CLEAN DEVELOPMENT MECHANISM
PROJECT DESIGN DOCUMENT FORM (CDM-SSC-PDD)
Version 03 - in effect as of: 22 December 2006

CONTENTS

Annexes

Revision history of this document

Version Number	Date	Description and reason of revision
01	21 January 2003	Initial adoption
02	8 July 2005	• The Board agreed to revise the CDM SSC PDD to reflect guidance and clarifications provided by the Board since version 01 of this document. • As a consequence, the guidelines for completing CDM SSC PDD have been revised accordingly to version 2. The latest version can be found at <http://cdm.unfccc.int/Reference/Documents>.
03	22 December 2006	• The Board agreed to revise the CDM project design document for small-scale activities (CDM-SSC-PDD), taking into account CDM-PDD and CDM-NM.

SECTION A. General description of small-scale project activity

A.1 Title of the small-scale project activity:

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

A.2. Description of the small-scale project activity:

Purpose of the project activity:

The purpose of this project is to reproduce methane from waste garbage by methane fermentation on site and to avoid dumping it at the solid waste disposal site (SWDS) in Phuket and Krabi. It's not only decrease the methane emissions from SWDS, but also the generation of renewable energy from garbage on site. Finally, using the renewable energy will cut down the fuel consumption of generator by diesel engines.

Description of GHG reduction:

This project is to reproduce biogas containing 60% of methane from waste garbage in the resort area. The wastes such as kitchen garbage, human waste and organic wastewater are collected systematically in the anaerobic tank of methane fermentation. The reproduced biogas supplies through into the 100 kW of Phosphoric Acid Fuel Cell (PAFC) as generator, then generated electricity is supplied through private grid to any facilities in the resort hotel. Using renewable energy there will reduce fuel consumption of generator by diesel engines and CO_2 emissions. To avoid dumping the garbage at SWDS reduces methane emissions from SWDS in Phuket and Krabi.

Therefore, in this project, reduction of GHG emissions by two different ways. One way is to reduce methane emissions by avoiding from dumping garbage. The other is to reduce CO2 emissions exhausted by fuel consumption by present generator.

The decision to consider the implementation of this project is judged by the possibility obtaining revenues from the price of Certified Emission Reduction.

Contribution of the project activity to sustainable development:

Execution of the project will acquire a building up a zero emission type resort facilities in such a remote island in the world. Also, a zero emission type resort invites an executive person from the world. Because, a lot of countries has a remote island for plan of a resort, a resort is hardly required the environmental friendly. When our project doing successfully, almost resort chase our project naturally for themselves.

The project activity contributes to the sustainable development by:

At a resort island in Thailand, there are few public inflastructure for sewage treatment and poor electrical power grid. The wastes as garbage are dumped at SWDS and an organic wastewater flowed through river to sea without wastewater treatment enough. In that area, the electric power supply is generated by diesel engine generators on site in general. The increase of visitors causes the increase of wastes and environment disruption in that area.

Electricity generated by PAFC using biogas is supplied through private grid to any facilities in the resort hotel. In this project using the renewable energy will reduce fuel consumption of generator by diesel engines. Avoiding dumping the wastes at SWDS reduces methane emissions from SWDS in Phuket and Krabi. The system that consists of methane fermentation and PAFC as generator using biogas make easy to the operations and maintenance by engineers without high education. Moreover, the maintenance cost of the PAFC is lower than a generator by gas engine. This system will be installed widely in an areas located in the same surroundings.

A.3. Project participants:

This project is operate by Phi Phi island resort &Spa mainly, Holiday-inn, Erawan Resort, Natural Resort operate together with Phi Phi island resort &Spa as garbage gathering. PAE Thailnad Public Co. Ltd. and Ecopros Co. Ltd. will construct the system as engineering. Krabi province and authorities of Phi Phi Island will remove a barrier of the rule for induction of the system.

A.4. Technical description of the small-scale project activity:

A.4.1. Location of the small-scale project activity:

A.4.1.1. Host Party (ies):

Kingdom of Thailand

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

The site enforcing the project belongs to the Krabi province in Thailand. The site is located in between the large island of Phuket and the western Andaman Sea coast of the mainland.

A.4.1.3. City/Town/Community etc:

The project site is located in mid north part of Phi Phi Don Island as shown in the Figure 1 and detailed information mentioned in the Table 1.

