FY2007 Survey of the CDM/JI Project

Survey of the Biomass Electric Generation System by the Phosphoric Acid Fuel Cells in Phi Phi Island in Thailand

Summary of the Report

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1. SUMMARRY OF THE PROJECT

This FS aims at the evaluation of feasibility of an electricity generation project, which plans to utilize bio-gas (methane gas) through the anaerobic digestion of human wastes and kitchen wastes (garbage and wastewater) from the resort hotel. The digested bio-gas will be input to Phosphoric-Acid Fuel Cells (PAFC) which is produced and already commercialized inside Japan, and electricity will be generated to meet the hotel's demand. As a result, the current practice of human wastes and kitchen wastewater disposal with open lagoons, and the methane gas released into the atmosphere will be reduced. At the same time, the reduction of fossil fuel use for diesel electricity generators will be achieved.

The project effects will be spread to remote island-type resorts in Southeast and South Asia and Micronesia regions, since it will provide a solution against the energy supply problem those resorts would face to.

1.1. Situation of the site for the project

Phi Phi Don Island is located offshore from Malay Peninsula and is isolated from the mainland electric grids. Current electric generation there is based on diesel generators for which fuels for diesel generators transported from outside are used, and thus the fuels price is higher. The proposed project will contribute to the self electricity supply and the independence from the outside fossil fuel.
PAFC as electric generators have many advantages compared to ordinary gas engine generators.

In the island, there are not public electrical grid (power supply), water supply and waste water treatment system. Therefore, It necessitate that these supply are provided by own facilities that constructed by own budget.

