**CLEAN DEVELOPMENT MECHANISM**
**PROJECT DESIGN DOCUMENT FORM (CDM-PDD)**
**Version 03 - in effect as of: 28 July 2006**

**CONTENTS**

## SECTION A. General description of project activity

### A.1. Title of the project activity:

Title: Dehydration and incineration of sewage sludge in Singapore
Version number of the document: 02
Date: 06/03/2009

### A.2. Description of the project activity:

The used water from both domestic and non-domestic sources in Singapore is collected through a comprehensive network of underground public sewers and treated by PUB (Public Utilities Board), a statutory board of the MEWR (Ministry of the Environment and Water Resources). The wastewater infrastructure of Singapore has rapidly developed to serve its increasing demand, and 100% of the population is served with modern sanitation which includes 6 WRPs (Water Reclamation Plants). In all the WRPs, the sludge produced from the aerobic treatment process is collected, digested and dewatered anaerobically for energy recovery and to reduce the volume. Presently, 800 tons of digested and dewatered sewage sludge with water content of 72 – 85 % is produced in Singapore. Part of the dewatered sewage sludge goes through an additional drying process to reduce the total volume. The water content of the dry sewage sludge is approximately 10%. The dewatered sludge (500 ton/day) and dry sludge (139 ton/day) are transported to the sludge disposal site located at Changi East Area on a daily basis.

The sludge disposal process is well managed by PUB. Trenches are excavated and the sludge is mixed with soil in the trenches. The trenches are then covered with excavated earth. The disposed sewage sludge still contains significant amount of carbon that has the potential for methane production. Considering the DOC (Degradable Organic Carbon) content of the sewage sludge, management of the disposal site, and methane gas detected at the surface of the disposal site by actual measurement, there is methane gas emission from the site at the present status. This is the scenario existing prior to the start of the implementation of the proposed project activity, and also the baseline scenario.

The proposed project activity is the first project in Singapore that aims to dehydrate and incinerate the sewage sludge produced from the WRPs. In the project scenario, the sewage sludge will be incinerated in a vortex incinerator, and the heat produced from the combustion process will be used on-site for the dehydration process. The incineration process will reduce the volume of the sludge dramatically, and at the same time completely take away the potential for methane production at the sludge disposal site. Therefore, the baseline emission which is the methane gas emission from the sludge disposal site will be avoided through an alternative treatment method in the project scenario.

The proposed project activity will be carried out by ECO Special Waste Management Pte. Ltd. (herein after referred to as “ECO”) under a BOO (Build-Own-Operate) scheme. The plant is now under construction, and it is planned to receive the sewage sludge from 1st April 2009.

**Environmental Sustainability**

ECO received the "In-principle No Objection" clearance for the proposed project activity from NEA (National Environment Agency) on 1st Oct 2007 and subsequent approval dated 28th Apr 2008 after submission of Industrial Allocation Form.

The project activity adopts Japan's advanced technology to dehydrate and incinerate sewage sludge. It is a well-developed and reliable technology equipped with comprehensive pollution protection equipment capable of meeting all the local environmental protection requirements, standards, and regulations.

Presently, the sewage sludge is disposed of by landfill and there is methane emission at the landfill site. With the implementation of the project activity, significant reduction of methane generation and waste reduction will be achieved through its high combustion and destruction efficiency of the incinerator.

The innovative concept of the project activity is fully demonstrating its environmental sustainability. The project development will lead to the achievement of less utilization of high carbon-intensity fuel, promoting renewable energy, reduction in GHG emission, and prolong the life span of landfill site.

**Economic Sustainability**

The project activity comprises of five duplicate trains in a single treatment plant to treat the sewage sludge generated from all WRPs (Water Reclamation Plants) in Singapore. The project participant believes that the project would be the largest single sewage sludge treatment plant in Southeast Asia.

The project utilizes more efficient technology through its innovative design. In-depth study of mass and heat balance allows the maximum utilization of sewage sludge as renewable resource to generate heat for sludge dehydration process which leads to the reduction in fossil fuel usage. Fossil fuel substitution by the renewable resource demonstrates the economic competitiveness and enhances the energy security through the mitigation of Singapore's dependence on imported fossil fuel.

Transfer of Japanese technology to Singapore through the project activity allows wider accessibility and thus provides business opportunities for further technological developments from the project. This will lead to capacity building of the technology in GHG reduction in Singapore and become a valuable asset to be exported to regional market where there is a rapidly growing demand for the technology.

**Social Sustainability**

The project activity adopts a cleaner and greener concept to reduce GHG emission and contributes towards a cleaner air with less landfill waste which will markedly improve the quality of life in Singapore.

It also becomes a good educational showcase to local communities and at national level, it is a commitment of Singapore in reducing carbon-intensity per unit GDP. Employment opportunities will be created and a comprehensive training program will be provided. This will contribute to the enhancement of local expertise leading to the achievement of knowledge-based industry in Singapore.

PUB's (Public Utilities Board) Waterhub is part of Singapore's effort in sharing its expertise on water-related services and technologies in the region. By integrating the dehydration and incineration technology from the project activity, it will perfectly fit to value-add the water management in Singapore.

Partnership with local research institution to explore sludge ash utilization will build up the competencies of local research community which will benefit the society.

**A.3. Project participants:**

| Name of Party involved(*) ((host)indicates a host Party) | Private and/or Public entity(ies) Project participants(*)(as applicable) | Kindly indicate if the Party involved wishes to be considered a project participant (Yes/No) |
|---|---|---|
| Singapore (host) | ECO Special Waste Management Pte. Ltd. | No |
| Japan | Sumitomo Mitsui Banking Corporation | No |
| Japan | Kajima Corporation | No |

(*) In accordance with the CDM modalities and procedures, at the time of making the CDM-PDD public at the stage of validation, a Party (country) involved may or may not have provided its approval. At the time requesting registration, the approval by the Party(ies) involved is required.

**A.4. Technical description of the project activity:**

**A.4.1. Location of the project activity:**

**A.4.1.1. Host Party(ies):**

Republic of Singapore

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

Tuas

**A.4.1.3. City/Town/Community etc.:**

23 Tuas View Circuit

**A.4.1.4. Details of physical location, including information allowing the unique identification of this project activity (maximum one page):**

The project site (103˚38'E and 1˚19'N) is in Tuas which is an industrial area located at the western end of Singapore main island. Tuas is designated as "Business 2" area by URA (Urban Redevelopment Authority) which is Singapore's national land use planning authority. "Business 2" are areas used or intended to be used for clean industry, light industry, general industry, warehouse, public utilities and telecommunication uses, and other public installations. Therefore, there are no residents nearby.

Changi reclaimed land where the sewage sludge is disposed of is located at the eastern end of Singapore main island (104˚00'E and 1˚19'N). The physical locations of the sites are as shown in Figure-1 and 2.


Figure-1 Physical location of the project site

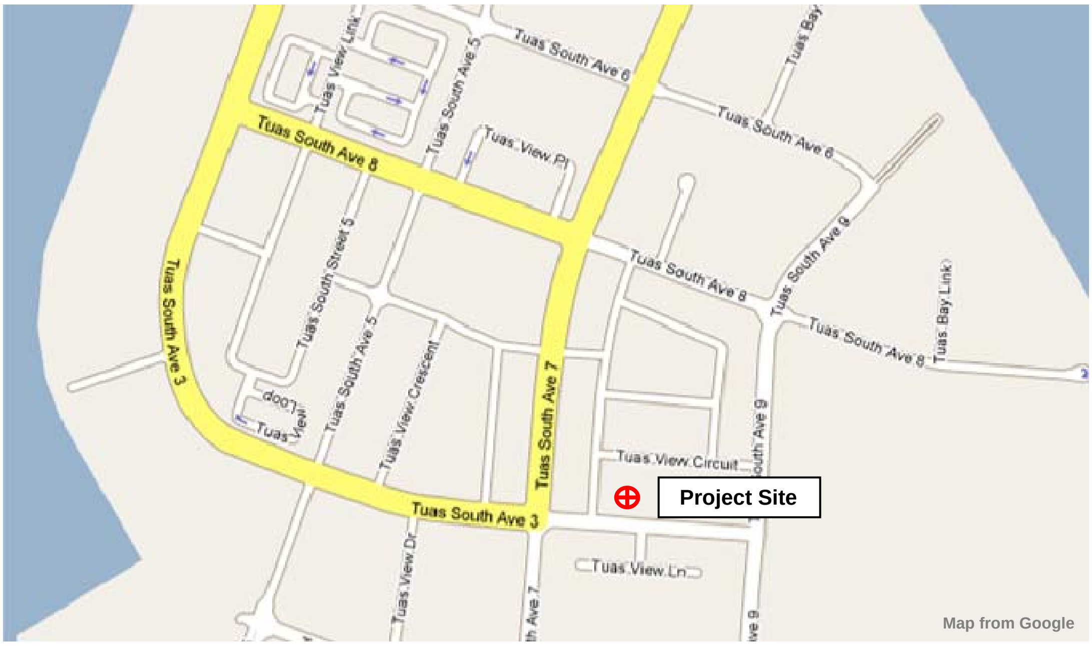


Figure-2 Physical location of the project site

**A.4.2. Category(ies) of project activity:**

Sectoral Scope 13: Waste handling and disposal

**A.4.3. Technology to be employed by the project activity:**

The 639 tons of sewage sludge (dewatered sludge: 500 ton/day dry sludge: 139 ton/day) produced from 6 WRPs (Water Reclamation Plants) that treats 100% of Singapore's used water is disposed at Changi Reclaimed Land. This is the scenario existing prior to the start of the project activity and it is also the baseline scenario. Figure-3 shows the scenario existing prior to the start of the project.

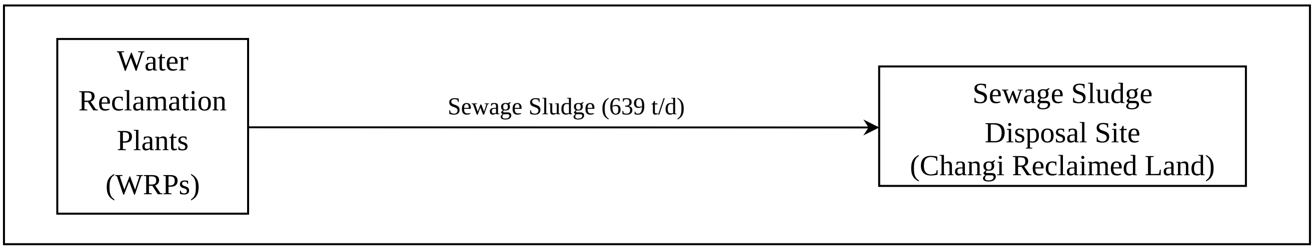


Figure-3 Scenario existing prior to the start of the project

In the project scenario, the 639 tons of sewage sludge produced daily from the WRPs will be treated by a sewage sludge dehydration and incineration plant. The ash produced will be disposed at Semakau landfill.

The plant will consume approximately 32.4 MWh and 3,620 $m^3$ of natural gas for the daily operation. The heat produced from the incineration will be used on-site for the dehydration process, exhaust gas will be treated by wet scrubber, and wastewater produced from the wet scrubber will be treated by a wastewater treatment facility. Figure-4 shows the project scenario.

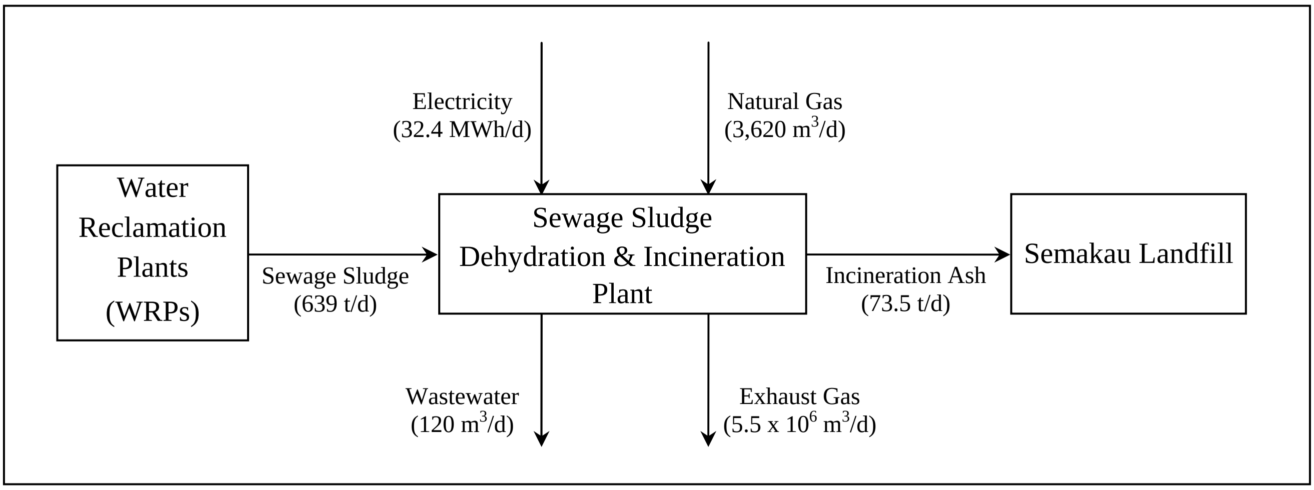


Figure-4 Project Scenario

Further detail of the plant is as shown in Figure-5.