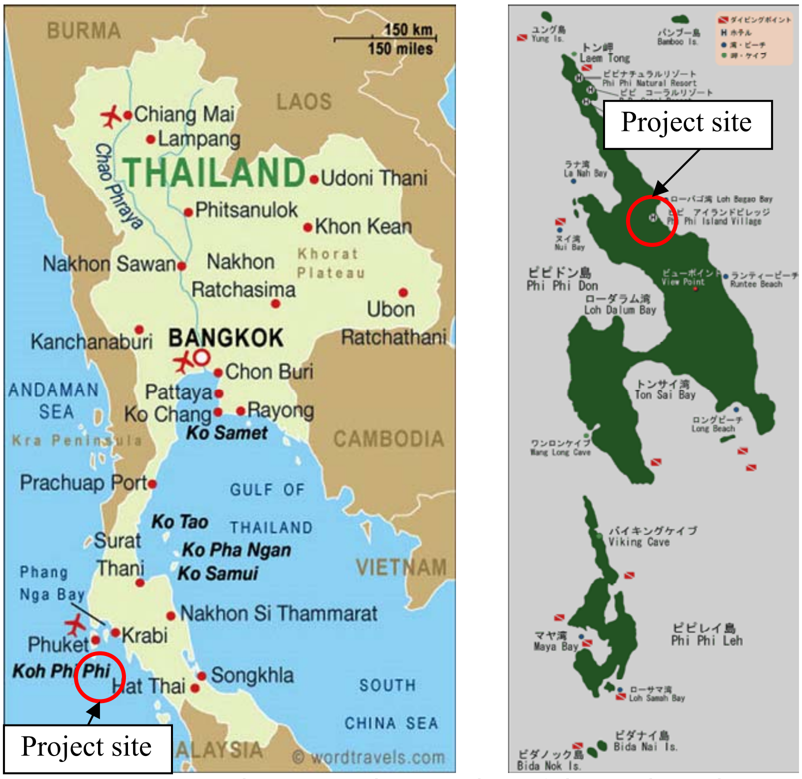


Figure 1. The location of the project site.

Table 1. Information of the project site

Name	Ko Phi Phi Don
Area	28 km2 (8 km and 3.5 km)
	50 km south-east of Phuket in Thailand
Islands Group	Main island of Phi Phi islands group
Administration	Krabi province
Transportation	Aircraft and ferry boat

A.4.1.4. Details of physical location, including information allowing the unique identification of this small-scale project activity:

Phi Phi islands are one of well-know resort islands of worldwide reputation located in southern Thailand. A great number of visitors from the all over the world visit the island to take a vacation among white sand beach and clear the sea. This island has serious environmental problems caused by coming many visitors over a permissible range by the natural. Because, These problems are a large amount of wastes and the environment disruption. Moreover, in Phi Phi island, there are additionally problems occurred by a poor electrical power grid and garbage disposal facility. Therefore, the people that living in the island has to bring fuel for generation of the electricity from outside as mainland. Contrary, the people have to bring wastes as garbage to outside as SWDS at Phuket and Krabi. These situations are to exhaust much CO2 emission in the process.

A.4.2. Type and category (ies) and technology/measure of the small-scale project activity:

Sectoral Scope: Number 1: Energy industries
Reference : AMS-I.A.
Methodology title: Electricity generation by the user

Sectoral Scope: Number 13: Waste handling and disposal
Reference : AMS-III.F.
Methodology title: Avoidance of methane emissions through controlled biological treatment of biomass

A.4.3. Estimated amount of emission reductions over the chosen crediting period:

The effect of the project is estimated to reduce GHG emissions by 10,898～31,183 t-CO_2e annually (Tab. 2.)

Table 2. Emission reductions over the crediting period

project period	GHG Emission / Emission Reduction (t-CO_2e)		
	BE_y	PE_y	ER_y
1st	15,802	4,904	10,898
2nd	25,864	8,091	17,774
3rd	32,609	10,226	22,382
4th	37,130	11,658	25,472
5th	40,160	12,618	27,543
6th	42,192	13,261	28,931
7th	43,553	13,692	29,861
8th	44,466	13,981	30,485
9th	45,078	14,175	30,903
10th	45,488	14,305	31,183

A.4.4. Public funding of the small-scale project activity:

There is not public funding for the project except from funding from government of Thailand.

A.4.5. Confirmation that the small-scale project activity is not a debundled component of a large scale project activity:

There is not a debundled component of a large scale project activity in this activity.

SECTION B. Application of a baseline and monitoring methodology

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

AMS-I.A. “Electricity generation by the user”
(Version 13 Sectoral Scope: 01, dated 26 September 2008)

AMS-III.F. “Avoidance of methane emissions through controlled biological treatment of biomass”
(Version 6 Sectoral Scope: 13, dated 02 August 2008)

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

B.2 Justification of the choice of the project category:

This project meets the applicability criteria of Version 13 of I.A. as:

Users do not have a grid connection for electricity and uses all of electricity that 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.

This project meets the applicability criteria of version 6 of III.F.as:

This project is a measure to avoid the emissions of methane to the atmosphere from biomass that would have been left to decay anaerobically in a SWDS. In the project activity, controlled biological treatment of biomass is inducted through anaerobic digestion in closed reactors equipped with biogas recovery. The amount of the emission reduction in this system is less than 60,000 t-CO2e annually. The location and characteristics of the disposal site of the biomass as garbage in the baseline conditions are known, in such a way as to allow the estimation of its methane emissions. In this project activity, parts of residual wastes from biological treatment are delivered to a SWDS. The emissions from SWDS by residual waste are calculated as "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site". The recovered biogas from anaerobic digestion is utilised for electrical energy generation directly. Component of the project activity uses a corresponding category under Type I.

