Summary of Fy2009 Feasibility Study on CDM/JI Project

Title: Biogas Power Generation and Biocompost Production Project at Sugar Mill and Bio-ethanol Factory in Thailand

Main Implementing Entity: Tohoku Electric Power Co., Inc.

FS Partners:

- Mitsubishi UFJ Securities Co., Ltd.
  (Assistance in preparation of PDD, co-benefit analysis and follow-up on initial validation)

1. Outline of the project

This project is biogas biogas-based power generation (10 MW) by reusing organic wastewater generated at an ethanol plant in Thailand. Technologies employed are production of biogas by anaerobic digester for organic wastewater from the ethanol plant in which molasses from a sugar mill adjacent to the ethanol factory are used as law material of ethanol, and electric power production by using the wastewater based biogas.

The sugar mill supplies molasses, a residue remaining after pressing sugar cane to extract its juice, to the adjacent ethanol plant as a raw material for ethanol. Greenhouse gas emissions are expected to be reduced by approximately 200,000 t-CO_2/year. A project development company in Thailand is responsible for developing this project, aiming to start operating the facility in the first quarter of 2011.

Original plan aimed to achieve two plans—biogas-based power generation (10 MW) and the production of organic fertilizer (90,000 tons/year)—in an integrated facility by reusing organic wastewater and organic solid wastes generated at the ethanol plant and the sugar mill with integration of following facility two facilities:

1) Biogas production and power generation facility: Biogas will be produced from organic wastewater, and used to generate 10 MW of electricity.
2) Composting facility: 90,000 tons of biocompost (organic fertilizer) will be produced each year.

At the biogas production facility, organic wastewater generated at an ethanol plant will be decomposed to produce biogas. Biogas will then be used as fuel in gas engines with a total capacity of 10 MW to generate electricity. Approximately 8 MW of the electricity generated will be sold to the Provincial Electricity Authority (PEA) in Thailand.

At the composting facility, filter cake, an organic solid waste from the sugar mill located adjacent to the ethanol plant, and treated effluent from the biogas facility will be mixed to produce biocompost. The biocompost produced will be sold to the sugar mill and supplied to the mill's contract plantations.

This project intended to utilize a combination of two technologies: biogas power generation technology by utilizing molasses, a byproduct generated at the sugar mill, as fuel; and technology for composting solid wastes. Specifically, the two technologies are:

1) A technology for recovering methane gas from organic wastewater by means of anaerobic digestion, and using the gas as fuel for generating electricity; and
2) A technology for mixing filter cake, an unused organic solid waste from the sugar mill, and wastewater treated in 1) above to produce biocompost

Technology 2 enables filter cake and treated effluent to be mixed in an anaerobic environment that allows digesting bacteria to thrive and accelerate the digestion. The main features of the technology are an automatically controlled spraying system and a particular combination of bacteria, fungi and actinomycetes. Technologies 1 and 2 are often used individually, but this will be the first integrated wastewater and solid waste treatment system to be installed in Thailand. With combination to these two technologies, greenhouse gas emissions were expected to be reduced by approximately 250,000 t-CO_2/year.

The study, however, found that the product of biocompost from the project does not satisfy the standards applied to fertilizers in Thailand.

Hence, it was decided to cancel the biocompost production component of the project and purse only the biogas production and electricity generation component.

Baseline methodology to be applied:

ACM0014 ver.3.1‘Mitigation of greenhouse gas emissions from treatment of industrial wastewater’

The original plan aimed at integration of the baseline methodologies of ACM0014 and AM0039 ver.2 ‘Methane emissions reduction from organic waste water and bioorganic solid waste using co-composting’. However, application of AM0039 was ultimately cancelled because of abandon of the biocompost production.

2. Details of the study conducted

(1) Study objectives

○ Objectives related to Clean Development Mechanism (CDM)

The CDM-related objectives of this study were:

- To study the applicability of baseline methodologies ACM0014 (electricity generation based on biogas from organic wastewater) and AM0039 (emissions reduction by reusing organic solid wastes), which were considered on an original business plan;
- To examine the appropriateness of the integrated application, which were considered on an original business plan, of the baseline methodologies ACM0014 and AM0039 because there is no precedent in the CDM registrations with the United Nations for such application;
- To check the validity of the existing data on the chemical oxygen demand (COD) content—a factor that greatly affects baseline emissions—of the existing open lagoons;
- To clarify what data are required for calculating emission reductions achieved by the above baseline methodologies;
- To define the items of the initial environmental examination (IEE), an examination required for CDM projects in Thailand, for this project in accordance with the examination guidelines created by the Thai government;
- To check the status of preparations made by the local counterpart (project development company) for gathering comments from stakeholders; and
- To estimate the effectiveness of the project in reducing organic solid wastes (t/year) and COD loads of organic wastewater (t/year) as part of evaluating the effectiveness of this project as a countermeasure against environmental pollution.

○ Objectives related to feasibility

The feasibility-related objectives of the study were:

- To identify the latest trends in Thailand regarding renewable energy projects, and the government’s policies, regulations, and decisions on electricity selling prices;
- To check the trends in the sugar refining and bioethanol industries to learn more about the sugar mill and the ethanol plant, the suppliers of raw materials for this project;
- To check what permits and licenses are necessary for this project, as well as the progress of discussions with the authorities to obtain them;

- To evaluate the conformity of compost produced from organic solid wastes under this project to the quality standards in Thailand;
- To investigate the progress of discussions with investors who are considering investing in this project, as well as the details of agreements and agreement levels with the investors;
- To examine each assumption for economic analysis to evaluate the feasibility of the project; and
- To evaluate the possibility of securing financing from public financial institutions in and outside Thailand, local financial institutions, and other sources.

(2) Details of the study conducted

This study investigated the following trends in Thailand to check the current conditions regarding the supply system of raw materials, which it is essential to establish for the project, as well as regarding sales of electricity and biocompost, the products of this project:

- Trend of the sugar industry in Thailand
- Trend of the ethanol industry in Thailand
- Preferential policies on renewable energy in Thailand
- Trend of the fertilizer industry in Thailand

In addition, basic information on the sugar mill and the ethanol plant (a subsidiary of the sugar mill), the suppliers of raw materials for this project, were gathered to ensure that they are among the most productive in Thailand.

The following matters related to this project were also investigated:

- Characteristics of organic wastewater and organic solid wastes from the sugar mill and the ethanol plant
- Details of the technologies used to produce biogas and biocompost
- Investigation of various project contracts and business licenses
- Analysis of the business model (economic feasibility, operational system, competitiveness of the business model)
- Laws and regulations concerning organic fertilizer in Thailand, and the effectiveness of the applied technologies

As a result of studying the characteristics of organic wastewater and organic solid wastes used for this project and the laws and regulations concerning organic fertilizer in Thailand, it was found that biocompost produced under this project is likely to fail to meet Thailand's organic fertilizer quality standards. This issue is explained in detail below.

○ Laws and regulations concerning organic fertilizer in Thailand

The law concerning fertilizer currently in force in Thailand is the "Fertilizer Act (No.2) B.E. 2550 (2007)" enacted in 2008. According to a survey conducted as part of this study to learn how the law was established, because the inappropriate payment of government subsidies to fertilizer manufacturers—which were introduced while the former administration was in power—became a common practice under the quality standards based on the former Fertilizer Act, a movement arose to adopt new fertilizer standards with new quality criteria and penalties after the new administration assumed power in 2006.

The new Fertilizer Act enacted in 2008 stipulates the obligation for companies to apply for and receive licenses for production and other operations for chemical fertilizer, organic fertilizer and biofertilizer, the obligations of licensed companies, and the regulations on the registration and publicity of products, as well as provides the quality standards for organic fertilizer under the "National Standards on Organic Fertilizer B.E. 2551 (2008)."

○ Results of the study with regard to the biocompost production plan

As a result of the study conducted by the project development company and the supplier that is to deliver the applied technology regarding Thailand's organic fertilizer quality standards, which the biocompost produced under this project is required to meet, it was found that the quality of biocompost is likely to fail to satisfy the national standards.

The National Standards on Organic Fertilizer B.E. 2551 (2008), which are quality standards for fertilizer products distributed in Thailand, are stricter than their predecessor due to the circumstances explained above, imposing electrical conductivity (EC) requirements, which are normally applied only to chemical fertilizer, on organic fertilizer as well (upper limit: 6 dS/m).

EC is an index of the fertilizer content in soil (the unit is either S/m or S/cm), which varies according to the total content of water-soluble fertilizer salts in soil (a state in which nitrogen and other fertilizer ingredients are ionized to NH_4^+, NO_3^-, etc.). When the content of fertilizer in soil is large, soil becomes more conductive and EC increases.

The appropriate EC value for farm products differs depending on the farm product being grown and the type of soil, and in Japan its upper limit is determined for each farm product by the prefectural government and supervisory organization. However, Thailand is the only country that imposes EC requirements on organic fertilizer, and although the local counterpart company has filed a protest against the requirements to the Ministry of Agriculture and Cooperatives, there is no prospect of the standards being revised in the future. Even if it is possible to ask agriculture industry organizations in Thailand to assist in protesting against the requirements, it is still necessary to build good relationships with the government slowly and steadily, and at present it would be extremely difficult to urge the government to revise the standards.

