# Guidelines for Measurement, Reporting and Verification of GHG Emission Reductions in JBIC GREEN Operation ("J-MRV Guidelines")

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# Guidelines for Measurement, Reporting and Verification of GHG Emission Reductions in JBIC GREEN Operation (the "J-MRV Guidelines")

## Preface

- As global warming could have adverse effects on the world economy, reduction of greenhouse gas (GHG) emissions is an international challenge that should be tackled through co-operation among all countries. To ensure the effective reduction of emissions, it is imperative that, in addition to reduction efforts in industrial countries including Japan, there is also accelerated and increased investment to facilitate reduction of emissions in developing countries, where ever-expanding energy use fueled by economic growth is expected to substantially increase emissions. Industrial countries are also called on to actively support the efforts of developing countries to reduce emissions.
- Against this backdrop, the Government of Japan enforced the act to revise part of the Japan Finance Corporation Act in March 2010 ("the Revised JFC Act") to strengthen support for projects that are expected to reduce emissions. Financial operations undertaken by JBIC pursuant to the Revised JFC Act for this purpose are referred to as "Global action for Reconciling Economic growth and Environmental preservation (GREEN)".
- In providing financing for projects that lead to reduction of emissions under GREEN, JBIC required measurement, reporting and verification of the GHG emission reductions in the projects in order to assess eligibility of the projects (provided that this process is only required for projects that JBIC decided to support before the end of June, 2018.). These guidelines ("Guidelines") contain principles and procedures for its process. The process of measuring, reporting and verifying GHG emission reductions in accordance with Section 2 and after is referred to as "J-MRV".
- J-MRV is intended to be a simple, practical and internationally acceptable process, based on JBIC's operational experience with reference to international good practices on quantification of emission reductions. JBIC shall make the Guidelines public and, if necessary, continue to improve them by lessons learnt from implementing J-MRV as well as taking account of international discussions regarding quantification of emission reductions.

## Section 1. Scope of the Guidelines

(1) Objective

- JBIC aims to support the efforts of developing countries through financing emission reduction projects aiming to prevent global warming by using simple and practical quantification measures. JBIC shall apply J-MRV in its day-to-day operations to achieve expeditious emission reductions in such projects.

(2) Eligible Projects

- JBIC shall, in principle, quantify GHG emission reductions in accordance with J-MRV in all projects, (provided that this process is only required for projects that JBIC decided to support before the end of June, 2018,) under GREEN that will lead to reduction of emissions. Such projects include those financed through credit lines that JBIC provides to financial institutions ("Credit Lines") and those financed through funds in which JBIC participates ("Funds"). For those GREEN projects JBIC decided to support on or after July 1, 2018, some of Guidelines apply, mutatis mutandis, but only when required by JBIC.
- J-MRV will measure GHG as set forth in the United Nations Framework Convention on Climate Change ("UNFCCC"). The emission reductions are quantified in terms of $CO_2$ equivalent tons converted in accordance with global warming coefficients set forth in the UNFCCC.

(3) Utilizing Measures/Mechanisms of International Institutions

- Notwithstanding the paragraph (2) above, in a case where JBIC cooperates with an international or other institution which has its own measures or mechanisms to quantify GHG emission reductions, JBIC may, taking into account the paragraph (1) above, apply such quantification measures/mechanisms instead of J-MRV, provided that JBIC confirms that such measures/mechanisms are equivalent to or above the level of J-MRV as a measure to quantify GHG emission reductions, in terms of the extent of reference to international good practices on quantification of emission reductions.
- JBIC will review the level of J-MRV and the measures/mechanisms of the

international or other institution by comparing their quantifying procedures, methodologies, accuracy of data, and emission factors/values.

(4) Organization of Advisory Committee

- JBIC shall set up an Advisory Committee ("Committee") consisting of outside experts. In administrating J-MRV, the Committee will use their expertise to provide opinions based on the Guidelines and the Administration Rules of the Advisory Committee (Annex 1).

## Section 2. Principles and Procedures

(1) General Concept

- J-MRV shall be implemented by using simple and practical quantification measures for emission reductions, based on JBIC's operational experience and with reference to the existing international practices for quantification, such as the Kyoto Mechanisms and ISO (International Organization for Standardization) standards (such quantification measures are defined as "J-MRV Methodologies").
- Templates of J-MRV Methodologies are specified in Annex 2.

(2) Project Boundary

- The project boundary is, in principle, that part of the project financed by JBIC as reasonably determined in accordance with JBIC's involvement in the project.

(3) Baseline Emissions

- The basic concepts regarding baseline emissions are as follows:

**Case A.**

**Renovation and Improvement of Existing Facilities**

The baseline emissions are determined by considering from various aspects such as the investment circumstances of the project, the availability and reliability of the data, and with reference to the following options. Theoretical values and estimates based on sampling results may be also used as necessary. Also, in case of a project involving expansion of production capacity, the baseline emissions are, in principle, to be determined as adjusted after

expanded capacity.

Options;

(a) The emissions of the project before renovation or improvement of the existing facility, based on the performance and operating conditions of equipment and facility.
(b) The emissions of similar projects with widely used facilities in the host country or region.
(c) The emissions of similar projects with recently-installed facilities in the host country or region.

**Case B.**

**Installing New Facility**

The baseline emissions are determined by considering from various angles such as the investment circumstances of the project, the availability and reliability of the data, and with reference to the following options. Theoretical values and estimates based on sampling results may be used as necessary.

Options;

(a) The emissions of similar projects with widely used facilities in the host country or region.
(b) The emissions of similar projects with recently-installed facilities in the host country or region.
(c) The emissions determined based on the emission factors of electricity as described below in the host country or region where the projects would be implemented.

(4) Emission Reductions

- The emission reductions are the difference between the baseline emissions and the actual emissions from the project.
- Emission factors required for calculating the baseline emissions and the actual emissions from the project are shown below. The table of emission factors and other related data (Appendix) will be revised by JBIC with reference to the opinions of the Committee.

A. The emission factors of electricity are determined, taking into

account the availability and reliability of the data referring to the following:

(1) the national emission factor in the host country;
(2) the emission factors of similar projects under the Kyoto Mechanisms; and
(3) the values derived from the data of the International Energy Agency (IEA) or other international agencies.

B. The fuel emission factors are, in principle, determined in accordance with the default value in the Intergovernmental Panel on Climate Change (IPCC) Guidelines.

(5) Insignificant Effect within the Project Boundary

- If insignificant emission sources are obvious, the total emission reductions shall be deducted by 5%, unless it would cause any substantial effects.

(6) Significant Effect outside of the Project Boundary ("Leakage")

- If significant Leakage effects are expected, the leakage emissions shall be considered in applying J-MRV Methodologies.

(7) Multiple Emission Sources

- If there are many similar kinds of emission sources within the project boundary, estimation on sampling or theoretical calculation may be used. In this case, emission reductions shall be deducted by 5% unless it would cause any substantial effects.

## Section 3. Procedures for J-MRV

(1) Preparing J-MRV Methodologies

- J-MRV employs J-MRV Methodologies in the Annex 3, in accordance with Section 2. above.
- If there is no appropriate J-MRV Methodology for quantification of the emission reductions in a project, JBIC shall provide a new methodology. Upon request from JBIC, the Committee shall review such new methodology draft in accordance with the Guidelines, and submit opinions to JBIC. JBIC shall designate it as an additional methodology and make it public.

- The Committee shall review J-MRV Methodologies annually, in principle, and submit opinions to JBIC upon request from JBIC. If necessary, JBIC shall revise J-MRV Methodologies and make them public.

(2) Planned Emission Reductions in Project Preparation Stage

- In the project preparation stage, JBIC shall calculate the expected emissions (projection), with reference to a feasibility study report provided by the borrower and/or the project proponent, and determine the baseline emissions with applying J-MRV Methodologies. The difference between the baseline emissions and the projection is defined as "Planned Emission Reductions".
- JBIC shall, as necessary, ask the Committee to review application of the relevant J-MRV methodology and the Planned Emission Reductions, and submit opinions on them.
- Prior to making the financing decision, JBIC shall agree with the borrower or the project proponent on a monitoring plan (monitoring items and methods) based on the appropriate J-MRV methodology.
- JBIC may retain outside experts on calculation of the Planned Emission Reductions.

(3) Measurement and Reporting of Emission Reductions after Completion of Construction / Installation of the project

- The borrower or the project proponent shall measure emissions of the project according to the monitoring plan and report them to JBIC.
- Such measurement and reporting shall be made, in principle, for one year period after the completion of construction / installation of the project.
- The borrower or the project proponent shall report to JBIC in the event of any material change from the original project plan of the project that is stated in the monitoring plan. In that event, JBIC shall request another measurement and report as necessary.

(4) Calculation and Verification of Emission Reductions

- Upon receiving a report on measurement results based on Section 3.(3) above, JBIC shall calculate and conduct verification of the emission reductions of the project promptly. JBIC may have a site visit, as necessary, in case further clarification is needed regarding the measurement.

- JBIC may retain outside experts on calculation of the emission reductions of the project.
- JBIC may ask the Committee to review the results of calculation and verification, and submit opinions, as necessary.

## Section 4. Provisions applicable to Credit Lines and Funds

- In the project preparation stage, since not all eligible projects are determined at the time of financing decisions in Credit Lines or Funds, JBIC may calculate Planned Emission Reductions as set forth in Section3.(2) above without attributing to individual projects based on feasibility study reports.
- In measurement, reporting and verification of emission reductions in Credit Lines or Funds, JBIC may simplify J-MRV Methodologies to be applied. JBIC may ask the Committee to review the above results and submit opinions on them.

## Section 5. Disclosure of Emission Reductions under J-MRV

- The emission reductions calculated based on the Guidelines shall be disclosed while complying with full considerations of confidentiality.
- JBIC shall set forth applicable disclosure procedures separately from the Guidelines.

Annex 1

## Administration Rules of the Advisory Committee ("Administration Rules")

### I: Objective

The Advisory Committee ("Committee") shall consist of outside experts and shall be established in order to facilitate the quantification of Greenhouse Gas (GHG) emission reductions of the projects in GREEN under the J-MRV Guidelines.

### II: Composition

1. The Committee shall consist of not more than seven (7) members.
2. Each member of the Committee shall have expertise and experience in climate change mitigation projects, the Kyoto Mechanisms, ISO (International Organization for Standardization) Standards, and other methods for quantifying emission reductions in energy-utilizing projects.
3. The members of the Committee shall elect one member as the chair person.

### III: Appointment of Members of the Committee

1. The members of the Committee shall be appointed by JBIC.
2. Each member shall be appointed for a three-year term and may be re-appointed for subsequent terms.
3. JBIC may dismiss any member of the Committee without prior consent of the relevant member if JBIC determines that any significant hindrance in the functioning of the Committee is likely to be caused by the relevant member.

### IV: Duties and Position of Members of the Committee

The members of the Committee shall conduct their duties as members on the basis of their expertise and with neutrality under the J-MRV Guidelines and these Administration Rules.

## V: The Committee

1. The Committee shall submit an opinion to JBIC on the following matters upon request from JBIC:

(1)The amount of emission reductions attributable to the projects under the J-MRV Guidelines;
(2)The provisions of the J-MRV Guidelines and J-MRV Methodologies (as revised from time to time) and other related matters;
(3)Other matters necessary for efficient implementation of the J-MRV Guidelines; and
(4)An annual review of the J-MRV Methodologies.

## VI: Convening of the Committee

The Committee shall be convened by the chair person, whenever necessary, upon request from JBIC.

## VII: Decisions

1. The Committee shall make decisions on the matters in Article V.
2. At least a majority of the members of the Committee shall be present to constitute a quorum.
3. The Committee's decisions shall be adopted by a majority of the votes of members who are present at the meeting of the Committee. In case of a tie, the chair person shall have the deciding vote.
4. In case of absence of a member, the relevant member may delegate the proxy vote to the chair person.
5. If a member may have a conflict of interest with respect any of the matters described in any item of Article V, including any case in which he/she is, or was, a director or an employee of any outside experts (including corporations) retained for planned emission reductions, J-MRV methodologies or other related matters under the J-MRV Guidelines, he/she may not exercise his/her voting right in the Committee.

## VIII: Minutes

A summary of decisions shall be made as the minutes for each meeting of the Committee.

## IX: Secretariat

1. The secretariat of the Committee shall be established within JBIC.
2. The secretariat shall manage the administration of the Committee.
3. The secretariat shall collect and provide to the Committee any necessary information to supplement or revise the provisions of J-MRV Guidelines, J-MRV methodologies and other relevant documents.

## X: Confidentiality

The members shall not disclose matters and information that they have acquired in connection with quantification of emission reductions in relation to a project to any third party, and shall maintain their confidentiality.

Annex 2

Templates of J-MRV Methodologies

1. Applicable Projects

2. Project Boundary

3. Concept and Formula of Emission Reductions
   (1) Basic Concept
   (2) Basic Formula

4. Baseline Emissions
   (1) Basic Concept
   (2) Basic Formula

5. Project Emissions
   (1) Basic Concept
   (2) Basic Formula

6. Effect outside of the Project Boundary (Leakage)

7. Measurement and Reporting of Emission Reductions

8. Reference
   (1) Supplementary Explanation
   (2) Referenced Standards and Methodologies

History of Revisions

# Methodology for Renewable Energy Projects

## 1. Applicable Projects

This methodology is applicable to projects that generate power and/or supply heat by using renewable energy sources, and projects that produce biofuel. The following table shows the main renewable energy sources and forms of energy utilization.

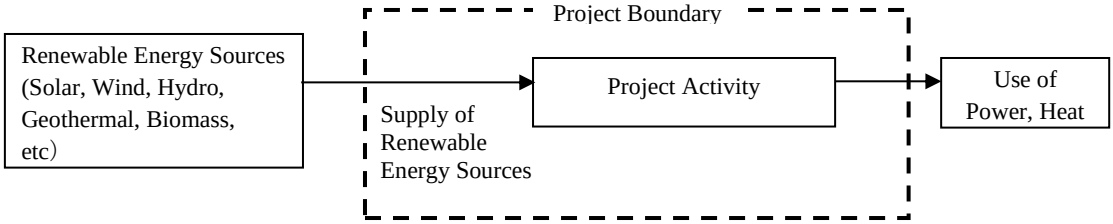
| Renewable Energy Sources / Forms of Energy Utilization | Solar | | Wind | Hydro | Geo thermal | Biomass |
|---|---|---|---|---|---|---|
| | Light | Heat | | | | |
| Power Generation | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Heat Supply | - | ✓ | - | - | ✓ | ✓ |
| Biofuel Production | - | - | - | - | - | ✓ |

Since biofuel production projects are different from the other renewable energy projects in some aspects, the methodology is divided as ANNEX.

## 2. Project Boundary

The project boundary encompasses activity of the applicable project to which JBIC finance is extended.

It also includes activities regarding the supply of renewable energy sources associated with the project.[1]




## 3. Concept and Formula of Emission Reductions

(1) Basic Concept

A. Power generation projects

In the case where power is generated by using renewable energy source, emission reductions are the difference between the amount of emission when the same amount of power generated by the renewable energy project was generated by the average emission rate of all power plants in the country (baseline

[1] Emissions from activities regarding the supply of renewable energy sources associated with the project include: $CO_2$ and $CH_4$ from geothermal steam in geothermal power projects; $CH_4$ from water reservoirs in hydro power projects; and emissions from fuel consumption for transportation of biomass. Refer to "5. Project Emissions" for details.

emissions) and the amount of emission from the project activity (project emissions).

B. Heat supply projects by using renewable energy sources

In the case where heat is supplied by using renewable energy source, emission reductions are the difference between the amount of emission when the same quantity of heat generated by the renewable energy project was generated by the most used fossil fuel in the country (baseline emissions) and the amount of emission from the renewable energy project activity (project emissions).