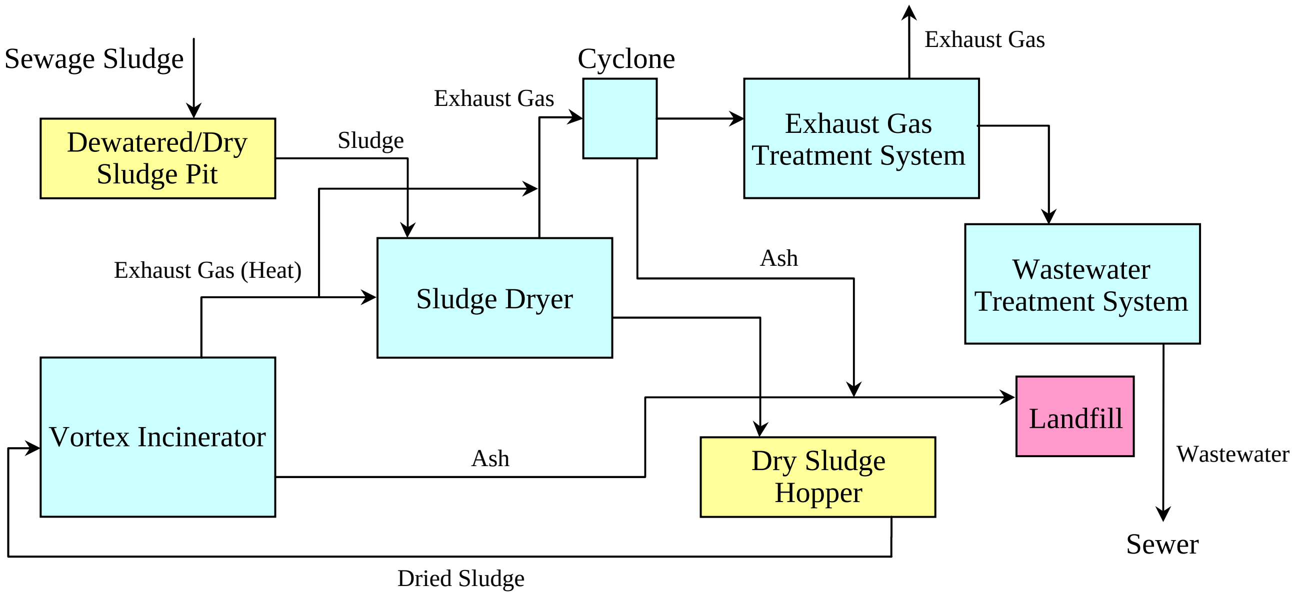


Figure-5 Schematic flow of the treatment

**Sludge Dehydration**

The sludge is put into the dryer to remove moisture to the self burning limit of combustible composition. The wet sludge that is put into the dryer is crushed into small pieces by the disintegrator blades at high speed. The crushed sludge falls to the bottom of the drum contacting with hot air and is raised again to the top by the lifter. The continuous process of crushing, drying and rotating inside the drum enlarge the surface area of sludge which produce the granulated dried sludge with high thermal efficiency.

**Sludge Destruction**

The dried sludge from the dryer will be fully destructed in the vortex incinerator. The vortex incinerator has rotating arms that mix the sludge and at the same time provide air for efficient equalized combustion. The air blown-out from the rotating arms creates a circulating flow inside the incinerator, thus keeping the temperature uniform for optimized combustion. Auxiliary burner fueled by natural gas is used to supplement the calorific value for stable operation.

**Energy Recovery from Combustion**

The exhaust heat of high temperature from the incinerator is utilized as heating source for the dehydration process of the sludge dryer.

**Exhaust Gas Treatment**

Negative pressure is kept in the enclosed sludge receiving room to ensure proper containment of unpleasant odor. The exhaust gas from the dryer and incinerator is further treated by secondary pollution protection equipment such as the wet scrubber system before final emission to the atmosphere.

**Wastewater Treatment**

Caustic medium is used to scrub acidic fume and produces scrubber wastewater that to be further treated by wastewater treatment plant. The plant is equipped with ash removal system with physical and chemical treatment prior to final pH adjustment and discharge into sewer.

Table- 1 Specification of main equipments

| No | Equipment | Specification |
|---|---|---|
| 1 | Dewatered and Dry Sludge Pit | • Dewatered Sludge Pit (32.5m x 9m x 5m) with storage capacity up to 2 days<br>• Dry Sludge Pit (24.5m x 9m x 5m) with storage capacity up to 3 days |
| 2 | Sludge Dryer | Rotating type model (KRD-330S) from Japanese manufacturer<br>• Size of 8m length and 2.3m of shell internal diameter<br>• Rotating speed (shell) of 2.32/min<br>• Sludge dehydration capacity of 5,325 kg/hr (65% water) |
| 3 | Vortex Incinerator | Rotating arm type model (VI-200) from Japanese manufacturer<br>• Size of 10.6m height and 5.8m in diameter<br>• 6 rotating arms with 11 air nozzles per rotating arm<br>• Sludge incineration capacity of 2,342 kg/hr (20% water) |
| 4 | Cyclone | Centrifugal multi-cyclone type dust collector<br>• 3.6m height with upper chamber containing 25 cylinders ( $\phi$ 266mm)<br>Centrifugal double-cyclone type dust collector<br>• 6.4m height and coated with anti-corrosion paint |
| 5 | Exhaust Gas Treatment System | • SS mesh type media packing scrubber<br>• 2 scrubber circulation pumps<br>• 6 spray headers and 2 perforated plates<br>• 18m height inclusive of chimney |
| 6 | Wastewater Treatment System | • Physical process – ash separation system comprising of ash settling tank, ash removal pump, ash filters and diffusers<br>• Chemical process – process tank and chemical dosing pump<br>• Cross-flow type cooling tower with capacity of 1.28 $m^3$/min |

Photo-1 Sludge dryer

Photo-2 Vortex Incinerator

### A.4.4. Estimated amount of emission reductions over the chosen crediting period:

The Project is expected to reduce an average of 104,547 t $CO_2$e annually, generating an estimated total of 1,045,473 t $CO_2$e for the duration of the fixed 10-year crediting period.

| **Years** | **Annual estimation of emission reductions in tons of $CO_2$e** |
|---|---|
| 2009 (April – December) | 28,521 |
| 2010 | 61,444 |
| 2011 | 84,946 |
| 2012 | 100,700 |
| 2013 | 111,260 |
| 2014 | 118,339 |
| 2015 | 123,083 |
| 2016 | 126,264 |
| 2017 | 128,396 |
| 2018 | 129,825 |
| 2019 (January – March) | 32,695 |
| **Total estimated reductions** (t $CO_2$e) | 1,045,473 |
| **Total number of crediting years** | 10 years |
| **Annual average over the crediting period of estimated reductions** (t $CO_2$e) | 104,547 |

### A.4.5. Public funding of the project activity:

The financial plans for the project activity do not involve any public funding from any countries.

## SECTION B. Application of a baseline and monitoring methodology

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

Approved baseline and monitoring methodology applied to the project activity is:

- "Avoided emissions from organic waste through alternative waste treatment processes" (AM0025 / version 11)

Approved methodological tools applied to the project activity are:

- "Tool for the demonstration and assessment of additionality" (version 05.2)
- "Tool to calculate the emission factor for an electricity system" (version 01.1)
- "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site"(version 04)

### B.2. Justification of the choice of the methodology and why it is applicable to the project activity:

As stated in the methodology, the methodology is applicable to scenarios which involve one or a combination of the following waste treatment options.

a) a composting process in aerobic conditions;
b) gasification to produce syngas and its use;
c) anaerobic digestion with biogas collection and flaring and/or its use;
d) mechanical/thermal treatment process to produce refuse-derived fuel (RDF)/stabilized biomass (SB) and its use. The thermal treatment process (dehydration) occurs under controlled conditions (up to 300 degrees Celsius). In case of thermal treatment process, the process shall generate a stabilized biomass that would be used as fuel or raw material in other industrial process. The physical and chemical properties of the produced RDF/SB shall be homogenous and constant over time;
e) incineration of fresh waste for energy generation, electricity and/or heat. The thermal energy generated is either consumed on-site and/or exported to a nearby facility. Electricity generated is either consumed on-site, exported to the grid or exported to a nearby facility. The incinerator is rotating fluidized bed or hearth or grate type.

The proposed project activity corresponds to e) incineration of fresh waste for energy generation, electricity and/or heat. The proposed project activity will generate heat from incineration of sewage sludge, the thermal energy generated will be used on-site for the dehydration process. The incinerator is a vortex incinerator which falls into the category of hearth type. In addition, the proposed project satisfies the following requirements shown in Table-2 as described in the methodology.

Table-2 Requirements described in the methodology

| Requirement | Project Condition |
|---|---|
| In the case of incineration of the waste, the waste should not be stored longer than 10 days. The waste should not be stored in conditions that lead to anaerobic decomposition and, hence, generation of $CH_4$. | The plant is designed to treat 100% of the daily incoming sludge. Therefore, the proposed project activity will not store the sewage sludge longer than 10 days. The sewage sludge will not be stored in an anaerobic condition. |

| Requirement | Project Condition |
|---|---|
| The proportions and characteristics of different types of organic waste processed in the project activity can be determined, in order to apply a multiphase landfill gas generation model to estimate the quantity of landfill gas that would have been generated in the absence of the project activity | Proportion and characteristics of dewatered and dry sludge can be determined. |
| The project activity may include electricity generation and/or thermal energy generation from the biogas, syngas captured, RDF/stabilized biomass produced, combustion heat generated in the incineration process, respectively, from the anaerobic digester, the gasifier, RDF/stabilized biomass combustor, and waste incinerator. The electricity can be exported to the grid and/or used internally at the project site. In case of RDF produced, the emission reductions can be claimed only for the cases where the RDF used for electricity and/or thermal energy generation can be monitored. | The project activity generates thermal energy from combustion heat generated in the incineration process. The thermal energy will be used on-site for the dehydration process of the sewage sludge. Emission reduction will not be claimed for the thermal energy generation, since it will not displace fossil fuel that would have been consumed in the absence of the project activity. |
| Waste handling in the baseline scenario shows a continuation of current practice of disposing waste in landfill despite environmental regulation that mandates the treatment of waste, if any, using any of the project activity mentioned above. | There are no laws, regulations, or government policies that restrict the disposal of sewage sludge. Therefore the baseline scenario shows that the current practice of disposing sewage sludge at the sludge disposal site will be continued. |
| The compliance rate of the environmental regulation during (part of) the crediting period is below 50%, if monitored compliance with the MSW rules exceeds 50%, the project activity shall receive no further credit, since the assumption that the policy is not enforced is no longer tenable. | There are no laws, regulations, or government policies that restrict the disposal of sewage sludge in Singapore. Therefore, the compliance rate does not need to be taken into account. |
| The project activity does not involve thermal treatment process of neither industrial or hospital waste. | The proposed project activity handles sewage sludge from water reclamation plants. Neither industrial nor hospital waste is treated in the project activity. |
| This methodology is not applicable to project activities that involve capture and flaring of methane from existing waste in the landfill. This should be treated as a separate project activity due to the difference in waste characteristics of existing and fresh waste, which may have an implication on the baseline scenario determination. | The proposed project does not involve landfill gas capture or flaring. |
| In case of waste incineration, if auxiliary fossil fuel is added into the incinerator, the fraction of energy generated by auxiliary fossil fuel is no more than 50% of the total energy generated in the incinerator. | The energy generated from the auxiliary fuel (natural gas) is below 50% of the total energy generated in the incinerator. |

The proposed project activity satisfies all requirements listed in the methodology, and emissions of GHG from the sludge disposal site will be avoided through an alternative waste treatment process. Therefore, the methodology is applicable to the proposed project activity.

## B.3. Description of the sources and gases included in the project boundary:

The spatial extent of the project boundary is the site of the project activity where the sewage sludge is incinerated. This includes the on-site electricity and natural gas consumption, and the emission of stack gas. The project boundary is as shown in Figure-6.

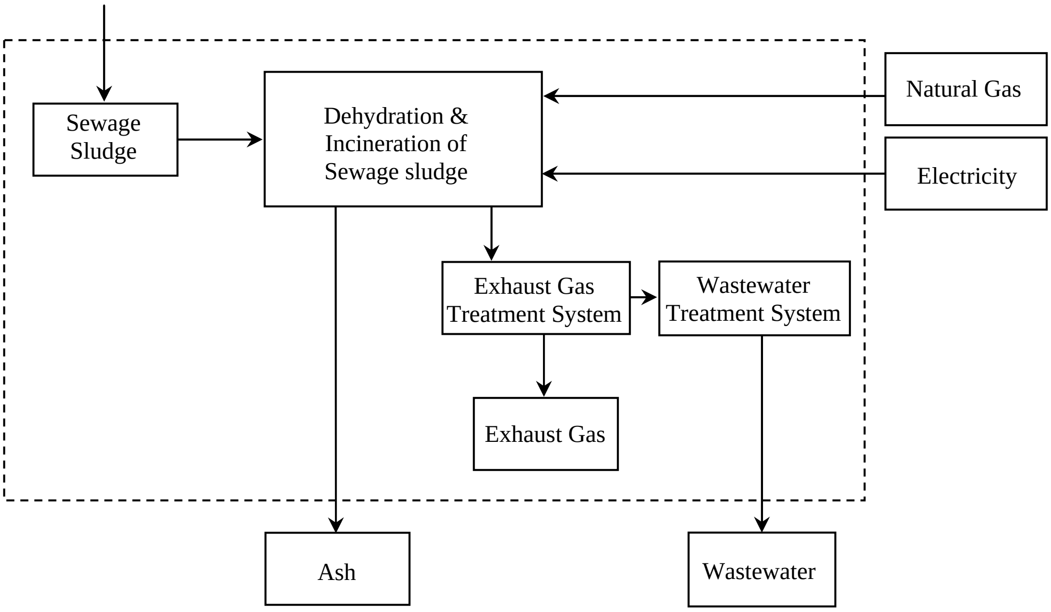


Figure-6 Project boundary

The greenhouse gases included in or excluded from the project boundary are shown in Table-3.

Table-3 The greenhouse gases included in or excluded from the project boundary

| | Source | Gas | Included? | Justification / Explanation |
|---|---|---|---|---|
| Baseline | Emissions from decomposition of sewage sludge at the sludge disposal site | $CH_4$ | Included | The major source of emissions in the baseline from the sludge disposal site. |
| | | $N_2O$ | Excluded | $N_2O$ emissions are small compared to $CH_4$ emissions from the sludge disposal site. This is conservative. |
| | | $CO_2$ | Excluded | Not accounted for. |
| | Emissions from electricity consumption | $CO_2$ | Excluded | There is no electricity consumption in the baseline scenario. |
| | | $CH_4$ | Excluded | Excluded for simplification. This is conservative. |
| | | $N_2O$ | Excluded | Excluded for simplification. This is conservative. |

| | Source | Gas | Included? | Justification / Explanation |
|---|---|---|---|---|
| | Emissions from thermal Energy generation | $CO_2$ | Excluded | There is no thermal energy generation in the baseline scenario. |
| | | $CH_4$ | Excluded | Excluded for simplification. This is conservative. |
| | | $N_2O$ | Excluded | Excluded for simplification. This is conservative. |
| Project Activity | On-site fossil fuel consumption due to the project activity | $CO_2$ | Included | Auxiliary fuel consumption for the incineration process. (Natural Gas) |
| | | $CH_4$ | 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 electricity use | $CO_2$ | Included | Electricity from the national grid is consumed on-site for the operation of the plant. |
| | | $CH_4$ | 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. |
| | Direct emissions from the waste treatment process | $CO_2$ | Excluded | The sewage sludge incinerated does not contain fossil based waste. |
| | | $N_2O$ | Included | The emission from stack gas will be monitored. |
| | | $CH_4$ | Included | The emission from stack gas will be monitored. |

**B.4. Description of how the baseline scenario is identified and description of the identified baseline scenario:**

The baseline scenario is identified using the "Tool for the demonstration and assessment of additionality" and the procedures specified in the methodology AM0025.

