Manual for Quantitative Evaluation of the Co-Benefits Approach to Climate Change Projects

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CONTENTS

Chapter 1. The Co-Benefits Approach to Climate Change Countermeasures and the CDM: General Remarks

1. 1 What Is the Co-Benefits Approach to Climate Change Countermeasures?

The co-benefits approach to climate change countermeasures and the Clean Development Mechanism (hereinafter referred to as "the co-benefits approach") involves initiatives that make it possible to fulfill the needs of a developing country at the same time as implementing climate change countermeasures and CDM projects.[1] Socioeconomic development and environmental problems are key issues—at both national and local levels—for many developing countries. Thus, by implementing projects in the form of climate change countermeasures designed to address these issues, it is possible to promote sustainable development in those countries at the same time as promoting proactive and highly effective initiatives to address climate change. For example, environmental pollution problems (air pollution, water pollution, waste, etc.) are becoming serious in developing countries, and some are making it a national priority to address them. Some options include improving the energy efficiency of thermal power plants (by switching to combined-cycle power generation), fuel switching (from coal to natural gas), the proper treatment of previously untreated domestic wastewater (by installing sewage treatment facilities), and so on. It is important to note that these actions are also effective ways to deal with climate change, because they reduce emissions of greenhouse gases (GHGs) like carbon dioxide (CO_2) and methane (CH_4).

Furthermore, as part of a nation's development, actions to improve the basic infrastructure of public transportation (e.g., long-distance rail connecting major cities) also stimulate the economy by spurring the growth of service industries and facilitating the mobility of people and goods. These lead to a development effect that improves the incomes and living standards of citizens. At the same time, these approaches also offer the benefits of suppressing GHG emissions from the transport sector to levels that will be lower than in a society centered on automobile- and road-based transportation.[2]

Thus, project activities that offer multiple benefits of satisfying the development needs of developing countries, at the same time as addressing climate change, give those countries the incentive to take greater initiative and more proactively tackle climate change. At the same time, for developed countries that provide support to developing countries, these are also worthwhile approaches that have the potential to broaden and promote the effectiveness of the assistance they provide for sustainable development. The discussion has only just begun internationally and in Japan, however, regarding exactly what types of projects should be considered to be employing the , and how their benefits should be evaluated.

The website of the "Co-Benefits of Climate Change Mitigation: Coordinator in Asia," under the U.S. Environmental Protection Agency, defines the "co-benefits approach" as follows:

"Co-benefits" refers to multiple benefits in different fields resulting from one policy, strategy, or action plan. Co-beneficial approaches to climate change mitigation are those that also promote positive outcomes in other areas such as concerns relating to the environment (e.g., air quality management, health, agriculture, forestry, and biodiversity), energy (e.g., renewable energy, alternative fuels, and energy efficiency) and economics (e.g., long-term economic sustainability, industrial competitiveness, income distribution).

The above wording focuses on climate change mitigation measures, but one can see that an extremely broad range of project categories is envisioned.

[1] Definition by Japan's Ministry of the Environment on the Kyoto Mechanisms Information Platform website.

[2] In terms of climate change countermeasures in the transport sector, developing countries would find it much more effective to avoid the automobile-centered design based on cars as evident in Los Angeles in the United States, for example, and to favor public transportation emphasizing subways and buses, as evident in cities like Tokyo and London.

Furthermore, in a document entitled "Direction of JICA Operation Addressing Climate Change," the Japan International Cooperation Agency (JICA) states that among its specific responses and orientation relating to JICA initiatives for climate change mitigation, it will work to "create cooperative frameworks together that will actively support the efforts of developing countries in ways that balance both emission reductions and economic growth, and can contribute to climate stabilization, and that it will expand cooperation of the 'co-benefits approach' in order to help simultaneously achieve development benefits and GHG emission reductions." The document lists some of the following examples.[3]

- Cooperation for the forest sector: Promotion of forest conservation, sustainable forest management, and afforestation/reforestation
- Cooperation for the energy sector: Promotion of clean energy
- Cooperation for the transportation sector: Urban planning and promotion of public transport
- Cooperation for the waste management sector: Promotion of integrated urban waste management

Jane Ellis of the Organization for Economic Cooperation and Development (OECD), at a side event hosted by the Japan Ministry of the Environment at an international climate meeting (COP 13), provided a perspective to understand the concept of co-benefits, and introduced information indicating how very broad the impacts of co-benefits are. She showed the great variety in the nature (direct and indirect), level (national, regional, local, etc.), and beneficiaries of co-benefits (governments, communities, project developers, etc.).

1. Are co-benefits direct or indirect?
2. At what levels do the co-benefits arise: national, regional, local, corporate?
3. To whom do the co-benefits accrue (government, community, project developer)?

Developing countries range in size from China—considered a superpower—to countries like Tuvalu—a small-island state in the South Pacific with a population of about 10,000 people. Obviously, although "sustainable development" for developing countries purportedly has the ultimate objective of improving human well-being, the objectives and means of development will differ for each country. Thus, the definitions, objectives, and measures taken to achieve sustainable development in developing countries will also differ with each country. If we understand this point, we can see that it is difficult determine how a certain developing country will define a certain outcome as a "benefit," and that it is difficult to use one sole definition for all developing countries.

1. 2 Overview of International Debate and Activities under the UNFCCC Relating to the Co-Benefits Approach

The purpose of the CDM, as defined by Article 12 of the Kyoto Protocol under the United Nations Framework Convention on Climate Change (UNFCCC), is to assist developed countries in achieving their emission reduction targets, and to assist developing countries in achieving sustainable development. In other words, the CDM's aim is to achieve the multiple benefits of reducing GHG emissions and satisfying the appropriate development needs of developing countries. Seen this way, it could be described as a mechanism that advocates the co-benefits approach. Examining the current status of United Nations-registered CDM projects, however, we see that more than half of all certified emission reduction units (CERs) are for projects with few benefits other than their very large effects as GHG emission reduction activities, such as the destruction of substances such as the hydrofluorocarbon HFC23 and nitrogen dioxide (N_2O). Thus, both developing and developed countries have again begun to point out the importance of the co-benefits approach under the CDM.

The Worldwide Fund for Nature (WWF) has devised the Gold Standard program, which differs from the CERs approach, for evaluating project activities that will result in benefits

[3] http://www.jica.go.jp/environment/pdf/info080501_en.pdf

such as environmental conservation.[4] This system evaluates contributions to CDM projects using three criteria: local environmental improvements (prevention of air pollution, water pollution, etc.; conservation of biodiversity), sustainable social development (securing employment, preventing poverty, access to energy, human capacity building), and economic/technical development. If a CDM project will ultimately meet certain standards, then the Gold Standard certification committee certifies it as a Gold Standard CDM project. Similarly, the International Institute for Sustainable Development (IISD) has proposed an evaluation methodology under its Development Dividend Project.[5] This methodology assigns a score using three criteria of economy, society, and the environment, with higher marks for private-sector project activities relating to things like energy conservation and solar power, and the lowest marks to the likes of HFC23 and N_2O emission reduction projects.

Regarding the lower ratings for CDM project achievements aiming to reduce HFC23 and N_2O emissions, however, some developing countries have expressed the view that not all large projects should be criticized, because, for example, revenues from the sale of CERs can contribute to sustainable development if they are invested into activities with high sustainable development benefits, and these activities can also attract investors to the CDM market.[6] At any rate, these evaluation methodologies are not exactly being widely accepted internationally at present.

The background for this debate is that although much progress has been made in methodologies for calculating and evaluating GHG emission reductions under the dual-purpose CDM, there has been very little consideration, even by the CDM Executive Board, regarding ways to evaluate assistance for the achievement of sustainable development. Nevertheless, recent discussions about reforming the CDM system include debate about giving incentives for CDM projects that will help support sustainable development in projects' host countries, a sign that the importance of the co-benefits approach is being recognized. In the formulation of national action plans for developing countries, the co-benefits approach is also being seen as an important concept in development plans that also include voluntary climate change activities. It bears mentioning, though, that some current discussions assert that actions based on national action plans should be "measurable, reportable, and verifiable" (MRV), so one could say that ideally, the outcomes of the co-benefits approach should also be so. Therefore, for the co-benefits approach to be applied to climate change countermeasures as well, it is becoming important to establish methods for quantitative evaluation of project outcomes—methods that can be easily applied in developing countries.

The next sections in this manual bring together the necessary criteria for quantitative evaluation of the co-benefits approach, and propose a draft framework of evaluation methodologies for this approach.

1. 3 The Co-Benefits Approach to Climate Change: Criteria for Evaluation Methodologies

Evaluation of the co-benefits approach must be based on the conditions that differ in each developing country and must also be easily and efficiently applicable. Consideration of the achievements of past initiatives would suggest employing the following criteria in any evaluation methodology:

(a) Able to reflect each country's own initiative, considering the diversity among developing countries and differences in their approaches toward sustainable development

(b) Transparent, fair, and reproducible

(c) Easy and quick to implement

[4] http://www.cdmgoldstandard.org/

[5] http://www.iisd.org/climate/markets/dividend.asp

[6] http://www.iges.or.jp/en/news/press/07_09_19.html

With such criteria in mind, we can classify the evaluation methodologies of the co-benefits approach as shown below. Project proponents should select the appropriate evaluation methodology from the options presented, considering the conditions in the country concerned, in order to quantitatively evaluate the project benefits.

Table 1-1 Levels of Evaluation Methodologies for the Co-Benefits Approach to Climate Change Countermeasures

Level	Description of Evaluation Methodology	Explanation
Tier 1	No calculation is made. The evaluation is done based on evaluation criteria corresponding to the actual details of the activity.	In cases where it is difficult to formulate the necessary equations to quantitatively calculate the benefits, data is difficult to obtain, and quantitative evaluation is difficult, one option is to evaluate the project based on predetermined criteria for *qualitative* evaluation.[7] This approach is the easiest to implement.
Tier 2	A quantitative evaluation is conducted to the extent possible, using a predetermined equation and the available measurement data.	This is a method to implement a *quantitative* evaluation of benefits. To the extent possible, it uses actual measurement data needed for a quantitative calculation of benefits. Where no measurement data is available, default values are used. Because this method requires the measurement of data, it is more difficult than Tier 1.
Tier 3	A quantitative evaluation is conducted using measurement data for activities and parameters, and using specific equations.	This is a method to implement a *quantitative* evaluation of benefits. It generally uses actual measurement data and specific equations. Because this method requires data measurement and the formulation of equations, it is the most difficult of the evaluation methodologies.

As for evaluation indicators to be used in evaluations, meanwhile, it is necessary to decide the level based on the situation in the project's host country and on the nature of the indicator in question. Table 1-2 shows the different levels for evaluation indicators based on the level of difficulty of the quantitative evaluation.

Table 1-2 Levels of Evaluation Indicators (Proposed)

Level	Features	Examples of Indicators
Level 1	Difficult to evaluate quantitatively and can only be expressed qualitatively	Economic stimulation, poverty reduction, etc.
Level 2	Data acquisition from measuring devices and quantitative evaluation by using equations can be conducted easily	Chemical oxygen demand (COD), sulphur oxides, fossil fuel consumption, waste management volume, offensive odors, power outage rates, etc.
Level 3	Data acquisition from measuring devices and quantitative evaluation using equations are more difficult than in Level 2	Reduction in waste disposal, economic value of environmental improvements, etc.

Table 1-3 provides a comparative summary based on completed CDM project activities, selected for being representative of the co-benefits approach. Information is also provided about areas of activity and evaluation methodologies. This table shows clearly that the recommended evaluation methodologies will differ depending on the co-benefits. The table also suggests that if we know the specific details of a climate change countermeasure, we can be specific about the co-benefits expected directly from that activity, and that by systematically summarizing this type of information, it is possible to clarify the types and areas of co-benefits of climate change countermeasures.

In conclusion, if we use the bottom-up approach to summarize and systematically describe the co-benefits obtainable from each climate change countermeasure, we can create a framework for evaluation of measures that follow the co-benefits approach.

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[7] For example, the way subjective indexes have been established as earthquake magnitude scales.

Table 1-3 Examples of Key Areas[8] and Evaluation Methodologies of the Co-Benefits Approach to Climate Change

Activity Using Co-Benefit Approach to Climate Change	Details of GHG Reduction Effect	Details of Co-Benefits	Evaluation Indicator[9]	Recommended Evaluation Methodology[10]	Type of Co-benefit	Target Area
-Fuel switching at a thermal power plant -Fuel switching of on-site power generator at a factory	Reduced CO_2 emissions due to fuel switching (from heavy oil to natural gas with lower carbon content)	Reduced sulphur oxide (SOx) emissions due to fuel switching (from heavy oil to natural gas with lower sulphur content)	SOx Fossil fuel consumption	Tier 2 or Tier 3	Air pollution prevention	Environmental protection
-Improve combustion efficiency of a thermal power plant, factory, etc.	Reduced CO_2 emissions due to reduced fossil fuel consumption, due to improved combustion efficiency	Reduced SOx emissions due to reduced fossil fuel consumption, due to improved combustion efficiency				
-Install energy conserving equipment in a factory	Reduced CO_2 emissions due to reduced fossil fuel consumption, due to improved energy efficiency	Reduced SOx emissions due to reduced fossil fuel consumption, due to improved energy efficiency				
- Install heat recovery/use systems in a cement kiln and coking furnace, etc.[11]	Reduced CO_2 emissions by using waste heat for power generation or other use, replacing fossil fuel use for power or heat generation	Reduced SOx emissions by using waste heat[12] for power generation or other use, replacing fossil fuel use for power or heat generation				
-Use fly ash from cement kiln and slag from blast furnace to make cement	Reduced CO_2 emissions due to reduced fossil fuel use, due to reduction in cement use because of the use of fly ash and blast furnace slag	Reduced SOx emissions from reduced fossil fuel use due to reduction in cement use, due to the use of fly ash and blast furnace slag				
		Reduction of waste	Waste volume		Sound waste management	
-Anaerobic treatment of concentrated organic wastewater[13]	Prevented leakage of CH_4 otherwise generated from oxidation pond	Prevented large discharges of concentrated COD effluent during heavy rains	COD	Tier 1	Water pollution prevention Offensive odor prevention	
-Aerobic treatment of domestic wastewater	Prevented leakage of CH_4 otherwise generated from untreated domestic wastewater	Reduced emissions of water pollutants (COD) from untreated domestic wastewater	COD	Tier 2 or Tier 3	Water pollution prevention	
- Methane gas recovery and reuse from municipal solid waste landfill	Prevent the generation of CH_4 from landfilled waste	Reduction of waste	Waste volume	Tier 2 or Tier 3	Sound waste management	
		Prevented generation of offensive odors	Offensive odor	Tier 2	Offensive odor prevention	
-Use of waste as fuel (power generation equipment, boiler)	Reduced CO_2 emissions due to reduced fossil fuel consumption,	Reduction of waste	Waste volume	Tier 2 or Tier 3	Sound waste management	

[8] Besides these, other areas such as water resources (e.g., prevention of leakage from municipal water lines) and urban planning (e.g., introduction of energy-saving housing) could be considered for the co-benefits approach, but there are currently no UN-registered CDM projects in these areas..
[9] See Table 1-2.
[10] Depending on the circumstances in the project's host country or region, methods other than those recommended here may be feasible. Regarding evaluation methodology level, please see Table 1-1.
[11] Where electrical and heat generation from renewable energy replaces fossil fuel energy sources, there is likely also a reduction in SOx emissions.
[12] Where coke dry quenching (CDQ) equipment is installed in a coking furnace, the generation of air pollutants such as particulates may be suppressed compared to cases where water is used for open-air quenching.
[13] This is corresponds to wastewater from palm oil mills, sugar refineries, etc., and livestock waste.

Activity Using Co-Benefit Approach to Climate Change	Details of GHG Reduction Effect	Details of Co-Benefits	Evaluation Indicator[9]	Recommended Evaluation Methodology[10]	Type of Co-benefit	Target Area
	due to substitution using waste as fuel	Prevented generation of offensive odors	Offensive odor	Tier 2	Offensive odor control	
-Reduction of power loss by improving, upgrading, improving efficiency of electrical power transmission network	Reduced CO_2 emissions due to lower fossil fuel use for power generation, due to reduced power loss	Reduced air pollution emissions due to reduced use of fossil fuels	- SOx -Fossil fuel consumption	Tier 2 or Tier 3	Air pollution prevention	
		Stabilization of electrical power supply	Power outage rate	Tier 2	Lower power outage rate	Electricity
-Improvement of public transport systems and introduction of LRT and other public transport systems	Reduced GHG emissions from automobiles	Reduced air pollution emissions due to reduced use of fossil fuels	-NOx -Fossil fuel consumption	Tier 2 or Tier 3	Air pollution prevention	Environmental protection
		Greater activity of people, goods, and services, and economic stimulation	Economic indicators	Tier 1	Stimulation of local economy	Economy

1. 4 Proposed Framework for Evaluation Methodologies of the Co-Benefits Approach to Climate Change (Draft)

Table 1-4 shows the general concept of an evaluation sheet based on the framework for evaluation methodologies using the bottom-up approach, which meets the three criteria described in Section 1.3. This evaluation sheet can be applied for the evaluation of co-benefits of individual climate change countermeasures (CDM project activities, official development assistance [ODA] projects, Green Investment Scheme [GIS] projects, and so on). The classification of co-benefits into Main Category and Sub-Category employs classifications of sustainable development in developing countries, but in the future some discussion is necessary relating to the suitability of these categories. The content of the Specific Area of Co-Benefit column can be determined by listing the co-benefits of each climate change countermeasure and then organizing and integrating them. The content in the Evaluation Indicator column can be determined depending on the Specific Area of Co-Benefit column, but it is important to broadly list the indicators with some consideration of the conditions in the country concerned. The Selected Evaluation Indicator and Selected Evaluation Methodology columns can be filled in based on the indicator and evaluation methodology used for evaluation of the co-benefit. The Evaluation Result column is completed based on the Selected Evaluation Methodology to indicate the result of qualitative analysis, in the case of Tier 1, and quantitative evaluation in the case of Tier 2 or Tier 3.

Recognizing the different orientation for sustainable development and prioritization of issues in different developing countries, it is useful to evaluate activities in ways that reflect the socioeconomic conditions and national priorities in each country. Thus, in the future, it would be desirable to also consider integrated evaluation methodologies that allow the scoring of co-benefits (including qualitative evaluations) by creating a hybrid approach of weighting coefficients for each co-benefit, established separately in each host country for evaluation results. Another topic going forward will be consideration of the potential to develop methods to inter-compare co-benefits—for example, to unify evaluation indicators by converting them to economic evaluation indicators.

