CDM
Project Design Document
of
JATROPHA CURCAS METHYL-ESTER BIODIESEL PROJECT IN SOUTH AFRICA

Bio-Diesel Refinery Co.

To be established in South Africa…

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三井物産

CLEAN DEVELOPMENT MECHANISM
PROJECT DESIGN DOCUMENT FORM (CDM-PDD)
Version 02 - in effect as of: 1 July 2004)

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Annexes

Terminology Definition for Transportation Fuels with Biomass Component for Diesel Engine

Biomass-based fuel	100% (pure) Biodiesel	Blended with Petro-diesel
FAME contents in the fuel	100%	*e.g.*, B20 [FAME: 20%, Petro-diesel: 80%]

[note] FAME (Fatty Acid Methyl Ester) is made from the esterification reaction between vegetable oil and methanol. The feedstock of the FAME can be only vegetable oil, and also the mixture of several vegetable oils.

Petro-diesel: 100% fossil fuel origin diesel fuel including petroleum and/or coal as its primary energy source.

SECTION A. General description of project activity

A.1 Title of the project activity:

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Jatropha Curcas Methyl-Ester Biodiesel Project in South Africa

A.2. Description of the project activity:

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Outline and Objective of the Project

"Jatropha Curcas Methyl-Ester Biodiesel[1] Project in South Africa" is a project targeting the methyl-ester bio-diesel fuel production of 100,000 ton FAME/year from Jatropha Curcas plantation.

The project is consisted of two parts:

1. Entrusts specified farmers (about 750) to plant Jatropha Curcas in unused land (15,000 ha),[2] and purchase the Jatropha Curcas seeds; (During the beginning stage of this project, Jatropha Curcas seeds used in this project will be purchased. Refer to B1.1, for detail information on purchasing condition.)
2. Produces/refines FAME from the Jatropha Curcas seeds oil generation process and sells the FAME in the market. The residues are fed back to the plantation site as a fertilizer.[2]

The produced FAME is sold directly or mixed with petro-diesel (blended biodiesel) at intermediate or gas stations and/or used as the agricultural machinery fuel, *etc* (through intermediate fuel supplier). Such usage of FAME reduces transportation-related CO_2 emissions by displacing petro-diesel fuel use in market, in comparison to emissions which otherwise would have occurred. (Even when petro-diesel fuel blended FAME is used, the substitution effect is still equal to that of pure FAME we have sold.)

Consistency with the South Africa Government Policy

In the White Paper on Renewable Energy approved in November 2003, an aim was set to increase the use of renewable energy by 5% of the total energy supply by 2012. It was also mentioned in the white paper that the high dependence on the coal[3] should be decreased, which currently is a large factor of greenhouse gas emission in South Africa. In order to strengthen this energy policy, the Ministry of Finance announced 30% exemption of the fuel tax on bio-fuel (not on the bio-fuel production), starting from February 2002. In addition, 50:30:20 accelerated depreciation is allowed for bio-fuel facilities since 2004. However, reductions of the diesel fuel levy and road accident fund levy for petro-diesel purchased by specific industries are not valid on purchases of biodiesel.

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[1] Fatty Acid Methyl-ester bio-diesel fuel (FAME) is produced by trans-esterification of vegetable oil with methanol in the presence of base catalyst. FAME is *different* from a fuel of mixture of vegetable oil and petro-diesel, which can be used for diesel engine. Therefore, throughout the PDD, "FAME" is used for only methyl-ester based bio-diesel fuel. Petro-diesel implies 100% fossil fuel (petroleum and/or coal) based diesel oil.

[2] Synthetic fertilizer is not used for plantation to avoid N_2O emissions from fertilizer production process.

[3] In South Africa, coal account for a large share of the total primary energy supply (about 80% in 2000). In the energy statistics of the final energy consumption in 2000, coal occupied 30%, whereas 33% for petroleum products, and 26% for electricity. However it should be noted that nearly half of the 'liquid' fuel products and more than 90% of electricity power generation are derived from coal.

In South Africa, 60% of the diesel fuels are made from coal and the efficiency of liquefaction process of coal is inferior to that of petro-diesels. This inefficient process results to emit large amount of GHG. In order to compensate this kind of situation, the government is trying to agree on new voluntary charter in 2005, which requires petro-diesel sellers to buy biodiesel, approximately 1–5% of the amount of petro-diesel they sold, if it is offered to them. Other than the tax break from the Minister of Finance and the purchase agreement from the oil companies, no special support or subsidies are currently expected for biodiesel producers. Also in transportation sector, South Africa is planning to introduce policy to restrict percentage of sulfur contained in diesel fuels under 0.05% by 2006 (which is met currently by bio-diesel).

With these policies, however, FAME (methyl-ester based biodiesel fuel) and higher quality bio-diesel fuel, has not yet been realized in South Africa to date.

Contribution to Sustainable Development of South Africa

As specified above, production of FAME, as a renewable energy, contributes to the sustainable development of South Africa through;

(1) improvement of the unemployment rate (30%) by establishing the Jatropha Curcas plantation (expected new job creation for approximately 50,000 workers),

(2) reducing high dependency rate on coal by switching to renewable energy,

(3) supply of high quality and inexpensive bio-diesel fuel,

(4) reducing air pollution as well as climate change mitigation,

(5) introduction of new technology, and

(6) effective utilization of idle farm field.

Technology Transfer Effect

Both the whole process of plantation and cultivation of Jatropha Curcas seeds to the production of FAME (from Jatropha Curcas) is the first attempt in South Africa.

A characteristic of FAME

Followings are positive characteristics of FAME produced in this project.

1. There is no emission of sulfur from the combustion process.
2. There is no solid left after the combustion process.
3. Since viscosity of FAME is high, there is an advantage of lubricating engine parts.
4. Jatropha Curcas absorbs CO_2 in atmosphere during its growing process. Though the use of FAME emits CO_2 in its combustion process, the amount of CO_2 in combustion process is smaller than that absorbed in the growing process. Thus in total, FAME consumption will reduce the amount of CO_2 in the atmosphere.
5. The per unit energy value of vegetable energy is said to have four times as that of energy value used during its production process. Thus when seen from long-term viewpoint, production cycle can be said as infinite.

A.3. Project participants:

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- Bio-Diesel Refinery Co. (SPC, to be established)
- Mitsui & Co., LTD.

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

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A.4.1.1. Host Party(ies):

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Republic of South Africa

A.4.1.2. Region/State/Province etc.:

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Kwazulu Natal State

Figure PDD-1: Map of Kwazulu Natal State, South Africa

A.4.1.3. City/Town/Community etc:

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FAME plant site: Richards Bay Industrial Development Zone (1A)

Plantation site: to be decided.

A.4.1.4. Detail of physical location, including information allowing the unique identification of this project activity (maximum one page):

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This industrial development zone was developed with an approval by the government in 1993. It is estimated to have investments, approximately up to 2.5 billion in South African Rand (ZAR).

Since Richard Bay is the world largest coal exporting port, to invite factories to the neighbouring area, it is currently planned to develop the area dividing into four blocks.

Figure PDD-2: Present Situation and Future Image of the Industrial Zone 1A

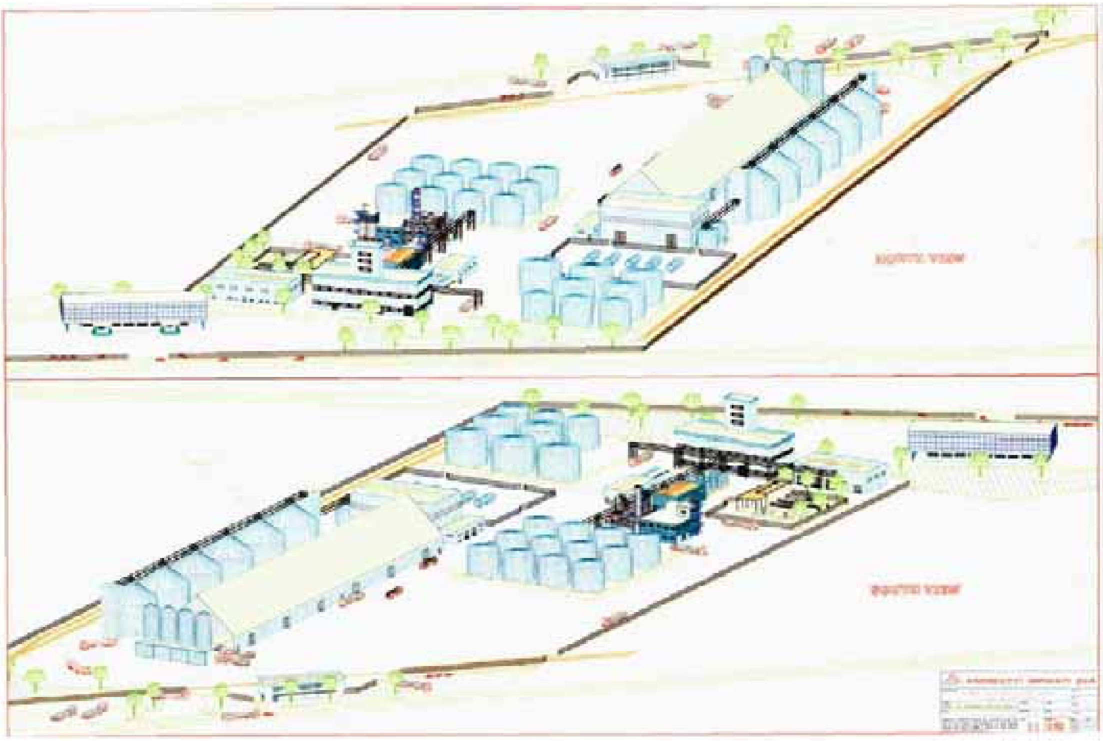

Figure PDD-2: Bird-Eye View of the Planned FAME Plant

A.4.2. Category(ies) of project activity:

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Type III Other Project Activities,
— III.C. Emission Reductions by Low-Greenhouse Gas Emitting Vehicles

in the categorization of small scale CDM projects.

Note: This categorization does not mean that the project is categorized as small scale CDM. The PDD has been prepared for full scale CDM.

The project is a sort of fuel-switching project from fossil fuel to biomass-based fuel in the transportation sector.