*STEP 1: Identification of alternative scenarios.*
The following scenarios M1-5 are defined as alternatives to the project activity.

M1. Sewage sludge dehydration and incineration not implemented as a CDM project;
M2. Composting of sewage sludge;
M3. Crystallization of sewage sludge;
M4. Disposal of sewage sludge at a sludge disposal site where methane gas captured is flared;
M5. Disposal of sewage sludge at a sludge disposal site without the capture of methane gas.

Alternative scenarios for power generation will not be considered since the project does not involve power generation.

Although the heat generated will be used on-site, alternative scenarios for heat generation will not be considered since the heat generated will not displace fossil fuel that would have been consumed in the absence of the project activity.

In Singapore, there are no laws, regulations, or government policies that specify or restrict certain types of treatment methods for sewage sludge.

Therefore, all alternative scenarios are in compliance with mandatory applicable legal and regulatory requirements.

*STEP 2: Identify the fuel for the baseline choice of energy source taking into account the national and/or sectoral policies as applicable.*
Electricity generation in Singapore is mainly dependent on thermal power generation using natural gas and the electrification of the country is 100%. Therefore, natural gas is identified as the baseline choice of energy source, and both natural gas and the electricity generated from its combustion is accessible through out the country with no supply constraints.

*STEP 3: Investment Analysis*

Since there are no mandatory laws or regulations that specify that the gases from the sludge disposal site must be captured and flared in Singapore, there will be no public funding, money grants, or any sort of incentive for the installation of gas collection and flaring equipments in scenario M4. There is no income other than the CDM related income. Therefore, it can be stated clearly that scenario M4 is economically unattractive, and shall be excluded from further consideration.

Composting is one of an effective and economical treatment method for sewage sludge but the end use of the product is crucial for project implementation. In Singapore, there is no potential domestic demand for compost derived from sewage sludge as these are not allowed to be used in water catchment areas as well as for agriculture purposes. For this reason, there is no income other than the CDM related income for scenario M2, and it can be stated clearly that it is economically unattractive, and shall be excluded from further consideration.

Scenario M1, or the proposed project activity implemented without the CDM related income, generates financial benefits from disposal fee of the sewage sludge received. The financial attractiveness of scenario M1 will be determined by using the benchmark analysis. The financial indicator is the PIRR and the benchmark is the prime lending rate of Singapore[1].

The PIRR is calculated according to the following basic conditions as shown in Table-4.

Table-4 Basic conditions for calculating the project IRR

| Item | | Description |
|---|---|---|
| Project period | | 10 years (1st April, 2008 – 31st March 2018) |
| Operation period | | 9 years (1st April, 2009 – 31st March 2018) |
| Annual operation days | | 320 days |
| Sludge A | Daily input of sewage sludge | 312 t/d* |
| | Disposal fee | 60 SGD/ton |
| Sludge B | Daily input of sewage sludge | 188 t/d* |
| | Disposal fee | 60 SGD/ton |
| Sludge C | Daily input of sewage sludge | 139 t/d* |
| | Disposal fee | 58 SGD/ton |

[1] Sourced from website of Monetary Authority of Singapore (http://www.mas.gov.sg/index.html)

| | |
|---|---|
| Inflation rate | 2.0%[2] |
| Corporate tax | 18.0% |
| Depreciation period | 9 years |
| Capital cost | 30,800,000 SGD |
| Annual operational cost | 7,835,000 SGD/yr (Average during 9 years) |

* Rounded up figure

The expense and income of the project are as shown in Table-5.

Table-5 Expense and income of the project

Unit: SGD

| | |
|---|---|
| Expense | |
| Initial Investment | 30,800,000 |
| O&M Cost per year[3] | 7,835,000 |
| (1) Landfill Disposal Cost | 1,762,000 |
| (2) Electricity Cost | 1,888,000 |
| (3) Natural Gas Cost | 1,267,000 |
| (4) Others | 2,918,000 |
| Expense Total (10 years) | 101,317,000 |
| Income | |
| Disposal fee (Sludge A) per year | 6,000,000 |
| Disposal fee (Sludge B) per year | 3,600,000 |
| Disposal fee (Sludge C) per year | 2,578,000 |
| Income Total (10 years)[4] | 109,600,000 |
| PIRR | 4.36% |

The project IRR is computed for 10 years starting from 1st April 2008 to 31st March 2018 which is the period stated in the contract between PUB and ECO. ECO will start to receive the sewage sludge from 1st April 2009 after completion of the treatment plant. Therefore, the operation period will be 9 years.

The inflation rate of 2.0% was set based on 3 years historical data of the "Consumer price index[5]" sourced from Singapore Department of Statistics and the trend of the rise of petrol and material cost during 2007. The average of the consumer price index from 2004 to 2006 is 1.1%. Taking into account the rising prices of petrol and materials in 2007, the inflation rate was set at 2.0% for a conservative feasibility study (The consumer price index of 2007 which was published in 2008 was 2.1%). The inflation rate of 2.0% is used for all operational costs except for landfill disposal cost, and labour cost.

Since the disposal fee for the Semakau landfill where the residual ash will be disposed is set by the government, the inflation rate of its cost is set differently. In April 1999 when Semakau landfill started its operation, the Ministry of Environment announced that it would increase the disposal fee progressively

[2] Some of the items included in the O&M cost does not use the inflation rate of 2.0%. The inflation rate used for landfill disposal cost and labour cost is 1.0% and 4.0% accordingly.

[3] No O&M cost during the first year (construction period)

[4] No income during the first year (construction period)

[5] Sourced from website of Department of Statistics Singapore (http://www.singstat.gov.sg/stats/themes/economy/hist/cpi.html)

from 57S$/ton to 87S$/ton to reflect the full cost of refuse disposal and encourage resource recycling to cut down waste production[6]. The current 77S$/ton was raised from 67S$/ton in May 2002. Because there is a chance of the disposal fee to increase to 87S$/ton during the 10 years project period, 1.0% was used as the inflation rate for landfill disposal cost. The inflation rate is set at 4.0% for the labour cost based on past 3 years internal data of ECO (Average total wage change from 2004 to 2006 in Singapore is 4.13% according to the data publicized by the Ministry of Manpower[7]).

The expenses for the project were fixed in January 2008 after several revisions of design and changes in operation expenses. The income for the project is a fixed amount stated in the contract between PUB and ECO. The assets will be depreciated during the project period according to the financial reporting standard of Singapore.

The benchmark that will be used is the prime lending rate of Singapore which is 5.33% published by Monetary Authority of Singapore. The PIRR calculated is 4.36%. Therefore, scenario M1 is economically unattractive based on the conditions above.

Sensitivity analysis is conducted for further study of the economical attractiveness of scenario M1. The items that constitute more than 20% to the total investment cost or the total project revenues are the initial investment and the disposal fee. The initial investment which amounts to S$30.8 million is not considered as a parameter since the major costs were fixed at the time of the feasibility study. The initial investment was completely fixed at the time of commencement of construction which amounts to S$31.0 million. The revenue which is the disposal fee of the sewage sludge is a fixed contract amount that will not change during the project period. Therefore, the parameters for the sensitivity analysis will be selected from the operational cost which is the only possible variable of the project cost.

Although no items in the operational cost constitutes more than 20% to the total investment cost, the items that constitute more than 10% to the total investment cost were selected to examine its influence to the PIRR.

1) Initial Investment (30% of total investment cost) not considered since fixed by contract
2) Disposal Fee (100% of total project revenue) not considered since fixed by contract
3) Landfill Disposal Cost (16% of total investment cost)
4) Electricity Cost (17% of total investment cost)
5) Natural Gas Cost (11% of total investment cost)

The calculation results for the PIRR are as shown in Table-6.

Table-6 PIRR calculation results for the sensitivity analysis

| | PIRR(%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | -10.0% | -7.5% | -5.0% | -2.5% | 0% | +2.5% | +5.0% | +7.5% | +10.0% |
| Landfill Disposal | 5.14 | 4.95 | 4.75 | 4.56 | 4.36 | 4.16 | 3.96 | 3.76 | 3.56 |
| Electricity | 5.19 | 4.99 | 4.78 | 4.57 | 4.36 | 4.15 | 3.94 | 3.72 | 3.51 |
| Natural Gas | 4.92 | 4.78 | 4.64 | 4.50 | 4.36 | 4.22 | 4.08 | 3.93 | 3.79 |

[6] Sourced from website of Singapore National Environment Agency (http://app.nea.gov.sg/cms/htdocs/article.asp?pid=1999)

[7] Sourced from website of Ministry of Manpower (http://www.mom.gov.sg/publish/momportal/en/communities/others/mrsd/statistics/Earnings_and_Wages.html)

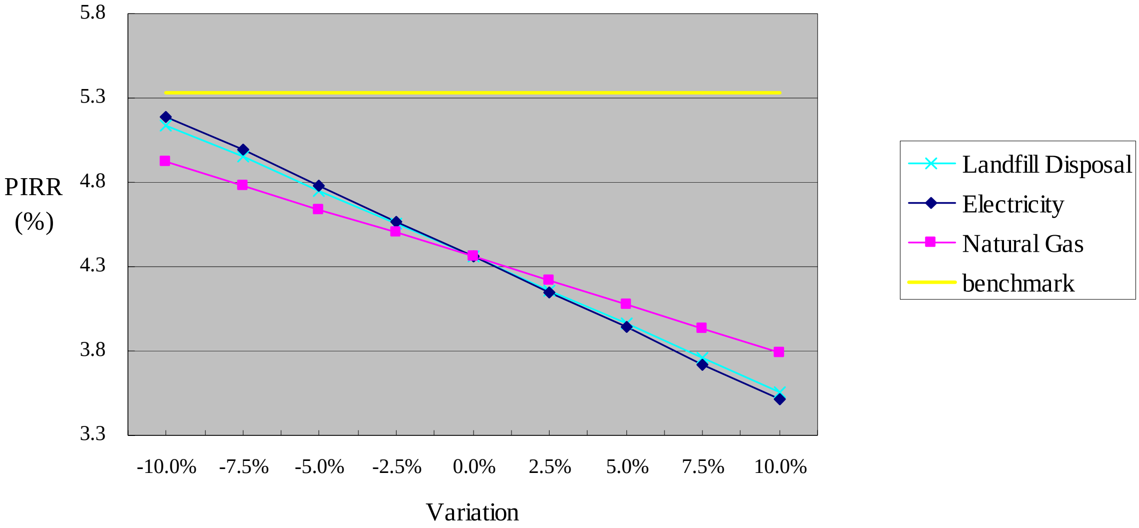


Figure-7 Result of sensitivity analysis

Figure-7 shows that the electricity price that constitutes 17% to the total investment cost has the biggest influence to the PIRR. The PIRR when the electricity price is reduced by 10% is 5.19% which is below the benchmark. The PIRR will hit the benchmark when the electricity price is reduced by 11.7%. However, the possibility of the occurrence of this scenario is very low considering the trend of the rise of electricity price that was observed at the time of the decision making for the project implementation (Average of 2004: 0.126S$/kWh, Average of 2005: 0.142S$/kWh, Average of 2006: 0.142S$/kWh, Average of 2007: 0.154S$/kWh).

Figure-7 shows that the landfill disposal cost that constitutes 16% to the total investment cost also has a significant influence to the PIRR. The PIRR when the landfill disposal cost is reduced by 10% is 5.14% which is below the benchmark. The PIRR will hit the benchmark when the landfill disposal cost is reduced by 12.5%. However, the disposal fee at Semakau landfill has increased since the start of its operation and it will continue to increase in the future according to the policy of the Ministry of the Environment. Therefore, it is very unlikely that the disposal fee would decrease by 12.5%.

The influence of natural gas is relatively small compared to electricity and landfill disposal cost. The PIRR when the cost is reduced by 10% for natural gas is 4.92% which is below the benchmark. The PIRR will hit the benchmark when the natural gas cost is reduced by 17.4%. The possibility of the occurrence of this scenario can also be considered very low taking into account the prices have kept its increase during the past few years (Average of 2005: 17.3S$/mmBtu, Average of 2006: 19.3S$/mmBtu, Average of 2007: 20.5S$/mmBtu).

In all cases shown in Figure-7, the PIRR was below the benchmark. Therefore, scenario M1 is economically unattractive, and shall be excluded from further consideration.

The project scheme for Scenario M3 is very similar to scenario M1 except for its high investment for plant construction and operation costs. Crystallization of the sewage sludge will require an additional plant that heats the ash created by incineration, or a gasification plant. In both cases, the initial cost and operation cost will be much higher than scenario M1. Therefore, it can be clearly stated that economical attractiveness of scenario M3 is lower than that of M1, and shall be excluded from further consideration.

Scenario M5 represents the present status in Singapore where sewage sludge is disposed at a sludge disposal site without the capture of methane gas. This is business as usual.

Through the assessment above, it is determined that the most plausible baseline scenario is M5 which is the disposal of sewage sludge at a sludge disposal site without the capture of methane gas.

**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 CDM project activity (assessment and demonstration of additionality):**

The additionality of the project activity is demonstrated and assessed using the "Tool for the demonstration and assessment of additionality" Version.05.2.

There is substantial evidence that the feasibility of the project with the incentive of CDM was seriously considered by the project participant since the project was affected by the increase of material cost. ECO has studied thoroughly the amount of emission reduction and the possibility of registration with consultation from professional source before making the final decision to proceed with the project activity. The investment decision was made on 4th January 2008 when ECO had a board meeting and the final decision was made for the major investment of the project. ECO signed the contract with the major equipment supplier on 10th January 2008. Therefore, this date is when ECO had committed to expenditures and thus the starting date of the proposed project activity.

Table-7 shows the timeline of events and actions taken to achieve CDM registration.

