

2008 CDM/JI Feasibility Study Report (Digest Version)

Investigation Name

Feasibility Study of Sewage Sludge Incineration CDM project in Singapore

Organization Name

The Japan Research Institute, Limited.

1. Project Outline

(1) Host Country, Region

The Tuas industrial area at the western end of the main island of Singapore

(2) Project Outline

All of the sewage sludge that comes from sewage treatment plants in Singapore is transported to the Changi sewage sludge and solid waste disposal site at the eastern end of the main island of Singapore and is dumped as landfill. The dumped sewage sludge at the Changi sewage sludge and solid waste disposal site undergoes anaerobic degradation, produces methane gas, and it is emitted into the atmosphere without being processed through methods such as flaring.

In this project, all of the sewage sludge that is currently being dumped in the Changi sewage sludge and solid waste disposal site is to be incinerated by ECO, which is a waste disposal company of Singapore, in the Tuas industrial area located at the western end of the main island of Singapore. By doing so, the dumped volume is reduced to only incineration ash while the amount of methane emitted into the atmosphere becomes zero.

The technology that is used in this project is sewage sludge drying & incinerating technology. The incinerator that ECO (ECO Industrial Environmental Engineering Pte. Ltd.) will incorporate is a high-performance incinerator VORTEX, which has made many creditable achievements in Japan. The VORTEX incinerator applies technology where air that is needed for combustion is blown out like fire-feeding bamboo pipes from the lower part of the agitating rotating arm inside the furnace to agitate the objects to be burned and completely incinerated. In addition, the heat that is generated from the incineration process is used in the drying process.

The project is to commence in April 2009 and structures such as the incineration facility are under construction.

2. Investigation Contents

(1) Issues for Investigation

The issues to be investigated for the project have been presented to the investigation committee and are as follows.

- The CDM approval process in the host country
- The present situation of waste disposal/sewage disposal methods in the host country
- How to establish the baseline
- Confirmation of additionality
- Confirmation of the methodology that can be applied (confirmation of conditions for application)
- Examination of monitoring methods (confirmation of capabilities, etc. of counterparts)
- Estimates of greenhouse gas reductions
- Environmental impact assessments
- Assessments by concerned parties on this project
- Analyses of economic potential
- Clarifying problems in realizing the projects

(2) Investigation Implementation Structure

<Kajima Corporation>

To provide support that is needed for this investigation such as data gathering and hearing surveys, and to create a PDD, in addition to field surveys along with observations and chemical analyses at the project implementation site.

<ECO>

The implementer of the project. To be in charge of operating and monitoring the plant in addition to investing in the project.

(3) Investigation Contents

The contents of the investigation and the overview of the findings are as shown below.

<Field Surveys>

On-site information and data needed for the CDM has been gathered in collaboration with Kajima Corporation, which is a Japanese cooperative organization. Refer to the trip report that has been attached separately for details on the field surveys.

<Investigations on the Baseline Scenario>

Examinations and plans for the baseline methodology of the project have been made. It has been confirmed that the approved methodology AM0025 can be applied in this business.

<Investigations on Monitoring Methods & Plans>

The appropriate monitoring method in the project has been clarified and the monitoring program has been planned. Implementations based on the approved methodology AM0025 can be made in this business.

<Investigations on the Project Implementation Duration and Credit Acquisition Duration>

The project implementation duration and credit acquisition duration have been examined and established. It has been concluded that it is appropriate for the duration of the sewage sludge incineration business implemented by ECO to be established in this project.

<Investigations on Greenhouse Gas Emission Calculations>

The greenhouse gas emissions in project implementation cases within project boundaries have been quantified based on observations made through field surveys, default values and performance values maintained by the host country or acknowledged internationally, etc. Examinations on leakages have also been made.

<Investigations on Environmental Impact>

The points below where impact on the environment can be avoided or lowered through this business have been confirmed.

- Avoiding/decreasing odors and air pollution from methane gas
- Avoiding/decreasing the declining quality of water around solid waste disposal sites

It has also been confirmed that there is no need for environmental impact assessments in the host country in this project.

<Investigations on Other Indirect Effects>

Indirect effects in the social, cultural, economical, etc. aspects have been examined with the characteristics of this business taken into account. As a result, factors such as pervasive effects on neighboring countries (Southeast Asian countries) have been considered.