A.4.3. Technology to be employed by the project activity:

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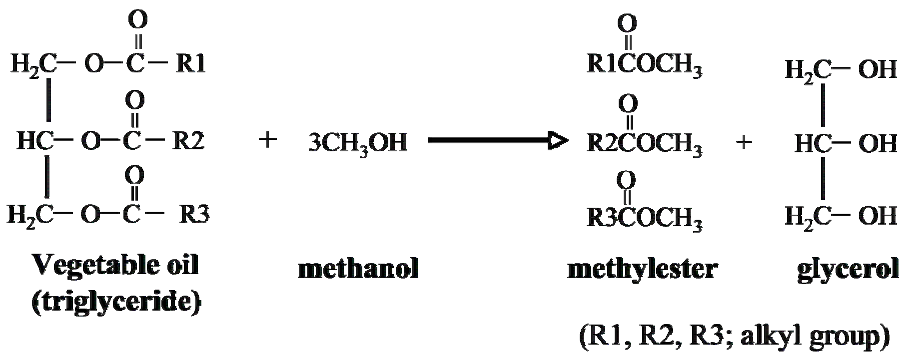
The core technology of this project is to produce FAME by using Jatropha Curcas seeds.

The chemical reaction on esterification:



is realized at the FAME plant with the following process flows. It is noted that all "C"s in methanol are transferred to glycerol (which is not combusted) stoichiometrically.

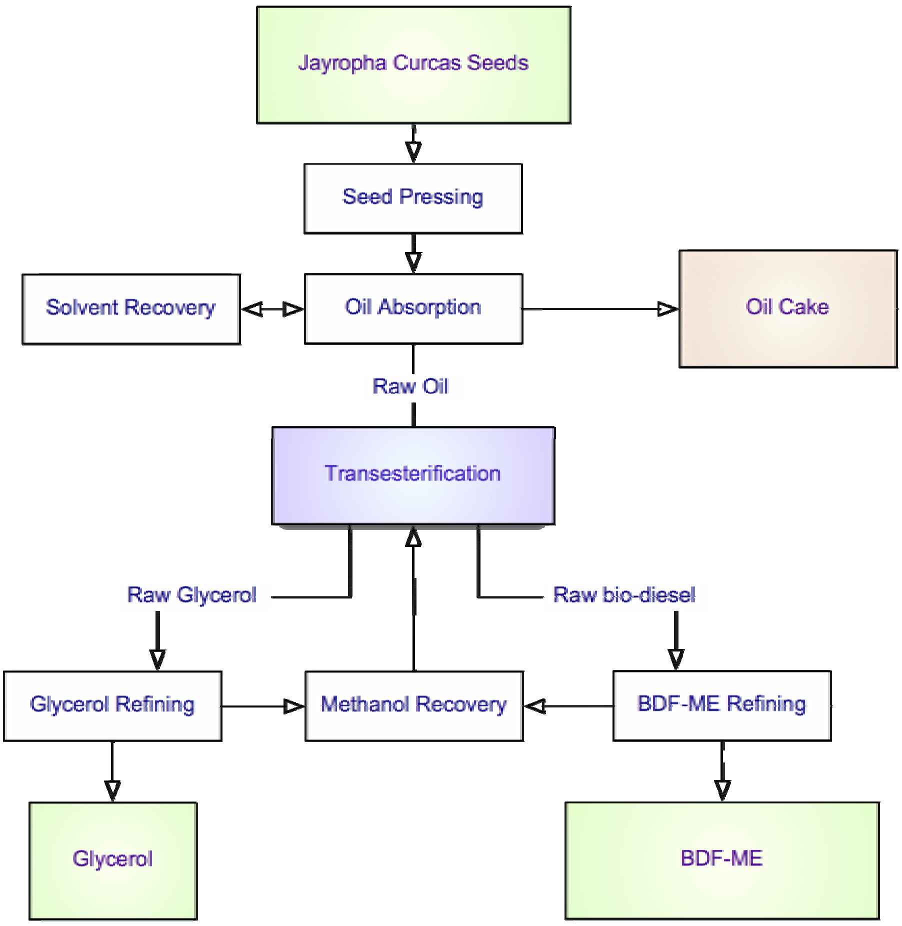


Figure PDD-3: Basic Process Flow of FAME Production

Raw materials are Jatropha Curcas seeds and methanol (CH_3OH). Jatropha Curcas oil and methanol react to ester with the existence of methanol.

Finally, the outputs of the process are FAME (ester) as a product, and residue after oil press, glycerin after esterification reaction as by-products. Oil press residue is recycled to the plantation site as fertilizer and glycerin is sold as a chemical material.

FAME, produced at the plant, can be used as a mixed fuel to petro-diesel. Such mixture reduces air pollutants such as particulate matter (PM), polycyclic aromatic hydrocarbons (PAH), carbon monoxide (CO), sulfur oxides (SO_X), *etc*. in comparison to petro-diesel. Pure FAME has its effect more than the mixture.


Figure PDD-4: Jatropha Curcas (trees/15 months and seed)

A.4.4. Brief explanation of how the anthropogenic emissions of anthropogenic greenhouse gas (GHGs) by sources are to be reduced by the proposed CDM project activity, including why the emission reductions would not occur in the absence of the proposed project activity, taking into account national and/or sectoral policies and circumstances:

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The principal logic of GHG emission reductions through the project is:

FAME produced in the project replace the usage of petro-diesel after it is sold in the market. Therefore CO_2 emissions are reduced in comparison to the baseline scenario, where such amount of FAME is not sold.

The emission reductions will be achieved by the unspecific vehicles, which utilize petro-diesel fuel. On the other hand, additionality of the project is demonstrated mainly by the barrier/investment analysis of the FAME production plant. The barrier/investment analysis includes FAME and other by-products, which has market value. The baseline scenario is assessed in three stages of material flow/value chain: Jatropha Curcas farm field, FAME production plant, and FAME consumption.

The emission reductions can be calculated from the supply side as the amount of FAME sold in the market, as those are to replace petro-diesel within a year. In addition, LCA analysis is applied because of non-negligible contribution of the fertilizer-related N_2O emissions and other adjustments.

A.4.4.1. Estimated amount of emission reductions over the chosen crediting period:

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Estimated mean amount of emission reductions is 2.6×10^5 tCO_2/yr, equivalent to 2.6×10^6 tCO_2 over the 10-year crediting period.

A.4.5. Public funding of the project activity:

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No public fund is used for this project.

SECTION B. Application of a baseline methodology

B.1. Title and reference of the approved baseline methodology applied to the project activity:

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Generalized baseline methodology for transportation bio-fuel production with LCA

(AM00xx)

B.1.1. Justification of the choice of the methodology and why it is applicable to the project activity:

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Here we check each *applicability condition* specified in the methodology as follows:

Conditions at the "biomass supply" stage are:

(a) Plantation of raw material (biomass) for the project does not lead to decrease of forest, or does not constrain the afforestation/reforestation activities;

A signed letter of the contracted farmers or seller of the Jatropha Curcas to confirm this condition will be attached to the PDD. In case, sellers' intention cannot be obtained at the time of validation, it will be verified at the time of verification.

This project plans to carry out Jatropha Curcas plantation, however, a few years are needed to grow these trees to get the sufficient amount of oil seeds. During the cultivation period of the seeds, to meet the amount needed in the converting process, around a half (50%) of the seeds consumed in the project are to be purchased in the first year of the project, (20% are planned to be purchased in the second year).

As for Jatropha Curcas seeds purchased outside of the boundary, project participants must use Jatropha Curcas seeds, which are grown without synthetic fertilizer and which has no possibility to substitute electricity used for lightings. In other words, project participants have to use seeds, which were planted additionally to its current usage.

If these conditions are satisfied, it is assured that Jatropha Curcas used in this project does not produce new GHG emissions.

(b) There are no other plans to utilize the area for other exclusive GHG emission reduction activities;

A signed letter of the contracted farmers or seller of the Jatropha Curcas to confirm this condition will be attached to the PDD. In case, sellers' intention cannot be obtained at the time of validation, it will be verified at the time of verification.

(b')In case waste oil is used as feedstock of the Bio-Fuel [for this project, FAME], such waste oil shall be biomass-based[4] and would not be utilized as an alternative to fossil fuel [in order to exclude the possibility of leakage].

Conditions (a) with (b) and (b') are mutually exclusive.

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[4] *If the waste oil is not purely biomass-based, some correction is needed to extract the biomass part.*

Condition (b') is met, in a sense, by confirming to use specific oil seeds grown outside of the boundary.

Above conditions are for excluding the possibility to displace other GHG emission reduction activities at the plantation site.

The conditions (a) and (b) are confirmed by signed letter of the land owner or the seller of the biomass. Condition (b') is confirmed by documented evidences. The OE may request other evidences for judgments, if and when necessary.

Conditions at the "Bio-Fuel production" stage are:

(c) The project is the optimal solution in its scale in the project participants' decision making considering several barriers with economical consideration, if a Bio-Fuel production plant by using the same biomass is invested;

Several aspects are considered for this project, such as

(1) financial constraint for project participants for lower and higher limits,

(2) technological constraint for lower and upper limits, and

(3) available contracted farm field for Jatropha Curcas plantation.

Among them, the third constraint is the key determinant.

(d) The project participants do not have any plan to implement other biomass based fuel production projects with different type of production process nearby or at the same place;

The reasons why Jatropha Curcas is chosen in comparison to other biomass, such as rape, are as followings:

- being a perennial plant, it can be easily harvested for more than fifty years,
- it matches the hot and dry climate of the plantation site,
- Chemical/physical specifications of the FAME are not much different from that from rape for use as a petro-diesel substitute.
- it has no influence related to food condition, since it is not edible.

The fourth reason is the key determinant for future risk to avoid conflict with food demand. South Africa's domestic supply of edible oils cannot meet demand so it imports large quantities and prices are therefore linked to the world market and unstable.

(e) The project plant cannot be attractive economically without the CER revenue, even if some subsidies[5] (if present) and sales revenue of by-products are included at the planning stage of the project or some prohibitive barriers to implement the project exist [additionality condition];

This condition is demonstrated to be met in the following sub-section B.2.

These conditions (c)–(e) exclude the case where any Bio-Fuel production scenario—in spite of its size and biomass-type—cannot be the baseline scenario of the project activity.