○ Decision on cancellation of the biocompost production plan

The technology that was planned to be applied in the biocompost production plan can control the amount of organic wastewater sprayed over organic solid wastes to accelerate microorganisms' production of hydrolase and rapid, efficient reaction between organic solid wastes and organic wastewater in an anaerobic environment, thus producing biocompost containing a huge number of chelate compounds, enzymes, phyto-vitamins, probiotics, amino acids, and bacteria. If this technology is used, COD must, in principle, be lower than 35,000 to 45,000 ppm to meet the EC upper limit specified above. However, a field study revealed that the EC of organic wastewater and organic solid wastes used for this project is 29.7 dS/m and 2.47 dS/m, respectively. The EC of organic wastewater is particularly high due to the high concentration of COD (more than 230,000 ppm). According to the technology supplier for the composting facility, if organic wastewater with high COD concentration exceeding 200,000 ppm is used, past experience has shown that the EC of biocompost produced exceeds 10 dS/m, and it has been confirmed that, even if organic wastewater is improved, it is technically very difficult to keep the EC of biocompost below the upper limit of 6 dS/m.

Despite the regulations regarding EC in Thailand, if biocompost produced under this project were to be used in a large plantation, it would cause no problem because the resultant salinity and ion concentrations in soil are very low. It is considered that, if a suitable amount of biocompost is added to soil, it is diluted significantly and does not hinder the growth of farm products even when its EC exceeds the upper limit. Nevertheless, since the expected quality of biocompost produced under this project is likely to fail to satisfy the Thai standards as explained above, it has been decided, after discussions with the project development company, to cancel the biocompost production plan.

According to the technology supplier, a similar integrated CDM project is currently under way in Nepal to generate electricity using biogas from organic wastewater and produce biocompost at an instant food factory. By referring to the results of the feasibility study for this project in Nepal and gathering detailed data, it is planned to continue examining the feasibility of similar projects.

3. Results of the study on implementing the project under CDM

Because it was decided to cancel the biocompost production plan as explained in the previous section, this section deals only with the biogas production and electricity generation plan, including the development of a baseline scenario and the calculation of expected emission reductions.

(1) Development of a baseline scenario and definition of the project boundary

The project activity involves the installation of a new anaerobic treatment system in an existing open lagoon based wastewater treatment facility at a tapioca starch production plant.

ACM0014 Version 03.1 has been chosen because the project activity matches with one of the applicable scenarios of the relevant methodology as shown in the table below:

Table: Scenario applicable to ACM0014 Version 03.1 compared to the project case

Scenario	Description of the historical situation	Description of the project activity	Project case
1	The wastewater is not treated, but directed to open lagoons that have clearly anaerobic conditions.	The wastewater is treated in a new anaerobic digester. The biogas extracted from the anaerobic digester is flared and/or used to generated electricity and/or heat. The effluent from the anaerobic digester after the treatment is directed to open lagoons or is treated under clearly aerobic conditions (e.g. dewatering and land application)	In the project situation, the wastewater is treated in a newly installed anaerobic digester. The biogas extracted from the anaerobic digester is used to generate electricity with the excess biogas being flared to ensure complete methane decomposition. The effluent from the anaerobic digester after the treatment is directed to open lagoons.

The project activity also meets all the applicability conditions set forth in the methodology, as described below.

- The depth of the anaerobic lagoons should be at least 1m.
- Heat and electricity needs per unit input of the water treatment facility remain largely unchanged before and after the project;
- Data requirements as laid out in this methodology are fulfilled
- The residence time of the organic matter on the open lagoon system should be at least 30 days
- Local regulations do not prevent discharge of wastewater in open lagoons

As per the baseline methodology, ACM0014 Version 03.1, the baseline determination follows a four-step process below.

Step 1: Identification of alternative scenarios

In accordance with the methodology, realistic and credible alternatives with regards to the possible scenarios that would occur in the absence of the project activity are listed below:

Wastewater treatment

W1. *The use of open lagoons for the treatment of the wastewater (continuation of current practice);*

W2. *Direct release of wastewater to a nearby water body;*

W3. *Aerobic wastewater treatment facilities (e.g. activated sludge or filtered bed type treatment);*

W4. *Anaerobic digester with methane recovery and flaring;*

W5. *Anaerobic digester with methane recovery and utilization for electricity or heat generation (The Project undertaken without being registered as a CDM project activity)*

Electricity generation

E1. *Power generation using fossil fuels in a captive power plant;*

E2. *Electricity generation in the grid (continuation of current practice);*

E3. *Electricity generation using renewable sources (The Project undertaken without being registered as a CDM project activity)*

Step 2: Eliminate alternatives that are not complying with applicable laws and regulations

Among all the identified alternative scenarios in Step 1 above, W2 "Direct release of wastewater to a nearby water body" is prohibited by the Thai regulation. All alternatives other than W2 comply with the applicable laws and regulations of Thailand. Therefore, Alternative W2 is eliminated from the further analysis.

Step 3: Eliminate alternatives that face prohibitive barriers

Scenarios that face prohibitive barriers should be eliminated by applying Step 3 of the latest version of the "Tool for the demonstration and assessment of additionality" agreed by the CDM Executive Board.

Table: Elimination of alternatives that face prohibitive barriers

Scenario	Identification of barriers
W1	It is the wastewater treatment practice most widely seen at ethanol plants in Thailand. Wastewater is left to stand in an open lagoon system so that COD will decompose under largely anaerobic conditions.
W3	Even though W3, introduction of aerobic wastewater treatment system, is making increasing inroads in South East Asia as an alternative waste management option, aerobic treatment of molasses-based wastewater is nonexistent within Thailand due to its complexity. The aerobic treatment of molasses-based wastewater is extremely difficult, and the project participants are not aware of any successfully working plants which employ this technology. As such, the local labour force has no knowhow regarding the operation of such a system. The installation and O&M costs for such a system will also be extremely high.
W4	Anaerobic bioreactor technology exists in Thailand, however, as in many other countries worldwide, it is a niche technology and not yet widespread. Since anaerobic digester technology is seen as a high risk, with limited performance guarantee, the majority of firms are still relying on lagoon based wastewater treatment system. These facts entail significant performance and technology risks in effluent treatment, which all translate to higher costs. Due to the high initial investment and O&M costs associated with implementation of anaerobic bioreactor technology along with the high technology risks, it would not be financially viable to install anaerobic digesters without additional income from CDM and from the generation of electricity.
W5	Even though this option is generally accepted as the best way to treat and utilize high COD/BOD

	wastewater, as described for W4 above, implementation of anaerobic bioreactor technology in Thailand faces a significant technological and investment barrier. Utilization of biogas for electricity generation brings certain revenue to the project developer (i.e. electricity cost saving or income from electricity sales). This revenue, however, is not sufficient to overcome risks associated with installation of anaerobic bioreactor technology, and even less for the challenging technology for treating molasses-based wastewater.
E1	The ethanol plant currently meets its electricity demand by purchasing electricity from the connected grid. Due to the high initial investment and O&M costs associated with implementation and maintenance of a captive power plant, the ethanol plant would not feel obliged to install another captive power plant. Operating and maintaining a captive power plant would add a significant technical burden to the factory operators.
E2	The ethanol plant currently meets their electricity demand by purchasing electricity from the grid. E2 faces no preventive barrier.
E3	There is no reliable and economically feasible renewable energy source is found in the vicinity of the project facility. The ethanol plant does not possess experience in power generation using renewable sources. Without know-how and experience, it would be very difficult for the plant operator of the ethanol plant to operate/maintain a new renewable power generation facility.

Thus, it is concluded that Alternative E2 is the only realistic and credible scenarios with regard to the possible scenarios that would occur in the absence of the project activity. Based on the step-wise approach conducted above, it is concluded that there is only one combination of the most plausible baseline scenario as follow:

W1: *The use of open lagoons for the treatment of the wastewater*, and

E2: *Electricity generation in the grid*

In accordance with the ACM0014 Version 03.1, the spatial extent of the project boundary for this project activity includes:

- The site where the wastewater is treated in both the baseline and the project scenario;
- The sites where any sludge is applied to lands;
- The anaerobic digester, the power and/or heat generation equipment and/or the flare installed under the project activity;
- The power plants connected to the grid, with the geographical boundary as specified in the latest approved version of the "Tool to calculate the emission factor for an electricity system".

The emission sources included in the project boundary are described in Table below.

Table : Emission sources included and excluded from the project boundary

	Source	Gas	Included/ Excluded	Justification/Explanation
Baseline	Wastewater treatment processes	CH_4	Included	This is the major source of emissions in the baseline from open lagoons.
		N_2O	Excluded	Excluded for simplification. This is conservative.
		CO_2	Excluded	CO_2 emissions from the decomposition of organic waste are not accounted for.

	Electricity consumption/ generation	CO_2	Included	Electricity is generated with biogas from anaerobic digesters under the project activity, and electricity generation in the grid is displaced by the project activity.
		CH_4	Excluded	Excluded for simplification. This is conservative.
		N_2O	Excluded	Excluded for simplification. This is conservative.
	Thermal energy generation	CO_2	Included	Excluded. Thermal energy is not generated with biogas from anaerobic digesters under the project activity.
		CH_4	Excluded	Excluded for simplification. This is conservative.
		N_2O	Excluded	Excluded for simplification. This is conservative.
Project Activity	Wastewater treatment processes	CH_4	Included	The treatment of wastewater under the project activity causes the following project emissions, which are included: (i) Methane emissions from the lagoons (effluent from the treatment under the project activity is directed to lagoons); (ii) Physical leakage of methane from the digester system; (iii) Methane emissions from flaring (excess biogas from the digester is flared);
			Excluded	The following emission sources are excluded as they do not affect the project activity: (iv) Methane emissions from land application of sludge; (the project does not involve land application of sludge) (v) Methane emissions from wastewater removed in the dewatering process (no dewatering facility is installed as a part of the project activity)
		CO_2	Excluded	CO_2 emissions from the decomposition of organic waste are not accounted for.
		N_2O	Excluded	The project does not involve land application of sludge.
	On-site electricity use	CO_2	Excluded	Electricity is consumed by the anaerobic digester which is implemented by the project activity. A biogas fuelled power generation system will be installed. The electricity consumed by the project activity will be supplied by the electricity generated with biogas, therefore this component will be excluded. Any on-site electricity consumption will be subtracted from the electricity generation of the biogas as per the methodology instructions.
		CH_4	Excluded	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	Excluded	Excluded for simplification. This emission source is assumed to be very small.
	On-site fossil fuel consumption	CO_2	Excluded	Not applicable to the project.
		CH_4	Excluded	Excluded for simplification. This emission source is assumed to be very small.
		N_2O	Excluded	Excluded for simplification. This emission source is assumed to be very small.