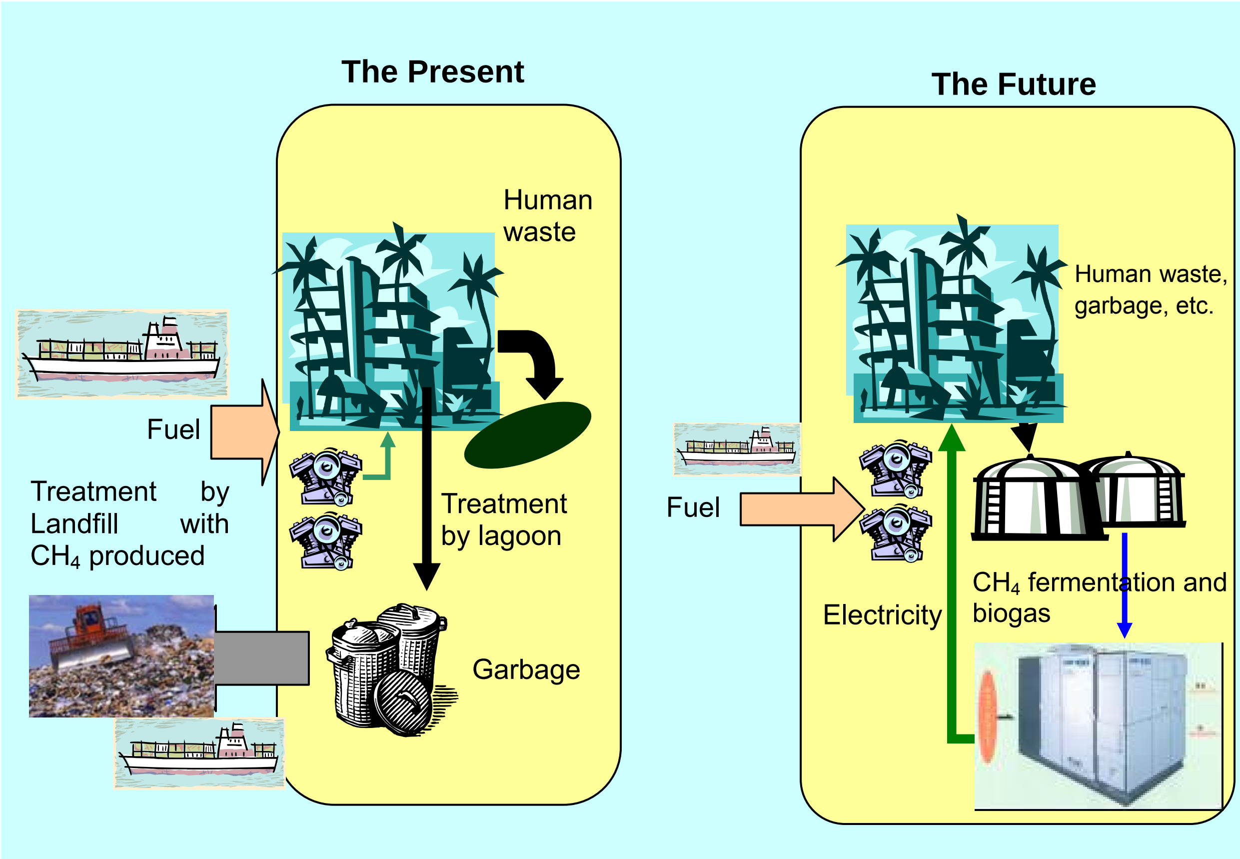

Fig.1. Conceptual illustration of the project.

1.2. Objective of the project

In the Phi Phi Island Village Beach Resort & Spa as tentative site for the survey, the waste as kitchen garbage and so on that produced by a stuff and visitors, the stuff collected it, then transferred to Phuket Island by boats and trucks. Finally, the waste were filled in the land. Other hand, the waste as wastewater is treated softly by watewater treatment system with low efficiency behind the resort. The energy as for electricity and heat, generated by diesel-electric system. The fuel for the generator, is transported from Phuket by ships. Therefore, the resort has already serious problems in environment. You can take the offensive odor in the face of the seashore.

The first purpose of this project is to generate methane from garbage on site and to avoid dumping it at a solid waste disposal site(SWDS). The methane emissions from SWDS is reduced. The second purpose is to generate renewable energy from garbage on site. Using the renewable energy at the resort will reduce oil consumption of diesel engines.

1.2.1. Title of the small-scale project activity

Electricity generation by fuel cell using biogas generated from garbage in Phi Phi island resort.

1.2.2. Description of the small-scale project activity

1.2.3. Purpose of the project activity

The first purpose of this project is to generate methane from garbage on site and to avoid dumping it at a solid waste disposal site(SWDS). The methane emissions from SWDS is reduced. The second purpose is to generate renewable energy as biogass from garbage on site. Using the renewable energy at the resort will reduce oil consumption of diesel engines.

1.2.4. Description of GHG reduction

This project is to generate biogas containing methane from garbage at resort. The wastes like kitchen garbage, human waste and so on are collected in unaerobic tank. The biogas is generated by fermentation in tank.
The biogas is used by phosphoric acid fuel cell (PAFC). Electricity generated by PAFC using biogas is supplied through private grid to the resort. Using the renewable energy at the resort will reduce oil consumption of diesel engines and CO_2 emissions. Avoiding dumping the wastes at SWDS reduces methane emissions from SWDS in Phuket. In this project, there are two different ways of GHG emissions reductions. One way is to reduce methane emissions by avoiding from dumping waste. The other is to
reduce CO_2 emissions discharged by oil consumption. The decision to consider the implementation of this project is influenced by the possibility obtaining revenues from the sale of Certified Emission Reduction.

1.2.5. The project activity contributes to the sustainable development by

In a Thailand resort island, there is a little public sewage treatment equipment and poor power grid. The wastes at resort is dumped at SWDS. The waste water flows into sea without water treatment enough. The electric power supply at resort is generated by diesel generators on site in general. The increase of visitors makes the increase of wastes and destructs environment in this area.

Electricity generated by PAFC using biogas is supplied through private grid to the resort. In this project using the renewable energy at the resort will reduce oil consumption of diesel engines. A voiding dumping the wastes at SWDS reduces methane emissions from SWDS in Phuket. The operations and maintenance of fermentation and PAFC using biogas is not a difficult work. The maintenance cost of PAFC is lower than of the engine. This system will be installed widely in this area.

Phi Phi island is one of famous resort islands located in southern Thailand. Many visitors from Europe and Asia come here to spend vacations. This area has serious problems caused by coming many visitors. This problems are a large amount of wastes and the destruction of the environment. In Phi Phi island, there are additionally problems that there is no power grid and no trash disposal facility. People in here has to bring oil and generate power by themselves and to bring garbage out from here. There are CO_2 emissions from diesel engines for power supply and methane emissions from dumping garbage at SWDS.

1.2.6. Application of a baseline and monitoring methodology

Approved SSC methodologies Version 2 of Annex 10 : Methodological tool - “Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site”.