The conditions (c) and (d) are verified by the OE by assessing the related material/information provided by the project participants in order to exclude the possibilities to construct Bio-Fuel

5 Subsidies introduced after the Marrakech Accords do not have to be considered in the development of the baseline scenario, as it is categorized as the "E–"-type policy.

production plant with other scale as the baseline scenario. How to confirm whether the condition (e) is met, is shown in the sub-section D.1 [in the NMB].

Conditions at the "Bio-Fuel consumption" stage are:

(f) The Bio-Fuel produced by the project shall be consumed as to displace fossil fuel based liquid fuel.

The condition (f) can be restated that the Bio-Fuel does neither displace other biomass-based fuels, discard, nor realize hidden demand.

This condition (f) is confirmed if all of the sub-conditions (i)–(v) below are met:

(i) The fossil fuel, which the Bio-Fuel is going to replace, is not banned to use legally or substantially in the host country, or the same Bio-Fuel type is not required to use by some mandatory regulation (which is not the type E– policy) in the host country.

Petro-diesel can be used in South Africa with no restriction.

(South Africa will restrict percentage of sulfur contained in diesel fuels under 0.05% by 2006. However, this restriction does not ban the use of petro-diesel. In South Africa, petro-diesels satisfying this restriction are already being sold, therefore it is unrealistic to think that FAME will substitute petro-diesel to meet this restriction.)

There is no mandatory requirement to use bio-diesel fuel in South Africa.

(ii) In case some mandatory or virtually mandatory regulation (targeting the fuel seller) to penetrate the Bio-Fuel or other compatible biomass-based fuels by setting some quantified threshold has been/will be introduced as non-type E– policy, the compatible biomass-based fuel penetrate more than the threshold level and/or competitive in the associated fuel market.

There is no mandatory requirement to use bio-diesel fuel in South Africa.

From 2005, petro-diesel makers may be required to buy bio-diesels through the voluntary charter. The amount of bio-diesels they have to buy will be approximately 1–5% of the amount of petro-diesels they sold. However this charter does not require to use bio-diesels, which means it will not be a conflict with this applicability condition.

(iii) The penetration rate of some biomass based fuels, which can be alternative to, and whose biomass-ratio is above the Bio-Fuel produced by the project, is less than [70]% in the host country,

Although South Africa is promoting to use biodiesel, penetration of biodiesel is and will be far below [70%] during the crediting period even the governmental plan will be successful.[6] Since the FAME produced in the project is not a mixture with petro-diesel, penetration of the blended biodiesel with petro-diesel is not necessary to be considered under this condition. However, even if it is considered, the penetration is much lower than the threshold. The penetration of FAME-alternatives (methyl-ester based bio-diesel fuel) is almost 0% in South Africa.

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[6] In 2002, diesel fuel demand in South Africa was 5.3 million ton/yr. In 2015, this demand will be 8.0 million ton/year (information source: South African Department of Minerals and Energy). This figure is far larger than the amount of FAME that this project is planning to produce. Thus even if the regulation will be successfully introduces, the penetration of biodiesels and FAME will be far below 70%.

(iv) *The Bio-Fuel produced by the project is sold through an ordinary sales channel, used in-house, or used to specific purpose as an alternative to fossil based fuel, and not be exported to/used in Annex I countries,*

The associated plan with signed agreement by the retailer of the FAME is shown to the validator.

(v) *Supply of the fossil fuel, which the Bio-Fuel displaces, has excess supply capacity in the host country, therefore the project does not create new/hidden demand of the fossil fuel, i.e., the Bio-Fuel displace fossil fuel fully under the competitive environment of the Bio-Fuel,*

In South Africa, fossil fuel based-diesel supply system has excess capacity as no supply limitations are conducted yet. Therefore, the demand of diesel fuel is not constrained, nor expected to be constrained in the foreseeable future.

The project participants shall demonstrate them with suitable evidences/documents, such as signed agreement by the wholesaler and/or retailer of the Bio-Fuel. The OE may request other evidences as it judges, if necessary.

Condition to assure that the build margin component of the grid electricity used is negligible:

(g) *In calculation of the CO_2 emission factor of the grid to which the Bio-Fuel plant is connected to, the electricity demand by the plant is small enough not to affect the power development plan, thus only operating margin component is applied.*

In order to justify the usage of operating margin, the project participants shall obtain the signed letter of the person who is in charge of the power development plan of the power company that the power development plan is never affected by the existence/non-existence of the facility.

This condition will be verified by the interview with the appropriate officer of the National Electricity Regulator (NER) or Escom.

Therefore, the methodology is applicable to the project.

B.2. Description of how the methodology is applied in the context of the project activity:

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In this sub-section B.2., we trace the logics in the methodology applying to the specific project. The bracket 〈〈 〉〉 shows that it is the project specific element.

We categorize the value chain to GHG emission reductions into three stages:

Stage 1: Biomass 〈〈Jatropha Curcas seeds〉〉 supply,

Stage 2: Bio-Fuel 〈〈FAME〉〉 production, and

Stage 3: Bio-Fuel 〈〈FAME〉〉 consumption.

In order to identify the baseline scenario, the alternative scenario options are to be listed up for each stage under the no CER revenue condition. These options are narrowed down, by applying the applicability conditions, to the unique baseline scenario.

[BLS: Baseline scenario, PJS: project scenario]

Stage 1 [Biomass 〈〈Jatropha Curcas seeds〉〉 supply]

In case that the biomass 〈〈Jatropha Curcas seeds〉〉 is supplied by the plantation in the PJS, possible baseline options of the plantation area are:

- Option 1-1: Current situation continues,
- Option 1-2: Deforestation with some use of the vacant area,
- Option 1-3: Afforestaion/reforestation is done,
- Option 1-4: Some other plants not used for biomass based fuel are planted;
- Option 1-5: Plant for bio-fuel, which is different from the plant in the PJS, is planted;
- Option 1-6: Plant for Bio-Fuel 〈〈FAME〉〉, which is that of the PJS, is planted;
- Option 1-7: Some facility, which emits GHGs is constructed.

By using the applicability conditions (sub-section A.3.), Option 1-3 is not realized through the condition (a). Options 1-1 and 1-4 are identical in the sense of emissions considering the condition (a). Option 1-5 is excluded from the condition (b). Option 1-2 and 1-7, which increases baseline emissions, can be neglected by selecting the conservative estimation.

Therefore, Option 1-1 (equivalent to 1-4 in GHG context) or Option 1-6 (*incl*. PJS) are remained as the possible scenario. In the case of this project, the Option 1-4 is excluded because the landowners have no such intention for contracted farmers. In case provisional purchase of Jatropha Curcas seeds in the initial stage (until full harvesting), the project participants are going to confirm the intension of the seller of the biomass.

In case that the biomass is supplied as biomass-based waste-oil, the condition (b’) excludes the case where some positive leakage are found. This project does not utilize biomass-based waste-oil.

As the result, continuation of current practice or the Option 1-6 (*incl*. PJS) are only the solutions left at this stage for the related land area use.

Stage 2 [Bio-Fuel 〈〈FAME〉〉 production]

Whether the Option 1-6 (*incl.* PJS) is realized or not is the unique question at this stage considering the remaining options at Stage 1.

The conditions (c) and (d) exclude the cases where other scale of the facility using the same biomass (by (c)), and where another biomass-based fuel with different production process is used (by (d)). And condition (e) excludes the PJS itself from the BLS candidate.

Therefore, the only remaining option is the continuation of current practice.

The method how to confirm the condition (e), is by the barrier analysis and/or by the economical analysis with calculations of the indicator used for investment decision-making at the planning stage.

The method how to confirm the condition (e) is by the barrier analysis and/or by the economical analysis with calculations of the indicator used for investment decision-making at the planning stage of the Bio-Fuel 〈〈FAME〉〉 production plant.

“Step 3. Barrier analysis” and/or “Step 2. Investment analysis” of the “Tool for the demonstration and assessment of additionality” is applied:

Step 3 (of the Additionality Tool):

Sub-step 3a. Identify barriers that would prevent implementation of type of the proposed project

(Sub-step 3b on the alternatives are not needed as no alternatives are left)

In the case of this project, several barriers are identified, such as:

- Technological barriers due to prevailing practice:

The project activity is the "first of its kind": No project activity of this type is currently operational in South Africa.

Step 2 (of the Additionality Tool):

Sub-step 2a. Determine appropriate analysis method

Sub-step 2b. – Option II. Apply investment comparison analysis, or

Sub-step 2b. – Option III. Apply benchmark analysis

Sub-step 2c. Calculation and comparison of financial indicators

Sub-step 2d. Sensitivity analysis (only applicable to options II and III)

For the investment analysis, all economical components—*e.g.*, costs of biomass plantation/purchase, internal energy use, feedstock use, transportation of the Bio-Fuel, *etc.*, and revenue such as from the sales of the Bio-Fuel, by-products, *etc*.—of the Bio-Fuel production plant shall be incorporated.

In addition to the Barrier analysis shown above, investment analysis shows difficulties in implementing this project as the baseline scenario.

The calculation of IRR shows that IRR is around 4.4%. The investors consider that the long-term interest rate is 11.5% and there are many high risk factors in South Africa.

Therefore, it concludes that the project is *not* an economically attractive course of action to invest. Outline of the calculation is shown in Annex 3, while details of the calculation are attached to the PDD.

In addition, "Step 4. Common Practice" is assessed for credibility check as follows:

In case that the penetration of the same type (differentiated by the mixing ratio of biomass component) of Bio-Fuel 〈〈FAME〉〉 is more than [10%] in the host country, the project participants shall demonstrate that the project is facing the prohibitive barriers without CER revenue with appropriate evidences.

Penetration of the FAME is 0% in South Africa. Therefore, it does not need to explain the barriers anymore.

It may be said that the new Charter, which the government is trying to agree in 2005 requiring petro-diesel sellers to buy biodiesel, approximately 1–5% of the amount of petro-diesel they sold, if it is offered to them, and other future governmental policy may change the situation in the future. However, these are recognized as "type E–" policy and are not needed to consider in order to identify the baseline scenario as specified by the CDM Executive Board.

Stage 3 [Bio-Fuel 〈〈FAME〉〉 consumption]

The applicability condition (f), together with (i)–(v), ensures that the Bio-Fuel 〈〈FAME〉〉, produced at Stage 2, displaces relevant normal fossil-based liquid fuel.