<Investigations on Comments from Concerned Parties>

A hearing investigation has been conducted on concerned agencies (NEA (National Environment Agency), PUB (Public Utility Board Singapore)), a company (ECO), and so on. Meetings between concerned parties have also been conducted as a part of the process of realizing the CDM. The results of the meetings show that this project has been evaluated highly.

<Investigations on Financial Planning>

The expenses, income, etc. needed for implementing this business have been estimated through discussions with companies. To be specific, the IRR (Internal Rate of Return) has been calculated, analyses on factors such as sensibility have been made, and the profitability of the project has been assessed. The results of the discussions show that the profitability of this project is low without income from credits.

<Creation of the PDD>

The PDD has been created.

<Investigations on How to Realize Co-benefits of Countermeasures against Global Warming and Pollution Control, and Indicating Them>

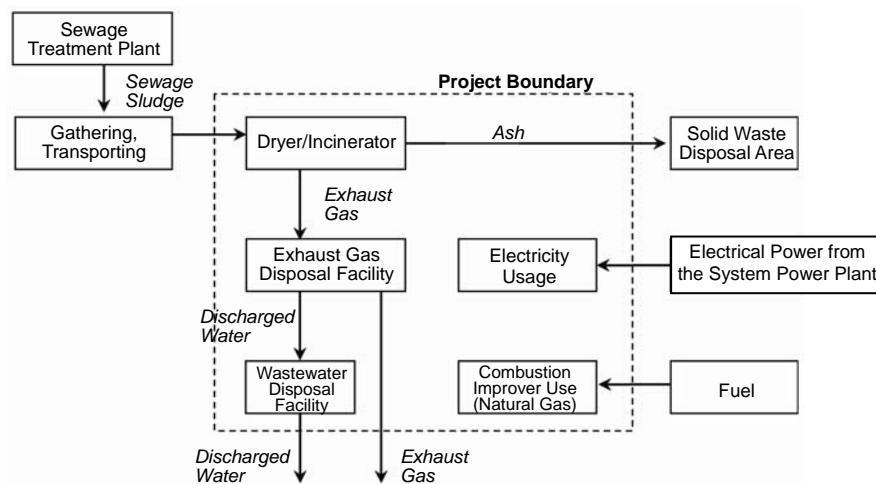
Examinations on the amount of solid waste that is not dumped at disposal sites due to sewage sludge incinerations, indications of the amount of incineration ash, etc. have been made and integrated assessment figures that include qualitative assessments have been developed.

3. Industrialization of the Project

(1) Establishing Project Boundaries and Baselines

<Project Boundaries>

The boundaries of the project are sewage sludge drying/incineration facilities and exhaust gas/wastewater disposal facilities that are needed afterwards.



<Applied Methodology>

The methodology to be applied in the project is the approved methodology AM0025 “Avoided emissions from organic waste through alternative waste treatment processes (version 11)”.

This methodology is applied under the assumption that methane, which is a greenhouse gas, is being generated through the anaerobic degradation of organic waste in landfills, and is designed to avoid the generation of methane through project activities that apply intermediate processing methods specified in the methodology. In addition, conditions for application such as how waste products are being handled and whether or not there is the obligation to apply intermediate processing methods are also specified. The “incinerating of waste products and the use of the

heat, electrical power, etc. that is generated” that is specified in the methodology is conformed to and all of the conditions for application have been met with this project.

<Establishing of Baselines>

Five alternatives for the disposing and treating of waste products have been conceived if there are no project activities in this project: “M1: The sewage sludge incineration business if there is no income through CDM businesses”, “M2: The composting of sewage sludge”, “M3: The melting of sewage sludge”, “M4: Dumping of sewage sludge in solid waste disposal sites that accompanies recovering gas from disposal sites”, and “M5: Dumping of sewage sludge in solid waste disposal sites that does not accompany recovering gas from disposal sites”. The baseline of the project will be set as “M5: Dumping of sewage sludge in solid waste disposal sites that does not accompany recovering gas from disposal sites” because investment analyses show that there is no profitability with M1, there is not much profitability with M2 because there is no demand for compost, there is not much profitability with M3 because it costs more than M1, and there is no profitability with M4 at all because it produces no income.

