# FISCAL 2005 CDM/JI PROJECT STUDY: PROVISIONAL REPORT SUMMARY VERSION

# UTILISATION OF BIOMASS AT PALM OIL MANUFACTURING FACTORIES IN SABAH, MALAYSIA

**Hokkaido Electric Power Co., Inc.**

## 1. Basic Elements Concerning Project Implementation

(1) Outline of the Proposed Project and Background of the Planning

○ Outline of the Proposed Project

The project, which targets a palm oil factory in Sabah, Malaysia, proposes to make effective use of palm oil mill effluent (POME) that is discharged from the said factory, with a view to generating electricity from biogas. The POME is currently treated in an aerobic and anaerobic open lagoon method, and biogas containing methane gas ($CH_4$) is discharged from the anaerobic open lagoons into the atmosphere. In the project, a closed methane fermentation system will be introduced in order to collect this $CH_4$, use it as the raw material (fuel) for generating electricity, and sell the said electricity to Sabah Province Electric Corporation (SESB). Figure 1 shows the conceptual diagram of the project activities.

As a result, the project will reduce emissions of methane gas discharged from anaerobic open lagoons; moreover, through connecting generated power to the grid, it will have a carbon dioxide ($CO_2$) emissions reduction effect by offering a substitute for energy from thermal power plants owned by SESB. Furthermore, in line with the alteration in the treatment method, the POME purification effect will be strengthened, thereby leading to an improvement in the local river environment.

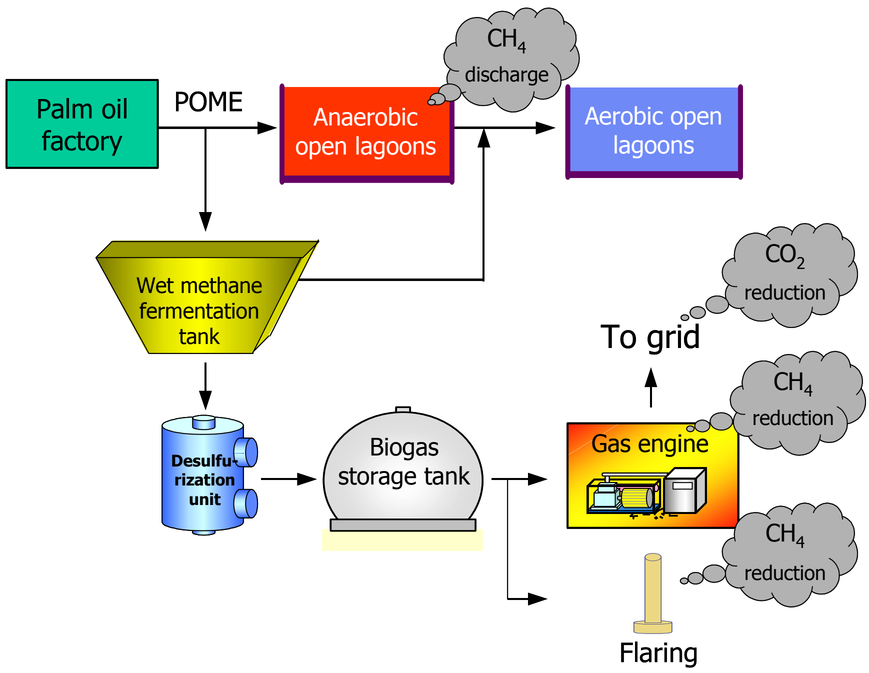


Figure 1 Conceptual Diagram of the Project Activities

○ Background of the Planning

One of the main industries of Malaysia is the palm oil industry; indeed Malaysia is the world's number one producer in this sector. There are more than 300 palm oil factories throughout Malaysia, and approximately 110 of these are located in Sabah Province, making it one of the most prosperous palm oil producing areas in the country. POME, which is generated in the palm oil refining process at these factories, is discharged into rivers after undergoing purification treatment. However, even though the Malaysian government controls the river discharge of POME, the river environment in the country is badly deteriorated and is a source of major concern.

There are a number of methods for treating POME from palm oil factories, however, the open lagoon method is adopted at more than 90% of factories because of its advantages in terms of cost and maintenance. Open lagoons are broadly divided into anaerobic open lagoons and aerobic open lagoons, and biogas containing $CH_4$ is discharged into the atmosphere during treatment in the former type. Since $CH_4$ has a global warming potential 21 times greater than carbon dioxide, reducing the amount of discharged biogas is an important means of preventing global warming. A further problem arising from biogas is its odor, which has a negative impact on the living environment of nearby residents and the working environment of factory workers.

Since the $CH_4$ contained in biogas can be utilized as a renewal energy, it is desirable to see the effective utilization of biogas that is discharged from palm oil factories.

○ Project Site Selection

Lumadan Factory, shown in Figure 2, was selected as the project site in consideration of the following points. This factory, one of eight owned by the project counterpart Sawit Kinabalu Co., was selected because the treatment process in its palm oil mill is standardized and because this factory promises higher profitability than the others based on the results of profitability assessment at representative factories.

Access to the factory is good. This makes it advantageous for carrying in materials when implementing surveys and construction work, and also for implementing management following project implementation.

Lumadan factory is located around 100 km southwest of the provincial capital Kota Kinabalu, which has the province's sole international airport, and it has the best access conditions out of all the factories owned by Sawit Kinabalu.

The factory is located close to the electricity grid, which is advantageous for selling the electric energy that will be generated in the project.

Since palm oil factories are usually constructed near plantations, in order to reduce the costs of transporting palm raw materials, they are remote from inhabited areas and electricity grids. Out of more than 200 palm oil factories located in western Malaysia (Malay Peninsula), only around 20 are situated within 20 km of a substation. Moreover, whereas the household electrification rate in Western Malaysia as of 2000 is 100%, this is only 79% in Sabah Province, indicating that the grid installation situation here is inferior to the rest of the country. Accordingly, it is inferred that the grid environment around palm oil factories in this province is not good.

In these circumstances, Lumadan facory is located approximately 17 km from the nearest substation, giving it an advantage over other factories in terms of grid linkage.