Baseline emissions are estimated as follows:

$$BE_y = BE_{CH4,y} + BE_{EL,y} + BE_{HG,y}$$

= 208,639 + 31,419 + 0

$= 240{,}058$ (tCO_2e/yr)

Where:

BE_y = Baseline emissions in year y (tCO_2e/yr)

$BE_{CH4,y}$ = Methane emissions from anaerobic treatment of the wastewater in open lagoons (scenario1) in the absence of the project activity in year y (tCO_2e/yr)

$BE_{EL,y}$ = CO_2 emissions associated with electricity generation that is displaced by the project activity in year y (tCO_2e/yr)

$BE_{HG,y}$ = CO_2 emissions associated with fossil fuel combustion for heating equipment that is displaced by the project in year y (tCO_2e/yr)

Baseline emissions for the project activity are calculated in the following three steps:

Step1: Calculation of baseline emissions from anaerobic treatment of the wastewater

The methodology proposes two alternative methods for the estimation of methane emissions from open lagoons:

(a) The Methane Conversion Factor (MCF) Method

(b) The Organic Removal Ratio (ORR) Method

In the case of method (a), the baseline methane emissions from anaerobic treatment of the wastewater in open lagoons are estimated based on the chemical oxygen demand (COD) of the wastewater that would enter the lagoon in the absence of the project activity ($COD_{PJ,y}$), the maximum methane producing capacity (B_0) and a methane conversion factor ($MCF_{BL,y}$) which expresses the proportion of the wastewater that would decay to methane. Meanwhile, method (b) measures the reduction of chemical oxygen demand (COD) in a waste water or sludge stream between its entry into and exit from the treatment system. Among these two options, option (a) The Methane Conversion Factor (MCF) Method is selected for the project activity.

$$BE_{CH4,y} = GWP_{CH4} \times MCF_{BL,y} \times B_O \times COD_{BL,y}$$

$$= 21 \times 0.596 \times 0.21 \times 79{,}380$$

$$= 208{,}639 \ (tCO_2e/yr)$$

Step 2: Baseline emissions from generation and/or consumption of electricity

The Project activity involves electricity generation with capacity of 10 MW class. Actual amount of power supply to the grid is estimated to be 8.2 MW (10MW×(1-18%)) based on assumption that load factor of the power generation with biogas from the new anaerobic biodigester is 18 % of total amount of power generation. Net quantity of electricity generated in year y with biogas from the new anaerobic biodigester is calculated as 64,994 MWh/year, based on assumption that annual operation time is 7,920 hours (330 days × 24 hours).

The grid emission factor used in the project activity was obtained from the official report from the Thai DNA, entitled “The estimation of emission factor for an electricity system in Thailand 2007”, issued on 26 January 2009. According to the document, the emission factor calculation follows procedures outlined in “Tool to calculate the emission factor for an electricity system” version01.1, which is the latest version currently available.

The Simple OM method was chosen as the method of calculating the Operating Margin (“OM”). However, in the aforementioned report, the Build Margin (“BM”) was calculated using generation data from IPPs only, ignoring generation from Electricity Generating Authority of Thailand (EGAT), Small Power Producers (SPPs), and Very Small Power Producers (VSPPs). However it is not possible to replicate the calculation because fuel consumption for each power plant connected to the grid is not disclosed in the document due to the confidentiality concerns.

TGO supports the use of this emission factor (0.5057 kgCO2/kWh) as Thai grid emission factor for now until the updated emission factor becomes available. However, as a conservative approach, the project participant has decided to use the total generation of all generators for calculating the BM, in order to arrive at a lower BM figure, and hence a lower CM.

As a result, BM is reduced to 0.3959 kgCO2/kWh (15,170,168 / 38,321 or (total generation of all IPP generators) /1000) and, accordingly, the emission factor (combined margin) is reduced to 0.4838 kgCO2/kWh.

Baseline emissions from the generation and / or consumption of electricity are calculated as follows:

$$BE_{EL,y} = (EC_{BL} + EG_{PJ,y}) \times EF_{BL,EL,y}$$
$$= (0 + 64{,}944) \times 0.4838$$
$$= 31{,}419 \ (tCO_2e/yr)$$

<u>Step 3: Baseline emissions from generation of heat</u>

The project activity does not involve heat generation from collected biogas, so baseline emissions from this source will be ignored.

(2) Project emissions

As discussed above, conditions of the project activity matches Scenario 1 provided in the baseline methodology applied (ACM0014 Version 03.1). Project emissions attributed to the project activity may include the following:

PE_y	= Project emissions in year *y* (tCO_2e/yr)
$PE_{CH4,effluent,y}$	= Project emissions from treatment of wastewater effluent from the anaerobic digester in year *y* (tCO_2e/yr)
$PE_{CH4,digest,y}$	= Project emissions from physical leakage of methane from the anaerobic digester in year *y* (tCO_2e/yr)
$PE_{flare,y}$	=Project emissions from flaring of biogas generated in the anaerobic digester in year *y* (tCO_2e/yr)
$PE_{sludge,LA,y}$	= Project emissions from land application of sludge in year *y* (tCO_2e/yr)
$PE_{EC,y}$	= Project emissions from electricity consumption in year *y* (tCO_2e/yr)
$PE_{FC,y}$	= Project emissions from fossil fuel consumption in year *y* (tCO_2e/yr)

Project emissions are calculated as follows:

$$PE_y = PE_{CH4,effluent,y} + PE_{flare,y} + PE_{sludge,LA,y} + PE_{EC,y} + PE_{FC,y}$$
$$= 23{,}450 + 17{,}550 + 0 + 0 + 0 + 0$$
$$= 41{,}000 \ (tCO_2e/yr)$$

<u>(i) Project methane emissions from effluent from the digester ($PE_{CH4,effluent,y}$)</u>

Effluent from the digesters installed under the project activity is directed to open lagoons.

$$PE_{CH4,effluent,y} = GWP_{CH4} \times MCF_{PJ,y} \times B_0 \times (COD_{PJ,effl,dig,y} - CPD_{PJ,effl,lag,y})$$
$$= 21 \times 0.6699 \times 0.21 \times (11{,}340 - 3{,}402)$$
$$= 23{,}450 \ (tCO_2e/yr)$$

<u>(ii) Project emissions related to physical leakage from the digester</u>

As the project involves installation of anaerobic biodigester which is to be connected with existing open lagoons, methane emissions from the new digester shall be considered:

$$PE_{CH4,digest,y} = F_{biogas,y} \times FL_{biogas,digest} \times w_{CH4,biogas,y} \times GWP_{CH4}$$
$$= 42{,}443{,}280 \times 0.05 \times 0.3937 \times 21 \times 0.001$$

= 17,550 (tCO_2e/yr)

(iii) Methane emissions from flaring

In general all of the biogas produced by the project is utilized for electricity generation. A flaring system will be installed by the project activity to combust excess biogas if any. For the ex-ante calculation, methane emissions from the flare are set to zero.

The amount of biogas sent to flare will be monitored as per the methodology and the methane emissions from flaring will be calculated in accordance with the “Tool to determine project emissions from flaring gases containing methane (hereunder “flaring tool”)”.

For enclosed flares, the temperature in the exhaust gas of the flare is measured to determine whether the flare is operating or not. Since, among the options for flaring systems, an enclosed flare system is chosen by the project participants, the project participants have decided to use option (a), continuous monitoring of compliance with manufacturer’s specifications of flare, in which a 90% default value is used as flare efficiency.

(iv) Project emissions from land application of sludge

This step is applicable if under the project activity sludge is applied on land. It is expected that sludge will not be generated by the project activity. Project emissions from this source are set to zero in the ex-ante calculation.

(v) Project emissions from electricity consumption and combustion of fossil fuels in the project

All of the electricity consumed by the project activity will be generated with biogas under the project activity.

(3) Monitoring plan

All monitoring equipment will be installed by experts and regularly calibrated to the highest standards by the project company. The project company will form a team to maintain and operate the project activity and monitor the parameters required by the methodology. The team will be composed of a plant manager, a Production/Biogas plant supervisor, a Genset/biogas boiler plant supervisor and operational staff.

Data / Parameter:	$\mathbf{F_{PJ,dig,m}}$
Data unit:	m^3 /month
Description:	Quantity of wastewater that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month *m*
Source of data to be used:	Measured by the ethanol plant
Value of data applied for the purpose of calculating expected emission reductions in section B.5	45,000
Description of measurement methods and procedures to be applied:	Volume of wastewater will be monitored continuously with a flow meter which will be installed before the digester. Collected data will be aggregated annually for calculations.
QA/QC procedures to be applied:	Flow meters will undergo maintenance / calibration subject to appropriate industry standards.
Any comment:	The value applied for the purpose of ex-ante estimation was calculated using the design daily flow rate of wastewater and expected annual operating days of the plant (330 days).

