement (70% energy savings). Investments into the doubling of the mill's capacity is expected to lead to higher margins for the mill, which will be partly paid out to FFB suppliers, increasing the margin of FFB producers.

In the original plan, also an additional cash-flow from carbon credits was foreseen through the Clean Development Mechanism (CDM). However, at the application for the Host Country Approval (UNFCCC trajectory), the CDM status of this project was rejected by the Host Countries Board. The Board found that the project would not be sustainable enough because of the low amount of Carbon Emission Reduction units (CER) relative to the height of the investment.

Figure 1.1 **Impact logic of implementing Zebra BV technology in palm oil production**



Source: On the basis of the description of the intervention from Zebra BV (2009) and Zebra BV (2013).

1.3 Aim of this study and research questions

This study aims to present the results of ex-ante impact assessments of the investment in new technologies by Zebra BV and the investment in doubling the capacity of the palm oil mill to both industry and policymakers. In the assessment, the 'before investment' situation is compared with the 'after investment' situation. Ex-ante impact assessments are conducted, based on models and reference data from credible sources and information from Zebra BV, as although at the time of the study both investments were made, the PalmPro mill was not processing fresh fruit bunches (FFB) yet.

The following six research questions are addressed in this study:

1. To what extent will greenhouse gas emissions be reduced as a result of the technology investment related to methane capture and usage?
2. To what extent will air quality be improved as a result of the technology investment related to methane capture and usage?
3. To what extent will water quality be improved as a result of the technology investment related to methane capture and usage?
4. To what extent will nutrient use improve as a result of the technology investment related to methane capture and usage?
5. To what extent will local prosperity improve as a result of the technology and mill capacity increase investments?
6. How can the sustainability results of the investments be related to the wider sustainability endeavours in the palm oil value chain?

1.4 Outline of this report

Chapter two presents the methodology of the research. The research questions are addressed separately in this report; the results of the environmental impact assessment (questions 1-4) in Chapter 3, followed by the socio-economic impact assessment results (question 5) in Chapter 4. Then, the findings of this study are placed in the wider sustainability endeavours in the palm oil value chain (Chapter 5). Chapter 6 concludes and provides recommendations.

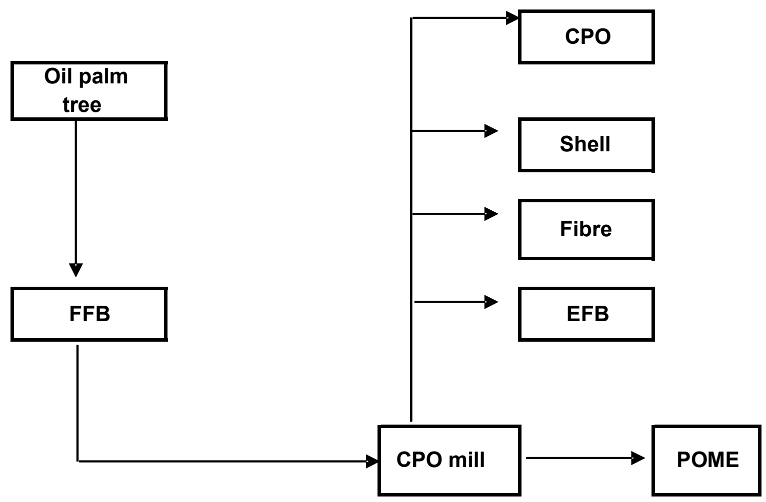
2 Background information on the investments

2.1 The technology investment related to methane capture and usage

Palm oil production is associated with the production of a number of residues, one of which is palm oil mill effluent (POME). A general flow scheme of palm oil production and its residues is shown in Figure 2.1. A more detailed scheme of palm oil production is presented in Appendix 1.

Fresh fruit bunches (FFB) from oil palm trees are processed into crude palm oil (CPO) in a CPO mill during which shells, fibres and empty fruit bunches (EFB) are produced as solid residues and POME as a liquid residue. POME is a viscous brown liquid with fine suspended solids at pH ranging between 4 and 5 (Najafpour et al., 2006). POME is generated through sterilisation of fresh oil palm fruit bunches, clarification of palm oil and effluent from hydrocyclone operations (Borja et al., 1996).

Figure 2.1 **General flow scheme of palm oil production**



In many mills, POME is stored in a chain of open lagoons during a certain period of time, where it is cooled and where part of its organic matter content is degraded biologically. Afterwards, POME is often discarded into surface water streams. A major drawback of this type of POME treatment is the biological degradation process. Due to the relatively high organic matter contents of POME and its relatively high degradation rate, the rate of oxygen supply to the pond is lower than the oxygen consumption rate, resulting in anaerobic conditions in the POME pond. POME degradation under anaerobic conditions results in the production of a mixture of carbon dioxide (CO_2) and methane (CH4), the predominant gas in natural gas. The mixture of CO_2 and CH4 is called biogas. The produced biogas escapes uncontrolled from the pond into the atmosphere. Since methane is 21 (25) times more effective as a greenhouse gas (GHG) than carbon dioxide, part of the beneficial GHG effects of bio-based palm oil production is negatively affected by methane production from POME degradation.

2.2 Controlled biogas production

An increasing number of palm oil mills are producing biogas from POME under controlled conditions in a biogas reactor (Poh and Chong, 2009), including mills in Indonesia and elsewhere in Asia. In that situation, the produced biogas can be used beneficially in the palm oil production process itself, or for other purposes. Generally, biogas is converted into electricity in a modified diesel generator or a gas turbine, and the electricity is applied in the mill or alternatively, fed into the electricity grid. The controlled conversion of POME into biogas is recognised as a Clean Development Mechanism under the Kyoto protocol (Tong and Jaafar, 2006). CDM can lead to co-financing of renewable energy projects through foreign investments (Menon, 2002). Certified emission reduction (CER) can be obtained by using methane gas as a renewable energy.

2.3 Controlled biogas production at the PalmPro mill in Palembang Indonesia

PalmPro Indonesia is a palm oil producer (a joint venture of Zebra BV and two Indonesian companies) which sources FFB from smallholder plantations in Palembang, Indonesia (Figure 2.2).

Figure 2.2 **Location of the PalmPro mill near Palembang, Indonesia (PT PalmPro, 2010)**

PT Palmpro (2010). Small scale project activity: Biogas Capture Project PT. PALMPRO. Clean Development Mechanism project design document form (CDM-SSC-PDD).

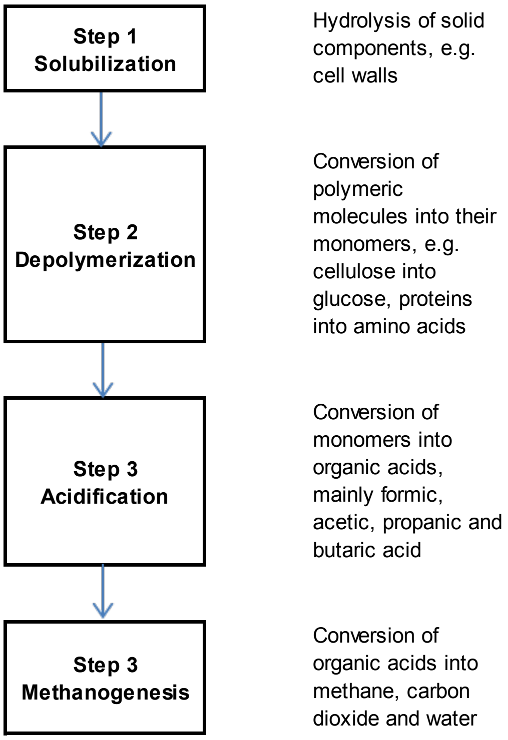
Together with Zebra Special Products BV, engineers for renewable energy projects, PalmPro has constructed a biogas reactor in order to produce biogas from POME in a controlled way. After conversion of a part of the biogas into electricity in a modified diesel engine, part of the electricity from fossil energy can then be replaced by electricity from POME biogas. The remaining biogas will be flared.

2.4 POME effluent treatment at the PalmPro mill

2.4.1 The baseline situation

In the baseline situation, POME from the mill was discarded in a number of different subsequent open lagoons. The first one is a cooling pond, followed by an acidification pond, where the initial anaerobic degradation of POME results in the production organic acids, mostly volatile fatty acids (VFA), leading to an acidification of the effluent. In the following POME pond, these organic acids are further degraded into biogas. A general description of the biochemistry of anaerobic conversion of organic matter into biogas is shown in Figure 3. The first step is the solubilisation of particulate matter followed by the depolymerisation of bio-polymers into their corresponding monomers. Next, these monomers are fermented into VFA, under the production of carbon dioxide (CO_2) and in the final steps the organic acids are converted into a mixture of CO_2, CH4 and water, either directly or via the production of hydrogen gas H2 and CO_2. For more information regarding the different steps see (Hamilton, 2009). Detailed information on the biochemistry of the final step can be found in Ferry (2002).

Figure 2.3 **Anaerobic conversion of organic matter into biogas, schematically**



The baseline situation regarding POME treatment is shown in Figure 2.4. Electricity for the mill is generated by a diesel generator fuelled by diesel oil. The electric conversion efficiency of the diesel generator is approximately 30%. So, 70% of the diesel energy is converted into heat, for which no efficient use is available. POME is treated in different ponds. Biogas is produced predominantly in the POME pond and after a final period in the polishing pond, the resulting effluent is discarded into a river. The polishing or aerobic pond is necessary to further reduce biological oxygen demand (BOD) concentration in order to produce effluent that complies with effluent discharge standards. At intervals of approximately 5 years, sludge is removed from the POME and polishing ponds, which is sun-dried and used as a fertiliser and soil conditioner at the mill's 5 ha oil palm plantation. So, all energy used in the baseline situation is fossil energy. PalmPro does not apply chemical fertilisers on their own oil palm plantation, whereas fertilisers used at oil palm plantations are usually a mixture of predominantly chemical fertilisers and a small fraction of organic fertilisers from the POME pond sludge. In the baseline situation no renewable fuel is used.

Figure 2.4 **Baseline situation of POME treatment at the PalmPro mill. The green area indicates the system boundary of the current sustainability analysis regarding energy and GHG**