(2) Basic Formula

Emission reductions are accounted by the difference between the baseline emissions and the project emissions.

$$ER_y = BE_y - PE_y \quad \cdots\cdots (1)$$

$ER_y$ : Annual emission reductions ($tCO_2/yr$)
$BE_y$ : Annual baseline emissions ($tCO_2/yr$)
$PE_y$ : Annual project emissions ($tCO_2/yr$)

## 4. Baseline Emissions

(1) Basic Concept[2]

A. In the case of power generation, baseline emissions are defined to be the amount of emission when the same amount of power generated by the renewable energy project was generated by the average emission rate of all power plants in the country.

B. In the case of heat supply, baseline emissions are defined to be the amount of emission when the same quantity of heat generated by the renewable energy project was generated by the most consumed fossil fuel in the country.

(2) Basic Formula

$$BE_y = BE_{elec,y} + BE_{heat,y} \quad \cdots\cdots (2)$$

$BE_y$ : Annual baseline emissions ($tCO_2/yr$)

[2] In the case where there are regulations/standards/guidelines or international standards in the country with regard to baseline emissions, those are taken into account as factors in accounting the baseline emissions. However, if the project activity is under the government's transitional measures, those factors are considered based on the project nature.

$BE_{elec,\,y}$ : Annual baseline emissions from power generation projects ($tCO_2$/yr)

$BE_{heat,\,y}$ : Annual baseline emissions from heat supply projects ($tCO_2$/yr)

A. Baseline emissions in power generation

$$BE_{elec,y} = EG_y \times EF_{elec} \quad \cdots\cdots (3)$$

$EG_y$ : Annual power generation in the project activity (MWh/yr)

$EF_{elec}$ : Emission factor for power generation[3] ($tCO_2$/MWh)

B. Baseline emissions in heat supply

$$BE_{heat,y} = Q_y \times EF_{fuel} / \eta_{facility} \quad \cdots\cdots (4)$$

$Q_y$ : Annual heat supply in the project activity (GJ/yr)

$EF_{fuel}$ : Emission factor of the most used fossil fuel in the country[4] ($tCO_2$/GJ)

$\eta_{facility}$ : Heat efficiency of baseline heat supply facility (default = 0.9)[5]

## 5. Project Emissions

(1) Basic Concept

In this methodology, basically, project emissions from power generation and heat supply using renewable energy sources are considered zero since they do not consume fossil fuel in their generating process. On the other hand, if any, emissions from the consumption of external power and fossil fuel within the

[3] Refer to "generating end emission factor" or "sending end emission factor" in the "1. Emission Factors for Electricity" of Appendix in this Guideline. However, other emission factor based on F/S report etc. may be applicable if the project substitutes in-house power generation or if the project is implemented in off-grid area inter alia, provided that there is a rational explanation.

[4] Emission factor of the most used fossil fuel in the country is either of the following.
1) For the emission factor of the most used fossil fuel in the country, refer to "2. Emission Factors of Fuels" of Appendix in this Guidelines, while the most used fossil fuel in the country shall be defined based on the data of the IEA, or,
2) Specific data in the F/S report etc., provided that there is a rational explanation.

[5] This default value is based on statistical data (source: "Handbook for heating, air-conditioning and sanitary engineering of Japan") of heat efficiency of various types of boilers. If there is any specific data of heat efficiency in the F/S report etc. for the project, it may be applicable, provided that there is a rational explanation.

project boundary should be taken into account.[6]

In addition, apart from the above, emissions associated with (i) Geothermal project, (ii) Hydro power project and (iii) Biomass project should be considered based on the APPENDIX.

(2) Basic Formula

$$PE_y = PE_{EC,y} + PE_{FC,y} + PE_{OE,y} \quad \cdots\cdots (5)$$

$PE_y$ : Annual project emissions ($tCO_2$/yr)

$PE_{EC,y}$ : Annual project emissions from external power consumption ($tCO_2$/yr)

$PE_{FC,y}$ : Annual project emissions from fossil fuel consumption ($tCO_2$/yr)

$PE_{OE,y}$ : Annual project emissions associated with geothermal project, hydro power project and biomass project ($tCO_2$/yr)

$$PE_{EC,y} = EC_{PJ,y} \times EF_{elec} \quad \cdots\cdots (6)$$

$EC_{PJ,y}$ : Annual consumption of external power in the project activity ($tCO_2$/yr)

$EF_{elec}$ : Emission factor for power generation[7] ($tCO_2$/MWh)

$$PE_{FC,y} = \sum_i \left( FC_{i,y} \times NCV_i \times EF_{fuel,i} \right) \quad \cdots\cdots (7)$$

$FC_{i,y}$ : Annual consumption of fossil fuel *i* in the project activity (t, kl/yr)

$NCV_i$ : Net calorific value of fossil fuel *i*[8] (GJ/t, kl)

$EF_{fuel,i}$ : Emission factor of fossil fuel *i*[9] ($tCO_2$/GJ)

As for the calculation formula for $PE_{OE,y}$ ,refer to APPENDIX.

## 6. Effect outside of the Project Boundary (Leakage)

[6] For example, emissions from fuel consumption for pre-processing biomass in power generation and heat supply projects, and from pumping up of geothermal steam are considered. However, emissions from the consumption of fuel in order to transport biomass are not taken into account.

[7] Refer to "generating end emission factor" or "sending end emission factor" in the "1. Emission Factors for Electricity" of Appendix in this Guideline. However, other emission factor based on F/S report etc. may be applicable if the project substitutes in-house power generation or if the project is implemented in off-grid area inter alia, provided that there is a rational explanation.

[8] Refer to Appendix (3. Net Calorific Values of Fuels) in this Guidelines.

[9] Refer to Appendix (2. Fuel Emission Factors of Fuels) in this Guidelines.

Leakage is not taken into account, unless it is obviously significant.[10].

## 7. Measurement and Reporting of Emission Reductions

The monitoring items are as follows:

A. In the case of power generation project

| Monitoring Items | | Source of Data | | Solar (light) | Solar (heat) | Wind | Hydro | Geo -thermal | Biomass |
|---|---|---|---|---|---|---|---|---|---|
| | | Planned Value | Result Value | | | | | | |
| $EG_y$ | Annual power generation (MWh/yr) | ・F/S report etc. | ・Record of electricity meter | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| $EC_{PJ,y}$ | Consumption of external power (MWh/yr) | | ・Record of electricity meter[11] | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| $FC_{i,y}$ | Consumption of fossil fuel *i* (t, kl/yr) | | ・Record in the project facility | - | ✓ | - | - | ✓ | ✓ |

B. In the case of heat supply project

| Monitoring Items | | Source of Data | | Solar (light) | Solar (heat) | Wind | Hydro | Geo -thermal | Biomass |
|---|---|---|---|---|---|---|---|---|---|
| | | Planned Value | Result Value | | | | | | |
| $Q_y$ | Annual heat supply in the project activity (GJ/yr) | ・F/S report etc. | ・Calculated value with calorimeter, flow meter etc.[12] | - | ✓ | - | - | ✓ | ✓ |
| $EC_{PJ,y}$ | Consumption of external power (MWh/yr) | | ・Record of electricity meter | - | ✓ | - | - | ✓ | ✓ |

[10] The potential effects outside the Project Boundary are: emissions in the upstream and downstream (lifecycle) of the project activity (e.g. emissions from biomass production and from manufacturing solar panels, etc.), or indirect emissions associated with the project activity (e.g. Decrease in GHG absorption sources caused by forest logging for location shift of the activity conducted prior to the project activity, or for producing new biomass). These will not be taken into account in this Methodology. However, JBIC will expect borrowers and relevant parties to take appropriate measures when significant source of leakage is found. As for biomass projects, JBIC will oblige borrowers and relevant parties to confirm the sustainability of the project when loan decision is made, and to observe such sustainable criteria after project implementation.

[11] If data on external power and fossil fuel consumption in the project activity are not obtainable, the figure calculated from consumption per one unit of power generation may be applicable.

[12] It is advisable to use calculated value with calorimeter. Depending on the project situation, calculated value with flow meter, thermometer, pressure meter etc. may be applicable as well.

| Monitoring Items | | Source of Data | | Solar (light) | Solar (heat) | Wind | Hydro | Geo -thermal | Biomass |
|---|---|---|---|---|---|---|---|---|---|
| | | Planned Value | Result Value | | | | | | |
| $FC_{i,y}$ | Consumption of fuel *i* (t, kl/yr) | | ・Record in the project facility | - | ✓ | - | - | ✓ | ✓ |

## 8. References

(1) Supplementary Explanation

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(2) Referenced Standards and Methodologies

A. Standards / Guidelines

・2006 IPCC Guidelines for National Greenhouse Gas Inventories

・Special Report on Renewable Energy Sources and Climate Change Mitigation, FINAL RESEASE, May 2011, IPCC

B. CDM Methodologies

| Energy Sources | Methodology | Small Scale Methodology |
|---|---|---|
| Solar | ACM0002, AM0019 | AMS-I.J., I.D.,I.F., I.C. |
| Wind | ACM0002, AM0019 | AMS-I.D., I.F. |
| Hydro | ACM0002, AM0019 | AMS-I.A., I.D.,I.F. |
| Geothermal | ACM0002, AM0072, AM0019 | AMS-I.D., I.F.,I.C. |
| Biomass | ACM0002, ACM0006, ACM0018, AM0042 | AMS-I.D., I.F.,I.C. |
| Biofuel production | ACM0017, AM0089 | AMS-I.H., III.T., III.A.K. |

History of Revisions

・ Released, June, 2010 (“Electric power generation and/or thermal energy supply from biomass residue”)

・ Revised, October, 2012

・ Revised, October, 2014

## APPENDIX

## Project Emissions associated with Geothermal Project, Hydro Power Project and Biomass Project

The details of project emissions from sources other than external power and fossil fuel consumption in section 5 above are described below.

### a) Geothermal project

Emissions of $CO_2$ and $CH_4$ from geothermal steam will be taken into account. However, if the steam is returned to underground after its heat use, as in the case of binary cycle power plant, it is not necessary to take into account.

$$PE_{OE,y} = M_{s,y} \times (W_{main,CO2} + W_{main,CH4} \times GWP_{CH4}) \quad \cdots\cdots (8)$$

$M_{s,y}$ : Annual steam production (t/yr)

$W_{main,CO2}$ : Weight percentage of $CO_2$ contained in the produced steam (wt%)[13]

$W_{main,CH4}$ : Weight percentage of $CH_4$ contained in the produced steam (wt%)[13]

$GWP_{CH4}$ : Global Warming Potential of methane[14] ($tCO_2/tCH_4$)

| Monitoring Items | | Source of Data | |
|---|---|---|---|
| | | Planned Value | Result Value |
| $M_{s,y}$ | Annual steam production(t/yr) | ・F/S etc. | ・Analytical data<br>・Planned amount of F/S etc. |
| $W_{main,CO2}$ | $CO_2$ weight percentage (wt%) | | |
| $W_{main,CH4}$ | $CH_4$ weight percentage (wt%) | | |

### b) Hydro power project

It is not necessary, in principle, to take $CH_4$ emissions from the run of the river hydro power plant and reservoir of hydro power plant into consideration. However, if $CH_4$ emissions from the reservoir of hydro power plant is identified large, they are

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[13] If the measured weight percentage (wt%) of $CO_2$ or methane does not exist, the weight percentage of $CO_2$ or methane per unit of generated electricity may be applicable. The value of $0.122tCO_2/MWh$ may be applicable as $CO_2$ emissions for generated electricity, and 10% of the weight percentage (wt%) of $CO_2$ may be applicable as $CH_4$ emissions for generated electricity (the figures are determined as standardized value in reference to several data sources including Special Report on Renewable Energy Sources and Climate Change Mitigation, Geothermal Energy FINAL RELEASE, May 2011, IPCC).
The formula for $PE_{OE,y}$ is as follws:
$PE_{OE,y} = EG_y \times (0.122 + (0.0122 \times GWP_{CH4}))$
$EG_y$ : Annual power generation in the project activity (MWh/yr)

[14] Refer to Appendix (4. Global Warming Potential of Greenhouse Gas) in this Guidelines.

taken into account with the default value (=0.09t$CO_2$/MWh).[15]

### c) Biomass project

While emission sources in the following table may be identified, their emissions are not taken into account for the reasons given below.[16]

| Emission Sources | Reasons for not considering |
|---|---|
| $CH_4$ and $N_2O$ from biomass combustion | Since the amount of these emissions is generally low, they are not taken into account. |
| $CH_4$ from biomass storage | Based on the assumption that biomass storage is to be kept in aerobic condition, these emissions are not taken into account. |

[15] Based on CDM: Executive Board Report (EB23)

[16] $CO_2$ emissions from biomass combustion are not taken into account since plants absorb $CO_2$ from the atmosphere during their growth.

## ANNEX

## Methodology for Biofuel Production Projects

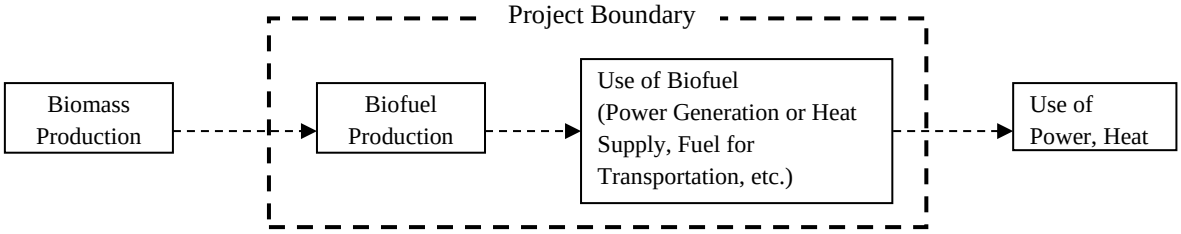
### 1. Applicable Projects

This methodology is applicable to biofuel production projects (producing biodiesel, bioethanol and biomass chips etc.).

### 2. Project Boundary

The project boundary encompasses activity of the biofuel production project to which JBIC finance is extended.

It also includes activities in which the biofuel produced in the project are used (as in power generation, heat supply, fuel for transportation, etc.)




### 3. Concept and Formula of Emission Reductions

(1) Basic Concept

Emission reductions by biofuel production project are difference between the assumed emissions from the use of conventional fuel replaced by biofuel (baseline emissions) and emissions from the production and use of biofuel (project emissions). The emission reductions from activities in which biofuel is produced and used on an annual basis are considered in this methodology.

(2) Basic Formula

Emission reductions are accounted by the difference between the baseline emissions and project emissions.

$$ER_y = BE_y - PE_y \quad \cdots\cdots (1)$$

$ER_y$ : Annual emission reductions ($tCO_2/yr$)

$BE_y$ : Annual baseline emissions ($tCO_2/yr$)

$PE_y$ : Annual project emissions ($tCO_2/yr$)

### 4. Baseline Emissions

(1) Basic Concept

The baseline emissions are the emissions from the replaced energy of conventional fuel which is the same amount of generated energy from biofuel.

(2) Basic Formula

$$BE_y = BF_y \times NCV_{PJ} \times EF_{fuel,i} \quad \cdots\cdots (2)$$

$BE_y$ : Annual baseline emissions ($tCO_2/yr$)
$BF_y$ : Annual production (mass or volume) of biofuel in the project (t, kl/yr)
$NCV_{PJ}$ : Net calorific value of the biofuel produced in the project (GJ/t, kl)
$EF_{fuel,\,i}$ : Emission factor of fossil fuel *i*[17] replaced by biofuel ($tCO_2/GJ$)

## 5. Project Emissions

(1) Basic Concept

Project Emissions are the emissions from biofuel production project and activities in which the biofuel produced in the project is used. However, $CO_2$ emissions from biofuel combustion are not taken into account.

