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

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Annexes

SECTION A. General description of project activity

A.1 Title of the project activity:

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Sunflower Methyl-Ester Biodiesel Project in Thailand

A.2. Description of the project activity:

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Outline and Objective of the Project

"Sunflower Methyl-Ester Biodiesel Project in Thailand" is a project targeting the methyl-ester bio-diesel fuel (BDF-ME, for short)[1] production from sunflower plantation of 15 kton/year (45 ton/day; 335 days/year). BDF-ME, produced by the project, is different from the mixture of bio-based oil and petro-diesel.[2]

Project consists of two parts:

1. Entrusts specified farmers to plant sunflower in unused land,[3] and purchase the sunflower seeds; and
2. Produces/refines BDF-ME from the sunflower seeds oil generation process and sells the BDF-ME in the market. The residues are fed back to the plantation site as fertilizer.

The produced BDF-ME is sold at gas stations and/or used as the agricultural machinery fuel, *etc* (through intermediate fuel supplier). Such BDF-ME reduces transportation-related CO_2 emissions by displacing petro-diesel fuel use in market in comparison to otherwise would be occurred.

Consistency with the Thai Government Policy

In Thailand, diesel fuel oil makes up 45% of petroleum (of which 90% is imported) and 80% of diesel is consumed as transportation fuel. Therefore, Thai Government sets a policy objective to promote transportation fossil fuel originated by indigenous biomass in order to contribute to the energy security and environmental protection. The bio-diesel fuels attracted interests with the Royal R&D project started in November 2000 as a turning point. In this R&D project, palm oil based fuel was developed, however, such trend slowed down because of circulation of inferior quality fuels.

As time goes by, the importance of the bio-diesel fuel has been realized again driven by a feasibility study by Ministry of Energy and the Navy released in May 2003. It sets a target to supply 2% of the automobile diesel fuel by bio-diesel by 2006. In addition, Ministry of Agriculture and Cooperatives released its proposal to double Palm oil production and its use as an alternative fuel by 2007. The Thai Government revealed its stance to continue its effort for penetration of bio-diesel. The land area of Palm plantation is projected to increase to 0.8 million acres in 2007 from current 0.6 million acres.

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[1] In Thailand, blended bio-diesel with petro-diesel is called BDF. On the other hand, Methyl-ester (BDF-ME) is produced by trans-esterification of vegetable oil with methanol in the presence of base catalyst. BDF-ME is *different* from prevalent bio-diesel fuel as a mixture of vegetable oil and petro-diesel. Therefore, throughout the PDD, "BDF-ME" is used for only pure methyl-ester based bio-diesel fuel, while others are called "other bio-diesel fuels". See the terminology definition in the previous page.

[2] The project has a possibility to utilize other indigenous plants such as Jatropha in the future.

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

However, BDF-ME (methyl-ester based bio-diesel fuel), higher quality bio-diesel fuel than the mixture type to petro-diesel, has not yet realized in Thailand to date.

Contribution to Sustainable Development of Thailand

As specified above, production of BDF-ME, as a renewable energy, contributes to the sustainable development of Thailand through

(1) strengthening energy security by reducing the expenditure to import oil by indigenous energy source,

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

(3) reducing fuel cost of agricultural machineries by self-supply of the bio-diesel,

(4) providing higher quality bio-diesel (*cf.*, conventional petro-diesel mixture type),

(5) introduction of new technology,

(6) effective utilization of idle farm field, and

(7) adding new values to the sunflower plantation.

Furthermore, this project is intended to be the core of the "bio-refinery" concept, which provides a new model of local recycling system of energy and resources as well as creation of employment and new industry by using by-products.