Table 1-4 Methods to Evaluate Projects Using the Co-Benefits Approach to Climate Change: Evaluation Sheet (Draft)

Co-Benefit Category		Specific Area of Co-Benefit	Evaluation Indicator	Selected Evaluation Indicator	Selected Evaluation Methodology			Evaluation Result
Main Category	Sub-Category				Tier 1	Tier 2	Tier 3	
Environmental protection	Environmental pollution prevention	Water pollution prevention	COD					
			Odors					
			Nitrogen					
			Phosphorus					
		Improvement of air quality	Sulphur oxides					
			Nitrogen oxides					
			Particulates					
		Waste management	Collection area coverage ratio					
			Waste collection rate					
			Recycling rate					
			Waste volume					
			COD					
			Odors					
	Natural resource protection	Forest resource protection, water resource protection, land resource protection, natural resource protection, etc.						
Economic infrastructure improvements	Securing electricity, energy	Stable electricity supply, rural electrification, improved power generation efficiency, etc.						
	Transportation	Improved public transportation, increased efficiency of mobility/logistics, etc.						
Support for productive sector	Agriculture	Improved agricultural infrastructure, improved livestock sector infrastructure, etc.						
	Mining and manufacturing	Improved mining and manufacturing infrastructure, fostering of core mining and manufacturing industries, etc.						
Social infrastructure improvements	Education	Improved infrastructure for education and empowerment						
	Healthcare, population	Improved medical infrastructure, improved livelihood infrastructure, etc.						
	Water supply, sanitation	Improved waterworks, improved sanitation infrastructure, etc.						

Shading indicates the scope of categories to be considered for future evaluation criteria.

Chapter 2. Quantitative Evaluation

2. 1 Purpose of this Evaluation Manual

In order to effectively promote the use of the co-benefits approach in developing countries, it is important to have specific methods to evaluate and properly determine the benefits of those activities.

To properly determine the benefits of a project, the more quantitative the evaluation methodology the better, but it is also important to use simple methods, so that when project participants actually use the evaluation methodology they are not required to deal with additional burdens, like the need to invest new funds, install sophisticated measurement devices, or engage in cumbersome monitoring tasks.

The objective of this evaluation manual is to encourage project parties to willingly and efficiently introduce and promote co-benefits-type CDM projects, by presenting the simplest and most qualitative methods possible to evaluate two or more project benefits on the environmental and climate change dimensions.

Here we focus on three categories of environmental pollution countermeasures (water quality improvement, air quality improvement, and waste management) within the co-benefits approach. We also summarize evaluation methodologies, usable equations, and examples of actual calculations in order to support and promote projects that will contribute to environmental pollution countermeasures while also acting as climate change countermeasures.

It should be noted, however, that this manual presents general evaluation methodologies for using the co-benefits approach, and it in no way discourages project parties from making creative adjustments to reflect the special characteristics of individual projects and conduct the most suitable evaluations based on the latest technical expertise. Finally, it should be noted that while the greatest possible effort was made to use up-to-date technical knowledge, it is likely that the GHG calculation methods, figures, and so on, used here for calculations will be updated or revised in future. As a result, this manual will need revisions, as appropriate, based on the latest available information.

2. 2 Procedure for Evaluation

The following flowchart suggests the procedural flow used in this manual for quantitative evaluation of co-benefits.

1. Comprehension of general project features in terms of co-benefits approach → Sections 1.1, 1.2 (p.1-3)

2. Comprehension of co-benefits → Section 1.3, Table 1-3（p. 3-6)

3. Identification of relevant cases/examples of the co-benefits approach → See Appendices

4. Evaluation of co-benefits:
    * Selection of evaluation category → Section 2.3 (p. 11)
    * Selection of evaluation indicators → Section 2.4 (p. 11)
    * Selection of evaluation level → Section 2.5 (p. 15)
    * Calculation of evaluation → Section 2.6 (p. 15)

5. Completion of evaluation sheet (draft) → Table-1.4 (p. 8)

Figure 2-1 Flow of Evaluation

1. Comprehension of general project features in terms of the co-benefits approach
Based on Section 1 of this manual, comprehend the general features of the co-benefits approach, international opinion, and initiatives.

2. Comprehension of co-benefits
Comprehend the co-benefits of climate change countermeasures and the CDM, with reference to the Details of the Co-Benefits listed in Table 1-3.

3. Identification of relevant cases/examples of the co-benefits approach
Study specific cases/examples of the co-benefits approach, referring to the Appendices at the end of this manual. For projects already registered as CDM projects, and those which had a Global Environment Center (GEC) feasibility study implemented, it is advisable to seek the relevant documents and use them as references.
Note that the Good Practice Matrixes on the “Co-Benefits Approach” website[14] (an information platform on the Kyoto Mechanisms) also carry some useful examples of the co-benefits approach, so it is advisable to refer to these as well (see “Tools” menu).

4. Evaluation of co-benefits
4-1. Selection of evaluation category
Select the evaluation category for the co-benefits to be verified. The target categories covered in this manual include water quality improvement, air quality improvement, and waste management.
4-2. Selection of evaluation indicators
While considering the special characteristics of the evaluation indicators, select the one(s) to be

[14] http://www.kyomecha.org/cobene/tools.html

used for verifying co-benefits.
4-3. Selection of evaluation level
Select the most appropriate evaluation level (Tier 1, Tier 2, or Tier 3) to be used when verifying the co-benefits, considering the availability of data and the conditions of the host country.
4-4. Calculation of evaluation
Evaluate the co-benefits based on the selected evaluation indicator and evaluation level. When doing so, use the evaluation calculation method that corresponds with the evaluation level.
For Tier 1, calculate the score based on the evaluation criteria and other items in the proposed evaluation criteria listed in this manual.
For Tier 2 and Tier 3, quantitatively calculate the benefits (e.g., reduction of water pollution, air pollution, or GHG emissions), based on the calculation methodology presented in this manual.

5. Completion of evaluation sheet (draft)
Summarize the results of the evaluation calculation by entering them on the evaluation sheet (draft). Enter the results into the columns "Selected Evaluation Indicators," "Selected Evaluation Methodology," and "Evaluation Result."

2. 3 Evaluation Categories

The purpose of the co-benefits approach is the implementation of climate change countermeasures that at the same time also promote initiatives that will contribute to sustainable development in developing countries. The development needs of developing countries cover many categories, from economic development to the solving of environmental problems, the reduction of poverty, and so on.

This manual for evaluation presents evaluation methodologies with a special focus on the co-benefits approach that will contribute to environmental pollution countermeasures seen as pressing issues among the broad development needs of developing countries—particularly for those experiencing rapid economic growth—and those countermeasures that also have a large potential to reduce GHG emissions. Among the possible categories, the focus of this manual is on the three listed below, which are important in developing countries and for which quantitative evaluation is relatively easy:

- Water quality improvement
- Air quality improvement
- Waste management

2. 4 Evaluation Indicators

The following evaluation indicators are for three categories of co-benefits-type CDM projects (water quality improvement, air quality improvement, and waste management).

2.4.1 Evaluation Indicators in the Water Quality Improvement Category

Table 2-1 provides evaluation indicators for the benefits of implementation of co-benefits-type CDM projects in the water quality improvement category, with a special focus on wastewater such as from factories and business operations.

Table 2-1 Evaluation Indicators in the Water Quality Improvement Category

Evaluation Indicator	Explanation of Indicator	Use of Indicator	Target Area
Chemical oxygen demand (COD)	Wastewater-borne organic matter (one cause of water pollution)	Evaluate the reduction in water pollution from the reduction of COD discharge due to the implementation of the project.	Environmental pollution countermeasure
Odors	Offensive odors generated from offensive odors substances in wastewater	Evaluate the reduction in offensive odors from changes in the odors index due to the implementation of the project.	
Methane (CH_4)	A GHG generated by anaerobic treatment of organic matter in wastewater, when wastewater is treated under anaerobic conditions (e.g., open lagoon). Methane's global warming potential is 21 times that of CO_2.	Evaluate the prevention of GHG generation from the volume of methane generation avoided due to the implementation of the project.	Climate change countermeasure
Carbon dioxide (CO_2)	GHGs associated with fossil fuel combustion or electricity consumption for operation of wastewater treatment facilities	Evaluate the GHG emission reduction from the reduced use of fossil fuels or electricity due to the implementation of the project.	

Besides the items indicated above as evaluation indicators for environmental pollution countermeasures, it is also possible to use other indicators if they can be estimated or measured. Examples include nitrogen and phosphorus, which lead to eutrophication of rivers, lakes, and seas, and hazardous or other substances thought to damage human health if discharged with wastewater into rivers, lakes, and seas.

Table 2-2 Notes on Indicators for Nitrogen, Phosphorus, and Hazardous Substances

Evaluation Indicator	Explanation of Indicator	Use of Indicator	Target Area
Nitrogen (N)	Substances that cause eutrophication of a water body	Evaluate the reduction in water pollution from the reduction of nitrogen emissions due to implementation of the project.	Prevention of environmental pollution
Phosphorus (P)	Substances that cause eutrophication of a water body	Evaluate the reduction in water pollution from the reduction of phosphorus emissions due to implementation of the project.	
Hazardous substances	Substances that may cause damage to human health if discharged into a water body	Evaluate the water pollution prevention effect from the prevention of discharge of hazardous substances due to implementation of the project.	

2.4.2 Evaluation Indicators in the Air Quality Improvement Category

The table below provides evaluation indicators for implementation effects of co-benefits-type CDM projects in the air quality improvement category, targeting exhaust and emissions from factories, business operations, automobiles, and other sources.

Table 2-3 Evaluation Indicators in the Air Quality Improvement Category

Evaluation indicator	Explanation of indicator	Use of indicator	Target area
Sulphur oxides (SOx)	Air pollutants generated from the oxidation of sulphur (S), from the combustion of fuels such as oil and coal	Evaluate the sulphur oxide emission reduction from the reduced use of fossil fuels due to the implementation of the project.	Environmental pollution countermeasure
Nitrogen oxides (NOx)	Compounds of nitrogen and oxygen generated from combustion and emitted from a variety of sources such as factories, business operations, automobiles, and households. They are usually first emitted as nitrogen monoxide, but after oxidation in the atmosphere convert to nitrogen dioxide.	Evaluate the nitrogen oxide emission reduction from the reduced emissions of NOx per unit of time due to the implementation of the project.	
Soot and dust	Soot and other solid particulates generated during the combustion of fuels such as coal and oil	Evaluate the soot and dust emission reduction from the reduced amount of soot and dust due to the implementation of the project.	
Carbon dioxide (CO_2)	GHGs associated with fossil fuel combustion or electricity consumption for operation of facilities, automobiles, etc.	Evaluate the GHG emission reduction from the reduced use of fossil fuels or electricity due to the implementation of the project.	Climate change countermeasure

2.4.3 Evaluation Indicators in the Waste Management Category

It is envisioned that projects in the waste management category will be implemented in one of three stages depending on the conditions in the region where the project is implemented. The following table indicates the details of the three stages envisioned and the target regions.

Table 2-4 Project Stage and Conditions of Target Regions Where Projects Are Implemented in the Waste Management Category

Stage		Conditions in Target Region	Details of Projects to be Implemented
1	Establishment of waste management infrastructure systems	Waste management policies have not yet been established, and waste management is not yet being conducted systematically or in an institutionalized way.	Create waste management infrastructure systems (e.g., waste collection systems, waste treatment systems) and establish waste management policies.
2	Initiatives to reduce the amount of waste	Proper waste management is being implemented, but the volume of waste is either steady or increasing.	Promote the 3Rs for waste (reduce, reuse, recycle) in order to reduce the volume of waste, and at the same time reduce GHG emissions.
3	Implementation of sound waste management	Waste management systems are in place, but because proper treatment is not being done, there are negative impacts on the surrounding environment.	Conduct proper treatment of waste that has been collected, reduce the negative impacts on the surrounding environment, and reduce GHG emissions.

The following table provides evaluation indicators to gauge the implementation effects of co-benefits-type CDM projects targeting waste management for the three stages described above.

Table 2-5 Evaluation Indicators in the Waste Management Category

Stage	Evaluation Indicator	Explanation of Indicator	Use of Indicator	Target Area
Establishment of waste management infrastructure systems	Collection area coverage ratio	Ratio of total area covered by collection of waste	Evaluate the effects of establishing waste management infrastructure systems, from the improvement of the waste collection area coverage ratio due to implementation of the project.	Environmental pollution countermeasure
	Waste collection ratio	Ratio of total waste actually collected	Evaluate the effects of establishing waste management infrastructure systems, from the improvement of the waste collection ratio due to implementation of the project.	
Initiatives to reduce the amount of waste	Amount of waste generated[15]	Waste generated amount	Evaluate the reduced volume of waste from the reduced amount of waste generated due to the implementation of the project.	
	Rate of recycling	Rate of recycling as energy or raw materials	Evaluate the reduced volume of waste from the improved rate of recycling due to the implementation of the project.	
	Waste disposal amount	Amount of final waste disposal (landfill)	Evaluate the reduced volume of waste from the reduced amount of final waste disposal (landfill) due to the implementation of the project.	
Proper waste treatment	Chemical oxygen demand (COD)	Amount of organic matter contained in leachate from landfill sites	Evaluate the decrease in water pollution from the reduction of COD concentrations due to the implementation of the project.	
	Odors	Odors generated from waste	Evaluate the control of offensive odors from changes in the odor index due to the implementation of the project.	
All stages	Methane (CH_4)	GHG emissions from landfill sites	Evaluate the amount of GHG emissions avoided from the landfill site due to the implementation of the project.	Climate change countermeasure
	Carbon dioxide (CO_2)	GHGs associated with fossil fuel combustion or electricity consumption for operation of facilities and garbage collection vehicles	Evaluate the GHG emission reduction from the reduced use of fossil fuels or electricity due to the implementation of the project.	

[15] Where the "amount of waste generated" cannot be used, due to circumstances in the project area or the data collection potential, the "amount of waste collected" can be used as an alternative.

2. 5 Timing of Evaluations

The evaluation of the co-benefits of co-benefits-type CDM projects is to be conducted both before and after project implementation.

Before project implementation	Estimate the results in the case of not implementing the project (baseline scenario) and the case of implementing the project (project scenario), and evaluate the difference.
After project implementation	Implement monitoring and evaluation of the effects of the project implementation.

2. 6 Evaluation of Co-Benefits-Type Projects (Water Quality Improvement Category)

Below are the evaluation calculation methodologies for each tier for co-benefits-type projects in the Water Quality Improvement Category. Also included below are calculation examples for evaluations using actual project examples. The Appendices also list examples of co-benefits-type projects in the Water Quality Improvement Category.

2.6.1 Calculation Methodology for Evaluations

(1) Evaluation Methodology for Tier 1

Where it is difficult to establish the necessary equations for quantitatively calculating benefits, data is difficult to obtain, and quantitative evaluation is difficult, evaluation is conducted based on predetermined qualitative evaluation criteria. No calculation is made, and the evaluation is done based on evaluation criteria corresponding to the actual details of the activity.

Table 2-6 Evaluation Criteria for Tier 1 (Water Quality Improvement)

Target Category	Evaluation Area	Evaluation Criteria	Type	Criteria Applied	Example	Expected Emission Reduction	Score[16]
Improvement of water quality	Environmental protection (reduction of water pollution)	Reduction in water pollutant discharge and suppression of odors is certain	Activity	・ Absolute certainty that direct processes to reduce water pollutant discharges and suppress odors can be introduced. ・ After implementation, monitoring of operational conditions can be conducted to confirm proper operation.	・ Recirculation/reuse of wastewater, cooling water, etc. ・ Reduced emissions of pollutants due to substitution of raw materials used ・ Installation of facilities to prevent large-scale discharge of wastewater from storage ponds during heavy rains	Large	5
						Small	4
		High probability of water pollutant discharge reduction and odor suppression	Activity	・ Equipment will be installed that will contribute to water pollutant discharge reduction and odor suppression. ・ After implementation, monitoring of operational conditions can be conducted, to confirm proper operation. ・ It is possible to monitor the status of initiatives relating to regulations of emissions and confirm whether or not they are being implemented.	・ Installation of coagulation-sedimentation equipment ・ Installation of floatation -separation equipment ・ Installation of clarifying filtration equipment ・ Installation of oxidation-reduction equipment ・ Installation of activated carbon adsorption equipment ・ Installation of membrane treatment equipment ・ Installation of activated sludge treatment equipment ・ Installation of biofilm treatment equipment ・ Installation of digester tank and other anaerobic treatment equipment ・ Installation of combined septic tank[17]	Large	3
			Controls and programs		・ Water pollutant discharge regulations ・ Low interest financing and tax incentives for investment needed for implementation of water pollutant discharge reduction measures ・ Subsidy programs to promote research and development	Small	2
		Water pollutant discharge reduction and odor suppression are likely, but qualitative (not quantitative).	Activity	・ Implementation of initiatives to raise awareness relating to impacts on surrounding environment of water pollutants and odors, and related countermeasures. ・ It is possible to implement follow-up studies on these initiatives, and confirm positive results.	・ Provision of related information through related organizations ・ Technical guidance ・ Education and awareness-raising	—	1

[16] probability level of reduction
[17] Septic tank for combined treatment of all domestic wastewater including that from urinals and toilets (hereinafter called "combined septic tank")

(2) Evaluation Methodologies for Tier 2 and Tier 3

Under Tier 2, as much as possible actual, measurement data is used—data that is necessary for quantitative calculation of benefits—and where no measurement data is available, default values are used, for a quantitative evaluation using a predetermined equation. The evaluation methodology used in Tier 2 can also be used in Tier 3, with the difference in Tier 3 being, for example, that the quantitative evaluation is implemented with case-specific parameters in the equations.

Below we examine the co-benefits approach, targeting highly organic wastewater discharged from business operations and other point sources, and present the evaluation methodology.

1) Evaluation Methodology for Benefits in the Environmental Pollution Countermeasures Area

In terms of the benefits relating to the environmental pollution countermeasures area, the effects of reduced COD—an indicator of organic matter in wastewater and one source of water pollution—are evaluated quantitatively, and the effects of reduced odors from wastewater are evaluated semi-quantitatively.

I. Evaluation Methodology for Reduction in COD Discharge

The methodology to evaluate COD levels contained in wastewater from project facilities is shown below.