Table-7 Timeline of events and actions taken to achieve CDM registration

| Date | Description of Events | Description of Evidence |
|---|---|---|
| 8th November 2007 | Board meeting of ECO to discuss the outline of the project as a CDM after the meeting between ECO, SMBC, and JRI on 6th November 2007 | Minutes of meeting |
| 14th November 2007 | Internal meeting of ECO to discuss in detail the CER amount and the possibility of registration after the meeting with SMBC on the same day | Minutes of meeting |
| 21st November 2007 | Meeting between NEA, ECO, SMBC, and JRI to discuss about the necessary procedure for Singapore government approval | Minutes of meeting |
| 4th January 2008 | Final feasibility study result | Feasibility study report |
| 4th January 2008 | Board meeting of ECO when the final decision was made to proceed with the proposed project activity (Serious consideration of CDM) | Minutes of meeting |
| 10th January 2008 (Start date of the project) | Contract with major equipment supplier | Contract |

| | | |
|---|---|---|
| 1st April 2008 | Start of construction of the plant | Stated in contract with PUB |
| 6th October 2008 | Agreement on CDM Validation Services with DOE | Contract |

Note: SMBC (Sumitomo Mitsui Banking Corporation)
JRI (Japan Research Institute)
NEA (National Environment Agency)

*Step 1: Identification of alternatives to the project activity consistent with current laws and regulations*

*Sub-step 1a: Define alternatives to the project activity*
The following scenarios M1-5 are defined as alternatives to the project activity.

M1. Sewage sludge dehydration and incineration not implemented as a CDM project;
M2. Composting of sewage sludge;
M3. Crystallization of sewage sludge;
M4. Disposal of sewage sludge at a sludge disposal site where methane gas captured is flared;
M5. Disposal of sewage sludge at a sludge disposal site without the capture of methane gas.

*Sub-step 1b: Consistency with mandatory laws and regulations:*
In Singapore, there are no laws, regulations, or government policies that specify or restrict certain types of treatment methods for sewage sludge.
All alternative scenarios are in compliance with mandatory applicable legal and regulatory requirements.

*Step 2: Investment Analysis*

*Sub-step 2a: Determine appropriate analysis method*
The benchmark analysis is applied.

*Sub-step 2b: Option Ⅲ. Apply benchmark analysis*
Scenario M1, or the proposed project activity implemented without the CDM related income, generates financial benefits from disposal fee of the sewage sludge received. The financial attractiveness of scenario M1 is as demonstrated in the previous section.

It can be concluded after applying the benchmark and sensitivity analysis that scenario M1 is unlikely to be the most financially attractive scenario.

*Step 4: Common practice analysis*
The proposed project activity that dehydrates and incinerates sewage sludge is the first-of-its-kind to be implemented in Singapore. Therefore, this step will not be applied.

It is demonstrated through the assessment above that the proposed project is additional.

## B.6. Emission reductions:

### B.6.1. Explanation of methodological choices:

***Project Emissions***

Project emissions are calculated using equation (1) provided in the methodology. $PE_{c,y}$, $PE_{a,y}$, $PE_{g,y}$, $PE_{r,y}$, $PE_{w,y}$, are excluded from the calculation since the proposed project activity involves only incineration.

$$PE_y = PE_{elec,y} + PE_{fuel,on-site,y} + PE_{i,y} \quad (1)$$

Where:

| | |
|---|---|
| $PE_y$ | is the project emissions during the year *y* ($tCO_2e$/yr) |
| $PE_{elec,y}$ | is the emissions from electricity consumption due to the project activity during the year *y* ($tCO_2$/yr) |
| $PE_{fuel,on-site,y}$ | is the emissions due to fuel consumption on-site in year *y* ($tCO_2$/yr) |
| $PE_{i,y}$ | is the emissions during the waste incineration process in year *y* ($tCO_2e$/yr) |

***Emissions from electricity use ($PE_{elec,y}$)***

The proposed project activity involves consumption of electricity. The emissions from electricity consumption are calculated using equation (2).

$$PE_{elec,y} = EG_{PJ,EF,y} \times CEF_{elec} \quad (2)$$

Where:

| | |
|---|---|
| $PE_{elec,y}$ | is the emissions from electricity consumption due to the project activity during the year *y* ($tCO_2$/yr) |
| $EG_{PJ,EF,y}$ | is the amount of electricity generated in an on-site fossil fuel fired power plant or consumed from the grid in the project activity, measured using an electricity meter (MWh/yr) |
| $CEF_{elec}$ | $CO_2$ emission factor for electricity generation in the project activity ($tCO_2$/MWh) |

Electricity will be purchased from the grid. $CEF_{elec}$ is provided by Singapore's DNA (Climate Change Unit, Resource Conservation Department, National Environment Agency).

***Emissions from fuel use on-site ($PE_{fuel,on-site,y}$)***

The proposed project activity involves on-site fossil fuel consumption. The emissions from fossil fuel consumption on-site are calculated using equation (3).

$$PE_{fuel,on-site,y} = F_{cons,y} \times NCV_{fuel} \times EF_{fuel} \quad (3)$$

Where:

| | |
|---|---|
| $PE_{fuel,on-site,y}$ | is the $CO_2$ emissions due to on-site fuel combustion in year *y* ($tCO_2$/yr) |
| $F_{cons,y}$ | is the fuel consumption on site in year *y* (l/yr) |
| $NCV_{fuel}$ | is the net calorific value of the fuel (MJ/l) |
| $EF_{fuel}$ | is the $CO_2$ emission factor of the fuel ($tCO_2$/MJ) |

***Emissions from waste incineration process ($PE_{i,y}$)***

The emissions from the waste incineration stacks are calculated using equation (4). $PE_{i,f,y}$ which is the $CO_2$ emissions from fossil-based waste incineration is excluded from the calculation since the proposed project activity aims to incinerate sewage sludge only, which does not contain fossil-based waste.

$$PE_{i,y} = PE_{i,s,y} \quad (4)$$

Where:

| | |
|---|---|
| $PE_{i,y}$ | is emissions during the waste incineration process in year $y$ ($tCO_2e/yr$) |
| $PE_{i,s,y}$ | is the $N_2O$ and $CH_4$ emissions from the final stacks from waste incineration in year $y$ ($tCO_2e/yr$) |

Emissions of $N_2O$ and $CH_4$ are estimated using equation (5) listed as Option 1 in the methodology.

Option 1:

$$PE_{i,s,y} = SG_{i,y} \times MC_{N2O,i,y} \times GWP_{N2O} + SG_{i,y} \times MC_{CH4,i,y} \times GWP_{CH4} \quad (5)$$

Where:

| | |
|---|---|
| $PE_{i,s,y}$ | is the total emissions of $N_2O$ and $CH_4$ from waste incineration in year $y$ ($tCO_2e/yr$) |
| $SG_{i,y}$ | is the total volume of stack gas from waste incineration in year $y$ ($m^3/yr$) |
| $MC_{N2O,i,y}$ | is the monitored content of nitrous oxide in the stack gas from waste incineration in year $y$ ($tN_2O/m^3$) |
| $GWP_{N2O}$ | is the Global Warming Potential of nitrous oxide ($tCO_2e/tN_2O$) |
| $MC_{CH4,i,y}$ | is the monitored content of methane in the stack gas from waste incineration in the year $y$ ($tCH_4/m^3$) |
| $GWP_{CH4}$ | is the Global Warming Potential of methane ($tCO_2e/tCH_4$) |

***Baseline Emissions***

Baseline emissions are calculated using equation (6) provided in the methodology. $BE_{EN,y}$ is excluded from the equation since the proposed project activity does not displace energy that would have been consumed in the baseline scenario.

$$BE_y = MB_y - MD_{reg,y} \quad (6)$$

Where:

| | |
|---|---|
| $BE_y$ | is the baseline emissions in year $y$ ($tCO_2e/yr$) |
| $MB_y$ | is the methane produced at the sludge disposal site in the absence of the project activity in year $y$ ($tCO_2e/yr$) |
| $MD_{reg,y}$ | is the methane that would be destroyed in the absence of the project activity in year $y$ ($tCO_2e/yr$) |

***Adjustment Factor (AF)***

Since regulatory or contractual requirements do not specify $MD_{reg,y}$ in the proposed project activity, Adjustment Factor (AF) will be used to determine the methane that would be destroyed in the absence of the project activity.

$$MD_{reg,y} = MB_y \times AF \quad (7)$$

Where:

| | |
|---|---|
| *AF* | is Adjustment Factor for $MB_y$ (%) |

***Rate of Compliance***

There are no laws, regulations, or government policies that specify or restrict certain types of treatment methods for sewage sludge in Singapore. Therefore, method for adjusting the baseline emissions by rate of compliance does not apply.

***Methane generation from the landfill in the absence of the project activity ($MB_y$)***

The amount of methane that is generated each year ($MB_y$) is calculated as per the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site". Parameter *j* (waste type category) is excluded from the equation since the waste considered in the proposed project activity is only sewage sludge.

$$MB_y = BE_{CH4,SWDS,y} \quad (8)$$

$$BE_{CH4,SWDS,y} = \phi \cdot (1 - f) \cdot GWP_{CH4} \cdot (1 - OX) \cdot \frac{16}{12} \cdot F \cdot DOC_f \cdot MCF \cdot \sum_{x=1}^{y} W_{j,x} \cdot DOC_j \cdot e^{-kj \cdot (y-x)} \cdot \left(1 - e^{-k,j}\right) \quad (9)$$

Where:

| | |
|---|---|
| $MB_y$ | is $BE_{CH4,SWDS,y}$ ($tCO_2e/yr$) |
| $BE_{CH4,SWDS,y}$ | is the 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* ($tCO_2e/yr$) |
| $\phi$ | is the model correction factor to account for model uncertainties (0.9) |
| *f* | is the fraction of methane captured at the SWDS and flared, combusted or used in another manner |
| $GWP_{CH4}$ | is the Global Warming Potential (GWP) of methane, valid for the relevant commitment period |
| *OX* | is the oxidation factor (reflecting the amount of methane from SWDS that is oxidised in the soil or other material covering the waste) |
| *F* | is the fraction of methane in the SWDS gas (volume fraction) (0.5) |
| $DOC_f$ | is the fraction of degradable organic carbon (DOC) that can decompose |
| $W_{j,x}$ | is the amount of waste type *j* prevented from disposal in the SWDS in the year *x* (tons) |
| *MCF* | is the methane correction factor |

| | |
|---|---|
| $DOC_j$ | is the fraction of degradable organic carbon (by weight) in the waste type *j* |
| $k_j$ | is the decay rate for the waste type *j* |
| $x$ | is the year during the crediting period: *x* runs from the first year of the first crediting period ($x$=1) to year *y* for which avoided emissions are calculated ($x$=$y$) |
| $y$ | is the year for which methane emissions are calculated |

***Baseline emissions from generation of electricity displaced by the project activity***

This section is not applicable since the proposed project activity does not involve electricity generation.

***Baseline emissions from electricity and heat cogeneration that is displaced by the project activity***

Although heat recovered from the incineration process is used on-site, this section is not applicable since fossil fuel that would have been consumed in the absence of the proposed project activity does not exist.

***<u>Leakage</u>***

The leakage emissions of the proposed project activity are estimated using equation (10). $L_{r,y}$ (leakage emissions from the residual waste from the anaerobic digester, the gasifier, the processing/combustion of RDF/stabilized biomass, or compost in case it is disposed of in landfills in year *y*) and $L_{s,y}$ (leakage emissions from end use of stabilized biomass in year *y*) are excluded from the equation since the proposed project activity is incineration of sewage sludge.

$$L_y = L_{t,y} + L_{i,y} \qquad (10)$$

Where:

| | |
|---|---|
| $L_y$ | is the leakage emissions during the year *y* ($tCO_2e/yr$) |
| $L_{t,y}$ | is the leakage emissions from increased transport in year *y* ($tCO_2e/yr$) |
| $L_{i,y}$ | is the leakage emissions from the residual waste from MSW incinerator in year *y* ($tCO_2e/yr$) |

***Emissions from increased transport***

*Sludge transportation from WRPs*

The sewage sludge that is presently transported from the Water Reclamation Plants to the disposal site at Changi, will be transported to the project site at Tuas in the proposed project activity. The study result of the travel distance of vehicles in the baseline and project scenario is as shown in Table-8.

Table-8 Travel distance of vehicles in the baseline and project scenario

| Water Reclamation Plant (WRP) | Distance from WRP to Disposal Site (Changi) | Distance from WRP to Project Site (Tuas) | Additional Distance |
|---|---|---|---|
| | km | km | km |
| Ulu Pandan | 42 | 26 | -16 |
| Kranji | 44 | 31 | -13 |
| Jurong | 48 | 13 | -35 |
| Bedok | 16 | 51 | 35 |
| Seletar | 32 | 47 | 15 |

| | | | |
|---|---|---|---|
| Changi | 9 | 59 | 50 |
| Total | 191 | 227 | 36 |

The study shows that the additional travel distance of vehicles in the project scenario is 36km in total. The amount of emission from increased transport for each transport route was further studied using the following equation.

$$L_{t,y} = NO_{vehicles,y} \times DT_y \times VF_{cons} \times NCV_{fuel,transport} \times D_{fuel} \times EF_{fuel,transport} \quad (11)$$

Where:

| | |
|---|---|
| $L_{t,y}$ | is the leakage emissions from increased transport in year *y* ($tCO_2e/yr$) |
| $NO_{vehicles,y}$ | is the number of vehicles for transport |
| $DT_y$ | is the additional distance travelled compared to baseline in year *y* (km) |
| $VF_{cons}$ | is the vehicle fuel consumption in litres per kilometre (l/km) |
| $NCV_{fuel,transport}$ | is the calorific value of the fuel (MJ/kg) |
| $D_{fuel}$ | is the fuel density (kg/l) |
| $EF_{fuel,transport}$ | is the emission factor of the fuel ($tCO_2/MJ$) |

Table-9 Emission from increased travel distance for each transport route

| Water Reclamation Plant (WRP) | $NO_{vehicles,y}$ | $DT_y$ | $VF_{cons}$ | $NCV_{fuel,transport}$ | $D_{fuel}$ | $EF_{fuel,transport}$ | $L_{t,y}$ |
|---|---|---|---|---|---|---|---|
| | - | km | l/km | MJ/kg | kg/l | $tCO_2/MJ$ | $tCO_2$ |
| Ulu Pandan | 3,564 | -16 | 2.2 | 43.0 | 0.85 | $74.1*10^{-6}$ | -70 |
| Kranji | 1,710 | -13 | | | | | -27 |
| Jurong | 3,114 | -35 | | | | | -134 |
| Bedok | 306 | 35 | | | | | 13 |
| Seletar | 306 | 15 | | | | | 6 |
| Changi | 4,448 | 50 | | | | | 274 |
| Total | | | | | | | 62 |

As shown in Table-9, emission of 62 ton $CO_2$/yr is expected from the change of transportation route for the proposed project activity. However, considering the expected average amount of emission reduction which is 104,547 ton $CO_2$/yr, this is considered negligible.