B.3. Description of the project boundary:

Table 3. Description of the source and gases included in the project boundary

Source	Gas	Included	Justification/explanation
Emissions from dumping waste at a solid waste disposal site	CH4	Yes	The major source of emissions in the baseline
Emissions from electricity generation	CO2	Yes	Emission from oil consumption
Emissions due to incremental transportation distances	CO2	Yes	Emission from oil consumption
Emissions from physical leakages of the anaerobic digester	CH4	Yes	Emission from digester tank
Emissions from dumping waste at a solid waste disposal site	CH4	Yes	Avoided from dumping waste at a solid waste disposal site
Emissions from electricity generation	CO2	Yes	Emissions from oil consumption

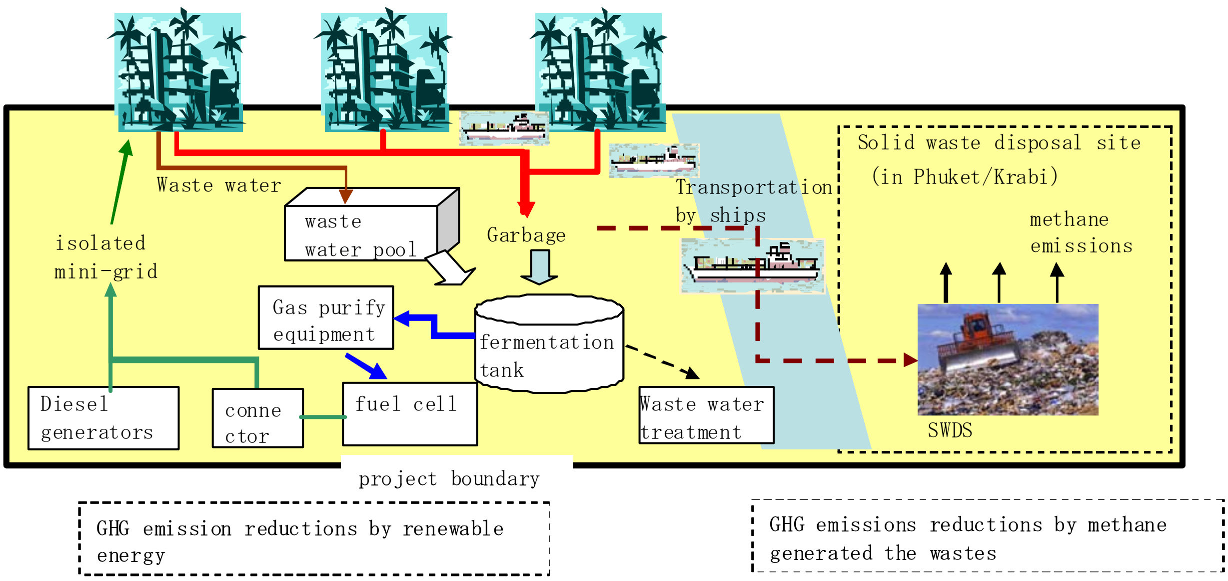


Figure 2. Illustration of the project boundary.

B.4. Description of baseline and its development:

Current state of the island resort in Thailand:
There are not a waste/wastewater treatment/incinerator facilities and a public power plant/grid. Therefore, each resorts handle it by themselves using own expense.

About the wastes from resort:
The wastewater flows into sea without water treatment enough in individual resort. Because, Phi Phi island had not public wastewater treatment system. The garbage at resort is brought out and dumped at SWDS.

About electric power supply:
The electric power supply in the island is generated from diesel engine generators on site by individual resorts in general. The capacity of these energy generators by the users is below several MW.

Gas engine generators using biogas:
Gas engine generator is popular technology for small power generation using natural gas and/or city gas. Efficiency of the generator from fuel to electricity is low so as to be small scale. Moreover, using biogas, the efficiency drop down below 25% rapidly. Because, biogas has low contents of energy (60% of CH_4) . Maintenance cost of the generator, it's about above 0.06 USD/kWh. The users in here does not consider having generators using biogas

B.5. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered small-scale CDM project activity:

The garbage from the resort is not dumped at SWDS directly. This activity makes to reduce methane emissions from SWDS and CO_2 emissions from fuel consumption by using biogas as renewable energy.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

BASELINE EMISSIONS
(1) Methane emissions

$$BE_y = BE_{CH4,SWDS,y} - (MD_{y,reg} \times GWP_{\_CH4}) + (MEP_{y,ww} \times GWP_{\_CH4})$$

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)
$MD_{y,reg}$	:Amount of methane that would have to be captured and combusted in the year y to comply with the prevailing regulations (tonne)
$MEP_{y,ww}$	:Methane emission potential in the year y of the wastewater co-composted.

$$BE_{CH4,SWDS,y} = \varphi \cdot (1-f) \cdot GWP_{CH4} \cdot (1-OX) \cdot 16/12 \cdot F \cdot DOCf \cdot MCF \cdot \sum_{x}\sum_{j} Q_{j,x} \cdot DOCj \cdot e{-kj} \cdot (y-x) \cdot (1-e{-kj})$$

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)
DOCf :Fraction of degradable organic carbon (DOC) that can decompose
MCF :Methane correction factor
$Q_{j,x}$:Amount of organic waste type *j* prevented from disposal in the SWDS in the year *x* (tons)
DOCj :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 ($Q_{j,x}$) through sampling and calculate the mean from the samples, as follows:

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

Where
Qj,x :Amount of organic waste type *j* prevented from disposal in the SWDS in the year *x* (tons)
Qx :Total amount of organic waste prevented from disposal in year *x* (tons)
Pn,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*

(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:

$$EB = \Sigma_i EG_i/(1-L)$$

Where:
EB :Annual energy baseline in kWh per year.
Σi :The sum over the group of “i” renewable energy technologies (e.g. solar home systems, solar pumps) implemented as part of the project.
EGi :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 EFy (CO2 emissions factor) which a small-scale project proponent may use.
EFy = 0.8 （kg-CO2/kWh）