Figure 2　Project Site Location Map

(2) Outline of the Host Country

The Malaysian economy recorded negative actual GDP growth of minus 7.4% in 1998 due to the effects of the 1997~1998 Asian economic crisis; however, it recovered to show positive growth of 5.8% in 1999 and 8.5% in 2000. After this, product exports declined and economic growth again slowed to 0.4% in 2001 as a result of the global economic slowdown; however, thanks to adoption of a new economic package consisting of fiscal policy expansion and promotion of consumption, it again recovered to 4.1% in 2002.

The main industry that supports the economy of Malaysia is the palm oil industry; indeed Malaysia is the world's number one producer in this sector. Palm oil, a vegetable oil made from oil palm, is widely used as the raw material for margarine and as the cooking oil for snack foods, etc.

(3) Local Policies Regarding CDM/JI, i.e. Criteria for CDM/JI Acceptance and DNA Establishment, etc.

○ Policy and conditions regarding CDM

Among countries of Southeast Asia, Malaysia has one of the most advanced systems for accepting CDM. It ratified the Framework Convention on Climate Change in July 1994 and the Kyoto Protocol in March 1999. In September 2002, the Ministry of Natural Resources and Environment was recognized as the country's DNA, and the Malaysian government approved CDM criteria in August 2003.

Latest information regarding CDM criteria and approval setup in Malaysia can be found on the homepage (http://www.ptm.org.my) of PTM, which is the window agency for CDM projects in the energy sector. A summary of the said information in Japanese can be found on the web site of the Kyoto Mechanism information platform.

○ Recent trends

As of December 20, 2005, the Government of Malaysia has approved five CDM projects, respectively invested in by Japan (two projects), Denmark (2 projects) and France (1). These include projects that propose to generate energy from EFB (empty fruit bunch) in the palm oil industry, however, none of them propose to utilize POME like in the project.

Concerning approval by the Malaysian government for cases where only treatment by flaring is conducted in a methane gas recovery project, there hasn't been a precedent so far, however, a PIN has been submitted and discussions are currently in progress in the technical committee, so the government stance on this matter should become clear in the near future. Moreover, during the hearing survey with the DNA, we were told that there is a strong possibility the project will receive approval because there is no reason to deny flaring treatment provided that the positive impacts on environmental improvement and sustainable development are clearly specified.

(4) Project Contribution to Sustainable Development and Technology Transfer in the Host Country

○ Points contributing to sustainable development

① Improvement of the river environment
② Improvement of odor from the anaerobic open lagoons
③ Reduction in generated amount of sludge
④ Ripple effect as an environmental improvement project
⑤ Employment creation as a result of project actualization (construction and operation)
⑥ Diversification of energy resources
⑦ Effective utilization of energy

○ Transfer of technology

① Technology concerning methane fermentation
② Technology concerning biogas power generation

(5) Implementation Setup of the Study

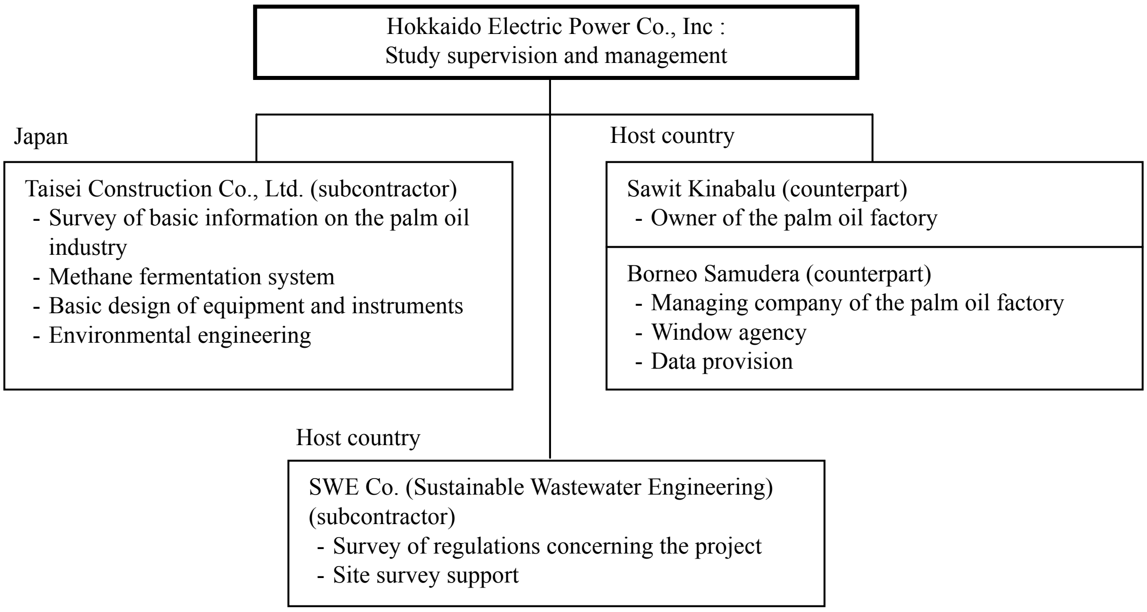


Figure 3 Implementation Setup of the Study

## 2. Project Formulation

(1) Specific Contents of the Project

○ Project site

Lumadan factory has an FFB treatment capacity of 45 t/h, although the treatment scale has been designed as 90 t/h in expectation of increased FFB harvest in the future. Land around the factory is owned by Sawit Kinabalu. Factory workers live in close proximity to the plant, however, there are no general residents living within 3 km of the factory.

○ Future FFB harvest plan

The plantation belonging to Lumadan factory is due for replanting, and Sawit Kinabalu has plans to expand the planted area in order to stabilize the FFB harvest. Table 1 shows the FFB harvest plan of Lumadan factory. Incidentally, since there are no specific harvest plans for 2015 onwards, in this study it is assumed that the FFB yield in 2014 will be maintained.

Table 1　FFB Harvest Plan of Lumadan Factory

| Year | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|
| FFB harvest (t) | 195,000 | 180,776 | 207,436 | 253,541 | 273,541 |
| Year | 2011 | 2012 | 2013 | 2014 | 2015 onwards |
| FFB harvest (t) | 303,028 | 322,309 | 337,901 | 344,268 | 344,268 |

○ Composition of POME

Concerning the chemical oxygen demand (COD) of POME discharged from the factory, Kyushu Industrial University is currently conducting international industrial-academic joint research with Malaysia Putra University and FELDA Co. at the Serting Hilir plant of FELDA Co. in southern central Malaysia, and as a result of conducting a hearing survey of this research, we found that the COD of POME discharged from the factory ranges between 30,000 ppm and 90,000 ppm, varying according to the FFB composition. Moreover, various sources give 50,000 ppm as a representative value.