<Leakage>

There are two causes for leakage emissions in the project; (A) leakage emissions due to increased transporting, and (B) leakage emissions arising from relict carbon in the incineration ash. After measuring the total travel distance of trucks that use each transportation pathway for (A); it is known that there will be zero leakage because emissions will decrease. Calculations for (B) under the assumption that the relict carbon volume in the incineration ash is 1% have also been made.

(2) Monitoring Program

The amount of sewage sludge brought to the drying & incinerating plant that is involved in the baseline emission calculations have been measured in scales of trucks with the AM0025 monitoring methodology. The electrical power, amount of fuel consumption, amount of exhaust gas, and the concentration ratios of methane and nitrous oxide in the exhaust gas that are produced through project activities and involved in the calculations of the emission volume of the project have been directly measured along with factors such as the carbon content of the incineration ash that is involved in the calculations of the leakage emissions. The monitoring items are as shown in the table below.

Parameters	Definitions	Data Source/ Measuring Method	Frequency
$EG_{PJ,EF,y}$	Amount of electricity used (MWh/year)	Measurements and Billing Statement	Continuously
$F_{cons,y}$	Amount of natural gas used as combustion improvers (t/year)	Same	Same
SG_y	exhaust gas volume (m^3 /year)	Measurements	Same
$MC_{N_2O,y}$	Nitrous oxide concentration in exhaust gas ($t-N_2O/m^3$)	Same	4 times/year
$MC_{CH_4,y}$	Methane concentration in exhaust gas ($t-CH_4/m^3$)	Same	Same
W_x	Amount of sewage sludge treated in drying & incinerating plants (t/year)	Same	Continuously
$A_{residual}$	incineration ash (t/year)	Same	Same
$FC_{residual}$	Amount of carbon in incineration ash (%)	Same	4 times/year

(3) Amount of Greenhouse Gas Reductions

The amount of greenhouse gas emissions reduced through the implementation of the project is as shown in the table below. It has been calculated to be implemented for nine months in 2009, which is the initial year of the project, and for three months in 2019, which is the final year, so the duration of the project will be a total of ten years.

Year	Baseline Emissions [t-CO ₂ /year]	Project Emissions [t-CO ₂ /year]	Leakage Emissions [t-CO ₂ /year]	Emission Reduction Volume [t-CO ₂ /year]
2009 (April to December)	34,933	5,765	646	28,521
2010	69,993	7,687	862	61,444
2011	93,495	7,687	862	84,946
2012	109,249	7,687	862	100,700
2013	119,809	7,687	862	111,260
2014	126,888	7,687	862	118,339
2015	131,632	7,687	862	123,083
2016	134,813	7,687	862	126,264
2017	136,945	7,687	862	128,396
2018	138,374	7,687	862	129,825
2019 (January to March)	34,833	1,922	216	32,695
Total	1,130,964	76,900	8,620	1,045,473

(4) Project Duration & Credit Acquisition Duration

Both the duration of the project and that of the credit acquisitions are from April 2009 to March 2019. This is the term during which ECO has been commissioned for the sewage sludge treatment business.

(5) Environmental Impact and Other Indirect Effects

Another way that this project will help improve the environment besides reducing greenhouse gas emissions is by greatly reducing landfill disposals because sewage sludge will be incinerated. Furthermore, the implementing of this project is not expected to cause any major impacts on the environment or surrounding areas because the site where it will be implemented is in an industrial area and there are facilities such as power generation facilities and incineration facilities nearby.

The incinerators used in the project will have extremely low effects on the environment because they incorporate Japanese technology and emissions of SO_x, NO_x, etc. are much lower than those of the standard values. Exhaust gas, wastewater, etc. are processed appropriately with devices such as scrubbers and treatment equipment, and the incineration ash is treated at the Semakau solid waste disposal site.

It is specified in Section 36 of Singapore's Environmental Pollution Control Act (EPCA) that pollution control studies (PCS) must be conducted when doing business that might affect the environment. However, the NEA's Pollution Control Department (PCD) has granted the project exemption from PCSs because the sewage sludge that is generated through the project is not a hazardous substance and because its environmental burdens are extremely low due to the advanced technology stated above.

Therefore, the environmental impact of this project is extremely low.

(6) Comments from Concerned Parties

We have heard the ideas and comments about the implementation of this project from concerned parties (organizations). In addition, a meeting between concerned parties (nearby factories, NGOs, related government agencies, universities, media, etc.) has been held and the comments and questions asked from those who participated are listed in this chapter.