(2) Basic Formula

$$PE_y = PE_{EC,y} + PE_{FC,y} \quad \cdots\cdots (3)$$

$PE_y$ : Annual project emissions ($tCO_2/yr$)
$PE_{EC,\,y}$ : Annual emissions from external power consumption ($tCO_2/yr$)
$PE_{FC,\,y}$ : Annual emissions from fossil fuel consumption ($tCO_2/yr$)

## 6. Effects outside the Project Boundary (Leakage)

Leakage is not taken into account, unless it is obviously significant.

## 7. Measurement and Reporting of Emission Reductions

The monitoring items are as follows:

| Monitoring Items | | Source of Data | |
|---|---|---|---|
| | | Planned Value | Result Value |
| $BF_y$ | Annual production (mass or volume) of biofuel (t, kl/yr) | ・F/S report etc. | ・Annual production volume of biofuel |
| $NCV_{PJ}$ | Net calorific value of the biofuel produced (GJ/t, kl) | ・F/S report etc. | ・Analytical data<br>・Value of similar biofuel |
| $EC_{PJ,y}$ | Consumption of external power (MWh/yr) | ・F/S report etc. | ・Record of electricity meter[18] |
| $FC_{i,y}$ | Consumption of fuel *i* (t, kl/yr) | ・F/S report etc. | ・Consumption record in the project facility[18] |

[17] If fossil fuel replaced by bio fuel is not identified, it may be substituted by the most used fossil fuel in the country (Refer to footnote 4).
[18] If data on external power and fossil fuel consumption in the activity are not obtainable, the figure calculated from the consumption per one unit of biofuel production may be applicable.

# Methodology for Introducing Energy Efficient Equipment/Facilities

## 1. Applicable Projects

This methodology is applicable to projects that reduce energy consumption by introducing new energy efficiency equipment/facilities, or rehabilitation, replacing, or operational improvement for existing equipment/facilities.

## 2. Project Boundary

The project boundary encompasses activity of the applicable project to which JBIC finance is extended.

## 3. Concept and Formula of Emission Reductions

(1) Basic Concept

A. Installation of new equipment/facilities

In the case where new energy efficient equipment/facilities are installed, emission reductions are the difference between the amount of emission from the average energy consumption of the presently most prevailing equipment/ facilities in the country which provides the same output as in the project activity (baseline emissions), and the amount of emission from the energy consumption of the project activity (project emissions).

B. Improvement of existing equipment/facilities[1]

In the case where existing equipment/facilities are improved, emission reductions are the difference between the amount of emission from the energy consumption of the existing equipment/facilities before the project was implemented (baseline emissions), and the amount of emission from the energy consumption of the project activity (project emissions).

(2) Basic Formula

Emission reductions are accounted by the difference between the baseline emissions and project emissions.

[1] Projects involving expansion of production capacity are included.

$$ER_y = BE_y - PE_y \quad \text{..... (1)}$$

$ER_y$: Annual emission reductions ($tCO_2/yr$)
$BE_y$: Annual baseline emissions ($tCO_2/yr$)
$PE_y$: Annual project emissions ($tCO_2/yr$)
y: Project implementation year

## 4. Concept and Formula of Baseline Emissions

(1) Basic Concept[2]

A. Installation of New Equipment/Facilities

In the case where new energy efficient equipment/facilities are installed, baseline emissions are defined to be the amount of emission from the average energy consumption of the presently most prevailing equipment/facilities in the country which provides the same output as in the project activity[3].

B. Improvement of Existing Equipment/Facilities

In the case where existing equipment/facilities are improved, baseline emissions are defined to be the amount of emission from the energy consumption of the existing equipment/facilities before the project is implemented.

(2) Basic Formula

a. Electricity using equipment/facilities

Select an appropriate calculation method from the following option-I and option-II considering the usage and features of the equipment/facilities and calculate emissions using the formula.

Option-I: <u>Calculation based on the annual operating hours</u>

(This is the case where baseline emissions are calculated based on the premise that the annual baseline operating hours are equal to the annual project operating hours.)

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[2] In the case where there are regulations/standards/guidelines in the country or de facto standards with regard to baseline emissions, those are taken into account as factors in determining the baseline emissions. However, if the project activity is under the government's transitional measures, those factors are considered based on the project nature.

[3] Estimated data and/or other reliable value in the country etc. may be applicable to calculate "the average energy consumption of the presently most prevailing equipment/facilities in the country which provides the same output as in the project activity."

$$BE_y = EC_{BL,y} \times EF_{elec,y} \quad \text{.....(2)}$$

$$EC_{BL,y} = \sum_{i=1}^{n} \left( P_{i,BL,y} \times OH_{PJ,y} \right) \quad \text{.....(3)}$$

$BE_y$: Annual baseline emissions ($tCO_2$/yr)

$EC_{BL,y}$: Annual baseline electricity consumption (kWh/yr)

$EF_{elec,y}$: Emission factor for electricity[4] ($tCO_2$/kWh)

n: Number of the baseline equipment/facilities[5] (unit)

i: Index of n units of baseline equipment/facilities

y: Project implementation year

$OH_{PJ,y}$: Average annual operating hours of the equipment/facilities in the project activity[6] (h/yr)

$P_{i,BL,y}$: Power (electricity consumption per hour) of the i-th baseline equipment/facility[7] (kW)

Use the values that most adequately represent the energy consumption characteristics of the equipment/facility.

Refer to Appendix 1 for the calculation method.

Option-II: Calculation based on the annual output[8]

(This is the case where baseline emissions are calculated based on the premise that the baseline output is equal to the project output. Refer to

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[4] In the case where a grid-connected power source is used, refer to "generating end emission factor" or "sending end of emission factor" in "1. Emission Factors for Electricity" of Appendix in this Guideline. However, other emission factor based on F/S report etc. may be applicable if the project uses a project in-house power source or an independent power source in an off-grid area, provided that there is a rational explanation.

[5] The number of the baseline equipment/facilities that can provide the same output as in the project activity. e.g. When the output provided by three units of equipment/facilities in the project activity can be provided by four units of baseline equipment/facilities, n = 4.

[6] When the baseline emissions are calculated based on the annual operating hours, the annual energy consumption is calculated based on the premise that the annual baseline operating hours are equal to the annual project operating hours.

[7] The power is also called "output". In the case where new equipment/facilities are installed, it is the output of the presently most prevailing equipment/facilities in the country which provides the same output as in the project activity. In the case where existing equipment/facilities are improved, it is the output of the equipment/facilities before the project was implemented.

[8] The output is the amount of the output or results produced by the project. For example, the output of a production project is the amount of products (tons) and the output of air conditioners is the quantity of heat (MJ, Mcal, or $KWh_{Thermal}$). Refer to Note 2 of Appendix 2 for details.

Appendix 2 for the formula. )

b. Fuel-using equipment/facilities[9]

$$BE_y = \sum_{i=1}^{n} \left( BC_{fuel,i,y} \times NCV_i \times EF_{fuel,i,y} \right) \quad \text{..... (4)}$$

$BE_y$: Annual baseline emissions ($tCO_2/yr$)

$BC_{fuel,i,y}$: Annual fuel consumption of the i-th baseline equipment/facility[10] (t, kl/yr)

$NCV_i$: Net calorific value of the fuel used for the i-th equipment/facility[11] (TJ/t, TJ/kl)

$EF_{fuel,i,y}$: Emission factor of the fuel used for the i-th equipment/facility[12] (tCO2/TJ)

n: Number of the baseline equipment/facilities[13] (unit)

i: Index of n units of baseline equipment/facilities

y: Project implementation year

## 5. Concept and Formula of Project Emissions

(1) Basic Concept

Project emissions are defined as the amount of emission from the energy consumption in the project activity.

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[9] When the baseline emissions are calculated in a manner such as the above "a. Electricity using equipment/facilities," or are calculated (I ) based on the annual operating hours or (II) based on the annual output, they can be calculated by using values relating to "fuel" instead of values relating to "electricity" (output P, electricity consumption EC, emission factor EF, specific energy consumption ε, energy efficiency η, etc.) in the formula (2), (3), Appendix 1, and Appendix 2.

[10] As for "A," in the case where new equipment/facilities are installed, it is the annual consumption of fuel i of the presently most prevailing equipment/facilities in the country which provides the same output as in the project activity. As for "B," in the case where existing equipment/facilities are improved, it is the annual fuel consumption of the equipment/facilities before the project was implemented.

[11] In the case where there is no specific data from the project operator, data in "3. Net Calorific Values of Fuels" of Appendix in this Guideline can be used as default. Note that the table is based on the net calorific value (NCV).

[12] In the case where there is no specific data from the project operator, data in "2. Fuel Emission Factors" of Appendix in this Guideline can be used as default.

[13] The same as footnote 5.

(2) Basic Formula

a. Electricity Using Equipment/Facilities

Select an appropriate calculation method from the following option-I and option-II considering the usage and features of the equipment/facilities and calculate emissions using the formula.

Option-I: Calculation based on the annual operating hours

(This is the case where the annual energy consumption in the project activity is calculated by multiplying the electricity consumption per hour with the annual operating hours.)

$$PE_y = EC_{PJ,y} \times EF_{elec,y} \quad \text{..... (5)}$$

$$EC_{PJ,y} = \sum_{i=1}^{n} \left( P_{i,PJ,y} \times OH_{PJ,y} \right) \quad \text{..... (6)}$$

$PE_y$: Annual project emissions ($tCO_2$/yr)

$EC_{PJ,y}$: Annual electricity consumption in the project activity (kWh/yr)

$EF_{elec,y}$: Emission factor for power generation[14] ($tCO_2$/kWh)

n : Number of energy efficient equipment/facilities introduced in the project activity (unit)

i: Index of n units of the equipment/facilities in the project activity

y: Project implementation year

$OH_{PJ,y}$: Average annual operating hours of the equipment/facilities in the project activity (h/yr)

$P_{i,PJ,y}$: Power (electricity consumption per hour) of the i-th energy efficient equipment/facility introduced in the project activity (kW)

As for P, the values that most adequately represent the energy consumption characteristics of the equipment/facility are applied.

Refer to Appendix 1 to calculate and determinate P.

[14] The same as footnote 4.

Option-II: Calculation based on the annual output[15]

(This is the case where the annual energy consumption in the project activity is calculated based on the project output and using the energy efficiency or specific energy consumption. Refer to Appendix 2 for the formula.)

b. Fuel-Using Equipment/Facilities[16]

$$PE_y = \sum_{i=1}^{n} \left( PC_{fuel,i,y} \times NCV_i \times EF_{fuel,i,y} \right) \quad \text{..... (7)}$$

$PE_y$: Annual project emissions ($tCO_2/yr$)

$PC_{fuel,i,y}$: Annual fuel consumption of the i-th energy efficient equipment/facility in the project activity (t, kl/yr)

$NCV_i$: Net calorific value of the fuel used for the i-th energy efficient equipment/facility[17] (TJ/t, TJ/kl)

$EF_{fuel,i,y}$: Emission factor of the fuel used for the i-th energy efficient equipment/facility[18] ($tCO_2/TJ$)

n: Number of energy efficient equipment/facilities introduced in the project activity (unit)

i: Index of n units of energy efficient equipment/facilities

y: Project implementation year

## 6. Effect outside of the Project Boundary (Leakage)

Leakage is not taken into account, unless it is obviously significant[19].

[15] The same as footnote 8.
[16] The same as footnote 9.
[17] The same as footnote 11.
[18] The same as footnote 12.
[19] The potential effects outside of the Project Boundary are: emissions in the upstream and downstream (lifecycle) of the project activity (e.g. emissions from manufacturing energy efficient equipment, etc.), or indirect emissions associated with the project activity. These will not be taken into account in this Methodology unless they are significant. However, JBIC will expect borrowers and relevant parties to take appropriate measures when a significant source of leakage is found.

## 7. Measurement and Reporting of Emission Reductions

a. Electricity-Using Equipment/Facilities

Project emission would be calculated by the method of option-I or option-II described in the section 5.(2) Basic Formula. The monitoring items are specified according to method of option-I or option-II selected in the project emission calculation as follows:

Option-I: In the case where the calculation is based on the annual operating hours

| Monitoring Items | | Source of Data | |
|---|---|---|---|
| | | Planning Value | Result Value |
| $EC_{PJ,y}$ | Annual electricity consumption in the project activity (kWh/yr) | | Power meters, operation records, etc. |
| n | Number of energy efficient equipment/facilities in the project activity | | Annual operation records, etc. |
| $OH_{PJ,y}$ | Average annual operating hours in the project activity (h/yr) | | Annual operation records, etc. |
| $P_{i,PJ}$ | Power (electricity consumption per hour) of the i-th equipment/facility (kW), i = 1, ..., n | | Power meters, operation records, etc. |
| Parameters for calculation of $P_{i,PJ}$ | If $P_{i,PJ}$ was calculated by the formula (i) to (vii) shown in the Appendix1, the numeric data for the element of these formula must be quantified here. For instance:<br>Rated power($P_{Rated}$),<br>Load factor(α),<br>Measured power($P_{Measured}$),<br>Hourly Output($L_h$),<br>Energy consumption efficiency(η), Specific energy consumption(ε), Power loss($P_{Loss}$),<br>User-defined power($P_{User\text{-}defined}$) | ・F/S report etc. | ・Power meters, operation records, etc.<br>・data measured by manufacturer of the equipment |

Option-II: In the case where the calculation is based on the annual output

| Monitoring Items | | Source of Data | |
|---|---|---|---|
| | | Planning Value | Result Value |
| $EC_{PJ,y}$ | Annual electricity consumption in the project activity (kWh/yr) | F/S report etc. | Power meters, operation records, etc. |
| $L_{PJ,y}$ | Annual output bu the Project. (unit/yr)<br>Note: refer to note2 in Appendix2 for "unit" | | Operation records., etc. |
| $\varepsilon_{PJ}$<br>or<br>$\eta_{PJ}$ | Project specific energy consumption (kWh/unit)<br>Project energy efficiency . (unit/kWh) | | Direct measurement, Operation records, etc. |

b. Fuel-Using Equipment/Facilities

| Monitoring Items | | Source of Data | |
|---|---|---|---|
| | | Planning Value | Result Value |
| $PC_{fuel,i,y}$ | Annual fuel consumption of the i-th energy efficient equipment/facility in the project activity (t/yr, kl/yr, etc.), i = 1, ..., n | F/S report etc. | Direct measurement, Operation records, etc. |
| $L_{PJ,y}$ | Annual output in the project activity (unit/yr)<br>Note1: As for "unit", refer to note2 in Appendix2.<br>Note2: The value of annual output is necessary as the premise of baseline emission's calculation. | | Direct measurement, Operation records, etc. |

8. References

(1) Supplementary Explanation

This methodology is applicable to projects using energy efficient electric devices such as motors, pumps, compressors, boilers, heat pumps, lighting, and air conditioners, and improving energy efficiency through measures such as fuel switching.