Meanwhile, as a result of two water quality surveys that were implemented in Lumadan factory, the COD was measured as approximately 20,000 ppm (18,964 ppm and 22,736 ppm), which was roughly 60% lower than the generally accepted value. Upon conducting a number of hearing surveys, we found that POME treatment processes in palm oil factories consist of either the centrifuge method or the decanter method and that the COD is lower due to the differences between these methods.

The centrifuge method of treatment has been conventionally used and is characterized by lower equipment costs compared to the decanter method. The decanter method is a newer approach that entails higher equipment costs, however, because it allows part of the sludge contained in POME to be removed during the treatment process, it has the feature of allowing for easier open lagoon maintenance. Since both approaches have their advantages and disadvantages, they are adopted according to the conditions of establishment at each factory.

Lumadan factory adopts the decanter process, and it is thought that the COD of POME removed to the open lagoons is low because part of the sludge content is removed beforehand. Furthermore, in order to confirm the water quality survey results, water quality analysis was implemented at two other plants belonging to Sawit Kinabalu that also adopt the decanter method. As a result, COD was found to be 21,560 ppm at Kunak factory and 23,280 ppm at Langkon factory, i.e. more or less the same as at Lumadan factory.

○ Setting of the Project Case

Since the COD of POME from Lumadan factory is approximately 20,000 ppm, far lower than the originally projected figure of 50,000 ppm, there is a possibility that profitability will suffer in the project. Accordingly, as is shown in Table 2, the commercial viability was assessed for three cases assuming differing COD values.

In Case 1 it was assumed that the project is implemented using POME in its current state at Lumadan factory (COD = 20,000 ppm). In Case 2, it was assumed that sludge extracted during treatment processes inside Lumadan factory is added to the POME from the factory for use as raw materials in the methane fermentation system. In other words, by reutilizing the sludge that is once removed, the COD value of the POME raw materials in the methane fermentation system is raised to the originally anticipated value of 50,000 ppm. In Case 3, it was assumed that the project is implemented at a factory comprising the same scale (POME COD = 50,000 ppm) as Lumadan but utilizing the centrifuge treatment method.

Table 2 Project Cases

| Case | COD(ppm) of POME discharged from the factory | COD(ppm) of POME put into the methane fermentation system |
|---|---|---|
| 1 | 20,000 | 20,000 |
| 2 | 20,000 | 50,000 |
| 3 | 50,000 | 50,000 |

○ New Wastewater Treatment Equipment

Figure 4 shows the conceptual flow of the new wastewater treatment equipment. POME discharged from the grid pond enters the new anaerobic ponds, where it is retained for 10 days. During this retention period, anaerobic fermentation causes biogas containing $CH_4$ to be generated together with sludge, and this has the effect of reducing COD through consuming the organic content of POME.

A cover is placed over the surface of the anaerobic ponds to prevent contact with the atmosphere. After biogas generated inside the anaerobic ponds has accumulated under the cover, it is removed from the system and sent to the flare stack or generator. Liquid inside the anaerobic pond is recirculated by circulatory pump. At this time, since sludge at the bottom of the tank is stirred up as suspended solids, it comes into contact with the POME and further enhances the anaerobic fermentation effect. Part of the circulating liquid is removed from the circulating line and conveyed to the adjoining anaerobic pond. After repeating this procedure a number of times, the treated effluent leaves the final anaerobic pond and enters the aerobic pond in the next process.

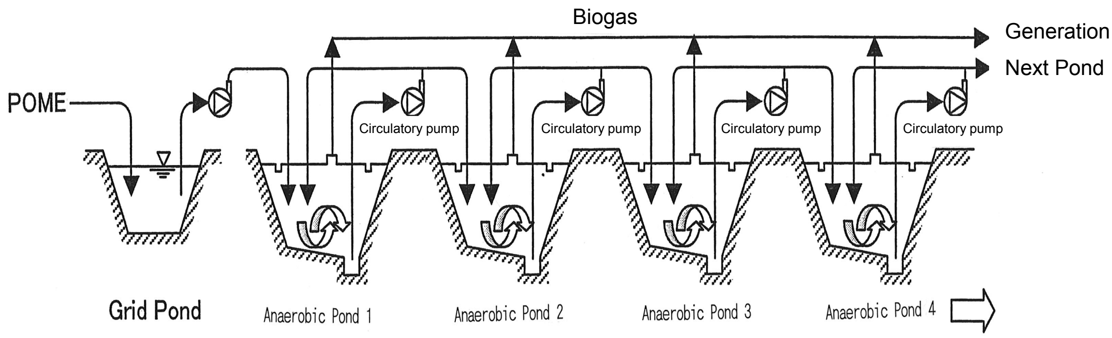


Figure 4　Conceptual Flow of the New Wastewater Treatment Equipment

(2) Setting of the Project Boundary and Baseline and Demonstration of Additionality

○ Methodology

AM0013 is considered to be the approved methodology that can be applied to the project. Since its predecessor, NM0038, has been established as the methodology for other biomass power generation projects utilizing POME from palm oil factories in Malaysia, AM0013 is considered to have high applicability to the project. Incidentally, the contents of this methodology were partially revised in May 2005.

Table 3 shows the applicability of the project in comparison to the applicable conditions of this methodology. As is shown in the table, because the project satisfies all the applicable conditions for AM0013 Version 02, this methodology shall be adopted in the project.