As explained in the sub-section A.3. (applicability conditions) of the NMB, we need to consider the possibility of the case where the Bio-Fuel 〈〈FAME〉〉 produced by the project plant may replace bio-fuels 〈〈biomass based fuel〉〉 produced by other plants (in the market). In general, the reason why a bio-fuel 〈〈biomass based fuel〉〉 production facility is operated is that the bio-fuel 〈〈biomass based fuel〉〉 is competitive in the market as an alternative to the fossil fuel-based liquid fuel 〈〈petro-diesel fuel〉〉 (*incl*. the effect of subsidies and/or CER credits). Therefore, it is *unrealistic* that such competitive bio-fuel 〈〈biomass based fuel〉〉 is replaced by the project Bio-Fuel 〈〈FAME〉〉. Considering the viewpoint of conservativeness, the methodology sets the sub-applicability sub-condition (ii) as the penetration of the alternative Bio-Fuel ⟨⟨FAME⟩⟩ as below [70%].[7] This is not the case in South Africa.

In addition, if the fossil fuel supply is limited and such limitation results to set ceiling on demand, the Bio-Fuel ⟨⟨FAME⟩⟩ supply simply meets the hidden demand, *i.e.*, the fossil fuel is not displaced. In order to exclude such situation, sub-condition (v) is set.

The logics above lead to a conclusion, that the baseline scenario is to continue current practice when all of the applicability conditions are met. Even if other bio-fuels ⟨⟨biomass based fuel⟩⟩ penetrate in the market, such effect does not influence the proposed project itself, and amount of emission reductions through the project.

B.3. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered CDM project activity:

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As shown in B.2., the baseline scenario is to continue current practice. In other words, the vehicles utilizing FAME in the project scenario, uses petro-diesel in the baseline scenario.

It is shown in section E that the baseline emissions are expected to be more than the project emissions, even if we include some other effects like N_2O emissions from fertilizer use. Therefore, the project is additional.

B.4. Description of how the definition of the project boundary related to the baseline methodology selected is applied to the project activity:

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As specified in the methodology, the principal GHG reductions will be realized by many vehicles[8] utilizing the FAME, which are produced in the project activity. This case is similar to the grid-connected renewable energy project-type. Therefore, the project boundary is chosen as

- the plantation site,
- transportation to the project site (FAME production facility),
- the project site,
- transportation to fuel-supply facility,
- fuel-supply facility, and
- all vehicles which utilizes the FAME produced by the project

referring the case of ACM0002, which includes all the power plants (where emission reductions are realized) connected to the grid to be in the boundary.

Taking the uncertainty analysis (see Annex 3 "Baseline Information") into account, some of the emissions can be neglected as shown in the figure below:

[7] It is noted that even alternative fuels (with biomass component)' penetration is 100%, emission reductions are realized if the biomass mixing ratio of the alternative fuel is lesser than that of the project Bio-Fuel.

[8] The relevant vehicles are unspecified (*i.e.*, not monitored) each by each in the methodology, however, when well-defined those can be identified strictly. ACM0002 does not estimate each power plant's emission reductions, while this case can monitor them in theory. However, because only aggregated value is needed to calculate emission reductions, monitoring methodology does not require monitoring of each vehicle.

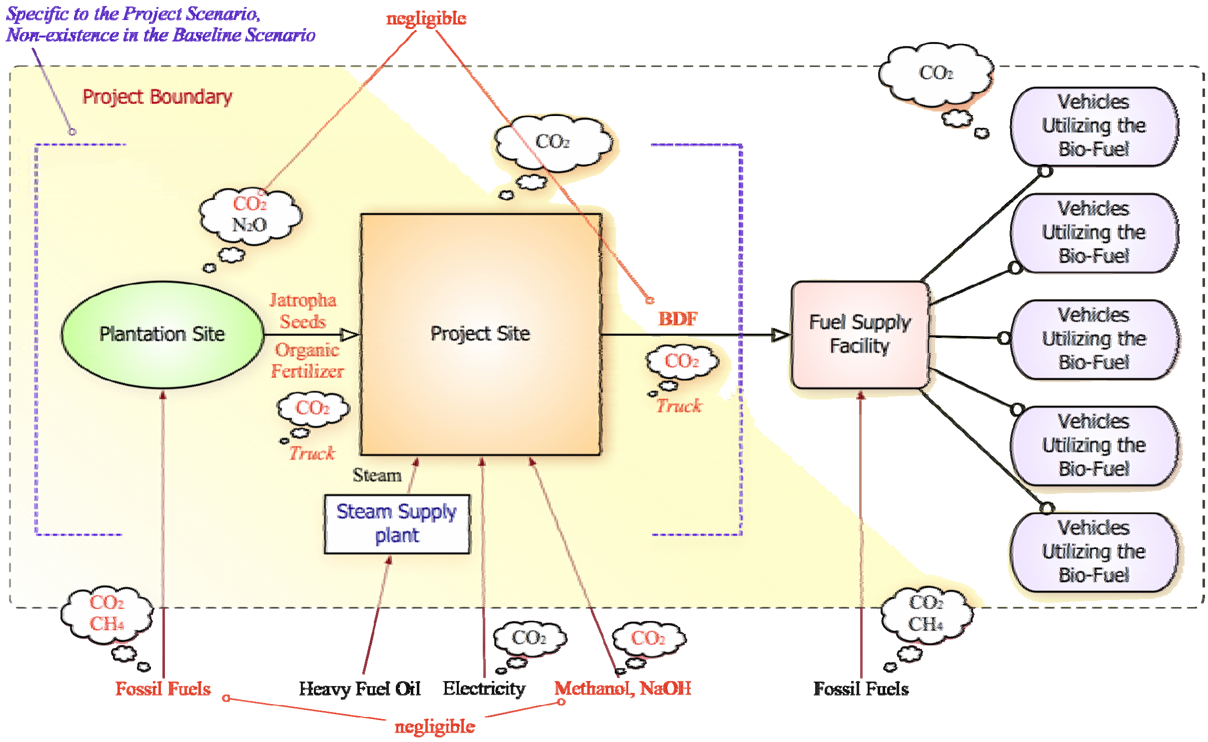

Figure PDD-2: Project Boundary and Associated GHG Emissions

Each emission source and associated GHGs are listed below:

		In the Boundary	Outside of the Boundary
Baseline Scenario	Significant (monitored)	•Each vehicle to utilize the FAME in the PJS (CO_2 from fossil fuel use substituted by FAME) *[substitution effect]*	•Exploitation, Refinement, Transportation of fossil fuels substituted by the Bio-Fuel [oil field/port/refinery/gas station] (CO_2, CH_4)[9]
	Negligible *or* Common (not monitored)	•Fuel supply facility (CO_2: common) •Each vehicle to utilize the FAME in the PJS (N_2O from fossil fuel use)	n.a.

[9] Strictly speaking, LCA effects outside of the boundary must be treated as leakage, while it is *simpler* to include such effects in the CO_2 emission factor of the fossil fuel. The methodology, therefore, treats such LCA effects as a modified emission factor of the fossil fuel.

Project Scenario	Significant (monitored)	• Steam supply plant to the Bio-Fuel plant (CO_2 from heavy fuel oil combustion) • Plantation site (N_2O from Fertilizer use) • Transportation of Jatropha Curcas seeds and Organic fertilizer (CO_2)	• Power Plants linked to the grid (CO_2 from electricity used in the FAME plant)
	Negligible *or* Common (not monitored)	• Transportation of FAME (CO_2) • Plantation site (CO_2 from Machinery use) • Each vehicle to utilize the FAME in the PJS (CO_2 from fossil fuel contained in the Bio-Fuel; common to BLS) • Fuel supply facility (CO_2: common) • Plantation site (CO_2 from Fertilizer use)	• Production process of feedstock (CO_2, *etc.*) • Exploitation, Refinement, Transportation of fossil fuels used at the plantation site [oil field/port/refinery/gas station] (CO_2, CH_4)[9] • Co-products outside of the boundary [transportation, *etc.*] (CO_2) • Commuter of the plant (CO_2)

In addition, basically the entire seed residues are fed back to the plantation site and the site does not utilize other fertilizer than the seed residue deriving from the project activity. However, if it utilizes synthetic fertilizer, it is monitored and N_2O emissions at its production stage are counted.

In the early stage of the project, when enough seeds cannot be harvested, some amount (around 60,000 ton in the first year) of seeds is imported. In this case, the relevant monitoring will be undertaken as in the case of contracted farmers' plantation.

B.5. Details of baseline information, including the date of completion of the baseline study and the name of person (s)/entity (ies) determining the baseline:

>>

The information needed for identification of the baseline scenario is:

- Plantation site related information:
  Information for excluding the possibility to displace other GHG emission reduction activities is provided as attachments to the PDD.
- FAME production plant related information:
  Information for excluding the possibility to implement this project even without CER revenue is provided as attachments and Annex 3 for investment analysis.

- FAME consumption related information:
  Information related to the biomass based fuel information in South Africa is provided as attachments.

The information needed for development of the baseline emissions formula is:

- Uncertainty analysis to identify negligible emission sources:
  Analysis is provided in Annex 3.
- LCA assessment:
  LCA assessment for petro-diesel fuel is provided in Annex 3. LCA for N_2O emissions for synthetic fertilize is provided in the methodology.

Completion date of the baseline study: DD/MM/YYYY (t.b.d.)

Note: This date is to be set when the PDD is finalized at the end of validation process.

The baseline is determined by:

Dr. Naoki Matsuo
Climate Experts Ltd.
n_matsuo@climate-experts.info

SECTION C. Duration of the project activity / Crediting period

C.1 Duration of the project activity:

C.1.1. Starting date of the project activity:

>>

XX/XX/XXXX
defined as the starting date of Jatropha plantation.

C.1.2. Expected operational lifetime of the project activity:

>>

10 years

C.2 Choice of the crediting period and related information:

C.2.1. Renewable crediting period

C.2.1.1. Starting date of the first crediting period:

>>

C.2.1.2. Length of the first crediting period:

>>

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

>>

XX/XX/XXXX
defined as the starting date of FAME plant operation.