(2) Referenced Standards and Methodologies

[CDM]

- AMS-II.C: Demand-side energy efficiency activities for specific technologies
- AMS-II.D: Energy efficiency and fuel switching measures for industrial facilities
- AMS-III.X: Energy Efficiency and HFC-134a Recovery in Residential Refrigerators
- AM0060: Power saving through replacement by energy efficient chillers
- AM0070: Manufacturing of energy efficient domestic refrigerators
- AMS-II.O: Dissemination of energy efficient household appliances
- AMS-II.J: Demand-side activities for efficient lighting technologies
- AM0056: Efficiency improvement by boiler replacement or rehabilitation and optional fuel switch in fossil fuel-fired steam boiler systems
- AM0020: Baseline methodology for water pumping efficiency improvements
- AM0106: Energy efficiency improvements of alime production facility through installation of new kilns
- AMS-III.Z: Fuel switch, process improvement and energy efficiency in brick manufacture
- ACM0023: Introduction of an efficiency improvement technology in a boiler
- AM0044: Energy efficiency improvement projects–boiler rehabilitation or replacement in industrial and district heating sectors
- AM0067: Methodology for installation of energy efficient transformers in a power distribution grid
- AM0097: Installation of high voltage direct current power transmission line
- AMS-II.A: Supply side energy efficiency improvements–transmission and distribution

History of Revisions

- Released, June, 2010
- Revised, October, 2012
- Revised, October, 2014
- Revised, November, 2017

Appendix 1

**Examples of the calculation and determination methods of power P (electricity consumption per hour) of equipment/facilities**

The following (i) to (vii) are examples of formulas for calculating power $P_{i,BL}$ and $P_{i,PJ}$ in the formulas (iii) and (vi) for calculating annual baseline and project electricity consumption. (In these examples, "i", which shows the equipment/facility, "BL" and "PJ", which show baseline or project, and "y", which shows the project year, in the formulas (3) and (6), are omitted.)

i. $P = P_{Rated}$ (Rated power[20]) (kW)

ii. $P = P_{Rated} \times \alpha$ (Rated power x hourly averaged load factor[21]) (kW)

iii. $P = P_{Measured}$ (Past measured data or experimental data) (kW)

iv. $P = L_h / \eta$ (Output per unit time/energy efficiency) (kW)

$L_h$: Output per unit time (unit/h)[22]

$\eta$: Energy consumption efficiency (unit/kWh)[23]

v. $P = L_h \times \varepsilon$ (Output per unit time x specific energy consumption)

$L_h$: Output per unit time (unit/h)

$\varepsilon$: Specific energy consumption (kWh/unit)[24]

vi. $P = P_{Loss}$ (Power loss per unit time[25]) (kW)

vii. $P = P_{User\text{-}defined}$ (Hourly averaged power consumption defined by the project operator[26]) (kW)

*In the case of vii., the project operator must show technical evidence.

[20] This is called "rated power", "nameplate power", "maximum continuous rating (MCR)", etc.

[21] The load factor α is the ratio (0.0-1.0) of required power during actual operation to the rated power. It is set based on the design values of the equipment, experimental measurement values, and the experience and knowledge of the project operator.

[22] The output represents workloads or results produced by a project activity. Since its unit varies depending on the activity, the general term “unit” is used in these formulas. Refer to Appendix 2, Note 2 for details.

[23] The energy efficiency η represents the output produced by a unit of energy. Refer to Appendix 2, Note 1 for details.

[24] The specific energy consumption ε represents the energy consumption necessary for producing a unit of output. Refer to Appendix 2, Note 1 for details.

[25] Power losses of power transmission and distribution systems, transformers, AC-DC converters, motors, and ICs are applicable.

[26] This value can be defined based on the knowledge of the project operator. The project operator must show technical evidence separately.

Appendix 2

**Formulas based on the annual output**

(1) Formula of baseline emissions

$$BE_y = EC_{BL,y} \times EF_{elec,y} \quad \text{..... (B1)}$$

$BE_y$ : Baseline emissions ($tCO_2$/yr)

$EF_{elec,y}$: Emission factor for electricity ($tCO_2$/kWh)[27]

$EC_{BL,y}$: Annual baseline electricity consumption (kWh/yr)

$EC_{BL,y}$ will be calculated using either of the following B2, B3, B4, or B5.

(a) Using specific energy consumption ε: Note 1

$$EC_{BL,y} = L_{PJ,y} \times \varepsilon_{BL} \quad \text{..... (B2)}$$

or

$$EC_{BL,y} = EC_{PJ,y} \times (\varepsilon_{BL} / \varepsilon_{PJ}) \quad \text{..... (B3)}$$

$EC_{PJ,y}$: Annual electricity consumption in the project activity

$L_{PJ,y}$: Project output (unit/yr) Note 2

$\varepsilon_{PJ}$ : Project specific energy consumption (kWh/unit)

$\varepsilon_{BL}$ : Baseline specific energy consumption (kWh/unit)

(b) Using energy efficiency η: Note 1

$$EC_{BL,y} = L_{PJ,y} / \eta_{BL} \quad \text{..... (B4)}$$

or

$$EC_{BL,y} = EC_{PJ,y} \times (\eta_{PJ} / \eta_{BL}) \quad \text{..... (B5)}$$

$EC_{PJ}$ : Annual electricity consumption in the project activity

$L_{PJ,y}$: Project output (unit/yr) Note 2

$\eta_{PJ}$ : Project energy efficiency (unit/kWh)

$\eta_{BL}$ : Baseline energy efficiency (unit/kWh)

(2) Formula of project emissions

$$PE_y = EC_{PJ,y} \times EF_{elec,y} \quad \text{..... (B6)}$$

$PE_y$ : Project emissions ($tCO_2$/yr)

$EF_{elec,y}$: Emission factor for electricity ($tCO_2$/kWh)[28]

$EC_{PJ,y}$: Annual project electricity consumption (kWh/yr)

$EC_{PJ,y}$ is calculated using either of the following B7 or B8.

(a) Using specific energy consumption ε:

[27] The same as footnote 4.

[28] The same as footnote 4.

$EC_{PJ,y} = L_{PJ} \times \varepsilon_{PJ}$ ..... (B7)

$\varepsilon_{PJ}$: Project specific energy consumption (kWh/unit)

(b) Using energy efficiency η:

$EC_{PJ,y} = L_{PJ} / \eta_{PJ}$ ..... (B8)

$\eta_{PJ}$: Project energy efficiency (unit/kWh)

Note 1:

- The specific energy consumption "ε" is the amount of energy consumption necessary for producing a unit of output. The energy efficiency "η" is the output produced by a unit of energy consumption.
- The specific energy consumption "ε" is the inverse of the energy efficiency "η" ($\varepsilon = 1/\eta$). Both are indicators of energy efficiency; however, it is common practice to use either one depending on the specific device (technology).
- Examples of the specific energy consumption "ε" and the energy efficiency "η" are as follows:

➢ Examples of using the specific energy consumption "ε"

(a) Electric power necessary for producing a unit of output (kWh/t)
(b) Electric power necessary for an electric fan to produce an airflow volume of 1 $Nm^3$ ($kWh/Nm^3$)
(c) Fuel efficiency of a transport vehicle (l/km)

➢ Examples of using the energy efficiency "η"

(a) Output produced by an electricity consumption of 1 kWh (t/kWh)
(b) Coefficient of performance (COP) or Annual performance factor (APF) of an air conditioner
(c) Efficiency of a motor ($kW_{Mechanical}/kW_{Electric}$)
(d) Efficiency of a pump ($kW_{Hydrodynamic}/kW_{Electric}$)
(e) Luminous efficiency (lumen/kW)
(f) Fuel efficiency of a transport vehicle (km/ℓ)

Note 2:

- The output "L" is the total amount of various workloads or results produced by the operation of the equipment/facilities in the project activity as shown below.
- Since the unit to measure the output "L" varies depending on the equipment/facilities, the term “unit” is generally used in the formulas in this methodology. Examples of the output "L" and its unit are as follows:

(a)Production devices and processing devices: Product; ton, $m^3$, $m^2$, unit
(b)Cooling and heating devices: Calorific value; $kWh_{Thermal}$, GJ, Kcal, BTU

(c)Boilers: Generated steam; ton-steam, GJ

(d)Pumps: Flow; Q (l/min) × head H (m) × time (min)

(e)Fans and compressors: Air flow; $Nm^3$

(f)Transmitters, distributers and transformers:

Electrical power transmitted/transformed; kWh,

Electrical power loss; kWh

(g)Transportation equipment and devices:[29]

Transportation volume; kg, kg・m, m, $m^3$, $m^3$・m, unit

・ The output L and its unit can be uniquely defined by the project operator.

[29] Transportation equipment and facilities, which transport goods, include transportation systems for material or products, loaders/unloaders, forklift trucks, conveyor belts, and pipelines.

# Methodology for
# Waste Energy Recovery Projects

## 1. Applicable Projects

This methodology is applicable to projects that generate power and/or supply heat by using facilities which recover and utilize waste energy such as waste heat, waste gas and waste pressure, and to projects that recover and utilize associated gas from oil wells.

Since associated gas recovery projects are different from the other waste energy recovery projects in some aspects, the formula of emission reductions is divided as ANNEX.

## 2. Project Boundary

The project boundary encompasses activity of the applicable project to which JBIC finance is extended.

## 3. Concept and Formula of Emission Reductions

(1) Basic Concept

Emission reductions are defined as the difference between the amount of emission without the waste energy recovery project (baseline emissions) and the amount of emission from the energy consumption of project activity (project emissions).

(2) Basic Formula

Emission reductions are calculated as the difference between the baseline emissions and project emissions.

$$\boxed{ER_y = BE_y - PE_y} \quad \cdots\cdots (1)$$

$ER_y$ : Annual emission reductions ($tCO_2/yr$)
$BE_y$ : Annual baseline emissions ($tCO_2/yr$)
$PE_y$ : Annual project emissions ($tCO_2/yr$)

## 4. Baseline Emissions

(1) Basic Concept[1]

A. The case of power generation

Baseline emissions are defined to be the amount of emissions when the same amount of power generated by the waste energy recovery project was generated by the average emission factor of all power plants serving the electricity, or by the in-house power generation facility inside the plant where project activity is implemented.[2]

B. The case of heat supply

Baseline emissions are defined to be the amount of emissions when the same quantity of heat generated by the waste energy recovery project was generated by average heat supply equipment/facilities in the country.

(2) Basic Formula

$$BE_y = BE_{elec,y} + BE_{heat,y} \quad \cdots\cdots (2)$$

$BE_y$ : Annual baseline emissions ($tCO_2$/yr)

$BE_{elec,\,y}$ : Annual baseline emissions in the case of power generation projects ($tCO_2$/yr)

$BE_{heat,\,y}$ : Annual baseline emissions in the case of heat supply projects ($tCO_2$/yr)

A. Baseline Emissions in the Case of Power Generation

$$BE_{elec,y} = EG_y \times EF_{elec} \quad \cdots\cdots (3)$$

$EG_y$ : Annual power generation in the project activity (MWh/yr)

$EF_{elec}$ : Emission factor for electricity[2] ($tCO_2$/MWh)

B. Baseline Emissions in the Case of Heat Supply

$$BE_{heat,y} = Q_y \times EF_{fuel} / \eta_{facility} \quad \cdots\cdots (4)$$

[1] In the case where there are regulations/standards/guidelines or international standards in the country with regard to baseline emissions, those are taken into account as factors in accounting the baseline emissions. However, if the project activity is under the government's transitional measures, those factors are considered based on the project nature.

[2] Refer to "generating end emission factor" or "sending end emission factor" in the "1. Emission Factors for Electricity" of Appendix in this Guideline. However, other emission factor based on F/S report etc. may be applicable if the project substitutes in-house power generation or if the project is implemented in off-grid area inter alia, provided that there is a rational explanation.

$Q_y$ : Annual heat supply in the project activity (GJ/yr)

$EF_{fuel}$ : Emission factor of the most used fossil fuel in the country[3] ($tCO_2/GJ$)

$\eta_{facility}$ : Heat efficiency of heat supply equipment/facility in the baseline (default = 0.9)[4]

## 5. Project Emissions

(1) Basic Concept

In this methodology, basically, project emissions from power generation and heat supply from waste energy are considered zero since they do not consume fossil fuel in their generating process. On the other hand, if any, emissions from the consumption of external power and fossil fuel within the project boundary should be taken into consideration.

(2) Basic Formula

$$PE_y = PE_{EC,y} + PE_{FC,y} \quad \cdots\cdots (5)$$

$PE_y$ : Annual project emissions ($tCO_2/yr$)

$PE_{EC,y}$ : Annual project emissions from external power consumption ($tCO_2/yr$)

$PE_{FC,y}$ : Annual project emissions from fossil fuel consumption ($tCO_2/yr$)

$$PE_{EC,y} = EC_{PJ,y} \times EF_{elec} \quad \cdots\cdots (6)$$

$EC_{PJ,y}$ : Annual consumption of external power in the project activity ($tCO_2/yr$)

$EF_{elec}$ : Emission factor for power generation[5] (tCO2/MWh)

$$PE_{FC,y} = \sum_i \left( FC_{i,y} \times NCV_i \times EF_{fuel,i} \right) \quad \cdots\cdots (7)$$

---

[3] Emission factor of the most used fossil fuel in the country is either of the following.
1) For the emission factor of the most used fossil fuel in the country, refer to "2. Emission Factors of Fuels" of Appendix in this Guidelines, while the most used fossil fuel in the country shall be defined based on the data of the IEA , or,
2) Specific data in the F/S report etc., provided that there is a rational explanation.

[4] This default value is based on statistical data (source: "Handbook for heating, air-conditioning and sanitary engineering of Japan") of heat efficiency of various types of boilers. If there is any specific data of heat efficiency in the F/S report etc. for the project, it may be applicable, provided that there is a rational explanation.

[5] Refer to"1. Emission Factors for Electricity" of Appendix in this Guidelines.

$FC_{i,y}$ : Annual consumption of fossil fuel *i* in the project activity (t, kl/yr)

$NCV_i$ : Net calorific value of fossil fuel *i*[6] (GJ/t, kl)

$EF_{fuel,i}$ : Emission factor of fossil fuel *i*[7] ($tCO_2$/GJ)

## 6. Effect outside of the Project Boundary (Leakage)

Leakage is not taken into account, unless it is obviously significant.[8]

## 7. Measurement and Reporting of Emission Reductions

The monitoring items are as follows:

A. In the case of power generation project

| Monitoring Items | | Source of Data | |
|---|---|---|---|
| | | Planned Value | Result Value |
| $EG_y$ | Annual power generation (MWh/yr) | ・F/S report etc. | ・Record of electricity meter |
| $EC_{PJ,y}$ | Annual consumption of external power (MWh/yr) | | |
| $FC_{i,y}$ | Annual consumption of fossil fuel *i* (t, kl/yr) | | ・Record in the project facility |

B. In the case of heat supply project

[6] Refer to Appendix (3. Net Calorific Values of Fuels) in this Guidelines.

[7] Refer to"2. Emission Factors for Fuel" of Appendix in this Guidelines.

[8] The potential effects outside the Project Boundary are: emissions in the upstream and downstream (lifecycle) of the project activity (e.g. emissions from manufacturing facilities which recover and utilize waste energy, etc.), or indirect emissions associated with the project activity. These will not be taken into account in this Methodology unless they are significant.

| Monitoring Items | | Source of Data | |
|---|---|---|---|
| | | Planned Value | Result Value |
| $Q_y$ | Annual heat supply (GJ/yr) | ・F/S report etc. | ・Measured value with calorimeter, flow meter, thermometer, pressure meter, etc.[9] |
| $EC_{PJ,y}$ | Annual consumption of external power (MWh/yr) | | ・Record of electricity meter |
| $FC_{i,y}$ | Annual consumption of fossil fuel *i* (t, kl/yr) | | ・Record in the project facility |

## 8. References

(1) Supplementary Explanation

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(2) Referenced Standards and Methodologies

- ACM0012ver3.2:"Consolidated baseline methodology for GHG emission reductions from waste energy recovery projects"
- AM0024ver2.1:"Baseline methodology for greenhouse gas reductions through waste heat recovery and utilization for power generation at cement plants"
- AM0066ver2:"GHG emission reductions through waste heat utilization for pre-heating of raw materials in sponge iron manufacturing process"
- AMS-III.Qver3:"Waste energy recovery (gas/heat/pressure) projects"

History of Revisions

- Released, June, 2010
- Revised, October, 2012
- Revised, October, 2014
- Revised, December, 2018

[9] It is advisable to use calorimeter, depending on the project situation, flow meter, thermometer, pressure meter etc. may be applicable.