Version 12 of 1.A. – “Electricity generation by the user”

Available on the UNFCC website:
(http://cdm.unfccc.int/methodologies/SSCmethodologies/approved.html)

This project meets the applicability criteria of version 2 of Annex 10 as:

- The solid waste disposal site where the waste would be dumped is clearly identified.
- The waste is not hazardous wastes.

This project meets the applicability criteria of Version 12 of 1.A. as:

- Users do not have a grid connection and uses all of electricity which is generated by the users. The capacity of these renewable energy generators dose not exceed 15 MW.
- This system in the activity is not a combined heat and power (co-generation) system.

1.3. Description of the project boundary

Table 1. Description of the source and gases included in the project boundary

	Source	Gas	Included	Justification/explanation
Baseline	Emissions from dumping waste at a solid waste disposal site	CH_4	Yes	The major source of emissions in the baseline
	Emissions from electricity generation	CO_2	Yes	Emission from oil consumption
Project activity	Emissions from dumping waste at a solid waste disposal site	CH_4	No	Avoided from dumping waste at a solid waste disposal site
	Emissions from electricity generation	CO_2	Yes	Emissions from oil consumption

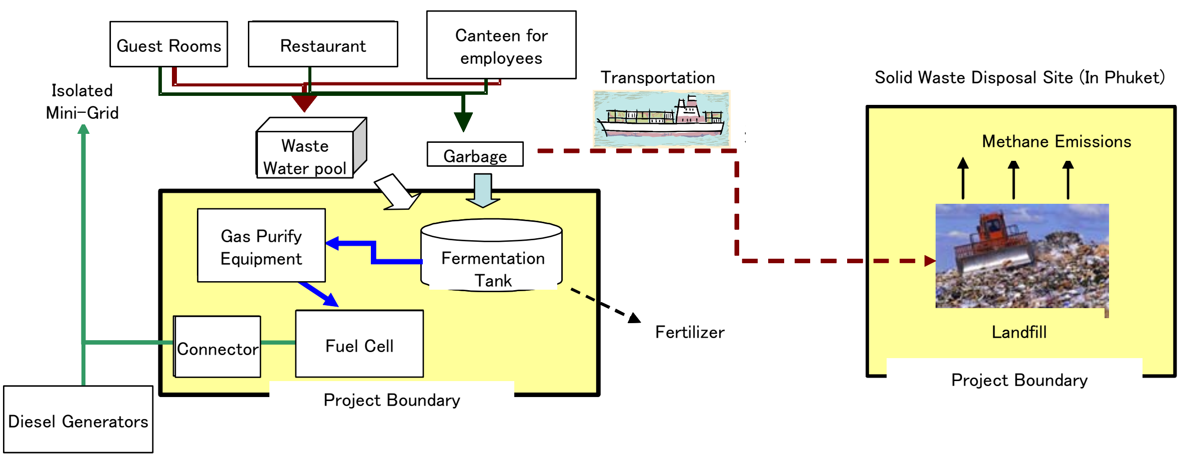

Fig.2. System Boundary of this project.

1.4. Description of baseline and its development

Current state of island resort in Thailand：

There are a few trash disposal facilities and a poor power grid.
Users managing resort facilities have to prepare them.

↓

（About the wastes from resort）

The waste water flows into sea without water treatment enough.
The Garbage at resort is brought out and dumped at SWDS.

（About electric power supply）

The electric power supply at resort is generated by diesel generators on site in general.
The capacity of these energy generators by the users is below several MW.
The demonstration and assessment of additionality about generators using biogas

Gas engine generators using biogas :

Power generation efficiency is low (below 25%）

Maintenance cost is high (above 0.06 USD/kWh)

The users in here does not consider having generators using biogas

【Baseline scenario】

The waste water at the resort flows into sea without water treatment enough. The garbage collected at resort is brought out from here and dumped at SWDS in Phuket.