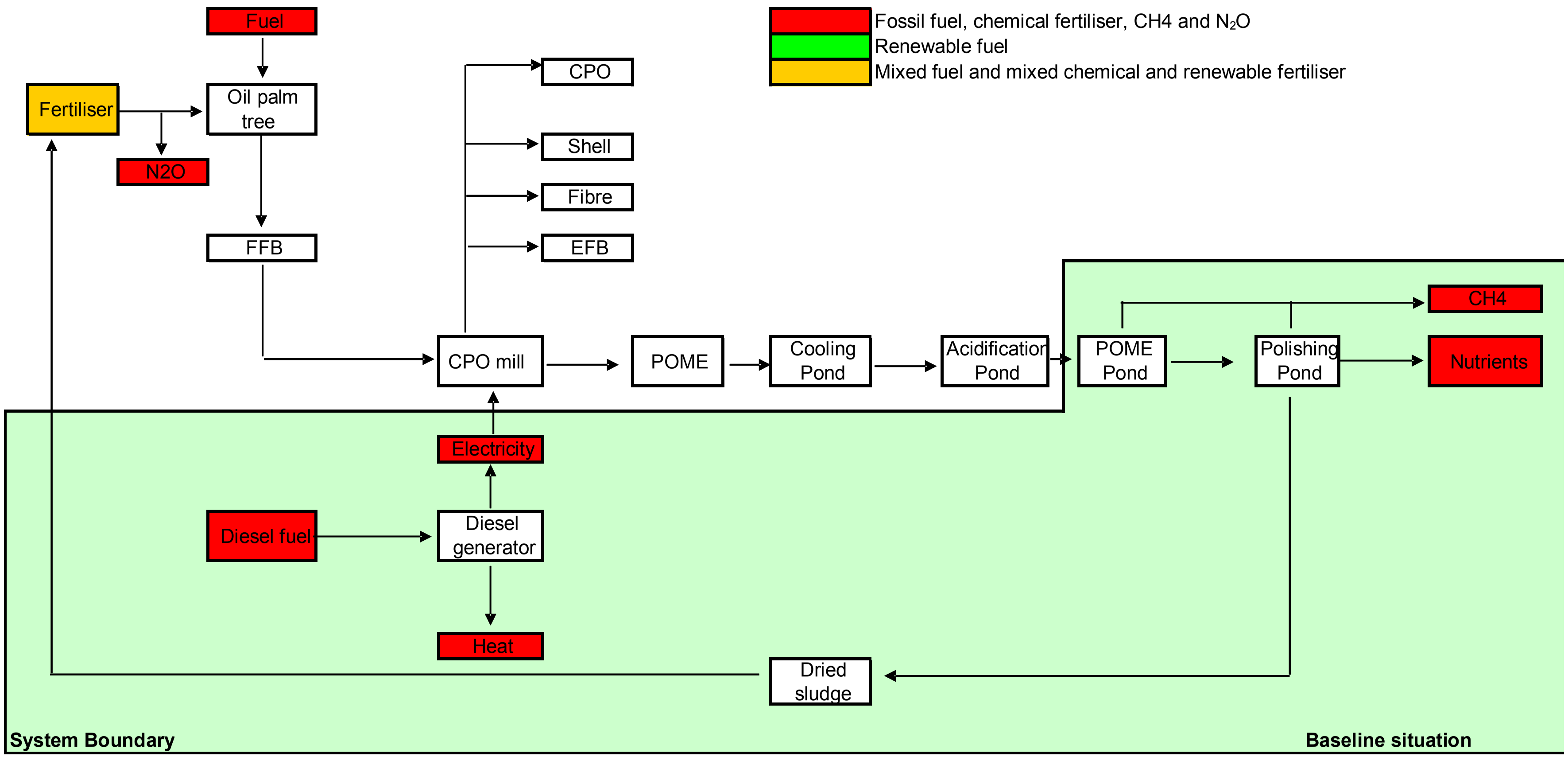
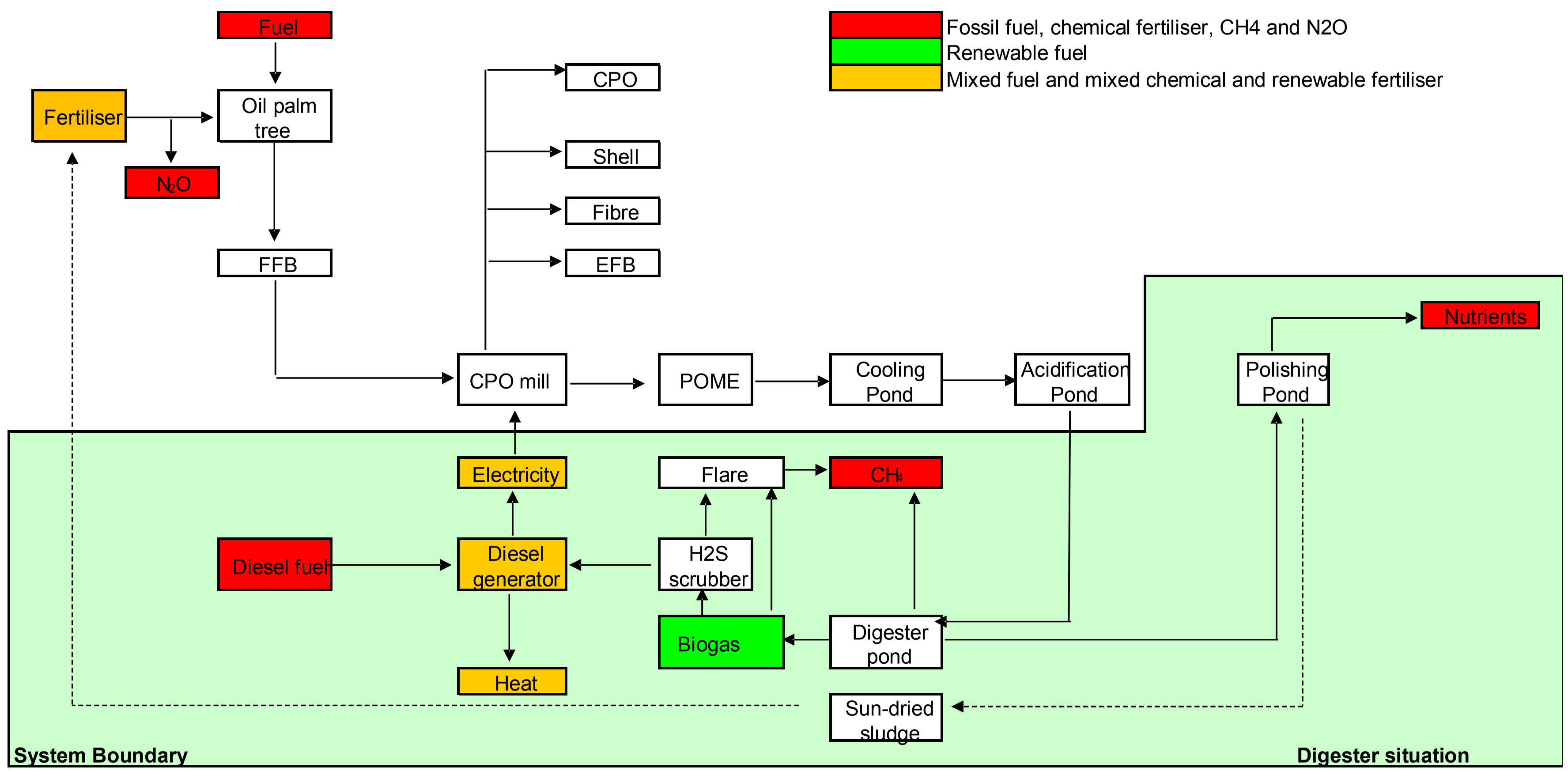


Figure 2.5 **Digester situation of POME treatment at the PalmPro mill**



2.4.2 The digester situation (after the investment has been made)

The situation after the construction of a biogas digester and the use of biogas in the modified diesel generator is shown in Figure 2.5. In the digester situation, the POME pond is completely covered and the biogas produced is captured to prevent biogas emissions into the atmosphere. Produced biogas is cleaned from hydrogen sulphide (H_2S) in a H_2S scrubber, after which it is combusted in a modified diesel generator to produce electricity and heat. The modified diesel generator operates at 70% biogas and 30% diesel. Thus 70% of the electricity needed for the mill originates from biogas while the remaining part still originates from fossil fuel. Biogas produced in excess is flared.

Effluent from the digester is cooled and post-treated in the polishing pond, after which it is discarded into the river. Similar to the baseline situation, every 5 years, sludge is removed from the POME and polishing ponds, sun-dried and used as a fertiliser and soil conditioner at the PalmPro 5ha oil palm plantation.

The system boundary for the current study is indicated by the green area in Figure 2.4 and Figure 2.5. It includes the POME and polishing ponds, the diesel generator and the dried sludge. It is assumed that no GHG gas emissions occur at the acidification pond due to its low pH. The CPO mill itself is not included inside the system boundaries. However, the application of digester effluent at the PalmPro oil palm plantation instead of discarding it into the river and its effects on fertiliser application will be discussed briefly in the environmental assessment.

2.5 Investing in almost doubling the capacity of the palm oil mill

Zebra BV invested in almost doubling its processing capacity at the mill to increase its production from 10,000 kg of FFB per hour to 18,000 kg of FFB per hour.

In order to increase the processing capacity, the mill was extended with infrastructure and machinery: the off-loading platform was doubled, an additional steriliser installed; an additional thresher installed; the mill ensured that both presses operated in parallel; the boiler fireplace was extended to double steam production and a kernel plant was installed for the extraction of sellable kernels.

Apart from the change in infrastructure and machinery, increasing the capacity of the palm oil mill will also lead to higher volumes of FFB to be sourced from smallholder producers in the area around the mill when sufficient feedstock is available.

3 Methodology

3.1 Introduction

As described in the introduction, ex-ante impact assessment approaches are followed in this study. The study follows a before/after investment assessment approach, comparing indicator values for the PalmPro mill between the situations in which the investments had not been made with the situations in which the investments had been made. The ex-ante assessments are based on data provided by Zebra BV and models and parameters from credible sources.

In this chapter, we describe the assessment framework, the indicators that are used in this study to answer the research questions and explain how the assessments were conducted.

3.2 Impact assessment framework

3.2.1 The Testing Framework for Sustainable Biomass as a starting point for the assessment

The starting point for the ex-ante impact assessments was the Testing Framework for Sustainable Biomass (Cramer et al., 2007). This testing framework provides principles and criteria for three types of analyses:

1. Measuring the sustainability of a company and its activities (company level).
2. Measuring the sustainability of technologies applicable to the use of residual flows.
3. Measuring sustainability on a macro level.

The Testing Framework allows for the assessment of residual flow technologies when the residual flows represent a negligible value (<10%) of the main product and when the residual flows have no other useful application (Cramer et al., 2007). For such assessments, fewer criteria apply than for company level assessments.

POME from the PalmPro mill has no other useful application than for the generation of biogas which was introduced by investing in the new technologies. LEI has calculated that the economic ratio between POME and the main product crude palm oil (CPO) is 6% (see Appendix 2). As this is below 10%, the criteria for measuring the sustainability of technologies applicable to the use of residual flows apply for the ex-ante technology impact assessment.

The requirements that apply for the impact assessment from the Testing Framework are presented in Table 3.1. See for all principles, criteria and indicators, the Testing Framework (Cramer et al., 2007) and Appendix 3.

But next to these Testing Framework requirements, system boundaries of the investments also influence which principles and criteria apply. A system boundary is 'a physical or conceptual boundary that encapsulates all the essential elements, subsystems, and interactions necessary to address a systems decision problem' (Parnell, Driscoll and Henderson (eds.), 2011, p36). For conducting impact assessments, it is critical to demarcate the system boundaries of the intervention to conduct meaningful analyses.

Table 3.1	Testing Framework requirements for residual flows with a negligible economic value and no other useful application	
Theme	**Requirements**	**Remarks**
Greenhouse gas emissions	Comply with criteria	Methane emissions may be reduced; this can have a positive effect on greenhouse gas balance
Competition with food	No requirements	
Biodiversity	No requirements	
Environment		
- Principle 5: Soil	Comply with criteria	
- Principle 6: Water	No requirements	
- Principle 7: Air	No requirements	
Prosperity	No requirements	Effects on prosperity are in principle positive with the use of residual flows that have no other useful application
Social well-being	No requirements	
Source: Cramer et al. (2007).		

3.2.2 System boundaries for the assessments

The technology assessment is not a complete life cycle analysis (LCA) of palm oil production. Instead it is focused on the part of the production process in which palm oil is extracted from FFB (extraction phase), and the effects of POME processing on fossil energy consumption, GHG emissions, water and air quality and the recycling of nutrients. The impact of the mill capacity increase is assessed focusing on the socio-economic impacts of the investment. The environmental impacts of this investment are not taken into consideration.

The system boundary for the environmental impact assessment is indicated by the green area in Figure 2.4 and Figure 2.5. It includes the POME and polishing ponds, the diesel generator and the dried sludge. It is assumed that no GHG gas emissions occur at the acidification pond due to its low pH. The CPO mill is not included inside the system boundaries. However, application of digester effluent at oil palm plantations instead of discarding it into the river and its effects on fertiliser application will be discussed briefly in the sustainability assessment.

Furthermore, the assessment does not have to report on the principle of 'prosperity' according to Cramer et al. (2007), but as the investments are expected to positively influence both the financial situation of the mill as well as the margin of its smallholder FFB suppliers, LEI has been asked by Zebra BV to provide detailed insights into why these impacts are expected to occur.

3.2.3 Impact assessment criteria and indicators

Based on the Testing Framework principles and criteria and the system boundaries of the investment, the impact assessment in this study will focus on the following themes:
1. Greenhouse gas emissions.
2. Water quality.
3. Air quality.
4. Recycling of nutrients.
5. Prosperity.

The principles, criteria and indicators for these themes are described in the subsequent sections.

3.3 Methodology for the environmental impact assessment

Several methods have been developed in order to evaluate the sustainability of renewable energy production. Some of these are quantitative, others are more qualitative. Several multilateral agencies have developed their own sets of sustainability indicators (Rogers et al., 1997). These sets of indicators are designed to be used at a national level. A description of sustainability indicators is given by Sutter (2003) and by Froger et al. (2010) which is more extensive and also based upon more recent information. Internationally, the protocol written under the Clean Development Mechanism (CDM) is widely used. The European Union has developed its own criteria for renewable energy under the Renewable Energy Directive (RED) and also individual countries have developed their own systems. In the Netherlands a set of criteria has been developed (the so-called Commission Cramer Criteria) named after the former Dutch minister of Environment. The latter has been converted into Netherland's Technical Agreements (NTA 8080 and NTA 8081). At a European level the BioGrace (Biograce, 2013) project has been developed to harmonise calculations of biofuel greenhouse gas (GHG) emissions according to the RED criteria. Thus, BioGrace supports the implementation of the EU Renewable Energy Directive (2009/28/EC) and the EU Fuel Quality Directive (2009/30/EC) into national laws. Also, specific tools for the evaluation of biogas production in reactors using several different substrates (co-digestion) are available (e.g. Zwart et al., 2006; Zwart and Kuikman, 2011).