PRJECT EMISSIONS

Project activity emissions consists of:
(1) CO_2 emissions due to incremental transportation distances;
(2) CO_2 emissions from electricity and/or fossil fuel consumption by the project activity facilities;
(3) In case of anaerobic digestion: methane emissions from physical leakages of the anaerobic digester;
(4) In case of composting: methane emissions during composting process;
(5) In case of composting (including co-composting of wastewater): methane emissions from runoff water;
(6) In case the residual waste from the biological treatment (slurry, compost or products from those treatments) are stored under anaerobic conditions and/or delivered to a landfill: the methane emissions from the disposal/storage of these residual waste/products.

$$PE_y = PE_{y\ transp} + PE_{y\ power} + PE_{y\ phy\ leakage} + PE_{y\ comp} + PE_{y\ runoff} + PE_{y\ res\ waste}$$

Where:

PE_y	:Project activity emissions in the year y ((t-CO_2e)
$PE_{y,transp}$	:Emissions from incremental transportation in the year y (t-CO_2e)
$PE_{y,power}$	:Emissions from electricity or fossil fuel consumption in the year y (t-CO_2e)
$PE_{y,phy\ leakage}$	:In case of anaerobic digestion: methane emissions from physical leakages of the anaerobic digester in year y (t-CO_2e)
$PE_{y,comp}$	:In case of composting: methane emissions during composting process in the year y (t-CO_2e)
$PE_{y,runoff}$	:In case of composting: methane emissions from runoff water in the year y (t-CO_2e)
$PE_{y,res}$	:waste In case residual waste/slurry/products are subjected to anaerobic storage or disposed in a landfill: methane emissions from the anaerobic decay of the residual waste/products (t-CO_2e)

Project emissions due to incremental transport distances ($PE_{y,transp}$) are calculated based on the incremental distances between:

(i) The collection points of biomass and the treatment site/site where anaerobic digestion takes place as compared to the baseline solid waste disposal site;
(ii) When applicable, the collection points of wastewater and treatment site as compared to baseline wastewater treatment site;
(iii) Treatment sites and the sites for soil application, landfilling and further treatment of the residual waste/products.

$$PE_{trans} = (Q_y / CT_y) * DAF_w * EF_{CO2} + (Q_{y,treatment\ i} / CT_{y\ treatment}) * DAF_{treatment,i} * EF_{CO2}$$

Where:

Q_y	:Quantity of raw waste treated and/or wastewater co-treated in the year *y* (tonnes)
CT_y	:Average truck capacity for transportation (tonnes/truck)
DAF_w	:Average incremental distance for raw solid waste and/or wastewater transportation(km/truck)
EF_{CO2}	:CO_2 emission factor from fuel use due to transportation (kgCO_2/km, IPCC default values or local values may be used)
i	:Type of residual waste/products and or compost
$Q_{y,treatment,I}$	:Quantity of residual waste/products and/or compost *i* produced in year *y* (tonnes)
$CT_{y\ treatment,i}$	:Average truck capacity for residual waste/products/compost *i* transportation(tonnes/truck)
$DAF_{treatment,i}$	:Average distance for residual waste/products/compost *i* transportation (km/truck)

For the calculation of project emissions from electricity by the project activity facilities ($PE_{y,power}$) all the energy consumption of all facilities installed by the project activity is included energy used for aeration and chopping of biomass for size reduction, and for the runoff wastewater treatment. Emission factors for grid electricity used is calculated as described in AMS I.D. For project activity emissions from fossil fuel consumption the emission factor for the fossil fuel is used (t-CO_2/tonne). IPCC default values are used.

In case of the controlled anaerobic digestion of biomass methane emissions due to physical leakages from the digester and recovery system ($PE_{y,phy\ leakage}$) is considered in the calculation of project emissions. The physical leakage emissions are estimated as follows:

$$PE_{y\ phy\ leakage} = Q_y * EF_{anaerobic} * GWP\_CH_4$$

Where:

$EF_{anaerobic}$:Emission factor for anaerobic digestion of organic waste (t-CH_4/ton waste treated).Emission factors is based on IPCC default values (table 4.1, chapter 4, Volume 5, 2006 IPCC Guidelines for National Greenhouse Gas Inventories). IPCC default values are 2 g-CH_4/kg waste treated on a dry weight basis and 1 g-CH_4/kg waste treated on a wet weight basis.

Methane emissions during composting ($PE_{y,comp}$) is calculated as follows:

$$PE_{y\ comp} = Q_y * EF_{composting} * GWP\_CH_4$$

Where:

$EF_{composting}$:Emission factor for composting of organic waste (t-CH_4/ton waste treated). Emission factors is based on IPCC default values (table 4.1, chapter 4, Volume 5, 2006 IPCC Guidelines for National Greenhouse Gas Inventories). IPCC default values are 10 g-CH_4/kg waste treated on a dry weight basis and 4 g-CH_4/kg waste treated on a wet weight basis.