Table 3　Applicable Conditions for AM0013. Version 02 and the Project

| No. | Applicable Conditions for AM0013. Version 02 | Applicability of the Project |
|---|---|---|
| 1 | The existing wastewater treatment system is an open lagoon system with an 'active' anaerobic condition, which is characterized as follows: | In the project, each condition is satisfied as indicated below: |
| | ①The depth of the open lagoon system is at least 1 m. | ①Depth is 5 m. |
| | ②The residence time of the sludge in the open lagoons should be at least one year. | ②The sludge residence time is around 4 years. |
| | ③The temperature of the sludge in the open lagoons is always at least 15°C. | ③The sludge temperature is 25℃ or more. |
| 2 | The methodology applies to forced methane gas extraction project cases, as there is a process change from open lagoon to accelerated methane gas generation in a closed tank digester or similar technology. | Since the project entails promoting methane fermentation through switching from present open lagoons to a closed treatment system, it satisfies this condition. |
| 3 | The captured methane is used for electricity generation, which avoids emissions due to displaced fossil fuels in the power grid. | Since captured methane is used for power generation in the project, this condition is satisfied. |
| 4 | Power generation capacity is 15 MW or less. | Since the power generation capacity in the project is around 1 MW, this condition is satisfied. |

○ Project boundary

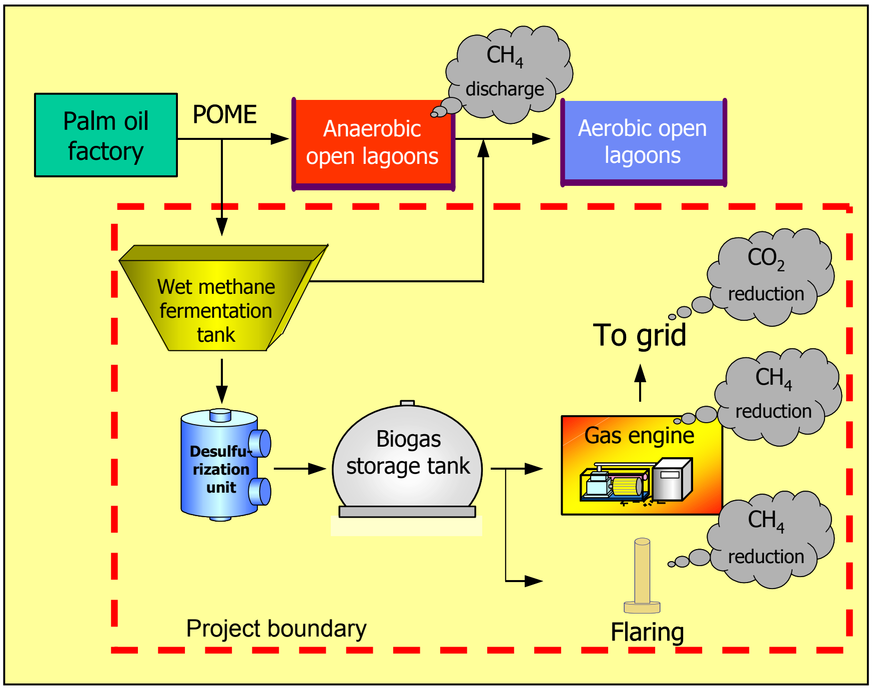


Figure 5　Project boundary

○ Tool for Baseline Setting and Demonstration of Additionality

In the approved methodology AM0013 Version 02, two options are given as the tool for baseline setting and demonstration of additionality. The methodology in Option A is expressed in the flowchart shown in Figure 6, whereas Option B is the latest tool out of the tools for the demonstration and assessment of additionality approved by the CDM Board. In the project, since the baseline setting method is clear, Option A has been adopted. Referring to the flowchart, the items pertaining to baseline setting are ①~⑤. Table 4 shows the results of examining each item in terms of the project. Both the diagram and the table conclude that the baseline for the project is the adoption of anaerobic open lagoons, i.e. maintenance of business as usual.

Table 4　Examination Results concerning Baseline Setting

| Examination Item | The Project | |
|---|---|---|
| ①Are anaerobic open lagoons used? | Yes | Anaerobic open lagoons are used. |
| ②Are recent environmental standards satisfied? | Yes | It is managed by the Sabah Department of Environment (DOE) of the Ministry of Natural Resources and Environment and satisfies environmental standards. |
| ③Is there likelihood of environmental standards being strengthened in future? | Yes | The DOE has plans to strengthen wastewater standards in future. |
| ④Can environmental standards be satisfied through increasing the number of open lagoons? | Yes | The environmental standards can be satisfied by increasing the number of open lagoons. |
| ⑤Is there enough land to increase the number of open lagoons? | Yes | Since Sawit Kinabalu also owns land around the factory, the number of open lagoons can be increased. |

Out of the items shown in the flowchart in Figure 6, those pertaining to the demonstration of additionality are ⑥ and ⑦. In the figure, “An additionality demonstration tool of the CDM Board” is stated, however, AM0013 Version 02 gives no specific explanation of how that is applied. The same methodology explains that ⑥ needs to be demonstrated through using IRR and NPV, etc. Concerning ⑦, it specifically states that it is necessary to explain there are no similar projects being implemented in the host country. Since the commentaries given for ⑥ and ⑦ are the same as Step 3 (economic analysis) and Step 4 (analysis of practices) of the CDM Board’s additionality demonstration tool, additionality in the project was demonstrated assuming that the “additionality demonstration tool of the CDM Board” in the diagram proposes examination of ⑥ and ⑦.

| |
|---|
| ⑥ Are the power sale revenue and fossil fuel substitution effect insufficient to upgrade the wastewater treatment method? |

Out of the investment analysis in the CDB Board’s “Tool for the demonstration and assessment of additionality,” analysis in the project was implemented using benchmark analysis assuming there is revenue from the sale of power in addition to CERs. As the benchmark here, interest on long-term government bonds in Malaysia was adopted.

In the project, the IRR based on power sales alone (no revenue from CERs) is less than 0.3% at maximum. Meanwhile, since the rate of interest on long-term government bonds is 4.21% (average value as of December 2005), revenue from power sales alone is insufficient to upgrade the wastewater treatment method.

| |
|---|
| ⑦ Is BAU different from the project case? |

There is no evidence to suggest that a similar project (relying on a broadly similar technology, of a similar scale, and taking place in a comparable environment with respect to the investment climate and access to technology) has been, is being, or will be implemented in Malaysia excluding CDM projects.

In consideration of the above points, the project is additional.