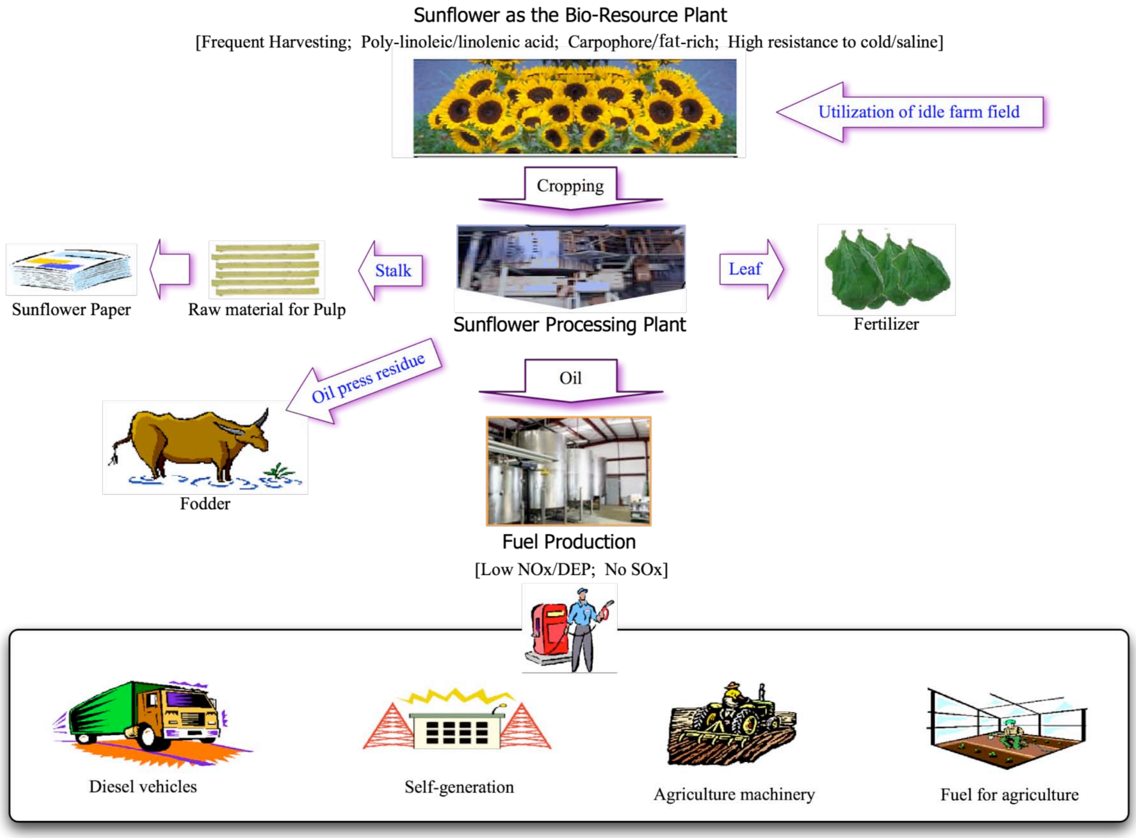

Figure PDD-1: Concept of Bio-Refinery

Technology Transfer Effect

Introduction of high quality BDF-ME technology (in comparison to conventional petro-diesel mixture type Palm diesel oil) is the first attempt in Thailand. In addition, technologies for co-products (stalk, honey, *etc*) are expected to get in operation as well as that of high value added such as jet fuel production (R&D is on-going in Japan). Sunflower plantation may attract tourists for sightseeing. Not only 'transferring' the technologies, but also cooperative development of technology is expected to strengthen the technological ability of Thailand.

Terminology Definition for Transportation Fuels with Biomass Component for Diesel Engine

Biomass-based fuel	100% (pure)	Blended with Petro-diesel
Esterification (using methanol)	Biodiesel (BDF-ME for methanol esterification)	Blended biodiesel (*e.g.*, B20 for 20% volume mixture)
Crude Vegetable Oil	Straight vegetable oil (SVO)	Blended vegetable oil

Petro-diesel: 100% fossil fuel origin diesel fuel.

A.3. Project participants:

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This project is operated by a consortium of many universities and companies in Thailand and Japan which are interested in BDF-ME.

The Parties involved are:

- Thailand (non-Annex I), and
- Japan (Annex I).

The project participants are:

- Sun Care Fuels Co. (SCF) [Japan]
- Sun Care Fuels Thailand, Ltd. (SCF Thailand) [Thailand] [to be established]
- UTIC FOODS (THAILAND) Co., Ltd. [Thailand]

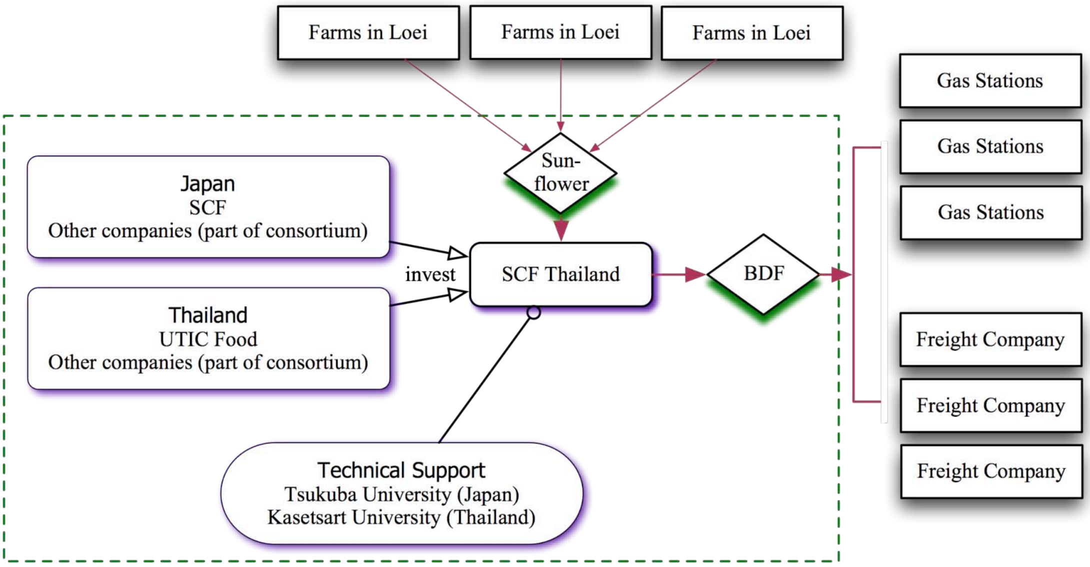

Figure PDD-2: Consortium Structure

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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Kingdom of Thailand

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

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Loei Province

A.4.1.3. City/Town/Community etc:

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Loei (BDF-ME plant),

T. Praba A. Phurya, Loei (plantation)

Figure PDD-3: Map of Thailand

Figure PDD-4: Map of Loei Province

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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The plantation site is a village in a district "Phu Rua", where a Buddhism temple sits at a center, and its surrounding villages. Specifications of the village are:

- Population: Around 250.
- Cultivated area: Around 480 ha (rice: 48 ha, Ginger: 32 ha; others: idle field)
- Principal crops: rice (in rainy season, but the land is not good for rice cultivation), ginger, vegetables [carrot, cabbage, onion] (just started from 10.2004)
- Revenue of farmer: Around 10,000 Baht (family with four people, in average)
- Land area per family: Around 2.4–4.8 ha
- Land ownership: Not specified. Self-reclaimed land is used appropriately.
- Cultivation cycle: Leave the land for around 5–6 years once ginger is cropped. Single cropping for rice.

Villages with similar situations locate around the village. Idle land area spreads, which have not been used after reclaim. This sunflower plantation (22,500 ha) utilizes such idle area. Therefore, the plantation does not result in deforestation.

At present, monks employ around 20 people for cropping of his land with a daily payment of 140 Baht (for men) and 120 Baht (for women). Under this very low-income level, the monks are trying to increase to the payment level up to 8,000 Baht/month (US$ 200/months, average level in Thailand), while no substantial income sources have been found to date.

Figure PDD-5: Photo of the village [rice crop area (nearby) and idle area]

Plant of BDF-ME production locates in the industrial complex in Loei, where Loei local government specifies for use. There is no residences locating nearby.

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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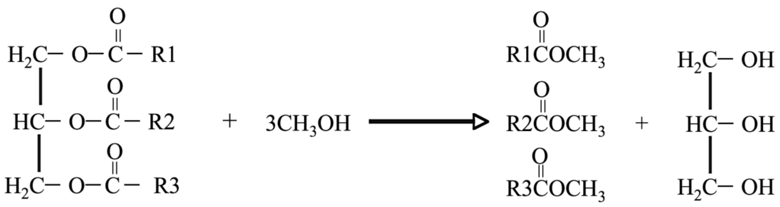
The core technology of this project is to produce BDF-ME by using sunflower seeds.