ANNEX

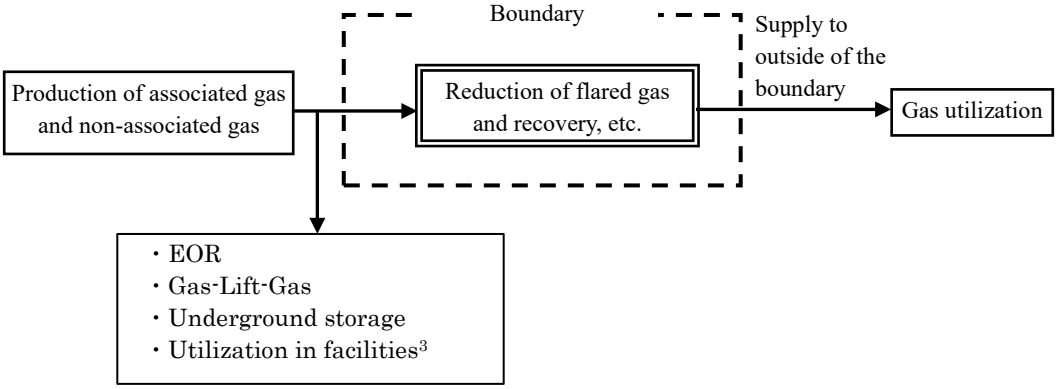
Formula of Emission Reductions for Projects of Associated Gas Flaring Reduction and Recovery at Oil/Gas Wells

1. Applicable Projects[1]

This formula is applicable to projects that reduce amount of flared associate gas and non-associated gas[2] at oil wells, oil-gas wells and gas wells, and recover and supply these gases.

2. Project Boundary

The project boundary encompasses activity of the associated gas flaring reduction and recovery project to which JBIC finance is extended. The recovered gas is supplied to outside of the boundary.




3. Concept and Formula of Emission Reductions

Emission reductions are the difference between; a sum of the emissions associate with "flaring of the associated gas without the project activity" and "energy (electricity and fossil fuel) consumption which is procured from outside the boundary" (baseline emissions), and a sum of the emissions associate with "flaring of the associated gas in the project activity (in case all the amount of associated gas would not be recovered and some of the gas would remain for the flaring)" and

[1] Among various types of greenhouse gases, particularly methane is covered in this formula. There are two major categories of methane: 1) methane from fossil fuel source such as associated gas from oil wells and coal mine methane, and 2) methane from biological origin such as landfill gas and biogas. The latter is not covered in this formula, but "Methodology for Waste Management Projects" may be applicable to landfill gas projects, and "Methodology for Renewable Energy Projects" may be applicable to biogas projects.

[2] In this methodology, gases produced in oil wells or oil-gas wells are defined as associated gas, and gases produced in gas-only wells are defined as non-associated gas.

[3] Facilities and equipment related to production of associated gas or non-associated gas.

"consumption of energy which is procured from outside the boundary" (project emissions).

4. Baseline Emissions

(1) Basic Concept[4]

Baseline emissions are a sum of the emissions associate with "flaring of the associated gas without the project activity" and "consumption of energy which is procured from outside the boundary".

(2) Basic Formula

$$\mathbf{BE_y = VF_{BL,y} \times NCV_{FG} \times EF_{FG} + EC_{BL,y} \times EF_{elec} + FC_{BL,y} \times NCV_{fuel} \times EF_{fuel}} \cdots (1)$$

$BE_y$ : Annual baseline emissions ($tCO_2/yr$)

$VF_{BL,y}$ : Annual amount of associated gas flared in the baseline ($m^3/yr$)

$NCV_{FG}$ : Net calorific value of associated gas flared[5] ($GJ/m^3$)

$EF_{FG}$ : $CO_2$ emission factor of associated gas flared[6] ($tCO_2/GJ$)

$EC_{BL,y}$ : Annual consumption of electricity which is procured from outside of the boundary in the baseline (MWh/yr)

$EF_{elec}$ : $CO_2$ emission factor of the electricity which is procured from outside of the boundary[7] ($tCO_2/MWh$)

$FC_{BL,y}$ : Annual consumption of fossil fuel which is procured from outside of the boundary in the baseline (ton, kl/yr)

$NCV_{fuel}$ : Net calorific value of the fossil fuel which is procured from outside of the boundary[8] (GJ/ton, kl)

$EF_{fuel}$ : $CO_2$ emission factor of the fossil fuel which is procured from outside of the boundary[9] ($tCO_2/GJ$)

Where $VF_{BL,y}$, $EC_{BL,y}$ and $FC_{BL,y}$ are calculated applying the following formulae.

$$\mathbf{VF_{BL,y} = VT_{PJ,y} \times FR} \cdots (2)$$

[4] In the case where there are regulations/standards/guidelines or international standards in the country with regard to baseline emissions, those are taken into account as factors in accounting the baseline emissions. However, if the project activity is under the government's transitional measures, those factors are considered based on the project nature.

[5] The default value of natural gas (In Appendix, "3. Net Calorific Values of Fuels") can be applied.

[6] The default value of natural gas (In Appendix, "2. Emission Factors of Fuels") can be applied.

[7] The grid emission factors (In Appendix, "1. Emission Factors for Electricity") can be applied.

[8] In the case where project specific data is not available; refer to Appendix, "3. Net Calorific Values of Fuels".

[9] In the case where project specific data is not available; refer to Appendix, ,"2. Emission Factors of Fuels".

$VT_{PJ,y}$ : Annual net production of associated gas in the project activity[10] ($m^3$/yr)

FR : Ratio between amount of associated gas flared and associated gas net production in the baseline[11]

$$\mathbf{EC_{BL,y} = EC_{PJ,y} \times \frac{VT_{BL}}{VT_{PJ,y}}} \quad \cdots\cdots (3)$$

$$\mathbf{FC_{BL,y} = FC_{PJ,y} \times \frac{VT_{BL}}{VT_{PJ,y}}} \quad \cdots\cdots (4)$$

$EC_{PJ,y}$ : Annual consumption of electricity which is procured from outside of the boundary in the project activity[12] (MWh/yr)

$FC_{PJ,y}$ : Annual consumption of fossil fuel which is procured from outside of the boundary in the project activity[12] (ton, kl/yr)

$VT_{BL}$ : Annual net production of associated gas in the baseline[13] ($m^3$/yr)

$VT_{PJ,y}$ : Annual net production of associated gas in the project activity ($m^3$/yr)

5. Project Emissions

Project emissions are calculated as a sum of the emissions associate with "flaring of the associated gas in the project activity (in case all the amount of associated gas would not be recovered and some of the gas would remain for the flaring)" and "consumption of energy (electricity and fossil fuel) which is procured from outside the boundary in the project activity".

$$\mathbf{PE_y = VF_{PJ,y} \times NCV_{FG} \times EF_{FG} + EC_{PJ,y} \times EF_{elec} + FC_{PJ,y} \times NCV_{fuel} \times EF_{fuel}} \quad \cdots (5)$$

$PE_y$ : Annual project emissions ($tCO_2$/yr)

$VF_{PJ,y}$ : Annual amount of associated gas flared in the project activity ($m^3$/yr)

$NCV_{FG}$ : Net calorific value of associated gas flared[5] (GJ/$m^3$)

[10] In oil wells, some amount of the produced associated gas may return to the well as gas lift gas, injection and storage etc. These amount is subtracted from the total production, and the net production is used for the calculation.

[11] Using the actual recorded data, FR is calculated through dividing "amount of flared gas" by "net production of associated gas". Averages of multiple year data should be used; however, if there is limitation on data acquisition, a single year data can be used.

[12] Count the amount solely related to the flaring reduction project. It can be set as zero, if the consumption data is not available.

[13] Net production excluding gas lift gas, injection and storage etc which are outside of the boundary. Averages of multiple year data should be used; however, if there is limitation on data acquisition, a single year data can be used.

$EF_{FG}$ : $CO_2$ emission factor of associated gas flared [6] ($tCO_2/GJ$)

$EC_{PJ,y}$ : Annual consumption of electricity which is procured from outside of the boundary in the project activity [12] (MWh/yr)

$EF_{elec}$ : $CO_2$ emission factor of the electricity which is procured from outside of the boundary [7] ($tCO_2/MWh$)

$FC_{PJ,y}$ : Annual consumption of fossil fuel which is procured from outside of the boundary in the project activity [12] (ton, kl/yr)

$NCV_{fuel}$ : Net calorific value of the fossil fuel which is procured from outside of the boundary[8] (GJ/ton, kl)

$EF_{fuel}$ : $CO_2$ emission factor of the fossil fuel which is procured from outside of the boundary[9] ($tCO_2/GJ$)

6. Measurement and Reporting of Emission Reductions

Monitoring items are as follows.

| Monitoring Item | | Source of Data | |
|---|---|---|---|
| | | Planned Value | Result Value |
| $VF_{PJ,y}$ | Annual amount of associated gas flared in the project activity ($m^3/yr$) | ・F/S report etc. | ・Record of gas flowmeter, operation record, etc. |
| $VT_{PJ,y}$ | Annual net production of associated gas in the project activity ($m^3/yr$) | | ・Record of gas flowmeter, operation record, etc. |
| $EC_{PJ,y}$ | Annual consumption of electricity which is procured from outside of the boundary in the project activity (MWh/yr) | | ・Record of electricity meter, operation record, etc. |
| $FC_{PJ,y}$ | Annual consumption of fossil fuel which is procured from outside of the boundary in the project activity (ton, kl/yr) | | ・Record of fuel meter, operation record, etc. |

7. References

(1) Supplementary Explanation

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(2) Referenced Standards and Methodologies

・ AM0009 v7 : Recovery and utilization of gas from oil wells that would otherwise be flared or vented

- AM0037 v3：Flare (or vent) reduction and utilization of gas from oil wells as a feedstock
- AM0074 v3 ： Methodology for new grid connected power plants using permeate gas previously flared and/or vented
- AM0077 v1 ： Recovery of gas from oil wells that would otherwise be vented or flared and its delivery to specific end-users

# Methodology for
# Power Generation Projects Using Low-Carbon Technology for Fossil Fuel

## 1. Applicable Projects

This methodology is applicable to projects that construct new fossil fuel fired power generation plants[1] by using low-carbon power generation technology[2], or projects that rehabilitate existing fossil fuel fired power generation plants by introducing low-carbon technology.

## 2. Project Boundary

The project boundary encompasses project activities that use low-carbon technology for new or existing fossil fuel fired power generation plants.

## 3. Concept and Formula of Emission Reductions

(1) Basic Concept

A. Construction of new power plants

In case of projects that construct new power plants, emission reductions are the difference between the amount of emission when the same amount of power generated by using low-carbon technology used by the project was generated by the average emission factor of electricity in the country (baseline emissions) and the amount of emission from the project activity (project emissions).

B. Rehabilitation of existing power plants[3]

In the case of projects that rehabilitate existing power plants, emission reductions are the difference between the amount of emission from the fossil fuel fired power generation plant before the project is implemented (baseline emissions) and the amount of emission from the project activity (project emissions).

(2) Basic Formula

$$ER_y = BE_y - PE_y \quad \cdots\cdots (1)$$

$ER_y$ : Annual emission reductions ($tCO_2/yr$)

[1] Always excepting cogeneration plants.

[2] In this methodology, "low-carbon power generation technology" is, whether it's particular or not, technology that promotes emission reduction in the country by improving $CO_2$ emission intensity of a power plant from the country's average $CO_2$ emission intensity of all power sources.

[3] Projects are limited to only when the same fossil fuel is used before and after the projects.

$BE_y$ : Annual baseline emissions ($tCO_2/yr$)

$PE_y$ : Annual project emissions ($tCO_2/yr$)

## 4. Baseline Emissions

(1) Basic Concept[4]

A. Construction of new power plants

Baseline emissions are defined as the power generation, which is the same amount of annual power generation in the project activity, generated with emission factor of "average for all power sources" in the country. However, when there are fuel supply constraints such as the energy policy of the country or the economics in the country, the baseline emissions are calculated from the average emission factor of the same fuel type as in the project activity.

B. Rehabilitation of existing power plants

Baseline emissions are defined to be the result value of emission from the fossil fuel fired power generation plant before the project is implemented.

(2) Basic Formula

$$\boxed{BE_y = EG_y \times EF_{elec}} \quad \cdots\cdots (2)$$

$BE_y$ : Annual baseline emissions ($tCO_2/yr$)

$EG_y$ : Annual power generation in the project activity (MWh/yr)

$EF_{elec}$ : Emission factor for power generation in the country ($tCO_2/MWh$)

A. Emission factor in the case of projects that construct new power plants

With regard to emission factor, refer to "generating end emission factor" or "sending end emission factor" in the "1. Emission Factors for Electricity" of Appendix in this Guideline. However, other emission factor based on F/S report etc. may be applicable if the project substitutes in-house power generation or if the project is implemented in off-grid area inter alia, provided that there is a rational explanation.

[4] In the case where there are regulations/standards/guidelines or international standards in the country with regard to baseline emissions, those are taken into account as factors in accounting the baseline emissions. However, if the project activity is under the government's transitional measures, those factors are considered based on the project nature.

B. Emission factor in the case of projects that rehabilitate existing power plants

$$EF_{elec} = \frac{EF_{fuel,i}}{\eta_{BL}} \times 3.6GJ/MWh \quad \cdots\cdots (3)$$

$EF_{fuel,i}$ : Emission factor of fuel $i$[5] ($tCO_2/GJ$)

$\eta_{BL}$ : Result or planned value of the power generation efficiency before the project was implemented

## 5. Project Emissions

(1)Basic Concept

Project emissions are defined as the amount of emission from the energy consumption in the project activity.

(2) Basic Formula

$$PE_y = FC_{i,y} \times NCV_i \times EF_{fuel,i} \quad \cdots\cdots (4)$$

$PE_y$ : Annual project emissions ($tCO_2/yr$)

$FC_{i,y}$ : Annual consumption of fossil fuel $i$ in the project activity (ton, kl, or $m^3/yr$)

$NCV_i$ : Net calorific value of fossil fuel $i$[6] (GJ/ ton, kl, or $m^3$)

$EF_{fuel,i}$ : Emission factor of fossil fuel $i$ ($tCO_2/GJ$)

## 6. Effect outside of the Project Boundary (Leakage)

Leakage is not taken into account, unless it is obviously significant.[7].

## 7. Measurement and Reporting of Emission Reductions after the Completion

The monitoring items are as follows:

---

[5] Refer to Appendix (2. Emission Factors of Fuels) in this Guideline.

[6] If data of net calorific/lower heating value (NCV/LHV) is not available, and data of gross calorific/ higher heating value (GCV/HHV) is only available, use converted net calorific value from the gross calorific value by using conversion factors (NCV=GCV*0.95 for coal and oil, or NCV=GCV*0.90 for gas) of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 2 Energy.

[7] The potential effects outside the Project Boundary are: emissions in the upstream and downstream (lifecycle) of the project activity (e.g. emissions from manufacturing low-carbon technology power plants, etc.), or indirect emissions associated with the project activity. These will not be taken into account in this Methodology unless they are significant.

| Monitoring Items | | Source of Data | |
|---|---|---|---|
| | | Planned Value | Result Value |
| $EG_y$ | Annual power generation in the project activity (MWh/yr) | ・F/S report etc. | ・Record of electricity meters. |
| $FC_{i,y}$ | Annual consumption of fossil fuel *i* in the project activity (t, kl or $m^3$/yr) | | ・Direct measurement of fuel consumption, or theoretical estimation based on the capacity and operating hours of the facility, etc. |
| $NCV_{i,}$ | Net calorific value of fossil fuel *i* (GJ/t, kl or $m^3$) | ・F/S report etc.[8] | ・The results of elemental analysis of the fuel specified for use in the newly constructed power plant (including replacement), if it is specified, or the fuel actually used in the existing power plant that is to be rehabilitated may be used. |

## 8. References

(1) Supplementary Explanation

—

(2) Referenced Standards and Methodologies

- AM0061: Methodology for rehabilitation and/or energy efficiency improvement in existing power plants --- Version 2.0.1
- AM0062: Energy efficiency improvements of a power plant through retrofitting turbines --- Version 2
- ACM0013: Consolidated baseline and monitoring methodology for new grid connected fossil fuel fired power plants using a less GHG intensive technology --- Version 4
- Tool to calculate the emission factor for an electricity system

History of Revisions

- Released, February, 2011
- Revised, October, 2012
- Revised, October, 2014

[8] Basically, refer to data based on F/S report, environment assessment report, etc. However, if such data is not available, default value in the "3. Net Calorific Values of Fuels" of Appendix in this Guidelines may be applicable.