*Ash transportation from project site to TMTS (Tuas Marine Transfer Station)*

There will be additional transportation of incineration ash from the project site to TMTS where all of the MSW incineration ash and non-incinerable refuse produced in Singapore are collected before taken to Semakau landfill by barges. The amount of ash produced per day is 73.5 tons, and the distance of travel is 5km. The calculated annual emission is approximately 12 ton $CO_2$/yr. Thus, the emission from ash transportation from the project site to TMTS is also considered negligible.

*Ash transportation from TMTS to Semakau landfill*

The incineration ash from the project site will be taken to Semakau landfill by barges after it is collected at TMTS. According to NEA's (National Environment Agency) annual report 2007, over 2,000 tons of incineration ash and non-incinerables are transported to Semakau landfill daily. Considering that the ash produced from the incineration of sludge is less than 5% of the total waste volume, the emission from ash transportation is negligible.

It is demonstrated through the assessment above that the leakage emission from transportation is considered negligible, and it will not be taken into account for the proposed project activity.

***Emissions from the residual waste from MSW incineration***

The leakage emission from the residual waste of incinerator is accounted for using the following equation.

$$L_{i,y} = A_{residual} \times FC_{residual} \times \frac{44}{12} \qquad (12)$$

Where:

| | |
|---|---|
| $L_{i,y}$ | is the leakage emissions from the residual waste of the incinerator in year *y* ($tCO_2e/yr$) |
| $A_{residual}$ | is the amount of residual waste from the incinerator (t/yr) |
| $FC_{residual}$ | is the fraction of residual carbon contained in the residual waste (%) |

***<u>Emission Reduction</u>***

The emission reductions are calculated by applying the following equation.

$$ER_y = BE_y - PE_y \qquad (13)$$

Where:

| | |
|---|---|
| $ER_y$ | is the emissions reductions in year *y* ($tCO_2e$) |
| $BE_y$ | is the emissions in the baseline scenario in year *y* ($tCO_2e$) |
| $PE_y$ | is the emissions in the project scenario in year *y* ($tCO_2e$) |

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

| **Data / Parameter:** | ***$CEF_{elec}$*** |
|---|---|
| Data unit: | $tCO_2/MWh$ |
| Description: | The emission factor for electricity generation corresponding to electricity used in the project activity. |
| Source of data used: | Value provided by Singapore's DNA |
| Value applied: | 0.4612 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | Determined using the "Tool to calculate the emission factor for an electricity system". The detail of calculation result can be received by Singapore's DNA (Climate Change Unit, Resource Conservation Department, National Environment Agency) |
| Any comment: | - |

| **Data / Parameter:** | ***$EF_{fuel}$*** |
|---|---|
| Data unit: | $tCO_2/MJ$ |
| Description: | Emission factor for natural gas |
| Source of data used: | IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adopted from Volume 2, Table 1.4) |
| Value applied: | $64.2*10^{-6}$ |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | A default value recommended in the IPCC 2006 Guidelines for National Greenhouse Gas Inventories is used since the carbon content of the natural gas is not available in Singapore. |
| Any comment: | |

| Data / Parameter: | ***$GWP_{N2O}$*** |
|---|---|
| Data unit: | - |
| Description: | Global Warming Potential of nitrous oxide |
| Source of data used: | Kyoto Protocol |
| Value applied: | 310 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | Valid for the First Commitment Period. |
| Any comment: | - |

| Data / Parameter: | ***$GWP_{CH4}$*** |
|---|---|
| Data unit: | - |
| Description: | Global Warming Potential of methane |
| Source of data used: | Kyoto Protocol |
| Value applied: | 21 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | Valid for the First Commitment Period. |
| Any comment: | - |

| Data / Parameter: | ***AF*** |
|---|---|
| Data unit: | % |
| Description: | Adjustment factor for $MB_{req,y}$ |
| Source of data used: | Estimation |
| Value applied: | 0 |
| Justification of the | There are no laws, regulations, or government policies that mandate the |

| | |
|---|---|
| choice of data or description of measurement methods and procedures actually applied : | destruction of SWDS gas, and activity to collect or destruct SWDS gas is not expected at the Changi reclaimed land which is the only SWDS for sewage sludge in Singapore. Therefore, $MD_{reg,y}$ is expected to be 0 through out the crediting period. |
| Any comment: | Changes in regulatory requirements relating to the baseline landfill will be monitored to update the adjustment factor at the beginning of each crediting period. |

| | |
|---|---|
| Data / Parameter: | $\phi$ |
| Data unit: | - |
| Description: | Model correction factor to account for model uncertainties of the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site" |
| Source of data used: | "Tool to determine the methane emissions avoided from disposal of 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 : | A default value provided in the "Tool to determine methane emission avoided from disposal of waste at a solid waste disposal site". |
| Any comment: | - |

| | |
|---|---|
| **Data / Parameter:** | ***F*** |
| Data unit: | - |
| Description: | Fraction of methane captured at the SWDS and flared, combusted or used in another manner |
| Source of data used: | "Tool to determine the methane emissions avoided from disposal of waste at a solid waste disposal site" |
| Value applied: | - |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | Already accounted for as AF (Adjustment Factor). |
| Any comment: | - |

| | |
|---|---|
| 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: | "Tool to determine the methane emissions avoided from disposal of waste at a solid waste disposal site" |
| Value applied: | 0.1 |

| | |
|---|---|
| Justification of the choice of data or description of measurement methods and procedures actually applied : | The default value of 0.1 for “managed solid waste disposal sites that are covered with oxidation material such as soil or compost” was determined by site investigation. |
| Any comment: | - |

| | |
|---|---|
| Data / Parameter: | ***F*** |
| Data unit: | - |
| Description: | Fraction of methane in the SWDS gas (volume fraction) |
| Source of data used: | “Tool to determine the methane emissions avoided from disposal of waste at a solid waste disposal site” |
| Value applied: | 0.5 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | A default value recommended in the IPCC 2006 Guidelines for National Greenhouse Gas Inventories. |
| Any comment: | - |

| | |
|---|---|
| Data / Parameter: | $DOC_f$ |
| Data unit: | - |
| Description: | Fraction of degradable organic carbon that can decompose |
| Source of data used: | “Tool to determine the methane emissions avoided from disposal of waste at a solid waste disposal site” |
| Value applied: | 0.5 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | A default value recommended in the IPCC 2006 Guidelines for National Greenhouse Gas Inventories. |
| Any comment: | - |

| | |
|---|---|
| Data / Parameter: | ***MCF*** |
| Data unit: | - |
| Description: | Methane correction factor |
| Source of data used: | “Tool to determine the methane emissions avoided from disposal of waste at a solid waste disposal site”. |
| Value applied: | 1.0 |
| Justification of the choice of data or description of measurement methods and procedures actually | The default value of 1.0 for “anaerobic managed solid waste disposal sites” was determined by site investigation. |

| | |
|---|---|
| applied : | |
| 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 (adopted from Volume 5, 2.3.2 Sludge), and PUB (Public Utilities Board), Singapore's national water agency |
| Value applied: | Dewatered Sludge: 7.4%; Dry Sludge: 29.4% |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | Sludge samples from all WRPs were taken to determine the DOC values for dewatered and dry sludge by laboratory analysis. Laboratory analysis was conducted at ICES (Institute of Chemical Engineering Sciences) which is a government research institute under A Star (Agency for Science, Technology and Research). |
| Any comment: | - |

| Dewatered Sludge | Dry Sludge |
|---|---|
| 7.4% | 29.4% |

| | |
|---|---|
| Data / Parameter: | ***$k_j$*** |
| Data unit: | - |
| Description: | Decay rate for the waste type *j* |
| Source of data used: | "Tool to determine the methane emissions avoided from disposal of waste at a solid waste disposal site" |
| Value applied: | Dewatered Sludge: 0.4; Dry Sludge: 0.4 |
| Justification of the choice of data or description of measurement methods and procedures actually applied : | Value applied for the conditions below.<br>>Rapidly degrading<br>>Tropical (MAT>20℃)<br>>Wet (MAP>1000mm) |
| Any comment: | Temperature and precipitation data sourced from Singapore NEA (National Environment Agency). |

| Dewatered Sludge | Dry Sludge |
|---|---|
| 0.4 | 0.4 |

### B.6.3. Ex-ante calculation of emission reductions:

***Project Emissions***

$$PE_y = PE_{elec,y} + PE_{fuel,on-site,y} + PE_{i,y} \quad (1)$$

Where:

$PE_y$ is the project emissions during the year *y* ($tCO_2e/yr$)

| | |
|---|---|
| $PE_{elec,y}$ | is the emissions from electricity consumption due to the project activity during the year $y$ ($tCO_2/yr$) |
| $PE_{fuel,on\text{-}site,y}$ | is the emissions on-site due to fuel consumption on-site in year $y$ ($tCO_2/yr$) |
| $PE_{i,y}$ | is the emissions during the incineration process in year $y$ ($tCO_2e/yr$) |

| $PE_y$ | $PE_{elec,y}$ | $PE_{fuel,on\text{-}site,y}$ | $PE_{i,y}$ |
|---|---|---|---|
| $tCO_2e/yr$ | $tCO_2/yr$ | $tCO_2/yr$ | $tCO_2e/yr$ |
| 7,687 | 4,782 | 2,905 | 0 |

***Emissions from electricity use ($PE_{elec,y}$)***

$$PE_{elec,y} = EG_{PJ,EF,y} \times CEF_{elec} \quad (2)$$

Where:

| | |
|---|---|
| $PE_{elec,y}$ | is the emissions from electricity consumption due to the project activity during the year $y$ ($tCO_2/yr$) |
| $EG_{PJ,EF,y}$ | is the amount of electricity generated in an on-site fossil fuel fired power plant or consumed from the grid in the project activity, measured using an electricity meter (MWh) |
| $CEF_{elec}$ | $CO_2$ emission factor for electricity generation in the project activity ($tCO_2/MWh$) |

| $PE_{elec,y}$ | $EG_{PJ,EF,y}$ | $CEF_{elec}$ |
|---|---|---|
| $tCO_2/yr$ | MWh | $tCO_2/MWh$ |
| 4,782 | 10,368 | 0.4612 |

***Emissions from fuel use on-site ($PE_{fuel,on\text{-}site,y}$)***

$$PE_{fuel,on-site,y} = F_{cons,y} \times NCV_{fuel} \times EF_{fuel} \quad (3)$$

Where:

| | |
|---|---|
| $PE_{fuel,on\text{-}site,y}$ | is the $CO_2$ emissions due to on-site fuel combustion in year $y$ ($tCO_2/yr$) |
| $F_{cons,y}$ | is the fuel consumption on site in year $y$ (ton/yr) |
| $NCV_{fuel}$ | is the net calorific value of natural gas (MJ/ton) |
| $EF_{fuel}$ | is the $CO_2$ emission factor of natural gas ($tCO_2/MJ$) |

| $PE_{fuel,on\text{-}site,y}$ | $F_{cons,y}$ | $NCV_{fuel}$ | $EF_{fuel}$ |
|---|---|---|---|
| $tCO_2/yr$ | ton/yr | MJ/ton | $tCO_2/MJ$ |
| 2,905 | 718 | 63,017 | $64.2*10^{-6}$ |

***Emissions from waste incineration processes ($PE_{i,y}$)***

$$PE_{i,s,y} = SG_{i,y} \times MC_{N2O,i,y} \times GWP_{N2O} + SG_{i,y} \times MC_{CH4,i,y} \times GWP_{CH4} \quad (5)$$

Where:

| | |
|---|---|
| $PE_{i,s,y}$ | is the total emissions of $N_2O$ and $CH_4$ from waste incineration in year $y$ ($tCO_2e$) |
| $SG_{i,y}$ | is the total volume of stack gas from waste incineration in year $y$ ($m^3/yr$) |

| | |
|---|---|
| $MC_{N2O,i,y}$ | is the monitored content of nitrous oxide in the stack gas from waste incineration in year $y$ ($tN_2O/m^3$) |
| $GWP_{N2O}$ | is the Global Warming Potential of nitrous oxide ($tCO_2e/tN_2O$) |
| $MC_{CH4,i,y}$ | is the monitored content of methane in the stack gas from waste incineration in the year $y$ ($tCH_4/m^3$) |
| $GWP_{CH4}$ | is the Global Warming Potential of methane ($tCO_2e/tCH_4$) |

| $PE_{i,y}$ | $SG_{i,y}$ | $MC_{N2O,i,y}$ | $GWP_{N2O}$ | $MC_{CH4,i,y}$ | $GWP_{CH4}$ |
|---|---|---|---|---|---|
| $tCO_2$/yr | $m^3$/yr | $tN_2O/m^3$ | $tCO_2e/tN_2O$ | $tCH_4/m^3$ | $tCO_2e/tCH_4$ |
| 0 | $1,766*10^6$ | 0 | 310 | 0 | 21 |

***Baseline Emissions***

$$BE_y = MB_y - MD_{reg,y} + BE_{EN,y} \qquad (6)$$

Where:

| | |
|---|---|
| $BE_y$ | is the baseline emissions in year $y$ ($tCO_2$/yr) |
| $MB_y$ | is the methane produced in the landfill in the absence of the project activity in year $y$ ($tCO_2e$/yr) |
| $MD_{reg,y}$ | is the methane that would be destroyed in the absence of the project activity in year $y$ ($tCO_2e$/yr) |
| $BE_{EN,y}$ | Baseline emissions from generation of energy displaced by the project activity in year $y$ ($tCO_2$/yr) |

| Year $y$ | $BE_y$ | $MB_y$ | $MD_{reg,y}$ | $BE_{EN,y}$ |
|---|---|---|---|---|
| | $tCO_2$/yr | $tCO_2e$/yr | $tCO_2e$/yr | $tCO_2$/yr |
| 2009 (April – December) | 34,933 | 34,933 | 0 | 0 |
| 2010 | 69,993 | 69,993 | | |
| 2011 | 93,495 | 93,495 | | |
| 2012 | 109,249 | 109,249 | | |
| 2013 | 119,809 | 119,809 | | |
| 2014 | 126,888 | 126,888 | | |
| 2015 | 131,632 | 131,632 | | |
| 2016 | 134,813 | 134,813 | | |
| 2017 | 136,945 | 136,945 | | |
| 2018 | 138,374 | 138,374 | | |
| 2019 (January – March) | 34,833 | 34,833 | | |