<NEA (National Environment Agency)>

- Confirmations regarding laws and regulations on subjects such as the processing of sewage sludge and landfill management show that there is no effect on the baseline and conformity.
- Singapore's DNA would like to provide this project with as much support within the boundaries of the DNA's role as possible for they would also like to make more achievements. They would also like to get reports on the project's development.
- Governmental approval can be granted in about one month at the earliest if there are no problems with the submitted PDD and PIN, and if the conditions for application have been met.

<PUB>

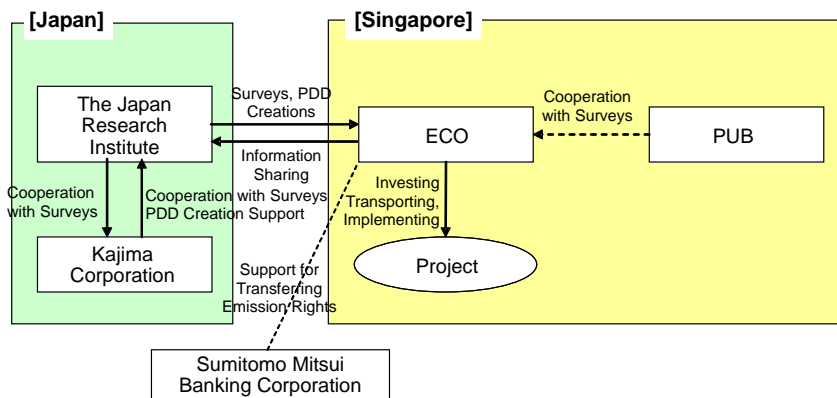
- They will provide necessary support in conducting field surveys and gathering information for the creating of the PDD.
- They are fully aware of the possibilities of information disclosures, interviews, etc. during the stages of the screening for validation and UN registration.

<Meetings between Concerned Parties>

- There were no uncertain items after the meeting and it has been confirmed that the participants give this project their support.
 - Their intention of expanding on similar projects from Singapore to other Southeast Asian countries in addition to broadly appealing the significance of the project within Singapore is magnificent. They should be promoted actively. (NGO)
 - There is substantial funding from the Japanese government. It is a very smooth scheme if business is done with transfers of technology from Japan and emission rights are transferred to Japan. (Academic)

(7) Implementation Structure of the Project

The implementation structure of the project is composed of five companies/organizations: ECO and PUB from Singapore, and Kajima Corporation, the Japan Research Institute, and Sumitomo Mitsui Banking Corporation from Japan. ECO is the project implementer and will make investments on its own. Kajima Corporation and the Japan Research Institute will provide support up to UN registration, and Sumitomo Mitsui Banking Corporation will be in charge of operations concerning the transferring of emission rights. PUB will provide lateral support as it is the organization that will place orders for the sewage sludge treatment business.



(8) Financial Planning

Initial investments (for equipment and construction costs, etc.) will be procured through ECO's own funds. Refer to the table below on (9) analyses of economic potential for details.

(9) Analyses of Economic Potential

The IRR will be 4.36% if there is no income from credits. It can be said to be a project of low profitability because it is of a low standard that falls below Singapore's prime rate of 5.33% (2007). Besides credit from income, there is also income from waste disposals, but the agreement with ECO and PUB stipulates that the prices are fixed for ten years. Therefore, the profitability of this project cannot be raised even if there is an increase in the income. Furthermore, huge cost reductions also cannot be expected because there has been a trend in the rising of major expenses such as electricity and natural gas rates in recent years. From the above, it can be said that CDM realization and the attaining of income from credits are necessary for this project to be established as one that makes sustainable profits.

The IRR will be 11.73% (with the credit price at 10 [€/t-CO₂]) if there is income from profits. IRR sensibility analyses of the selling price of credits have been made because the income from credit sales is large and has an effect on profitability. The analyses show that there is the need to sell credit at prices of 8 [€/t-CO₂] or more in order to maintain profit rates of over 10%.