The chemical reaction on esterification:



Vegetable oil (triglyceride) methanol methylester glycerol

(R1, R2, R3; alkyl group)

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

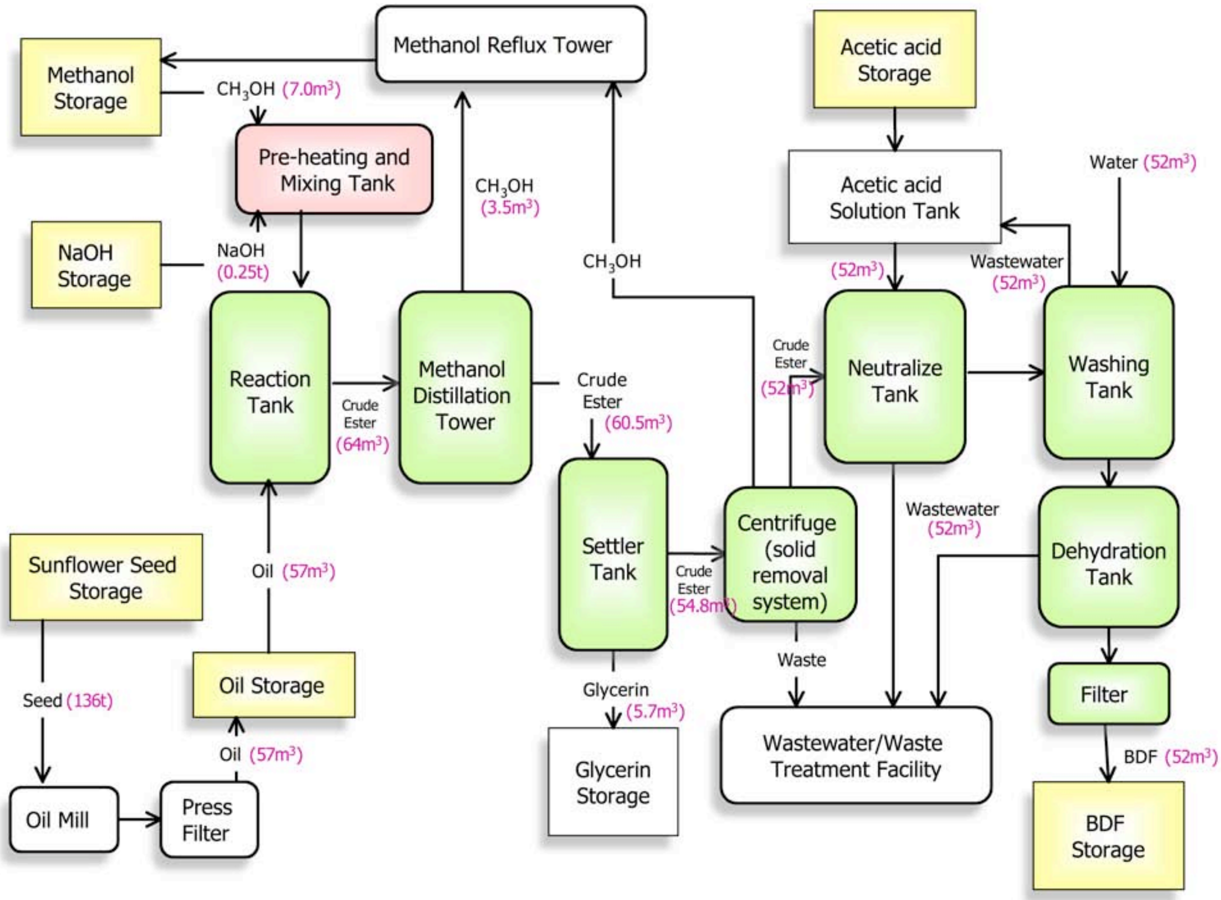


Figure PDD-6: Process Flow of BDF-ME Production (Daily Material Flow)

Raw materials are sunflower seeds and methanol (CH_3OH). In addition, sodium hydroxide (NaOH; catalyst), 0.5% acetic acid solution (CH_3COOH; for primary washing), and water (H_2O; for secondary washing) are needed. Sunflower oil and methanol react to ester with the existence of methanol.

Finally, the outputs of the process are BDF-ME (ester) as a product, and residue after oil press, glycerin after esterification reaction as by-products. Oil press residue is sold as fertilizer or fodder and glycerin is sold as a chemical material.

BDF-ME, 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 BDF-ME has its effect more than the mixture.

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:

> *BDF-ME produced in the project replaces the usage of petro-diesel after they are sold in the market. Therefore CO_2 emissions are reduced in comparison to the baseline scenario where such amount of BDF-ME is not sold.*

The emission reductions will be achieved by 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 BDF-ME production plant. The barrier/investment analysis includes BDF-ME and other by-products, which has market value. However, since it is very uncertain at this stage, the analysis does not include the whole bio-refinery concept because it is very uncertain at this stage. The baseline scenario is assessed in three stages of material flow/value chain: sunflower farm field, BDF-ME production plant, and BDF-ME consumption.

The emission reductions can be calculated from the supply side as the amount of BDF-ME 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 amount of emission reductions is around 3.38×10^4 tCO_2/yr for typical year, or equivalent to 3.32×10^5 tCO_2 over the 10-year crediting period.

Provisional calculation is shown below:

year	Plantation Area [ha]	Sunflower Seeds [t/yr]	Sunflower Oil [t/yr]	BDF-ME [t/yr]	$Fertilizer^{in}_{y}$ [t/yr]	$FF^{BFP}_{NG,y}$ [TJ/yr]	EL_y [MWh/yr]	PE_y [tCO_2eq/yr]	BE_y [tCO_2eq/yr]	L_y [tCO_2eq/yr]	ER_y [tCO_2eq/yr]
2006	18,000	36,000	13,320	12,000	22,680	8.14	3,680	8,437	38,397	2,428	**27,532**
2007	22,500	45,000	16,650	15,000	28,350	10.18	4,600	11,117	47,996	3,035	**33,844**
2008	22,500	45,000	16,650	15,000	28,350	10.18	4,600	11,117	47,996	3,035	**33,844**
2009	22,500	45,000	16,650	15,000	28,350	10.18	4,600	11,117	47,996	3,035	**33,844**
2010	22,500	45,000	16,650	15,000	28,350	10.18	4,600	11,117	47,996	3,035	**33,844**
2011	22,500	45,000	16,650	15,000	28,350	10.18	4,600	11,117	47,996	3,035	**33,844**
2012	22,500	45,000	16,650	15,000	28,350	10.18	4,600	11,117	47,996	3,035	**33,844**
2013	22,500	45,000	16,650	15,000	28,350	10.18	4,600	11,117	47,996	3,035	**33,844**
2014	22,500	45,000	16,650	15,000	28,350	10.18	4,600	11,117	47,996	3,035	**33,844**
2015	22,500	45,000	16,650	15,000	28,350	10.18	4,600	11,117	47,996	3,035	**33,844**
Sum	220,500	441,000	163,170	147,000	277,830	99.76	45,080	108,492	470,360	29,744	**332,124**
Average	22,050	44,100	16,317	14,700	27,783	9.98	4,508	10,849	47,036	2,974	**33,212**

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 village head, on behalf of all landowners, to confirm this condition will be attached to the PDD.

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

A signed letter of the village head, on behalf of all landowners, to confirm this condition will be attached to the PDD.

(b') *In case waste oil is used as feedstock of the Bio-Fuel, 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 (c) are mutually exclusive. This condition (b') does not fit the case of this project.

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 as it judges, if 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 limit,

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

(3) available contracted farm field for sunflower plantation.

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

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 reason why sunflower[5] is chosen is:

- Residue after oil press and sunflower leaves becomes good organic fertilizer. It reduces synthetic fertilizer use, therefore less N_2O emissions (at the synthetic fertilizer production stage). This is not the case for palm. In addition, sunflower plantation contributes to the soil thanks to the existence of leguminous bacteria.
- Climate of northern region of Bangkok does not fit for palm plantation. On the other hand, it fits for sunflower plantation.

in comparison to other biomass such as palm.

(e) *The project plant cannot be attractive economically without the CER revenue, even if some subsidies[6] (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 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 Thailand without any restriction. And there is no requirement to use bio-diesel fuel in Thailand.

(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*

[5] Sunflower used by the project is hybrid species such as "Pacific" and/or "JUMBO" developed by Pacific Seeds (Thai) Ltd. or Pioneer Hi-Bred (Thailand) Co., Ltd. The hybrid species has higher crop yields per ha than ordinary one. Especially, "Pacific" contains very high rate of oleic acid (around 95%). [Possibly amended…]

[6] *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.*

biomass-based fuel penetrate more than the threshold level and/or competitive in the associated fuel market.

There is no requirement to use bio-diesel fuel in Thailand.

(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 Thailand is promoting to use bio-diesel, penetration of bio-diesel (mostly palm oil based) is and will be far below 70% during the crediting period even the governmental plan will be successful.[7] Since the BDF-ME produced by the project is not a mixture with the petro-diesel, penetration of the palm based bio-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 BDF-ME-alternatives (methyl-ester based bio-diesel fuel) is almost 0% in Thailand.

(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 BDF-ME 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 Thailand, petro-diesel supply system has excess capacity as no supply limitations are conducted. 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 EGAT.

Therefore, the methodology is applicable to the project.

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[7] In 2002, diesel fuel demand in Thailand is 15 million toe/yr. This demand is expected to increase more than the economic growth. The governmental study shows that “2% in 2006” (05.2003, Ministry of Energy), and 7 million ton of Palm oil for fuel in 2007 (05.2003, Ministry of Agriculture and Cooperatives).

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 ⟨⟨sunflower seeds⟩⟩ supply,

Stage 2: Bio-Fuel ⟨⟨BDF-ME⟩⟩ production, and

Stage 3: Bio-Fuel ⟨⟨BDF-ME⟩⟩ 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 ⟨⟨sunflower seeds⟩⟩ supply]

In case that the biomass ⟨⟨sunflower 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 ⟨⟨BDF-ME⟩⟩, 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.

In case that the biomass is supplied as biomass-based waste-oil, the condition (b') exclude 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 ⟨⟨BDF-ME⟩⟩ 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))

under the current legal framework of the host country. And condition (e) excludes the PJS itself[8] from the BLS candidates.

Therefore, the only remained 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 of the Bio-Fuel ⟨⟨BDF-ME⟩⟩ production plant.

"Step 3. Barrier analysis" and/or "Step 2. Investment analysis" of the "Tool for the demonstration and assessment of additionality" is applied. If barrier analysis well demonstrates that the project would not be implemented as the baseline scenario, the investment analysis is needed. While, if the barrier analysis is insufficient, investment analysis is needed in addition (in this case, the barrier analysis is recognized as the supportive analysis to demonstrate additionality).

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 as shown above)

The barriers may include barriers, *e.g.*, cumbersome/complex procedures to get approval to construct/operate the bio-Fuel production facility, lack of acceptability of the Bi-Fuel in the market, limited access by the consumers because of fewer Bio-Fuel supply facilities, risks associated with new Bio-Fuel technology (e.g., lack of skills), lack of finance suppliers to implement the Bio-Fuel production project, *etc*. as specific examples of the generalized expression of the "Additionality Tool" to this type of projects.

In the case of this project, one of the barriers are:

- 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 Thailand.

  The related evidences on the penetration of BDF-ME from Sunflower and technological difficulties in Thailand are attached to the PDD (attachment at later stage).

However, the largest barrier is the "cost" to implement such a project because there are no economical incentives in Thailand to invest in BDF-ME production project. Specific calculation is provided in the following Step 2.

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)

The method to assess this investment analysis is the same as shown in the "Additionality Tool". Specific to this type of projects, 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.

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[8] The project may use other indigenous biomass, not planned in the beginning at later stage, by using the same production process.

In addition to the Barrier analysis shown above, investment analysis shows difficulties in implementing this project as the baseline scenario. This might be related to the absence of the incentive scheme in Thailand.