Equation for Calculating Emission Reduction

$$ER_{COD,y} = BE_{\mathrm{COD},y} - PE_{COD,y}$$

Where

$ER_{COD,y}$	Reduction in COD discharge (tons/year)
$BE_{COD,y}$	Baseline scenario COD discharge (tons/year)
$PE_{COD,y}$	Project scenario COD discharge (tons/year)

Equation for Calculating COD Discharge (Baseline Scenario)

$$BE_{COD,y} = COD_{const,treatment} * (1 - R_{COD,BL}) * Q_{BL,y}$$

Where

$COD_{const,treatment}$	COD concentration of wastewater flowing into wastewater treatment system (mg/m^3)
$R_{COD,BL}$	COD removal rate
$Q_{BL,y}$	Quantity of effluent (m^3/year)

Equation for Calculating COD Discharge (Project Scenario)

$$PE_{COD,y} = COD_{const,treatment} * (1 - R_{COD,PJ}) * Q_{PJ,y}$$

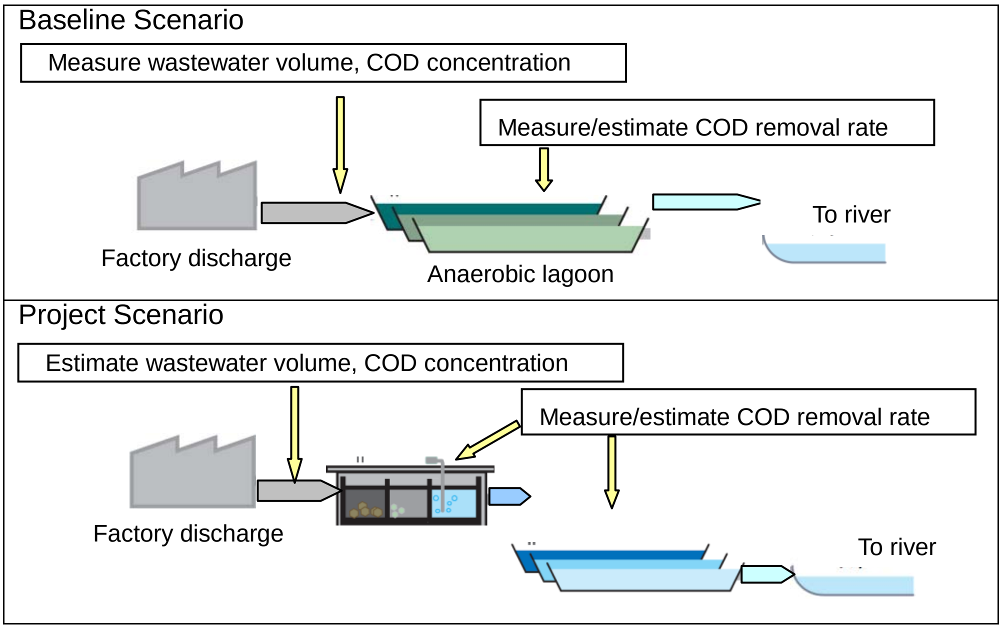
Where

$COD_{const,treatment}$	COD concentration of wastewater flowing into wastewater treatment system (mg/m^3)
$R_{COD,PJ}$	COD removal rate
$Q_{PJ,y}$	Quantity of wastewater (m^3/year)

<u>Data Collection Methods for Quantitative Evaluations</u>

Type	Data Item	Data Collection Method
Data required to calculate emissions under baseline scenario	Quantity of wastewater flowing into treatment system per year (m^3)	Measure the quantity of wastewater flowing into treatment system
	COD concentration in wastewater flowing into treatment system (mg/m^3)	Observed values of COD concentration in wastewater flowing into wastewater treatment system
	COD removal rate by treatment system	Use system specifications and observed values
Data required to calculate emissions under project scenario	Quantity of wastewater flowing into treatment system per year (m^3)	Estimate the quantity of wastewater flowing into wastewater treatment system
	COD concentration in wastewater flowing into treatment system (mg/m^3)	Estimate COD concentration in wastewater flowing into wastewater treatment system
	COD removal rate by treatment system	Use system specifications

Data Collection Locations for Quantitative Evaluations
Below are the locations for collection of data required for quantitative evaluation. Where wastewater is discharged at multiple locations, it is necessary to collect data at each location to calculate the discharge quantity. The evaluation is to be conducted by using the total of these separate discharge quantities.



II. Evaluation Methodologies for Odors

Odor is selected as an indicator of offensive odors generated from offensive odor substances in effluent, and an odor index or the concentration of the target substance is used, based on quantitative (or semi-quantitative) evaluation.

Odors are measured and evaluation is conducted in order to evaluate the suppression effects on offensive odors due to the project implementation. The following method is used for the measurement of odors:
Evaluation based on an odor index, measured using the Triangle Odor Bag Method for Odor Sensory Measurement or a simplified version of that method.

Below is an overview and explanation of this method.

Triangle Odor Bag Method for Odor Sensory Measurement

The Triangle Odor Bag Method involves filling three odor bags (capacity of three liters each) with odorless air, preparing a diluted sample by drawing a certain volume of collected sample into one bag, then having subjects identify the bag containing the odor by sniffing to compare with the two other bags containing no odors. The dilution multiple at which the subjects can no longer detect the odor is called the "odor concentration," with the following relationship: Odor index = 10 x log (odor concentration).

No.	Item	Description
1	Panel selection	Select at least six subjects.[18]
2	Sample collection	Collect about 10 liters of sample air over the course of six to 30 seconds, using an airtight vacuum glass container, a sample collection container with an internal sample collection bag, or a sample collection bag with a suction pump.
3	Judgment test	(a) Fill a three-liter polyester bag (referred to as an "odor bag") with odorless air that has been passed through activated carbon, and seal with a silicon rubber stopper. (b) Prepare three odor bags per set, and inject the sample air into one of them to attain a predetermined dilution ratio. (c) Give the odor bags to each panel and have the subjects identify the bag containing the odor. Repeat three times for each dilution ratio. (d) Assign a score of 1.00 for each correct choice by the panel, a score of 0.00 for each incorrect choice, and a score of 0.33 each time the panel cannot answer. Calculate the average of all measurements by the panel, and terminate the process when the average rate of correct answers is less than 0.58. If the rate is 0.58 or greater, dilute again by a factor of 10 and continue the process.

The odor index is calculated using the following equation:

Odor index $Y = 10\log\left(M * 10^{\frac{r_i - 0.58}{r_i - r_0}}\right)$

Odor concentration $Y' = M * 10^{\frac{r_i - 0.58}{r_i - r_0}}$

Where

- M Dilution ratio of initial trial
- r_i Average rate of correct answers for initial trial
- r_0 Average rate of correct answers after increasing M by a factor of 10

[18] Panel members must have passed a panel selection test using five types of standard odor liquids.

Table 2-7 Relationship of Odor Intensity and Odor Index

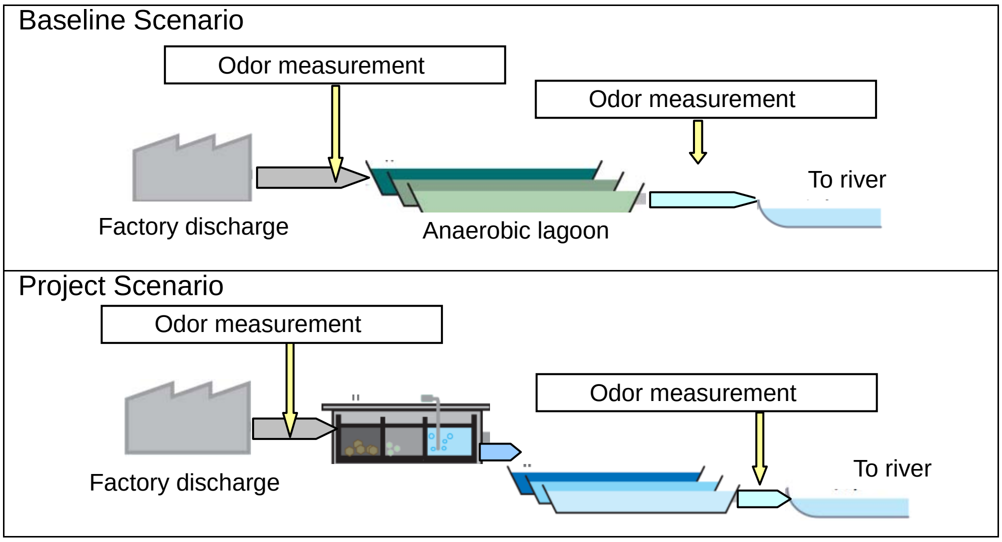
Odor Intensity	Description	Corresponding Odor Index
0	Odorless	
1	Barely perceptible	
2	Weak but identifiable	Odor intensity 2.5→10～15 Odor intensity 3.0→12～18 Odor intensity 3.5→14～21
3	Easily perceptible	
4	Strong	
5	Intense	

<u>Gas Measurement Method with Detection Tube</u>

With the gas measurement method using a detection tube, a predetermined amount of the sample gas is aspirated through a detection tube, and the detection agent changes color due to a chemical reaction with the target gas sample. The length of the discoloration layer resulting from the aspiration of a certain volume of the target gas over a specified amount of time is correlated with the concentration of the target gas in the air sample. Based on the relationship between the length of the discolored layer and the concentration, a reading of the length of the discolored layer is taken from the gauge printed in the detection tube, in order to determine the gas concentration.

Data Collection Locations for Evaluations

Below are the locations for collection of data required for evaluation. Where wastewater is discharged at multiple locations, it is necessary to collect data at each location and evaluate the odors. The final evaluation is to be conducted using the maximum value of these separate evaluations.



2) Evaluation Methodology for Reductions of GHG Emissions:

The GHG reduction is evaluated from the total emissions reduction of methane gas (CH_4)—a GHG generated from the anaerobic treatment of organic material in wastewater—and the emission reduction (or increase) of GHGs generated in association with the combustion of fossil fuels used for the operation of the wastewater treatment facilities.

The calculation of the GHG emission reduction is selected from the two methods indicated below, depending on the situation.

Options for Evaluation Methodologies

Option 1: Evaluation methodology using equations to calculate GHG emission reduction from wastewater treatment systems

Option 2: Evaluation methodology using reference tables to estimate GHG emission reduction from wastewater treatment systems.

Option 1: Evaluation methodology using equations to calculate GHG emission reduction from wastewater treatment systems

The GHG emission reduction associated with the installation or upgrading of a wastewater treatment system is evaluated using the equation indicated below. The equation is made with reference to AMS III-I of the small-scale CDM methodology.[19] For the CDM, besides the following equations, other calculation methodologies exist for GHG emission reduction. More details are available on the UNFCCC website.[20]

Equation for Calculating GHG Emission Reduction

$$ER_{CO_2,y} = BE_{CO_2,y} - PE_{CO_2,y}$$

Where

$ER_{CO2,y}$	GHG emission reduction amount (tCO_2e)[21]
$BE_{CO2,y}$	Baseline scenario GHG emissions (tCO_2e)
$PE_{CO2,y}$	Project scenario GHG emissions (tCO_2e)

Equation for Calculating GHG Emissions (Baseline Scenario)

$$BE_{CO_2,y} = BE_{CO_2,power,y} + BE_{CO_2,ww,y} + BE_{CO_2,s,treatment,y} + BE_{CO_2,sfinal,y}$$

Where

$BE_{CO2,power,y}$	GHG emissions from energy used in existing wastewater treatment system (tCO_2e)
$BE_{CO2,ww,y}$	GHG (methane) emissions from anaerobic water treatment system (tCO_2e)
$BE_{CO2,s,treatment,y}$	GHG (methane) emissions generated from sludge treatment system (tCO_2e)
$BE_{CO2,sfinal,y}$	GHG (methane) emissions generated from final sludge (tCO_2e)

$$BE_{CO_2,power,y} = EG_y * OR_y * EF_y \quad \cdots\cdots (1)$$

Where

EG_y	Energy consumption per year (MWh/yr)
OR_y	Operating rate of wastewater treatment system
EF_y	Emission factor of grid where electricity is procured (tCO_2/MWh)

$$BE_{CO_2,ww,y} = \sum_{i,m}\left(Q_{ww,m,y} * COD_{removed,i,m,y} * MCF_{anaerobic,i}\right) * B_0 * UF_{BL} * GWP_{CH4} \quad \cdots\cdots (2)$$

Where

$Q_{ww,m,y}$	Quantity of effluent per year treated by wastewater treatment system (m^3/year)
i	Type of wastewater treatment system

[19] CDM methodology AMS-III.I Avoidance of methane production in wastewater treatment through replacement of anaerobic systems by aerobic systems

[20] http://cdm.unfccc.int/methodologies/index.html

[21] Tons-CO_2- equivalent

$COD_{removed,i,m,y}$	COD concentration of wastewater treated in wastewater treatment system (ton/m^3)
$MCF_{anaerobic,i}$	Methane correction factor (see Table 2-4)
B_o	Maximum methane generation potential (IPCC default value): 0.21 ($kgCH_4$/kgCOD)
UF_{BL}	Model correction factor: 0.94
GWP_{CH4}	Global warming potential (IPCC default value): 21

Table 2-8 Methane Correction Factors (MCF), IPCC Default Values[22]

Path or type of wastewater treatment system	MCF
Ocean, river, lake wastewater	0.1
Aerobic treatment	0.0
Untreated or overload – aerobic treatment	0.3
Anaerobic sludge digestion equipment (without methane capture)	0.8
Anaerobic sludge reactor (without methane capture)	0.8
Anaerobic – shallow lagoon (depth of less than 2 meters)	0.2
Anaerobic – deep lagoon (depth of 2 meters or more)	0.8

$$BE_{CO_2,s,treatment,y} = \sum_j S_{j,BL,y} * MCF_{s,treatment,j} * DOC_s * UF_{BL} * DOC_F * F * \frac{16}{12} * GWP_{CH4} \quad \cdots\cdots (3)$$

If the sludge is composted, the following equation applies:

$$BE_{CO_2,s,treatment,y} = \sum_j S_{j,BL,y} * EF_{composting} * GWP_{CH4} \quad \cdots\cdots (3)'$$

Where

$S_{j,BL,y}$	Dry weight of sludge to be processed in sludge treatment system (tons)
j	Type of sludge treatment system
DOC_s	For cases of degradable organic matter in untreated sludge: Default values (sewage sludge: 0.5; factory sludge: 0.257)
$MCF_{s,treatment,j}$	Methane correction factor (see Table 2-4)
UF_{BL}	Model correction factor (0.94)
DOC_F	Ratio of organic matter converting to biogas (IPCC default value): 0.5
F	Ratio of methane in biogas (IPCC default value): 0.5
$EF_{composting}$	Emission factor for composting of organic waste (IPCC default value): 0.01 (tCH_4/ton dry weight basis)

$$BE_{CO_2,sfinal,y} = S_{final,BL,y} * DOC_s * UF_{BL} * MCF_{s,BL,final} * DOC_F * F * \frac{16}{12} * GWP_{CH4} \quad \cdots\cdots (4)$$

Where

$S_{final,BL,y}$	Dry weight of final sludge generated in wastewater treatment system (tons)
DOC_s	For cases of degradable organic matter in untreated sludge: Default values (sewage sludge: 0.5; factory sludge: 0.257)
UF_{BL}	Model correction factor (0.94)
$MCF_{s,BL,final}$	Methane correction factor (see Table 2-4)
DOC_F	Ratio of organic matter converting to biogas (IPCC default value): 0.5
F	Ratio of methane in biogas (IPCC default value): 0.5
GWP_{CH4}	Global warming potential (IPCC default value): 21

[22] 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 5 (Waste)

Equation for Calculating GHG Emissions (Project Scenario)

$$PE_{CO_2,y} = PE_{CO_2,power,y} + PE_{CO_2,ww,y} + PE_{CO_2,s,treatment,y} + PE_{CO_2,sfinal,y}$$

Where

$PE_{CO2,power,y}$	GHG emissions from energy used in wastewater treatment system (tCO_2e)
$PE_{CO2,ww,y}$	GHG (methane) emissions from aerobic water treatment system (tCO_2e)
$PE_{CO2,s,treatment,y}$	GHG (methane) emissions generated from sludge treatment system (tCO_2e)
$PE_{CO2,sfinal,y}$	GHG (methane) emissions generated from final sludge (tCO_2e)

$$PE_{CO_2,power,y} = EG_y * EF_y \quad \text{(1)}$$

Where

EG_y	Energy consumption per year (MWh/yr)
EF_y	Emission factor of grid where electricity is procured (tCO_2/MWh)

$$\mathrm{PE}_{CO_2,ww,y} = \sum_k \left(\mathrm{Q}_{ww,k,y} * \mathrm{COD}_{removed,k,y} * \mathrm{MCF}_{anaerobic,k}\right) * \mathrm{B}_0 * \mathrm{UF}_{PJ} * \mathrm{GWP}_{CH4} \quad \text{(2)}$$

Where

$Q_{ww,k,y}$	Quantity of effluent treated per year (m^3)
k	Type of wastewater treatment system
$COD_{removed,k,y}$	COD concentration of wastewater treated in wastewater treatment system (ton/m^3)
$MCF_{anaerobic,k}$	Methane correction factor (see Table 2-4)
B_o	Maximum methane generation potential (IPCC default value): 0.21 ($kgCH_4$/kgCOD)
UF_{PJ}	Model correction factor (1.06)
GWP_{CH4}	Global warming potential (IPCC default value): 21

$$PE_{CO_2,s,treatment,y} = \sum_l S_{l,PJ,y} * MCF_{s,treatment,l} * DOC_s * UF_{PJ} * DOC_F * F * \frac{16}{12} * GWP_{CH4} \quad \text{(3)}$$

If the sludge is composted, the following equation applies.

$$PE_{CO_2,s,treatment,y} = \sum_l S_{l,PJ,y} * EF_{composting} * GWP_{CH4} \quad \text{(3)'}$$

Where

$S_{l,PJ,y}$	Dry weight of sludge to be processed in sludge treatment system (tons)
l	Type of sludge treatment system
DOC_s	For cases of degradable organic matter in untreated sludge: Default values (sewage sludge: 0.5; factory sludge: 0.257)
$MCF_{s,treatment,l}$	Methane correction factor (see Table 2-4)
UF_{PJ}	Model correction factor (1.06)
DOC_F	Ratio of organic matter converting to biogas (IPCC default value): 0.5
F	Ratio of methane in biogas (IPCC default value): 0.5
$EF_{composting}$	Emission factor for composting of organic waste (IPCC default value): (tCH_4/ton waste treated)
GWP_{CH4}	Global warming potential (IPCC default value): 21

$$PE_{CO_2,sfinal,y} = S_{final,PJ,y} * DOC_s * UF_{PJ} * MCF_{s,PJ,final} * DOC_F * F * \frac{16}{12} * GWP_{CH4} \quad \cdots\cdots\cdots (4)$$

Where

$S_{final,PJ,y}$	Dry weight of final sludge generated in wastewater treatment system (tons)
DOC_s	For cases of degradable organic matter in untreated sludge: Default values (sewage sludge: 0.5; factory sludge: 0.257)
UF_{PJ}	Model correction factor (1.06)
$MCF_{s,PJ,final}$	Methane correction factor (see Table 2-4)
DOC_F	Ratio of organic matter converting to biogas (IPCC default value): 0.5
F	Ratio of methane in biogas (IPCC default value): 0.5
GWP_{CH4}	Global warming potential (IPCC default value): 21

<u>Option 2: Evaluation methodology using reference tables to estimate GHG emission reduction from wastewater treatment systems</u>

This is a method to calculate the GHG emission reduction from wastewater treatment systems, from reference tables calculated from data including the COD concentration, quantity of wastewater, the COD removal rate of the wastewater treatment facilities, and so on. The amounts of GHG emissions are taken from reference tables for both the baseline scenario and project scenario, and the GHG emission reduction amount is calculated from the difference. It should be noted, however, that the amount of GHG emissions from sludge is not included.