3.3.1 Greenhouse gas emissions

The United Nations Framework Convention on Climate Change (UNFCCC) Clean Development Mechanism approach (CDM) was selected for the current assessment since it is a world-wide accepted method, based upon Intergovernmental Panel on Climate Change (IPCC) criteria and also accepted by the Indonesian government. The latter is relevant since the Indonesian government has to approve the CDM proposals for biogas installations of POME treatment. Moreover, the CDM methodology has specific criteria for systems in which biogas emissions from open lagoons can be compared to systems with controlled production of biogas, followed by a conversion into electricity in a diesel generator. Other approaches, e.g. the method used by Thamsiriroj and Murphy (2008), have been developed to assess the sustainability of complete production and transport chains of biofuels. These methods are less suitable for the assessment of specific steps within the palm oil production and transport chain. The CDM methodology has also been used for assessments of other POME treatment plants in South East Asia (Pacific Consultants, 2008; Nuibe, 2008; Yeoh, 2004; Malsum, 2005 and also K. Chuchuoy et al., 2009).

The following CDM Methodological tools have been used:

- To calculate electricity production (CDM - Executive Board EB 39 Report, Annex 7),
  - Including: Indicative simplified baseline and monitoring methodologies for selected small-scale CDM project activity categories (CDM Executive Board I.A./Version 14 Sectoral Scope: 01).
- To determine project emissions from flaring gases containing methane (CDM - Executive Board EB 28 Meeting report Annex 13).
- To assess methane recovery in wastewater treatment (CDM Executive Board III.H./Version 16 Sectoral scope: 13 EB 58).
- To calculate project or leakage CO_2 emissions from fossil fuel combustion, Version 2 (CDM - Executive Board EB 41 Report Annex 11).

Details of the UNFCCC baseline and digester calculations are given in Appendix 4 and can also be found in the references cited above.

In addition to the CDM approach, and at the request of AgentschapNL, the environmental assessment has also been conducted by using BioGrace, which follows the methodology as given in Annex V of the Renewable Energy Directive (2009/28/EC) - which is equal to Annex IV of the Fuel Quality Directive (2009/30/EC). A direct comparison is not possible, since both models differ in several aspects. For instance, the standard parameter values regarding the GHG potential for methane are 21 and 25 in UNFCCC and BioGrace respectively, and the latter cannot be changed in the public version of the model. Another example is the specific methane production of 1.3218 g per MJ CPO in BioGrace. This parameter is not used directly in the UNFCCC model and can only be calculated after a complete model run. Other parameter differences are shown in Table 3.2.

Therefore, both the UNFCCC and the BioGrace parameters needed to be modified, to make a sensible comparison possible. The parameter values used for model comparison are also shown in Table 3.2.

Finally, the UNFCCC results have been compared with the CDM project design document form results from Zebra BV (PT PalmPro, 2010), which also used the UNFCCC approach, albeit with some different parameter values for the project calculations (Table 3.2).

For this purpose the parameters of the PalmPro mill before investment and after investment situations have been used in the sheets regarding palm oil production of the BioGrace Excel tool, which is available to the public.

Transformation of UNFCCC parameter values into BioGrace parameter values

An important difference between the UNFCCC and BioGrace approach is the units in which the outcomes are expressed. UNFCCC calculates the amount of CO_2 equivalents for the total amount palm oil produced, whereas BioGrace expresses the specific outcome in CO_2 equivalents per MJ of palm oil produced. This means that the input data for the UNFCCC calculations needed to be transformed into input data for BioGrace regarding the amount of diesel for the generator and the production of methane during the processes.

Emissions from combined heat and power

The BioGrace 'Emissions from CHP' (combined heat and power) were calculated using the specific values for diesel consumption (in MJ per MJ palm oil) and the BioGrace default value of 87.64 g CO_2/MJ diesel. The specific values for diesel consumption (i.e. Steam from CHP (Cell C 74) in BioGrace sheets 'H-PO' and 'H-PO (CH4-capt)' has been calculated from the total amounts of diesel consumed and palm oil produced and their specific energetic values of 43 and 37 MJ per kg, respectively. This resulted in a value of 0.015643363 MJ of diesel per MJ of palm oil.

Emissions from POME

BioGrace uses a specific default CH_4 emission value of 1.3218 g of CH_4 per MJ of palm oil. According to AgentschapNL (J. Neeft, personal communication) this value has been provided by Joint Research Centre of the European Commission (JRC), but its exact origin is not known. When methane is captured, BioGrace uses a specific default CH_4 emission value of 0.

For the current BioGrace assessment we have calculated the specific CH4 emission value for the baseline situation from the total amount of methane produced, the total amount of FFB processed, a specific CPO production of 0.1998 kg per kg of FFB (Pehnelt and Vietze, 2011) and 37 MJ per kg of CPO. This resulted in a specific CH_4 emission value of 1.1823 g of CH_4 per MJ of palm oil for the baseline situation and 0.1178 g of CH_4 per MJ of palm oil for the digester situation. The latter is based on a 5% methane leakage from the digester and a flare efficiency of 90%.

The major differences between the UNFCCC and BioGrace input values and calculations, regarding GHG emissions during the palm oil extraction process are listed in Table 3.2.

Table 3.2	Default parameter values for the UNFCCC and BioGrace models and the values used to compare the results of both models		
Parameter value	**UNFCCC**	**BIOGRACE**	**UNFCCC=BIOGRACE**
CO_2 eq CH4 (g CO_2/g CH4)	21	25	25
CO_2 eq diesel (g CO_2/MJ)	74.1	87.64	87.64
CH4 production CPO (g/MJ)	0.7115	1.32	0.7115
CH4 production CPO (CH4 capture) (g/MJ)	0.1178	0	0.1178
CPO per FFB (kg/kg)	0.2015	0.344	0.344
CPO LHV (MJ/kg)	37	37	37
Diesel LHV (MJ/kg)	43.0	43.1	43.1
Steam from CHP (MJ/MJ CPO)	0.0156	0.0156	0.0156
Steam from CHP (CH4 capture (MJ/MJ CPO)	0.0047	0.0047	0.0047
Oil Yield	0.2811	0.53	0.2811 a)

a) Has no effect on extraction in BIOGRACE, only on transport and production.

The UNFCCC and BIOGRACE default parameter values are shown in Table 3.2. The last column shows which parameter values has been used for the calculation where UNFCCC equalises BIOGRACE as much as possible. Both tools never completely equalise due to differences in the approach.

3.3.2 Nutrient use, water quality and air quality

The possible effects of methane capture on nutrient use of the oil palm plantation (nitrogen only) and water quality are assessed in a semi-quantitative way, since reliable quantitative data are lacking. For the same reason, the effect on air quality will be described in a qualitative way only. The methodology and assumptions used for the assessments are briefly described in the results section (Chapter 4).

3.4 Methodology for the socio-economic impact assessment

3.4.1 Prosperity

The following principle from the Testing Framework applies to measurements of prosperity: 'The production of biomass must contribute towards local prosperity.' The criterion related to this principle is that there should be a 'positive contribution of private company activities towards the local economy and activities'.

The following indicators are mentioned in the Testing Framework under the prosperity principle:

- *The direct economic value that is created*
  The Global Reporting Initiative Economic Performance Indicator EC 1 is to be used for reporting, which includes the following elements: direct economic value generated and distributed, including revenues, operating costs, employee compensation, donations and other community investments, retained earnings, and payments to capital providers and governments.
- *Policy, practice and the proportion of the budget spent on local supply companies*
  The Global Reporting Initiative Economic Performance Indicator EC 6 is to be used for reporting, which includes the following elements: policy, practice and the proportion of the budget spent on local supply chains.
- *The procedures for appointment of local staff and the share of local senior management*
  The Global Reporting Initiative Economic Performance Indicator EC 7 is to be used for reporting, which

includes the following elements: procedures for local hiring and proportion of senior management hired from the local community at significant locations of operation.

These indicators will be used in reporting on the expected changes due to the investments. As again system boundaries apply, these indicators will be reported upon where relevant and applicable with regard to the intervention. Explanations on which elements are not reported upon are presented in the text.

3.5 Methodology for placing the expected sustainability improvements in the wider sustainability endeavours in the palm oil value chain

To answer the research question 'how can the sustainability results of the project be related to the wider sustainability endeavours in the palm oil value chain', LEI has conducted a quick-scan review of the literature in search of information from:

- Life Cycle Assessments (LCAs) of palm oil production from Indonesia or South East Asia
- Assessments of production, incomes, poverty and livelihood developments for Indonesian smallholder FFB producers.

The results of this study are then compared with the information from the literature to assess how the expected sustainability gains from the investments can be evaluated, compared to other sustainability challenges in palm oil production.

4 Environmental impact assessment results of the technology investment related to methane capture and usage

4.1 GHG emissions using UNFCCC parameters

GHG baseline and project emissions for the UNFCCC and BioGrace calculations are shown in Table 4.1., both in total amounts of CO_2 equivalents for 100,000 tonnes of FFB and in g of CO_2 per MJ CPO produced. Columns 3 and 4 show the results using the default parameters for each of the models, columns 5 and 6 show the results using the same parameter values for both models. Details of the UNFCCC baseline and project calculations are given in Appendix 4.

Flow schemes of the UNFCC calculated baseline and project emissions are shown in Figure 4.1 and Figure 4.2, respectively.

The UNFCCC calculations result in a baseline emission of 11,142 kg of CO_2 eqs at 100,000 tonnes of FFB processed annually. The projects emissions are 1,887 kg of CO_2 eqs, resulting in a saving of 9,298 kg of CO_2 eqs.

The UNFCCC results are lower than the BioGrace default results, which is mainly due to two factors: a higher GHG emission value for methane (25 vs. 21 kg of CO_2 eqs per kg of CH4) and a higher methane production per MJ CPO produced (1.3218 vs. 0.7115 g of CH4 per MJ of CPO) in the BioGrace model. However, the outcomes are quite comparable if the same parameter values are used in both models. Despite the differences between the UNFCCC and BioGrace results, both outcomes result in a reduction of GHG emission of approximately 80% during FFB processing due to methane capture.

Table 4.1 **GHG emissions using the UNFCCC and BioGrace models, calculated in tonnes of CO_2 for 100,000 tonnes of processed FFB with default parameter values and calculated in g of CO_2 per MJ of CPO after using the same parameter values for both models**

		Tonnes of CO_2		g CO_2/MJ CPO	
		UNFCCC	**BIOGRACE**	**UNFCCC**	**BIOGRACE**
Baseline	Diesel	943.6	939.8	1.3	1.58
	Methane	8914.3	20,358.6	15.1	18.39
	Total Baseline	**11,142.8**	**21,298.3**	**16.3**	**19.97**
Project	Diesel	283.1	352.4	0.38	0.47
	Methane reactor	1,495.9	4326.2 a)	1.70	0.0
	Methane Flare	1,009.2		1.07	3.05
	Total Project	**1,866.69**	**4678.6**	**3.15**	**3.52**
	CO_2 saved	**9,298.3**	**16,619.7**	**13.18**	**16.45**
	Diesel saved (tonnes/annually)	207.3	Not calculated		

a) Including 10% emission from flare.