Data / Parameter:	$F_{PJ,effl,dig,m}$
Data unit:	m^3 /month
Description:	Quantity of wastewater from the digester in month *m*
Source of data to be used:	Measured by the ethanol plant
Value of data applied for the purpose of calculating expected emission reductions in section B.5	45,000-
Description of measurement methods and procedures to be applied:	Volume of treated wastewater from the digester will be monitored continuously with a flow meter which will be installed after the digester. Collected data will be aggregated annually for calculations.
QA/QC procedures to be applied:	Flow meters will undergo maintenance / calibration subject to appropriate industry standards.
Any comment:	The value applied for the purpose of ex-ante estimation was calculated using the design daily flow rate of wastewater and expected annual operating days of the plant (330 days).

Data / Parameter:	$F_{PJ,effl,lag,m}$
Data unit:	m^3 /month
Description:	Quantity of wastewater from the open lagoon in which the wastewater from the digester is treated in month *m*
Source of data to be used:	Measured by the ethanol plant
Value of data applied for the purpose of calculating expected emission reductions in section B.5	45,000-
Description of measurement methods and procedures to be applied:	Volume of treated wastewater from the open lagoon will be monitored continuously with a flow meter which will be installed after the last lagoon. Collected data will be aggregated annually for calculations.
QA/QC procedures to be applied:	Flow meters will undergo maintenance / calibration subject to appropriate industry standards.
Any comment:	The value applied for the purpose of ex-ante estimation was calculated using the design daily flow rate of wastewater and expected annual operating days of the plant (330 days).

Data / Parameter:	$w_{COD,dig,m}$
Data unit:	t COD/ m^3
Description:	Average chemical oxygen demand in the wastewater that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month m
Source of data to be used:	Measured by the ethanol plant
Value of data applied for the purpose of calculating expected	0.21 (tentative value)

emission reductions in section B.5	
Description of measurement methods and procedures to be applied:	Regular sampling of wastewater flowing into a digester will be monitored with COD analyzer.
QA/QC procedures to be applied:	Measure the COD according to national or international standards
Any comment:	

Data / Parameter:	$\mathbf{w_{COD,effl,dig,m}}$
Data unit:	t COD/ m^3
Description:	Average chemical oxygen demand in treated wastewater from the digester o in month m
Source of data to be used:	Measured by the ethanol plant
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.021 (tentative value)
Description of measurement methods and procedures to be applied:	Regular sampling of wastewater flowing into a digester will be monitored with COD analyzer.
QA/QC procedures to be applied:	Measure the COD according to national or international standards
Any comment:	

Data / Parameter:	$w_{COD,effl,lag,m}$
Data unit:	t COD/ m^3
Description:	Average chemical oxygen demand in the effluent from the open lagoon in which the effluent from the digester is treated.
Source of data to be used:	Measured by the ethanol plant
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.0063
Description of measurement methods and procedures to be applied:	Regular sampling of treated wastewater from the open lagoon will be monitored with COD analyzer.
QA/QC procedures to be applied:	Measure the COD according to national or international standards
Any comment:	

Data / Parameter:	$\mathbf{T_{2.m}}$
Data unit:	K
Description:	Average temperature at the project site in month *m*
Source of data to be used:	National or regional weather statistics
Value of data applied for the purpose of calculating expected	

emission reductions in section B.5	
Description of measurement methods and procedures to be applied:	
QA/QC procedures to be applied:	
Any comment:	

Data / Parameter:	$EG_{PJ,y}$
Data unit:	MWh/year
Description:	Net quantity of electricity generated in year y with biogas from the new anaerobic digester
Source of data to be used:	Measurements on site
Value of data applied for the purpose of calculating expected emission reductions in section B.5	64,944
Description of measurement methods and procedures to be applied:	Monitored continuously using electricity meters. Data will be recorded with a digital recording system and results will be kept electronically.
QA/QC procedures to be applied:	Electricity meters will undergo maintenance/calibration in accordance with manufacturer's specifications.
Any comment:	

Data / Parameter:	$F_{biogas,y}$
Data unit:	m^3 /yr
Description:	Amount of biogas collected in the outlet of the new digester in year *y*
Source of data to be used:	Measured by the ethanol plant
Value of data applied for the purpose of calculating expected emission reductions in section B.5	42,443,280
Description of measurement methods and procedures to be applied:	Amount of biogas will be measured continuously with a gas flow meter. The collected data will be aggregated annually for calculations.
QA/QC procedures to be applied:	Flow meters will undergo maintenance / calibration subject to appropriate industry standards.
Any comment:	

Data / Parameter:	$w_{CH4,biogas,y}$
Data unit:	kg CH_4 / m^3
Description:	Concentration of methane in biogas in the outlet of the new digester
Source of data to be used:	Measured by the ethanol plant
Value of data applied for the	0.3938

purpose of calculating expected emission reductions in section B.5	
Description of measurement methods and procedures to be applied:	Using calibrated continuous gas analyser or alternatively with periodical measurement at 95% confidence level. For ex-ante calculation, the value was calculated using biogas methane concentration, molar mass of methane (16.0425gCH_4/mol)
QA/QC procedures to be applied:	Near infrared spectrometry will undergo maintenance / calibration subject to appropriate industry standards. The project proponents shall define the error for different levels of measurement frequency. The level of accuracy will be deducted from average concentration o measurement.
Any comment:	

Data / Parameter:	$\mathbf{S_{LA,y}}$
Data unit:	m^3/year
Description:	Quantity of sludge applied to land in year
Source of data to be used:	Measured by the ethanol plant
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0
Description of measurement methods and procedures to be applied:	It is expected that the sludge will not be generated under the project activity. However, the end-use of the sludge will be monitored and documented and in case of land application, the project emissions from such activity will be calculated ex-post.
QA/QC procedures to be applied:	N/A
Any comment:	

Data / Parameter:	$\mathbf{w_{N,sludge,LA}}$
Data unit:	t N/ t sludge
Description:	Mass fraction of nitrogen in the sludge applied to land in year y
Source of data to be used:	Measured by the ethanol plant
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0
Description of measurement methods and procedures to be applied:	It is expected that the sludge will not be generated under the project activity. However, the end-use of the sludge will be monitored and documented and in case of land application, sample sludge will be submitted to a certified third party laboratory to analyze nitrogen in sludge.
QA/QC procedures to be applied:	

Any comment:	

Data / Parameter:	$fv_{i,h}$
Data unit:	-
Description:	Volumetric fraction of component i in the residual gas in the hour h where i = CH_4, CO, CO_2, O_2, H_2, N_2
Source of data to be used:	Measured by the ethanol plant using a continuous gas analyzer
Value of data applied for the purpose of calculating expected emission reductions in section B.5	CH_4: 70% CO: 0% CO_2: 0% O_2: 0% H_2: 0% N_2 : 30%
Description of measurement methods and procedures to be applied:	This parameter will be monitored continuously and values will be averaged hourly. The same basis (dry or wet) will be considered for this measurement and the measurement of the volumetric flow rate of the residual gas ($FV_{RG,h}$) when the residual gas temperature exceeds 60˚C.
QA/QC procedures to be applied:	Analysers will be periodically calibrated according to the manufacturer's recommendation. A zero check and a typical value check will be performed by comparison with a standard certified gas.
Any comment:	$PE_{flare,y}$ for ex-ante calculation was set to 0 tCO2/yr . As a simplified approach, project participants may only measure the methane content of the residual gas and consider the remaining part as N_2.

Data / Parameter:	$FV_{RG,h}$
Data unit:	m^3/h
Description:	Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour *h*
Source of data to be used:	Measured by the ethanol plant using a flow meter
Value of data applied for the purpose of calculating expected emission reductions in section B.5	-
Description of measurement methods and procedures to be applied:	This parameter will be monitored continuously and values will be averaged hourly. The same basis (dry or wet) will be considered for this measurement and the measurement of volumetric fraction of all components in the residual gas ($fv_{i,h}$) when the residual gas temperature exceeds 60˚C.
QA/QC procedures to be applied:	Flow meters are to be periodically calibrated according to the manufacturer's recommendation.
Any comment:	$PE_{flare,y}$ for ex-ante calculation was set to 0 tCO2/yr .

Data / Parameter:	T_{flare}
Data unit:	^oC

Description:	Temperature in the exhaust gas of the flare
Source of data to be used:	Measurements by the ethanol plant
Value of data applied for the purpose of calculating expected emission reductions in section B.5	-
Description of measurement methods and procedures to be applied:	Continuously monitored. Measure the temperature of the exhaust gas stream in the flare by a Type N thermocouple. A temperature above 500˚C indicates that a significant amount of gases are still being burnt and that the flare is operating.
QA/QC procedures to be applied:	Thermocouples should be replaced or calibrated every year.
Any comment:	$PE_{flare,y}$ for ex-ante calculation was set to 0 tCO2/yr .

(4) Greenhouse gas emission reductions (or absorptions)

The greenhouse gas emission reductions through this project are expected to be 199,058 tons of CO_2 equivalent per year. The table below shows the details.

Year		2011	2012	2013	After 2014
Waste Water Treatment	Baseline Emissions	208,639	208,639	208,639	208,639
	Project Emissions	41,000	41,000	41,000	41,000
	Leakage	0	0	0	0
Power Generation	Baseline Emissions	31,419	31,419	31,419	31,419
	Project Emissions	0	0	0	0
	Leakage	0	0	0	0
Total		199,058 tCO_2	199,058 tCO_{22}	199,058 tCO_2	199,058 tCO_2

(5) Project period, crediting period

The Tohoku Electric Power Company explained to its local counterpart the importance of drawing up the “Prior Considerations of the CDM” and submitting the document to the United Nations Framework Convention on Climate Change (UNFCCC) Secretariat and the Thailand Greenhouse Gas Management Organization (TGO), a governmental organization responsible for greenhouse gas emission reductions in Thailand, and the local counterpart agreed to do so. The local counterpart then prepared the document based on the format and draft text presented by the Tohoku Electric Power Company, and submitted it to the UNFCCC Secretariat and TGO on November 3, 2009.