The calculation of IRR shows that IRR is around 1.6% (with tax) without CER revenue. The investors consider that this level of IRR implies that the project is not enough to invest. Therefore, it concludes that the project is *not* an economically attractive course of action. 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 ⟨⟨BDF-ME⟩⟩ 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 BDF-ME is 0% in Thailand at the time of PDD preparation. Therefore, it does not need to explain the barriers anymore. (Evidences are to be prepared)

Stage 3 [Bio-Fuel ⟨⟨BDF-ME⟩⟩ consumption]

The applicability condition (f), together with (i)–(v), ensures that the Bio-Fuel ⟨⟨BDF-ME⟩⟩, 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 ⟨⟨BDF-ME⟩⟩ produced by the project plant may replace bio-fuels ⟨⟨bio-diesel⟩⟩ produced by other plants (in the market). In general, the reason why a bio-fuel ⟨⟨bio-diesel⟩⟩ production facility is operated is that the bio-fuel ⟨⟨bio-diesel⟩⟩ 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 ⟨⟨bio-diesel⟩⟩ is replaced by the project Bio-Fuel ⟨⟨BDF-ME⟩⟩. Considering the viewpoint of conservativeness, the methodology sets the sub-applicability sub-condition (iii) as the penetration of the alternative Bio-Fuel ⟨⟨BDF-ME⟩⟩ as below [70%].[9] The actual penetration rate of BDF-ME is almost 0% in Thailand at the time of drafting this PDD.

In addition, if the fossil fuel supply is limited and such limitation results to set ceiling on demand, the Bio-Fuel ⟨⟨BDF-ME⟩⟩ 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 ⟨⟨bio-diesels⟩⟩ 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:

>>

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

[9] It is noted that even alternative bio-fuels' penetration is 100%, emission reductions are realized if the biomass mixing ration of the alternative bio-fuel is lesser than that of the project Bio-Fuel.

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:

>>

As specified in the methodology, the principal GHG reductions through the project are realized by many vehicles[10] utilizing the project BDF-ME. 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 (BDF-ME production facility),
- the project site,
- transportation to fuel-supply facility,
- fuel-supply facility, and
- all vehicles which utilizes the BDF-ME 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:

[10] The relevant vehicles are unspecified (*i.e.*, not monitored) each by each in the methodology, however, well-defined as 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.

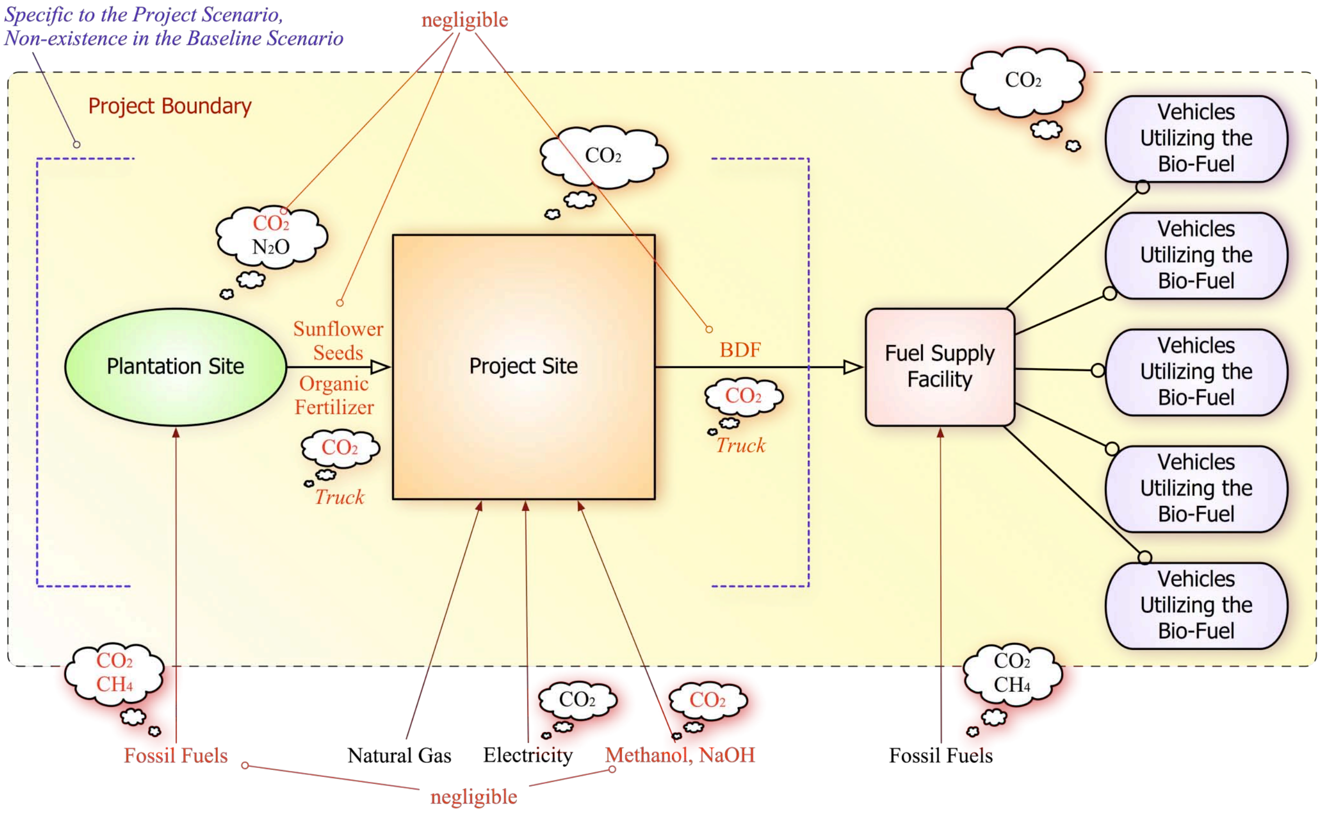

Figure PDD-7: Project Boundary and Associated GHG Emissions

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 BDF-ME in the PJS (CO_2 from fossil fuel use substituted by BDF-ME) *[substitution effect]*	• Exploitation, Refinement, Transportation of fossil fuels substituted by the Bio-Fuel [oil field/port/refinery/gas station] (CO_2, CH_4)[11]
	Negligible *or* Common (not monitored)	• Fuel supply facility (CO_2: common) • Each vehicle to utilize the BDF-ME in the PJS (N_2O from fossil fuel use)	n.a.