Project emissions from runoff water from the composting facility ($PE_{y,runoff}$) are calculated as follows:

$$PE_{y,runoff} = Q_{y,ww,runoff} * COD_{y,ww,runoff} * B_{o,ww} * MCF_{ww,treatment} * UF_b * GWP\_CH_4$$

Where:

$Q_{y,ww,runoff}$:Volume of runoff water in the year *y* (m^3)

$COD_{y,ww,runoff}$:Chemical oxygen demand of the runoff water leaving the composting facility in the year *y* (t/m^3)

$B_{o,ww}$:Methane producing capacity of the wastewater (IPCC default value for domestic wastewater of 0.21 kg-CH_4/kg.COD)[4]

$MCF_{ww,\ treatment}$:Methane correction factor for the wastewater treatment system where the runoff water is treated (MCF value as per table III.F.1)

UF_b :Model correction factor to account for model uncertainties (1.06)[5]

Methane emissions from anaerobic storage and disposal in a landfill of the residual waste/products/compost from the biological treatment ($PE_{y,res\ waste}$) are calculated as per the "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site".

$$PE_{y,res,waste} = \phi \times (1-f) \times GWP\_CH_4 \times (1-OX) \times 16/12 \times F \times DOC_f \times MCF \times \sum_{x=1}^{y} \sum_{i} Q_{treatment,i} \times DOC_j \times e^{-ki \times (y-x)} \times (1-e^{-ki})$$

Where:

$Q_{y,treatment}$: Quantity of residual waste *i* produced in year *y* (tonnes)

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
GWPCH4 :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)
DOCf :Fraction of degradable organic carbon (DOC) that can decompose
MCF :Methane correction factor
Wj,x (tons) :Amount of organic waste type *j* prevented from disposal in the SWDS in the year *x*
DOCj :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 to the year y for which avoided emissions are calculated
y :Year for which methane emissions are calculated

B.6.2. Data and parameters that are available at validation:

(Copy this table for each data and parameter)

Data / Parameter:	**Φ**
Data unit:	-
Description:	Model correction factor to account for model uncertainties
Source of data used:	Approved SSC methodologies “Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site“
Value applied:	0.9
Justification of the choice of data or description of measurement methods and procedures actually applied :	IPCC 2006 default values are used, since there are no country specific data or region specific data available.

Data / Parameter:	**OX**
Data unit:	-
Description:	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste)
Source of data used:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories.
Value applied:	0
Justification of the choice of data or description of measurement methods and procedures actually applied :	IPCC 2006 default values are used, since there are no country specific data or region specific data available.
Any comment:	

Data / Parameter:	**F**
Data unit:	-
Description:	Fraction of methane in the SWDS gas (volume fraction)
Source of data used:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value applied:	0.5
Justification of the choice of data or description of measurement methods and procedures actually applied :	IPCC 2006 default values are used, since there are no country specific data or region specific data available.
Any comment:	

Data / Parameter:	**DOC_f**
Data unit:	-
Description:	Fraction of degradable organic carbon (DOC) that can decompose
Source of data used:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value applied:	0.5
Justification of the choice of data or description of measurement methods and procedures actually applied :	IPCC 2006 default values are used, since there are no country specific data or region specific data available.
Any comment:	

Data / Parameter:	**MCF**
Data unit:	-
Description:	Methane correction factor
Source of data used:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories
Value applied:	0.4
Justification of the choice of data or description of measurement methods and procedures actually applied :	Garbage in Phi Phi island have been dumped at a unmanaged-shallow solid waste disposal site.
Any comment:	

Data / Parameter:	**DOC_j**
Data unit:	-
Description:	Fraction of degradable organic carbon (by weight) in the waste type *j*
Source of data used:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Tables 2.4 and 2.5)
Value applied:	15
Justification of the choice of data or	Garbage in Phi Phi island is mainly food, food waste, beverages (other than sludge).

description of measurement methods and procedures actually applied :	
Any comment:	

Data / Parameter:	**K_j**
Data unit:	-
Description:	Decay rate for the waste type *j*
Source of data used:	IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Table 3.3)
Value applied:	0.4
Justification of the choice of data or description of measurement methods and procedures actually applied :	Garbage in Phi Phi island is mainly food, food waste, beverages and (other than sludge). Average annual temperature and average annual precipitation in Phuket is beyond 25℃ and 1,000 mm.
Any comment:	

Data / Parameter:	**EF_{CO2}**
Data unit:	kg-CO2/km
Description:	CO2 emission factor from fuel use due to transportation
Source of data used:	Avoidance of methane production from biomass decay through composting
Value applied:	1.1087 kg-CO2/km
Justification of the choice of data or description of measurement methods and procedures actually applied :	$EF_{CO2e} = EF_{T\ CO2} + (EF_{T\ CH4} * 21)+(EF_{T\ N2O}* 310)$ $EF_{T\ CO2}$: emission factor of CO2 in transport = 1097(g-CO2/km) $EF_{T\ CH4}$: emission factor of CH4 in transport = 0.06(g-CH4/km) $EF_{T\ N2O}$: emission factor of N2O in transport = 0.031(g-N2O/km)
Any comment:	

Data / Parameter:	**$EF_{anaerobic}$**
Data unit:	g-CH4/kg
Description:	Emission factor for anaerobic digestion of organic waste
Source of data used:	IPCC default values(table 4.1, chapter 4, Volume 5, 2006 IPCC Guidelines for National Greenhouse Gas Inventories)
Value applied:	1 g-CH4/kg waste treated on a wet weight basis
Justification of the choice of data or description of measurement methods and procedures actually applied :	Organic waste that produced in Phi Phi island is mainly garbage.
Any comment:	

B.6.3 Ex-ante calculation of emission reductions:

BASELINE EMISSIONS

(1) The amount of baseline emissions is calculated as follows:

$BE_y = BE_{CH4,SWDS,y} - (MD_{y,reg} \times GWP_{\_CH4}) + (MEP_{y,ww} \times GWP_{\_CH4})$

$MD_{y,reg}$ =0 : There is no regulation for methane captured and combusted

$MEP_{y,ww}$ =0 : Co-composting of wastewater is not included in the project activity.