Equation for Calculating GHG Emission Reduction

$$ER_{CO_2,y} = BE_{CO_2,y} - PE_{CO_2,y}$$

Where

$ER_{CO2,y}$	GHG emission reduction amount (tCO_2e)
$BE_{CO2,y}$	Baseline scenario GHG emissions (tCO_2e)
$PE_{CO2,y}$	Project scenario GHG emissions (tCO_2e)

Table 2-9 Reference Table for Calculation of GHG Emission Reductions Due to Wastewater Treatment Systems

		COD level (mg/m^3)			
		5,000 (0.005 t/m^3)	10,000 (0.01 t/m^3)	30,000 (0.03 t/m^3)	50,000 (0.05 t/m^3)
Waste water volume (m^3/day)	65% treatment efficiency				
	1,000	2,841	6,507	21,170	35,833
	5,000	15,404	33,733	40,911	68,386
	10,000	31,108	27,174	82,123	137,072
	75% treatment efficiency				
	1,000	2,896	6,617	21,501	36,384
	5,000	15,680	34,284	51,214	85,557
	10,000	31,659	34,043	102,729	171,414
	85% treatment efficiency				
	1,000	2,951	6,727	21,831	36,936
	5,000	15,955	34,836	61,517	102,729
	10,000	32,211	40,911	123,334	205,757
	95% treatment efficiency				
	1,000	3,006	6,837	22,162	37,487
	5,000	16,231	35,387	71,820	119,900
	10,000	32,762	47,780	143,940	240,100

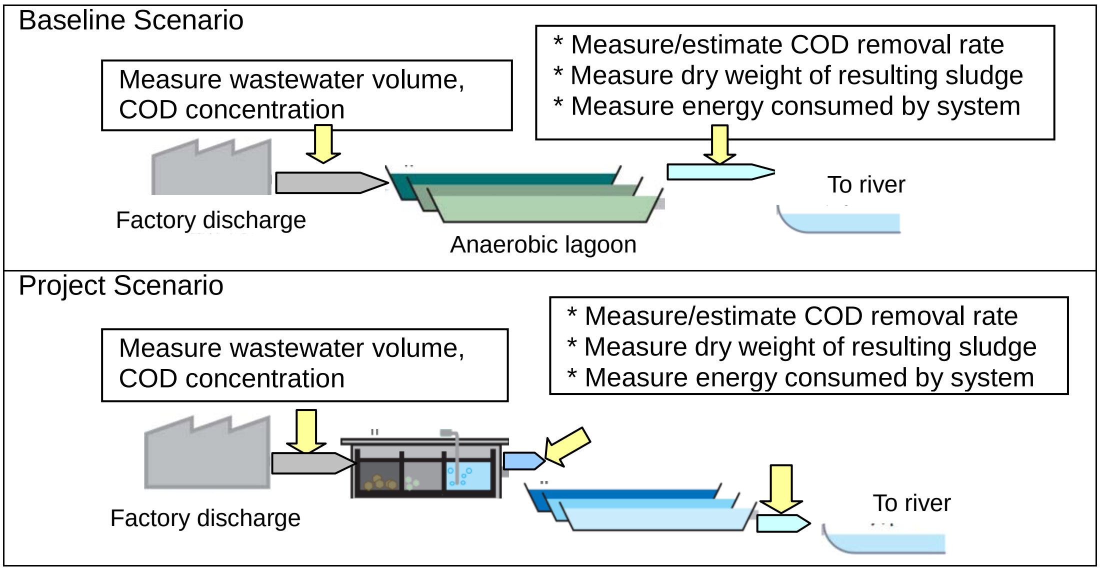
Source: "CER Estimation Toolkit," Global Environment Center.

Data Collection Methods for Quantitative Evaluations

Below are the data items and data collection methods required for quantitative evaluation.

Type	Data Item	Data Collection Method
Data required to calculate emissions under baseline scenario	Annual energy required to operate wastewater treatment system (MWh)	- Calculate from amount of electricity and fuel used
	Operating rate of wastewater treatment system per year	- Calculate from operating time of system
	Emission factor of grid where electricity is procured, or emission factor for each fuel used	- Obtain emission factor data for the grid connected to, or for fuel used - In the absence of data, use IPCC default values
	Quantity of wastewater flowing into wastewater treatment system per year (m^3)	- Measure the quantity of wastewater flowing into wastewater treatment system
	COD concentration removed by wastewater treatment system (mg/m^3)	- Use wastewater treatment system specifications or observed values
	Dry weight of sludge to be processed in sludge treatment system	- Observe value of dry weight before sludge treatment
	Dry weight of final sludge generated	- Observe value of dry weight after sludge treatment
Data required to calculate emissions under project scenario	Annual energy required to operate wastewater treatment system (MWh)	- Estimate from amount of electricity and fuel use
	Emission factor of grid where electricity is procured, or emission factor for each fuel used	- Obtain emission factor data for the grid connected to, or for fuel used - In the absence of data, use IPCC default values
	Quantity of wastewater flowing into wastewater treatment system per year (m^3)	- Estimate the quantity of wastewater flowing into wastewater treatment system
	COD concentration removed by wastewater treatment system (mg/m^3)	- Use wastewater treatment system specifications or observed values
	Dry weight of sludge to be processed in sludge treatment system	- Observe value of dry weight before sludge treatment
	Dry weight of final sludge generated	- Observe value of dry weight after sludge treatment

Data Collection Locations for Evaluations
Below are the locations for collection of data required for evaluation. Where wastewater is discharged at multiple locations, it is necessary to collect data at each location and then calculate the discharge quantity. The evaluation is to be conducted by using the total of these separate discharge quantities.



2.6.2 Monitoring

Monitoring is conducted after project implementation in order to verify the effects of the project.

(1) Monitoring of Effects in the Environmental Pollution Countermeasures area

The details of monitoring of effects in the environmental pollution countermeasures area are shown below.

1) Monitoring for Tier 1

Where evaluation is implemented under Tier 1, in order to determine the effects of project implementation, monitoring is conducted as shown below.

Subject of Evaluation	Monitoring Description
Projects relating to “activities” such as installation of equipment	Operating conditions are monitored and if operations are normal, it is judged that the discharge of water pollutants is reduced.
Projects relating to “Controls and Programs” (e.g., formulation of regulations, etc.)	The status of initiatives to introduce regulations, etc., is monitored, and if legislation is actually formulated toward compliance with regulations, it can be assumed that the potential exists for a reduction on the discharge of water pollutants.

2) Monitoring for Tier 2 and Tier 3

Where monitoring is implemented under Tier 2 or Tier 3, monitoring is conducted as shown below to determine the effects of project implementation. Using the monitoring data obtained and the equation provided above, it is determined whether or not project implementation results in benefits.

I. Monitoring Items

Evaluation Items	Monitoring Description
Volume of effluent discharged from the wastewater treatment system (m^3)	Estimate of the volume of effluent discharged from the wastewater treatment system
COD concentration in effluent	Observed values of COD concentration immediately before

discharged into rivers and lakes	effluent is discharged into rivers and lakes, etc.
Odors	Monitoring of odors generated from effluent

II. Monitoring Methodologies and Frequency

Data Item	Monitoring Method	Frequency
Volume of effluent discharged from the wastewater treatment system (m^3)	Direct measurement of discharged volume	Once per month
COD concentration in effluent discharged into rivers and lakes	Select one of the following methodologies for measuring COD concentrations: - Measure the potassium permanganate consumed after reacting for 30 minutes in a boiling water bath (100ºC) of sulfuric acid and potassium permanganate, then calculates the level of organic pollution in the sample.[23] - Simplified measurement method: Packed measurement method[24]	Once per month
Odors	Measure odors using the triangle odor bag method or a simplified version of that method.	Once per month

(2) Monitoring of Reductions of GHG Emissions

The details of monitoring of GHG emission reduction effects are shown below. Using the monitoring data obtained and the equation provided above, it is determined whether or not project implementation results in benefits.

I. Monitoring Items

Evaluation Items	Monitoring Description
Energy required to operate wastewater treatment system (MWh)	Amount of electricity and fuel use
Quantity of wastewater flowing into wastewater treatment system (m^3)	Quantity of wastewater flowing into wastewater treatment system
COD concentration flowing into wastewater treatment system (mg/m^3)	COD concentration flowing into wastewater treatment system (mg/m^3)
Dry weight of sludge to be processed in sludge treatment system	Dry weight before sludge treatment
Final dry weight of sludge generated	Dry weight after sludge treatment

II. Monitoring Methodologies and Frequency

Monitoring Items	Monitoring Method	Frequency
Energy required to operate wastewater treatment system (MWh)	Estimate of fuel (electricity) used	Once per month
Quantity of wastewater flowing into wastewater treatment system (m^3)	Direct measurement of wastewater volume flowing into system	Once per month
COD concentration removed by wastewater	Select one of the following methodologies for measuring COD concentrations: - Measure the potassium permanganate	Once per month

[23] Another method is the potassium dichromate measurement method, but it produces higher readings of COD.

[24] This is a simplified method to measure approximate concentrations of a target substance by noting the color changes after the reaction of a test substance when a test liquid is drawn into a tube containing the target substance.

treatment system (mg/m^3)	consumed after reacting for 30 minutes in a boiling water bath (100°C) of sulfuric acid and potassium permanganate, then calculates the level of organic pollution in the sample.[25] - Simplified measurement method: Pack measurement method	
Dry weight of sludge to be processed in sludge treatment system	Measurement of dry weight of sludge	Once per month
Final dry weight of sludge generated	Measurement of dry weight of sludge	Once per month

2.6.3 Examples of Calculations for Evaluations

Below is an example of calculations of co-benefits in the water quality improvement category, using data from a UN-registered CDM project. Please refer to the Project Design Document (PDD) of said project for examples of calculations of GHG reduction effects.

(1) Project Outline

Project title;
Methane recovery and utilization through organic wastewater treatment in Malaysia (Ref No. 1783)

This project is at a palm oil mill in Malaysia, and involves the installation of anaerobic wastewater treatment equipment to treat highly organic wastewater, with the aim of reducing GHG emissions by suppressing the generation of methane gas emitted from the organic wastewater.
This palm oil mill can process 80 tons of fresh fruit bunches (FFB) and generates 288,000 m^3 annually of highly organic wastewater containing palm oil. This wastewater is treated in an open lagoon, and in the process a large amount of methane gas is released into the atmosphere.

Below are the key parameters of the wastewater as noted in the project's Project Design Document (PDD).

- Wastewater discharge per year: 288,000 m^3
- COD concentration in wastewater: 0.0500 (t-COD/m^3)
- Type of wastewater treatment before project implementation: Open lagoon (depth 2 m or greater)
- Type of wastewater treatment after project implementation: Anaerobic wastewater treatment equipment

(2) Evaluation of Co-Benefits

1) Evaluation If Tier 1 Is Used

Because this project involves the "installation of anaerobic treatment equipment," it is expected that COD concentrations in the wastewater will be reduced. As a result it is possible to increase the benefit of reduced discharge of water pollutants. With anaerobic treatment equipment, however, because the benefits fluctuate considerably depending on the operating conditions and other factors, monitoring is necessary to ensure that the benefits are obtained after project implementation, and to verify that water pollutant discharge is actually reduced. Furthermore, because the amount of reduced emissions is expected to be great in the case of project implementation, the co-benefit evaluation using Tier 1 earns a score of "3."

2) Evaluation If Tier 2 Is Used

If Tier 2 is used to evaluate the co-benefits of this project, the co-benefits are evaluated quantitatively using an equation for calculating COD emission reduction by "installation of anaerobic treatment equipment."

The equation for calculating COD levels under the baseline scenario is presented below.

[25] Another method is the potassium dichromate measurement method, but it produces higher readings of COD.

$BE_{COD,y} = COD_{const,treatment} * (1 - R_{COD,BL}) * Q_{BL,y}$ Where $COD_{const,treatment}$ — COD concentration of wastewater flowing into treatment system (mg/m^3) $R_{COD,BL}$ — COD removal rate $Q_{BL,y}$ — Quantity of wastewater (m^3/year)

The COD removal rate achieved by the treatment equipment is assumed to be 10% under the baseline scenario.

The COD level in the baseline scenario is calculated as follows:

$$BE_{COD,y} = 0.05(t - COD / m^3) * (1 - 0.1) * 288{,}000\left(m^3\right) = 12{,}960\left(t - COD\right)$$

Similarly, assuming a COD removal rate by the treatment equipment to be 95% under the project scenario, the COD level under the project scenario is calculated as follows:

$$PE_{COD,y} = 0.05(t - COD / m^3) * (1 - 0.95) * 288{,}000\left(m^3\right) = 720\left(t - COD\right)$$

Thus, the COD discharge reduction is 12,960 – 720 = 12,240 (t-COD).

2. 7 Evaluation of Co-Benefits-Type Projects (Air Quality Improvement Category)

Below are evaluation calculation methodologies, by level of evaluation (Tier 1 and Tier 2) for co-benefits-type projects in the air quality improvement category, as well as calculation examples for evaluations using actual project examples. The Appendices also list examples of co-benefits-type projects in the Air Quality Improvement Category.

2.7.1 Calculation Methodology for Evaluations

(1) Evaluation Methodology for Tier 1

Where it is difficult to establish the necessary equations to quantitatively calculate benefits, data is difficult to obtain, and quantitative evaluation is difficult, evaluation is conducted based on predetermined qualitative evaluation criteria. No calculation is made, and the evaluation is done based on evaluation criteria corresponding to the actual details of the activity.

Table 2-10 Evaluation Criteria for Tier 1 (Air Quality Improvement)

Target Category	Evaluation Area	Evaluation Criteria	Type	Criteria Applied	Example	Expected Emission Reduction	Score[26]
Improvement of air quality	Environmental protection (reduction of air pollutants)	A reduction in air pollutant emissions is virtually certain	Activity	・ Absolute certainty that direct processes to reduce air pollutant emissions can be introduced. ・ After implementation, monitoring of operational conditions can be conducted to confirm proper operation.	・ Fuel switching (to fuels with low sulphur and low nitrogen content) improvement of combustion equipment. ・ Upgrading to high-performance boilers installation of waste-heat and exhaust-gas recovery equipment.	Large	5
						Small	4
		High probability of reduction in air pollutant emissions	Activity	・ Equipment will be installed that will contribute to air pollutant emission reduction. ・ After implementation, monitoring of operational conditions can be conducted, to confirm proper operation. ・ It is possible to monitor the status of initiatives relating to regulations of emissions and confirm whether or not they are being implemented.	・ Installation of flue gas desulfurization equipment. ・ Installation of flue gas denitrification equipment. ・ Installation of particulate precipitators.	Large	3
			Controls and programs		・ Regulation of air pollutant emissions. ・ Low interest financing and tax incentives relating to investments needed to promote implementation of air pollutant emission reduction measures. ・ Subsidy programs for research and development	Small	2
		Air pollutant discharge reduction is likely, but qualitative (not quantitative)	Activity	・ Implementation of initiatives to raise awareness relating to impacts of air pollutants on surrounding environment, and related countermeasures ・ It is possible to implement follow-up studies on these initiatives, and confirm positive results.	・ Provision of related information through related organizations ・ Technical guidance ・ Education and awareness raising	—	1

[26] probability level of reduction

Evaluation Methodologies for Tier 2 and Tier 3

Under Tier 2, as much as possible, actual measurement data is used—data that is necessary for quantitative calculation of benefits—and where no measurement data is available, default values are used for a quantitative evaluation using a predetermined equation. The evaluation methodology used in Tier 2 can also be used in Tier 3, with the difference in Tier 3 being, for example, that the quantitative evaluation is implemented with case-specific parameters in the equations.

Below we examine the co-benefits approach targeting stationary sources such as business operations, and mobile sources such as automobiles, and present the evaluation methodology.

1) Evaluation Methodology for Benefits in the Environmental Pollution Countermeasures Area

In terms of the benefits relating to the environmental pollution countermeasures area, the effects of reduced emissions of sulphur oxides and nitrogen oxides—causes of air pollution—are evaluated quantitatively.

I. Evaluation Methodology for Reduction of Sulphur Oxide Emissions

The methodology to evaluate the amounts of sulphur oxides contained in flue gas emissions from project facilities (stationary sources) is shown below.