Cash flow "without income from credits" (Units: S\$)

項目	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	
Cost		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	
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	
Expenses Total		10,692,137	10,826,187	10,963,237	11,103,367	11,246,657	11,393,188	11,543,047	11,696,321	11,853,100	
Income Waste Disposal Income		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	
Income Credit Sale Income		0	0	0	0	0	0	0	0	0	
Income Total		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	
Current Income and Expenses		1,485,640	1,351,591	1,214,541	1,074,411	931,121	784,590	634,731	481,457	324,678	
Corporate Tax		267,415	243,286	218,817	193,394	167,802	141,226	114,252	86,662	58,442	
Current Income		1,218,225	1,108,305	995,923	881,017	763,519	643,364	520,479	394,795	266,236	
Initial Investment	(30,800,000)										
Credit Volume (t-CO ₂)		12,872	30,230	43,345	52,136	58,029	61,979	64,627	66,402	67,591	
IRR=	4.36%	(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

Cash flow "with income from credits" (Units: S\$)

項目	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	
Cost		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	
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	
Expenses Total		10,696,137	10,830,187	10,967,237	11,107,367	11,250,657	11,397,188	11,547,047	11,700,321	11,857,100	
Income Waste Disposal Income		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	
Income Credit Sale Income		567,568	1,222,736	1,690,425	2,003,930	2,214,074	2,354,946	2,449,352	2,512,654	2,555,080	
Income Total		12,745,346	13,400,513	13,868,203	14,181,708	14,391,852	14,532,724	14,627,129	14,690,431	14,732,858	
Current Income and Expenses		2,049,208	2,570,327	2,900,966	3,074,341	3,141,195	3,135,536	3,080,083	2,990,111	2,875,758	
Corporate Tax		368,858	462,659	522,174	553,381	565,415	564,396	554,415	538,220	517,637	
Current Income		1,680,351	2,107,668	2,378,792	2,520,959	2,575,780	2,571,139	2,525,668	2,451,891	2,358,122	
Initial Investment	(30,800,000)										
Credit Volume (t-CO ₂)		28,521	61,444	84,946	100,700	111,260	118,339	123,083	126,264	128,396	
IRR=	11.73%	(30,800,000)	5,102,573	5,529,890	5,801,014	5,943,182	5,998,002	5,993,362	5,947,890	5,874,113	5,780,344

(10) Additionality Demonstration

The "tool for the demonstration and assessment of additionality - version 05.2" by the executive CDM board is used to demonstrate the additionality of the project.

<STEP 1: The Identifying of Alternate Means for the Project>

Scenarios M1 to M5 can be assumed as alternatives.

- M1: The sewerage sludge incineration business if there is no income through CDM businesses
- M2: The composting of sewage sludge
- M3: The melting of sewage sludge
- M4: Dumping of sewage sludge in solid waste disposal sites that accompanies recovering gas from disposal sites

- M5: Dumping of sewage sludge in solid waste disposal sites that does not accompany recovering gas from disposal sites

All of the scenarios comply with Singapore's regulations.

<STEP 2: Investment Analyses, or STEP 3: Hazards Analyses>

Whether or not it is possible to avoid implementing the proposed project as a CDM business (not taking into account the profits from sales of credits) will be verified. "Option III: benchmark analyses (when income other than CDM income can also be anticipated)" will be adopted from the verification method shown in the additionality manual because there are no alternative projects that can be used for comparison with this project in Singapore.

The IRR will be adopted for examinations as the most appropriate financial indicator for this project. The assessment figures (benchmark) show Singapore's prime rate (2007) as 5.33% and the prerequisites that are needed for IRR calculations are as shown in the table below.

Item	Conditions	Item	Conditions
Project Duration	10 years	Operation Term	9 years
Number of Operating Days Per Year	320 days	Inflation Rate	2.0%
Waste Disposal Volume	639 [t/d]	Corporate Tax	18% (standard tax rate of the host country)
Waste Disposal Costs	Undried Sludge: 60 S\$ Dried Sludge: 58 S\$	Depreciation	Same for 9 years

IRR calculations based on these conditions for when the project is not implemented as a CDM business show 4.36%, which is lower than the assessment figure, and that there is low profitability for it to be run as a business.

There have also been evaluations on the degree of effects that there will be on operational profitability if there are fluctuations in the prerequisites of the evaluations above. There are specifications in the guidelines for the additionality demonstration tool to conduct sensibility analyses on total investment or total income parameters that are 20% or above. In this case, initial investments are 20% or more of total investments and disposal costs, which are the only forms of revenue, are 20% or more of the total income. However, the initial investments have already been determined because construction has already begun with this case and disposal costs have already been settled in the agreements between the companies and the promoters so the only parameters that can fluctuate are those within the operating costs. Furthermore, there are no operating costs that account for 20% or more of the total investments. With that, the degree of IRR effects that incineration ash disposal costs, electrical power rates, and natural gas rates have were confirmed as operating costs that account for 10% or more of the total investments.