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

$$BE_{CH4,SWDS,y} = \phi \times (1-f) \times GWP\_CH_4 \times (1-OX) \times 16/12 \times F \times DOC_f \times MCF \times \sum_{x=1}^{y}\sum_{i} Q_{i,x} \times DOC_j \times e^{-ki \times (y-x)} \times (1-e^{-ki})$$

W1: Total amount of organic waste prevented from disposal in year x (tons)

W_1 : 6.6 t/d : Information from researching on this site

Table 4. GHG emissions in project period

Project period	GHG Emission (t-CO_2e)
1st	15,010
2nd	25,072
3rd	31,817
4th	36,338
5th	39,368
6th	41,400
7th	42,761
8th	43,674
9th	44,286
10th	44,696

(2) CO2 emissions

EB ＝ EFy ×ΣiEGi/(1-L)

EG_i ＝ 792 MWh : Amount of power supply estimated by renewable energy

L ＝ 20% :Average technical distribution losses that would have been observed in diesel powered mini-grids installed by distribution companies in isolated areas.

EF_{CO2} ＝ 0.8 (kg-CO2/kWh)

EB ＝792 t-CO2/y

Amount of power generation output by fuel cell using biogas

$G_{FC} = \eta_{FC} \times W_1 \times P_{BG} \times R_{CH4} \times 330(d/year)$

η_{FC} : 35 % Power generation coefficient of the fuel cell using biogas

W_1 : 6.6 t/d Amount per day of organic waste like kitchen waste
P_{BG} : 0.161 m3/kg Biogas volume generated by 1 kg of organic waste
R_{CH4} : 63 % Fraction of methane in the biogas
T_{CH4} : 37,180 kJ/m^3 Methane's heat of combustion

$$G_{FC} = 0.35 \times 6.6 \times 0.161 \times 0.63 \times 37{,}180 \times 330$$
$$= 2{,}850 \text{ GJ} = 792 \text{ MWh}$$

PROJECT EMISSIONS

Project activity emissions consists of:

(1) CO2 emissions due to incremental transportation distances;
(2) CO2 emissions from electricity and/or fossil fuel consumption by the project activity facilities;
(3) In case of anaerobic digestion: methane emissions from physical leakages of the anaerobic digester;
(4) In case of composting: methane emissions during composting process;
(5) In case of composting (including co-composting of wastewater): methane emissions from runoff water;
(6) In case the residual waste from the biological treatment (slurry, compost or products from those treatments) are stored under anaerobic conditions and/or delivered to a landfill: the methane emissions from the disposal/storage of these residual waste/products.

$$PEy = PE_{y\ transp} + PE_{y\ power} + PE_{y\ phy\ leakage} + PE_{y\ comp} + PE_{y\ runoff} + PE_{y\ res\ waste}$$

(1) CO_2 emissions due to incremental transportation distances

$$PE_{y\ transp} = (Q_y / CT_{y,boat}) \times DAF_{w,boat} \times EF_{CO2,boat} + (Q_y / CT_{y,truckt}) \times DAF_{wtruckt} \times EF_{CO2,truck} + (Q_{y\ treatment\ i} / CT_{y\ treatment\ boat}) \times DAF_{treatment\ boat} \times EF_{CO2,boat} + (Q_{y\ treatment\ i} / CT_{y\ treatment\ truck}) \times DAF_{treatment,truck} \times EF_{CO2,truck}$$

Q_y : 2,409 t/d Quantity of raw waste treated and wastewater co-treated in the year *y*
$CT_{y,boat}$: 3.56 t/boat Average truck capacity for transportation
CT_{ytruck} : 4.00 t/truck
$DAF_{w,boat}$: -62 km/boat Average incremental distance for raw solid waste and/or wastewater transportation
$DAF_{w,truck}$: -0 km/truck
$EF_{CO2,boat}$: 6.77 kg-CO2/km
$EF_{CO2,truck}$: 1.10787 kg-CO_2/km CO_2 emission factor from fuel use due to transportation (IPCC default values or local values may be used)
$Q_{y,treatment,i}$: 763 t/y Quantity of residual waste *i* produced in year *y* (t)
$CT_{y\ treatmentboat}$: 2.1 t/boat Average truck capacity for residual waste *i* transportation(t/truck)
$CT_{y\ treatmentruck}$: 2.1 t/truck
$DAF_{treatmentboat}$: 80 km/boat Average distance for residual waste *i* transportation (km/truck)
$DAF_{treatmenttruck}$: 30 km/truck

$$PE_{trans} = (2{,}409/3.56)*(-62)*6.77 + (2409/4.0)*0*1.11 + (763/2.1)*80*6.77 + (763/2.1)*30*1.11$$
$$= -74 \text{ t-}CO_{2e}$$