Figure 4.1 **Flow scheme of the Baseline situation emissions at 100,000 tonnes of FFB processed**

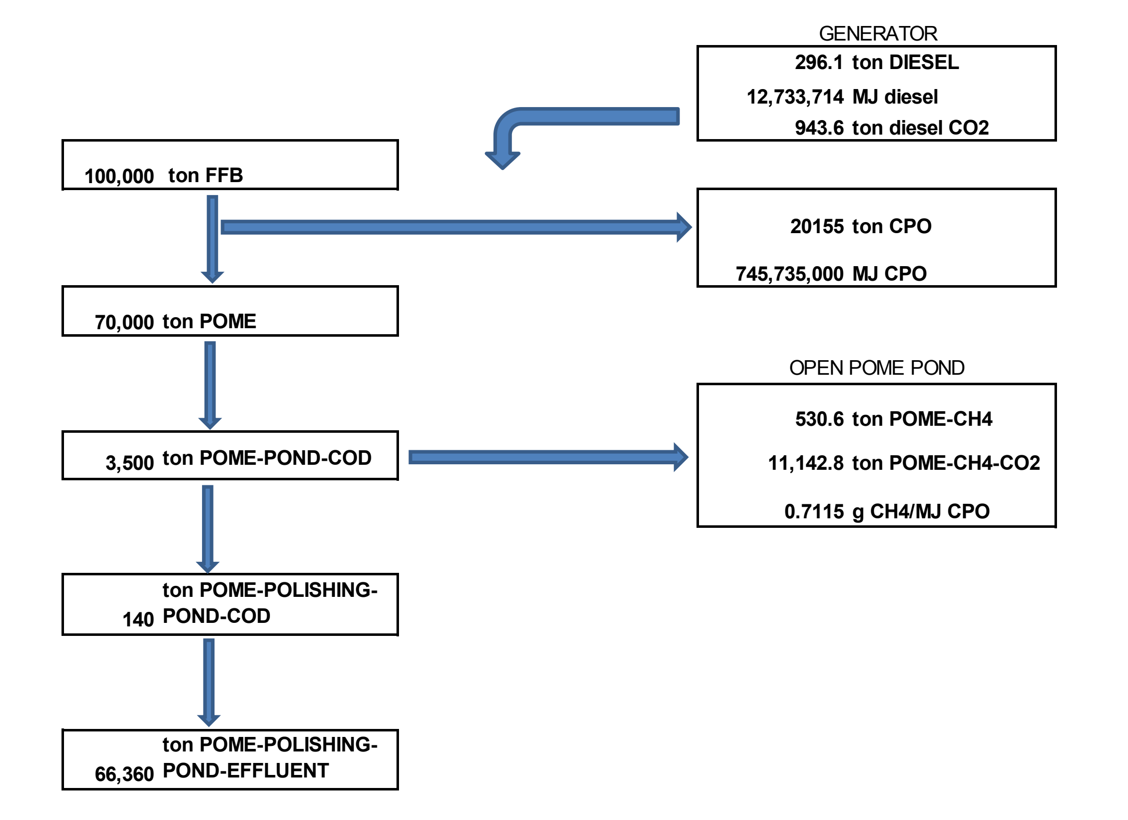
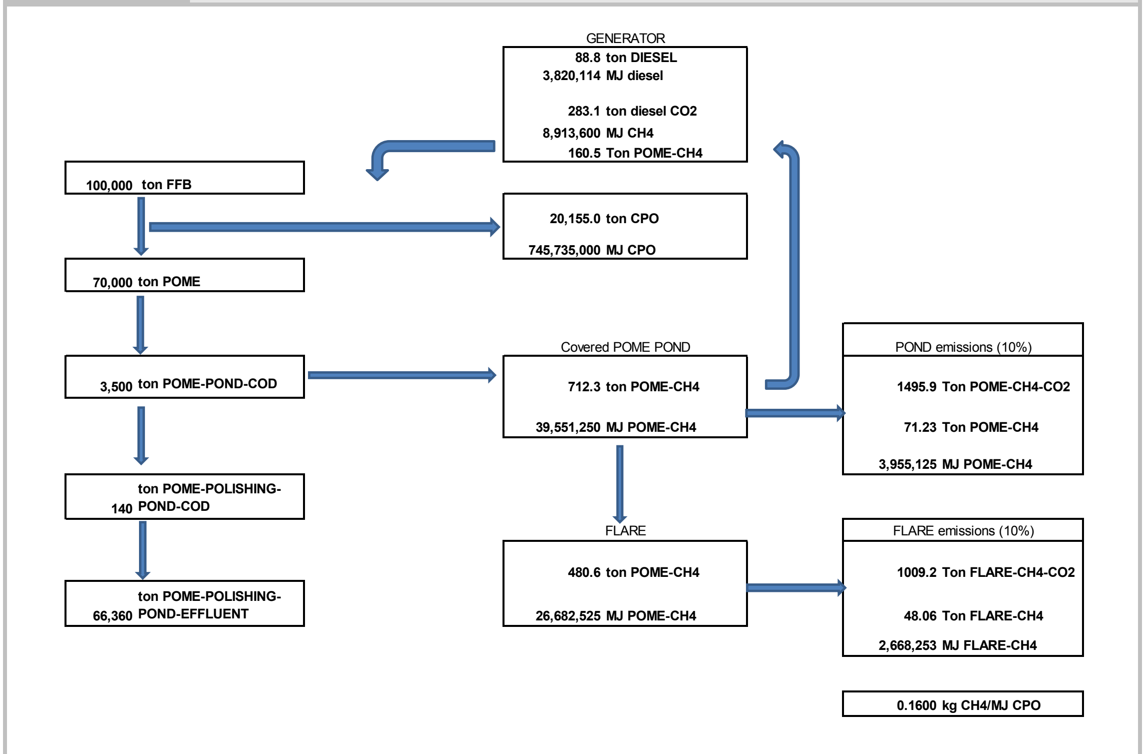


Figure 4.2 **Flow scheme of the Digester situation emissions at 100,000 tonnes of FFB processed**



From here onwards, only the UNFCCC results will be discussed.

4.1.1 Methane leakage

Of the 712.3 tonnes of methane captured, only 160.5 tonnes is sufficient to cover the 70% energy need for the CPO mill. Zebra BV indicates that methane leakage in their system is lower than the 10% used in the UNFCCC tool, because special membranes and pipes are used. Using the UNFCCC parameters, approximately 71.2 tonnes would still be leaking from the covered POME pond or otherwise and is emitted into the atmosphere. Such leakage could be reduced further if a completely closed reactor tank instead of a covered POME pond would be used. The remaining 480.6 tonnes is flared at an efficiency of 90%.

4.1.2 Flaring

In addition to the savings of energy from diesel by flaring, potentially far more fossil energy could be saved if an alternative for flaring could be found. If, for instance, all biogas would be scrubbed to remove H_2S and compressed subsequently, the biogas could be transported elsewhere to feed modified diesel generators to produce local electricity, or be used as a cooking gas. In that case, another equivalent of 370 tonnes of diesel could be saved, representing an additional 1,400 tonnes of CO_2 eqs. According to PalmPro, H_2S scrubbing is energy neutral and compression energy is only approximately 1.8 MJ per m^3 biogas (STOWA, 2011). So, from an energy point of view, compression of biogas and utilisation of this compressed gas would be a strong further improvement of the overall sustainability of palm oil production.

4.2 Nutrient use

Currently no information of the total nitrogen (N) content of PalmPro/Zebra POME is available. However, from a recent study regarding 6 different Malaysian POME studies a total N/COD (chemical oxygen demand) ratio with an average value of 0.028905 kg N per kg COD (+/- 0.003) can be estimated (Ibrahim et al., 2012).

Using that value for the PalmPro mill, the annual POME production of total N can be estimated to be 101.5 (+/- 10.05) tonnes of nitrogen, equivalent to approximately 1.45 g of N per kg of POME.

In an open POME pond, under anaerobic conditions, part of this nitrogen is likely to be mineralised into Ammonia (NH_3), and another part is deposited in the pond sludge. Depending on the pH, part of the ammonia will be emitted into the atmosphere in case of an open POME pond. Such emission will be prevented in case of a covered POME pond. Then the ammonia is likely to be converted into nitrate while the effluent remains in the (aerobic) polishing pond.

N-application rates for oil palm trees are approximately 1 kg of N per ha per year (Goh, 2006) and at a tree density of approximately 140 trees per ha (FAO, 2013) this would require approximately 140 kg of N per ha per year. For the production of 100,000 tonnes of FFB, an area of 4,000 ha is required (at an annual yield of 25 tonnes of FFB (TNAU, 2013). So, if all N is kept in the effluent during methane recovery and the subsequent polishing phase, and if such effluent would be used for the irrigation of palm trees, instead of being discarded into surface waters, approximately 700 ha of oil palm trees could be fertilised. Moreover, irrigation fertilisation by POME effluent would prevent any unnecessary discard of nitrogen into surface waters.

Of course we realise that the above estimation is a very optimistic one. The amount of N available for fertilisation in the POME effluent is probably lower than estimated above. Nevertheless, for every kg of N from POME effluent and POME sludge, a kg of N from chemical fertilisers could be saved, equivalent to 5,88 kg of CO_2 (Biograce, 2013). POME sludge is already used for this purpose, but application of POME effluent would lead to a further improvement.

4.3 Water quality

Methane capture in itself will probably have no or only little effect on the quality of surface waters. Both with and without methane capture, polishing pond effluent is discharged into the river, and methane capture probably has no effect on the quality of polishing pond effluents. However, if irrigation of the oil palm trees by polishing pond effluent could be achieved, also a tremendous reduction of nutrient load into the river could be possible, equivalent to the same amount (101.5 tonnes of N) as has been estimated in Section 4.2. In addition, also other nutrients and also remaining COD present in the polishing pond effluent would not be discarded into the river.

4.4 Air quality

Next to a tremendous reduction in GHG emissions, methane capture also leads to an improvement of air quality. Most of the odorous emissions from the open POME pond will be reduced, if not fully prevented as a result of covering. Especially H_2S emissions will be reduced greatly, since part of the H_2S will be removed by scrubbing and 90% of the remaining H_2S will be combusted in the flare. The latter, however, may lead to the production of SO_2, resulting in an local increase in SO_2 of the atmosphere. Scrubbing of all biogas, including the gas to be flared, would prevent such SO_2 emissions.

4.5 Conclusions and recommendations

1. Methane capture of POME results in an 80% reduction of GHG emissions during CPO extraction, both for the UNFCCC and the BioGrace tools.
2. The total reduction under the UNFCCC tool is over 9,000 tonnes of CO_2 at 100,000 tonnes of FFB processed. Under the BioGrace tool, the reduction is almost 17,000 tonnes of CO_2. The difference is largely explained by a higher GHG emission value for methane and a higher methane production per MJ CPO produced in the BioGrace tool.
3. If similar parameter values are used for both tools, they give very similar results of CO_2 produced per MJ CPO produced.
4. Utilisation of POME methane may annually replace over 207 tonnes of diesel (at 100,000 tonnes of FFB processed). This may lead to cost savings of EUR186,701, when one litre of diesel would cost EUR0.80.[1]
5. An even higher GHG emissions reduction could be obtained if instead of flaring, excess biogas would be compressed and used for local electricity production or cooking, because that would decrease fuel (in this case wood) used for local energy. In that case H_2S scrubbing would be required for all biogas. Whether using the excess biogas indeed decreases GHG emissions further, depends on the biogas conversion efficiency.
6. Methane capture also leads to a reduction of odour emission, especially H_2S.
7. Flaring of biogas, non-scrubbed for H_2S, leads to local emissions of SO_2.
8. Application of POME effluent to irrigate palm trees after methane capture, would lead to an additional reduction of GHG emission from fossil fuel due to a lower need for fertiliser N. Moreover, this would prevent the discharge of POME N and other nutrients and COD into surface waters.

LEI recommends PalmPro to evaluate the actual technology impact on GHG emissions, air and water quality and, when applicable, nutrient savings. Furthermore, we recommend that PalmPro communicate the information in this report to palm oil businesses and other stakeholders, as it may be an inspiration for other palm oil mills to make similar investments which can benefit the mill as well as the environment. Fur-

[1] http://www.mytravelcost.com/petrol-prices/ (visited 13-3-2013)

thermore, the information in this report could also feed debates on sustainable palm oil production, and inform organisations such as UNFCCC, the organisations developing the BioGrace tool, governments, NGOs and knowledge institutes.

5 Socio-economic impact assessment results of the technology and capacity increase investments

5.1 The expected impact of the technology investment related to methane capture and usage

Investing in the three technologies is not only expected to lead to an improvement with regard to environmental indicators; from a financial perspective, Zebra Special Products BV expects the investment to lead to a net profit for the mill over time. The expected payback period is 12 years.

5.1.1 The economic value created, distributed and retained because of the investment

The Prosperity Principle (Cramer et al., 2007) indicates that the following indicators should be reported upon: the direct economic value created (change in revenues), the economic value distributed (operation costs, employee wages, payments to providers of capital, payments to governments and community investments) and the economic value retained (the economic value generated less the economic value distributed). The information for these indicators for the technology investment related to methane capture and usage is presented in Table 5.1 below.

Table 5.1 **Information from a profit and loss prognosis to calculate the direct economic value created, distributed and retained because of the technology investment related to methane capture and usage**

Direct economic value generated a)	
Revenues b)	Revenues are not expected to change because of the technology investment
Economic value distributed	Total operating costs are expected to decrease with about EUR20,125 for the first 10 years, and with EUR46,500 for the years afterwards
Operating costs	Fuel costs are expected to decrease by EUR70,000 (a decrease of 70%). This decrease is expected because of the investment in the technologies that replace fossil fuel by electricity from POME biogas. Depreciation costs are expected to increase by EUR27 thousand
Employee wages and benefits	Employee wages and benefits are expected to increase with about EUR3,550 because two extra staff are hired for managing the reactor
Payments to providers of capital	Financing costs are expected to increase by EUR10,700
Payments to the government	Company tax paid to the government is expected to increase by EUR8,625
Community investments	Community investments are not expected to change
Economic value retained (Economic value generated less Economic value distributed)	The net result is expected to increase by about EUR20,125 per year for the first 10 years. Afterwards the net result increase is about EUR46,500 per year. The expected payback period is 11.4 years.

a) Reporting elements stem from the Global Reporting Initiative Economic Performance Indicators EC1; b) All figures indicate yearly costs or revenues, no discount rate was applied.
Source: Information from Zebra BV.