# Methodology for Transport Projects in the Urban Area

## 1. Applicable projects

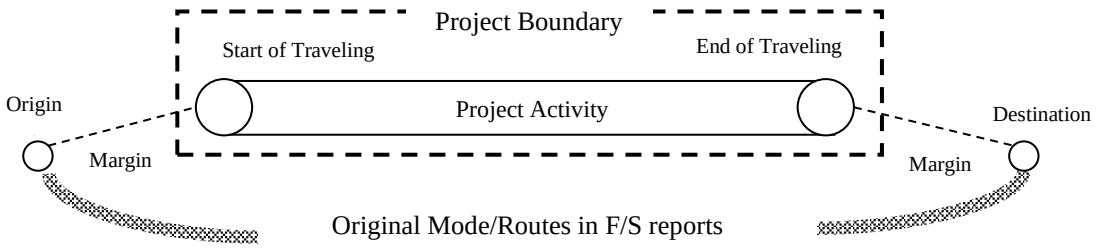
This methodology is applicable to (1) modal shift to mass transit[1] and (2) individual policy measure in the urban area.[2] The following table shows the outlines of these projects:

| Project Type | Outlines |
|---|---|
| Modal Shift to Mass Transit | Projects which are expected to reduce greenhouse gas (GHG) emissions in the urban area through modal shift in transportation. Usually it is a shift from the conventional transport mode to mass transit or more efficient transport mode. (Example: a project encouraging a shift from buses and owner-driven motor vehicles to railways.) |
| Ad hoc/One-off Policy Measures for Vehicles | Projects which are expected to reduce GHG emissions in the urban area through policy measures other than modal shift. (Example: fuel switch for motor vehicles.) |

Since in Ad hoc/One-off policy measures for vehicles are different from the modal shift to mass transit in some aspects, the methodology is divided as ANNEX.

## 2. Project Boundary

The project boundary encompasses activity of the applicable project to which JBIC finance is extended.[3]




[1] Conversion to mass transit in the short-distance freight transportation is not realistic. Modal shift of freight transportation in urban areas are outside the scope of this methodology.

[2] The traffic flow measures intended to mitigate traffic congestion such as bypass construction and traffic information are expected to reduce emission theoretically. Because it is difficult to be stylized as a methodology for those measures and preferable to correspond it individually, we exclude those measures from the methodology.

[3] Generally, transport in the margin of the project changes from motorbikes or buses to walking or bicycles. Therefore, it would generate smaller level of emissions. Thus such emissions are not considered in order to simplify the procedure of this methodology.

## 3. Concept and Formula of Emission Reductions

### (1) Basic Concept

Emission reductions are the difference between the project emissions and the emissions that would have generated due to the transportation of the same number of passengers who use the project activity.[4] The transportation here means the baseline transportation *i*.

### (2) Basic Formula

Emission reductions are accounted by the difference between baseline emissions and project emissions.

$$ER_y = BE_y - PE_y \quad \cdots\cdots(1)$$

$ER_y$ : Annual emission reductions ($tCO_2$/yr)
$BE_y$ : Annual baseline emissions ($tCO_2$/yr)
$PE_y$ : Annual project emissions ($tCO_2$/yr)

## 4. Baseline Emissions

### (1) Basic Concept

The baseline emissions are the emissions that would have generated due to the transportation *i* of the same number of passengers who use the project activity.

### (2) Basic Formula[5]

Baseline Emissions＝(Average Annual travel distance of the transportation *i* × Vehicles)×(Fuel consumption rate)×(Net calorific value of fuel)×(CO2 emission factor)

$$BE_y = \sum_i \left( \frac{P_{PJ,y} \times MS_{BL,i} \times TD_{PJ}}{OC_{BL,i}} \times SFC_{BL,i} \times NCV_{BL,i} \times EF_{fuel,i} \right)^{6} \quad \cdots\cdots(2)$$

$P_{PJ,y}$ : Number of passengers using the project service (passengers/yr)

---

[4] The transportation *i* indicates one of the baseline transportation modes such as bus, passenger car.
[5] When electricity is the source of power, electricity consumption rate (MWH/vehicle km) and an emission factor for electricity ($tCO_2$/MWh) may be applicable. For annual transport volume in the project activity (vehicle km/yr), it can be accounted with any other reasonable parameters.
[6] SFC×NCV×EF means the average amount of $CO_2$ emissions per kilometer and Appendix table I can be referenced for it.

$MS_{BL,i}$ : Share of the baseline transportation *i* (%)[7]

$TD_{PJ}$ : Average distance traveled by passengers in the project (km)[8]

$OC_{BL,i}$ : Average occupancy rate of the baseline transportation *i* (passengers/vehicle)[9]

$SFC_{BL,i}$ : Fuel consumption rate of the baseline transportation *i* (ℓ/vehicle km)[10]

$NCV_{BL,i}$ : Net calorific value of fuel in the baseline transportation *i* (GJ/ℓ)[11]

$EF_{fuel,i}$ : $CO_2$ Emission factor of the fuel used by the baseline transportation *i* ($tCO_2$/GJ)[12]

## 5. Project Emissions

### (1) Basic Concept

Project emissions should be emissions based on either by energy consumption in the project activity or operation volume (passengers/ occupancy rate × travel distance ) in the project activity.

### (2) Basic Formula

A. Formula based on energy consumption data[13]

Project Emissions = (Fuel consumption) × (Net calorific value of fuel) × (CO2 emission factor)

$$\boxed{PE_y = FC_{PJ,y} \times NCV_{PJ} \times EF_{fuel,PJ}} \quad \cdots\cdots(3)$$

$FC_{PJ,y}$ : Annual fuel consumption in the project activity (ℓ/yr)[10]

$NCV_{PJ}$ : Net calorific value of fuel in the project activity (GJ/ℓ)[11]

$EF_{fuel,PJ}$ : $CO_2$ Emission factor of fuel used for the project activity ($tCO_2$/GJ)[12]

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[7] The share of each transportation *i* in the baseline transportation. To account this share, use it by following order; A. figure in FS report, and B. figure in the city transport master plan. In case of B., Railways, bicycles and walking can be ignored as it rarely shift from these means of transport to MRT.

[8] A method which uses the average distance of travel in the transportation i is inappropriate as it includes the margin.( please refer the footnote 3)

[9] Use it by following order; (1) figures in FS Reports, etc., (2) released figures of the cities where the project is implemented, (3) the default figures(Appendix table I)

[10] Volume basis (ℓ), not weight basis (t), may be applicable here for the amount of fuel.

[11] Refer to Appendix (3. Net Calorific Values of Fuels) in this Guidelines.

[12] Refer to Appendix (2. Emission Factors of Fuels) in the this Guideline.

[13] Refer to electricity consumption and emission factor when the source of power is electricity.

B. Formula based on operation volume data[14]

Project Emissions＝(Operation volume)×(Fuel consumption rate)×(Net calorific value of fuel) ×(CO2 emission factor)

$$PE_y = \frac{P_{PJ,y} \times TD_{PJ}}{OC_{PJ}} \times SFC_{PJ} \times NCV_{PJ} \times EF_{fuel,PJ} \quad \cdots\cdots(4)$$

$P_{PJ,y}$ : Annual passengers in the project (passengers/yr)

$TD_{PJ}$ : Average distance traveled by the passengers using the project (km)

$OC_{PJ}$ : Average occupancy rate in the project activity (passengers/ vehicle)

$SFC_{PJ}$ : Fuel consumption rate per kilometer in the project activity (ℓ/ vehicle km)

$NCV_{PJ}$ : Net calorific value of fuel used in the project activity (GJ/ℓ)

$EF_{fuel,PJ}$ : $CO_2$ Emission factor of the fuel used in the project activity ($tCO_2$/GJ)

## 6. Effect outside of the Project Boundary (Leakage)

Leakage is not taken into account, unless it is obviously significant.[15]

## 7. Measurement and Reporting of Emission Reductions

The monitoring items are as follows:

| Monitoring Item | | Source of Data | | Note |
|---|---|---|---|---|
| | | Planned Value | Result Value | |
| $P_{PJ,y}$ | Annual passangers transported by project (passenger/yr) | ・F/S report etc. | ・Records by the project operator | Either EC or FC is monitored according to the source of energy (electricity, fuel) or the formula by which the project activity will be accounted. |
| $TD_{PJ}$ | Average trip distance by project (km) | | | |
| $EC_{PJ,y}$ | Annual electricity consumption for project (MWh/yr) | | | |
| $FC_{PJ,y}$ | Annual fuel consumption for project(ℓ/yr) | | | |

[14] Refer to electricity consumption rate (MWh/vehicle km) and emission factor of electricity ($tCO_2$/MWh) when the source of power is electricity. Annual operation volume (vehicle km/yr) can be accounted in any manner possible.

[15] The potential effects outside the Project Boundary are: emissions in the upstream and downstream (lifecycle) of the project activity (e.g. emissions from the construction, fuel collection, manufacturing and transporting, etc.), or indirect emissions associated with the project activity (e.g. induced traffic (rebound effect), etc). These will not be taken into account in this Methodology unless they are significant.

8. References

(1) Supplementary Explanation

—

(2) Referenced Standards and Methodologies

- ACM0016. v2：Baseline Methodology for Mass Rapid Transit Projects
- AMS III.U. v1：Cable Cars for Mass Rapid Transit System (MRTS)

History of Revisions

・Released, October, 2012

## APPENDIX

### List of Default Value

(Appendix table I)

Occupancy rate by types of vehicles and $CO_2$ emission per kilometer

| Types of vehicles | Occupancy rate ( $OC_{BL,i}$) | $CO_2$ emission per kilometer $SFC_{BL,i} \times NCV_{BL,i} \times EF_{fuel,i}$ ($gCO_2$/ vehicle km) |
|---|---|---|
| Passenger cars（Gasoline） | 2.5 | 375 |
| Passenger cars（Diesel） | 2.5 | 256.25 |
| Passenger cars（Natural Gas） | 2.5 | 293.75 |
| Bikes（2 Strokes） | 1.5 | 112.5 |
| Bikes（4 Strokes） | 1.5 | 75 |
| Minibuses（Gasoline） | 12.0 | 720 |
| Minibuses（Diesel） | 12.0 | 600 |
| Buses（Diesel） | 40.0 | 1,000 |
| Buses（Natural Gas） | 40.0 | 1,200 |

Reference: Sperling,D.,D.Salon(2002),"An Overview of Greenhouse Gas Reduction Strategies", Transportation in Developing Countries, pp15,University of California

## ANNEX

### Formula of Emission Reductions in One-off Policy Measures for Vehicles

(1) Concept of Emission Reductions

Emission reductions in one-off policy measures for vehicles are the differences between the emissions from energy consumption or operation without the project activity (baseline emissions) and the emissions from the project activity (project emissions).

(2) Formula of Emission Reductions

A. Formula based on the energy consumption data

(a) Baseline Emissions

$$BE_y = FC_{PJ,y} \times \frac{SFC_{BL}}{SFC_{PJ}} \times NCV_{BL} \times EF_{fuel,BL} + EC_{PJ,y} \times \frac{SEC_{BL}}{SEC_{PJ}} \times EF_{elec} \quad \cdots\cdots\cdots\cdots (1)^{16}$$

$FC_{PJ,y}$ : Annual fuel comsumption in the project activity (ℓ/yr)

$SFC_{BL}$ : Fuel consumption rate before implementation of the one-off measure project (ℓ/ vehicle km)[17]

$SFC_{PJ}$ : Fuel consumption rate in the project activity (ℓ/ vehicle km)[17]

$NCV_{BL}$ : Net calorific value of fuel used before implementation of one-off measure project (GJ/ℓ)

$EF_{fuel,BL}$ : $CO_2$ Emission factor of fuel used before implementaion of the one-off measure project ($tCO_2$/GJ)

$EC_{PJ,y}$ : Annual electricity consumption in the project activity (MWh/yr)

$SEC_{BL}$ : Electricity consumption rate before implementation of the one-off measure project (MWh/ vehicle km)[17]

$SEC_{PJ}$ : Electricity consumption rate in the project activity (MWh/ vehicle km)[17]

$EF_{elec}$ : Emission factor of electricity ($tCO_2$/MWh)[18]

(b) Project Emissions

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[16] When only external power is used as a power source, the term 1 related to fuel use is unnecessary. In case of fuel change, the term 2 related to use of electricity is unnecessary. The same applies to (2) ～(4).

[17] Refer to figures from catalogue or default value or the plan for the project, etc.

[18] Refer to "1. Emission Factors for Electricity" of Appendix in this Guideline.

$$PE_y = FC_{PJ,y} \times NCV_{PJ} \times EF_{fuel,PJ} + EC_{PJ,y} \times EF_{elec} \quad \cdots\cdots(2)^{16}$$

$FC_{PJ,y}$ : Annual fuel consumption in the project activity (ℓ/yr)
$NCV_{PJ}$ : Net calorific value of fuel used in the project activity (GJ/ℓ)
$EF_{fuel,PJ}$ : Emission factors of fuel used in the project activity ($tCO_2$/GJ)
$EC_{PJ,y}$ : Annual consumption of electricity in the project activity (MWh/yr)
$EF_{elec}$ : Emission factor of electricity ($tCO_2$/MWh)[18]

Monitoring items:

| Monitoring Items | | Planning Value | Result Value |
|---|---|---|---|
| $FC_{PJ,y}$ | Annual fuel consumption in the project activity (ℓ/yr) | Estimated figures in the F/S reports, etc | Records by the project operator |
| $EC_{PJ,y}$ | Annual electricity consumption in the project activity (MWh/yr) | Estimated figures in the F/S reports, etc | Records by the project operator |

B. Formula based on the operation volume data

(a) Baseline Emissions

$$BE_y = VK_{PJ,y} \times SFC_{BL} \times NCV_{BL} \times EF_{fuel,BL} + VK_{PJ,y} \times SEC_{BL} \times EF_{elec} \quad \cdots\cdots(3)^{16}$$

$VK_{PJ,y}$ : Annual operation volume in the project activity (vehicle km/yr)
$SFC_{BL}$ : Fuel consumption rate before implementation of the one-off measure porject (ℓ/ vehicle km)[17]
$NCV_{BL}$ : Net calorific value of fuel used before implementation of the one-off measure project (GJ/ℓ)
$EF_{fuel,BL}$ : $CO_2$ Emission factor of fuel used beofre implementation of the one-off measure project ($tCO_2$/GJ)
$SEC_{BL}$ : Rate of electricity consumption before implementation of the one-off measure project (MWh/ vehicle km)[17]
$EF_{elec}$ : Emission factor of electricity ($tCO_2$/MWh)[18]

(b) Project Emissions

$$PE_y = VK_{PJ,y} \times SFC_{PJ} \times NCV_{PJ} \times EF_{fuel,PJ} + VK_{PJ,y} \times SEC_{PJ} \times EF_{elec} \quad \cdots\cdots(4)^{16}$$

$VK_{PJ,y}$ : Annual operation volume in the project activity (vehicle km/yr)
$SFC_{PJ}$ : Rate of fuel consumption in the project activity (ℓ/ vehicle km)[17]
$NCV_{PJ}$ : Net calorific value of fuel used in the project activity (GJ/ℓ)
$EF_{fuel,PJ}$ : $CO_2$ Emission factor of fuel used in the project activity ($tCO_2$/GJ)

$SEC_{PJ}$ : Rate of electricity consumption in the project activity (MWh/ vehicle km)[17]

$EF_{elec}$ : Emission factor of electricity ($tCO_2$/MWh)[18]

Monitoring items:

| Monitoring Item | | Planned Value | Result Value |
|---|---|---|---|
| $VK_{PJ,y}$ | Annual operation volume of the project activity (vehicle km/yr) | Estimated transport demand in FS reports, etc. | Records by the project operator |

# Methodology for Waste Management Projects

## 1. Applicable Projects

This methodology is applicable to waste management projects [1] that aim to treatment/disposal of waste with or without recovery/utilization of energy from the waste, consisting of (i) incineration, (ii) electricity generation/heat supply by digestion gas, (iii) refuse derived fuel (RDF), (iv) composting, (v) landfill gas (LFG) recovery, and (vi) semi-aerobic landfill system[2].