***Adjustment Factor (AF)***

$$MD_{reg,y} = MB_y \times AF \qquad (7)$$

Where:

| | |
|---|---|
| $AF$ | is the Adjustment Factor for $MB_y$ (%) |

| $MD_{reg,y}$ | $MB_y$ | $AF$ |
|---|---|---|

| | | |
|---|---|---|
| $tCO_2e/yr$ | $tCO_2e/yr$ | % |
| 0 | See table above | 0 |

***Methane generation from the landfill in the absence of the project activity ($MB_y$)***

$$MB_y = BE_{CH4,SWDS,y} \quad (8)$$

$$BE_{CH4,SWDS,y} = \phi \cdot (1-f) \cdot GWP_{CH4} \cdot (1-OX) \cdot \frac{16}{12} \cdot F \cdot DOC_f \cdot MCF \cdot \sum_{x=1}^{y} W_{j,x} \cdot DOC_j \cdot e^{-kj \cdot (y-x)} \cdot (1-e^{-kj}) \quad (9)$$

Where:

| | |
|---|---|
| $MB_y$ | is $BE_{CH4,SWDS,y}$ ($tCO_2e/yr$) |
| $BE_{CH4,SWDS,y}$ | is the 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* ($tCO_2e/yr$) |
| $\phi$ | is the model correction factor to account for model uncertainties (0.9) |
| *f* | is the fraction of methane captured at the SWDS and flared, combusted or used in another manner |
| $GWP_{CH4}$ | is the Global Warming Potential (GWP) of methane, valid for the relevant commitment period |
| *OX* | is the oxidation factor (reflecting the amount of methane from SWDS that is oxidised in the soil or other material covering the waste) |
| *F* | is the fraction of methane in the SWDS gas (volume fraction) (0.5) |
| $DOC_f$ | is the fraction of degradable organic carbon (DOC) that can decompose |
| $W_{j,x}$ | is the amount of waste type *j* prevented from disposal in the SWDS in the year *x* (tons) |
| *MCF* | is the methane correction factor |
| $DOC_j$ | is the fraction of degradable organic carbon (by weight) in the waste type *j* |
| $k_j$ | is the decay rate for the waste type *j* |
| *x* | is the year during the crediting period: *x* runs from the first year of the first crediting period (*x*=1) to year *y* for which avoided emissions are calculated (*x*=*y*) |
| *y* | is the year for which methane emissions are calculated |

| Year *y* | $MB_y$ | $BE_{CH4,SWDS,y}$ |
|---|---|---|
| | $tCO_2e/yr$ | $tCO_2e/yr$ |
| 2009 (April – December) | 34,933 | 34,933 |
| 2010 | 69,993 | 69,993 |
| 2011 | 93,495 | 93,495 |
| 2012 | 109,249 | 109,249 |
| 2013 | 119,809 | 119,809 |
| 2014 | 126,888 | 126,888 |
| 2015 | 131,632 | 131,632 |
| 2016 | 134,813 | 134,813 |
| 2017 | 136,945 | 136,945 |
| 2018 | 138,374 | 138,374 |
| 2019 (January – March) | 34,833 | 34,833 |

| $\phi$ | $f$ | $GWP_{CH4}$ | $OX$ | $F$ | $DOC_f$ | $MCF$ |
|---|---|---|---|---|---|---|
| - | - | - | - | - | - | - |
| 0.9 | 0 | 21 | 0.1 | 0.5 | 0.5 | 1.0 |

| | $W_{j,x}$ | $DOC_j$ | $k_j$ |
|---|---|---|---|
| | tons/yr | % | - |
| Dewatered Sludge | 160,000 | 7.4 | 0.4 |
| Dry Sludge | 44,480 | 29.4 | 0.4 |

***Baseline emissions from generation of electricity displaced by the project activity***

This section is not applicable since the proposed project activity does not involve any electricity generation.

***Baseline emissions from electricity and heat cogeneration that is displaced by the project activity***

This section is not applicable since the proposed project activity does not involve electricity or heat cogeneration.

***<u>Leakage</u>***

$$L_{i,y} = A_{residual} \times FC_{residual} \times \frac{44}{12} \qquad (12)$$

Where:

$L_{i,y}$ is the leakage emissions from the residual waste of the incinerator in year $y$ ($tCO_2e/yr$)

$A_{residual}$ is the amount of residual waste from the incinerator (t/yr)

$FC_{residual}$ is the fraction of residual carbon contained in the residual waste (%)

| $L_{i,y}$ | $A_{residual}$ | $FC_{residual}$ |
|---|---|---|
| $tCO_2e/yr$ | t/yr | % |
| 862 | 23,520 | 1.0 |

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

The ex-ante emission reductions throughout the crediting period are estimated as below:

| Year $y$ | $ER_y$ | $BE_y$ | $PE_y$ | $L_y$ |
|---|---|---|---|---|
| | $tCO_2e/yr$ | $tCO_2e/yr$ | $tCO_2e/yr$ | $tCO_2e/yr$ |
| 2009 (April – December) | 28,521 | 34,933 | 5,765 | 646 |
| 2010 | 61,444 | 69,993 | 7,687 | 862 |
| 2011 | 84,946 | 93,495 | 7,687 | 862 |
| 2012 | 100,700 | 109,249 | 7,687 | 862 |
| 2013 | 111,260 | 119,809 | 7,687 | 862 |

| | | | | |
|---|---|---|---|---|
| 2014 | 118,339 | 126,888 | 7,687 | 862 |
| 2015 | 123,083 | 131,632 | 7,687 | 862 |
| 2016 | 126,264 | 134,813 | 7,687 | 862 |
| 2017 | 128,396 | 136,945 | 7,687 | 862 |
| 2018 | 129,825 | 138,374 | 7,687 | 862 |
| 2019 (January – March) | 32,695 | 34,833 | 1,922 | 216 |
| Total | 1,045,473 | 1,130,964 | 76,900 | 8,620 |

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

### B.7.1 Data and parameters monitored:

| **Data / Parameter:** | ***$EG_{PJ,EF,y}$*** |
|---|---|
| Data unit: | MWh/year |
| Description: | The amount of electricity consumed from the grid in the project activity. |
| Source of data to be used: | ECO Special Waste Management Pte. Ltd. |
| Value of data applied for the purpose of calculating expected emission reductions in section B.5 | 10,368 MWh |
| Description of measurement methods and procedures to be applied: | Electricity consumption will be measured by an electric meter of the dehydration incineration plant and aggregated annually. |
| Monitoring Frequency | Continuous |
| QA/QC procedures to be applied: | Maintenance and calibration of meters will be carried out by a third party according to relevant local/international standards. Data will be cross checked by electricity bill. |
| Any comment: | - |

| **Data / Parameter:** | ***$F_{cons,y}$*** |
|---|---|
| Data unit: | tons/year |
| Description: | The natural gas consumption for the auxiliary burner of the incinerator |
| Source of data to be used: | ECO Special Waste Management Pte. Ltd. |
| Value of data applied for the purpose of calculating expected emission reductions in section B.5 | 718 tons |
| Description of measurement methods and procedures to be applied: | Amount of natural gas consumption will be monitored by the original invoices from the natural gas supplier and flow meters that are installed for individual trains. Data will be aggregated annually. |
| Monitoring Frequency | Continuous |
| QA/QC procedures to be applied: | Consistency between the invoice and accumulated data of the flow meter will be checked periodically. |
| Any comment: | - |

| **Data / Parameter:** | ***$NCV_{fuel}$*** |
|---|---|
| Data unit: | MJ/ton |
| Description: | Net calorific value of natural gas |

| | |
|---|---|
| Source of data to be used: | Based on NCV value provided by the gas supplier |
| Value of data applied for the purpose of calculating expected emission reductions in section B.5 | 63,017 |
| Description of measurement methods and procedures to be applied: | NCV of natural gas is monitored daily by the gas supplier, and it is provided by the gas supplier. The monthly data of NCV will be used to calculate the project emission from natural gas consumption. |
| Monitoring Frequency | Continuous |
| QA/QC procedures to be applied: | |
| Any comment: | - |

| **Data / Parameter:** | $SG_y$ |
|---|---|
| Data unit: | $m^3$/year |
| Description: | Stack gas volume flow rate |
| Source of data to be used: | ECO Special Waste Management Pte. Ltd. |
| Value of data applied for the purpose of calculating expected emission reductions in section B.5 | $1,766*10^6$ $m^3$/y |
| Description of measurement methods and procedures to be applied: | The flow rate of the stack gas will be monitored using a flow meter. |
| Monitoring Frequency | Continuous |
| QA/QC procedures to be applied: | Maintenance and calibration of meters will be carried out by a third party according to relevant local/international standards. |
| Any comment: | - |

| **Data / Parameter:** | $MC_{N2O,y}$ |
|---|---|
| Data unit: | $tN_2O/m^3$ |
| Description: | Fraction of $N_2O$ |
| Source of data to be used: | Outsourced |
| 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: | Stack gas composition will be monitored by gas analyzer. |
| Monitoring Frequency | Quarterly |
| QA/QC procedures to be applied: | Gas analyzing will be carried out by a third party according to relevant local/international standards. |
| Any comment: | - |

| **Data / Parameter:** | $MC_{CH4,y}$ |
|---|---|
| Data unit: | $tCH_4/m^3$ |
| Description: | Fraction of $CH_4$ |
| Source of data to be used: | Outsourced |
| 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: | Stack gas composition will be monitored by gas analyzer. |
| Monitoring Frequency | Quarterly |
| QA/QC procedures to be applied: | Gas analyzing will be carried out by a third party according to relevant local/international standards. |
| Any comment: | - |

| **Data / Parameter:** | $W_j$ |
|---|---|
| Data unit: | tons |
| Description: | Total amount of waste type *j* prevented from disposal in year *x* |
| Source of data to be used: | ECO Special Waste Management Pte. Ltd. |
| Value of data applied for the purpose of calculating expected emission reductions in section B.5 | (see table below) |

| Year | $W_{dewatered}$ | $W_{dry}$ |
|---|---|---|
| 2009 (April – December) | 120,000 | 33,360 |
| 2010 | 160,000 | 44,480 |
| 2011 | 160,000 | 44,480 |
| 2012 | 160,000 | 44,480 |
| 2013 | 160,000 | 44,480 |
| 2014 | 160,000 | 44,480 |
| 2015 | 160,000 | 44,480 |
| 2016 | 160,000 | 44,480 |
| 2017 | 160,000 | 44,480 |
| 2018 | 160,000 | 44,480 |
| 2019 (January – March) | 40,000 | 11,120 |

| | |
|---|---|
| Description of measurement methods and procedures to be applied: | The amount of incoming waste will be measured by a weighbridge on a continuous basis and aggregated annually. Data will be recorded in a manner that the quantity of dewatered sludge and dry sludge can be clearly distinguished. |
| Monitoring Frequency | Continuous |
| QA/QC procedures to be applied: | The weighbridge will be subject to appropriate maintenance and periodic calibration. |
| Any comment: | - |

| **Data / Parameter:** | $A_{residual}$ |
|---|---|
| Data unit: | tons/year |
| Description: | The amount of the residual waste from the incinerator |
| Source of data to be used: | ECO Special Waste Management Pte. Ltd. |
| Value of data applied for the purpose of calculating expected emission reductions in section B.5 | 23,520 tons |
| Description of measurement methods and procedures to be applied: | The amount will be measured at the weighbridge. |
| Monitoring Frequency | Daily, aggregated annually. |
| QA/QC procedures to be applied: | The weighbridge will be subject to appropriate maintenance and periodic calibration. |
| Any comment: | - |

| **Data / Parameter:** | $FC_{residual}$ |
|---|---|
| Data unit: | % |
| Description: | Fraction of residual carbon in the residual waste of the incinerator |
| Source of data to be used: | Outsourced |
| Value of data applied for the purpose of calculating expected emission reductions in section B.5 | 1 |
| Description of measurement methods and procedures to be applied: | Sampling will be conducted to achieve maximum uncertainty range of 20% at a 95% confidence level. |
| Monitoring Frequency | Quarterly |
| QA/QC procedures to be applied: | Analyzing of the residual waste will be carried out by a third party according to relevant local/international standards. |
| Any comment: | - |

**B.7.2. Description of the monitoring plan:**

ECO will collect and store relevant data in a systematic and reliable way, evaluate them regularly, generate reports, and ensure the availability of pertinent information for verification. An electronic spreadsheet file will be kept to accumulate all monitored variables, which will be presented to the DOE for verification.

***Organization Structure and Monitoring Procedures***
The basic organization structure as currently planned is described in Figure-8. Detail on monitoring and QA/QC procedures for each monitoring items will be put in to the Monitoring Manual which will be finalized before start of operation.

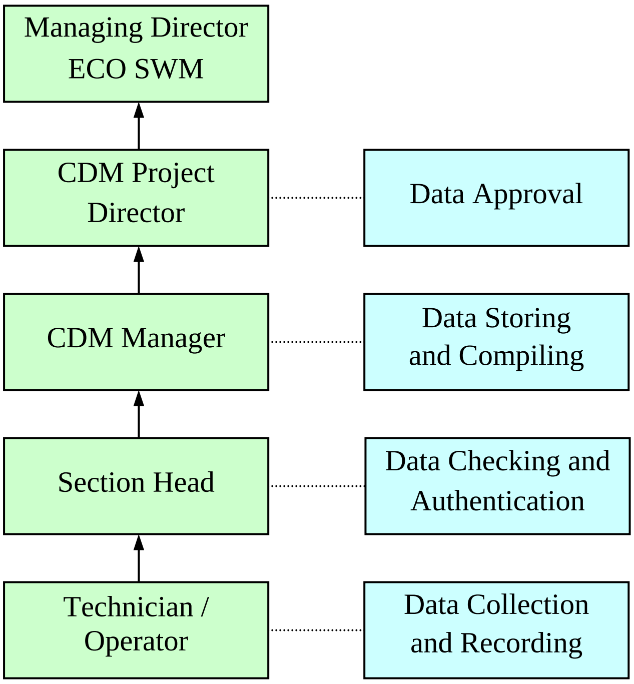


Figure-8 Basic organization structure

Data for the monitoring items will be collected and recorded by the Technicians or Operators at the project site. Then the collected and recorded data will be passed to the Section Head for checking and authentication. The CDM Manager will receive the authenticated data from the Section Head where the data will be cross checked with other sources such as invoices from suppliers. The data will be stored and compiled for calculation of the emission reduction and summarized for the monitoring report. The CDM Project Director will finally approve the data and will report to the Managing Director.