IRR sensibility analyses in cases where incineration ash disposal costs, electrical power rates, and natural gas rates each fluctuate from -10% to +10% showed that they were all below the assessment figures (5.33%). Therefore, it has been confirmed that this project is not appealing financially as an investment.

Fluctuation Range of Operating Costs	-10%	-7.5%	-5.0%	-2.5%	0%	+2.5%	+5.0%	+7.5%	+10%
Incineration Ash Disposal Costs	5.14	4.95	4.75	4.56	4.36	4.16	3.96	3.76	3.56
Electrical Power Rates	5.19	4.99	4.78	4.57	4.36	4.15	3.94	3.72	3.51
Natural Gas Rates	4.92	4.78	4.64	4.50	4.36	4.22	4.08	3.93	3.79

Units: %

<STEP 4: Analyses of General Practices>

This project is the first sewage sludge incineration business ever to be conducted in Singapore. Furthermore, there is a fluid bed and drum-type drying furnace in operation as a part of advanced sewage treatment in Putrajaya, which is a federal territory in the nearby country of Malaysia that is under development as a new administrative capital, but their plants cannot be compared with those of this project because they are fully funded by the government and their profitability cannot be taken into account. In addition it is customary to turn the sewage sludge into fertilizer and compost and have it disposed of in the final stage after drying it in the sun, and there is no incineration. For the reasons above, this project is "the first of its kind" and there is no need to implement STEP 4.

(11) Prospects/Issues for Industrialization

Construction has already begun for this project and operation of the sewage disposal and sludge incineration business is to begin in April 2009. The validation of the CDM industrialization has been initiated and the procedures to get approval from Singapore's government have begun. Therefore, efforts in CDM industrialization are proceeding smoothly.

There are various business risks in this project. The risks in order of importance at the moment are assumed to be CDM project realization risks, credit price risks, and technical risks.

The utmost efforts are being made to avoid these risks so that this business can be implemented. Details on the risks and their countermeasures are as shown below.

4. (Pre) Validation (only when implemented)

Not to be implemented within the range of this survey.

5. Realization of Co-benefits in the Host Country

(1) Assessments on Pollution Control in the Host Country

According to NEA staff members, remarks from ECO, meetings between concerned parties, etc; Singapore faces the following issues.

- It is difficult to procure new disposal sites
- They want to solve the problem of the declining quality of water and odors near solid waste disposal sites
- They want to contribute to the prevention of global warming through technology

The following forms of environmental improvement and pollution control can be anticipated and the issues above can be solved through this project.

- The amount of waste products can be greatly reduced through incineration and pressing issues faced at disposal sites can be improved
- Only inactive incineration ash is dumped through incineration and the declining quality of water and odors near solid waste disposal site can be controlled

- Capacity building in global warming prevention technology in the host country can be done when Japan's incineration technology, which is not widespread in Southeast Asian countries, is transferred

(2) Proposition of Co-benefit Indicators (when there are survey results that can be proposed)

This CDM project will improve the reducing the volume of landfill disposal. This project is been planning that reduce the volume of landfill disposal from 639[t/d] in the current situation to 73[t/d]. CDM projects can be assessed from viewpoints other than those on greenhouse gasses reductions while referring to items like the ones above and setting axes such as the ones in the table below.

Evaluation Items	Points	Perspectives of Evaluations	Cases		
			Incineration	Compost	Landfill Disposal
Reduction	40	Degree of the volume reduction rate from the current situation	40	30	0
Water Pollution Prevention	5	Improvement rate from the current situation	5	3	0
Odor Control	5	Improvement rate from the current situation	5	3	0
Pollutant Indicator (out of 50 points)			50	36	0
Technology Transfers	20	Whether or not it is the first of its kind	20	10	0
Understanding of Residents	10	Whether or not it creates jobs	5	8	10
Government Policies of the Host Country	20	Affinity with government policies	20	5	0
Social Indicator (out of 50 points)			40	23	10
Co-benefit Indicator Scoring (out of 100 points)			90	59	10