The following table shows outlines of the waste management projects.

| Project Type | Outlines |
|---|---|
| Incineration | Incineration treatment of waste. In some cases, heat from incineration is recovered and utilized for power generation and/or heat supply. |
| Electricity generation/heat supply by digestion gas | Organic waste is decomposed under anaerobic condition. Methane generated is recovered and utilized for power generation and/or heat supply. |
| Refuse derived fuel (RDF) | Waste is sorted, shredded, dried and pressed to produce refuse derived fuel[3] and used for power generation and/or heat supply. |
| Composting | Organic waste is decomposed under aerobic condition to produce compost. |
| Landfill gas (LFG) recovery | Methane generated from land filled waste is recovered and flared, or used for power generation and/or heat supply. |
| Semi-aerobic landfill system | Leach ate collection and venting pipes are installed in the bottom of sanitary landfill sites so that the leach ate come out and air can enter into the landfill naturally (and creates semi-aerobic conditions), and methane emission is reduced. |

## 2. Project Boundary

The project boundary encompasses activity of the applicable project to which JBIC finance is extended. It does not include activities collection and transportation of waste for the project implementation[4].

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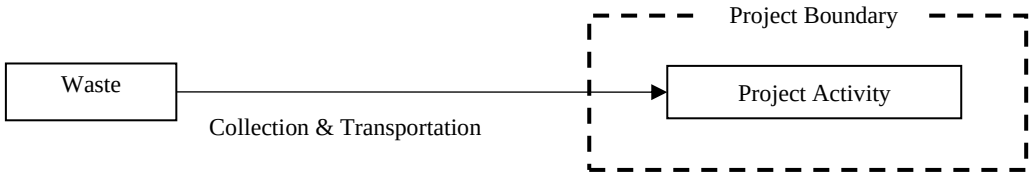
[1] This methodology is mainly based on the methane emission reduction by waste treatment. However, energy substitution by recovered energy (Waste to Energy) such as power generation or heat supply by methane or heat from the waste treatment process is also considered as additional effects. Regarding project types, (iv) composting and (vi) semi-aerobic landfill system, energy is not recovered nor utilized, (ii) power generation/heat supply by digestion gas and (iii) refuse derived fuel is premised on recovery and utilization of energy from waste. In (i) incineration and (v) landfill gas recovery may include energy recovery and utilization.

[2] This methodology is not applicable to waste recycling project (such as plastic recycling). If the project activity utilizing recycled materials has higher energy efficiency compared to a production from raw materials, J-MRV methodology for "Project which improves energy efficiency of equipment" may be applicable.

[3] Solid fuel deriving from waste generally consists of refuse derived fuel (RDF), refuse paper & plastic fuel (RPF) etc.

[4] This methodology does not take into account emissions from the collection and transportation of waste because of its relatively low amount.




## 3. Concept and Formula of Emission Reductions

(1) Basic Concept

Emission reductions are the difference between the amount of methane emissions from the land filled waste without any treatment (baseline emissions) and the amount of emissions from the energy consumption in the project activity (project emissions).

In the case where power generation/heat supply by the energy recovery/utilization is included in the project, emission reductions is calculated taking into account with the assumption that the power/heat is generated by standard method in the country. (Baseline emissions and project emissions should be calculated respectively.)

(2) Basic Formula

Emission reductions are calculated by the difference between baseline emissions and project emissions.

$$\boxed{ER_y = BE_y - PE_y} \quad \cdots\cdots (1)$$

$ER_y$ : Annual emission reductions ($tCO_2/yr$)
$BE_y$ : Annual baseline emissions ($tCO_2/yr$)
$PE_y$ : Annual project emissions ($tCO_2/yr$)

## 4. Baseline Emissions

(1) Basic Concept[5]

C. In the case of waste management project, baseline emissions are the amount of methane emissions generated from the land filled waste without any intermediate treatment[6] such as incineration etc.

[5] In the case where there are regulations/standards/guidelines or international standards in the country with regard to baseline emissions, those are taken into account as factors in accounting the baseline emissions. However, if the project activity is under the government's transitional measures, those factors are considered based on the project nature.

[6] Most way of final disposal of waste is landfill disposal, therefore, in this methodology, "(i) incineration", "(ii) electricity generation/heat supply by digestion gas", "(iii) refuse derived fuel" and "(iv) composting" are classified as intermediate treatment, meanwhile, "(v) landfill gas recovery" and "(vi) semi-aerobic landfill system" are classified as final disposal.

D. In the case of recovery/utilization of energy from waste for power generation and/or heat supply are associated with, emissions from the energy generation are added to the baseline emissions with the assumption that power/heat is generated by standard method in the country.

(2) Basic Formula[7]

$$BE_y = BE_{CH4,y} + BE_{EN,y} \quad \cdots\cdots (2)$$

$BE_y$ : Annual baseline emissions ($tCO_2/yr$)

$BE_{CH4,y}$ : Annual baseline emissions associated with methane generation from landfill of waste (tCO2e/yr)

$BE_{EN,y}$ : Annual baseline emissions associated with the same amount of power generation/heat supply by recovery/utilization of energy from waste in the project activity ($tCO_2/yr$)[8]

Calculation Formula of $BE_{CH4,y}$

Gross methane emissions from land filled waste are estimated during the project period by using FOD formula[9] described in the IPCC Guideline. Then, annual baseline methane emissions are calculated by dividing the gross methane emissions by the project period and multiplying it by correction coefficient of methane emissions.

$$BE_{CH4,y} = \frac{FOD_{PP}}{PP} \times GWP_{CH4} \times CCF \quad \cdots\cdots (3)$$

$FOD_{PP}$ : Gross methane emissions during the project period estimated by using FOD formula in the IPCC Guideline ($tCH_4$)[10]

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[7] Some parameters have the default values or their references in the description of calculation formula. However, if there are specific values in the country or in the project activity, they are also applicable.

[8] This emissions should be taken into account only in the case of power generation/heat supply by recovery/utilization of energy from waste is associated with.

[9] First Order Decay (FOD) model of the IPCC Guidelines estimates methane emissions from landfill wastes considering biological decomposition over time. This methodology applies the FOD recommended in the "2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 5 Waste Chapter 3". However, the actual methane emissions depend largely on waste composition and treatment condition. As a result, the actual amount of recovered methane in many CDM projects were far lower compared to the estimated amount by using FOD model. Thus, the equation (3) is corrected by CCF (Refer to footnote12).

[10] In the IPCC Guidelines, FOD has three calculation options from Tier 1 to Tier 3 approaches depending on content of obtained data (annual amount of treated waste (Wy), composition ratio of each waste type in treated waste (Cj), etc.). In this methodology, Tier 1 approach may be applicable, which uses various default values if obtained data is limited. Wy value can be monitored in a typical

PP : Project period (yr)[11]

$GWP_{CH4}$ : Global warming potential of methane ($tCO_2/tCH_4$)[12]

CCF : Correction coefficient of methane emissions (default = 0.5)[13]

Calculation Formula of $BE_{EN,y}$

In cases where electricity generated/heat supplied by recovery/utilization of energy, the following emissions are added to the baseline emissions.

$$\begin{aligned} BE_{EN,y} &= BE_{elec,y} + BE_{heat,y} \\ &= EG_y \times EF_{elec} + Q_y \times EF_{fuel}/\eta_{facility} \end{aligned} \quad \cdots\cdots (4)$$

$BE_{elec,y}$ : Annual baseline emissions associated with electricity generation ($tCO_2/yr$)

$BE_{heat,y}$ : Annual baseline emissions associated with heat supply ($tCO_2/yr$)

$EG_y$ : Annual electricity generation in the project activity (MWh/yr)

$EF_{elec}$ : Emission factor for power generation in the country[14] ($tCO_2/MWh$)

$Q_y$ : Annual heat supply in the project activity (GJ/yr)

$EF_{fuel}$ : Emission factor of the most used fossil fuel in the country[15] ($tCO_2/GJ$)

$\eta_{facility}$ : Heat efficiency of baseline heat supply facility(default = 0.9)[16]

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year (e.g. annual gross weight of waste treated in 2nd year is monitored after completion), and it can be considered as same value in each year during the project period.

[11] Refer to planned value of the project period in the F/S report etc. .

[12] Refer to Appendix (4. Global Warming Potential of Greenhouse Gas) in this Guidelines.

[13] Correction coefficient of methane emissions (CCF) is derived from data of registered CDM projects related to landfill gas recovery (63 projects applying ACM (Approved Consolidated Methodology) 0001 from 2006 to 2011). Concretely, CCF is set based on the following calculation. The average ratio between methane generation estimated in the project design documents (PDDs) of those 63 projects and actual CER acquisition amount is 0.49. The value for the CCF above mentioned is result in accordance with CDM methodology which adjusts original FOD formula in the IPCC Guidelines by using model correction factor (0.9). Therefore the readjustment value (0.44), which is multiplication of the average ratio (0.49) and model correction factor (0.9), is derived for comparison with IPCC-based estimated value.

[14] Refer to "generating end emission factor" or "sending end emission factor" in the "1. Emission Factors for Electricity" of Appendix in this Guideline. However, other emission factor based on F/S report etc. may be applicable if the project substitutes in-house power generation or if the project is implemented in off-grid area inter alia, provided that there is a rational explanation

[15] Emission factor of the most used fossil fuel in the country is either of the following.
1) For the emission factor of the most used fossil fuel in the country, refer to "2. Emission Factors of Fuels" of Appendix in this Guidelines, while the most used fossil fuel in the country shall be defined based on the data of the IEA , or,
2) Specific data in the F/S report etc., provided that there is a rational explanation.

[16] This default value is based on statistical data (source: "Handbook for heating, air-conditioning and sanitary engineering of Japan") of heat efficiency of various types of boilers. If there is any specific data of heat efficiency in the F/S report etc. for the project, it may be applicable, provided that there is a rational explanation.

## 5. Project Emissions

(1) Basic Concept

Since project emissions are differed from measure to measure respectively in their waste management classifications, they should be taken into account and calculated in combination with the following factors.

| Factors of Project Emissions / Project Type | a | b | c | | | d | e |
|---|---|---|---|---|---|---|---|
| | Power consumption | Fuel consumption | Incineration | Electricity/heat by digestion gas | RDF | Composting | Semi-aerobic landfill system |
| | $PE_{EC,y}$ | $PE_{FC,y}$ | $PE_{igr,y}$ | | | $PE_{r,y}$ | $PE_{a,y}$ |
| Incineration | ✓ | ✓ | ✓ | | | | |
| Electricity generation/heat supply by digestion gas | ✓ | ✓ | | ✓ | | | |
| RDF | ✓ | ✓ | | | ✓ | | |
| Composting | ✓ | ✓ | | | | ✓ | |
| LFG recovery | ✓ | ✓ | | | | | |
| Semi-aerobic landfill system | ✓ | ✓ | | | | | ✓ |

(2) Basic Formula

Project emissions are calculated as a function of their classifications of the project activity in combination with the following factors.

a) Calculation formula of project emissions from power consumption ($PE_{EC,y}$)

$$PE_{EC,y} = EC_{PJ,y} \times EF_{elec} \quad \cdots\cdots (5)$$

$EC_{PJ,y}$ : Annual consumption of external power in the project activity (MWh/yr)

$EF_{elec}$ : Emission factors for power generation ($tCO_2$/MWh)

b) Calculation formula of project emissions from fuel consumption ($PE_{FC,y}$)

$$PE_{FC,y} = FC_{i,y} \times NCV_i \times EF_{fuel,i} \quad \cdots\cdots (6)$$

$FC_{i,y}$ : Annual consumption of fossil fuel i (ton, kl, $m^3$/yr)

$NCV_i$ : Net calorific value of fossil fuel i[17] (GJ/ton, kl, $m^3$)

$EF_{fuel,i}$ : Emission factor of fossil fuel i[18] ($tCO_2/GJ$)

c) Calculation formula of project emissions from incineration/electricity and/or heat by digestion gas/RDF ($PE_{igr,y}$)[19]

$$PE_{igr,y} = PF_{igr,f,y} + PE_{igr,s,y} \quad \cdots\cdots (7)$$

$PE_{igr,f,y}$ : Annual project emissions of carbon dioxide associated with incineration/electricity and/or hear by digestion gas/RDF ($tCO_2/yr$)

$PE_{igr,s,y}$ : Annual project emissions of dinitrogen monoxide and/or methane associated with incineration/electricity and/or heat by digestion gas/RDF ($tCO_2e/yr$)

$$PE_{igr,f,y} = \sum_j \left(W_y \times C_j \times CCW_j \times FCF_j\right) \times CE \times 44/12 \quad \cdots\cdots (8)$$

$W_y$ : Annual amount of treated waste (ton/yr)

$C_j$ : Composition ratio of waste type j in treated waste (weight basis)[20]

$CCW_j$ : Percentage of total carbon content in waste type j[21]

$FCF_j$ : Percentage of fossil carbon fraction in total carbon in waste type j[22]

CE : Combustion efficiency of waste (default = 1)[23]

44/12 : Ratio of molecular weight between carbon dioxide and carbon ($CO_2/C$)

$$PE_{igr,s,y} = W_y \times (EF_{N2O} \times GWP_{N2O} + EF_{CH4} \times GWP_{CH4}) \times 10^{-3} \quad \cdots\cdots (9)$$

$EF_{N2O}$ : Emission factor of dinitrogen monoxide ($gN_2O/t$) (default = 100)[24]

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[17] Refer to Appendix (3. Net Calorific Values of Fuels) in this Guidelines.

[18] Refer to Appendix (2. Emission Factors of Fuels) in this Guidelines.

[19] As for incineration, emissions from combustion of waste are taken into account. As for electricity generation/heat supply by digestion gas and RDF, emissions from combustion of digestion gas/RDF are taken into account.

[20] Select the applicable value for each region from "Table2.3, Volume 5 Waste, 2006 IPCC Guidelines for National Greenhouse Gas Inventories", in the case of no composition data of solid waste is available.

[21] Select the applicable value for each waste component from "Table2.4, Volume 5 Waste, 2006 IPCC Guidelines for National Greenhouse Gas Inventories", according to its classification.

[22] As for carbon dioxide emission from biomass combustion, it can be considered as carbon neutral. Only carbon derived from fossil fuel is taken into account. Select an applicable value according to the classification of solid waste from the "Table 2.4, Volume 5 Waste, 2006 IPCC Guidelines for National Greenhouse Gas Inventories".

[23] As for the incineration treatment, this default value may be applicable according to "Table5.2, Volume 5 Waste, 2006 IPCC Guidelines for National Greenhouse Gas Inventories".