Equation for Reduction of Sulphur Oxide Emissions

$$ER_{SOx,y} = BE_{SOx,y} - PE_{SOx,y}$$

Where

$ER_{SOx,y}$	Reduction in sulphur oxide emissions (tons/year)
$BE_{SOx,y}$	Baseline scenario sulphur oxide emissions (tons/year)
$PE_{SOx,y}$	Project scenario sulphur oxide emissions (tons/year)

Equation for Sulphur Oxide Emissions, Weight Basis (Baseline Scenario)

$$BE_{SO_X,y} = BFC_y * CR_{sulphur,fuel} / 100 * 64 / 32 * \left(1 - BDR/100\right) * 10^{-3}$$

Where

BFC_y	Annual fuel use (kg/year)
$CR_{sulphur,fuel}$	Sulphur composition ratio in fuel (% by weight)
BDR	Facility's desulfurization ratio

Equation for Sulphur Oxide Emissions, Weight Basis (Project Scenario)

$$PE_{SO_X,y} = PFC_y * CR_{sulphur,fuel} / 100 * 64 / 32 * \left(1 - PDR/100\right) * 10^{-3}$$

Where

PFC_y	Annual fuel use (kg/year)
$CR_{sulphur,fuel}$	Sulphur composition ratio in fuel (% by weight)
PDR	Facility's desulfurization ratio

Equation for Sulphur Oxide Emissions, Volume Basis (Baseline Scenario)

$$BE_{SO_X,y} = BFC_y * CR_{sulphur,fuel} / 100 * 64 / 22.4 * (1 - BDR / 100) * 10^{-3}$$

Where

BFC_y	Annual fuel use (Nm^3/year)
CR_{unit}	Sulphur composition ratio in fuel (% by volume)
BDR	Facility's desulfurization ratio

Equation for Sulphur Oxide Emissions, Volume Basis (Project Scenario)

$$PE_{SO_X,y} = PFC_y * CR_{sulphur,fuel} / 100 * 64 / 22.4 * (1 - PDR / 100) * 10^{-3}$$

Where

PFC_y	Annual fuel use (Nm^3/year)
CR_{unit}	Sulphur composition ratio in fuel (% by volume)
PDR	Facility's desulfurization ratio

Data Collection Methods for Quantitative Evaluations

Below are the data items and related data collection methods required for quantitative evaluation.

Type	Data Item	Data Collection Method
Data required to calculate emissions under baseline scenario	Fuel use amount	Measure amount of fuel use
	Sulphur composition ratio in fuel	Obtain data on ratio of sulphur composition in fuel
	Facility's desulfurization ratio	Obtain specifications for desulfurization equipment
Data required to calculate emissions under project scenario	Fuel use amount	Estimate amount of fuel use
	Sulphur composition ratio in fuel	Obtain data on ratio of sulphur composition in fuel
	Facility's desulfurization ratio	Make assumptions about specifications for desulfurization equipment

II. Evaluation Methodology for Reduction of Nitrogen Oxide Emissions

A) Stationary Sources

The methodology to evaluate the amounts of nitrogen oxides contained in flue gas and other emissions from project facilities is shown below.

Equation for Reduction of Nitrogen Oxide Emissions

$$ER_{NOx,y} = BE_{NOx,y} - PE_{NOx,y}$$

Where

$ER_{NOx,y}$	Reduction in nitrogen oxide emissions (tons/year)
$BE_{NOx,y}$	Baseline scenario nitrogen oxide emissions (tons/year)
$PE_{NOx,y}$	Project scenario nitrogen oxide emissions (tons/year)

Equation for Nitrogen Oxide Emissions (Baseline Scenario)

$$BE_{NO_X,y} = BE_{NOx,const} * 10^{-6} * BE_{volume,h} * h * 46/22.4 * 10^{-3}$$

Where

$BE_{NOx,const}$	NOx concentration (ppm)
$BE_{volume,h}$	Dry exhaust gas volume (Nm^3/h)[27]
h	Annual hours of operation of the facilities per year (h)

Equation for Nitrogen Oxide Emissions (Project Scenario)

$$PE_{NO_X,y} = PE_{NOx,const} * 10^{-6} * PE_{volume,h} * h * 46/22.4 * 10^{-3}$$

Where

$PE_{NOx,const}$	NOx concentration (ppm)
$PE_{volume,h}$	Dry exhaust gas volume (Nm^3/h)
h	Annual hours of operation of the facilities per year (h)

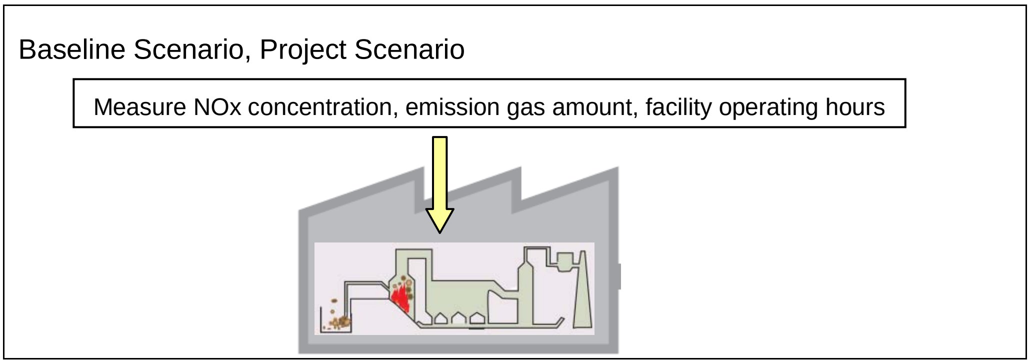
<u>Data Collection Methods for Quantitative Evaluations</u>

Below are the data items and related data collection methods required for quantitative evaluation.

Type	Data Item	Data Collection Method
Data required to calculate emissions under baseline scenario	NOx concentration	Measure NOx concentrations emitted
	Amount of dry exhaust gas emitted per hour	Measure the amount of dry exhaust gas emitted per hour
	Annual hours of operation of the facilities per year	Track the annual hours of operation of the facilities per year
Data required to calculate emissions under project scenario	NOx concentration	Estimate NOx concentrations emitted
	Amount of dry exhaust gas emitted per hour	Estimate the amount of dry exhaust gas emitted per hour
	Annual hours of operation of the facilities per year	Estimate the annual hours of operation of the facilities per year

Data Collection Locations for Evaluations

Below are the locations for collection of data required for evaluation. Where exhaust is emitted at multiple locations, it is necessary to collect data at each location and then calculate the emission quantity. The evaluation is to be conducted by using the total of these separate emission quantities.



B) Mobile Sources

The methodology to evaluate the amounts of nitrogen oxides contained in exhaust gas and other emissions from mobile sources under the project is shown below.

[27] Measure amount of emissions and use value after converting to dry gas amount.

Equation for Reduction of Nitrogen Oxide Emissions

$$ER_{NOx,y} = BE_{NOx,y} - PE_{NOx,y}$$

Where

$ER_{NOx,y}$	Reduction in nitrogen oxide emissions (tons/year)
$BE_{NOx,y}$	Baseline scenario for emissions (tons/year)
$PE_{NOx,y}$	Project scenario for emissions (tons/year)

Equation for Nitrogen Oxide Emissions (Baseline Scenario)

$$BE_{NOx,y} = \sum_{i,j,t}(N_{car,BL} * D_{car,BL} * EF_{NOx,km})$$

Where

$N_{car,BL}$	Number of type i vehicles using fuel type j on road type t
$D_{car,BL}$	Distance travelled (km) per year by type i vehicles using fuel type j on road type t
$EF_{NOx,km}$	NOx emissions per unit of distance travelled (Nm^3/km)

Equation for Nitrogen Oxide Emissions (Project Scenario)

$$PE_{NOx,y} = \sum_{i,j,t}(N_{car,PJ} * D_{car,PJ} * EF_{NOx,km})$$

Where

$N_{car,PJ}$	Number of type i vehicles using fuel type j on road type t
$D_{car,PJ}$	Distance travelled (km) per year by type i vehicles using fuel type j on road type t
$EF_{NOx,km}$	NOx emissions per unit of distance travelled (Nm^3/km)

Data Collection Methods for Quantitative Evaluations

Below are the data items and related data collection methods required for quantitative evaluation.

Type	Data Item	Data Collection Method
Data required to calculate emissions under baseline scenario	Number of target vehicles under baseline scenario	Actual baseline counts of numbers of vehicles, by vehicle type, fuel type, road type
	Distance travelled by target vehicles under baseline scenario	Actual baseline counts of vehicle distances travelled, by vehicle type, fuel type, road type
	NOx emissions per unit of distance travelled	Study on NOx emissions per unit of distance travelled by vehicles under baseline scenario
Data required to calculate emissions under project scenario	Number of vehicles under project scenario	Actual counts of numbers of vehicles, by vehicle type, fuel type, and road type, under the project scenario
	Distance travelled by vehicles under project scenario	Actual distance travelled, by vehicle type, fuel type, and road type, under the project scenario
	NOx emissions per unit of distance travelled	Studies on NOx emissions per unit of distance travelled by vehicles under project scenario (e.g., catalog values)

III. Evaluation Methodology for Reduction of Smoke and Soot Emissions

The methodology to evaluate the amounts of smoke and soot contained in flue gas and other emissions from project facilities (stationary sources) is shown below.

Equation for Reduction of Smoke and Soot Emissions

$$ER_{Dust,y} = BE_{Dust,y} - PE_{Dust,y}$$

Where

$ER_{Dust,y}$	Reduction in smoke and soot emissions (tons/year)
$BE_{Dust,y}$	Baseline scenario for smoke and soot emissions (tons/year)
$PE_{Dust,y}$	Project scenario for smoke and soot emissions (tons/year)

Equation for Smoke and Soot Emissions (Baseline Scenario)

$$BE_{Dust,y} = BE_{Dust,const} * BE_{volume,h} * h$$

Where

$BE_{Dust,const}$	Smoke and soot concentrations (g/m^3)
$BE_{volume,h}$	Dry exhaust gas volume (Nm^3/h)
h	Annual hours of operation of the facilities per year (h)

Equation for Smoke and Soot Emissions (Project Scenario)

$$PE_{Dust,y} = PE_{Dust,const} * PE_{volume,h} * h$$

Where

$PE_{Dust,const}$	Smoke and soot concentrations (g/m^3)
$PE_{volume,h}$	Dry exhaust gas volume (Nm^3/h)
h	Annual hours of operation of the facilities per year (h)

<u>Data Collection Methods for Quantitative Evaluations</u>

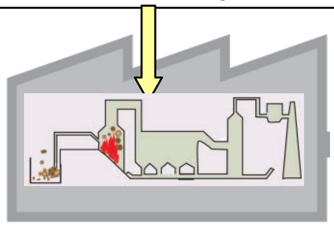
Below are the data items and related data collection methods required for quantitative evaluation.

Type	Data Item	Data Collection Method
Data required to calculate emissions under baseline scenario	Smoke and soot concentration	Measure smoke and soot concentrations emitted
	Amount of dry exhaust gas emitted per hour	Measure the amount of dry exhaust gas emitted per hour
	Annual hours of operation of the facilities per year	Tabulate the annual hours of operation of the facilities per year
Data required to calculate emissions under project scenario	Smoke and soot concentration	Estimate smoke and soot concentrations emitted
	Amount of dry exhaust gas emitted per hour	Estimate the amount of dry exhaust gas emitted per hour
	Annual hours of operation of the facilities per year	Estimate the annual hours of operation of the facilities per year

Data Collection Locations for Evaluations
Below are the locations for collection of data required for evaluation. Where exhaust is emitted at multiple locations, it is necessary to collect data at each location and then calculate the emission quantity. The evaluation is to be conducted by using the total of these separate emission quantities.

Baseline Scenario, Project Scenario

Measure NOx concentration, emission gas amount, facility operating hours



2) Evaluation Methodology for Reductions of GHG Emissions:

The GHG emission reduction is evaluated from the reduction in the amount of GHGs generated in connection with the combustion of fossil fuels used in the operation of facilities (stationary sources) and operation of vehicles (mobile sources).

I. Stationary Sources

The GHG emission reduction associated with the upgrading or performance improvement of a facility or fuel switching is evaluated using the equation indicated below.

Equation for Calculating GHG Emission Reduction

$$ER_{CO_2,y} = BE_{CO_2,y} - PE_{CO_2,y}$$

Where

$ER_{CO2,y}$	GHG emission reduction amount (tCO_2e/year)
$BE_{CO2,y}$	Baseline scenario GHG emissions (tCO_2e/year)
$PE_{CO2,y}$	Project scenario GHG emissions (tCO_2e/year)

Equation for Calculating GHG Emissions (Baseline Scenario)

$$BE_{CO_2,y} = BFC_y * NCV_{unit} * EF_y$$

Where

BFC_y	Annual fuel use (kg or l or Nm^3/year)
NCV_{unit}	Calorific value per unit of fuel use (MJ/kg or l or Nm^3): IPCC default values
EF_y	CO_2 emission factor, by fuel ($kgCO_2$/MJ): IPCC default values

Equation for Calculating GHG Emissions (Project Scenario)

$$PE_{CO_2,y} = PFC_y * NCV_{unit} * EF_y$$

Where

PFC_y	Annual fuel use (kg or l or Nm^3/year)
NCV_{unit}	Calorific value per unit of fuel use (MJ/kg or l or Nm^3): IPCC default values
EF_y	CO_2 emission factor, by fuel (kgCO_2/MJ): IPCC default values

Data Collection Methods for Quantitative Evaluations

Below are the data items and related data collection methods required for quantitative evaluation.

Type	Data Item	Data Collection Method
Data required to calculate emissions under baseline scenario	Fuel use amount	Measure annual fuel use data
	Calorific value per unit of fuel use	Use IPCC default values
	CO_2 emission factor for fuels	Use IPCC default values
Data required to calculate emissions under project scenario	Fuel use amount	Estimate annual fuel use
	Calorific value per unit of fuel use	Use IPCC default values
	CO_2 emission factor for fuels	Use IPCC default values

II. Mobile Sources

The methodology to evaluate the amounts of GHGs contained in exhaust gas and other emissions from mobile sources under the project is shown below.

Equation for Calculating GHG Emission Reduction

$$ER_{CO_2,y} = BE_{CO_2,y} - PE_{CO_2,y}$$

Where

$ER_{CO2,y}$	GHG emission reduction amount (tCO_2e/year)
$BE_{CO2,y}$	Baseline scenario GHG emissions (tCO_2e/year)
$PE_{CO2,y}$	Project scenario GHG emissions (tCO_2e/year)

Equation for Calculating GHG Emissions (Baseline Scenario)

$$BE_{CO_2,y} = \sum_{i,j,t} (N_{car,BL} * D_{car,BL} * FC_{car,BL} * NCV_{unit}) * EF_{CO_2}$$

Where

$N_{car,BL}$	Number of type i vehicles using fuel type j on road type t
$D_{car,BL}$	Distance travelled (km) by type i vehicles using fuel type j on road type t
$FC_{car,BL}$	Average fuel consumed by type i vehicles using fuel type j on road type t (kg or l or Nm^3/km)
NCV_{unit}	Calorific value per unit of fuel use (MJ/kg or l or Nm^3): IPCC default values
EF_{CO2}	CO_2 emission factor, by fuel (kgCO_2/MJ): IPCC default values

Equation for Calculating GHG Emissions (Project Scenario)

$$PE_{CO_2,y} = \sum_{i,j,t}(N_{car,PJ} * D_{car,PJ} * FC_{car.PJ} * NCV_{unit}) * EF_{CO_2}$$

Where

$N_{car,PJ}$	Number of type i vehicles using fuel type j on road type t under project scenario
$D_{car,PJ}$	Distance travelled (km) by type i vehicles using fuel type j on road type t under project scenario
$FC_{car,PJ}$	Average fuel consumed by type i vehicles using fuel type j on road type t (kg or l or Nm^3/km)
NCV_{unit}	Calorific value per unit of fuel use (MJ/kg or l or Nm^3): IPCC default values
EF_{CO2}	CO_2 emission factor, by fuel (kgCO_2/MJ): IPCC default values

Data Collection Methods for Quantitative Evaluations

Below are the data items and related data collection methods required for quantitative evaluation.

Type	Data Item	Data Collection Method
Data required to calculate emissions under baseline scenario	Number of vehicles under baseline scenario	Actual baseline counts of numbers of vehicles, by vehicle type, fuel type, road type
	Distance travelled by vehicles under baseline scenario	Actual baseline counts of vehicle distances travelled, by vehicle type, fuel type, road type
	Amount of fuel consumed	Study on average fuel use (fuel efficiency) by vehicles under baseline scenario
Data required to calculate emissions under project scenario	Number of vehicles under project scenario	Actual counts of numbers of vehicles, by vehicle type, fuel type, and road type, under the project scenario
	Distance travelled by vehicles under project scenario	Actual distance travelled, by vehicle type, fuel type, and road type, under the project scenario
	Amount of fuel consumed	Studies on average fuel use (fuel efficiency) by vehicles under project scenario (e.g., catalog values)

2.7.2 Monitoring

Monitoring is conducted after project implementation in order to verify the effects of the project.

(1) Monitoring of Effects in the Environmental Pollution Countermeasures Area

The details of monitoring of effects in the environmental pollution countermeasures area are shown below.

1) Monitoring for Tier 1

Where evaluation is implemented under Tier 1, in order to determine the effects of project implementation, monitoring is conducted as shown below.

Subject of Evaluation	Monitoring Description
Projects relating to “activities” such as installation of equipment	If the operating conditions are monitored to confirm that operations are normal, it can be assumed that there is a reduction in the emissions of air pollutants
Projects relating to “Controls and Programs” (e.g., formulation of regulations, etc.)	If the status of initiatives to introduce regulations, etc., is monitored to confirm that legislation is actually formulated toward compliance with regulations, it can be assumed that the potential exists for a reduction in the emissions of air pollutants.

2) Monitoring for Tier 2 and Tier 3

Where evaluation is implemented under Tier 2 or Tier 3, monitoring is conducted as shown below to determine the effects of project implementation. Using the monitoring data obtained and the equation provided above, it is determined whether or not project implementation results in benefits.

I. Monitoring Items

Target Substance	Category	Evaluation Items	Monitoring Description
Sulphur oxides	Stationary sources	Fuel use amount	Fuel use amount
Nitrogen oxides	Stationary sources	NOx concentration	NOx concentrations in exhaust gases
		Exhaust gas amount	Amount of dry exhaust gas
		Annual hours of operation of the facilities per year	Annual hours of operation of the facilities per year
	Mobile sources	Number of vehicles	Number of vehicles
		Distance travelled by vehicles	Distance travelled by vehicles
		NOx emissions per unit of distance travelled	NOx emissions per unit of distance travelled by vehicles

II. Monitoring Methodologies and Frequency

Target Substance	Category	Monitoring Items	Monitoring Method	Frequency
Sulphur oxides	Stationary sources	Fuel use amount	Measure amount of fuel use	Once per month
Nitrogen oxides	Stationary sources	NOx concentrations in exhaust gases	Measure NOx concentrations in exhaust gases. Select one of the following methodologies for measuring ・Zinc reduction naphthyl-ethylenediamine absorptiometry method[28] ・Naphthyl-ethylenediamine absorptiometry method[29]	Once per month
		Exhaust gas amount	Measure amount of gas emissions and convert to dry gas equivalent[30]	Once per month
		Annual hours of operation of the facilities per year	Obtain annual hours of operation of the facilities per year	Once per year
	Mobile sources	Number of vehicles	Implement traffic volume studies to determine number of vehicles using roads	Once per year
		Distance travelled by vehicles	Implement traffic volume studies, to determine distances travelled by vehicles	Once per year
		NOx emissions per unit of distance travelled by vehicles	Measure NOx emissions per unit of distance travelled by vehicles	At start of project implementation

(2) Monitoring of Reductions of GHG Emissions

The details of monitoring of GHG emission reduction effects are shown below. Using the monitoring data obtained and the equation provided above, it is determined whether or not project

28 Zinc reduction naphthyl-ethylenediamine absorptiometry method (Zn-NEDA method): Refer to JIS K 0104
29 Naphthyl-ethylenediamine absorptiometry method (NEDA method): Refer to JIS K 0104.
30 Measure amount of emissions and use value after converting to dry gas amount.

implementation results in benefits.