As can be seen from Table 5.1, the economic value retained because of the investment is expected to be positive in time as the decrease in fossil fuel energy costs is expected to be greater than the increase in other costs, and especially when the investment costs are depreciated. Calculated over the PalmPro part of the investment (about EUR270,000), this leads to a pay-back period of the investment of 11.4 years.

5.2 The expected impact of the investment in doubling the mill's processing capacity

5.2.1 The economic value created, distributed and retained because of the investment

Zebra BV does not only expect that investing in the doubling of the mill's capacity leads to an improved margin for the PalmPro mill; they also expect that because of it, a higher price per kilogram of FFB can be paid to their FFB suppliers.

To assess the expected economic value retained (economic value generated less economic value distributed) for the investment, and whether a higher price can indeed be paid out FFB suppliers, a profit and loss prognosis has been made by Zebra BV. One important aspect of the prognosis, is the fact that investors require a pay-back period of maximum three years for approving the investment. In Table 5.2 information from the prognosis is presented.

Table 5.2 Information from a profit and loss prognosis to calculate the direct economic value created, distributed and retained because of investing in doubling the mill's processing capacity

Direct economic value generated [a]	
Revenues [b]	Revenues are expected to increase from EUR6.6m to about EUR12.5m (an increase of 90%)
Economic value distributed	Total operating costs are expected to increase from EUR6.2m to about EUR11.5m (an increase of 86%)
Operating costs	Costs for FFB are expected to increase from EUR5.7m to EUR11m (an increase of 93%). This includes a price increase of 100Rp per kg FFB (from IDR1,400 to IDR1,500) to be paid to FFB suppliers (a price increase of 7% per kilogram FFB) Maintenance costs are expected to increase from EUR120,000 to EUR200,000 (an increase of 67%) Fuel costs are expected to decrease from EUR150,000 to EUR112,000 (a decrease of 25%). This decrease is expected because of the investment in the technologies that replace fossil fuel by electricity from POME biogas [c]. Depreciation costs are expected to increase from EUR170,000 to EUR320,000 (an increase of 88%)
Employee wages and benefits	Labour costs are not expected to change
Payments to providers of capital	Financing costs are expected to increase from EUR68,000 to EUR192,000 (an increase of 180%)
Payments to the government	Company tax paid to the government is expected to increase from EUR54,000 to EUR134,000 (an increase of 150%)
Community investments	Community investments are not expected to change
Economic value retained (Economic value generated less Economic value distributed)	The net result is expected to increase from EUR126,000 to EUR314,000 per year (an increase of 150%). The expected pay-back period of the investment is 3 years.

a) Reporting elements stem from the Global Reporting Initiative Economic Performance Indicators EC1; b) All figures indicate yearly costs or revenues, no discount rate was applied; c) The initial costs savings from the technology investment was higher (about EUR70,000 per year), but due to the doubling of the capacity, the volume of fuel required for the mill's operations increases.
Source: Information from Zebra BV.

As can be seen from the profit and loss prognosis, the PalmPro mill will have a pay-back period of the investment of 3 years while it pays 100 Indonesian Rupiah (IDR) more per kilogram of FFB to suppliers than before the investment was made. Moreover, PalmPro's net yearly result also increases because of the investment.

Based on these figures, PalmPro has stated that they will indeed increase the price paid out to FFB suppliers by IDR100 per kilogram of FFB (from IDR1,400 to IDR1,500 per kilogram of FFB) for at least the first three years after they invested in doubling the mill's capacity. But they also expect to continue to pay this higher price in the future.

5.2.2 Assumptions of the potential to maintain the price premium over time

Two assumptions underlie the potential to maintain the price premium over time:
1. The Indonesian government advises the price to be paid to smallholder FFB producers based on the CPO commodity price. This price can change often and is a legal minimum amount to be paid out to the producers per kilogram of FFB. In 2012, this price was about IDR1,075 per kg of FFB to be paid to smallholder producers. When the government increases its advised price, it will be based on an increased CPO price. Consequently, the mill's margin will not change and the premium price of IDR100 per kg can still be paid out.
2. When producers would not deliver sufficient amounts of FFB to the PalmPro mill, the margin will not be as high as calculated and the premium price cannot be maintained.

5.2.3 Characteristics of the smallholder producers supplying FFB to PalmPro mill

Information from PalmPro (2013) on their 1,600 smallholder producers who supply FFB to their mill indicates that the producers usually have 2 hectares (ha) of oil palm plantation. On this acreage, they produce between 2,000 and 3,000 kg of FFB per month (which equals 24,000-36,000 kg of FFB per year and 12,000-18,000 per ha per year). The farmers are situated in a radius of 120 kilometres from the PalmPro mill (about 3 hours by truck). The majority of the farmers (88-100%, depending on the village) says to privately own the land with the oil palm plantations. The age of the oil palm plantations ranges between 2 and 14 years (at the time of this study) and planting density is between 35 and 200 trees per hectare.

5.2.4 The palm oil value chain between the smallholder farmers and the palm oil mill

The PalmPro mill does not source FFB directly from smallholder producers but from middlemen who, in turn, source from the smallholder farmers to supply the mill with sufficient feedstock. The mill has informal contracts (by word) with the middlemen to guarantee a sufficient supply of FFB for the mill's operations.

There are two types of middlemen: 'big' middlemen and 'small' middlemen (PalmPro, 2013). 'Big' middlemen usually have a legal identity and obtain delivery orders from the mill. They divide and sell these delivery orders to 'small' middlemen, who source FFB directly from the farmers and deliver the FFB directly to the mill. Some small middlemen have informal contracts with their farmers (in the form of cash advances, or inputs on credit) to ensure that they deliver to them, other middlemen do not. When such contracts exist, the smallholders must rely on FFB from neighbours when their production is not sufficient for the contract terms.

Middlemen perform several roles: they sometimes hire workers to harvest the FFB (for about IDR40 per kg); they bulk the FFB (for about IDR80 per kg) and transport the FFB to the mill. Including their profit, the price paid to the middlemen by the mill for a kilogram of FFB ranges between IDR1,350 and IDR1,450, depending on the transport costs.

5.2.5 Distribution of the FFB price premium within the value chain

As the mill does not trade directly with the FFB producers, but with the middlemen, it cannot guarantee that the 100 IDR price premium will actually end up fully with the smallholders. The mill has indicated that they have very openly communicated to the farmers about their plan to increase the FFB price by IDR100 per kilogram. This, and the fact that the middlemen negotiate their profit with the mill, and not with the smallholders because of the 'fixed' price for FFB, leads them to expect that 90% of the price premium

(IDR90 per kg) will be paid out to the smallholder FFB producers by the middlemen. Which share of the price premium finally ends up at smallholder level, remains to be seen, including whether the share would differ between farmers who have a contract with a middleman and farmers who do not. The mill intends to evaluate this in the first three years in which the premium will be paid out.

Even though the PalmPro mill has not (yet) opted to obtain RSPO (Roundtable on Sustainable Palm Oil) certification for the palm oil it produces (and thus also for FFB from smallholder plantations), we will reflect here on the elements of the RSPO standard related to fairness and transparency of dealing with smallholders and compare them with PalmPro mill's policy.

In the RSPO guidance for independent smallholders (RSPO, 2010), criterion 6.10 indicates that 'growers and mills deal fairly and transparently with smallholders and other local businesses'. This criterion is translated into three indicators: i) current and past prices paid for FFB shall be publicly available; ii) pricing mechanisms for FFB and inputs/services shall be documented (where these are under the control of the mill or plantation); iii) evidence shall be available that all parties understand the contractual agreements they enter into, and that contracts are fair, legal and transparent. The following guidance is given for group managers: group managers must ensure that i) current and past prices paid for FFB are freely available to group members and other parties; ii) fair and transparent mechanisms must be established to pay members and other parties for their FFB; iii) agreed payments are made in a timely manner. Furthermore, 'transactions with group smallholders should deal fairly with issues such as the role of middle men, transport and storage of FFB, quality and grading, and inputs from family labour' and 'smallholders must have access to the grievance procedure under criterion 6.3, if they consider that they are not receiving a fair price for FFB, whether or not middle men are involved'.

It appears that PalmPro mill complies with several of these criteria, considering the facts that PalmPro pays middlemen according to their cost structure (e.g. the higher the transport costs, the higher the price paid them per kg of FFB), that PalmPro has communicated widely about the expected price premium of IDR100 that they pay for FFB supplies as agreed upon delivery, that roles and responsibilities of the mill, middlemen and smallholders are clear within the supply chain and that clear quality standards are implemented at the mill.

5.2.6 Share of the price premium in the income from palm oil production for smallholder producers

Smallholder producers supplying to PalmPro mill usually have 2 hectares of oil palm plantation on which they produce between 2,000 and 3,000 kg of FFB per month (which equals 24,000-36,000 kg of FFB per year). Based on a price of IDR1,075 per kg, they earn on average a gross income of IDR32,250,000 per year (about EUR2,500[1] for a production of 2,500 kg of FFB per month). If the price would increase to IDR1,165 (an increase of IDR90 per kg), their earnings would increase by 8.4%, leading to an additional gross income of EUR214 (IDR2,700,000). This seems to be a substantial income increase for the smallholder farmers.

For all 1,600 smallholders combined who supply FFB to the PalmPro mill, this would mean an annual increase in gross income of IDR4.3bn, which equals EUR342,000. The middlemen are also expected to profit from the price premium (IDR10 per kg of FFB). Both margin increases combined appear to be a substantial financial injection into the region in which the mill operates.

A substantial increase in income could assist farmers in investing in their oil palm plantation or food production because it could assist them to access inputs, when they did not use any previously, or to access high quality inputs when such types of inputs were not affordable previously. Improving input use could lead to increasing productivity and farm efficiency. Access to high quality inputs is seen as a major challenge in FFB production just as access to capital (see Section 6.3.2.). Increasing revenues could also decrease farmers' dependency on capital providers to invest in FFB production. Whether smallholder FFB producers would indeed use the price premium to invest in FFB production remains to be seen.

[1] Based on production level of 2,500 FFB per month and an exchange rate of IDR100,000 to EUR7,912 (www.Oanda.com, 14/3/2013)

5.2.7 Are indirect effects expected on the price other mills pay to FFB suppliers and producers?

When the price premium is paid out to FFB suppliers and (partly) to the smallholder producers, this may lead to other mills in the neighbourhood also increasing the price paid for FFB when no sufficient supply of FFB is available for their operations. In the area in which the PalmPro mill operates, other mills also operate. According to Zebra BV (2013), those other mills can and do source from the same FFB producers, but they mainly source FFB from their own plantations; they do not rely on FFB produced by smallholders. Zebra BV therefore does not expect them to start paying a higher price than the advised price as it would decrease their margins. Furthermore, no shortage of supply is expected that could drive up the price and increase competition for FFB from smallholders because new plantations have been established recently within the PalmPro mill area, with first harvests expected when the mill will operate in its full capacity.

5.2.8 Are indirect effects expected because of the doubling of the mill's processing capacity?

When the mill almost doubles its processing capacity, they also need to almost duplicate the volume of FFB sourced from smallholder producers. PalmPro expects that the required volumes of FFB will be available by the time the mill operates in full capacity, as new plantations were established during the time the mill was built, which will lead to sufficient supply of FFB to be available to deliver the required volumes. The number of farmers of whom FFB is sourced is not expected to be almost doubled as some farmers have relatively big plantations and can increase their FFB supply to the mill from their plantations. The increase in demand for FFB is thus not expected to lead to new plantations to be established.

5.3 Policy, practice and the proportion of the budget spent on local supply companies

Another indicator to report on from the Prosperity Principle (Cramer et al., 2007) is the policy and practice in working with local companies and the proportion of the budget spend on local supply companies.

For both investments, local companies were used for realising the reactor (preparing the site, building the reactor etc.), supplying the hardware elements of the reactor (e.g. the flare, pipes, hoses, flow meters etc.), building the infrastructure for increasing the mill's capacity and supplying the extra machinery needed for the capacity increase. All contractors and hardware suppliers were Indonesian companies.