[11] 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)	• Each vehicle to utilize the BDF-ME in the PJS (CO_2 from non-bio C-content (originated in methanol) in the BDF-ME) • Project site (CO_2 from Natural Gas combustion) • Plantation site (N_2O from Fertilizer use)	• Power Plants linked to the grid (CO_2 from electricity used in the BDF-ME plant)
	Negligible *or* Common (not monitored)	• Transportation of BDF-ME, Sunflower seeds, and Organic fertilizer (CO_2) • Plantation site (CO_2 from Machinery use) • Each vehicle to utilize the BDF-ME in the PJS (CO_2 from fossil fuel contained in the Bio-Fuel;[12] common to BLS) (N_2O: negligible) • 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)[11] • Co-products outside of the boundary [transportation, *etc.*] (CO_2) • Commuter of the plant (CO_2)

It is noted that the BDF-ME plant does not combust feedstock in its production process.

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

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.

[12] In case that the BDF-ME is mixed with the petro-diesel, fossil-fuel-origin CO_2 is emitted from combustion of petro-diesel component. However, this emission is regarded as common for the BLS and PJS, therefore neglected.

- BDF-ME 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.
- BDF-ME consumption related information:
  Information related to the bio-diesel information in Thailand is provided as attachments.

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

- Emission factors
  Data/information is provided in Annex 3.
- Uncertainty analysis to identify negligible emission sources:
  Analysis is provided in Annex 3, including mean mileage information.
- 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:

Ms. Junko Tanaka
Sun Care Fuels Co.
tanaka@suncarefuels.com

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:

>>

01/07/2005.

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

>>

20 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:

>>

01/01/2008.

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. BF^{mass}_{y}	*BDF-ME sold or utilized in a certain year (in mass)*	*Weight meter*	*[ton-BioFuel]*	*m*	*daily*	*100%*	*electronic*	*Check against* BF^{Vol}_{y} *and fuel sales record. More accurate one is prioritized to be used.*
P2. $COEF^{FF}_{NG}$	CO_2 *emission factor of the natural gas combusted at the BDF-ME production plant*	*Provided by fuel supplier or statistics*	*[*tCO_2/m^3*-NG]*	*c*	*Once at the time of drafting the PDD*	*100%*	*electronic*	*Data obtained from natural gas supplier. If non-available, data specified in the IPCC GHG Inventory Guidelines is used. IPCC default: 15.3 tC/TJ*
P3. $PE^{Plantation}$_$N2O_y$	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
P4. $Fertilizer^{in}_{y}$	*fertilizer input to the plantation site*	*Weight meter*	*[ton-fertilizer]*	*m*	*monthly*	*100%*	*electronic*	*Checked against the fertilizer purchase receipt.*
P5. $UREA\_EQ^{in}$	*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*
P6. $FF^{BFP}_{NG,y}$	*Natural gas consumption at the BDF-ME production plant*	*Flowmeter*	*[*m^3/yr*]*	*c*	*Daily*	*100%*	*electronic*	*Checked against the sales record.*

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:

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

where

$FF^{BFP}_{NG,y}$: Natural gas consumption at the BDF-ME plant (in volume) [m^3/yr]

$COEF^{FF}_{NG}$: CO_2 emission factor of natural gas [tCO_2/m^3]

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

$COEF^{FS}$: CO_2 emission factor of the non-bio feedstock (methanol) contained in the BDF-ME [tCO_2/ton-BDF]
For this project, set as zero because no C contained in methanol remains in the BDF (*i.e.*, every C in methanol is transferred to glycerol).

$PE^{Plantation}\_N2O_y$: N_2O emissions from fertilizer use at plantation site (direct)

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

where

$Fertilizer^{in}_{y}$: fertilizer input to the plantation site [ton-fertilizer/yr],
$UREA\_EQ^{in}_{y}$: 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 1^{st} Commitment Period) [tCO_2eq/tN_2O]

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	*Bio-Fuel 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 Bio-Fuel*	*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 Bio-Fuel 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. $COEF^{FF}$	*Life-cycle CO_2 equivalent emission factor of the fossil fuel, which the Bio-Fuel 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). *Oxidization factor:* *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:

$$BE_y = BF_y * COEF^{FF} * (1 + \delta)$$

where

BF_y : BDF-ME 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 BDF-ME [ton/m^3]

HV_y: Thermal content of the BDF-ME per unit of mass [GJ/ton]

$COEF^{FF}$: Life-cycle CO_2 equivalent emission factor of the fossil fuel, which the BDF-ME 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 BDF-ME 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 BDF-ME. This is justified by the fact that both BDF-ME 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 Bio-Fuel 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 bio-based fertilizer*	-	*[tCO_2eq]*	*c*	*yearly*	*100%*	*electronic*	$BE\_N2O_y = BioFertilizer^{out}_y * UREA\_EQ^{out} * COEF\_N2O$

	(by-product of the Bio-Fuel)							* 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 BDF-ME 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 BDF-ME)

$= BioFertilizer^{out}_{y} * UREA\_EQ^{out} * COEF\_N2O * GWP\_N2O$ [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, P4, P6, B2, L1, L5	*Low*	*Check against the sales/purchase receipts/records.*
Measurable parameters at the Bio-Fuel plant	*Low*	*Management system is settled.*
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.

Every variable parameter with time dependence is to be depicted in a graph to avoid some human errors and/or accidental events.

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 on monitoring 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:

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

where

$FF^{BFP}_{NG,y}$: Natural gas consumption at the BDF-ME plant (in volume) [m^3/yr]

$COEF^{FF}_{NG}$: CO_2 emission factor of natural gas [tCO_2/m^3]

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

$COEF^{FS}$: CO_2 emission factor of the non-bio feedstock (methanol) contained in the BDF-ME [tCO_2/ton-BDF]

For this project, set as zero because no C remains in the BDF (*i.e.*, every C in methanol is transferred to glycerol).