1.5. Emission reductions

1.5.1. Baseline emissions

1.5.1.1. Methane emissions

$$BE_{CH4,SWDS,y} = \varphi \cdot (1-f) \cdot GWP_{CH4} \cdot (1-OX) \cdot 16/12 \cdot F \cdot DOC_f \cdot MCF \cdot \sum_{x=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k_j \cdot (y-x)} \cdot (1-e^{-kj})$$

Where

$BE_{CH4,SWDS,y}$ ＝Methane emissions avoided during the year y from preventing waste disposal at the solid waste disposal site (SWDS) during the period from the start of the project activity to the end of the year y (t-CO_2e)

φ ＝ Model correction factor to account for model uncertainties (0.9)

f ＝ Fraction of methane captured at the SWDS and flared, combusted or used in another manner

GWP_{CH4} ＝ Global Warming Potential (GWP) of methane, valid for the relevant commitment period

OX ＝ Oxidation factor (reflecting the amount of methane from SWDS that is oxidised in the soil or other material covering the waste)

F ＝ Fraction of methane in the SWDS gas (volume fraction) (0.5)

DOC_f ＝ Fraction of degradable organic carbon (DOC) that can decompose

MCF ＝ Methane correction factor

$W_{j,x}$ ＝ Amount of organic waste type j prevented from disposal in the SWDS in the year x (tons)

DOC_j ＝ Fraction of degradable organic carbon (by weight) in the waste type j

kj ＝ Decay rate for the waste type j

j ＝ Waste type category (index)

x = Year during the crediting period: x runs from the first year of the first crediting period (x = 1) to the year y for which avoided emissions are calculated (x = y)
y = Year for which methane emissions are calculated

Where different waste types j are prevented from disposal, determine the amount of different waste types
($W_{j,x}$) through sampling and calculate the mean from the samples, as follows:

$$W_{j,x} = W_x \cdot \sum_{n=1}^{z} P_{n,j,x} \,/\, z$$

Where
$W_{j,x}$ = Amount of organic waste type j prevented from disposal in the SWDS in the year x (tons)
W_x = Total amount of organic waste prevented from disposal in year x (tons)
$P_{n,j,x}$ = Weight fraction of the waste type j in the sample n collected during the year x
z = Number of samples collected during the year x

1.5.1.2. CO_2 emissions

The energy baseline is the fuel consumption of the technology in use or that would have been used in the absence of the project activity. The project participants may use one of the following energy baseline formulae:

$$EB = \Sigma_i O_i / (1-l)$$

Where:
EB = Annual energy baseline in kWh per year.
Σ_i = The sum over the group of "i" renewable energy technologies (e.g. solar home systems, solar pumps) implemented as part of the project.
O_i = The estimated annual output of the renewable energy technologies of the group of "i" renewable energy technologies installed (in kWh per year)
l = Average technical distribution losses that would have been observed in diesel powered mini-grids installed by public programmes or distribution companies in isolated areas, expressed as a fraction.

The emissions baseline is the value that EB times EF_y (CO_2 emissions factor) which a small-scale project proponent may use.

$$EF_y = 0.8 \quad (kg\text{-}CO_2/kWh)$$

1.5.2. Project Emissions

1.5.2.1. Methane emissions

There is no methane emissions.

1.5.2.2. CO_2 emissions

O_i = G_{FC} − CE_{FT}

O_i : Amount of power supply estimated by renewable energy
G_{FC} : Amount of power generation output by fuel cell using biogas
CE_{FT} : Power consumption of fermentation equipment

(1) Amount of power generation output by fuel cell using biogas

G_{FC} = $\eta FC \cdot W_1 \cdot PBG \cdot R\ CH_4 \cdot 365(d/y)$

Where:
η_{FC} : 38 % Power generation coefficient of the fuel cell using biogas
W_1 : 0.9 t/d Amount per day of organic waste like kitchen waste
P_{BG} : 0.74 m^3/kg Biogas volume generated by 1kg of organic waste
R_{CH4} : 60 % Fraction of methane in the biogas
T_{CH4} : 37,180 kJ/m^3 Methane's heat of combustion

(2) Power consumption and thermal energy of fermentation equipment

Fermentation equipment is supplied enough thermal energy produced in power generation and does not need extra energy.

CE_{FT} = $W_1 \cdot IEFT \cdot 365(d/y)$

IE_{FT} : 350 kWh/t Power consumption of fermentation equipment for 1ton garbage

1.6. Ex-ante calculation of emission reductions

The amount of methane produced in the year y ($BE_{CH4,SWDS,y}$) is calculated as follows:

$$BE_{CH4,SWDS,y} = \varphi \cdot (1-f) \cdot GWP_{CH4} \cdot (1-OX) \cdot 16/12 \cdot F \cdot DOC_f \cdot MCF \cdot \sum_{X=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k_j \cdot (y-x)} \cdot (1-e^{-kj})$$

W_1 = 0.9 t/d (Information from engineer at the resort)
W_1 : Total amount of organic waste prevented from disposal in year x (t)