With regard to normal mill operations, nothing will change with regard to buying relationships with input suppliers because of the investments, apart from the fact that the PalmPro mill will source much less diesel than before the investments because diesel is replaced by electricity generated from POME biogas. The PalmPro mill will continue to source FFB from smallholder suppliers. Many plantations have been established during the time the mill was built, which will lead to sufficient supply of FFB to be available to deliver the required volumes.

The proportion of the total budget spent on local supply companies (budget decrease for sourcing diesel, budget increase for sourcing FFB) is expected to increase, when all other costs remain the same, as the increase of the costs for sourcing FFB far outweighs the decrease in costs for sourcing diesel (see Table 5.1 in Section 5.2).

5.4 The procedures for the appointment of local staff and the share of local senior management

Another indicator to be reported on based on the Prosperity Principle (Cramer et al., 2007) is the change in 'procedures for the appointment of local staff' and 'the share of local senior management in the entire management team'.

Procedures for the appointment of local staff did not change because of the investments made, and neither was extra senior management staff recruited. So no change occurred in the proportion of senior management from the local community relative to senior management from outside Indonesia. PalmPro mill did appoint two extra persons from the local community, who live within a 500-meter radius from the mill, to manage the reactor. No extra staff are hired because of the investing in the doubling of the mill's capacity.

5.5 Conclusions and recommendations

This study concludes that, with regard to the expected socio-economic impact because of the investments:

1. The economic value retained (economic value generated minus economic value distributed) at the PalmPro mill of both investments is expected to be positive in time.
2. A large decrease in the mill's operating costs is expected because of the replacement of diesel by electricity generated from POME biogas.
3. A premium of IDR100 per kilogram of FFB can be paid out to FFB suppliers after investing in doubling the mill's capacity with a pay-back period of the investment of three years.
4. The PalmPro mill intends to pay out the price premium of IDR100 per kg of FFB at least in the first three years after the investment is made.
5. PalmPro expects that 90% of the price premium of IDR100 ends up at smallholder FFB producer level. This would lead to an extra annual income per smallholder producer of about IDR2.7m (EUR214), which is a substantial increase of 8.4%.
6. Also the middlemen are expected to profit from the price premium (IDR10 per kg of FFB).
7. For all 1,600 smallholders who supply to PalmPro mill and the middlemen combined, the annual increase in income is expected to be at least IDR4.3bn (EUR342,000), which appears to be a substantial financial injection into the region in which the PalmPro mill operates.
8. The price premium is not expected to lead to a higher price for FFB paid by other mils in the PalmPro mill area as there is no shortage of supply and the other mills do not depend on smallholder FFB supplies for their operations.
9. The increase in demand for FFB is not expected to lead to new plantations as sufficient feedstock will be available when the PalmPro mill operates in full capacity.
10. The policy and practice of working with local companies will not change because of the investments.
11. The proportion of the budget spend on local supply companies is expected to increase as the increase of costs for sourcing FFB far outweighs the decrease in costs for sourcing diesel.
12. The procedures for the appointment of local staff and the share of local senior management relative to the share of foreign senior management will both not change because of the investments.

LEI recommends that PalmPro indeed evaluates which share of the price premium will end up at the smallholder level, as they intend to do, when the price premiums are paid out, because that would clarify whether their assumptions hold true. Another evaluation can be conducted on how both the technology investment related to methane capture and usage and the premium price impact on the livelihoods of the smallholder farmers, their families, the middlemen, workers and other community members. Such information would be of use to other actors operating in palm oil mill production (companies, governments, NGOs, farmers etc.) as well as knowledge institutes.

6 Relative sustainability gain in the palm oil chain

6.1 Assessing the relative sustainability gain in the palm oil chain with regard to the investments

In this chapter, the study results are placed in a wider sustainability perspective of the palm oil production chain, using information from the literature as a benchmark. LEI focuses specifically on the relative greenhouse gas emissions and the poverty reduction potential of the investments.

6.2 Greenhouse gas emissions throughout the palm oil value chain

For the assessment what the relative share is of the GHG emissions reduction because of the technology investment related to methane capture and usage compared to GHG emissions in other stages of the palm oil supply chain, a quick-scan of LCA studies was conducted. The review has focused on information from the following supply chain stages: i) production of inputs for FFB production, ii) raw material transport to plantation, iii) land conversion, iv) FFB production, v) transport to the mill, vi) processing FFB into CPO etc. at the mill, vii) transport of CPO from the mill to the Netherlands/Europe/USA. We do not take into account GHG emissions further downstream the supply chain, as there are a myriad of options available for further processing the CPO (electricity, biofuel, food and healthcare products) and reviewing all their contributions lies outside the scope of this study.

Within the FFB production stage, an LCA study on FFB production in Malaysia (with analyses up to the stage where FFB arrives at the mill, and assuming continued land use for oil palm production) found that production and application of nitrogenous fertilisers at plantations have the highest contribution to pollution (emissions to air, water, and soil) compared to all other production elements (Zulkifli et al., 2010). Energy used in FFB production and transport has the second highest contribution.

Assessing GHG emissions throughout palm oil supply chains, Wicke et al. (2008) demonstrate that land use change, 'is the most decisive factor in overall GHG emissions' while collecting CH4 from POME treatment is the 'second most beneficial option for GHG emission reduction'. Schmidt (2007) and the Roundtable on Sustainable Palm Oil Working Group on Greenhouse Gases (RSPO, 2009) come to the same conclusion.

Zebra BV and PalmPro thus tackle the second most important contributor of GHG emissions in the palm oil supply chain by implementing new technologies to capture methane emissions from POME effluent for fossil fuel replacement. As they do not produce fresh fruit bunches themselves, tackling the most important contributor to GHG emissions, land use change, is not in their direct sphere of influence. PalmPro already applies POME sludge to a plantation of 5ha, to which no chemical fertiliser is applied. They also intend to apply biogas reactor effluent to that plantation. As a larger acreage of oil palm plantation could be treated with all the sludge and effluent, Palmpro could further improve its environmental performance by applying POME effluent to irrigate a larger acreage of palm trees after methane capture. This would lead to an additional reduction of GHG emission from fossil fuel due to a lower need for fertiliser N, which is the biggest contributor to air, water, and soil pollution in FFB production.

6.3 Poverty reduction potential of increasing the price for FFB

6.3.1 Income from FFB production for smallholder producers

For the comparison whether the IDR90-price increase would be as substantial for other farmers as for the farmers supplying the PalmPro mill, we reviewed information from the literature on characteristics of smallholder palm oil producers in Indonesia and South East Asia: average acreage, production of FFB per hectare (ha) per year, and income from FFB per year, see Table 6.1 for more information.

Table 6.1	**Income from FFB production for smallholder producers**		
Indicator	**PalmPro mill**	**Information from the literature**	**Source**
Oil palm acreage (average in ha)	2	2	Vermeulen and Goad (2006 Feintrenie et al. (2011
FFB yield per ha (tonne per ha)	12-18	2.6 15-30 10-17 Max 17	Sheil et al. (2009) Sheil et al.(2009) Vermeulen and Goad (2006) Fairhurst and McLaughlin (2009)
Income (EUR per year)	2,500 (gross income)	754-1,313 (net income) 142-319 (net income) 5,280 (net income)	Susila (2004) Vermeulen and Goad (2006) Feintrenie et al. (2011)

The average acreage of smallholder oil palm plantations in Indonesia is reported as 2 ha (Vermeulen and Goad, 2006; Feintrenie et al., 2011), which is similar to average acreage of the smallholders supplying the PalmPro mill.

In Indonesia, average annual FFB yields per hectare rose between 1.58 tonnes per ha in 1967 to 2.6 tonnes per ha in 2006, while under good conditions, 15-30 tonnes per ha can be produced (Sheil et al., 2009). Other studies report FFB yields of 10-17 tonnes per ha (Vermeulen and Goad, 2006) and a maximum of 17 tonnes per ha for Indonesian smallholder FFB producers (Fairhurst and McLaughlin, 2009). The 12-18 tonnes per ha of FFB reported in this study thus seems to be representative for the Indonesian smallholder FFB sector.

Indonesian smallholder FFB producers earned between EUR754 and EUR1,313 per year in 2002[1] (Susila, 2004), had a net return between EUR142 and EUR319 per year in 2005 (Vermeulen and Goad, 2006), and a net income of EUR5,280 per year in 2011 (Feintrenie, 2011). Even though we do not know what the net income will be of the smallholders supplying FFB to PalmPro mill as we do not have information about their costs, and CPO and FFB price changes probably have influenced yearly FFB incomes over time, and the smallholder situations may be different throughout Indonesia (e.g. age of trees, planting density, agronomic and climatic conditions), it seems to be that the gross incomes of smallholders supplying FFB to PalmPro of, on average, EUR2,500 appears to be a realistic figure.

Based on the information on the literature review, an increase of IDR90 per kg of FFB would also be a substantial improvement in the income for other Indonesian smallholder FFB producers when it would be paid out.

6.3.2 FFB prices versus other challenges in FFB production

Even though an increase in the FFB price would increase smallholders incomes when all else stays equal, the FFB price itself is not the only factor influencing smallholder farmer incomes. Within the production system, for instance, great improvements can be made with regard to increasing productivity per hectare (Tailliez et al., 2005; Vermeulen and Goald; 2006, Sheil et al., 2009). Furthermore, these literature sources also mention challenges in access to capital, access to high quality inputs, access to information and extension, land disputes, tenural uncertainty and CPO and FFB price volatility. And farmers face difficulties when unproductive plantation periods do not generate income while maintenance costs are made

[1] Income figures from the literature are converted into euros, when required, using the exchange rate of the year in which the information was collected.

(Feintrenie, 2011). Thus, increasing the price for FFB is not the only option available to tackle these issues and improve the incomes of the farmers. However, looking at the costs of all the activities that can be undertaken, increasing the FFB price is a relatively easy way of improving the incomes of smallholder farmers (ceteris paribus) while implementing the other activities can be very costly and time consuming.

6.3.3 Potential impacts when other mills would increase their capacities

The investment in doubling the PalmPro mills' capacity is not expected to lead to new plantations being established as explained earlier. But when other mills would invest in a similar way, this could have a negative impact on nature and the environment. Smallholder farmers could namely react by increasing the productivity of their plantation, but they could also establish new plantations. As 10% of additional CPO production is reached by increasing productivity on existing plantations and 90% from the expansion of production area (USDA, 2012), doubling the demand for FFB by a mill could lead to the expansion of oil palm production area in the 'neighbourhood' of the mill. Such an expansion could lead to deforestation, the degradation of natural habitat, loss of biodiversity and environmental problems (Sheil et al., 2009, Teoh, 2010).

7 Conclusions and recommendations

7.1 Conclusions and recommendations on the technology investment related to methane capture and usage

Investing in technologies to capture methane emissions from POME to be used in power generation, replacing fossil fuels, is expected to lead to the following results:

1. Methane capture of POME results in an 80% reduction of GHG emissions during CPO extraction, both for the UNFCCC and the BioGrace tools.
2. The total reduction under the UNFCCC tool is over 9,000 tonnes of CO_2 at 100,000 tonnes of FFB processed. Under the BioGrace tool the reduction is almost 17,000 tonnes of CO_2. The difference is largely explained by a higher GHG emission value for methane and a higher methane production per MJ CPO produced in the BioGrace tool. If similar parameter values are used for both tools, they give very similar results of CO_2 produced per MJ CPO produced.
3. Utilisation of POME methane may replace over 207 tonnes of diesel annually (at 100,000 tonnes of FFB processed). This may lead to cost-savings of EUR186,701.
4. Methane capture also leads to a reduction of odour emission, especially H_2S.
5. Flaring of biogas, non-scrubbed for H_2S, leads to local emissions of SO_2.
6. A positive economic return ('economic value retained') because of the investment.

Even higher GHG emissions reduction could be obtained if instead of flaring, excess biogas would be compressed and used for local electricity production or cooking, because that would decrease fuel (in this case wood) used for local energy. In that case H_2S scrubbing would be required for all biogas. Whether using the excess biogas indeed decreases GHG emissions further, depends on the biogas conversion efficiency. Furthermore, even though PalmPro already applies POME sludge on 5 ha of oil palm plantation, the application of POME effluent to irrigate a larger acreage of palm trees after methane capture, would lead to an additional reduction of GHG emission from fossil fuel due to a lower need for fertiliser N. Moreover, this would prevent the discharge of POME N and other nutrients and COD into surface waters.

Zebra BV and PalmPro tackle the second most important contributor of GHG emissions in the palm oil supply chain by implementing these new technologies. As they do not produce fresh fruit bunches themselves, tackling land use change, the most important contributor to GHG emissions, is not in their direct sphere of influence.