***Calibration Certificates, Other Relevant Documents***
Calibration of the monitoring equipment, meters, and weighbridges used will be done on a regular basis as recommended by the suppliers of the equipment or by the authorities. Records of the calibration certificates will be kept at the plant site and a duplicate will be stored at ECO. For parameters that will be

monitored by third parties, certification of the third parties will also be compiled and presented to the verifier if necessary.

***Training***
ECO will engage a CDM consultant for training of the CDM related staffs. The training may include but not be limited to the following;

- Importance of monitoring
- Detailed explanation on monitoring and QA/QC procedures
- Countermeasures for emergency situations and detail on incident reporting and corrective actions

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

19/01/2009

Dr. Kozo Bando
General Manager CDM/JI Group
Environmental Engineering Division
Kajima Corporation
5-11, Akasaka 6-Chome, Minato-ku, Tokyo, 107-8348, JAPAN
Tel: (81) 3 5544 0742
Fax: (81) 3 5544 1736
E-mail: bandok@kajima.com

Kajima Corporation is 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:

10/01/2008
(Date when ECO signed the contract with the major equipment suppliers)

#### 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:

NA

##### C.2.1.2. Length of the first crediting period:

NA

**C.2.2. Fixed crediting period:**

**C.2.2.1. Starting date:**

01/04/2009 or the date of registration, whichever is later

**C.2.2.2. Length:**

10 years

## SECTION D. Environmental impacts

**D.1. Documentation on the analysis of the environmental impacts, including transboundary impacts:**

The proposed project activity employs the advanced technology from Japan to dehydrate and incinerate sewage sludge. The system is well-equipped with pollution control equipment which is able to ensure all the anticipated environmental impacts are below the regulated values. Control measures will be implemented to ensure no significant environmental impact has been arisen from the project activity.

***Air Pollution Impact***

Exhaust gas is released to the atmosphere during the incineration of sewage sludge. The amount of air pollutants emitted to the air such as $SO_x$ and $NO_x$ are controlled by the cyclone and wet scrubber. The concentration level of air pollutants released, which are within the allowable limits for National Emission Standards for Air Pollutants in Code of Practice on Pollution Control (Appendix 19), is listed as follows:

| Source | Air Pollutants | Concentration of Air Pollutants |
|---|---|---|
| Exhaust gas | $SO_2$ | Max. 500mg/Nm$^3$ |
| | $NO_x$ | Max. 700mg/Nm$^3$ |
| | Dust | Max. 100mg/Nm$^3$ |
| | Dioxins and Furans | Max. 0.05ngTEQ/Nm$^3$ |
| | CO | Less than 625mg/Nm$^3$ |
| | HCl | Less than 200mg/Nm$^3$ |
| | Smoke | Ringelmann No.1 |

***Water Pollution Impact***

The ash which is the end product from the incineration process will be disposed at Semakau landfill. The ash will be tested in accordance with the requirements of Leaching Test – Recommended Acceptance Criteria for Suitability of Industrial Wastes for Landfill Disposal, NEA.

The quantity of trade effluent (in m$^3$ per day) generated from the wet scrubber is approximately 120 and shall be treated to meet the Trade Effluent Discharge Limit.

The nature and characteristics of trade effluent, which are within the allowable limits for Trade Effluent Discharge in Code of Practice on Pollution Control (Appendix 9), are listed as follows:

| Parameters | Quality Before Treatment | Quality after treatment |
|---|---|---|
| pH | 4-7 | 6-9 |
| BOD | Less than 400mg/l | Less than 400mg/l |

| | | |
|---|---|---|
| COD | 3,500mg/l | Less than 600mg/l |
| Suspended Solids | Less than 400mg/l | Less than 400mg/l |
| Total Dissolved Solids | Less than 400mg/l | Less than 3,000mg/l |
| Detergents | Nil | Nil |
| Oil & Grease | Nil | Nil |
| Fe | Less than 40mg/l | Less than 40mg/l |
| $SO_4$ | 30,000mg/l | Less than 1,000mg/l |

***Odour Impact***
Odour nuisance may arise from the sludge receiving and handling building of the sludge treatment plant. With the proper containment within the sludge receiving building for dewatered and dry sludge, the odour is drawn through the vacuum ducts in the handling building and burned off in the incinerator before it is released to the atmosphere.

***Noise Impact***
The equipments which are installed in open surrounding operate at a very low noise level, except for the Circulation and Induced Fans whose noise level can reach as high as 90 decibels (dB). For these equipments, suitable acoustic enclosures are designed and constructed to contain the noise emitted by the equipments to locally acceptable level.

**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:**

The proposed project activity will meet all of the requirements and expect no significant environmental impacts.

## SECTION E. Stakeholders' comments

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

Public consultation was undertaken as a part of the development of the Project activity. The public consultation was held at the Raffles Country Club (Raffles Lounge) on 4th September, 2008. The announcement of the meeting was made by invitation letter to neighboring companies, national authorities, NGO, academic institutions, and others. A total of 29 people participated in the meeting. (Other than project participants)
Throughout the meeting, followings were presented to the participants.

- Purposes of the proposed project activity
- General description of the proposed project activity
- Environmental impact of the proposed project activity
- Benefits of the proposed project activity related to sustainable development
- Outline of CDM

Photo-3 Stakeholders' Meeting at Raffles Country Club

Photo-4 Q&A Session

## E.2. Summary of the comments received:

The Q&A session of the meeting was conducted by Mrs. Tam Li Phin (Director, School of Engineering Centre of Innovation Environmental & Water Technology, Ngee Ann Polytechnic) to ensure the meeting to be held in a proper and transparent manner.
The concerns raised by the stakeholders were answered clearly and thoroughly by the project participants. The stakeholders understood and were satisfied with the answers, and expressed their support for the implementation of the project.

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

There were no issues raised that required further explanations or interaction with the stakeholders.

# Annex 1

## CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

| | |
|---|---|
| Organization: | ECO Special Waste Management Pte. Ltd. |
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| Represented by: | - |
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| | |
|---|---|
| Organization: | Sumitomo Mitsui Banking Corporation |
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| Telephone: | - |
| FAX: | - |
| E-Mail: | - |
| URL: | http://www.smbc.co.jp/global/index.html |
| Represented by: | - |
| Title: | General Manager |
| Salutation: | Mr. |
| Last name: | Kakita |
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| | |
|---|---|
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| | |
|---|---|
| Organization: | Kajima Corporation |
| Street/P.O.Box: | 3-1, Motoakasaka 1-chome, |
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| City: | Minato-ku |
| State/Region: | Tokyo |
| Postcode/ZIP: | 107-8388 |
| Country: | Japan |
| Telephone: | (81) 3 5544 1111 |
| FAX: | (81) 3 6438 2700 |
| E-Mail: | - |
| URL: | http://www.kajima.co.jp/welcome.html |
| Represented by: | - |
| Title: | General Manager |
| Salutation: | Dr. |
| Last name: | Bando |
| Middle name: | - |
| First name: | Kozo |
| Department: | CDM/JI Group, Environmental Engineering Division |
| Mobile: | (81) 90 4714 9778 |
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| Direct tel: | (81) 3 5544 0742 |
| Personal e-mail: | bandok@kajima.com |

## Annex 2

### INFORMATION REGARDING PUBLIC FUNDING

The financial plans for the project activity do not involve any public funding from any countries.

## Annex 3

## BASELINE INFORMATION

### 1. Amount of Sewage Sludge

The amount of sewage sludge under the contract between PUB and ECO is as calculated below.
ECO will receive sewage sludge from PUB for 9 years.

| | |
|---|---|
| Dewatered Sludge | 1,440,000 ton |
| Dry Sludge | 400,000 ton |

Therefore, the total amount per annum is 204,444 ton according to the calculation below.

(1,440,000 + 400,000)ton / 9years = 204,444 ton/year

The value applied to the PDD is calculated from the plant capacity and operation days per annum.

| | |
|---|---|
| Dewatered Sludge | 500 ton/day |
| Dry Sludge | 139 ton/day |

(500 + 139)ton * 320days = 204,480 ton/year

Since the capacity is a rounded figure, the total amount per annum is slightly different from 204,444 ton/year.

## 2. Baseline Emission

$$MB_y = BE_{CH4,SWDS,y}$$

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

**Parameters**

| | | | | |
|---|---|---|---|---|
| 1 | $\phi$ | Model correstion factor to account for model uncertainties | 0.9 | - |
| 2 | f | Fraction of methane captured at the SWDS and flared, combusted or used in another | 0 | - |
| 3 | OX | Oxidation factor | 0.1 | - |
| 4 | F | Fraction of methane in the SWDS gas (volume fraction) | 0.5 | - |
| 5 | DOCf | Fraction of degradable organic carbon (DOC) that can decompose | 0.5 | - |
| 6 | MCF | Methane correction factor | 1.0 | - |
| 7-1 | $DOC_{dewatered}$ | Fraction of degradable organic carbon (by weight) in the dewatered sludge | 0.074 | - |
| 7-2 | $DOC_{dry}$ | Fraction of degradable organic carbon (by weight) in the dry sludge | 0.294 | - |
| 8 | k | Decay rate | 0.4 | - |
| 9 | W | Amount of waste prevented from disposal in the SWDS | 204,480 | ton |

**Gas Emission Computation**

| Year | Sludge Disposal | gas emission (tonCO$_2$/year) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | t/year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
| 2020 | | | | | | | | | | | | |
| 2019 | 204,480 | 9 months | | | | | | | | | 3 months | 46,577 |
| 2018 | 204,480 | | | | | | | | | | 46,577 | 31,222 |
| 2017 | 204,480 | | | | | | | | | 46,577 | 31,222 | 20,928 |
| 2016 | 204,480 | | | | | | | | 46,577 | 31,222 | 20,928 | 14,029 |
| 2015 | 204,480 | | | | | | | 46,577 | 31,222 | 20,928 | 14,029 | 9,404 |
| 2014 | 204,480 | | | | | | 46,577 | 31,222 | 20,928 | 14,029 | 9,404 | 6,304 |
| 2013 | 204,480 | | | | | 46,577 | 31,222 | 20,928 | 14,029 | 9,404 | 6,304 | 4,225 |
| 2012 | 204,480 | | | | 46,577 | 31,222 | 20,928 | 14,029 | 9,404 | 6,304 | 4,225 | 2,832 |
| 2011 | 204,480 | | | 46,577 | 31,222 | 20,928 | 14,029 | 9,404 | 6,304 | 4,225 | 2,832 | 1,899 |
| 2010 | 204,480 | | 46,577 | 31,222 | 20,928 | 14,029 | 9,404 | 6,304 | 4,225 | 2,832 | 1,899 | 1,273 |
| 2009 | 153,360 | 34,933 | 23,416 | 15,696 | 10,522 | 7,053 | 4,728 | 3,169 | 2,124 | 1,424 | 954 | 640 |
| total | 2,198,160 | 34,933 | 69,993 | 93,495 | 109,249 | 119,809 | 126,888 | 131,632 | 134,813 | 136,945 | 138,374 | 139,332 |
| Baseline Emission | | **34,933** | **69,993** | **93,495** | **109,249** | **119,809** | **126,888** | **131,632** | **134,813** | **136,945** | **138,374** | **34,833** |

= 204,480 × 9/12

= 139,332 × 3/12

## 3. IRR Spread Sheet

### (1) PIRR for basic scenario

IRR 4.36%

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| Capital Investment | (30,800,000) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Landfill Cost | | 1,692,499 | 1,709,424 | 1,726,518 | 1,743,784 | 1,761,221 | 1,778,834 | 1,796,622 | 1,814,588 | 1,832,734 |
| Electricity Cost | | 1,741,824 | 1,776,660 | 1,812,194 | 1,848,438 | 1,885,406 | 1,923,114 | 1,961,577 | 2,000,808 | 2,040,824 |
| Natural Gas | | 1,169,219 | 1,192,604 | 1,216,456 | 1,240,785 | 1,265,600 | 1,290,912 | 1,316,731 | 1,343,065 | 1,369,927 |
| Others | | 2,666,373 | 2,725,276 | 2,785,847 | 2,848,139 | 2,912,206 | 2,978,105 | 3,045,895 | 3,115,637 | 3,187,392 |
| Operation Cost Total | | 7,269,915 | 7,403,964 | 7,541,015 | 7,681,145 | 7,824,434 | 7,970,966 | 8,120,825 | 8,274,098 | 8,430,878 |
| Revenue (Disposal fee) | | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 |
| Depreciation | | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 |
| Tax | | 267,415 | 243,286 | 218,617 | 193,394 | 167,602 | 141,226 | 114,252 | 86,662 | 58,442 |
| Balance | (30,800,000) | 4,640,447 | 4,530,527 | 4,418,145 | 4,303,239 | 4,185,742 | 4,065,586 | 3,942,702 | 3,817,017 | 3,688,458 |

### (2) PIRR for landfill cost +10% scenario

IRR 3.56%

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| Capital Investment | (30,800,000) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Landfill Cost | | 1,861,749 | 1,880,367 | 1,899,170 | 1,918,162 | 1,937,344 | 1,956,717 | 1,976,284 | 1,996,047 | 2,016,008 |
| Electricity Cost | | 1,741,824 | 1,776,660 | 1,812,194 | 1,848,438 | 1,885,406 | 1,923,114 | 1,961,577 | 2,000,808 | 2,040,824 |
| Natural Gas | | 1,169,219 | 1,192,604 | 1,216,456 | 1,240,785 | 1,265,600 | 1,290,912 | 1,316,731 | 1,343,065 | 1,369,927 |
| Others | | 2,666,373 | 2,725,276 | 2,785,847 | 2,848,139 | 2,912,206 | 2,978,105 | 3,045,895 | 3,115,637 | 3,187,392 |
| Operation Cost Total | | 7,439,165 | 7,574,907 | 7,713,667 | 7,855,523 | 8,000,556 | 8,148,849 | 8,300,487 | 8,455,557 | 8,614,151 |
| Revenue (Disposal fee) | | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 |
| Depreciation | | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 |
| Tax | | 236,950 | 212,517 | 187,540 | 162,006 | 135,900 | 109,207 | 81,912 | 54,000 | 25,453 |
| Balance | (30,800,000) | 4,501,662 | 4,390,354 | 4,276,571 | 4,160,249 | 4,041,321 | 3,919,721 | 3,795,379 | 3,668,221 | 3,538,174 |