C.2.2.2. Length:

>>

10 years

SECTION D. Application of a monitoring methodology and plan

D.1. Name and reference of approved monitoring methodology applied to the project activity:

>>

Generalized monitoring methodology for transportation bio-fuel production with LCA (AM00xx)

D.2. Justification of the choice of the methodology and why it is applicable to the project activity:

>>

The applicability conditions of the monitoring methodology is identical to those of the baseline methodology. See sub-section B.1.1.

D.2. 1. Option 1: Monitoring of the emissions in the project scenario and the baseline scenario								
D.2.1.1. Data to be collected in order to monitor emissions from the project activity, and how this data will be archived:								
ID number *(Please use numbers to ease cross-referencing to D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
P1. $FF^{BFP}_{heavy\ oil,\ y}$	*Heavy oil combusted at the Steam supply plant to the FAME production plant*	*Weight meter or other meter*	*[kilo liter]*	*m*	*daily*	*100%*	*electronic*	*Checked against the fuel purchase receipt.* *Data provided by the steam supplier for relevant amount of steam supplied.*
P2. $COEF^{FF}_{heavy\ oil}$	*LCA CO_2 emission factor of heavy oil (incl. oxidization factor)*	*Fuel supplier, statistics, and/or scientific literature*	*[tCO_2/ kilo liter]*	*c*	*Once in the beginning of the crediting period*	*100%*	*electronic*	*Direct part of emission factor: Fuel supplier or other statistics, if unavailable. Appropriateness of the data source is checked by OE.* *Indirect part:* *Project participants shall provide related objective information, such as scientific documents/paper with relative comparison between several studies. The appropriateness of the information is judged by the OE, as a validator, considering the cases applied beforehand. Life-cycle assessment is not needed if the project participants cannot provide such information as a conservative estimation (only*

								CO_2 emissions from direct combustion is considered). Oxidization factor: Defaults in the IPCC Guidelines/Good Practice Guidance are used.
P3. BF^{mass}_y	FAME sold or utilized in a certain year (in mass)	*Weight meter*	*[ton-FAME]*	*m*	*daily*	*100%*	*electronic*	*Check against BF^{Vol}_y and fuel sales record. More accurate one is prioritized.*
P4. $COEF^{FS}$	CO_2 emission factor of the non-bio feedstock contained in the FAME	-	*[tCO_2/ton-FAME]*	*c*	*Once at the time of drafting the PDD*	*100%*	*electronic*	*Theoretical calculation. Zero for this case, therefore no need to be monitored.*
P5. $PE^{Tarnsp1}_y$	Transportation-related CO_2 emissions from plantation site to the project site	-	*[tCO_2/yr]*	*c*	*monthly*	*100%*	*electronic*	*Calculated by multiplying P6 and P7*
P6. $EN^{TR}_{mode1,y}$	energy used for transportation mode *i*[10]	*Receipt of payment*	*[kilo liter]*	*m*	*monthly*	*100%*	*electronic*	*Receipts of payment are used. Check against the records of mileage recorder*
P7. $COEF^{TR}_{mode1}$	CO_2 emission coefficient for transportation mode *i*	*Statistics*	*[tCO_2/ kilo liter]*	*c*	*Once in the PDD*	*100%*	*electronic*	*National statistics and/or IPCC Guidelines/GPG is used*
P8. $PE^{Plantation}$_N2O$_y$	N_2O emissions from fertilizer use at plantation site (direct)	-	*[tCO_2eq/yr]*	*c*	*monthly*	*100%*	*electronic*	$PE^{Plantation}$_N2O$_y$ = $Fertilizer^{in}_y$ * UREA_EQ^{in} * $COEF^{Direct}$_N2O * GWP_N2O
P9. $Fertilizer^{in}_y$	fertilizer input to the plantation site	*Weight meter*	*[ton-fertilizer]*	*m*	*monthly*	*100%*	*electronic*	*Checked against the fertilizer purchase receipt.*

[10] "Transportation mode" implies ship, railway, truck, *etc.*

P10. $UREA\_EQ^{in}$	urea-equivalence factor of the fertilizer for N-component	-	*[ton-urea/ton-fertilizer]*	*c*	*Every time when fertilizer is changed*	*100%*	*electronic*	*Calculated by using the data of fertilizer supplier*

D.2.1.2. Description of formulae used to estimate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

>>

Project emissions within the project boundary in a certain year *y* is given by:

$$PE_y = FF^{BFP}_{heavy\ oil,\ y} * COEF^{FF}_{heavy\ oil} + BF^{mass}_y * COEF^{FS} + PE^{Tarnsp1}_y + PE^{Plantation}\_N2O_y$$

where

$FF^{BFP}_{heavy\ oil,\ y}$: heavy oil combusted at the steam supply plant to the FAME production plant [kl/yr]

$COEF^{FF}_{heavy\ oil}$: LCA CO_2 emission factor of the heavy oil (*incl*. oxidization factor) [tCO_2/kl]

BF^{mass}_y : FAME sold or utilized in a certain year (in mass) [ton- FAME/yr]

$COEF^{FS}$: CO_2 emission factor of the non-bio feedstock contained in the FAME [tCO_2/ton- FAME] (zero for this case)

$PE^{Tarnsp1}_y$: Transportation-related CO_2 emissions from plantation site to the project site
$= \sum_{transportation\ mode1} EN^{TR}_{mode1,y} * COEF^{TR}_{mode1}$ [tCO_2/yr]

where $EN^{TR}_{modei,y}$: energy used for transportation mode *i*,
$COEF^{TR}_{modei}$: CO_2 emission coefficient for transportation mode[11] *i*.

$PE^{Plantation}\_N2O_y$: N_2O emissions from fertilizer use at plantation site (direct)
$= Fertilizer^{in}_y * UREA\_EQ^{in} * COEF^{Direct}\_N2O * GWP\_N2O$ [tCO_2eq/yr]

where $Fertilizer^{in}_y$: fertilizer input to the plantation site [ton-fertilizer/yr],
$UREA\_EQ^{in}$: urea-equivalence factor of the fertilizer for N-component [ton-urea/ton-fertilizer],
$COEF^{Direct}\_N2O$: direct N_2O emission factor of the fertilizer (=1.0%) [tN_2O/ton-urea],
GWP_N2O: GWP potential for N_2O (=310 for 1st Commitment Period) [tCO_2eq/tN_2O]

[11] "Transportation mode" implies ship, railway, truck, *etc*.

D.2.1.3. Relevant data necessary for determining the baseline of anthropogenic emissions by sources of GHGs within the project boundary and how such data will be collected and archived :								
ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
B1. BF_y	*FAME sold or utilized in a certain year (thermal content)*	-	*[GJ]*	*c*	*daily*	*100%*	*electronic*	$BF_y = BF^{vol}_y * Density_y * HV_y$
B2. BF^{vol}_y	*Volume content of BF_y*	*Volumeter*	*[m^3]*	*m*	*daily*	*100%*	*electronic*	*Check against BF^{mass}_y and fuel sales record. More accurate one is prioritized.*
B3. $Density_y$	*Mass density of the FAME*	*Densi-meter*	*[ton/m^3]*	*m*	*monthly*	*sampling*	*electronic*	*In the early stage of project implementation, more frequent sampling should be done in order to assess fluctuation*
B4. HV_y	*Thermal content of the FAME per unit of mass*	*See comment*	*[GJ/ton]*	*m/c*	*monthly*	*sampling*	*electronic*	*Chemical component analysis or combustion test is applied in the beginning. Later, $Density_y$ is used to approximate this value. In the early stage of project implementation, more frequent sampling should be done in order to assess fluctuation*
B5. $COEF^{FF}_{petro\text{-}diesel}$	*Life-cycle CO_2 equivalent emission factor of the fossil fuel, which the FAME substitutes*	*Fuel supplier, statistics, and/or scientific literature*	*[tCO_2/ physical unit]*	*c*	*Once in the beginning of the crediting period*	*100%*	*electronic*	*Direct part of emission factor: Fuel supplier or other statistics, if unavailable. Appropriateness of the data source is checked by OE. Indirect part: Project participants shall*

								provide related objective information, such as scientific documents/paper with relative comparison between several studies. The appropriateness of the information is judged by the OE, as a validator, considering the cases applied beforehand. Life-cycle assessment is not needed if the project participants cannot provide such information as a conservative estimation (only CO_2 emissions from direct combustion is considered). *<u>Oxidization factor</u>: Defaults in the IPCC Guidelines/Good Practice Guidance are used.*

D.2.1.4. Description of formulae used to estimate baseline emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

>>

The baseline emissions BE_y within in the boundary in a certain year *y* is given by:

$$BE_y = BF_y * COEF^{FF}_{petro\text{-}diesel} * (1 + \delta)$$

where

BF_y : FAME sold or utilized in a certain year (thermal content) [GJ/yr]

$= BF^{vol}_y * Density_y * HV_y$

where : BF^{vol}_y: Volume content of BF_y [m^3/yr],

$Density_y$: Mass density of the FAME [ton/m^3]

HV_y: Thermal content of the FAME per unit of mass [GJ/ton]

$COEF^{FF}_{petro\text{-}diesel}$: Life-cycle CO_2 equivalent emission factor of the petro-diesel, which the FAME substitutes [tCO_2eq/GJ]

δ : Adjustment factor related to the difference of fuel efficiency for km drive per GJ

$= [L_{biofuel}/L_{fossil}] - 1$

where : L_{fossil}: Mean mileage of the fossil fuel to be replaced per GJ [m/GJ],

$L_{biofuel}$: Mean mileage of the FAME to be replaced per GJ [m/GJ].

Life-cycle GHG emission factor of the fossil fuel:

The LCA effect is included in the emission factor $COEF^{FF}$ as it is easier to understand. However, strictly speaking, it is outside of the boundary. The detailed assessment of LCA studies is provided in Annex 3. Here we set additional 10% as a provisional and conservative figure to the non-LCA emission factor of petro-diesel fuel.

The mean mileage information per GJ:

As shown in Annex 3, several credible studies show that δ can be set as zero within the uncertainty range for FAME. This is justified by the fact that both FAME and petro-diesel has similar molecular structure with long chain hydrocarbon, therefore no significant difference for combustion mode in engine.

D. 2.2. Option 2: Direct monitoring of emission reductions from the project activity (values should be consistent with those in section E).