(2) CO_2 emissions from electricity and/or fossil fuel consumption by the project activity facilities

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

$PE_{y\ power} = CP_{y,power} \times EF_{CO2}$

$CP_{y,power}$: 281,721 kWh all the energy consumption of all equipment by Fuji

EF_{CO2} : 0.8 kg-CO_2/kWh emissions from fossil fuel

$PE_{y\ power} = 281{,}721 \times 0.8$

$= 225$ t-CO_{2e}

(3) Methane emissions from physical leakages of the anaerobic digester

$PE_{y\ phy\ leakage} = TVair \times MT \times 16 / 0.024 \times GWP\_{CH4}$

TV_{air} : 11.3 m3

MT : 1 times/y

$PE_{y\ phy\ leakage\ e} = 11.3 \times 1 \times 16/0.024 \times 21$

$= 0.16$ t-CO_{2e}

(4) Methane emissions during composting process

$PE_{y\ comp} = Q_y * EF_{composting} * GWP\_CH_4$

In this project, the composting process is included in the anaerobic digester.

$PE_{y\ comp} = 0$ t-CO_{2e}

(5) Methane emissions from runoff water

$PE_{y,runoff} = Q_{y,ww,runoff} * COD_{y,ww,runoff} * B_{o,ww} * MCF_{ww,treatment} * UF_b * GWP\_CH_4$

In this project, the wastewater is lead into the anaerobic digester.

$PE_{y,runoff} = 0$ t-CO_{2e}

(6) Methane emissions from the disposal of these residual waste.

$$PE_{y,res,waste} = \phi \times (1-f) \times GWP\_CH_4 \times (1-OX) \times 16/12 \times F \times DOC_f \times MCF$$

$$\times \sum_{x=1}^{y} \sum_i Q_{treatment,i} \times DOC_j \times e^{-ki \times (y-x)} \times (1-e^{-ki})$$

y

$Q_{y,treatment}$: 763 t/y Quantity of residual waste *i* produced in year *y* (tonnes)

Table 5. GHG emissions of methane emissions from disposal of residual waste

Project period	GHG Emission (t-CO_2e)
1st	4,753
2nd	7,940
3rd	10,075
4th	11,507
5th	12,467
6th	13,110
7th	13,541
8th	13,830
9th	14,024
10th	14,154

B.6.4 Summary of the ex-ante estimation of emission reductions:

Table 6. GHG emission reduction in project period

Project period	Emission reduction of methane	Emission reduction by renewable energy	Annual estimation of emission reduction
1st	10,106	792	10,898
2nd	16,982	792	17,774
3rd	21,590	792	22,382
4th	24,680	792	25,472
5th	26,751	792	27,543
6th	28,139	792	28,931
7th	29,069	792	29,861
8th	29,693	792	30,485
9th	30,111	792	30,903
10th	30,391	792	31,183

B.7 Application of a monitoring methodology and description of the monitoring plan:

B.7.1 Data and parameters monitored:

Data / Parameter:	**Q_j**
Data unit:	Tons
Description:	Amount of organic waste type *j* prevented from disposal in the SWDS
Source of data to be used:	The date sheet of operation
Value of data	2,409 t
Description of measurement methods and procedures to be applied:	The data is based on the historical recorded data in the plant.
QA/QC procedures to be applied:	N/A
Any comment:	

Data / Parameter:	**EG_i**
Data unit:	kWh
Description:	Amount of power supply estimated by renewable energy
Source of data to be used:	Onsite Technicians/Workers
Value of data	792,000 kWh
Description of measurement methods and procedures to be applied:	Electricity is to be continuously metered through the use of an electricity meter.
QA/QC procedures to be applied:	Electricity meters undergo maintenance/calibration according to domestic or international standards
Any comment:	

Data / Parameter:	**P_{BG}**
Data unit:	m3/kg
Description:	Biogas volume generated by 1 kg of organic waste
Source of data to be used:	Onsite Technicians/Workers
Value of data	0.161 m3/kg
Description of measurement methods and procedures to be applied:	On-site metering using electronic continuous flow meters.
QA/QC procedures to be applied:	Flow meters undergo maintenance/calibration according to appropriate industry standards.
Any comment:	

Data / Parameter:	**R_{CH4}**

Data unit:	%
Description:	Fraction of methane in the biogas
Source of data to be used:	Onsite Technicians/Workers
Value of data	63 %
Description of measurement methods and procedures to be applied:	Electronic on-site sample analysis. At least quarterly Interval to satisfy statistical 95% confidence level.
QA/QC procedures to be applied:	Sampling is carried out, adhering to internationally recognized procedures. This is being carried out at least quarterly.
Any comment:	

Data / Parameter:	**CT_y**
Data unit:	t/truck
Description:	Average truck capacity for transportation
Source of data to be used:	The date sheet of operation
Value of data	2.9 t/truck
Description of measurement methods and procedures to be applied:	The data is based on the historical recorded data in the plant.
QA/QC procedures to be applied:	N/A
Any comment:	

Data / Parameter:	**DAF_w**
Data unit:	km/truck
Description:	Average incremental distance for raw solid waste transportation
Source of data to be used:	The date sheet of operation
Value of data	-62 km/truck
Description of measurement methods and procedures to be applied:	The data is based on the historical recorded data in the plant.
QA/QC procedures to be applied:	N/A
Any comment:	