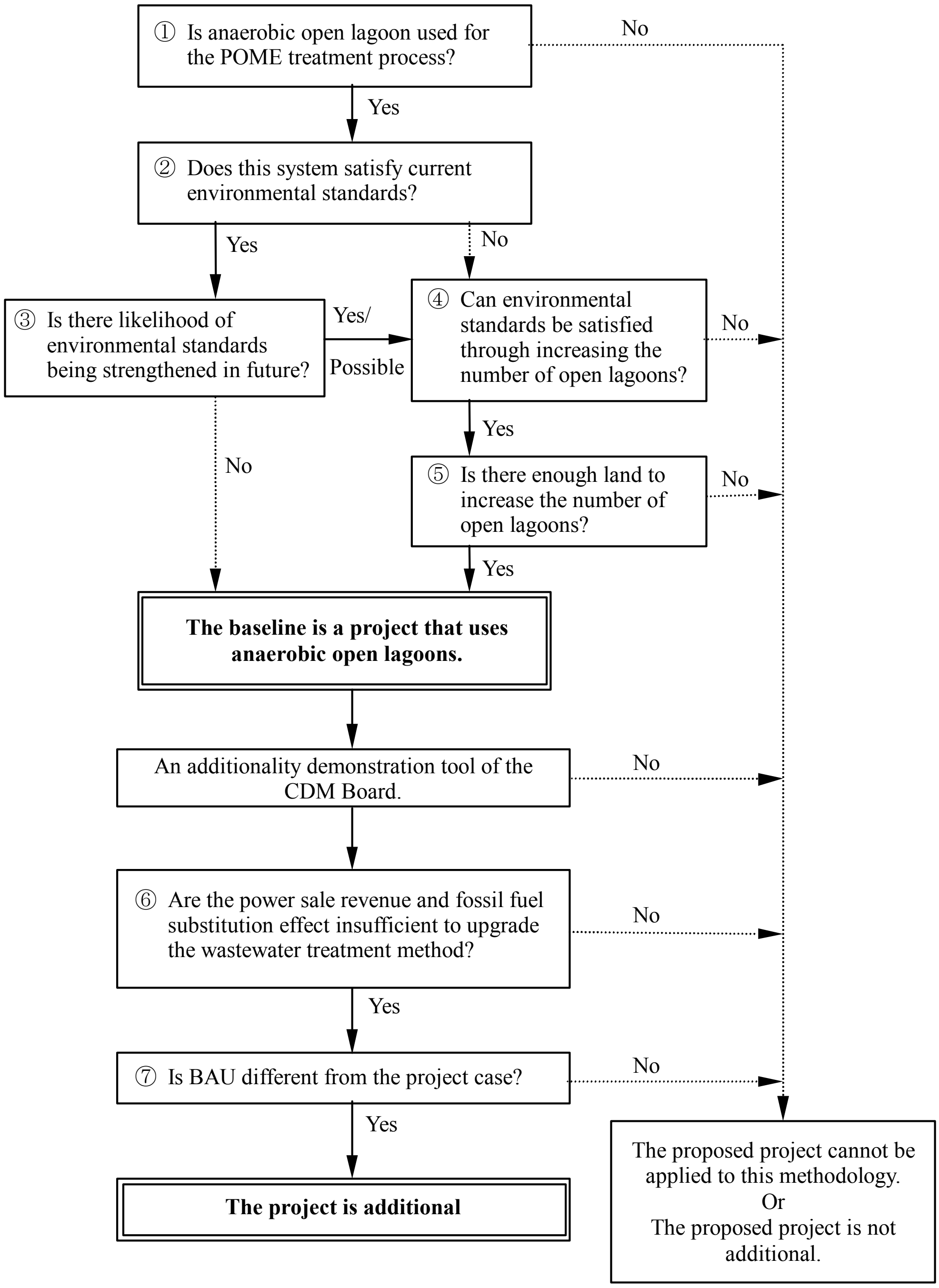


Figure 6 Flowchart of the Tool For Setting the Baseline and Demonstrating Additionality

(3) GHG Reductions and Leakage Resulting from Project Implementation

○ Target Greenhouse Gases

Table 5 List of Greenhouse Gases Accompanying the Project Activities

| | Source | Greenhouse Gas | |
|---|---|---|---|
| Baseline scenario | Wastewater treatment facilities (open lagoons) | $CH_4$ | Targeted (D) |
| | | $CO_2$ | Not targeted because this is carbon neutral |
| | Grid power | $CO_2$ | Targeted (E) |
| | | $N_2O$ | Not targeted out of the conservative viewpoint |
| Project scenario | Wastewater treatment facilities (existing open lagoons) | $CH_4$ | Targeted (A) |
| | | $CO_2$ | Not targeted because this is carbon neutral |
| | Wastewater treatment facilities (closed treatment facilities) | $CH_4$ | Targeted (B) |
| | Gas storage tanks | $CH_4$ | Not targeted because generated quantities are negligible. *However, monitoring will be conducted and it will be counted if the generated amount of GHG exceeds 1% of total GHG reductions. (C) |
| | Fossil fuel consumption at startup time | $CO_2/N_2O$ | |

○ GHG Emissions Resulting from Project Implementation

(A) Methane gas emissions from the open lagoons:

$PE_{y1} = COD_P \times Bo \times MCF \times GWP_{CH4}$ ............................................................ Formula 1

$PE_{y1}$ : Methane gas emissions from the open lagoons ($kgCH_4/yr$)

$COD_P$ : Chemical oxygen requirement (measured value) at the open lagoon inlet (fermentation tank outlet) (kgCOD/yr)

Bo : Maximum methane generation coefficient ($kgCH_4/kgCOD$) = 0.238 $kgCH_4/kgCOD$

MCF : Methane conversion factor (－) = 0.97

$GWP_{CH4}$ : Global warming potential = 21 (according to the IPCC)

Concerning $COD_P$, measured values taken after project implementation will be used. Meanwhile, $COD_P$ was calculated using the following method in order to examine commercial viability in the project:

$COD_P = COD_X \times FFB_y \times PCF \times (1 - RER)$ ..................................................Formula (2)

CODx : COD value per $1m^3$ of POME ($kgCOD/m^3POME$*)

FFBy : Annual treated amount of FFB (tFFB/yr)

PCF : Generated amount of POME per 1t of treated FFB (m3POME/tFFB)

RER : COD removal efficiency (=0.90)

Concerning PCF, this is calculated using the following formula:

PCF = CFF×2.5 ....................................................................................Formula (3)

CFF : Refine CPO per 1t of treated FFB (tCPO/tFFB)
(= 0.212 tCPO/tFFB)

PCF : Discharged POME per 1t of refined CPO ($m^3$POME/tCPO)
(= 2.5 $m^3$POME/tCPO)

(B) $CH_4$ emissions from the methane fermentation system

In the project, since it is also planned to introduce a flaring system so that $CH_4$ can be combusted even when the generator is stopped, leakage of $CH_4$ from the methane fermentation system will be extremely small. However, since it cannot be denied that there will be some leakage from the system itself, it is assumed from a conservative standpoint that there will be emissions equivalent to 5% of the $CH_4$ (＝$PE_{y2}$) that is collected when the project is underway. Moreover, a similar value is also adopted in the PDD for NM0085 “Vinasse Anaerobic Treatment Project - Compañía Licorera de Nicaragua, S. A. (CLNSA).”