1) Monitoring Items

Category	Evaluation Items	Monitoring Description
Stationary sources	Fuel use amount	Fuel use amount data
Mobile sources	Number of vehicles	Number of vehicles
	Distance travelled by vehicles	Distance travelled by vehicles
	Amount of fuel consumed	Average fuel consumption amount (fuel efficiency)

2) Monitoring Method

Category	Monitoring Items	Monitoring Method	Frequency
Stationary sources	Fuel use amount	Obtain data on amount of fuel use at the facilities	Once per month
Mobile sources	Number of vehicles	Implement traffic volume studies to determine number of vehicles using roads	Once per year
	Distance travelled by vehicles	Implement traffic volume studies to determine distance travelled by vehicles	Once per year
	Amount of fuel consumed	Measure average fuel consumption amount by vehicles	At start of project implementation

2.7.3 Examples of Calculations for Evaluations

Below is an example of calculations of co-benefits in the air quality improvement category, using data from a UN-registered CDM project. Please refer to the Project Design Document (PDD) of the said project for examples of calculations of the GHG reduction effects.

(1) Project Outline

Project title;
Switching of fuel from Low Sulphur Waxy Residue fuel oil to natural gas at Gangnam branch or the Korea District Heating Corporation Project (Ref No. 0835)

This project is to convert from four boilers using “low sulphur waxy residue” (LSWR) fuel oil to three boilers using natural gas for district heating.

Currently the four boilers being used for district heating consume fuel oil as the fuel to operate. The purpose is to reduce the emissions of GHGs and pollutants such as sulphur oxides from fossil fuels, by converting these boilers to natural gas boilers and using natural gas as the fuel.

Two of the existing boilers have a capacity to provide 51 Gcal/h and the other two are rated at 102 Gcal/h; the total fuel oil consumption for all four boilers amounts to 113,040 kL/year. The sulphur concentration in the fossil fuel being used is about 0.3% or less.

If three new natural gas-fired boilers are installed with a capacity of 103.2 Gcal/h each, the annual consumption of natural gas will be 112,810,463 m^3/year.

Below are the key parameters of the boilers as noted in the project’s PDD.

- Existing boilers: (fuel oil burning): 51 Gcal/h x 2 units, 102 Gcal/h x 2 units
- Fuel consumption: 113,040 kL/year of fuel oil (sulphur concentration: less than 0.3%)
- Project details: Upgrade to three natural gas boilers, natural gas use will be 112,810,463 m^3/year
- Desulfurization ratio of the facilities: about 90%

(2) Evaluation of Co-Benefits

1) Evaluation If Tier 1 Is Used

If Tier 1 is used to evaluate the co-benefits of this project, because it is "fuel conversion by replacing boilers" being implemented, we estimate the reduction of emissions of sulphur oxides. If this is a "fuel conversion by replacing boilers" and the facilities are operated, and the fuel oil firing boilers are completely removed, it is certain that there will be a reduction in air pollutant emissions. Therefore, after project implementation, it is necessary to implement checks to confirm that the facilities are actually operating. Furthermore, because it is expected that the amount of reduced emissions will be great if the project is implemented, the co-benefit evaluation using Tier 1 earns a score of "3."

2) Evaluation If Tier 2 Is Used

If Tier 2 is used to evaluate the co-benefits of this project, the reduction of sulphur oxides by "fuel conversion by replacing boilers" is evaluated quantitatively using an equation.

The equation for the amount of sulphur oxide emissions under the baseline scenario is presented below.

Equation for Calculating Emissions, Volume Basis (Baseline Scenario)

$$BE_{SO_X,y} = BFC_y * CR_{sulphur,fuel} / 100 * 64 / 22.4 * (1 - BDR/100) * 10^{-3}$$

Where

BFC_y	Annual fuel use (kL/year)
$CR_{sulphur,fuel}$	Sulphur composition ratio in fuel (% by volume)
BDR	Facility's desulfurization ratio

Thus, the sulphur oxide emissions of the baseline scenario will be as follows:

$$BE_{SOx,y} = 113{,}040\ (\mathrm{k}\ell) * 0.3/100 * 64/22.4 * (1 - 90/100) = 96.9\ \mathrm{t/year}$$

If it is assumed that there is virtually no sulphur content in the natural gas, we can conclude that the sulphur oxide emissions will almost completely stop thanks to project implementation.
The reduction of sulphur oxide emissions would amount to 96.9 t/year.[31]

[31] The amount indicated in the PDD for reduction of sulphur oxides emissions is 95 tons.

2. 8 Evaluation of Co-Benefits-Type Projects (Waste Management Category)

Below is an example of a co-benefits-type project in the waste management category, as well as evaluation calculation methodologies and examples of evaluation calculations. Included in the Appendices is a list of examples of co-benefits-type CDM projects in the Waste Management Category.

2.8.1 Calculation Methodology for Evaluations

(1) Evaluation Methodology for Tier 1

Where it is difficult to establish the necessary equations to quantitatively calculate benefits, data is difficult to obtain, and quantitative evaluation is difficult, evaluation is conducted based on predetermined qualitative evaluation criteria. No calculation is made, and the evaluation is done based on evaluation criteria corresponding to the actual details of the activity.

Table 2-11 Evaluation Criteria for Tier 1, for Waste Management

Target Category	Evaluation Area	Evaluation Criteria	Type	Criteria Applied	Example	Expected Emission Reduction	Score[32]
Waste management	Environmental protection (solutions to problems relating to waste management)	Reduction in problems relating to waste management (including offensive odors) is certain	Activity	・ Absolute certainty that direct processes to reduce the amount of waste and negative impacts on the surrounding environment can be introduced. ・ After implementation, monitoring of operational conditions can be conducted, to confirm proper operation.	[Improvement of waste management infrastructure systems] ・ Implementation of improvements in waste treatment facilities and landfill sites [Implementation of sound waste management] ・ Implementation of incineration as intermediate treatment ・ Adoption of new landfill management approaches in final landfill sites [Implementation of waste volume reduction efforts] ・ Composting and recycling of waste ・ Recycling of waste as energy and raw materials ・ Recycling of animal waste and biomass as sources of biomass fuel	Large	5
						Small	4
		High probability of reduction in problems relating to waste management (including offensive odors)	Activity	・ Equipment will be installed that will contribute to waste reduction and a reduction of negative impacts on the surrounding environment ・ After implementation, monitoring of operational conditions can be conducted, to confirm proper operation. ・ For efforts to reduce waste (e.g., 3Rs), it is possible to monitor the state of efforts and confirm that they are being implemented	[Improvement of waste management infrastructure systems] ・ Improvements in waste collection systems and collection vehicles [Implementation of efforts for sounder waste management] ・ Adoption of new landfill management approaches in final landfill sites	Large	3
			Controls and programs		・ Regulations relating to waste management ・ Manifest system relating to waste management ・ Low interest financing and tax incentives for investment needed for measures to alleviate waste problems ・ Subsidy programs for research and development	Small	2
		Reduction in problems relating to waste management (including offensive odors) are likely, but can only be evaluated qualitatively (not quantitatively)	Activity	・ Implementation of initiatives to raise awareness relating to impacts on surrounding environment of illegal dumping and waste abandonment as well as offensive odors, and related countermeasures ・ It is possible to implement follow-up studies on these initiatives, and confirm positive results.	・ Provision of related information through related organizations ・ Technical guidance ・ Education and awareness raising	–	1

32 probability level of reduction

(2) Evaluation Methodologies for Tier 2 and Tier 3

Under Tier 2, as much as possible, actual measurement data is used—data that is necessary for quantitative calculation of benefits—and where no measurement data is available, default values are used, for a quantitative evaluation using a predetermined equation. The evaluation methodology used in Tier 2 can also be used in Tier 3, with the difference in Tier 3 being, for example, that the quantitative evaluation is implemented with case-specific parameters in the equations.

The evaluation of projects in the waste management category will depend on the situation of waste management in the target region, and on the details of the project implemented. The table below indicates the envisioned stages of waste management and the situation in the target region, as well as the evaluation methodologies for the co-benefits at each stage.

Stage		Details of Project Implementation	Evaluation Indicators
1	Establishment of waste management infrastructure systems	Create waste management infrastructure systems (e.g., waste collection systems, waste treatment systems) and establish waste management policies	Collection area coverage ratio Waste collection ratio
2	Initiatives to reduce the amount of waste	Promote the 3Rs for waste (reduce, reuse, recycle), in principle in that sequence, in order to reduce the volume of waste, and at the same time reduce GHG emissions.	Waste volume (amount generated, amount collected, amount processed) Recycling rate
3	Implementation of sound waste management	Conduct proper treatment of waste that has been collected, reduce the negative impacts on the surrounding environment, and reduce GHG emissions	COD concentration in leachate from landfill sites Offensive odor

1) Stage 1：Establishment of waste management infrastructure systems

I. Evaluation Methodology for Benefits in the Environmental Pollution Countermeasures Area

In terms of the benefits relating to the environmental pollution countermeasures area, the improved waste collection area coverage ratio and improved waste collection ratio are evaluated quantitatively.

A) Evaluation Methodology for Improvements in Collection Area Coverage Ratio

The methodology shown below is to evaluate improvements in the collection area coverage ratio in the waste collection area due to the implementation of systematic and organized waste collection in connection with the project.

Equation for Improvement in Collection Area Coverage Ratio

$$R_{Area} = R_{Area,PJ} - R_{Area,BL}$$

Where

R_{Area}	Improvement in collection area coverage ratio (%)
$R_{Area,PJ}$	Collection area coverage ratio after project implementation (%)
$R_{Area,BL}$	Collection area coverage ratio before project implementation (%)

The collection area coverage ratio (both before and after project implementation) is calculated using the following equation:
Collection area coverage ratio = actual area (or population) covered by waste collection ÷ planned collection area (or population)

Data Collection Methods for Quantitative Evaluations

Below are the data items and related data collection methods required for quantitative evaluation.

Data Item	Data Collection Method
Actual area (or population) covered by waste collection	Obtain figures from mapping (management data) of area (or population) actually covered by waste collection services
Planned collection area (or population)	Obtain figures from mapping (statistical data) of area (or population) to be covered by planned waste collection services

B) Evaluation Methodology for Waste Collection Ratio

The methodology shown below is to evaluate improvements in the waste collection ratio due to the implementation of systematic and organized waste collection in connection with the project.

Equation for Calculating Improvements in Waste Collection Ratio

$$R_{Collection} = R_{Collection,PJ} - R_{Collection,BL}$$

Where

$R_{Collection}$	Improvement in waste collection ratio (%)
$R_{Collection,PJ}$	Waste collection ratio after project implementation (%)
$R_{Collection,BL}$	Waste collection ratio before project implementation (%)

The waste collection ratio is calculated using the following equation:
Waste collection ratio = actual amount of waste collected (weight or volume) ÷ planned amount of waste to be collected (weight or volume)

Data Collection Methods for Quantitative Evaluations

Below are the data items and related data collection methods required for quantitative evaluation.

Data Item	Data Collection Method
Actual volume of waste collected	Measure, for example, by installing truck scales such as at waste treatment facilities, to determine the actual amount of waste collected
Planned amount of waste to be collected	Planned amounts of waste to be collected, based on waste management infrastructure system improvement plans and so on

II. Evaluation Methodology for Reductions of GHG Emissions

The GHG emission reduction is evaluated from the total GHG emissions from waste collection vehicles. Note that it is also necessary to consider GHGs generated in connection with incineration in cases where waste incineration is conducted as a form of intermediate treatment.

A) GHG Emissions from Waste Collection Vehicles

For GHG emissions from waste collection vehicles, please refer to evaluation methodology for GHG reductions “ II. Mobile Sources” in the “Air Quality Improvement” category.

2) Stage 2: Initiatives to reduce the amount of waste

I. Evaluation Methodology for Benefits in the Environmental Pollution Countermeasures Area

In terms of the benefits relating to the environmental pollution countermeasures area, the reduction in amount of waste generated (or amount of waste collected) due to the reduction in waste volume, the improved recycling rate due to the recycling of waste as energy or raw materials, and the reduction in the amount of final landfill, are evaluated quantitatively.

A) Evaluation Methodology for Reduction of Amount of Waste Generated

The methodology shown below is to evaluate the reduction in amount of waste generated by implementing project activities. Note that where it is difficult to obtain data on waste generated in amount, quantitative evaluation is conducted using “amount collected” at the waste collection stage.

Equation for Calculating Reduction of Amount of Waste Generated

$$W_{volume} = W_{volume,PJ} - W_{volume,BL}$$

Where

W_{volume}	Reduction in amount of waste generated (tons)
$W_{volume,PJ}$	Amount of waste generated after project implementation (tons)
$W_{volume,BL}$	Amount of waste generated before project implementation (tons)

<u>Data Collection Methods for Quantitative Evaluations</u>

Below are the data items and related data collection methods required for quantitative evaluation.

Data Item	Data Collection Method
Amount of waste generated (tons)	Conduct surveys through interviews and various other means, by waste source, to determine amount of waste at the waste generation stage Note that where it is difficult to obtain data on waste generated amount, substitute data on waste collected amounts after waste collection.

B) Evaluation Methodology for Improvement in Recycling Rate

The methodology shown below is to evaluate improvements in the recycling rate due to recycling of waste as energy or raw materials, in connection with the project.

Equation for Calculating Improvement in Recycling Rate

$$R_{Recycle} = R_{Recycle,PJ} - R_{Recycle,BL}$$

Where

$R_{Recycle}$	Improvement in recycling rate (%)
$R_{Recycle,PJ}$	Recycling rate after project implementation (%)
$R_{Recycle,BL}$	Recycling rate before project implementation (%)

The recycling rate is calculated using the following equation:

Recycling rate = amount of waste recycled ÷ total amount of waste

<u>Data Collection Methods for Quantitative Evaluations</u>

Below are the data items and related data collection methods required for quantitative evaluation.

Data Item	Data Collection Method
Amount of waste recycled (tons)	Calculate the amount of waste recycled from after collection to final landfill
Total amount of waste (tons)	Total amount of waste collected

C) Evaluation Methodology for Reduction of Amount of Waste Landfilled

The methodology shown below is to evaluate the reduction in amount of waste landfilled by implementing project activities.

Equation for Calculating Reduction of Amount of Waste Landfilled

$$D_{volume} = D_{volume,PJ} - D_{volume,BL}$$

Where

D_{volume}	Reduction in amount of waste landfilled (tons)
$D_{volume,PJ}$	Amount of waste landfilled after project implementation (tons)
$D_{volume,BL}$	Amount of waste landfilled before project implementation (tons)

Data Collection Methods for Quantitative Evaluations

Below are the data items and related data collection methods required for quantitative evaluation.

Data Item	Data Collection Method
Amount of waste landfilled (tons)	Measure the amount of waste transported into final landfill sites by installing truck scales at landfill sites, and by other means.

II. Evaluation Methodology for Reductions of GHG Emissions:

The GHG emission reduction is evaluated after selecting the evaluation target from among the options indicated below, depending on the details of the project implemented.

Evaluation Target	Details and Methodology of Evaluation
Reduced GHG (CO_2) emissions associated with reduced amount of waste generated	Evaluate from the reduction of GHG (CO_2) emissions from waste collection vehicles and from the reduction in GHG (CO_2) emissions from waste incinerated—due to the reduction in use of waste collection vehicles and reduction in waste incineration (thanks to intermediate processing), both associated with the reduction in amount of waste generated (or waste collected) For specific evaluation methodologies, please refer to section on “II. Mobile Sources” in 2.7 Air Quality Improvement, and “Amount of CO_2 Emissions Generated When Incinerating Waste” in the section titled “Implementation of Sound Waste Management.”
Reduced GHG (CO_2) emissions due to recycling of waste as energy or raw materials	Evaluate from the reduction of GHG (CO_2) emissions generated in connection with the combustion of fossil fuels, due to use of energy and raw materials from waste as an alternative to fossil fuels used in operation of facilities and equipment (fixed sources) and so on. For specific evaluation methodologies, please refer to section “I. Stationery Sources” under “Evaluation Methodologies for Reductions of GHG Emissions” in 2.7 Air Quality Improvement.
Reduced GHG (CH_4) emissions due to reduction in amount of final landfill of waste	Evaluate from reduction of GHG (CH_4) emissions generated in landfill sites, in connection with the reduction of amount of waste going into the landfill site. For specific evaluation methodologies, please refer to section on “Reduced CH_4 Emissions Generated from Waste Landfill Sites” in the section titled “Implementation of Sound Waste management.”

3) Stage 3: Implementation of Sound Waste Management

I. Evaluation Methodology for Benefits in the Environmental Pollution Countermeasures Area

In terms of the benefits relating to the environmental pollution countermeasures area, the effects of reduced COD concentrations—an indicator of organic matter in leachate from waste landfill sites—are evaluated quantitatively, and the effects of reduced odors—an indicator of offensive odors—are evaluated semi-quantitatively.

A) Reduction in COD Concentrations (an indicator of organic matter in leachate from waste landfill sites)
The methodology to evaluate COD concentrations in leachate from landfill sites is shown below.

Equation for Calculating Reduction in COD Concentrations

$$ER_{COD} = BE_{COD} - PE_{COD}$$

Where

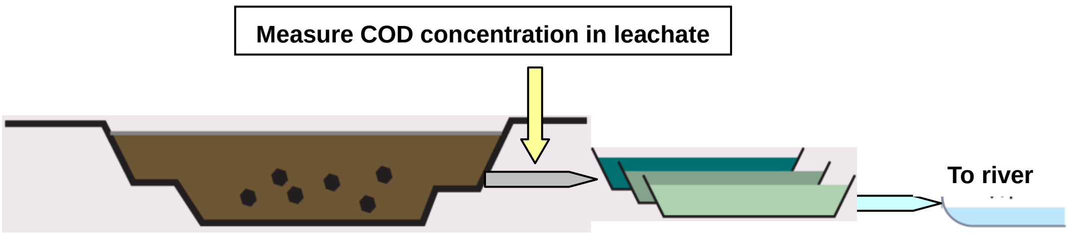
ER_{COD}	Reduction in COD concentrations discharged (mg/m^3)
BE_{COD}	Baseline scenario COD concentrations (mg/m^3)
PE_{COD}	Project scenario COD concentrations (mg/m^3)

Data Collection Methods for Quantitative Evaluations
Below are the data items and related data collection methods required for quantitative evaluation.