Although the Tohoku Electric Power Company and the local counterpart have not reached a clear agreement on the project commencement date, the local counterpart is anxious to start the project in early 2010. The crediting period is 21 years in total (seven years x 3).

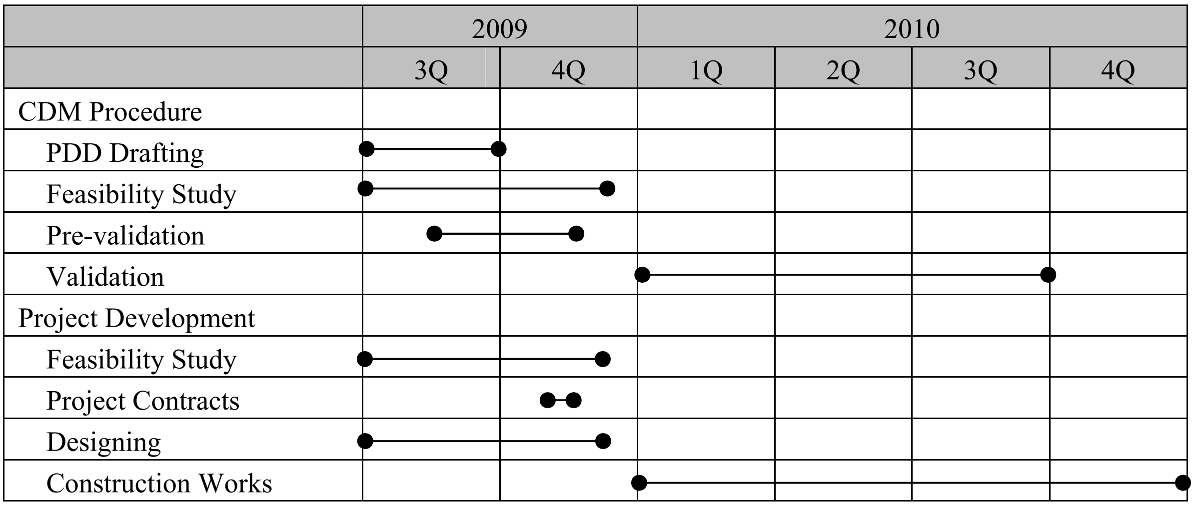


Figure Project Schedule

(6) Environmental impacts and indirect impacts

This project involves constructing a facility to produce biogas and generate electricity in the ethanol plant, where there currently exists a site in which organic solid wastes are temporarily stored until disposal underground, as well as open lagoons to let organic wastewater evaporate rather than discharging it. The new facility will be constructed in a specific area on the premises of the ethanol plant.

The Thai government defines the types and scales of projects that are subject to an Environmental Impact Assessment (EIA) for each of the seven project categories (factory, residential building and commercial facility, transportation, energy, water resources, river basin, mine), but this project does not fall under any of these types or scales. However, the project is subject to an Initial Environmental Evaluation (IEE) enforced by the government. In the IEE, it is required to report the current situation of the project site in terms of "existing physical natural resources," "biological resources," "human use values," and "quality of life values," and specify expected direct and indirect impacts on the environment, measures to prevent or alleviate the impacts, and monitoring methods.

The project site can be accessed by driving north on National Route 1, a major highway running north from Bangkok, the capital of Thailand, for about 170 km, and turning east from National Route 1 and driving on about another 10 km. The site is surrounded by flat fields and sugar cane fields. There are no residential areas around the ethanol plant except a few scattered sugar cane farmers, and so the project is unlikely to cause any impact on the natural or living environment.

The IEE is currently being prepared by the local counterpart, and the basic points of the IEE have already been explained to the local authorities and have been approved. When the IEE is completed officially, it will be explained to Thailand's agencies in charge: the Ministry of Natural Resources and Environment (MONRE) and the Office of Natural Resources and Environmental Policy & Planning (ONEP).

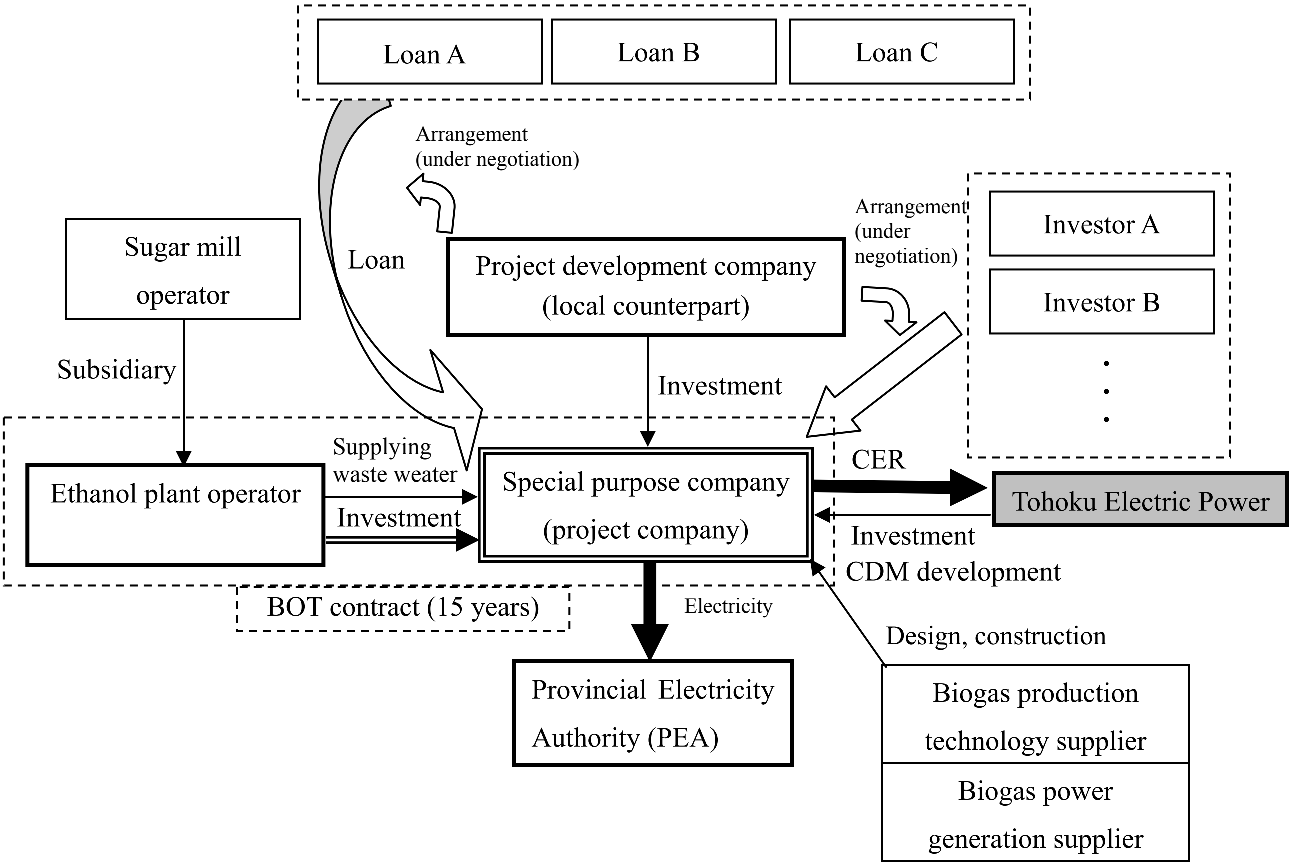
(7) Comments from stakeholders

A stakeholder meeting usually required to be held to receive a license for the project and a stakeholder meeting for CDM are considered to be the same, and it is rational to hold them at the same time. However, this would require making adjustments with the licensing authorities.

The local counterpart is currently preparing for a stakeholder meeting to gather comments from stakeholders regarding the composting and biogas-based power generation plans, while making prior arrangements with the relevant local governments. It has not yet been confirmed who will attend the stakeholder meeting, but attendants are expected to be primarily the members of the regional federation of communities and representatives from each community. According to the meeting plan, the outline of the project and facilities used for composting, biogas production, and electricity generation will be explained, and the attendants will visit the project site before their comments are collected.

The local counterpart and the ethanol plant operator are making arrangements so that the stakeholder meeting can be held by the end of March.

(8) Project implementation setup



(9) Financial plan

According to the current plan formulated by the local counterpart, 60% of the total project costs are planned to be covered by loans. It is also planned that the ethanol plant operator and the project development company will each provide less than 10% of the capital of the special-purpose company, while other investors in and outside Thailand will contribute the rest of the capital. Mezzanine loans and other schemes are also planned to be adopted to secure funds. As for the investors in and outside Thailand, negotiations are currently under way with two companies (other than the Tohoku Electric Power Company) for investment of up to about 15% and 10%, respectively, of the capital.

The project is also planned to be implemented using project finance loans, and the local counterpart is currently negotiating with three major commercial banks in Thailand, and so far has received basic agreement from these banks to finance up to 65% of the total project costs.

It is also planned that negotiations with the Asian Development Bank (ADB) will be conducted to explore the possibility of securing financing from the ADB. At a recent meeting between the Tohoku Electric Power Company and the ADB, the following matters were confirmed.