(C) $CO_2$ emissions from the methane fermentation system

Concerning quantities of $CO_2$ emissions from the methane fermentation system starting power source, since $CH_4$ leakage from the system and $CH_4$ emissions in exhaust gas are very small, they are considered to be negligible. However, these will be monitored and, if they amount to more than 1% of the annual CER quantity, they will be counted as target gases in the project.

As an example of the calculation results, Table 6 shows the results for Case 2.

Table 6 GHG Emissions in Line with the Project Activity ($tCO_2$/yr): Case 2

| No. | Item | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Open lagoons | 2,665 | 3,257 | 3,514 | 3,893 | 4,141 | 4,341 | 4,423 | 4,423 |
| 2 | Methane fermentation system | 1,199 | 1,466 | 1,581 | 1,752 | 1,863 | 1,954 | 1,990 | 1,990 |
| 3 | Backup power source | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total (=PEy) | | 3,864 | 4,723 | 5,096 | 5,645 | 6,004 | 6,295 | 6,413 | 6,413 |
| No. | Item | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
| 1 | Open lagoons | 4,423 | 4,423 | 4,423 | 4,423 | 4,423 | 4,423 | 4,423 | 4,423 |
| 2 | Methane fermentation system | 1,990 | 1,990 | 1,990 | 1,990 | 1,990 | 1,990 | 1,990 | 1,990 |
| 3 | Backup power source | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total (PEy) | | 6,413 | 6,413 | 6,413 | 6,413 | 6,413 | 6,413 | 6,413 | 6,413 |

○ GHG Emissions at the Baseline

(D) Methane gas emissions from the open lagoons:

Methane emissions from the open lagoons in an anaerobic environment are calculated using the following formula:

$$BE_{OLy} = PE_{y1} = COD_B \times Bo \times MCF \times GWP_{CH4}$$

(E) $CO_2$ emissions from fossil fuels equivalent to the sold amount of electricity

$CO_2$ emissions from fossil fuels equivalent to the sold amount of electricity are calculated based on Option 1 in AM0013.Version 02 using the mean value across all grid power sources for the discharge coefficient. The following formula is used:

$$BE_{Ey} = EG_y \times EF_E$$

$BE_{Ey}$ : $CO_2$ emissions from fossil fuels equivalent to the sold amount of electricity ($tCO_2$/yr)

$EG_y$ : Sold amount of electricity (MWh/yr)

$EF_E$ : Mean $CO_2$ discharge coefficient across all SESB power sources ($tCO_2$/MWh) (measured value)

As an example of the calculation results, Table 7 shows the GHG emissions (=Bey) for Case 2. It should be noted that these are estimate figures, whereas actual GHG emissions will be calculated based on measured values.

Table 7 GHG Emissions in at the Baseline ($tCO_2$/yr): Case 2

| No. | Item | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Open lagoons | 10,660 | 13,029 | 14,057 | 15,572 | 16,563 | 17,365 | 17,692 | 17,692 |
| 2 | Power sales | 0 | 2,609 | 2,815 | 3,118 | 3,317 | 3,467 | 3,467 | 3,467 |
| Total (=BEy) | | 10,660 | 15,638 | 16,872 | 18,691 | 19,880 | 20,831 | 21,159 | 21,159 |
| No. | Item | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
| 1 | Open lagoons | 17,692 | 17,692 | 17,692 | 17,692 | 17,692 | 17,692 | 17,692 | 17,692 |
| 2 | Power sales | 3,467 | 3,467 | 3,467 | 3,467 | 3,467 | 3,467 | 3,467 | 3,467 |
| Total (=BEy) | | 21,159 | 21,159 | 21,159 | 21,159 | 21,159 | 21,159 | 21,159 | 21,159 |

○ Leakage

Based on the approved methodology AM0013. Version 02, there is no leakage in the project.

○ GHG Emission Reductions

Table 7 shows the GHG emission reductions in each project case. Total GHG emission reductions over the project life of 16 years are calculated as 246,145 $CO_2$ in Case 1, 218,399$tCO_2$ in Case 2, and 614,645 $CO_2$ in Case 3.

Table 8 GHG Emission Reductions in the Project

| Year | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|
| Case 1 | 9,114 | 12,184 | 13,145 | 14,562 | 15,488 | 16,238 | 16,541 | 16,541 |
| Case 2 | 6,796 | 10,915 | 11,776 | 13,046 | 13,876 | 14,537 | 14,745 | 14,745 |
| Case 3 | 22,786 | 30,459 | 32,862 | 36,404 | 38,721 | 40,584 | 41,283 | 41,283 |
| Year | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
| Case 1 | 16,541 | 16,541 | 16,541 | 16,541 | 16,541 | 16,541 | 16,541 | 16,541 |
| Case 2 | 14,745 | 14,745 | 14,745 | 14,745 | 14,745 | 14,745 | 14,745 | 14,745 |
| Case 3 | 41,283 | 41,283 | 41,283 | 41,283 | 41,283 | 41,283 | 41,283 | 41,283 |