D.2.2.1. Data to be collected in order to monitor emissions from the project activity, and how this data will be archived:

ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

D.2.2.2. Description of formulae used to calculate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

>>

D.2.3. Treatment of leakage in the monitoring plan

D.2.3.1. If applicable, please describe the data and information that will be collected in order to monitor leakage effects of the project activity

ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
L1. EL_y	*Electricity consumed at the FAME production plant*	*Wattmeter*	*[MWh]*	*m*	*monthly*	*100%*	*electronic*	*Check against the power purchase receipt*
L2. $COEF^{EL}_y$	*CO_2 emission factor of the used electricity*	*Statistical data*	*[tCO_2/MWh]*	*c/e*	*yearly*	*100%*	*electronic*	*$COEF^{EL}_y$ is obtained by using the calculation method of Simple OM specified in ACM0002.* *In order to justify the usage of OM, the project participants shall obtain the signed letter of the person who is in charge of the power development plan of the power company that the power development plan is never affected by the existence/non-existence of the facility.*
L3. $Loss_y$	*Transmission loss of the grid, if grid electricity is used*	*Statistical data*	*[no dimension]*	*c/e*	*yearly*	*100%*	*electronic*	*Statistical data is applied for the latest year.*
L4. BE_N2O_y	*N_2O emissions substituted by*	-	*[tCO_2eq]*	*c*	*yearly*	*100%*	*electronic*	*BE_N2O_y = $BioFertilizer^{out}_y$*

	bio-based fertilizer (by-product of the Bio-Fuel)							* $UREA\_EQ^{out}$ * $COEF\_N2O$ * GWP_N2O [tCO_2eq/yr]
L5. $BioFertilizer^{out}_y$	*Bio-based fertilizer sold out in the market*	*Weight meter*	*[t-(bio-fertilizer)]*	*m*	*monthly*	*100%*	*electronic*	*Check against the sales record*
L6. $UREA\_EQ^{out}_y$	*Coefficient to convert from bio-based fertilizer to synthetic urea fertilizer*	*Calculation*	*[ton-urea/ton-fertilizer]*	*c*	*yearly*	*100%*	*electronic*	*Calculated by using the data of fertilizer*
L7. $PE^{Indirect}\_N2O_y$	*Indirect N_2O emissions from fertilizer use at plantation site (emitted at the fertilizer production facility) in PJS*	-	*[tCO_2eq]*	*c*	*yearly*	*100%*	*electronic*	$PE^{Indirect}\_N2O_y = Fertilizer^{in}_y * UREA\_EQ^{in}_y * COEF^{Indirect}\_N2O * GWP\_N2O$

D.2.3.2. Description of formulae used to estimate leakage (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

>>

Leakage L_y, as the net emission change in a certain year y, is given by:

$$L_y = EL_y * COEF^{EL}_y / (1 - Loss_y) - BE\_N2O_y + PE^{Indirect}\_N2O_y$$

where

EL_y : Electricity consumed at the FAME production plant [MWh/yr]

$COEF^{EL}_y$: CO_2 emission factor of the used electricity [tCO_2/MWh]

$Loss_y$: Transmission loss of the grid [no dimension]

BE_N2O_y: N_2O emissions substituted by bio-based fertilizer (by-product of the FAME)

$= BioFertilizer^{out}_y * UREA\_EQ^{out} * COEF\_N2O * GWP\_N2O$ [tCO_2eq/yr]

where: $BioFertilizer^{out}_{y}$: Bio-based fertilizer sold out in the market [t-(bio-fertilizer)/yr]

$UREA\_EQ^{out}_{y}$: Coefficient to convert from bio-based fertilizer to synthetic urea fertilizer [t-urea/t-(bio-fertilizer)]

$COEF\_N2O^{tot}$: N_2O emission factor of the synthetic urea fertilizer (direct + indirect) (=0.030) [tN_2O/t-urea]

GWP_N2O : GWP of N_2O (=310 in the 1st Commitment Period) [tCO_2eq/tN_2O]

$PE^{Indirect}\_N2O_y$: Indirect N_2O emissions from fertilizer use at plantation site (emitted at the fertilizer production facility) in PJS

$= Fertilizer^{in}_{y} * UREA\_EQ^{in} * COEF^{Indirect}\_N2O * GWP\_N2O$ [tCO_2eq/yr]

where $COEF^{Direct}\_N2O$: indirect N_2O emission factor of the fertilizer (=2.0%) for synthetic fertilizer only [tN_2O/ton-urea]

The CO_2 emission factor of the electricity used $COEF^{EL}_{y}$ is obtained by using the calculation method of Operating Margin specified in "Consolidated baseline methodology for grid-connected electricity generation from renewable sources" (ACM0002). Taking data availability and conservativeness into consideration, "Simple OM" is used for calculation.

D.2.4. Description of formulae used to estimate emission reductions for the project activity (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

>>

Emission reductions ER_y is given by:

$$ER_y = BE_y - PE_y - L_y$$

using the notations defined above.

D.3. Quality control (QC) and quality assurance (QA) procedures are being undertaken for data monitored		
Data *(Indicate table and ID number e.g. 3.-1.; 3.2.)*	Uncertainty level of data (High/Medium/Low)	Explain QA/QC procedures planned for these data, or why such procedures are not necessary.
P1, P3, P6, P9, B2, L1, L5	*Low*	*Check against the sales/purchase receipts/records.*
Measurable parameters at the FAME plant	*Low*	*Management system is settled.*

P2, B5	*Low to Middle*	*Thorough and comparable analysis is done for LCA part (for fertilizer (not specified as monitoring items) and fossil fuel)*

Basic approach is to double-check the measured value, not relied on a single value.

D.4 Please describe the operational and management structure that the project operator will implement in order to monitor emission reductions and any leakage effects, generated by the project activity

>>

Management system based on ISO9000 is to be established to maintain the credibility of the measured value.

D.5 Name of person/entity determining the monitoring methodology:

>>

Dr. Naoki Matsuo

Climate Experts Ltd.

n_matsuo@climate-experts.info

SECTION E. Estimation of GHG emissions by sources

E.1. Estimate of GHG emissions by sources:

>>

Project emissions within the project boundary in a certain year *y* is given by:

$$PE_y = \quad FF^{BFP}_{heavy\ oil,y} * COEF^{FF}_{heavy\ oil} + BF^{mass}_{y} * COEF^{FS} + PE^{Tarnsp1}_{y} + PE^{Plantation}\_N2O_y$$

where

$FF^{BFP}_{heavy\ oil,y}$: Heavy fuel oil combusted at the steam supply plant [kl/yr]

$COEF^{FF}_{heavy\ oil}$: LCA CO_2 emission factor of the heavy oil (*incl*. oxidization factor) [tCO_2/kl]

BF^{mass}_{y} : FAME sold or utilized in a certain year (in mass) [ton- FAME/yr]

$COEF^{FS}$: CO_2 emission factor of the non-bio feedstock contained in the FAME [tCO_2/ton- FAME]. Zero for this case.

$PE^{Tarnsp1}_{y}$: Transportation-related CO_2 emissions from plantation site to the project site $= \sum_{transportation\ mode1} EN^{TR}_{mode1,y} * COEF^{TR}_{mode1}$ [tCO_2/yr]

where $EN^{TR}_{modei,y}$: energy used for transportation mode *i*,
$COEF^{TR}_{modei}$: CO_2 emission coefficient for transportation mode[12] *i*.

$PE^{Plantation}\_N2O_y$: N_2O emissions from fertilizer use at plantation site (direct) $= Fertilizer^{in}_{y} * UREA\_EQ^{in} * COEF^{Direct}\_N2O * GWP\_N2O$ [tCO_2eq/yr]

where $Fertilizer^{in}_{y}$: fertilizer input to the plantation site [ton-fertilizer/yr],
$UREA\_EQ^{in}$: urea-equivalence factor of the fertilizer for N-component [ton-urea/ton-fertilizer],
$COEF^{Direct}\_N2O$: direct N_2O emission factor of the fertilizer (=1.0%) [tN_2O/ton-urea],
GWP_N2O: GWP potential for N_2O (=310 for 1st Commitment Period) [tCO_2eq/tN_2O]

Life-cycle GHG emission factor of the fossil fuel:

The LCA effect is included in the emission factor $COEF^{FF}$ as it is easier to understand. However, strictly speaking, it is outside of the boundary. The detailed assessment of LCA studies is provided in Annex 3. Here we set additional 15% as a provisional and conservative figure to the non-LCA emission factor of heavy oil.

Transportation of Jatropha Curcas and fertilizer :

Diesel running trucks are planned to be in use for transportation of Jatropha Curcas and fertilizer, from plantation site to BDF plant. If the trucks are going to use BDM-ME, the fuel used in transportation is not necessary to be counted (however, the amount consumed here is not included in BF^{mass}).

Furthermore, this project is planning to purchase deficiencies of Jatropha Curcas seeds for the first two years. It is need to consider CO_2 emissions from the transportation related to this activity. The calculation can be done based on receipts of payment for transportation fuels.

---

12 "Transportation mode" implies ship, railway, truck, *etc*.

In a year when FAME is produced 1.0 * 10^5 ton/yr, project emissions are estimated as:

PE_y = 13,660 [kilo liter-heavy oil/yr] * 3.1 [tCO_2/kilo liter-heavy oil]
+ 1,500 [kilo liter-diesel] * 2.6 [tCO_2/kilo liter-diesel]
+ 140,000 [ton-fertilizer] * 0.12 [ton-urea/ton-fertilizer]
* 0.010 [tN_2O/ton-urea] * 310 [tCO_2eq/tN_2O]
= (42,346 + 3,900 + 52,080) [tCO_2eq/yr]
= 0.98 * 10^5 [tCO_2eq/yr]

In the above *ex ante* estimation, the value of each factor is set as follows:

$FF^{BFP}_{heavy\ oil,y}$: Estimated from chemical reaction formula, while measured *ex post* to to obtain actual emission reductions.
$COEF^{FF}_{NG}$: IPCC default value, while provided by the fuel supplier at the project implementation stage.
BF^{mass}_{y} : Assumption in this estimation. To be measured *ex post*.
$COEF^{FS}$: Theoretical calculation. Set as zero.
$Fertilizer^{in}_{y}$: Estimated from sunflower seed composition, while measured *ex post*.
$UREA\_EQ^{in}_{y}$: Provisional value assuming N-component of the fertilizer is 5.3%, [13] while measured *ex post*.
$COEF^{Direct}$_N2O: Set as 1.0% (See Annex of the baseline methodology).