The ADB and Thailand have formed a strategic partnership recently, aimed at upgrading infrastructure, securities market, and environmental projects. This biogas-based power generation project is consistent with the ADB's policy, as well as with the Thai government's policy of expanding the share of renewable energy sources in the energy supply by 2011. Biogas power generation is expected to reduce air pollution by sulfur dioxide and nitrogen oxides generated from gas thermal power plants, which are the main power source in Thailand. The project is also expected to create employment and develop industry in the region. If the ADB's senior loan is used for this kind of project, up to 25% of the total project costs can be loaned at a rate below general lending rates. The loan term will be about five years.

(10) Economic analysis and demonstration of additionality (See the attached document for assumptions and cash flow.)

The economic analysis of the biogas power generation project can be performed by analyzing the cash flow of the project, whose total costs amount to US$30.355 million. With this analysis, it is also possible to demonstrate additionality. The demonstration of additionality is one of the CDM requirements, and must be completed using the "tool for the demonstration and assessment of additionality" (additionality tool) under ACM0013.

There are three investment analysis techniques that are granted by the additionality tool: simple cost analysis (Option I), investment comparison analysis (Option II), and benchmark analysis (Option III). For the analysis of this project, the benchmark analysis (Option III) was applied.

Initially, the equity internal rate of return (EIRR) was calculated based on assumed project cost values. The project period is 23 years, and the EIRR for the biogas power generation project was calculated to be 17.4% without revenues from CER sales.

The benchmark must be determined based on standard parameters in the market. Considering the fact that the investors have decided to make investments on the assumption that all electricity generated will be sold to the grid, it is appropriate that some kind of benchmark used in the power generation industry should be adopted for the benchmark for this analysis for the convenience of the investors. In addition, since there is no benchmark for CDM projects set by the designated national authorities (DNA) or others in Thailand, project participants need to determine the benchmark for each project based on available published data.

It was therefore decided to use the return on equity (ROE) calculated from net income and capital of companies in the energy and power sector with reference to the financial data of listed companies published by the Stock Exchange of Thailand as the benchmark. The benchmark thus determined was 23.51%, and therefore, the EIRR (17.4%) did not exceed the benchmark. This project is therefore considered unprofitable and infeasible by normal business standards, and it was concluded that there is additionality.

The additionality tool also requires sensitivity analysis. For this project, sensitivity analysis was conducted for two scenarios: one in which annual operation costs are reduced by 10%, and the other in which project costs are reduced by 10%. As a result of this analysis, the EIRR was found to be 18.27% in the former scenario, and 20.39% in the latter scenario. Both these rates are lower than the benchmark of 23.51%, demonstrating again, in sensitivity analysis, that the project is an additional project that cannot be implemented without CDM.

(11) Prospects for feasibility

Although organic wastewater from the ethanol plant must be analyzed continuously to work out more accurate baseline emissions, the project—as pointed out in the prevalidation—is not deviating significantly from the baseline methodology, and it is judged that CDM is feasible.

As regards feasibility, the project will utilize organic wastewater supplied stably by the large ethanol plant—a subsidiary of one of the leading sugar refiners in Thailand—as a raw material, and its long-term supply is guaranteed by a build-operate-transfer (BOT) contract signed with the ethanol plant operator. Electricity generated under this project will be sold to the Provincial Electricity Authority (PEA) over a long period, and its price is clearly defined by the Thai government, making it possible to evaluate the project's long-term cash flow. In addition, this project is eligible for a subsidy for the electricity selling price and exemption from corporate tax for a certain period under the Very Small Power Producer (VSPP) scheme, and it is expected that, unlike many other CDM projects, this project will enjoy relatively stable profits.

With all these factors considered, this project is considered to be feasible, and the Tohoku Electric

Power Company is planning to discuss with the local counterpart the company's way of participating in the project, the company's role, schedule, and other matters. When agreement on these basic conditions is reached, the Tohoku Electric Power Company and the local counterpart will discuss more detailed conditions regarding the company's participation in the project with a view to reaching an agreement in the second quarter of 2010.

4. Prevalidation

(1) Outline of the prevalidation

Deloitte Touche Tohmatsu, a Designated Operational Entity (DOE), conducted a site review and interviews with the project development company and the ethanol plant operator on January 11 and 12.

This prevalidation was performed as part of a validation of the project for CDM registration with the United Nations. In this prevalidation, (1) the project site was inspected, and the way that organic wastewater from the ethanol plant is treated was checked to verify the appropriateness of the baseline methodology and the calculated emission reductions; and (2) interviews were conducted with the expected project participants (project development company and ethanol plant operator) to verify the applicability of CDM to the project.

- Inspection of the project site, and investigation of the way that organic wastewater from the ethanol plant is treated to verify the appropriateness of the baseline methodology and the calculated emission reductions
- Interviews with the expected project participants to verify the applicability of CDM to the project

(2) Views of the DOE regarding the project

The following were major pointed out by the DOE:

1. From the comparison between the Project Design Document (PDD) and the actual current status, no particular problems were found regarding the applicability of the ACM0014 methodology.
2. It should be noted that the project was planned, and the PDD was prepared, based on the local feasibility study. A feasibility study report may be requested to be submitted during the validation process.
3. From the interview with the ethanol plant operator, it was confirmed that the operator intends to use—in addition to organic waste water generated in the initial stage of the ethanol distillation process—organic waste liquid generated during the subsequent process as well (the volume of the liquid and its COD content are said to be small) as raw materials for the project. If this is the case, the drainage volume and the properties of COD substances currently reported must be modified accordingly. It is also necessary to review the baseline emissions, construction costs, and other numerical data because these data change according to the input value.
4. It is necessary to check accurate drawings of the four existing open lagoons, as well as evidence of the functions and operational method (flow of organic wastewater) of the lagoons.
5. As regards additionality, a technological barrier appears to exist. Although there was a comment during the interview on the recent increase in anaerobic treatment facilities in Thailand, this project appears to be the first anaerobic example for the alcohol industry. If this is the case, some of the barriers are technology transfer and other problems related to anaerobic treatment.

With regard to 2 above, the local counterpart will prepare a feasibility study report, in addition to the initial environmental examination (IEE) report currently being prepared, to make it available by the time of official validation. As regards 3., while it is necessary to ascertain the intention of the operator, ongoing and additional water quality monitoring will be conducted for about six months to check, based on the results of this monitoring, whether the figures used in the current plan are appropriate. As for 4., because there are no accurate drawings of the open lagoons at present, discussions will be made with the local counterpart regarding the preparation of such drawings.

4. Study results of co-benefits

(1) Evaluation of the effectiveness of environmental pollution countermeasures in the host country

As indicated in the table below, COD and odors are used as indicators to evaluate the effectiveness of co-benefits-type global warming countermeasures and CDM projects in the water quality improvement category, with a special focus on wastewater such as from factories and business operations.

Table: Co-benefits-type global warming countermeasures in the water quality improvement category

Evaluation indicator	Explanation of indicator	Use of indicator	Target area
Chemical oxygen demand (COD)	Amount of organic matter contained in wastewater, which is one of the causes of water pollution	To evaluate the reduction of the COD due to the implementation of the project	Countermeasures against environmental pollution
Odors	Offensive odors generated from offensive odor substances in wastewater	To evaluate the control of offensive odors from changes in the odor index due to the implementation of the project	

1. Method for evaluating COD emission reductions

The quantitative evaluation of the project for improving the environment was conducted using the Tier 2 methodology.

[Calculation of COD emissions in the baseline scenario]

$COD_{const,treatment}$	$R_{COD,BL}$	$Q_{BL,y}$
0.21 $tCOD/m^3$	70%	45,000 m^3/month × 12 months
$BE_{COD,y}$		
0.21 × (1 – 0.7) × 45,000 × 12 = 34,020 tCOD		

[Calculation of COD emissions in the project scenario]

$COD_{const,treatment}$	$R_{COD,PJ}$	$Q_{PJ,y}$
0.21 $tCOD/m^3$	97%	45,000 m^3/month × 12 months
$PE_{COD,y}$		
0.21 × (1 – 0.97) × 45,000 × 12 = 3,402 tCOD		

[Calculation of emission reductions]

$BE_{COD,y}$	$PE_{COD,y}$
34,020 tCOD	3,402 tCOD
$ER_{COD,y}$	
34,020 tCOD – 3,402 tCOD = 30,618 tCOD	

2. Odor evaluation method

Because odors could not be measured on site in this study due to little opportunity to discuss the measurement method with the local counterpart and the ethanol plant operator, it has been decided that odors will be evaluated through the field study and interviews in the surrounding areas based on the Tier 1 evaluation criteria.

Odors from the existing open lagoons are causing a serious environmental problem to the neighboring areas, and the project owner must urgently address this problem. With this project, wastewater from the plant will be sent to a treatment device to remove 90% of COD, a major cause of odors, before discharge into the lagoons. This process will ensure that odors are controlled effectively and reduced significantly. The probability level of reduction is therefore the maximum “5” score.

Appendix: Parameters for Business Plan and Cash-flow Analysis

Parameters for Business Plan and Economic Analysis

In these lists of parameters for business plan, parameters for abandoned organic compost production are also cited for reference.