$PE^{Plantation}\_N2O_y$: N_2O emissions from fertilizer use at plantation site (direct)

$= Fertilizer^{in}_{y} * UREA\_EQ^{in}_{y} * COEF^{Direct}\_N2O$ * GWP_N2O [tCO_2eq/yr]

where

$Fertilizer^{in}_{y}$: fertilizer input to the plantation site [ton-fertilizer/yr],
$UREA\_EQ^{in}_{y}$: 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]

In a typical year when BDF-ME is produced $15*10^3$ ton/yr, project emissions are estimated as:

$$\begin{aligned} PE_y = \; & 10.18 \text{ [TJ/yr]} * 15.3 \text{ [tC/TJ]} * (44/12) \text{ [tCO}_2\text{/tC]} \\ & + 28{,}350 \text{ [ton-fertilizer]} * 0.12 \text{ [ton-urea/ton-fertilizer]} \\ & \quad * 0.010 \text{ [tN}_2\text{O/ton-urea]} * 310 \text{ [tCO}_2\text{eq/tN}_2\text{O]} \\ = \; & (571 + 10{,}546) \text{ [tCO}_2\text{eq/yr]} \\ = \; & 11.1 * 10^3 \text{ [tCO}_2\text{eq/yr]} \end{aligned}$$

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

$FF^{BFP}_{NG,y}$: 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.

$Fertilizer^{in}_{y}$: 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:

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

where

EL_y : Electricity consumed at the BDF-ME 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 BDF-ME)

$= BioFertilizer^{out}_{y} * UREA\_EQ^{out} * COEF\_N2O * GWP\_N2O$ [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 1^{st} 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 BDF-ME is produced $15*10^3$ ton/yr, leakage is estimated as:

$$L_y = (4.6*10^3 \text{ [MWh/yr]}) * 0.64 \text{ [tCO}_2\text{/MWh]} / (1 - 0.03) - 0 + 0$$

$$= 3.0 * 10^3 \text{ [tCO}_2\text{/yr]}$$

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

EL_y : Estimated from BDF-ME plant design, while measured *ex post*.

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

$COEF^{EL}_y$: Calculated by using EGAT's data (see Annex 3 for calculation).
Calculated every year using the latest information *ex post*.
Confirmation letter of no existence of the Build Margin component will be obtained as a signed letter from EGAT (staff responsible for power development).

$Loss_y$: Data obtained from EGAT'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 BDF-ME is produced $15*10^3$ ton/yr, total project emissions are estimated as:

$$PE^{tot}_y = 14.7*10^3 \ [tCO_2eq/yr]$$

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:

$$BE_y = BF_y * COEF^{FF} * (1 + \delta)$$

where

BF_y : BDF-ME 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 BDF-ME [ton/m^3]

HV_y: Thermal content of the BDF-ME per unit of mass [GJ/ton]

$COEF^{FF}$: Life-cycle CO_2 equivalent emission factor of the fossil fuel, which the BDF-ME 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 BDF-ME 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 12% 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. This is justified by the fact that both BDF-ME and petro-diesel has similar molecular structure with long chain hydrocarbon, therefore no significant difference for combustion mode in engine.

In a year when BDF-ME is produced $15*10^3$ ton/yr, baseline emissions are estimated as:

$$BE_y = BF_y * COEF^{FF}$$
$$= 15*10^3 \text{ [ton-BDF/yr]} * 0.89 \text{ [ton-Diesel/ton-BDF]} * 3.21 \text{ [tCO}_2\text{/ton-Diesel]} * 1.12$$
$$= 48.0*10^3 \text{ [tCO}_2\text{/yr]}$$

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

BF_y : Set as $15*10^3$ ton/yr as an assumption converted to [GJ/yr] by using the thermal content of BDF-ME, 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 Thai statistics/information at a later stage) corrected by LCA assessment which is 10% 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 BDF-ME is produced $15*10^3$ ton/yr, emission reductions are estimated as:

$$ER_y = 33.2 * 10^3 \text{ [tCO}_2\text{eq/yr]}$$

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

>>

Estimated amount of emission reductions is around 3.38×10^4 tCO_2/yr for typical year, or equivalent to 3.32×10^5 tCO_2 over the 10-year crediting period.

Provisional calculation is shown below:

year	Plantation Area [ha]	Sunflower Seeds [t/yr]	Sunflower Oil [t/yr]	BDF-ME [t/yr]	$Fertilizer^{in}_{y}$ [t/yr]	$FF^{BFP}_{NG,y}$ [TJ/yr]	EL_y [MWh/yr]	PE_y [tCO_2eq/yr]	BE_y [tCO_2eq/yr]	L_y [tCO_2eq/yr]	ER_y [tCO_2eq/yr]
2006	18,000	36,000	13,320	12,000	22,680	8.14	3,680	8,437	38,397	2,428	**27,532**
2007	22,500	45,000	16,650	15,000	28,350	10.18	4,600	11,117	47,996	3,035	**33,844**
2008	22,500	45,000	16,650	15,000	28,350	10.18	4,600	11,117	47,996	3,035	**33,844**
2009	22,500	45,000	16,650	15,000	28,350	10.18	4,600	11,117	47,996	3,035	**33,844**
2010	22,500	45,000	16,650	15,000	28,350	10.18	4,600	11,117	47,996	3,035	**33,844**
2011	22,500	45,000	16,650	15,000	28,350	10.18	4,600	11,117	47,996	3,035	**33,844**
2012	22,500	45,000	16,650	15,000	28,350	10.18	4,600	11,117	47,996	3,035	**33,844**
2013	22,500	45,000	16,650	15,000	28,350	10.18	4,600	11,117	47,996	3,035	**33,844**
2014	22,500	45,000	16,650	15,000	28,350	10.18	4,600	11,117	47,996	3,035	**33,844**
2015	22,500	45,000	16,650	15,000	28,350	10.18	4,600	11,117	47,996	3,035	**33,844**
Sum	220,500	441,000	163,170	147,000	277,830	99.76	45,080	108,492	470,360	29,744	**332,124**
Average	22,050	44,100	16,317	14,700	27,783	9.98	4,508	10,849	47,036	2,974	**33,212**

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:

Sunflower plantation

The plantation is to utilize unused land area with improvement and maintenance of the farm field. Therefore, we see no negative impacts.

In addition, residue of BDF-ME production feeds back to the plantation site as high quality organic fertilizer; recycling of natural resources is accomplished.

BDF-ME production

Glycerin, a by-product of the BDF-ME, 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 Thailand is to be assessed against the predicted wastewater quality of the BDF production facility. Compliance with the regulation will be shown by the data of wastewater quality. To be elaborated later.

BDF-ME consumption

BDF-ME 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.

The data concerning the air quality comparison to the petro-diesel will be provided.