E.2. Estimated leakage:

>>

Leakage L_y, as the net emission change in a certain year *y*, is given by:

$$L_y = EL_y * COEF^{EL}_y / (1 - Loss_y) - BE\_N2O_y + PE^{Indirect}\_N2O_y$$

where

EL_y : Electricity consumed at the FAME production plant [MWh/yr]
$COEF^{EL}_y$: CO_2 emission factor of the used electricity [tCO_2/MWh]
$Loss_y$: Transmission loss of the grid [no dimension]
BE_N2O_y: N_2O emissions substituted by bio-based fertilizer (by-product of the FAME)
= $BioFertilizer^{out}_y * UREA\_EQ^{out} * COEF\_N2O * GWP\_N2O$ [tCO_2eq/yr]
where: $BioFertilizer^{out}_y$: Bio-based fertilizer sold out in the market [t-(bio-fertilizer)/yr]
$UREA\_EQ^{out}_y$: Coefficient to convert from bio-based fertilizer to synthetic urea fertilizer [t-urea/t-(bio-fertilizer)]

[13] See *http://www.jaac.or.jp/saien/basic/hiryou/*.

$COEF\_N2O^{tot}$: N_2O emission factor of the synthetic urea fertilizer (direct + indirect) (=0.030) [tN_2O/t-urea]

GWP_N2O : GWP of N_2O (=310 in the 1st Commitment Period) [tCO_2eq/tN_2O]

$PE^{Indirect}\_N2O_y$: Indirect N_2O emissions from fertilizer use at plantation site (emitted at the fertilizer production facility) in PJS

$= Fertilizer^{in}_y * UREA\_EQ^{in} * COEF^{Indirect}\_N2O * GWP\_N2O$ [tCO_2eq/yr]

where $COEF^{Direct}\_N2O$: indirect N_2O emission factor of the fertilizer (=2.0%) for synthetic fertilizer only [tN_2O/ton-urea]

The CO_2 emission factor of the electricity used $COEF^{EL}_y$ is obtained by using the calculation method of Operating Margin specified in "Consolidated baseline methodology for grid-connected electricity generation from renewable sources" (ACM0002).

In a year when FAME is produced 1.0 * 10^5 ton/yr, leakage is estimated as:

$$L_y = (1.3 * 10^4 \text{ [MWh/yr]}) * 0.92 \text{ [tCO}_2\text{/MWh]} / (1 - 0.03) - 0 + 0$$
$$= 1.2 * 10^4 \text{ [tCO}_2\text{/yr]}$$

In the above *ex ante* estimation, the value of each factor is set as follows:

EL_y : Estimated from FAME plant design, while measured *ex post*.

$COEF^{EL}_y$: Preliminary calculation based on coal fired power plant which dominates the grid. Calculated every year using the latest information *ex post* using the data of the National Electricity Regulator (NER) or Escom. Confirmation letter of no existence of the Build Margin component will be obtained as a signed letter from Eskom (staff responsible for power development).

$Loss_y$: Data obtained from NER's statistics. Up-dated every year *ex post*.

$BioFertilizer^{out}_y$: Set zero as there are no such plan, while measured *ex post*.

$UREA\_EQ^{out}_y$: Measured *ex post*, if needed.

$COEF\_N2O^{tot}$: Set as 3.0% (See Annex of the baseline methodology).

$PE^{Indirect}\_N2O_y$: Set zero as there are no such plan, while measured *ex post*, if needed.

E.3. The sum of E.1 and E.2 representing the project activity emissions:

>>

The total project emissions including the leakage is given by

$$PE^{tot}_y = PE_y + L_y$$

In a year when FAME is produced 1.0 * 10^5 ton/yr, total project emissions are estimated as:

$$PE^{tot}_y = 1.10 * 10^5 \text{ [tCO}_2\text{eq/yr]}$$

E.4. Estimated anthropogenic emissions by sources of greenhouse gases of the baseline:

>>

The baseline emissions BE_y within in the boundary in a certain year y is given by:

$BE_y = BF_y * COEF^{FF}_{petro\text{-}diesel} * (1 + \delta)$

where

BF_y : FAME sold or utilized in a certain year (thermal content) [GJ/yr]

$= BF^{vol}_y * Density_y * HV_y$

where : BF^{vol}_y: Volume content of BF_y [m^3/yr],

$Density_y$: Mass density of the FAME [ton/m^3]

HV_y: Thermal content of the FAME per unit of mass [GJ/ton]

$COEF^{FF}_{petro\text{-}diesel}$: Life-cycle CO_2 equivalent emission factor of the petro-diesel, which the FAME substitutes [tCO_2eq/GJ]

δ: Adjustment factor related to the difference of fuel efficiency for km drive per GJ

$= [L_{biofuel}/L_{fossil}] - 1$

where : L_{fossil}: Mean mileage of the fossil fuel to be replaced per GJ [m/GJ],

$L_{biofuel}$: Mean mileage of the FAME to be replaced per GJ [m/GJ].

Life-cycle GHG emission factor of the fossil fuel:

The LCA effect is included in the emission factor $COEF^{FF}$ as it is easier to understand. However, strictly speaking, it is outside of the boundary. The detailed assessment of LCA studies is provided in Annex 3. Here we set additional 30% as a provisional and conservative figure to the non-LCA emission factor of petro-diesel fuel, whose 60% is made from coal. See Annex 3 for this estimation.

The mean mileage information per GJ:

As shown in Annex 3, several credible studies show that δ can be set as zero within the uncertainty range. This is justified by the fact that both FAME and petro-diesel has similar molecular structure with long chain hydrocarbon, therefore there will be no significant difference for combustion mode in engine.

In a year when FAME is produced $1.0*10^5$ ton/yr, baseline emissions are estimated as:

$BE_y = BF_y * COEF^{FF}$

$= 1.0*10^5$ [ton-BDF/yr] * 0.89 [ton-Diesel/ton-BDF] * 3.21 [tCO_2/ton-Diesel] * 1.3

$= 3.7 *10^5$ [tCO_2/yr]

In the above *ex ante* estimation, the value of each factor is set as follows:

BF_y : Set as $1.0*10^5$ ton/yr as an assumption converted to [GJ/yr] by using the thermal content of FAME, while measured *ex post* for both parameters.

$COEF^{FF}$: Petro-diesel CO_2 emission factor (obtained provisionally by IPCC default (20.2 [tC/TJ] * 43.33 [TJ/10^3ton] * 44/12 [tCO_2/tC]), while obtained by South African statistics/information at a later stage) corrected by LCA assessment which is 30% as shown above and in Annex 3 for details.

δ: Set zero as shown above and in Annex 3.

E.5. Difference between E.4 and E.3 representing the emission reductions of the project activity:

>>

Emission reductions ER_y is given by:

$$ER_y = BE_y - PE_y - L_y$$

using the notations defined above.

In a year when FAME is produced $1.0*10^5$ ton/yr, emission reductions are estimated as:

$$ER_y = 2.6 * 10^5 \text{ [tCO}_2\text{eq/yr]}$$

E.6. Table providing values obtained when applying formulae above:

>>

Estimated mean amount of emission reductions is around $2.6 * 10^5$ tCO_2/yr, equivalent to $2.6 * 10^6$ tCO_2 over the 10-year crediting period.

The operation of the FAME production is scheduled to be stable over the lifetime, we expect no significant annual fluctuation on the GHG emission reductions.

SECTION F. Environmental impacts

F.1. Documentation on the analysis of the environmental impacts, including transboundary impacts:

>>

The environmental impacts are categorized into three stages:

Jatropha Curcas plantation

The plantation is to utilize unused land area with improvement and maintenance of the farm field, and this project improves circumstances of high unemployment rate in South Africa.

Therefore, we see no negative impacts.

In addition, residue of FAME production is fed back to the plantation site as high quality organic fertilizer; recycling of natural resources is accomplished.

FAME production

Glycerin, a by-product of the FAME, is sold to the chemical manufacturer and used as a feedstock of chemical substance.

Wastewater effluent from the plant is treated within the plant. The compliance of effluent regulation is checked before flashing to outer environment.

Regulation of effluent wastewater in Richard Bay area:

Effluent water more than 3,000 ton/day, or

Temperature > 56 ^{o}C;
Solid waste: > 50 mg/litre and heavy metal, fluoride, colored/sparkling wastewater,

an agreement is needed with the Environmental Office.

is to be assessed against the predicted wastewater quality of the BDF production facility and show that the regulation will be complied with. To be elaborated later.

FAME consumption

FAME not only reduces CO_2 emissions, but also reduces other air pollutants, such as PM, PAH, CO, SO_X. NO_X may be a little bit more than petro-diesel, while tuning of engine is reported to decrease emissions.

South Africa purposes reduction of percentage of sulfur, so this project contributes the purpose.

F.2. If environmental impacts are considered significant by the project participants or the host Party, please provide conclusions and all references to support documentation of an environmental impact assessment undertaken in accordance with the procedures as required by the host Party:

>>

No significant environmental impacts are found at a later stage.

SECTION G. Stakeholders' comments

>>

G.1. Brief description how comments by local stakeholders have been invited and compiled:

>>

To be elaborated…

G.2. Summary of the comments received:

>>

To be elaborated…

G.3. Report on how due account was taken of any comments received:

>>

To be elaborated…

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

Organization:	Biodiesel Refinery Co. (to be established)
Street/P.O.Box:	
Building:	
City:	
State/Region:	
Postfix/ZIP:	
Country:	
Telephone:	
FAX:	
E-Mail:	
URL:	
Represented by:	
Title:	
Salutation:	
Last Name:	
Middle Name:	
First Name:	
Department:	
Mobile:	
Direct FAX:	
Direct tel:	
Personal E-Mail:	

Organization:	Mitsui & Co., Ltd.
Street/P.O.Box:	2-1, Ohtemachi 1-chome
Building:	
City:	Chiyoda-ku
State/Region:	Tokyo
Postfix/ZIP:	100-0004
Country:	Japan
Telephone:	
FAX:	
E-Mail:	
URL:	
Represented by:	
Title:	
Salutation:	
Last Name:	
Middle Name:	
First Name:	
Department:	
Mobile:	
Direct FAX:	
Direct tel:	

Personal E-Mail:	

Annex 2

INFORMATION REGARDING PUBLIC FUNDING

No public funds are used for this project.