Operation of plant

Items	Unit	Numbers	Remarks
Number of days for compost production a year	Hours	3,840	240 days × 16 hours/day
Number of days for biogas generation a year	Hours	7,920	330 days × 24 hour/day
Plant utilization ratio	%	Until one year from commencement 80 % two years 90 % After three years 95 %	

Production capacity

Items	Unit	Numbers	Remarks
Bio-compost production output	t/year	90,000	200,000t/year × 0.45
Biogas generation output	kW	10,000	
Annual output of power generation	kWh	79,200,000	10,000kW × 7920 hours
Plant use power ratio	%	18	
Power output for sales	kW	8,500	10,000kW × (1-0.15)
Annual amount of power sales	kWh	67,320,000	8,500kW × 7920hours
Certified Emission Reductions (CERs)	t-CO_2	247,000	

Law materials

Items	Unit	Numbers	Remarks
Sugarcane input	t/year	10,000,000	100,000 t/day
Press mud conversion	-	0.02	
Filter cake	t/year	200,000	10,000,000×0.02
Conversion ratio	-	0.45	
Enzymes and chemicals	t/year	650	
Diesel fuel	ℓ/year	307,000	
Lubricants and consumables	unit	1	

Land use

Items	Unit	Numbers	Remarks
Bio-compost production facilities	acre	73	
Biogas power generation facilities	acre	32	

Operation and maintenance

A. Bio-compost production

Items	Unit	Numbers	Remarks
Operation & Maintenance	1000USD/year	113	Eslacation 5%
Insurance	1000USD/year	50	5% of Equipment and construction cost, Escalation 1%
Administration and management	1000USD/year	201	5% of Equipment and construction cost, Escalation 5%
Technical consultant fee	1000USD/year	75	Escalation 5%
Operator	People	50	
Salary per a operator	1000USD/year	3.43	10,000THB/month
Administrator	People	3	
Salary per an administrator	1000USD/year	5.14	15,000THB/month
Fringe benefit	%	8.33	monthly salary

B. Biogas power generation

Items	Unit	Numbers	Remarks
Operation & Maintenance	1000USD/year	276	Eslacation 5%
Insurance	1000USD/year	102	5% of Equipment and construction cost, Escalation 1%
Administration and management	1000USD/year	408	5% of Equipment and construction cost, Escalation 5%
Technical consultant fee	1000USD/year	100	Escalation 5%
Operator	People	20	

Salary per a operator	1000USD/year	3.43	10,000THB/month
Fringe benefit for operator	%	0	
Administrator	People	3	
Salary per an administrator	1000USD/year	5.14	15,000THB/month
Fringe benefit for administrator	%	8.33	monthly salary

Purchasing and Sales

Items	Unit	Numbers	Remarks
（Purchasing）			
Solid state waste		8.57	300THB/t,　Escalation 5%
Enzymes and chemicals		1,170	500EUR/t,　Escalation 5%
Diesel fuel	USD/ℓ	0.57	20THB/ℓ,　Escalation 5%
Lubricants and consumables	USD/unit・year	202,623	Escalation 5%
Land lease	USD/acre・year	42.86	1,500THB,　Escalation 0%
（Sales）			
Bio-compost	USD/t	71.43	2,500THB/t,　Escalation 5%
Electricity	USD/kWh	0.08	2.8155THB/kWh,　Escalation 3%
VSPP ADDER (8 years after commencement)	USD/kWh	0.01	0.3THB/kWh,　Escalation 0%
Certified Emission Reductions (CERs)	t-CO_2	10.0	Escalation 0%

Tax

Cooperate income tax	Until 8 years from commencement　0 13 yeas　15% After 14 years　30%

Depreciation

Equipment	Straight-line method　20 years
Building	Straight-line method　20 years

Investment（Unit 1000USD）

Items		Bio-compost Production	Biogas power generation	Total
a. Equipment and Construction				
	Biogas generation plant		11,000	11,000
	Biogas cleaning plan		6,000	6,000
	Power plant		8,000	8,000
	Bio-compost production plant	2,264		2,264
	Civil cost	3,367		3,367
	Building Warehouse, Packing house	3,171		3,171
	Spare parts	500		500
b. Technical consultant fee		350	500	850
	（Sub total）a+b	10,051	25,500	35,552
c. Pre-operation costs				
	Project management team	250	200	450
	O&M team	75	70	145
	Development cost	500	500	1,000
	Commissioning, Test-run, training	207	150	357
	Working capital	434	300	734
	（Sub total）	1,466	1,220	2,686
	Other expenses	435	1,336	1,912
	（Sub total）a+b+c	11,972	28,056	40,150
d. Financing costs				
	Upfront financing cost	478	842	1,204
	Capitalized interest	414	1,457	2,085
	（Sub total）	892	2,299	3,290
Total investment amount　a+b+c+d		12,854	30,355	43,439

Finance

Debt / Equity	6:4
Cost for pre-financing	4% of total investment cost

Interest during construction	3%
Interest for loan	8%
Duration	6 years
Grace period	1 years after commencement

Table: Economic Ananysis on Biogas Power Generation (Excluding Bio-compost Production Activity)

(Profit and Loss Statement; Including Sales of CERs)

	Unit	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19	Y20	Y21	Y22	Y23
BIOCOMPOST PRODUCTION																									
Production input capacity	tons/year		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Capacity utilisation			100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Actual production throughput	tons/year		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Composting conversion rate	ton/ton		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total organic fertilier production	tons/year		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ELECTRICITY GENERATION																									
Hours of operation	hours/year		7,920	7,920	7,920	7,920	7,920	7,920	7,920	7,920	7,920	7,920	7,920	7,920	7,920	7,920	7,920	7,920	7,920	7,920	7,920	7,920	7,920	7,920	7,920
Net electrical capacity	kW		8,200	8,200	8,200	8,200	8,200	8,200	8,200	8,200	8,200	8,200	8,200	8,200	8,200	8,200	8,200	8,200	8,200	8,200	8,200	8,200	8,200	8,200	8,200
Net electricity generation	kWh/year		64,944,000	64,944,000	64,944,000	64,944,000	64,944,000	64,944,000	64,944,000	64,944,000	64,944,000	64,944,000	64,944,000	64,944,000	64,944,000	64,944,000	64,944,000	64,944,000	64,944,000	64,944,000	64,944,000	64,944,000	64,944,000	64,944,000	64,944,000
BY-PRODUCTS																									
Carbon credits	CERs/year		199,058	199,058	199,058	199,058	199,058	199,058	199,058	199,058	199,058	199,058	199,058	199,058	199,058	199,058	199,058	199,058	199,058	199,058	199,058	199,058	199,058	199,058	199,058
RAW MATERIALS																									
Actual production throughput	tons/year		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Enzymes and Chemicals	tons/year		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fuel for machines	Liters/years		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lubricants and consummables	Lot		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Land lease	acres		32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
PRICES AND COSTS																									
Biocompost price	USD/ton		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Filter cake cost	USD/ton		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Enzyme and chemical price	USD/ton		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diesel fuel	USD/li		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lubricants and consummables	USD/Lot		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Land lease	USD/acre		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electricity tariff to PEA	USD/kWh		0.080	0.083	0.085	0.088	0.091	0.093	0.096	0.099	0.102	0.105	0.108	0.111	0.115	0.118	0.122	0.125	0.129	0.133	0.137	0.141	0.145	0.150	0.154
VSPP renewable subsidy	USD/kWh		0.009	0.009	0.009	0.009	0.009	0.009	0.009	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbon credits	USD/CER		10	10	10	10	10	10	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OPERATING REVENUES																									
Sales of organic fertilizer	1000 USD/yr		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electricity sales	1000 USD/yr		5,781	5,938	6,099	6,265	6,437	6,613	6,795	6,425	6,618	6,817	7,021	7,232	7,449	7,672	7,902	8,139	8,383	8,635	8,894	9,161	9,436	9,719	10,010
Sales of carbon credits	1000 USD/yr		1,991	1,991	1,991	1,991	1,991	1,991	1,991	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total revenue	1000 USD/yr		7,772	7,928	8,090	8,256	8,427	8,604	8,785	6,425	6,618	6,817	7,021	7,232	7,449	7,672	7,902	8,139	8,383	8,635	8,894	9,161	9,436	9,719	10,010
OPERATING COSTS																									
Press mud cost	1000 USD/yr		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Enzymes and Chemicals	1000 USD/yr		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fuel for machines	1000 USD/yr		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lubricants and consummables	1000 USD/yr		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Land lease	1000 USD/yr		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Maintenance	1000 USD/yr		383	402	422	443	465	488	513	538	565	593	623	654	687	721	757	795	835	877	921	967	1,015	1,066	1,119
Insurance	1000 USD/yr		128	129	130	131	133	134	135	137	138	139	141	142	144	145	147	148	150	151	153	154	156	157	159
Administration & management	1000 USD/yr		510	536	562	590	620	651	683	718	754	791	831	872	916	962	1,010	1,060	1,113	1,169	1,227	1,289	1,353	1,421	1,492
Technical consultants	1000 USD/yr		100	105	110	116	122	128	134	141	148	155	163	171	180	189	198	208	218	229	241	253	265	279	293
Labor cost	1000 USD/yr		85	90	94	99	104	109	114	120	126	132	139	146	153	161	169	177	186	195	205	216	226	238	249
Total operating costs	1000 USD/yr		1,205	1,260	1,318	1,379	1,443	1,510	1,580	1,653	1,730	1,811	1,896	1,986	2,079	2,177	2,280	2,389	2,502	2,621	2,746	2,878	3,015	3,160	3,312
GROSS OPERATING MARGIN	**1000 USD/yr**		**6,566**	**6,668**	**6,771**	**6,877**	**6,984**	**7,094**	**7,206**	**4,772**	**4,888**	**5,005**	**5,125**	**5,246**	**5,369**	**5,495**	**5,622**	**5,751**	**5,881**	**6,014**	**6,148**	**6,283**	**6,420**	**6,559**	**6,699**