In Thailand, air pollution issue is getting worse. The Government promotes alternative fuels in order to comply with the environmental target, which is almost the same level as EU nowadays. Around 80% of the automobile fuels is petro-diesel, BDF-ME is surely contribute to decrease air pollution in Thailand.

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 confirmed at 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

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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

Natural Gas ($COEF^{FF}_{NG}$):

In Section E, provisional emission factor is calculated by using the default factor IPCC GHG Inventory Guidelines.

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.

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

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

It is recommended to obtain $COEF^{EL}_{,y}$, by using the calculation method (Operating Margin) of ACM0002. Since there are no public data available and accessible for load dispatch, “Simple OM” method (weighted average of power plants connected to the grid excluding low-cost/must-run plants) is applied (as a conservative estimation).

Details of the calculation is shown below:

Emission Factor Calculation (Simple OM) by using Energy Consumption in Electricity Generation in 2003 (EGAT Power Development Plan 2004)

	Electricity Generation		Fuel Consumption			Emission Factor (IPCC)		Oxidization	CO_2 emissions	Emission Factor
	Ratio (%)	(GWh/yr)		unit	(kton/yr)	(tC/TJ)	(TJ/kton)	factor	($MtCO_2$/yr)	($ktCO_2$/kWh)
Hydro	8.7%	10,180								
Natural Gas	71.5%	83,500	1,895	MMSCFD/yr	15,151	15.3	52.3	99.5%	44.23	0.530
Heavy Oil	1.8%	2,150	533	Mlitre/yr	517	21.1	42.0	99.0%	1.66	0.774
Diesel	0.0%	45	12	Mlitre/yr	10	20.2	43.3	99.0%	0.03	0.720
Lignite	14.7%	17,134	16	Mton/yr	16,000	12.1	27.6	98.0%	19.26	1.124
Imported Coal	2.2%	2,526		not specified		26.4	28.7	98.0%	2.39	0.948
Renewable	0.9%	1,103								
EGAT-TNB	0.1%	105								
Total	100.0%	116,743								**0.641**

[Note] The data includes plants under EGAT, EGCO, RATCH, IPP, SPP, Lao PDF (hydro)
Carbon emission factor for coal and lignite are Thai specific values from IPCC God Practice Guidance
"Heavy oil" is regarded as "residual fuel oil" in the IPCC category
CO_2 emissions from imported IPP/SPP coal powers are calculated by assuming electricity generation efficiency is 36%, which is calculated by using the IEA "Energy Balances" (2002 data; autoproducer electricity by coal)

Outline of the Investment Analysis

Summary of the spreadsheet is shown below. Detailed sheets are attached to the PDD.

[unit] million yen		2006	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	2018	2019	2020
Calculation for Investment Analysis																
Cash Flow after Tax		-	-11	83	112	113	114	115	115	116	117	117	118	-10	-10	-10
Accumulated Cash Flow after Tax [S]		-	-11	72	185	298	412	526	642	758	874	992	1,110	1,100	1,090	1,080
[S] - Invested Capital		-1,000	-1,000	-950	-900	-850	-800	-750	-700	-650	-600	-550	-500	-500	-500	-500
[IRR] (excl. interest, incl. tax)													3.78%			
[IRR] (incl. interest, incl. tax)													**1.58%**			
Amortization of Deferred Assets:	10 years			Start of the Crediting Period									End of the Crediting Period			

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: 48 ktCO_2/yr

Project emissions: 13 ktCO_2/yr (fertilizer-related N_2O: 10 ktCO_2/yr)

Leakage: 3 ktCO_2/yr

In the first origin, the amount of BDF-ME sold is measured with less than 1% error, while fuel efficiency gap may be the same order of the baseline emissions (~ 0.5 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 (~2 ktCO_2eq/yr).

Therefore, if the level of some emission source is much less than 1 ktCO_2/yr, it can be neglected.

For minor emissions:

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

Rough estimation shows that

[medium-size tractor (20 ps) is used twice (seeding and harvesting)]

CO_2 emissions are roughly 150 tCO_2/yr. This amount is not significant, thus neglected.

(b) Sunflower seeds and fertilizer transportation

Rough estimation shows that

[15 ton truck with 0.77 kgCO_2/km, 50 km distance, 45 kton-seed/yr (28.5 kton-fertilizer/yr)]

CO_2 emissions of the above situation are roughly 230 tCO_2/yr. This amount is not significant, thus neglected.

(c) BDF-ME transportation

Transportation of BDF-ME is much smaller than that of seeds and fertilizer, thus neglected.

(d) Methanol production and (minus of) Glycerin production

This results to the higher order infinitesimal correction factor[14] than the case where C-component of the feedstock is transferred to the bio-fuel stoichiometrically.

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

[14] C-component in the methanol is less than 10% of the total emission reductions, if such effect is assumed to be included in the calculation of emission reductions. Therefore, leakage effect due to methanol production and glycerin production can be regarded as the order of 1%.

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.

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;
- 12% is a conservative estimation taking the numbers specified in the studies and shorter distance of Thailand from Gulf than Japan.

Unit ($t\text{-}CO_2/TJ$) / 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 ($t\text{-}CO_2/TJ$)	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.

Therefore, we set +12% as the emission factor adjustment to include life-cycle effects.

The non-refinery processes such as production stage and transportation stage emissions are basically consistent among the studies.

Mean Mileage Information Related to BDF-ME and Petro-Diesel

It is not easy to measure the mean mileage difference between petro-diesel and (some mixture) of the BDF-ME 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 BDF-ME and petro-diesel has similar molecular structure with 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

This monitoring plan includes several aspects not specified in the Section D for accurate monitoring of data to calculate emission reductions *ex post*:

Monitoring management system:

Based on the ISO9000 management system, the management system for monitoring is to be established. Internal auditing system is included in the management system.

Procedures for data collection:

For monitoring of each parameter, procedures are to be established to minimize errors and keep consistency in the data series.

Format for data reporting:

After collecting the data of each parameter, they are compiled and analyzed in a spreadsheet to calculate emission reductions as well as to check the consistency of the data.

Monitoring points:

The points where the parameters are monitored are to be specified.

For these purposes, training programme will be established before implementation of the project.

Details of the above are provided as a manual for monitoring after establishment of technical as well as personnel specification of the project.

- - - - -