(4) Monitoring Plan

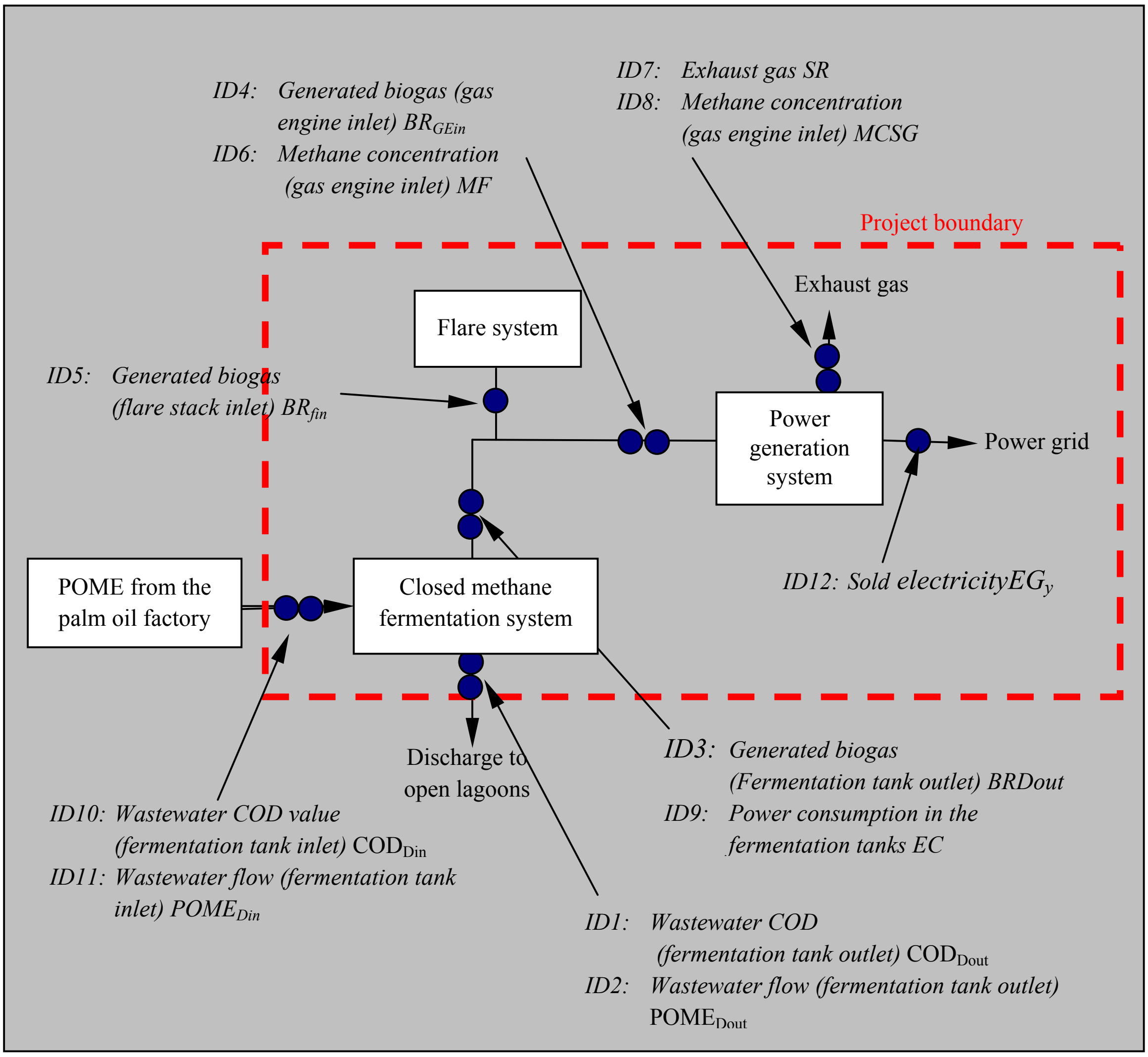


Figure 7 Monitoring Plan Diagram

(5) Environmental Impact and Other Indirect Effects

○ Environmental Impact

Upon conducting a hearing with Department of Environment Sabah regarding environmental regulations, we were told that there is no need to implement an Environmental Impact Assessment (EIA). However, concerning air quality, water quality, stack and noise, we found that it is necessary to conduct assessment with respect to environmental regulations. The project is thought to basically satisfy all the regulatory values, however, it is planned to implement a detailed study in future.

○ Other Indirect Effects

① Reduction in the amount of generated sludge
② Effective utilization of land
③ Higher sophistication of operation management and maintenance
④ Economic effects

(6) Comments from Stakeholders

Table 9 Comments from Stakeholders

| Stakeholder | Comments |
|---|---|
| Ministry of Natural Resources and Environment Conservation and Environmental Management Division (DNA) | In view of the fact that the project will improve the wastewater environment of the palm industry, which is Malaysia's major industry, and the fact that it is good for energy utilization, we welcome its implementation as a CDM undertaking. |
| Ministry of Natural Resources and Environment Department of Environment (Sabah) | In view of the fact that the project will improve the wastewater environment of the palm industry, which is Malaysia's major industry, we welcome it.<br>Although no EIA is required, a report of simple environmental impact assessment will be needed. |
| Malaysia Energy Centre (PTM) | The proposed project satisfies the established criteria in Malaysia. In view of the fact that the project will improve the wastewater environment of the palm industry, which is Malaysia's major industry, and the fact that it is good for energy utilization, we welcome its implementation as a CDM undertaking.<br>Since the proposed project has not yet been implemented in Malaysia, it will likely have a ripple effect on the rest of the country. |
| Energy Commission Malaysian Industrial Development Authority (MIDA) | The proposed project is the first of its kind to be implemented in Malaysia. Since its implementation will create a major ripple effect and promote effective energy utilization, we welcome it. |
| Sabah Department of Tourism, Culture and Environment | The proposed project will make a major contribution to environmental improvement, and Sabah Department of Tourism, Culture and Environment will spare no effort in cooperating with it. |
| Sabah Electricity Sdn. Bhd. (SESB) | Since the proposed project will make use of reusable energy, we welcome it. |
| Beaufort Town Office | In view of the fact that the project will improve the wastewater environment of the palm industry, which is Malaysia's major industry, and the fact that it is good for energy utilization, we welcome its implementation as a CDM undertaking. |