Data / Parameter:	$Q_{y,treatment,i}$
Data unit:	t/y
Description:	Quantity of residual waste *i* produced
Source of data to be used:	The date sheet of operation
Value of data	763 t/y

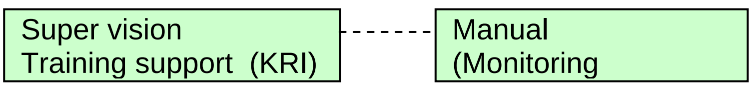
Description of measurement methods and procedures to be applied:	The data is based on the historical recorded data in the plant.
QA/QC procedures to be applied:	N/A
Any comment:	

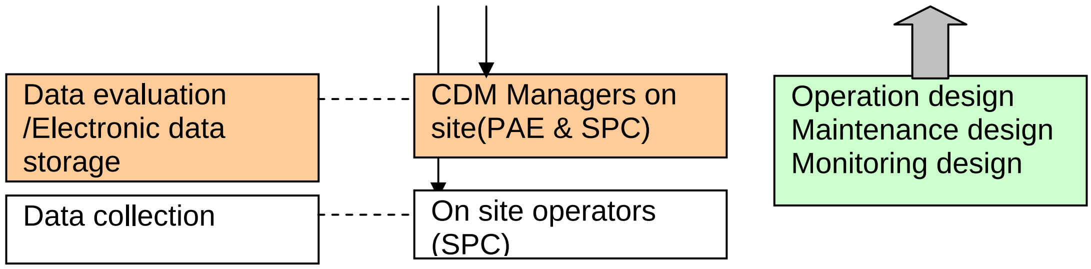
Data / Parameter:	$DAF_{treatment,i}$
Data unit:	km/truck
Description:	Average distance for residual waste *i* transportation
Source of data to be used:	The date sheet of operation
Value of data	80 km/truck
Description of measurement methods and procedures to be applied:	The data is based on the historical recorded data in the plant.
QA/QC procedures to be applied:	N/A
Any comment:	

Data / Parameter:	$CP_{y,power}$
Data unit:	kWh
Description:	Energy consumption of all equipment
Source of data to be used:	Onsite Technicians/Workers
Value of data	281,721 kWh
Description of measurement methods and procedures to be applied:	Electricity is to be continuously metered through the use of an electricity meter.
QA/QC procedures to be applied:	Electricity meters undergo maintenance/calibration according to domestic or international standards
Any comment:	

B.7.2 Description of the monitoring plan:

All monitoring facilities will be installed and regularly calibrated for quality control by a reliable constructor (PAE Thailand) with the appropriate industry standards. Execution will be carried out by PAE Thailand, record and store relevant data. Such data will be made available to the DOE for verification in a transparent manner.





B.8 Date of completion of the application of the baseline and monitoring methodology and the name of the responsible person(s)/entity(ies)

Date of completion: 28/ 2/2009

KRI, Inc.
Kyoto Research Park, 134, Chudoji Minami-machi, Shimogyo-ku, Kyoto 600-8813, JAPAN
Phone +81-75-322-6830
FAX +81-75-322-6820
E-mail：wakayama@kri-inc.jp

KRI, Inc. is the CDM advisor to the Project and is also a project participant listed in Annex 1.

SECTION C. Duration of the project activity / crediting period

C.1 Duration of the project activity:

C.1.1. Starting date of the project activity:

01/09/2010

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

10 years

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

C.2.1. Renewable crediting period

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

C.2.1.2. Length of the first crediting period:

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

C.2.2.2. Length:

SECTION D. Environmental impacts

D.1. If required by the host Party, documentation on the analysis of the environmental impacts of the project activity:

(1) An influence to a local environment

In Phi Phi Island, there are some serious problems by surroundings of remote Island. Lots of people visit the island, they drop and produce any kind of waste during visiting the island. Also, they require comfortable accommodation, light, fresh water and air-conditioner that driven by much electricity. In Phi Phi, there is not a wastes treatment facility and public power plant. All of fuel for generator and living and foods has to be transported from Phuket and Krabi, contrary, all of wastes have to be transported back to Phuket and Krabi. In this project, wastes in resort hotels can be used as fuel for electric generators. Amount of garbage that has to be transported out of island will be less than existing condition. In Krabi and Phuket province, there are lots of islands like Phi Phi Island and this system is applicable to there.

(2) An effects to transfer of skill / development

In this project, the maintenance skill will be transferred to local engineers. The plant is mainly consists of CH4 fermentation tank, gas holder, purification system for biogas, treatment system for wastewater and fuel cell (PAFC). The maintenance of the plant is not complex and does not require high technique than combustion engine generator.

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

None

SECTION E. Stakeholders' comments

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

Comments of each of stakeholders about the project were received at the meeting in Thailand in October 2008, December 2008 and January 2009.

E.2. Summary of the comments received:

The specific comments about the project are as follows:
From Phi Phi Island Village & Spa, Holiday inn, Erawan resort and Natural resort, this project is expected to keep Phi Phi Island clean. In this project, there are some problems to solve. Where shall the plant be located? Will the collecting garbage emit smell? Is the plant able to drive in business as usual?

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

None

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

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

Annex 2

INFORMATION REGARDING PUBLIC FUNDING

Annex 3

BASELINE INFORMATION

Annex 4

MONITORING INFORMATION

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