Table 2. GHG emissions in project period

Project period	GHG emissions (t-CO_2e)
1st	2,047
2nd	3,419
3rd	4,339
4th	4,955
5th	5,368
6th	5,645
7th	5,831
8th	5,956
9th	6,039
10th	6,095
11th	6,132
12th	6,158
13th	6,174
14th	6,186
15th	6,193

1.5.2.3. GHG emission reduction by renewable energy

$$O_i = G_{FC} - CE_{FT}$$

O_i : Amount of power supply estimated by renewable energy
G_{FC} : Amount of power generation output by fuel cell using biogas
CE_{FT} : Power consumption of fermentation equipment

(1) Amount of power generation output by fuel cell using biogas

$$G_{FC} = \eta FC \cdot W_1 \cdot PBG \cdot R\ CH_4 \cdot 365(d/y)$$

ηFC : 38% Power generation coefficient of the fuel cell using biogas
W_1 : 0.9 t/d Amount per day of organic waste like kitchen waste
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R CH_4 : 60 % Fraction of methane in the biogas
T CH_4 : 37,180 kJ/m^3 Methane's heat of combustion

$$G_{FC} = 0.38 \cdot 0.9 \cdot 0.74 \cdot 0.6 \cdot 37{,}180 \cdot 365$$
$$= 2{,}061\ GJ = 572\ MWh$$

(2) Power consumption and thermal energy of fermentation equipment

Fermentation equipment is supplied enough thermal energy produced in power generation and does not need extra energy.

$$CE_{FT} = W_1 \cdot IE_{FT} \cdot 365(d/y)$$

IE_{FT} : 350* kWh/t Power consumption of fermentation equipment for 1ton garbage

（* : According to a report “Renewable energy by garbage fermentation” Ministry of environment in Japan）

$$CE_{FT} = 0.9 \cdot 350 \cdot 365$$
$$= 115 \text{ MWh}$$

$$O_i = G_{FC} - CE_{FT} = 457 \text{ MWh}$$

1.5.2.4. Baseline GHG emissions

$$GHG_B = \Sigma_i O_i / (1\text{-}l) \cdot EF_y = 457 \text{ t-}CO_2$$

1.5.3. Summary of the ex-ante estimation of emission reductions

1.5.3.1. Environmental Impacts

An enforcement site and environmental effect to the environs are analyzed by carrying out this project. It is it with transduction by 2011, and, with a sea bream, an RPS system to oblige electric power utility to the use of renewable energy with constant percentage is going to promote transduction of renewable energy, and this project is an undertaking along a governmental policy.

1.5.3.2. An influence to a local environment

"Garbage" occurring in a resort establishment by enforcement of this project in large quantities can be developed into resources. The region concerned is sea bream, but it is an eminent resort, and there are lot of accommodations in Phi Phi Don Island. The geographical convenience is the accommodations to grind, but it is thought that similar energy system is adopted around that purpose. We depend, and, as of the result, an enhancement of more sewage treatment plan it about fouled sewage drained in minimum processing in each establishment, and antipollution of neighboring sea can be planned. In addition, by navigation of the cargo boats which carries waste so that landfill does waste such as garbage, biomass power generation; of diesel power generation; because light it, and it is it with decrease of the fuel ability, can reduce navigation of a tanker.

1.5.3.3. An effects to transfer of skill / development

By this project, garbage methane fermentation facility, recovery / purification facility of biogas, fuel cell power generation facilities are introduced. CH_4 fermentation facility and technique to relate to gas recovery / purification facility are not the technique that it is basically difficult.

In addition, about production of fuel cell stack, high technique is necessary, but, judging from the user side generating electricity, it is watched remoteness by manufacturer, and there is little turnover region about maintenance, and, about fuel cell, straw mat open market operations are comfortable facility than internal combustion engine such as an engine.

Because conventional fossil energy was cheap, judging from an aspect of diffusion, the these equipment did not advance to the transduction up to these days without percent being correct with an aspect of a cost wholly.

In businessman administering a resort establishment, transduction is not planned in particular almost because it is not facility inducing a lodging visitor directly.

However, surge of interest for global environment affects a tourism industry, and environment consideration becomes a theme in a European and American famous hotel chain.

Therefore it is expected if this technical effect is recognized by this project when the movement that a lot of high quality resorts adopt voluntarily in sea bream doing a store location appears.