	Unit	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19	Y20	Y21	Y22	Y23
Depreciation expense	1000 USD/yr	-	1,518	1,518	1,518	1,518	1,518	1,518	1,518	1,518	1,518	1,518	1,518	1,518	1,518	1,518	1,518	1,518	1,518	1,518	1,518	1,518	-	-	-
Profit before interests & taxes	**1000 USD/yr**	**-**	**5,049**	**5,150**	**5,254**	**5,359**	**5,467**	**5,576**	**5,688**	**3,254**	**3,370**	**3,487**	**3,607**	**3,728**	**3,852**	**3,977**	**4,104**	**4,233**	**4,364**	**4,496**	**4,630**	**4,766**	**6,420**	**6,559**	**6,699**
Interest income & expenses																									
Interest on cash	1000 USD/yr	-	3	8	13	19	25	32	43	54	62	70	79	87	95	104	113	121	130	139	148	157	166	176	185
Interest payment	1000 USD/yr		1,384	1,093	801	510	219	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Income tax payment	1000 USD/yr	-	-	-	-	-	-	-	-	-	515	534	553	572	592	1,224	1,265	1,306	1,348	1,390	1,433	1,477	1,976	2,020	2,065
	1000 USD/yr																								
Profit after tax	**1000 USD/yr**	**-**	**3,667**	**4,065**	**4,465**	**4,868**	**5,273**	**5,609**	**5,731**	**3,308**	**2,917**	**3,024**	**3,133**	**3,243**	**3,355**	**2,857**	**2,952**	**3,048**	**3,146**	**3,244**	**3,345**	**3,446**	**4,611**	**4,714**	**4,819**

Table: Economic Ananysis on Biogas Power Generation (Excluding Bio-compost Production Activity)

(Cashflow Analysis; CIncluding Sales of CERs)

	Unit	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19	Y20	Y21	Y22	Y23
OPERATING REVENUES																									
Sales of organic fertilizer	1000 USD/yr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electricity sales	1000 USD/yr		5,781	5,938	6,099	6,265	6,437	6,613	6,795	6,425	6,618	6,817	7,021	7,232	7,449	7,672	7,902	8,139	8,383	8,635	8,894	9,161	9,436	9,719	10,010
Sales of carbon credits	1000 USD/yr		1,991	1,991	1,991	1,991	1,991	1,991	1,991	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total revenue	1000 USD/yr	-	7,772	7,928	8,090	8,256	8,427	8,604	8,785	6,425	6,618	6,817	7,021	7,232	7,449	7,672	7,902	8,139	8,383	8,635	8,894	9,161	9,436	9,719	10,010
OPERATING COSTS																									
Press mud cost	1000 USD/yr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Enzymes and Chemicals	1000 USD/yr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fuel for machines	1000 USD/yr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lubricants and consummables	1000 USD/yr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Land lease	1000 USD/yr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Maintenance	1000 USD/yr	-	383	402	422	443	465	488	513	538	565	593	623	654	687	721	757	795	835	877	921	967	1,015	1,066	1,119
Insurance	1000 USD/yr	-	128	129	130	131	133	134	135	137	138	139	141	142	144	145	147	148	150	151	153	154	156	157	159
Administration & management	1000 USD/yr	-	510	536	562	590	620	651	683	718	754	791	831	872	916	962	1,010	1,060	1,113	1,169	1,227	1,289	1,353	1,421	1,492
Technical consultants	1000 USD/yr	-	100	105	110	116	122	128	134	141	148	155	163	171	180	189	198	208	218	229	241	253	265	279	293
Labor cost	1000 USD/yr	-	85	90	94	99	104	109	114	120	126	132	139	146	153	161	169	177	186	195	205	216	226	238	249
Total operating costs	1000 USD/yr	-	1,205	1,260	1,318	1,379	1,443	1,510	1,580	1,653	1,730	1,811	1,896	1,986	2,079	2,177	2,280	2,389	2,502	2,621	2,746	2,878	3,015	3,160	3,312
Gross profit from operation	1000 USD/yr	-	6,566	6,668	6,771	6,877	6,984	7,094	7,206	4,772	4,888	5,005	5,125	5,246	5,369	5,495	5,622	5,751	5,881	6,014	6,148	6,283	6,420	6,559	6,699
Change in working capital	1000 USD/yr	-	597	11	11	11	12	12	12	(200)	13	13	13	14	14	15	15	15	16	16	16	17	17	18	18
Interest on cash	1000 USD/yr	-	3	8	13	19	25	32	43	54	62	70	79	87	95	104	113	121	130	139	148	157	166	176	185
Upfront fee	1000 USD/yr	842																							
Interest on loan	1000 USD/yr	1,457	1,384	1,093	801	510	219	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Income tax payment	1000 USD/yr	-	-	-	-	-	-	-	-	-	515	534	553	572	592	1,224	1,265	1,306	1,348	1,390	1,433	1,477	1,976	2,020	2,065
Financing																									
Capital expenditure	1000 USD/yr	28,056	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Funded by: Loan	1000 USD/yr	18,213	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Equity	1000 USD/yr	12,142	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total funding	1000 USD/yr	30,355	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Loan repayment	1000 USD/yr	-	3,643	3,643	3,643	3,643	3,643	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pay to statutory reserve	1000 USD/yr	-	183	203	223	243	264	97	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cash available for distribution	**1000 USD/yr**	**-**	**761**	**1,726**	**2,106**	**2,488**	**2,873**	**7,017**	**7,236**	**5,026**	**4,422**	**4,528**	**4,637**	**4,747**	**4,859**	**4,360**	**4,454**	**4,550**	**4,648**	**4,746**	**4,846**	**4,947**	**4,593**	**4,697**	**4,801**

	Unit	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19	Y20	Y21	Y22	Y23
Project IRR (Post-Tax)																									
Net Cash Flows Before Interest, Debt Service & after taxTax	1000 USD	-	6,566	6,668	6,771	6,877	6,984	7,094	7,206	4,772	4,888	5,005	5,125	5,246	5,369	5,495	5,622	5,751	5,881	6,014	6,148	6,283	6,420	6,559	6,699
less: Corporate Tax	1000 USD	-	0	0	0	0	0	0	0	0	(515)	(534)	(553)	(572)	(592)	(1,224)	(1,265)	(1,306)	(1,348)	(1,390)	(1,433)	(1,477)	(1,976)	(2,020)	(2,065)
less: Capital Expenditure	1000 USD	(30,355)	0	0	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NCF Attributable to Project Sponsors	1000 USD	(30,355)	6,566	6,668	6,771	6,877	6,984	7,094	7,206	4,772	4,373	4,471	4,572	4,674	4,777	4,270	4,357	4,444	4,533	4,623	4,714	4,806	4,444	4,539	4,634
Project IRR (Post-Tax) 14.58%	@ 23 years		*#NUM!*	*-41.1%*	*-18.2%*	*-4.7%*	*3.7%*	*9.2%*	*12.8%*	*14.6%*	*15.8%*	*16.7%*	*17.5%*	*18.1%*	*18.6%*	*18.9%*	*19.2%*	*19.4%*	*19.6%*	*19.7%*	*19.9%*	*20.0%*	*20.0%*	*20.1%*	*20.2%*
Equity IRR (Free Cash)																									
Net Cash Flows Before Interest, Debt Service & Tax	1000 USD	-	6,566	6,668	6,771	6,877	6,984	7,094	7,206	4,772	4,888	5,005	5,125	5,246	5,369	5,495	5,622	5,751	5,881	6,014	6,148	6,283	6,420	6,559	6,699
less: Corporate Tax	1000 USD	-	-	-	-	-	-	-	-	-	(515)	(534)	(553)	(572)	(592)	(1,224)	(1,265)	(1,306)	(1,348)	(1,390)	(1,433)	(1,477)	(1,976)	(2,020)	(2,065)
less: interest payment			(1,384)	(1,093)	(801)	(510)	(219)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Less: principal payment	1000 USD	-	(3,643)	(3,643)	(3,643)	(3,643)	(3,643)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
less: Equity Contribution	1000 USD	(12,142)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NCF Attributable to Project Sponsors	1000 USD	(12,142)	1,539	1,932	2,327	2,724	3,123	7,094	7,206	4,772	4,373	4,471	4,572	4,674	4,777	4,270	4,357	4,444	4,533	4,623	4,714	4,806	4,444	4,539	4,634
26.21%	@ 23 years	(12,142)	1,539	1,932	2,327	2,724	3,123	7,094	7,206	4,772	4,373	4,471	4,572	4,674	4,777	4,270	4,357	4,444	4,533	4,623	4,714	4,806	4,444	4,539	4,634
Equity IRR (Free Cash)			#NUM!	#NUM!	-28.1%	-11.8%	-1.2%	10.9%	17.2%	19.8%	21.4%	22.7%	23.6%	24.2%	24.8%	25.1%	25.4%	25.6%	25.8%	25.9%	26.0%	26.1%	26.1%	26.2%	26.2%
Equity IRR (Dividends)																									
Dividend Distributed	1000 USD	-	761	1,726	2,106	2,488	2,873	7,017	7,236	5,026	4,422	4,528	4,637	4,747	3,875	2,857	2,952	3,048	3,146	3,244	3,345	3,446	4,593	4,697	4,801
less: Equity Contribution	1000 USD	(12,142)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NCF Attributable to Project Sponsors	1000 USD	(12,142)	761	1,726	2,106	2,488	2,873	7,017	7,236	5,026	4,422	4,528	4,637	4,747	3,875	2,857	2,952	3,048	3,146	3,244	3,345	3,446	4,593	4,697	4,801
Equity IRR (Dividends) 24.15%	@ 23 years		*#NUM!*	*#NUM!*	*#NUM!*	*-16.5%*	*-5.4%*	*7.8%*	*14.6%*	*17.6%*	*19.4%*	*20.7%*	*21.7%*	*22.4%*	*22.9%*	*23.2%*	*23.4%*	*23.5%*	*23.7%*	*23.8%*	*23.9%*	*24.0%*	*24.0%*	*24.1%*	*24.1%*