7.2 Conclusions and recommendations on the mill capacity increase investment

Investing in almost doubling the capacity of the PalmPro mill is expected to lead to:

1. A positive economic return ('economic value retained') because of the investment.
2. Paying out a premium of IDR100 per kilogram of FFB to FFB suppliers for at least three years after the investment was made.
3. 90% of the price premium of IDR100 ending up at smallholder FFB producer level. This would lead to an extra annual income per smallholder producer of about IDR2.7m (EUR214), which is a substantial increase of 8.4%.
4. Middlemen also profiting from the price premium (IDR10 per kg of FFB).
5. An annual increase in income for all 1,600 smallholders who supply to PalmPro mill and the middlemen combined, of at least IDR4.3bn (EUR342,000). This which appears to be a substantial financial injection into the region in which the PalmPro mill operates.
6. An increase in the proportion of the budget spend on local supply companies as the increase of costs for sourcing FFB far outweighs the decrease in costs for sourcing diesel.

The increase in demand for FFB from PalmPro mill is not expected to lead to new plantations as sufficient feedstock will be available when the mill operates in full capacity. Furthermore, the price premium is not expected to lead to a higher price for FFB paid by other mils in the PalmPro mill area as there is no shortage of supply and the other mills do not depend on smallholder FFB supplies for their operations.

Finally, the procedures for the appointment of local staff, the share of local senior management relative to the share of foreign senior management, and the policy and practice of working with local companies are not expected to change because of the investments.

Based on the information from the literature, an increase of IDR90 per kg of FFB would also be a substantial improvement in the income for other Indonesian smallholder FFB producers. However, an increase in the FFB price is not the only factor influencing smallholder farmer incomes. Within the production system, for instance, great improvements can be made with regard to increasing productivity per hectare. Furthermore, challenges in access to capital, access to high quality inputs, access to information and extension, land disputes, land tenure, and unproductive plantation periods, as well as CPO and FFB price volatility, are also factors that influence the incomes of smallholder farmers. Looking at the costs of all these options, increasing the FFB price is a relatively easy way of improving the incomes of smallholder farmers (ceteris paribus) while addressing the other challenges can be very costly and time consuming.

One note needs to be placed here: when other mills would also invest in increasing their processing capacity, this could have a negative impact on nature and the environment. Smallholder farmers could namely react by increasing the productivity of their plantation, but they could also expand oil palm production areas by establishing new plantations. Such an expansion could lead to deforestation, the degradation of natural habitat, loss of biodiversity and environmental problems.

7.3 Recommendations

LEI recommends PalmPro evaluate the actual technology impact on GHG emissions, air and water quality and, when applicable, nutrient savings. Furthermore, we recommend PalmPro to communicate the information in this report to palm oil businesses and other stakeholders, as it may be an inspiration for other palm oil mills to make similar investments which can benefit the mill as well as the environment. Furthermore, the information in this report could also feed debates on sustainable palm oil production, and inform organisations such as UNFCCC, the organisations developing the Biograce tool, governments, NGOs and knowledge institutes.

LEI also recommends PalmPro evaluate which share of the price premium will end up at the smallholder level, as they intend to do, when the price premiums are paid out, because that would clarify whether their assumptions hold true.

Another evaluation can be conducted on how both the technology investment related to methane capture and usage and the premium price impact on the livelihoods of the smallholder farmers, their families, the middlemen, workers and other community members. Such information would be of use to other actors operating in palm oil mill production (companies, governments, NGOs, farmers etc.) as well as knowledge institutes.

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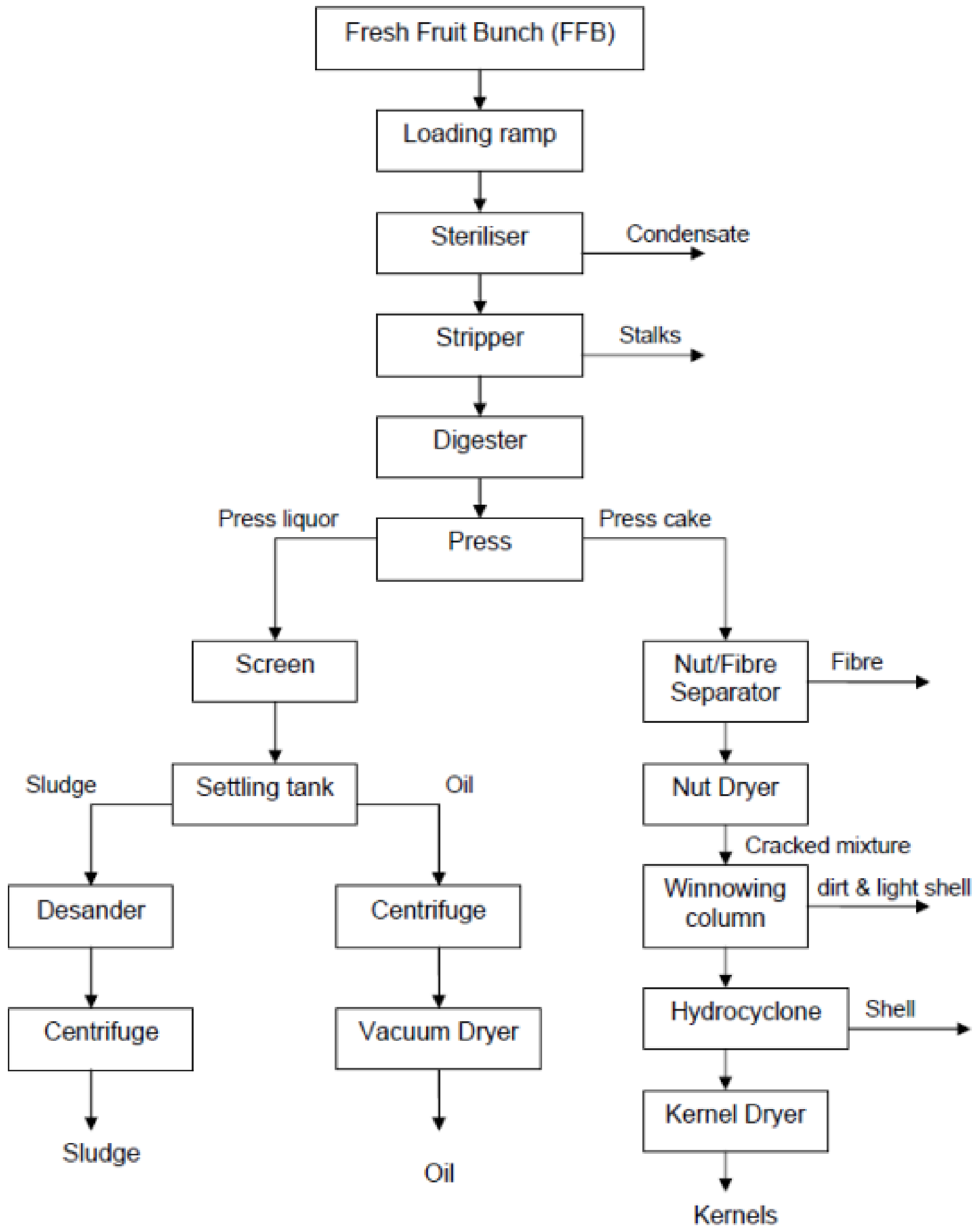
Appendix 1

Detailed flow scheme of palm oil production

Detailed flow scheme of palm oil production. Source: Ling Yu Lang, 2007. Treatability of palm oil mill effluent (POME) using black liquor in an anaerobic treatment process. Thesis submitted in fulfilment of the requirements for the degree of Master of Science Universiti Sains Malaysia; July 2007.



Appendix 2

Calculation of the ratio of the economic value of POME/CPO +PKO

As the assessment of the Zebra BV project is about applying technologies applicable to residual flows, LEI has calculated whether the residual flows represents a negligible economic value of the main product and whether it has no other useful applications. As POME (the residual flow) has no other useful applications, LEI has thus calculated the value of POME (the residual flow) with respect to the value of CPO (the main product) + PKO using the following assumptions:

- Per 1 tonne CPO, 1.5 m^3 POME is produced, resulting in 30m^3 of biogas
- The processing of 5 tonnes of FFB costs 50 kWh=17 l
-
- 70% of the biogas can be used as a replacement of diesel, 30% is 'flared' for Carbon Credits
- Diesel costs per litre are 1 euro

Calculated to costs per hectare, the economic value of CPO is EUR1,600 per hectare, and the economic value of POME is EUR96 per hectare. This means that the economic value of the POME is 6% of the economic value of CPO. See for more information the table below.

ZEBRA/ PALMPRO	**CPO**	**Unit**	**PKO**	**Unit**	**PKM**	**Unit**	**POME**	**Unit**	**Biogas**	**Unit**	**Diesel**	**Unit**
1 ha production (in tonnes)	3.2	t/ha	0.34	t/ha	0.42	t/ha	4.8	m^3	96	m^3	96	l
Average annual price in 2008 (EUR per tonne)	500	€/t	Nihil	€/t							1	€/l
1 ha value (RM)	1600	€/ha	Nihil	€/ha							96	€/ha
Ratio economic value POME/CPO + PKO											6.00%	

POME: Palm Oil Mill Effluent
CPO: Crude Palm Oil
PKO: Palm Kernel Oil

Appendix 3

Principles, criteria, and indicators from the Testing Framework

Table A2.1	Principles and criteria from the Testing Framework for residual flows with a negligible economic value and no other useful application	
Principle	**Criterion**	**Indicator**
Principle 1 The greenhouse gas balance of the production chain and application of the biomass must be positive.	**Criterion 1.1**: In the application of biomass a net emission reduction of greenhouse gases must take place along the whole chain. The reduction is calculated in relation to a reference situation with fossil fuels.	**1.1.1 minimum requirement** The emission reduction of greenhouse gases amounts to at least 50-70% for electricity production and at least 30% for biofuels, calculated with the method described in chapter 4. These are minimum requirements. Here the basic principle must be that policy instruments should promote a higher percentage above the minimum requirement by differentiating strongly on the basis of the emission reduction of greenhouse gases.
Principle 2 Biomass production must not be at the expense of important carbon sinks in the vegetation and in the soil.	**Criterion 2.1** Conservation of above-ground (vegetation) carbon sinks when biomass units are installed.	**2.1.1 minimum requirement** The installation of new biomass production units (BPUs) must not take place in areas in which the loss of above-ground carbon storage cannot be recovered within a period of ten years of biomass production. The reference date is 1 January 2007, with the exception of those biomass flows, for which a reference date already applies from other certification systems (currently under development).
	Criterion 2.2 The conservation of under-ground (soil) carbon sinks when biomass units are installed.	**2.2.1 minimum requirement** The installation of new biomass production units must not take place in areas with a great risk of significant carbon losses from the soil, such as certain grasslands, peat areas, mangroves and wet areas. The reference date is 1 January 2007, with the exception of those biomass flows for which a reference date already applies from other certification systems (currently under development).
Principle 5 In the production and processing of biomass the soil and the soil quality are retained or improved.	**Criterion 5.1:** No violation of national laws and regulations that are applicable to soil management.	**Indicator 5.1.1 (minimum requirement)** Relevant national and local regulations must be complied with, with respect to: • Waste management; • The use of agrochemicals (fertilisers and pesticides); • The mineral system; • The prevention of soil erosion; • Environmental impact reporting; • Company audits. At least the Stockholm convention (12 most harmful pesticides) must be complied with, also where national legislation is lacking.

Table A2.1	Principles and criteria from the Testing Framework for residual flows with a negligible economic value and no other useful application (continued)	
Principle	**Criterion**	**Indicator**
	Criterion 5.2: In the production and processing of biomass best practices must be applied to retain or improve the soil and soil quality.	**Reporting 5.2.1** The formulation and application of a strategy aimed at sustainable soil management for the: • The prevention and control of erosion; • The conservation of nutrient balance; • The conservation of organic matter in the soil; • The prevention of soil salination.
	Criterion 5.3: The use of residual products must not be at variance with other local functions for the conservation of the soil.	**Reporting 5.3.1** The use of agrarian residual products must not be at the expense of other essential functions for the maintenance of the soil and the soil quality (such as organic matter, mulch, straw for housing). The residual products of the biomass production and processing must be used optimally (so, for example, no unnecessary burning or removal).
Principle 6 In the production and processing of biomass ground and surface water must not be depleted and the water quality must be maintained or improved.	**Criterion 6.1:** No violation of national laws and regulations that are applicable to water management.	**Indicator 6.1.1 (minimum requirement)** Relevant national and local laws and regulations must be observed, with respect to: • The use of water for irrigation; • The use of ground water; • The use of water for agrarian purposes in catchment areas; • Water purification; • Environmental impact assessments; • Company audits.
	Criterion 6.2: In the production and processing of biomass best practices must be applied to restrict the use of water and to retain or improve ground and surface water quality.	**Reporting 6.2.1** The formulation and application of a strategy aimed at sustainable water management with regard to: • Efficient use of water; • Responsible use of agrochemicals.
	Criterion 6.3: In the production and processing of biomass no use must be made of water from non-renewable sources.	**Indicator 6.3.1 (minimum requirement)** Irrigation or water for the processing industry must not originate from non-renewable sources.
Principle 7 In the production and processing of biomass the air quality must be maintained or improved.	**Criterion 7.1:** No violation of national laws and regulations that are applicable to emissions and air quality.	**Indicator 7.1.1 (minimum requirement)** Relevant national and local regulations must be observed with respect to: • Air emissions; • Waste management; • Environmental impact assessments; • Company audits.