### (3) PIRR for landfill cost -10% scenario

IRR 5.14%

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| Capital Investment | (30,800,000) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Landfill Cost | | 1,523,249 | 1,538,482 | 1,553,867 | 1,569,405 | 1,585,099 | 1,600,950 | 1,616,960 | 1,633,129 | 1,649,461 |
| Electricity Cost | | 1,741,824 | 1,776,660 | 1,812,194 | 1,848,438 | 1,885,406 | 1,923,114 | 1,961,577 | 2,000,808 | 2,040,824 |
| Natural Gas | | 1,169,219 | 1,192,604 | 1,216,456 | 1,240,785 | 1,265,600 | 1,290,912 | 1,316,731 | 1,343,065 | 1,369,927 |
| Others | | 2,666,373 | 2,725,276 | 2,785,847 | 2,848,139 | 2,912,206 | 2,978,105 | 3,045,895 | 3,115,637 | 3,187,392 |
| Operation Cost Total | | 7,100,665 | 7,233,022 | 7,368,363 | 7,506,767 | 7,648,312 | 7,793,083 | 7,941,162 | 8,092,640 | 8,247,604 |
| Revenue (Disposal fee) | | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 |
| Depreciation | | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 |
| Tax | | 297,880 | 274,056 | 249,695 | 224,782 | 199,304 | 173,245 | 146,591 | 119,325 | 91,431 |
| Balance | (30,800,000) | 4,779,232 | 4,670,700 | 4,559,720 | 4,446,229 | 4,330,162 | 4,211,450 | 4,090,025 | 3,965,813 | 3,838,742 |

### (4) PIRR for electricity cost +10% scenario

IRR 3.51%

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| Capital Investment | (30,800,000) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Landfill Cost | | 1,692,499 | 1,709,424 | 1,726,518 | 1,743,784 | 1,761,221 | 1,778,834 | 1,796,622 | 1,814,588 | 1,832,734 |
| Electricity Cost | | 1,916,006 | 1,954,327 | 1,993,413 | 2,033,281 | 2,073,947 | 2,115,426 | 2,157,734 | 2,200,889 | 2,244,907 |
| Natural Gas | | 1,169,219 | 1,192,604 | 1,216,456 | 1,240,785 | 1,265,600 | 1,290,912 | 1,316,731 | 1,343,065 | 1,369,927 |
| Others | | 2,666,373 | 2,725,276 | 2,785,847 | 2,848,139 | 2,912,206 | 2,978,105 | 3,045,895 | 3,115,637 | 3,187,392 |
| Operation Cost Total | | 7,444,097 | 7,581,630 | 7,722,234 | 7,865,989 | 8,012,975 | 8,163,277 | 8,316,982 | 8,474,179 | 8,634,960 |
| Revenue (Disposal fee) | | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 |
| Depreciation | | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 |
| Tax | | 236,062 | 211,307 | 185,998 | 160,122 | 133,665 | 106,610 | 78,943 | 50,648 | 21,707 |
| Balance | (30,800,000) | 4,497,618 | 4,384,841 | 4,269,546 | 4,151,667 | 4,031,138 | 3,907,890 | 3,781,852 | 3,652,951 | 3,521,111 |

(5) PIRR for electricity cost -10% scenario

IRR 5.19%

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| Capital Investment | (30,800,000) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Landfill Cost | | 1,692,499 | 1,709,424 | 1,726,518 | 1,743,784 | 1,761,221 | 1,778,834 | 1,796,622 | 1,814,588 | 1,832,734 |
| Electricity Cost | | 1,567,642 | 1,598,994 | 1,630,974 | 1,663,594 | 1,696,866 | 1,730,803 | 1,765,419 | 1,800,727 | 1,836,742 |
| Natural Gas | | 1,169,219 | 1,192,604 | 1,216,456 | 1,240,785 | 1,265,600 | 1,290,912 | 1,316,731 | 1,343,065 | 1,369,927 |
| Others | | 2,666,373 | 2,725,276 | 2,785,847 | 2,848,139 | 2,912,206 | 2,978,105 | 3,045,895 | 3,115,637 | 3,187,392 |
| Operation Cost Total | | 7,095,733 | 7,226,298 | 7,359,796 | 7,496,301 | 7,635,894 | 7,778,654 | 7,924,667 | 8,074,018 | 8,226,795 |
| Revenue (Disposal fee) | | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 |
| Depreciation | | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 |
| Tax | | 298,768 | 275,266 | 251,237 | 226,666 | 201,539 | 175,842 | 149,560 | 122,677 | 95,177 |
| Balance | (30,800,000) | 4,783,277 | 4,676,213 | 4,566,745 | 4,454,811 | 4,340,345 | 4,223,281 | 4,103,551 | 3,981,083 | 3,855,806 |

(6) PIRR for natural gas cost +10% scenario

IRR 3.79%

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| Capital Investment | (30,800,000) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Landfill Cost | | 1,692,499 | 1,709,424 | 1,726,518 | 1,743,784 | 1,761,221 | 1,778,834 | 1,796,622 | 1,814,588 | 1,832,734 |
| Electricity Cost | | 1,741,824 | 1,776,660 | 1,812,194 | 1,848,438 | 1,885,406 | 1,923,114 | 1,961,577 | 2,000,808 | 2,040,824 |
| Natural Gas | | 1,286,141 | 1,311,864 | 1,338,101 | 1,364,863 | 1,392,160 | 1,420,004 | 1,448,404 | 1,477,372 | 1,506,919 |
| Others | | 2,666,373 | 2,725,276 | 2,785,847 | 2,848,139 | 2,912,206 | 2,978,105 | 3,045,895 | 3,115,637 | 3,187,392 |
| Operation Cost Total | | 7,386,837 | 7,523,225 | 7,662,661 | 7,805,223 | 7,950,994 | 8,100,057 | 8,252,498 | 8,408,405 | 8,567,870 |
| Revenue (Disposal fee) | | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 |
| Depreciation | | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 |
| Tax | | 246,369 | 221,820 | 196,721 | 171,060 | 144,821 | 117,990 | 90,550 | 62,487 | 33,783 |
| Balance | (30,800,000) | 4,544,571 | 4,432,733 | 4,318,396 | 4,201,495 | 4,081,962 | 3,959,731 | 3,834,730 | 3,706,886 | 3,576,124 |

(7) PIRR for natural gas cost -10% scenario

IRR 4.92%

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| Capital Investment | (30,800,000) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Landfill Cost | | 1,692,499 | 1,709,424 | 1,726,518 | 1,743,784 | 1,761,221 | 1,778,834 | 1,796,622 | 1,814,588 | 1,832,734 |
| Electricity Cost | | 1,741,824 | 1,776,660 | 1,812,194 | 1,848,438 | 1,885,406 | 1,923,114 | 1,961,577 | 2,000,808 | 2,040,824 |
| Natural Gas | | 1,052,297 | 1,073,343 | 1,094,810 | 1,116,706 | 1,139,040 | 1,161,821 | 1,185,058 | 1,208,759 | 1,232,934 |
| Others | | 2,666,373 | 2,725,276 | 2,785,847 | 2,848,139 | 2,912,206 | 2,978,105 | 3,045,895 | 3,115,637 | 3,187,392 |
| Operation Cost Total | | 7,152,993 | 7,284,704 | 7,419,369 | 7,557,066 | 7,697,874 | 7,841,875 | 7,989,152 | 8,139,792 | 8,293,885 |
| Revenue (Disposal fee) | | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 | 12,177,778 |
| Depreciation | | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 | 3,422,222 |
| Tax | | 288,461 | 264,753 | 240,513 | 215,728 | 190,383 | 164,463 | 137,953 | 110,837 | 83,101 |
| Balance | (30,800,000) | 4,736,323 | 4,628,320 | 4,517,895 | 4,404,983 | 4,289,521 | 4,171,441 | 4,050,673 | 3,927,148 | 3,800,792 |

# Annex 4

## MONITORING INFORMATION

Monitoring will be conducted in accordance with the monitoring plan. Figure-9 shows the position of where each monitoring items shall be monitored.

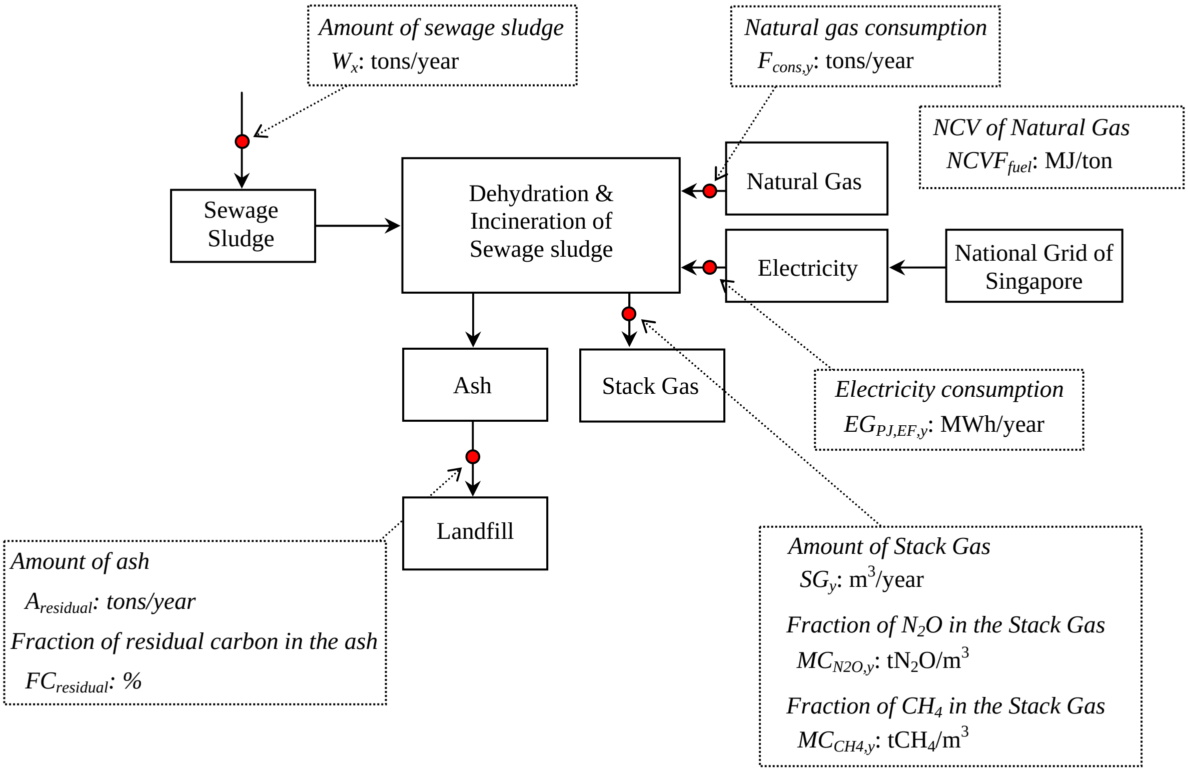


Figure-9 Position of where the monitoring items shall be monitored

Figure-10 shows the detail position of the monitoring points.

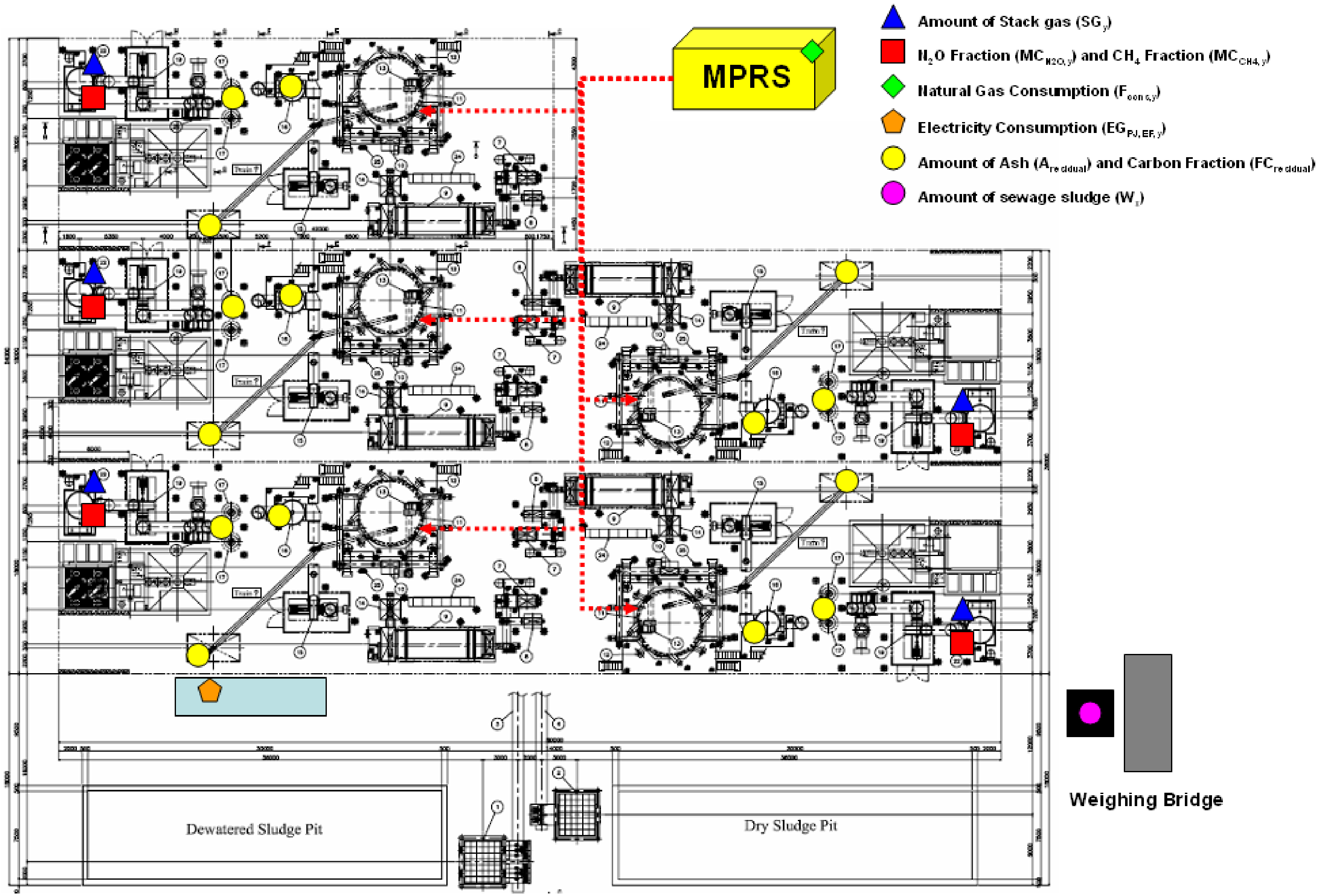


Figure-10 Monitoring points