Data Item	Data Collection Method
COD concentrations in leachate (mg/m^3)	Measure concentrations in leachate from landfill sites.

Data Collection Locations for Evaluations
Below are the locations for collection of data required for evaluation.

Baseline Scenario, Project Scenario



B) Evaluation Methodology for Reduction of Offensive Odors
An odor is selected as an indicator of offensive odors generated from offensive odor substances in effluent, and an odor index is used, based on quantitative (or semi-quantitative) evaluation. For specific evaluation methodologies, please refer to section on “Evaluation Methodology for Reduction of Offensive Odors” in the Water Quality Improvement category.

II. Evaluation Methodology for Reductions of GHG Emissions
The GHG emission reduction is evaluated by the reduction in emissions of methane (CH_4), a GHG generated from waste landfill sites, and where waste incineration is conducted as a form of intermediate treatment, it is necessary to evaluate the total amount by also considering the GHGs generated in connection with incineration.

A) Reduced CH_4 emissions generated from waste landfill sites
The calculation methodology for the reduction of CH_4 emissions generated from waste landfill sites is selected from the two methods indicated below, depending on the situation.

Options for Evaluation Methodologies
Option 1: Evaluation using calculation tool for avoided CH4 emissions from a waste landfill site[33]
Option 2: Evaluation using reference tables that estimate GHGs emitted from waste landfill sites using data such as the population emitting the waste brought to the landfill site, and site

33 Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site

management approach.

Option 1: Evaluation using calculation tool for avoided methane emissions from a waste landfill site

For CH_4 generated at a waste landfill site, calculate the amount using the IPCC-prescribed “Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site” based on the First Order Decay (FOD) model.

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

Where

$BE_{CH4,SWDS,y}$	GHG emissions generated from final waste landfill site (tCO_2e)
φ	Model correction factor for calculating uncertainties in the model
f	Ratio of recovered methane that is handled by flaring, combustion, or use
GWP_{CH4}	Methane global warming potential: 21
OX	Oxidation factor: managed landfill site (0.1), other site (0)
F	Default value for ratio of methane (by volume) in gases emitted from landfill site: 0.5
DOC_f	Default value for fraction of degradable organic carbon (DOC) which decomposes: 0.5
MCF	Methane correction factor
$W_{j,x}$	Weight of organic waste type j buried in landfill site in year x (tons)
DOC_j	Fraction of degradable organic carbon (DOC) contained in waste type j (by weight)
k_j	Decay rate of waste type j
j	Waste type
x	Year in which waste was landfilled (the x value ranges from the year the landfill was started [x=1] until the year the methane emissions are calculated [x=y])
y	Year in which methane emissions are calculated

Table 2-12 DOC_j Default Values[34]

Waste type j	DOCj (% wet waste)	DOCj (% dry waste)
Wood and wood products	43	50
Pulp, paper and cardboard (other than sludge)	40	44
Food, food waste, beverages and tobacco (other than sludge)	15	38
Textiles	24	30
Garden, yard and park waste	20	49
Glass, plastic, metal, other inert waste	0	0

[34] 2006 IPCC Guidelines for National Greenhouse Gas Inventories

Table 2-13 kj Default Values[35]

Waste type j		Boreal and temperate (MAT < 20ºC)		Tropical (MAT > 20ºC)	
		Dry (MAP/PET<1)	Wet (MAP/PET >1)	Dry (MAP < 1000mm)	Wet (MAP > 1000mm)
Slowly degrading	Pulp, paper, cardboard (other than sludge), textiles	0.04	0.06	0.045	0.07
Moderately degrading	Wood and wood products	0.02	0.03	0.025	0.035
	Other (non-food) organic putrescible garden and park waste	0.05	0.10	0.065	0.17
Rapidly degrading	Food, food waste, beverages and tobacco	0.06	0.185	0.085	0.40

Option 2: Evaluation Methodology Using Reference Table

This method estimates GHGs emitted from waste landfill sites using data such as the population emitting the waste brought to the landfill site, and site management approach.

Table 2-14. Reference Table for Calculating GHG Emissions from Waste Landfill Sites

		Landfill Management Level								
		1. Managed			2. Unmanaged (Deep)			3. Unmanaged (Shallow)		
South-Eastern Asia		1st year	7th year	Average of 1st – 7th year	1st year	7th year	Average of 1st – 7th year	1st year	7th year	Average of 1st – 7th year
Population supplying waste to landfill site (thousand persons)	100	10,519	3,990	6,527	8,415	3,192	5,222	4,208	1,596	2,611
	300	31,558	11,969	19,581	25,246	9,575	15,665	12,623	4,787	7,832
	1,000	105,193	38,896	65,271	84,155	31,916	52,217	42,077	15,958	26,108
	3,000	315,580	119,687	195,812	252,464	95,749	156,650	126,232	47,875	78,325
	10,000	1,051,933	398,956	652,706	841,546	319,165	522,165	420,773	159,582	261,083
Eastern Europe										
Population supplying waste to landfill site (thousand persons)	100	14,444	11,010	12,658	11,555	8,808	10,127	5,778	4,404	5,063
	300	43,332	33,031	37,975	34,666	26,425	30,380	17,333	13,212	15,190
	1,000	144,440	110,103	126,582	115,552	88,082	101,266	57,776	44,041	50,633
	3,000	433,319	330,309	379,747	346,655	264,247	303,797	173,328	132,124	151,899
	10,000	1,444,397	1,101,029	1,265,822	1,155,517	880,823	1,012,658	577,759	440,412	506,329
South America										
Population supplying waste to landfill site (thousand persons)	100	8,743	4,430	6,328	6,994	3,544	5,063	2,497	1,772	2,531
	300	26,229	13,289	18,985	20,983	10,631	15,188	10,491	5,316	7,594
	1,000	87,429	44,298	63,285	69,943	35,438	50,628	34,972	17,719	25,314
	3,000	262,287	132,893	189,854	209,830	106,314	151,883	104,915	53,157	75,941
	10,000	874,290	442,976	632,846	699,432	354,381	506,276	349,716	177,190	253,138

Source: "CER Estimation Toolkit," Global Environment Centre Foundation.

[35] 2006 IPCC Guidelines for National Greenhouse Gas Inventories

Data Collection Methods for Quantitative Evaluations

Below are the data items and related data collection methods required for quantitative evaluation.

Type	Data Item	Data Collection Method
Data required to calculate methane emissions generated from waste landfill site	Amount of organic waste buried	Obtain statistical data (estimates) on organic waste buried
	Ratio of degradable organic carbon, by waste type	Use the relevant data indicated by the calculation tool
	Decay rate, by waste type	Use the relevant data indicated by the calculation tool
	Population	Local population emitting waste

B) Amount of CO_2 Emissions Generated When Incinerating Waste

Calculate the amount of CO_2 emissions generated when incinerating waste by using equations published by the IPCC.[36]

$$CO_2 emissions = \sum_i (SW_i * dm_i * CF_i * FCF_i * OX_i) * \frac{44}{12}$$

Where

SWi	Total solid waste incinerated (Gg/year)
dmi	Dry matter content in waste incinerated
CFi	Carbon content in dry weight
FCFi	Fossil carbon fraction contained
OXi	Oxidation factor (1.0)

Table 2-15. Default Values for Coefficients

Parameters	Management Practice	MSW	Industrial Waste (%)	Clinical Waste (%)	Sewage Sludge (%)	Fossil Liquid Waste (%)
Dry matter content in % of wet weight (dmi)	-	-	NA	NA	NA	NA
Total carbon content in % of dry weight	-	-	50	60	40-50	80
Fossil carbon fraction in % of total carbon content	-	-	90	40	0	100
Oxidation factor in % of carbon input	Incineration	100	100	100	100	100

Data Collection Methods for Quantitative Evaluations

Below are the data items and related data collection methods required for quantitative evaluation.

Type	Data Item	Data Collection Method
Data required for calculation of CO_2 emissions generated when incinerating waste	Total solid waste incinerated	Calculate total solid waste incinerated

[36] 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 5

2.8.2 Monitoring

Monitoring is conducted after project implementation in order to verify the effects of the project.

(1) Monitoring of Effects in the Environmental Pollution Countermeasures Area

The details of monitoring of effects in the environmental pollution countermeasures area are shown below.

1) Monitoring for Tier 1

Where evaluation is implemented under Tier 1, in order to determine the effects of project implementation, monitoring is conducted as shown below.

Subject of Evaluation	Monitoring Description
Projects relating to “activities” such as installation of equipment	If the operating conditions are monitored to confirm that operations are normal, it can be assumed that problems associated with waste management are partially alleviated
Projects relating to “Controls and Programs” (e.g., formulation of regulations, etc.)	If the status of initiatives to introduce regulations, etc., is monitored to confirm that legislation is actually formulated toward compliance with regulations, it can be assumed that the potential exists to lead to solutions to waste-related problems.

2) Monitoring for Tier 2 and Tier 3

Where evaluation is implemented under Tier 2 or Tier 3, monitoring is conducted as shown below to determine the effects of project implementation.

I. Monitoring Items

Stage	Evaluation Items	Monitoring Description
1	Area covered by waste collection	Expansion of collection area (land area data)
	Amount of waste collected	Amount of waste collected
2	Amount of waste generated (amount of waste collected)	Amount of waste generated or collected
	Recycling rate	Amount of waste recycled
	Amount of waste landfilled	Amount of waste placed in landfill
3	COD concentration	COD concentration in wastewater leaching from waste landfill site (mg/m^3)
	Odors	Odors from wastewater leaching from waste landfill site, and from area around waste landfill site

II. Monitoring Methodologies and Frequency

Monitoring Items	Monitoring Method	Frequency
Waste collection area	Measure area covered by waste collection from maps and the like	Once per month
Amount of waste collected	Measure from amount of waste transported into waste landfill site	Each time
Amount of waste generated (amount of waste collected)	Conduct surveys through interviews and various other means, by waste source, to determine amount of waste at the waste generation stage Note that where it is difficult to obtain data on waste generated amount, substitute by using the amount of waste after it is collected, by using truck scales and so on.	Once per month
Recycling rate	Calculate the amount of waste recycled and total amount of waste from data on the amount of waste transported into intermediate processing facilities and into final landfill sites	Once per month

Amount of waste landfilled	Measure using truck scales and compile data on the amount of waste transported into final landfill sites	Each time
COD concentrations (mg/m^3)	Select one of the following methodologies for measuring COD concentrations Measure the potassium permanganate consumed after reacting for 30 minutes in a boiling water bath (100°C) of sulfuric acid and potassium permanganate, then calculate the level of organic pollution in the sample.[37] Simplified measurement method: Packed measurement method	Once per month
Odors	Measure odors using the triangle odor bag method or a simplified version of that method.	Once per month

(2) Monitoring of Reductions of GHG Emissions

The details of monitoring of GHG emission reduction effects are shown below.

1) Monitoring Items

Stage	Evaluation Items	Monitoring Description
1	Number of waste collection vehicles	Number of waste collection vehicles
	Distance travelled by waste collection vehicles	Distance travelled by waste collection vehicles
	Average amount of fuel consumption by waste collection vehicles	Amount of fuel used by waste collection vehicles
2	Number of waste collection vehicles	Number of waste collection vehicles
	Distance travelled by waste collection vehicles	Distance travelled by waste collection vehicles
	Average amount of fuel consumption by waste collection vehicles	Amount of fuel used by waste collection vehicles
	Amount of waste incinerated	Amount of waste incinerated
	Fossil fuel consumption	Data on amount of fossil fuel used by facilities
	Amount of methane generated	Amount of methane generated from landfill sites
3	Amount of methane generated	Amount of methane generated from landfill sites
	Amount of waste incinerated	Amount of waste incinerated

2) Monitoring Methodologies and Frequency

Stage	Monitoring Items	Monitoring Method	Frequency
1	Number of waste collection vehicles	Investigate the number of waste collection vehicle	Once per month
	Distance travelled by waste collection vehicles	Investigate the distance travelled by waste collection vehicles	Once per month
	Amount of fuel consumed by waste collection vehicles	Investigate data on the amount of fuel consumed by waste collection vehicles	Once per month
2	Number of waste collection vehicles	Investigate the number of waste collection vehicles	Once per month
	Distance travelled by waste collection vehicles	Investigate the distance travelled by waste collection vehicles	Once per month
	Amount of fuel consumed by waste collection vehicles	Investigate data on the amount of fuel consumed by waste collection vehicles	Once per month

[37] Another method is the potassium dichromate measurement method, but it produces higher readings of COD.

	Amount of waste incinerated	Quantify and summarize data on the amount of waste incinerated	Once per month
	Fossil fuel consumption	Record and summarize data on amount of fossil fuels used	Once per month
	Amount of methane generated	Install equipment to measure and monitor amount of methane generated from landfill sites	Once per month
3	Amount of methane generated	Install equipment to measure and monitor amount of methane generated from landfill sites	Once per month
	Amount of waste incinerated	Quantify and summarize data on the amount of waste incinerated	Once per month

2.8.3 Examples of Calculations for Evaluations

As for examples of calculations of co-benefits in the waste management category, the following data is provided for reference of integrated waste management programs previously implemented in developing countries. Please refer to the Project Design Document (PDD) of the UN-registered projects for examples of calculations of the GHG reduction effects.

(1) Project Outline

A certain developing country is developing an integrated waste management plan, by determining the actual state of waste management in parts of the country and considering long-term measures to make improvements.

This project has formulated the following basic strategy:
Establish basic rules relating to waste management, such as improvements in legal infrastructure.
Strengthen institutional arrangements relating to waste management.
Establish systematic collection services (such as establishing collection routes and support systems, data management, communication with citizens, etc.).
Consensus-building among local governments (about improving operation of landfill sites; construction and operation of intermediate processing stations, etc.).
Start to apply the 3Rs (reduce, reuse, recycle).
Apply the polluter-pays principle, and consider the needs of the poorest in society.

(2) Evaluation of Co-Benefits

1) Evaluation If Tier 1 Is Used

If Tier 1 is used to evaluate the co-benefits of this project, because it is “improvement of regulatory framework based on comprehensive program for industrial waste management, and establishment of collection service” being implemented, we estimate the reduction of illegal dumping and other problems. In the case of “improvement of regulatory framework” and “establishment of collection service,” if it can be confirmed that the related legislation enters into force and the system improvements for collection service are implemented, we can assume that they could lead to solutions to waste problems and that the benefits of waste reduction would be large. Thus, the co-benefit evaluation using Tier 1 earns a score of “3.”

2) Evaluation If Tier 2 Is Used

If Tier 2 is used to evaluate the co-benefits of this project, for Type 1: Overall optimization of waste management system and improvement of landfill site management system, the reduction in COD concentration in leachate is evaluated quantitatively from the improvement of collection area coverage ratio, an increase in the amount of waste collected, a change in the management approach at the landfill site. The following are values assumed based on the project described above.

I. Improvements in Collection Area Coverage Ratio

About 70% of the area is currently covered by waste collection. By project implementation, the improvement in the waste collection area coverage ratio would be the following if increased to about 82%:

Improvement in collection area coverage ratio = 82% – 70% = 12%.

II. Reduction in COD Concentrations in Leachate from Landfill Site

The current COD concentration in leachate from the waste landfill site is 1,500 mg/m^3.
By implementation of the project, through reduction in the amount of organic waste brought to the landfill site and in the decomposition of organic matter, if the COD concentration in leachate were reduced to 1,000mg/m^3, the COD concentration in leachate would be calculated as follows:

Reduction in COD concentration = 1,500 mg/m^3 − 1,000 mg/m^3 = 500 mg/m^3

Appendices

Table 2-16. Water Quality Improvement Category: Selected List of Projects Using the Co-Benefits Approach

Category		Description of Project	Co-Benefit Indicator	Co-Benefit Effect	Target Area	Pollution Source	Pollutants Other Than Those Counted by Co-Benefit Indicators	Project Examples (Registered as CDM Projects, Etc.)	
Point sources	House-hold	- Reduce methane emissions and/or capture methane, by newly installing (or expanding or repairing) facilities, where sewage is discharged directly into rivers due to inadequate sewage treatment facilities or capacity - Reduce methane emissions and/or capture methane, by rehabilitating or bolstering the sewerage system, where the system is in poor condition and leads to discharged household wastewater stagnating on the ground - Reduce methane emissions and/or capture methane, by constructing wastewater recycling facilities or improving the recycled-water piping network, in regions experiencing both water pollution and water scarcity - When newly installing or repairing sewage treatment facilities, introduce energy-efficient equipment. - Introduce sewage treatment to villages (100 to 200 households), capture methane to generate electricity, and provide electricity to the village.	- COD - Odors - CH_4 - CO_2	- Reduced emissions of water pollutants (COD) from untreated domestic wastewater - Reduced emissions of GHGs (methane) generated from wastewater - Reduction of fossil fuel or energy consumption thanks to installation of energy-efficient equipment	Sewage treatment	Sewage and domestic wastewater from business establishments, restaurants, households	- SS - Coliform bacteria	CDM-REGISTERED PROJECTS (None) - No such CDM projects have yet been registered, but one listed methodology to reduce GHG emissions involves reducing the amount of energy required to supply water to end users of municipal waterworks, by improving the efficiency of pumping (AM0020). ODA PROJECTS, ETC. - ODA projects by JICA under yen loans include construction of sewage treatment plants, upgrades of wastewater/sewage treatment systems, expansion of water pumping stations, sewage treatment (water recycling) plant improvements, etc. Some projects also include training for personnel of the implementing bodies. - Capacity building is also being offered, including project planning for sewage treatment projects, and operations/maintenance of sewage treatment plants, etc.	
	Factories	Reduce methane emissions and/or capture methane (and use it to generate electricity), by changing the treatment process for concentrated organic wastewater - Capture methane by anaerobic treatment processes - Change an inefficient anaerobic treatment process into an efficient anaerobic treatment process, and capture methane - Reduce methane emissions by changing an inefficient aerobic treatment process that released methane, into an efficient aerobic treatment process - Change an inefficient aerobic treatment process into an efficient anaerobic treatment process, and capture methane Reduce amount of energy use relating to wastewater treatment, by introducing energy-efficient wastewater treatment technology Use wastewater for energy or as a raw material. - Recover/concentrate and burn black liquor from paper manufacturing industry and use as biomass energy - Recover inorganic matter generated after combustion of black liquor from paper manufacturing industry, to produce NaOH, Na_2S, etc. - Recover alcohol from blackstrap molasses and use to generate electricity Reduce volume of wastewater and reduce GHG emissions (i.e., clea	- COD - Odors - CH_4 - CO_2	・Reduce emissions of water pollutants by enhancing efficiency of wastewater treatment ・Reduced emissions of GHGs (methane) generated from wastewater ・Reduction of fossil fuel or energy consumption thanks to installation of energy-efficient equipment ・Use resources effectively by reusing wastewater	Paper manufactur-ing industry	Cleaning processes in pulp, paper manufacturing, etc.	- Black liquor - SS	No such CDM projects have yet been registered, but one listed methodology to reduce GHG emissions involves reducing the amount of energy consumed in traditional soda manufacturing processes, by recovering caustic soda from black liquor (AMS-III.M).	Under two-stuff loans relating to environmental pollution remediation and environmental protection, JICA is implementing various activities, including training for cleaner production, and related development studies.
						General effluent from pulp, paper manufacturing, etc.	- SS	- 2 registered CDM projects (concentrated organic wastewater treatment) - AM0013: 1 project (newsprint manufacturing) - AMS-III.H: 1 project (paper factory)	
					Food	Effluent from starch, sugar factories, etc.	- Waste blackstrap molasses - Dye substances	- 2 registered CDM projects (concentrated organic wastewater treatment) - AM0022: 1 project (starch factory) - AMS-III.H: 1 project (corn product factory)	
						Effluent from beverage manufacturing plants (beer, brewed liquors, soft drinks)	- SS	- 8 registered CDM projects (some duplication) (concentrated organic wastewater treatment) - AM0013: 2 projects (alcohol manufacturing from monosaccharides, ethanol plant) - AMS-III.H: 5 projects (alcohol manufacturing from molasses, distilleries [3], beer/soda manufacturing) - AMS-III.I: 1 project (distillery)	
						Effluent from seafood processing plants	- SS - Oil substances		
						Effluent from abattoirs	- SS - Oil substances		
						Effluent from agar manufacturing	Plant residue (SS)		
						Effluent from manufacturing plants for miso paste, shoyu sauce, edible amino acids, vinegar, etc.	SS		