Table A2.1	**Principles and criteria from the Testing Framework for residual flows with a negligible economic value and no other useful application (continued)**	
Principle	**Criterion**	**Indicator**
	Criterion 7.2: In the production and processing of biomass best practices must be applied to reduce emissions and air pollution.	**Reporting 7.2.1** The formulation and application of a strategy aimed at minimum air emissions, with regard to: • Production and processing; • Waste management.
	Criterion 7.3: No burning as part of the installation or management of biomass production units (BPUs).	**Indicator 7.3.1 (minimum requirement)** Burning must not be applied in the installation or the management of biomass production units, unless in specific situations as described in ASEAN guidelines or other regional good practices.
Principle 8 The production of biomass must contribute towards local prosperity.	**Criterion 8.1:** Positive contribution of private company activities towards the local economy and activities.	**Reporting 8.1.1** Description of: • The direct economic value that is created; • Policy, practice and the proportion of the budget spent on local supply companies; • The procedures for appointment of local staff and the share of local senior management. On the basis of Economic Performance Indicators EC 1, 6 & 7 of GRI: (Global Reporting Initiative).
Principle 9: The production of biomass must contribute towards the social well-being of the employees and the local population.	**Criterion 9.1** No negative effects on the working conditions of employees.	**Indicator 9.1.1 (minimum requirement)** Comply with the Tripartite Declaration of Principles concerning Multinational Enterprises and Social Policy (compiled by the International Labour Organisation).
	Criterion 9.2 No negative effects on human rights	**Indicator 9.2.1 (minimum requirement)** Comply with the Universal Declaration of Human Rights of the United Nations. It concerns here: non-discrimination; freedom of trade union organisation, child labour; forced and compulsory labour; disciplinary practices, safety practices and the rights of indigenous peoples.
	Criterion 9.3 The use of land must not lead to the violation of official property and use, and customary law without the free and prior consent of the sufficiently informed local population	**Indicator 9.3.1 (minimum requirement)** Comply with the following requirements: • No land use without the informed consent of original users; • Land use must be carefully described and officially laid down. • Official property and use, and customary law of the indigenous population must be recognised and respected
	Criterion 9.4 Positive contribution to the well-being of local population	**Reporting 9.4.1** • Description of programmes and practices to determine and manage the effects of company activities on local population; On the basis of the Social Performance Indicator SO1 of the GRI: (Global Reporting Initiative).

Table A2.1 **Principles and criteria from the Testing Framework for residual flows with a negligible economic value and no other useful application (continued)**

Principle	Criterion	Indicator
	Criterion 9.5 Insight into possible violations of the integrity of the company	**Reporting 9.5.1** Description of: • Degree of training and risk analysis to prevent corruption; • Actions taken in response to cases of corruption. On the basis of the Social Performance indicators SO_2, SO3 and SO4 of the GRI (Global Reporting Initiative).

Source: Cramer et al., 2007.

Appendix 4

Details and summary of the UNFCCC calculations

Baseline emissions

Methodology AMS III H , Version 16

BASELINE EMISSIONS			**Reference**
$BE_y = Q_{y,ww} \times COD_{y,remove,i} \times B_{o,ww} \times MCF_{ww,treatment,i} \times UF_{bl} \times GWP\_CH_4$			(AMS IIIH, par 20)
BE_y	**12086.4**	**tCO_2e**	

Baseline Emission Fuel consumption, AMS.1.C option B			
Volume of Diesel Consumed	296133	kg	Project Description
Net Calorific Value of Diesel	43.00	MJ/kg	IPCC 2006, default value
Diesel Emission Factor	74,100.00	kgCO2/TJ	IPCC 2006, default value
$BE_{y, power}$	**943.6**	tCO_2e	

$BE_{ww,treatment, y} = Q_{y,ww} * COD_{y,removed,i} * B_{o,ww} * MCF_{ww,treatment\ Bo,ww} * Ufbl * GWPch4$			
$Q_{y,ww}$	70,000	m3 POME /yr	
$COD_{y,removed,i}$	0.048	kg COD/m3 POME	PALMPRO
$B_{o,ww}$	0.21	$kgCH_4$/kgCOD removed	IPCC 2006
$MCF_{ww,treatment,i}$	0.8		lower value Table IIIH1
Ufbl	0.94		(AMS IIIH, par 20)
GWP_CH_4	21		(AMS IIIH, par 20)
$BE_{ww,treatment, y}$	**11142.8**	tCO_2e	

Project emissions

Methodology AMS III H , Version 16

PROJECT ACTIVITY EMISSIONS			**Reference**
PEy = PEpower,y + PEww,treated,y + PEs,treatment,y + PEww,discharge,y + PEs,final,y + PEfugitive,y + PEbiomass,y + PEflaring,y			
PE_y	**2788.11**	**tCO_2e**	
Project Emission Fuel consumption, AMS.1.C option B			
Volume of Diesel Consumed	88840	kg	PALMPRO
Net Calorific Value of Diesel	43.00	MJ/kg	IPCC 2006, default value
Diesel Emission Factor	74,100.00	kgCO2/TJ	IPCC 2006, default value
$PE_{y, power}$	**283.1**	tCO_2e	

$PE_{ww,treatment, y} = Q_{y,ww} * COD_{y,removed,i} * B_{o,ww} * MCF_{ww,treatment\ Bo,ww} * Ufbl * GWPch4$			Reference
$Q_{y,ww}$	70,000	tonPOME COD /yr	PALMPRO
$COD_{y,removed,i}$	0.048	kg COD m3/POME	PALMPRO
$B_{o,ww}$	0.21	$kgCH_4$/kgCOD removed	(AMS IIIH, par 20)
$MCF_{ww,treatment,i}$	0.8		lower value Table IIIH1
Ufbl	0.94		(AMS IIIH, par 20)
GWP_CH_4	21		(AMS IIIH, par 20)
$PE_{ww,treatment, y}$	**11142.8**	tCO_2e	

$PE_{y,fugitive} = PE_{fugitive,ww,y} + PE_{fugitive,s,y}$			
$PE_{y,fugitive,ww}$	1495.87		
$PE_{y,fugitive,s}$	0	tCO_{2e}	
$PE_{y,fugitive}$	**1495.9**	**tCO_2e**	
$PE_{y,fugitive,ww} = (1 – CFE_{ww}) * MEP_{ww,treatment,y} * GWP\_CH4$			
CFE_{ww}	90%		Capture Efficiency: default AMS IIIH: 90%
$MEP_{ww,treatment, y}$	712.320	t	Calculated
GWP_CH4	21		(AMS IIIH, par 20)
$PE_{y,fugitive,ww}$	**1495.9**		
$MEP_{ww,treatment,y} = Q_{ww,y} * Bo,ww * UFpj * COD_{removed,PJ,k,y} * MCF_{ww,treatment}$			
$Q_{y,ww}$	70000	m^3/yr	PALMPRO
$COD_{y,removed,i}$	0.048	t/m^3 POME	PALMPRO
$B_{o,ww}$	0.25	$kgCH_4$/kgCOD	AMS IIIH.
Ufpj	1.06		
$MCF_{ww,treatment}$	0.8		
$MEP_{ww,treatment,y}$	**712.3**	**tCH_4/yr**	
$PE_{y,fugitive,s} = (1 – CFE_s) * MEP_{y,s,treatment} * GWP\_CH4$			as sludge is sun dried use for soil application
CFE_s	N/A		
$MEP_{y,s,treatment}$	N/A		
$PE_{y,fugitive,s}$	**0.0**	**tCO_2e**	
$MEP_{y,s,treatment} = S_{y,untreated} * DOC_{y,s,untreated} * DOC_F * F * 16/12 * MCF_{s,treatment}$			as sludge is sun dried use for soil application
$S_{y,untreated}$	N/A	t	
$DOC_{y,s,untreated}$	N/A		
DOC_F	N/A		
F	N/A		
$MCF_{s,treatment}$	N/A		
$MEP_{y,s,treatment}$	**0.0**	**tCH_4/yr**	

PEflare,y = $TM_{RG,h}$ * (1-nflare,h) /1000			
$TM_{RG,h}$ = FV rg,h * fv CH4, RG, h * rh	480.5536	ton CH4/a	CALCULATED
FV rg,h	0	Nm3/a	
fv CH4,RG,h	0.6	m3CH4/m3 biogas	AMS IIIH
rho CH4	0.72	kg/nm3	AMS IIIH
nflare,h	90%		default AMS IIIH: 90%
GWP_CH4	21	ton CO2/ton CH4	
PEflare,y	**1009.2**		

$PE_{y,discharged}$ = $Q_{y,ww}$ * $[CH4]_{y,ww,treated}$ * GWP_CH4			
$Q_{y,ww}$	N/A		
$[CH4]_{y,ww,treated}$	0	t/m3	
$PE_{y,discharge}$	**0.0**	**tCO_2e**	

$PE_{y,upgrading}$	**0**	**tCO_2e**	Not applicable for the project activity 2 (a) (refer AMS IIIH ver 9)
$PE_{y,leakage,pipeline}$	**0**	**tCO_2e**	

$PE_{y,biomass\_storage}$*			
Φ	0.9		Emission due to temporary storage of PKS at site
f	0		
GWP	21		
OX	0		
F	0.5		IPCC 2006
DOCf	0.5		IPCC 2006
MCF	0.4		IPCC 2006
Wjx	-		IPCC 2006
DOCj	0.43		
k	0.035		IPCC 2006
x	1		IPCC 2006
$PE_{y,biomass}$	**0.0**	**tCO_2e**	

EMISSION REDUCTION			
ER_y = BE_y – PE_y - $Leakage_y$			
ER_y	**9298.3**	**tCO_2e**	

Summary

Methodology UNFCCC AMS III H , Version 16	100,000.00	ton FFB	

EMISSION REDUCTION	
$ER_y = BE_y - Pey$	
ER_y 9,298.3	tCO_2e

BASELINE EMISSIONS		
$BE_y = Q_{y,ww} \times COD_{y,remove,i} \times B_{o,ww} \times MCF_{ww,treatment,i} \times UFbl \times GWP\_CH_4$		
BE_y 12,086.4	tCO_2e	
$BE_{y, power}$ 943.6	tCO_2e	
$BE_{ww,treatment, y}$ 11,142.8	tCO_2e	

PROJECT ACTIVITY EMISSIONS		
PEy = PEpower,y + PEww,treated,y + PEs,treatment,y + PEww,discharge,y + PEs,final,y + PEfugitive,y + PEbiomass,y + PEflaring,y + PE upgrading,y + PE leakage, pipeline,y		
PE_y	2,788.1	tCO_2e
$PE_{y, power}$	283.1	tCO_2e
$PE_{ww,treatment, y}$	0.0	tCO_2e
$PE_{s,treatment, y}$	0.0	tCO_2e
$PE_{ww,discharge, y}$	0.0	tCO_2e
$PE_{s,final, y}$	0.0	tCO_2e
$PE_{y,fugitive} = PE_{fugitive,ww,y} + PE_{fugitive,s,y}$	1,495.9	
$PE_{y,biomass\_storage}$	0.0	tCO2e
$PE_{y,upgrading}$	0.0	tCO_2e
$PE_{y,leakage,pipeline}$	0.0	tCO_2e
PEflare,y	1,009.2	tCO2e

The mission of Wageningen UR (University & Research centre) is 'To explore the potential of nature to improve the quality of life'. Within Wageningen UR, nine specialised research institutes of the DLO Foundation have joined forces with Wageningen University to help answer the most important questions in the domain of healthy food and living environment. With approximately 30 locations, 6,000 members of staff and 9,000 students, Wageningen UR is one of the leading organisations in its domain worldwide. The integral approach to problems and the cooperation between the various disciplines are at the heart of the unique Wageningen Approach..

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