## 3. Towards Project Realization

### (1) Project Implementation Setup

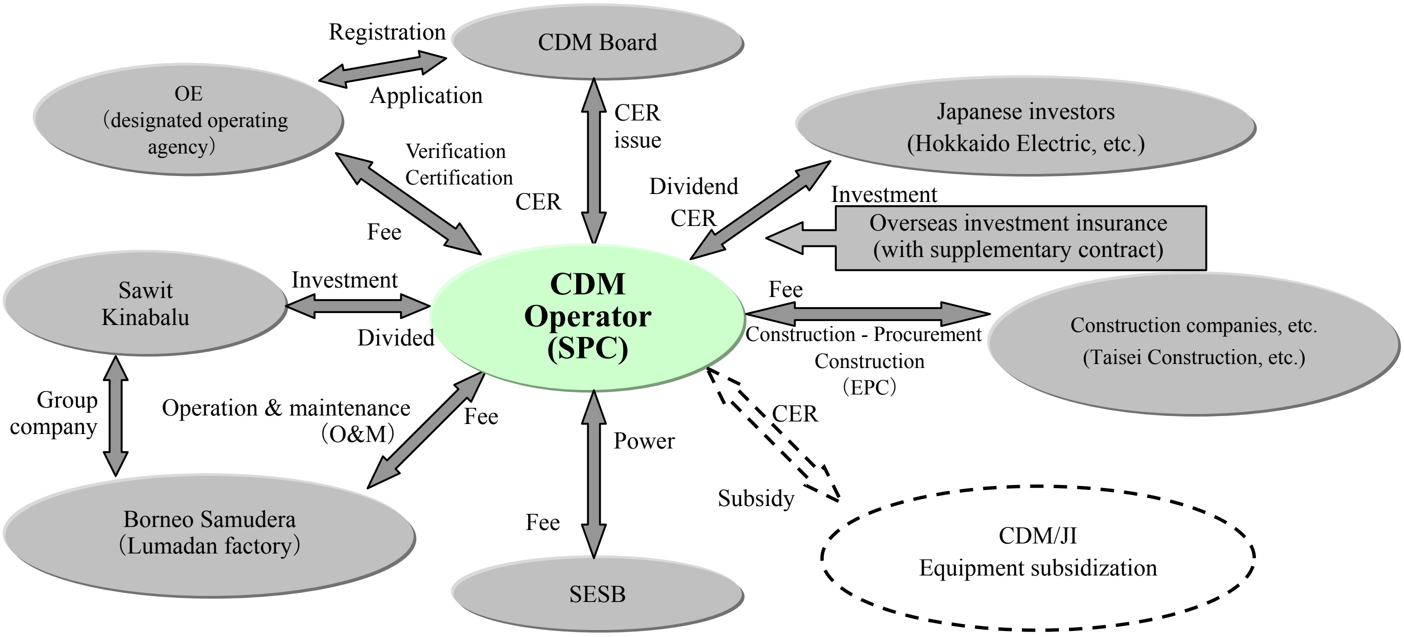


Figure 8 Project Implementation Setup Diagram

### (2) Fund Plan for Project Implementation

It is planned to advance the project based mainly on direct investment, while utilizing subsidization systems of the Government of Japan.

### (3) Cost vs. Effect

○ Initial investment amount

- Case 1: 300 million yen
- Case 2 and 3: 460 million yen

○ Internal rate of return (IRR, after tax)

Table 10 Internal Rate of Return (IRR): After Tax

| Project Case | CER price ($USD/tCO_2$) | CER acquisition period | | |
|---|---|---|---|---|
| | | 0 years | 5 years | 16 years |
| Case 1 | 5 | Minus | Minus | Minus |
| | 10 | Minus | Minus | 4.3% |
| Case 2 | 5 | 0.3% | 1.0% | 3.0% |
| | 10 | 0.3% | 1.9% | 5.1% |
| Case 3 | 5 | 0.3% | 2.6% | 6.8% |
| | 10 | 0.3% | 5.2% | 11.6% |

It can be seen that when there are no CERs (CER acquisition period is 0), the IRR is less than 1% in all cases. When there are CERs (CER acquisition period 5 years and 16 years), the IRR reaches a maximum level of around 5% in Cases 1 and 2. As for Case 3, the IRR is around 12% when the CER acquisition period is 16 years and the CER price is 10 USD/tCO2, and 5% when the acquisition period is 5 years. Accordingly, it was found that the project may be feasible as a private sector undertaking even taking into account the country risk of Malaysia. Moreover, examination was conducted on flaring only as a separate scheme (no power generation), however, since power sales account for a high proportion of revenue, commercial feasibility was low.

(4) Prospects and Issues Towards Concrete Project Realization

Whereas the project has poor commercial feasibility in Cases 1 and 2, which target Lumadan factory, Case 3, which targets the plant that uses the centrifuge process, has the potential for implementation as a private sector undertaking.

In future, it is desirable to implement examination on the following issues with respect to a plant that has the same conditions as demonstrated in Case 3.

① Composition of POME

Since the composition of FFB, which provides the raw materials for POME, differs according to the harvest season, and the COD of POME fluctuates greatly between 30,000 and 90,000 ppm, the generated amount of methane also varies. It is necessary to set the scale of power generation upon taking fluctuations in the amount of methane generation into account, so it will be necessary to implement detailed design upon gauging annual fluctuations in COD.

② POME emissions

Although POME emissions are monitored following the purification treatment, there is no monitoring of the amount of POME that is directly discharged from the factory. In this study, the amount of POME was calculated using the refined amount of CPO that was investigated. Since the refined amount of CPO per unit of FFB differs slightly between harvesting times, it will be necessary to gauge these variations and review the scale of the methane fermentation system as the need arises.

③ Factors when calculating GHG emission reductions

In the project, even though the AM0013. Version 02 methodology is used to calculate GHG emission reductions, because the default values in this methodology are not used for the factors when calculating, there is some risk concerning CDM registration. For this reason, it will be necessary to conduct validation at an early stage and advance registration with the CDM Board.

④ Power sale price

The sale of power is a major source of revenue in the project. Since it is planned to utilize the SREP, which is a system of preferential treatment for renewal energy, the power sale price is determined based on negotiations with the power company on the project site. Accordingly, it will be necessary to register with the SREP at an early point and fix the power unit rate.

⑤ Methane fermentation system

Although methane fermentation technology has already been established in Japan, it has not been applied to a system using POME as raw materials anywhere in the world. Accordingly, since there is some uncertainty arising from the peculiar properties of POME, it will be necessary to implement detailed design upon introducing a demonstration plant to gauge these properties.