						Effluent from animal/plant oil and fat manufacturing (palm oil, lard, salad oil, etc.)	- Waste liquid from oil expression - SS - Coliform bacteria	・16 registered CDM projects (concentrated organic wastewater treatment) －AM0013: 2 projects (avoided methane emissions from organic wastewater treatment) －AM0022: 4 projects (avoided wastewater and on-site energy use emissions in the industrial sector) －AM0039: 1 project (methane emissions reduction from organic wastewater and bioorganic solid waste using co-composting) －AMS-III.H: 9 projects (methane recovery during wastewater treatment)	
					Textile industries	Effluent from textile factories	Dye substances		
					Cokes production	Effluent from cokes manufacturing factories	- Oil substances - Ammonia water - Coal tar		
					Petro-chemical industry	Wastewater from oil refinery (including wastewater from business establishments)	- Oil substances - Hydrogen sulfide - Ammonia - Phenol		
					Rubber products manufactur-ing	Effluent from natural rubber manufacturing plant	Residue (SS)		
					Leather manufactur-ing	Effluent from leather factory	- SS - n-hexane extract - Chrome		
	Livestock	Reduce methane emissions and/or capture methane (and use it to generate electricity), by changing the treatment process for livestock waste	- COD - Odors - CH_4 - CO_2	- Reduce emissions of water pollutants from untreated wastewater - Reduced emissions of GHGs (methane) generated from wastewater	Barns	Livestock farming effluent	- SS - Coliform bacteria	- There are many registered CDM projects relating to emission reduction/capture of methane from livestock waste. - AM0006 (→ACM0010): Multiple projects (GHG emission reductions from manure management systems) - AM0016 (→ACM0010): Multiple projects (GHG mitigation from improved animal waste management systems in confined animal feeding operations) - ACM0010: 1 project (Consolidated methodology for GHG emission reduction from manure management systems) - AMS-III.D: Multiple projects (Methane recovery in animal manure management systems)	
Non-point sources	Rivers, canals, roadways	Improve bottom sediment and water quality, and reduce methane emissions and/or capture methane, by dredging and aeration of bottom sludge in lakes, river courses, etc.	- COD - Odors - CH_4 - CO_2	- Improve condition of bottom sediment and water quality - Reduced emissions of GHGs (methane) by improvement of condition of bottom sediment and water quality	Mountain forests, denuded land	Rivers, canals, lakes	- SS - Nitrogen - Phosphorus		

*Feasibility studies (FS) conducted by the Glocal Environment Centre Foundation.

Table 2-17. Air Quality Improvement Category: Selected List of Projects Using the Co-Benefits Approach

Category	Description of Project	Co-Benefit Indicator	Co-Benefit Effect	Target Area	Pollution Source	Pollutants Other Than Those Counted by Co-Benefit Indicators	Project Examples (Registered as CDM Projects, Etc.)
Mobile Sources	PROJECT-BASE - Shift from gasoline to biofuels - Introduce low-emission vehicles (with low emissions of GHGs and air pollutants) POLICY-BASE - Introduce/strengthen vehicle inspection programs - Ease traffic congestion by improving the transport network - Introduce intelligent transportation systems (ITS) - Promote environmentally-conscious driving - Promote the use of public transportation (rail, etc.)	- Nitrogen oxides (NO_x) - CO_2	- Reduced air pollution emissions due to reduced use of fossil fuels	Vehicles		- PM - CO - Hydrocarbons	CDM-REGISTERED PROJECTS - Registered CDM projects —AM0031: 1 project (bus rapid transit [BRT] systems) —AM0047: Production of biodiesel based on waste oils and/or waste fats from biogenic origin for use as fuel —AMS-III.C: Emssion reduction by low GHG-emission vehicles ODA PROJECTS - Currently being implemented are projects to help ease traffic congestion, and integrated transportation plan formulation, etc.
Stationary Sources	- Use of biobriquets - Use of biogas - Introduce improved kilns - Introduce solar cookers - Improve distri	・Sulfur oxides (SO_x) ・Nitrogen oxides (NO_x) ・Particulates ・CO_2	・Reduced SO_x emissions due to reduced fossil fuel consumption, due to improved energy efficiency ・Reduced SO_x emissions due to reduced fossil fuel consumption, due to improved combustion efficiency ・Reduced SO_x emissions by using waste heat for power generation or other use, replacing fossil fuel use for power or heat generation ・Prevention of particulate dispersion by converting treatment	Residential/commercial	Households		CDM-REGISTERED PROJECTS - 1 registered CDM project - AM0044: Energy efficiency improvements by boiler rehabilitation or replacement - AMS-I.C: 1 project (solar cookers) ODA PROJECTS - Projects include assistance to formulate investment plans for briquets manufacturing equipment, and village development including introduction of improved kilns.
	- Rehabilitation of boilers - Upgrading to high-efficiency boilers - Shifting from single cycle to combined cycle - Repowering - Rehabilitation of power distribution grid - Shift to fuels with lower sulfur and nitrogen content - Change from old to energy-efficient flue gas desulfurization equipment			Industrial	Boilers (thermal power plants)	- CO - Hydrocarbons	CDM-REGISTERED PROJECTS - 9 registered CDM projects - AMS-II.A: Energy-efficiency on supply side (power distribution) - AMS-II.B: 9 projects, supply-side energy efficiency (power generation) - There are many methodologies for fuel shifting projects ODA PROJECTS, ETC. - Project examples include thermal power plant rehabilitation, power distribution grid efficiency improvements, and thermal power plant conversion from fuel oil to gas combustion. - NEDO is implementing model projects and other projects.
	- Shift to fuels with lower sulfur and nitrogen content - Conversion to high-efficiency boilers - Use heat recovery as a substitute for fossil fuel - Shift to processes that will reduce amount of energy use				Boilers (other types)	- CO - Hydrocarbons	- 1 registered CDM project - AM0017: Steam system efficiency improvements by replacing steam traps and returning condensate - AM0018: Methodologies for steam optimization systems (many registered) - AMS-II.C: Demand-side energy-efficiency activities for specific technologies (many registered) - There are many methodologies for fuel shifting projects - NEDO is implementing heat recovery model projects and other projects.
	Prevention of particulate dispersion (as quenching is done within sealed cooling tower) by introducing cokes dry quenching (CDQ) equipment, and GHG emission reduction by the use of waste heat				Coke oven	- CO - Benzene and other volatile organic compounds (VOCs)	- ACM0012 is a CDM-approved methodology relating to GHG emission reductions from waste energy recovery. - NEDO is implementing model projects and other projects.

	- Flare gas recovery and use				Oil refineries, etc.		- CDM-approved methodologies include AM0009, AM0037, etc.
	- Introduce fluidized bed firing method - Reduce amount of clinker produced in cement production by using byproducts such as fly ash as a substitute for clinker.		- Reduced SOx emissions from reduced fossil fuel use due to reduction in cement use, due to the use of fly ash and blast furnace slag		Firing furnace		- CDM-approved methodologies include ACM0005, etc. - NEDO is implementing Fluidized-bed Advanced cement Kiln System (FAKS) demonstration projects.
Other	- Electricity demand-side energy conservation - Electric power generation using otherwise unutilized energy - Increase the renewables' share of electrical power generation (limited only to cases that result in lower emissions of air pollutants)	- Sulfur oxides (SOx) - Nitrogen oxides (NOx) - Particulates - CO2	- Reduced SOx emissions due to reduced fossil fuel consumption, due to improved energy efficiency	Emissions indirectly related to electricity		- CO - Hydrocarbons	- There are CDM-approved methodologies relating to energy conservation (AMS-II.C, AMS-II.D, etc.). - There are many CDM-approved methodologies relating to biomass, hydropower, etc. - Some ODA projects being implemented involve renewable energy. - NEDO is implementing projects relating to renewable energy.

*Feasibility studies (FS) conducted by the Glocal Environment Centre Foundation.

Table 2-18. Waste Management Category: Selected List of Projects Using the Co-Benefits Approach

Category	Countermeasures	Description of Project	Co-Benefit Indicator	Co-Benefit Effect	Project Examples (Registered as CDM Projects, Etc.)
・Waste and sewage from business establishment, restaurants, households ・Sludge from sewage treatment facilities (as well as other organic waste emitted from factories, etc.)	Establishment of waste management infrastructure systems	improvement of waste collection/transport systems - Newly introduce or repair waste collection vehicles that will expand the collection area and increase collection efficiency, and construct systematic/institutionalized waste collection/treatment systems.	- Collection coverage area ratio - Waste collection ratio	Implement systematic/institutionalized waste management administrative structure by establishing waste management infrastructure systems.	ODA PROJECTS - ODA projects being implemented include overall improvements in waste treatment systems (procurement of garbage collection vehicles, construction of waste transfer stations, improvement of vehicle repair centers, improvement of landfill sites, etc.).
	Reduction of waste volume	- Reduce the amount of waste emitted, by introducing composting and sorted collection of waste. - Reduce the amount of waste treatment, by recycling waste as energy and raw materials.	- Amount of waste generated (collected) - Recycling rate - Waste treatment amount	Promotion of efforts to reduce waste volume	
	Implementation of sound waste management	- Reduce methane emissions and capture methane at the landfill disposal stage, by introducing semi-aerobic waste treatment methods, etc. - Mitigate methane emissions generated from waste and improve water quality of leachate, by applying semi-aerobic treatment methods, etc.	- Odors - COD	Reduction of the negative impacts on the surrounding environment, by implementation of proper waste treatment	CDM PROJECTS - ACM0001: Landfill methane capture/use (many projects) - AM0025: Composting, gasification, anaerobic digestion, refuse-derived fuel (RDF)/stabilized biomass (SB), incineration (6 projects registered) - AMS-III.G: Methane capture/use at small-scale landfill sites: (4 projects registered) - AMS-III.D: Waste in small-scale agriculture (many projects registered) - AMS-III.E: Small-scale RDF/SB (many projects registered) - AMS-III.F: Small-scale composting - AMS-III.L: Stabilization through pyrolysis of waste - AMS-III.R: Biogas digester at the household/small farm level (1 project registered) - Model project study currently being conducted using semi-aerobic treatment method
- Animal and plant residue from food products manufacturing plants, beverage manufacturing plants (beer, brewed liquors, soft drinks), etc. - Wood waste (sawdust, bark) from pulp, paper, and paper product industry - Oil cake, clay waste, EFB, from animal/plant oil and fat manufacturing (palm oil, lard, salad oil, etc.) - Waste plastic emitted from factories, etc. - Waste transported to incineration treatment facilities	Recycling as energy source	- Recycle and reuse sludge from residue as energy, by anaerobic digestion and methane recovery - Reuse as biomass energy the generated byproducts (chaff, bagasse and other residue, oil cake, EFB, etc.) - Reduce the amount of fossil fuel used, by turning waste plastic into solid fuel, and recycling it through use as fuel for combustion - Use heat from incineration of waste as energy.	- Sulfur oxides (SOx) - CO2	- Reduced emissions of GHGs (methane) generated from waste - Reduction of GHG emissions, by using as substitute fuel for fossil fuels - Reduction of air pollutant emissions, by using as substitute fuel for fossil fuels	CDM PROJECTS - ACM0006: Wood biomass waste utilization (electric power generation, cogeneration, etc.) (many projects registered) - AM0042: New cultivation or residue utilization of wood biomass (electric power generation) - AMS-I.A,B,C,D: Electrical power generation and heat utilization from biomass waste (many projects registered)
- Coal ash from coal-fired power generation plants - Blast furnace slag from steel manufacturing plants)	Recycle as raw material	- Conduct effective use of waste and reduce the amount of f	- CO2	- Reduce the amount of fossil fuel used, by reusing waste as raw material	CDM PROJECTS - ACM0003: Use biomass as a substitute raw material in cement (many projects registered) - ACM0005: Blended cement (many projects registered) - AM0033: Use slag and other materials as substitute raw material in cement manufacture - AM0040: Use as substitute raw material in cement clinker - AM0057: Use EFB as raw material in pulp/paper - AMS-III.J: Use biomass as substitute for fossil-fuels as source of CO2 for beverages

Reference: Internal Rate of Return for the Co-Benefits Approach to Climate Change and the CDM

When promoting co-benefits-type CDM projects, it is necessary to accurately determine the feasibility of the project implementation, and to identify and promote those projects that have the highest project feasibility. Important yardsticks for this evaluation include the above-described co-benefits relating to air pollution, water pollution, and waste issues, as well as reductions of GHG emissions, and also the internal rate of return (IRR) to evaluate the economic feasibility of the project in question. For co-benefits-type CDM projects, when considering the IRR, it is also necessary to consider ways to calculate the co-benefit effects (environmental benefits) relating to water pollution, air pollution, waste issues, and so on.

Below are examples of calculations of environmental benefits calculated for economic internal rate of return (EIRR) of Japanese official development assistance (ODA) projects implemented in the past.

IRR is the decision-making criterion most widely used by banks and corporate financial departments, as well as in public investment, ODA, and so on, when seeking answers to the following types of questions.

- Does the recovery of sludge or sediment from the river bottom justify the investment?
- Which of these should be installed in a steel plant: Expensive coke dry quenching (CDQ), or conventional coke wet quenching (CWQ) equipment?
- What is the maximum expenditure that can be applied for environmental equipment as part of the total project cost?

Internal rate of return (IRR): An indicator to measure the return on investment during the project period (the discount rate that will result in a net profit or loss of zero during the project)

Internal rate of return（r）$\equiv \sum\{(B-C)_t \div (1+r)^t\}=0$ where t=1,2,・・・・, n

(For the IRR, the equipment service life or other measure is set as the project period. Thus for equipment that will last 30 years, the equation is a thirtieth-degree polynomial equation.)

	Type	Outflow	Inflow	Type of Return	Evaluation Criteria
FIRR (Financial internal rate of return)	With cash revenue	Expenditure	Revenue	Cash	Compare with interest rate levels in the region concerned
EIRR (Economic internal rate of return)	Without cash revenue	Cost	Benefit	Tangible or intangible benefit	Example: 4% (Japan), 12% (developing country)

- FIRR is measured by monetary value of revenues and expenditures. For EIRR, on the other hand, the method of converting monetary value of “benefits” varies with the conditions of the country in question.
- Projects with an EIRR below 12% are not, in principle, eligible for review by international financial institutions such as the World Bank and Asian Development Bank. In post-project

evaluations, the EIRR is re-calculated, and in the case of the ADB, a project rating 8% or higher is rated as a "general success," 6 to 7% as a "partial success," and under 4% as a "failure."

- The private sector always calculates FIRR in investment decisions. EIRR is an indicator that looks at economic benefits and costs from the perspective of the national economy, and is largely used for public projects and ODA, but it sometimes cannot be calculated in certain sectors.
- These terms are commonly abbreviated as ERR and FRR, respectively. Also, where it is obvious to readers, FIRR is often denoted simply as IRR in certain documents, such as the PDD of CDM projects.

Project Example	FIRR	EIRR	Benefits reported in terms of EIRR
World Bank: Combined cycle gas turbine power plant in Huizhou (China)	5.3% (without CER emission credits), 6.0% (with)	12.7%	Electricity generation, reduction of air pollutant emissions, reduction of CO_2 emissions
World Bank power and water sector rehabilitation (Madagascar)	24.8% to 51.0% depending on the component evaluated	14.4%	Electricity generation, cost savings from diesel oil substitution
World Bank energy sector rehabilitation (Kosovo)	Not calculated	27%	Health benefits (disability adjusted life years, or DALY, based on epidemiology) due to dismantling of coal-fired power plant
ADB urban environmental improvements (Anhui, China)	Not calculated	12.7% to 35.8% depending on the component evaluated	Increase in land values
ADB coal mine methane development (China)	6.2% to 7.2% depending on the component evaluated	21.1% to 27.5% depending on the component evaluated 30.9% to 42.1% if global environmental benefits are counted	Natural gas and electricity production, global environmental benefits
ADB urban development for small and medium cities midland (Vietnam)	3.9% to 11.7% depending on the component evaluated	14.2% to 24.4% depending on the component evaluated	Clean water supply (reduction of time required to draw water, users' willingness to pay, etc.) Sewage treatment (reduction of negative effects on health and land)

Source: World Bank, Asian Development Bank