Annex 3

BASELINE INFORMATION

CO_2 Emission Factors Used in the Estimation

Heavy Fuel Oil ($COEF^{FF}_{heavy\ oil}$):

In Section E, provisional emission factor is calculated by using the carbon content of 20.2 tC/TJ.

While at the implementation stage of the project, the data is to be provided by the fuel supplier on chemical composition of the natural gas. Using such chemical composition data, CO_2 emission factor is calculated theoretically. This will be done once by finalizing the validation, while redone if the fuel supplier or specification of the natural gas is changed.

Methanol ($COEF^{FS}$):

CO_2 emission factor of the non-bio feedstock (methanol, in this case) contained in the FAME [tCO_2/ton-BDF]. This comes from the C-component of the methanol which is a feedstock of the FAME and left in the final product (FAME).

However, the same number of C is transferred to glycerin. Therefore, we do not need to count this effect.

Grid Electricity ($COEF^{EL}_{,y}$):

In Section E, provisional emission factor is set as 0.92 tCO_2/MWh.

It is confirmed that only Operating Margin component exists (no Build Margin component) for the electricity consumption for such small facility by the signed letter from the Eskom staff who is responsible for power development plan.

I order to obtain $COEF^{EL}_{,y}$, the calculation method (Operating Margin) of ACM0002 is used. As there are no public data available and accessible for load dispatch, here “Simple OM” method (weighted average of power plants connected to the grid excluding low-cost/must-run plants) is applied.

Outline of the Investment Analysis

IRR is calculated as 4.4% without CER revenue with the uncertainty range of ±30%.

Spreadsheets with assumptions and sensitivity analysis (in Japanese) are provided to the Operational Entity.

Uncertainty Analysis of Each GHG Emission Source

The possible uncertainties associated with the emission reduction calculation basically comes from:

(1) Petro-diesel fuel displacement (baseline emissions), and

(2) Fertilizer-related N_2O emissions (project emissions).

Typically, emissions of each scenario are:

Baseline emissions: $3.7 * 10^5$ tCO_2/yr

Project emissions: $1.0 * 10^5$ tCO_2/yr (fertilizer-related N_2O: $0.5 * 10^5$ tCO_2/yr)

Leakage: $0.1 * 10^5$ tCO_2/yr

In the first origin, the amount of FAME sold is measured with less than 1% error, while fuel efficiency gap may be the same order of the baseline emissions (~ 4 $ktCO_2$/yr).

In the second origin, N_2O emission factor may have several dozen per cent error in it intrinsically. However, N_2O emissions level is only around 20% of that of the baseline emissions. Therefore, the uncertainty level comes from N_2O may be several % of total baseline emissions (~10 $ktCO_2$eq/yr).

Therefore, if the level of some emission source is much less than 2 $ktCO_2$/yr, it can be neglected.

For minor emissions:

(a) Fossil fuel used at the plantation site (machinery use)

We do not find significant usage of tractor or other machinery as the harvesting is undertaken manually, thus neglected.

(b) Jatropha Cracus seeds and fertilizer transportation

Rough estimation shows that

[10 ton truck with 0.77 $kgCO_2$/km, 100 km distance, 250 kton-seed/yr]

CO_2 emissions of the above situation are roughly 4 $ktCO_2$/yr. This amount is not significant, but cannot be neglected. Therefore, this amount is monitored.

(c) FAME transportation

Transportation of FAME is much smaller than that of seeds and fertilizer, thus neglected.

Therefore, we can neglect these emissions; no need to be monitored.

LCA Analysis Related to Petro-Diesel Emission Factor

If we incorporate LCA (especially, N_2O emissions from fertilizer production/use, which is significant in total emission reductions) for the project emission estimation, it is reasonable and consistent to incorporate such assessment for the baseline emissions.

In South Africa, around 60% of the fossil fuel based diesel oil is made from coal. However, as there are almost no information available related to the LCA analysis of the coal-based diesel oil, here we assess petroleum-based diesel oil.

There are several studies of LCA analysis for petroleum products.

First, we must identify what "type" of LCA calculation principle is applied for this case related to "allocate" indirect GHG emissions to plural petroleum products. The most frequently used one is to allocate them to the *physical quantity* of the final products (*excl*. wastes). We choose this principle because it is

- Most well studied method;
- Recommended in the ISO 14040; and
- Reasonable as the petroleum products are "joint" products, *i.e.*, every product cannot be separately produced.

We surveyed studies by PEC (Japan), IEEJ (Japan), DEFRA (UK), NREL (US) precisely.

As the result, we can conclude that

- Refinery process is the most contributing part and origin of divergence in the lifetime except for direct combustion;

Unit ($t-CO_2/TJ$) / Source	Studied by	Consumption Country	Production Stage: Self Consumption	Production Stage: Flaring	Crude Oil Transportation	Refinery	Domestic Transporttaion	Up-front Part Aggregation	Combustion Stage IPCC Default	Life Cycle ($t-CO_2/TJ$)	Emission Factor Adjustment
Report on Lyfecycle Inventory for Transportation Fuels (FY 2001)	PEC	Japan	1.10		1.00	2.80	0.40	5.30	74.07	79.37	7.2%
EVALUATION OF THE COMPARATIVE ENERGY, GLOBAL WARMING AND SOCIO-ECONOMIC COSTS AND BENEFITS OF BIODIESEL	DEFRA	UK	n/a	n/a	n/a	n/a	n/a	9.93	74.07	84.00	13.4%
Report on LCI for Automobile Fuels at Refinary Stage (FY 2002)	PEC	Japan	n/a	n/a	n/a	6.57	n/a	9.07	74.07	83.14	12.2%
Analysis of the Qualification of Environmental Loads by Resources Import and Effects of Allocation Method on LCI	NIES	Japan	2.30			3.61	0.00	5.91	74.07	79.98	8.0%
Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus (NREL)	Domestic Production (CO_2 only, No CH_4)	US	1.08		0.41	8.32	0.42	10.23	74.07	84.30	13.8%
Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus (NREL)	Foreign Production (CO_2 only, No CH_4)	US	1.83		1.77	8.32	0.42	12.34	74.07	86.40	16.7%
Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus (NREL)	Domestic Production (CO_2 + CH_4)	US	1.32		0.43	8.47	0.43	10.64	74.07	84.71	14.4%
Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus (NREL)	Foreign Production (CO_2 + CH_4)	US	2.33		1.79	8.47	0.43	13.02	74.07	87.09	17.6%
Lyfecycle Inventory Analysis of the Fossil Fuels Used in Japan	IEEJ	Japan	0.76	0.56	0.79	2.72	0.23	5.05	74.07	79.12	6.8%
Report of Comparison of Analyses on the LCA methods for Petroleum, LNG and Coal	PEC	Japan	0.82	0.61	0.86	3.31	0.20	5.80	74.07	79.87	7.8%

[Allocation criteria at refinery stage dominates the diversity of the results]

In the table above, some +7% is calculated only if the allocation to the Diesel is extremely higher than to the Gasoline (*e.g.*, for PEC's report, it is around 5 times). The allocation rule is completely different from the criteria shown above for these studies and we cannot find appropriate and logical reasons to apply these results to the case of this project. Therefore, we do not select these results applicable to this project. Excluding these results, we see the adjustment factor as

13.4%	DEFRA (UK)	Only aggregated value is in the report
12.2%	PEC (Japan)	Several criteria are assessed. This number is based on the criteria above.
17.6%	NREL (US)	Foreign production with CO_2 and CH_4 emissions.

In case of South Africa, only Refinery and Domestic transportation is included. Based on above consideration and data availability (PEC and NREL), it seems relevant and conservative to set +10% for the additional CO_2 emissions from Refinery and Domestic transportation.

For coal based portion (60%) of the diesel fuel, it is assessed that the refining process efficiency is around 62%.

Therefore, the additional CO_2 emissions than those contained in the final diesel product is:

$0.6 * 100/0.62 + 0.4 * 1.1 = 1.4.$

This means that +40% CO_2 is emitted in comparison to the direct combustion of pure petroleum diesel fuel. Taking conservativeness criteria into account, we set

+30%

as the adjustment factor to calculate CO_2 emissions abated by the FAME.

Mean Mileage Information Related to FAME and Petro-Diesel

It is not easy to measure the mean mileage difference between petro-diesel and (some mixture) of the FAME measured by a unit of thermal content, as it may be dependent on the driving style and congestion of the roads, with less statistical data.

However, theoretically, these are very close or no significant difference for combustion modes in engine because both FAME and petro-diesel has similar molecular structure with C16 long chain hydrocarbon. Therefore, it can be regarded as "identical" in the first approximation.

"Life Cycle Inventory of Biodiesel and Petroleum Diesel" (NREL/SR-580-24089), which may be one of the most technically thorough and comprehensive report on Bio-Diesel Fuel, says (p.177):

> The fuel economy of the bus burning biodiesel is based on combustion data in a modern four-stroke diesel engine. Table 110 presents fuel economy data for the same four-stroke diesel engine used to calculate the fuel economy of the diesel fuel (Graboski 1997). The root mean square (RMS) error in fuel economy by each method is approximately 1.5%. The data clearly show the following:
>
> - The energy efficiency determined by both methods (based on CO_2 and on fuel use) for each blend are the same within experimental error. Thus, the fuel composition and lower heating value data used to estimate fuel economy from CO_2 and fuel flow data are internally consistent.
> - Within experimental error, the energy efficiency is *independent* of biodiesel content. The neat biodiesel actually shows a better fuel economy of around 3%. This is thought to be insignificant within the experimental error of the data.

Table 110: Economy Data for Biodiesel Fuels in a Modern Series 60 Engine

% Biodiesel by Volume in Diesel Fuel	Engine Efficiency (Btu/bhp-h)	
	Calculated from Measurements of CO_2 Emissions	Calculated from Fuel Consumption Data
0%	7176	7326
20%	7040	7192
35%	7080	7130
65%	7006	7133
100%	7038	7038
Avg/Stdv	7116	97 (1.4%)

Therefore, we can conclude that such fuel efficiency difference δ is regarded as zero which can be regarded as a conservative estimation based on the above study.

Annex 4

MONITORING PLAN

To be elaborated after concrete plan is settled during validation.