[24] This default value is defined as average one of "Table 5.6, Volume 5 Waste, 2006 IPCC Guidelines for National Greenhouse Gas Inventories", except for sewerage sludge.

$EF_{CH4}$ : Emission factors of methane according to type of incineration ($gCH_4/t$)[25]

$GWP_{N2O}$ : Global warming potential of dinitrogen monoxide ($tCO_2/tN_2O$)[26]

$GWP_{CH4}$ : Global warming potential of methane ($tCO_2/tCH_4$)[26]

d) Calculation formula of project emissions from composting ($PE_{c,y}$)[27]

$$PE_{c,y} = W_{c,y} \times (EF_{c,N2O} \times GWP_{N2O} + EF_{c,CH4} \times GWP_{CH4}) \quad \cdots\cdots (10)$$

$W_{c,y}$ : Annual amount of treated organic waste (t/yr)

$EF_{c,N2O}$ : Emission factor of dinitrogen monoxide according to type of biological treatment ($tN_2O$/t-waste)[28]

$EF_{c,CH4}$ : Emission factor of methane according to type of biological treatment ($tCH_4$/t-waste) [25]

e) Calculation formula of project emissions from semi-aerobic landfill system ($PE_{a,y}$)[29]

$$PE_{a,y} = BE_{CH4,y} \times MCF \quad \cdots\cdots (11)$$

$BE_{CH4,y}$ : Refer to the formula (3) above mentioned.

MCF : Methane correction factor for semi-aerobic landfill system [30] (default = 0.5)

## 6. Effect outside of the Project Boundary (Leakage)

Leakage is not taken into account, unless it is obviously significant.[31].

## 7. Measurement and Reporting of Emission Reductions after the Completion

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[25] Select an applicable value from "Table 5.3, Volume 5 Waste, 2006 IPCC Guidelines for National Greenhouse Gas Inventories", according to its classification of type of incineration.

[26] Refer to Appendix (4. Global Warming Potential of Greenhouse Gas) in this Guidelines.

[27] This formula takes into account the emissions from composting process. In the case of methane recovery and utilization/destruction, this item need not be considered.

[28] Select an applicable value from "Table 4.1, Volume 5 Waste, 2006 IPCC Guidelines for National Greenhouse Gas Inventories", according to whether waste weight is dry basis one or wet basis one.

[29] This formula takes into account emissions from semi-aerobic landfill system, however, semi-aerobic landfill system can reduce methane emissions compared to that from anaerobic landfill.

[30] If each landfill implements operation under semi-aerobic/anaerobic condition, methane correction factor (MCF) is set to be 0.5/1.0 respectively according to "Table 3.1, Volume 5 Waste, 2006 IPCC Guidelines for National Greenhouse Gas Inventories".

[31] The potential effects outside the Project Boundary are: emissions in the upstream and downstream (lifecycle) of the project activity (e.g. emissions from construction of waste treatment facilities, transportation of materials, etc.). These will not be taken into account in this Methodology unless they are significant.

The monitoring items are as follows:

✓✓: Required items, ✓: Required if necessary

| Monitored Items | | Planned Value | Result Value | Items Required |
|---|---|---|---|---|
| $W_y$ | Gross weight of treated /disposed waste (ton/yr) | Planned value in F/S report etc. | A) Measured value by meter etc.<br>B) Planned value in F/S report etc. | ✓✓ |
| $C_j$ | Composition of waste to be treated/disposed | A) Planned value in F/S report etc.<br>B) IPCC default value[32] | A) Analytical data of waste composition<br>B) IPCC default value | ✓✓ |
| $EC_{PJ,y}$ | Annual consumption of external power (MWh/yr) | Planned value in F/S report etc. | Record of electricity meter | ✓ |
| $FC_i$ | Annual consumption of fossil fuel i (ton or kl or $m^3$/yr) | Planned value in F/S report etc. | Record of fuel consumption in object facility | ✓ |
| $EG_{d,y}$ | Annual electricity generation (MWh/yr) | Planned value in F/S report etc. | Record of electricity meter | ✓ |
| $Q_y$ | Annual heat supply (GJ/yr) | Planned value in F/S report etc. | Calculated value by using calorimeter, flowmeter etc.[33] | ✓ |

## 8. References

(1) Supplementary Explanation

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(2) Referenced Standards and Methodologies

- AM0025 (Ver.12): "Avoided emissions from organic waste through alternative waste treatment processes"
- ACM0001 (Ver.11): "Consolidated baseline and monitoring methodology for landfill gas project activity"
- AMS-III.G. (Ver.6.0): "Landfill methane recovery"
- 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5 Waste

History of Revisions

- Released, October, 2012
- Revised, October, 2014

[32] Select an applicable value from "Table 2.3, Volume 5 Waste, 2006 IPCC Guidelines for National Greenhouse Gas Inventories", according to the classification of waste type.

[33] It is advisable to use calorimeter, Depending on the project situation, flow meter, thermometer, pressure meter etc. may be applicable.

# Methodology for Water Projects

## 1. Applicable Projects

This methodology is applicable to the following water projects[1] such as energy-efficient water treatment projects, water-saving projects, and methane recovery and utilization projects. Outlines of each project are shown as follows[2].

| Project Type | Outlines |
|---|---|
| Energy efficient water treatment projects | Energy efficient water supply and sewage treatment projects by introducing advanced technologies and reduce the energy consumption. (e.g. reverse osmosis (RO) membrane, high efficiency water pump, Membrane Bioreactor (MBR), etc.) |
| Water-saving projects | Water-saving projects in supply and distribution water process by improving water management such as reducing water leakage rate and decreasing consumption for water treatment/production through saving amount of water supply in future (e.g. Introduction of well-sealed/ highly durable water pipe) |
| Methane recovery/utilization projects | Recovery and utilization of methane gas which are generated from sewage water treatment process. (e.g. introduction of the anaerobic treatment system and methane recovery in the sewage treatment) |

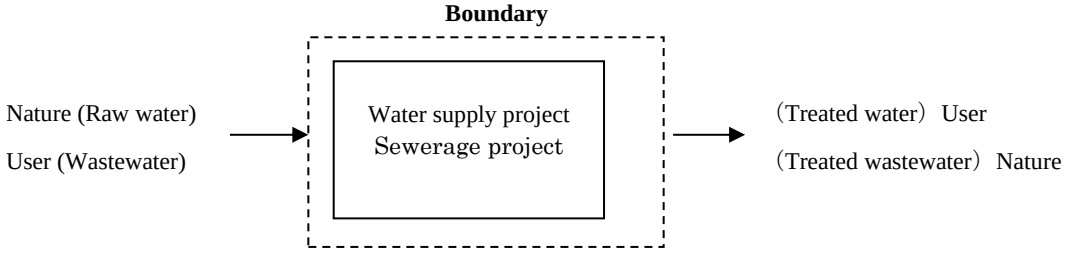
Since the general concept of emission reduction calculation methodology is different for Methane recovery/utilization projects with the other two project types, the methodology for methane recovery/utilization is shown in the Annex.

## 2. Project Boundary

The project boundary encompasses the project activity regarding water supply and sewage to which JBIC's finance is extended.

[1] "Water projects" dealt in this methodology divided into water supply projects and sewerage treatment projects. As for the water supply projects, they usually include intake process from the natural water sources (e.g. river, groundwater, sea, etc.), purification, desalination (seawater conversion), water supply and distribution, as well as customer service such as maintenance and tariff collection. On the oher hand, sewerage treatment projects include sewerage water treatment, sewerage sludge treatment, methane recovery and utilization project and discharge to the natural water body. Water recycling project is also included in the sewerage projects.

[2] Although "water recycling projects" could be more energy efficient and reduce green house gas emission, it is not covered in this methodology, as the characteristics of the projects differ widely and it is difficult to integrate them to a standardized methodology. Some projects of Energy efficient water treatment projects and Water-saving projects are covered by energy efficiency project methodology when the emission reduction is calculated by energy consumption only and not by water unit.




## 3. Concept and Formula of Emission Reductions

(1) Basic Concept

A. Energy efficient water treatment projects

In the case of energy efficient water treatment projects, emission reductions are the difference between the amount of emission estimated using the average unit[3] of the same type project (baseline emissions) and the amount of emission from the project activity (project emissions).

B. Water–saving projects

In the case of water-saving management projects, emission reductions are the difference between the amount of emission from the energy consumption corresponding to the amount of saved water by the supply/distribution process of the project activity[4] (baseline emissions) and the emission from the energy consumption used for the water-saving management in the project activity (project emissions).

(2) Basic Formula

Emission reductions are accounted by the difference between baseline emissions and project emissions.

$$ER_y = BE_y - PE_y \quad \cdots\cdots(1)$$

$ER_y$ : Annual emission reduction ($tCO_2$/year)

$BE_y$ : Annual baseline emission ($tCO_2$/year)

$PE_y$ : Annual project emission ($tCO_2$/year)

[3] In this methodology, the emission unit means the amount of energy consumption per unit of processing water in individual business, and the average emission unit means the average of the emission units of businesses.

[4] Assuming that the corresponding energy would be saved as per the amount of saved water by water leakage management, etc.

## 4. Baseline Emissions

(1) Basic Concept

A. Energy efficient water treatment projects

Baseline emissions of energy efficient water treatment project will be calculated based on the average emission unit[5] which would be available from the same type of the projects in the country/project area.

In cases of highly advanced technologies[6] which have not been commonly applied in the area (hereinafter called "advanced water treatment technology") will be introduced by the project for specific reason (to get high quality water, for example[7]), the average emission unit[8] of any other highly advanced technology and/or other alternative measures[9] which can achieve same level, can be adopted to calculate the baseline emissions.

B. Water –saving management projects

Baseline emissions of water–saving management project will be calculated based on the average emission unit of the conventional water supply/treatment system in the county/project area.

(1) Formula of Baseline Emissions

A. Baseline emissions of the energy efficient water treatment project

$$BE_y = BU_y \times PW_{treated,y} \quad \cdots\cdots(2)$$

$BE_y$ : Annual baseline emission($tCO_2$/year)

$BU_y$ : Average emission unit based on the baseline ($tCO_2/m^3$)

$PW_{treated,y}$: Annual water volume treated in the project ($m^3$/year)

$$BU_y = (BC_y \times EF_y) \div BW_{treated,y} \quad \cdots\cdots(3)$$

$BC_y$ : Average annual energy consumption in the baseline (MWh/year or

[5] Statistical data and/or other reliable data in the country and/or project area may be applicable to calculate an "average emission unit".

[6] For example, reverse osmosis membrane method, membrane bioreactor (MBR) will be defied as an "advanced water treatment technology".

[7] In addition to the water quality, the purpose of water use (drinking water, industrial water) and/or limitation of the land for the supply and sewage project should be included.

[8] To set the average emission unit for these technologies, value based on the literature, catalog, estimate value obtained from the specification on energy consumption, emission of alternative scenario in the Feasibility Study of the project can be adopted.

[9] Simple distillation, filtration with polymeric membrane, ceramic membrane would be decided as an "other highly advanced technology".

GJ/year)

$EF_y$ : Emission factor
(Electricity or fossil fuel $tCO_2/MWh$ or $tCO_2/MJ$) [10]

$BW_{treated,y}$ : Average annual water volume treated in the baseline ($m^3$/year)

B. Baseline emissions of the water–saving management projects

$$BE_y = BU_y \times PW_{reduced,y} \quad \cdots\cdots(4)$$

$BE_y$ : Annual baseline emission ($tCO_2$/year)

$BU_y$ : Average emission unit of the water supply/treatment and/or desalination ($tCO_2/m^3$)

$PW_{reduced,y}$ : Annual water volume saved in the project ($m^3$/year)

$$BU_y = (BC_y \times EF_y) \div BW_{treated,y} \quad \cdots\cdots(5)$$

$BC_y$ : Annual energy consumption in the baseline (MWh/year or GJ/year)

EF : Emission factor (Electricity or fossil fuel $tCO_2/MWh$ or $tCO_2/MJ$)

$BW_{treated,y}$ : Average annual water volume treated in the baseline ($m^3$/year)

## 5. Project Emissions

(1) Basic concept

A. Energy efficient water treatment project

Emission from the Energy efficient water treatment projects is derived from the energy consumption which is necessary for the energy efficient water treatment process in the project.

B. Water-saving management project

Emission from the Water-saving management projects is derived from the energy consumption which is necessary for the water-saving management activity in the project. If energy consumption in the project is not measurable, planned value and/or estimated value used in the Feasibility study can be used for the calculation of the project emissions.

[10] For electricity, grid emission factors shown in the appendix (1. Emission Factors for Electricity) of this guideline may be applicable for the calculation. If there are any appropriate emission factors other than this guideline value, it can be adopted for the calculation. For fossil fuel, emission factors shown in the appendix (2. Emission Factors of Fuels) of this guideline may be applicable for the calculation.

(2) Formula of project Emissions

A. Project emissions of the energy efficient water treatment project

$$PE_y = PC_y \times EF_y \quad \cdots\cdots(6)$$

$PE_y$ : Annual project emission (t-$CO_2$/year)

$PC_y$ : Annual average energy consumption in the project (MWh/year or GJ/year)

$EF_y$ : Emission factor (Electricity or fossil fuel (t-$CO_2$/MWh or t-$CO_2$/MJ)

B. Project emission of the water–saving management project

$$PE_y = PC_y \times EF_y \quad \cdots\cdots(7)$$

$PE_y$ : Annual project emission (t-$CO_2$/year)

$PC_y$ : Annual average energy consumption in the project (MWh/year or GJ/year)

$EF_y$ : Emission factor electricity or fossil fuel (t-$CO_2$/MWh or t-$CO_2$/MJ)

## 6. Effect outside of the Project Boundary (Leakage)

Leakage is not taken into account, unless it is obviously significant.[11].

## 7.Measurement and Reporting of Emission Reductions after the Completion

The monitoring items are as follows:

A. Energy efficient water treatment project

| Monitoring Items | | Source of Data | |
|---|---|---|---|
| | | Planned Value | Result Value |
| $PW_{treated, y}$ | Average annual water volume treated in the project ($m^3$/year) | ・F/S report etc. | ・Records by the project operator |
| $PC_y$ | Annual average energy consumption in the project (MWh/year or GJ/year) | | |

[11] The potential effects outside the Project Boundary are: emissions in the upstream and downstream (lifecycle) of the project activity (e.g. construction or renewal of pipeline in the water-saving management projects, etc.). These will not be taken into account in this Methodology unless they are significant.

B. Water-saving management project

| Monitoring Items | | Source of Data | |
|---|---|---|---|
| | | Planned Value | Result Value |
| $PW_{reduced, y}$ | Average annual water volume saved in the project（$m^3$/year） | ・F/S report etc. | ・Planned value in F/S report etc. |
| $PC_y$ | Annual average energy consumption in the project (MWh/year or GJ/year) | | ・Records by the project operator |

## 8. References

(1) Supplementary Explanation

—

(2) Referenced Standards and Methodologies

A. Standards / Guidelines

・ 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 5

B. CDM Methodologies

| Project type | Methodology/Tools | CDM Small scale methodology |
|---|---|---|
| a)Energy efficient water treatment projects | Tool to calculate project or leakage $CO_2$ emissions from fossil fuel combustion<br>Tool to calculate baseline, project and/or leakage emissions from electricity consumption | AMS I-C, I-D, II-C, AMS II-D |
| b) Water–saving management projects | – | AMS I-C, I-D, II-C, AMS II-D |
| c) Methane utilization / collection project | ACM0014 (AM0013, *AM0022*) , ACM0006, AM0039 | AMS III-H, III-I |

History of Revisions

・Released, October, 2012

・Revised, October, 2014

ANNEX

Methodology for Methane Recovery and Utilization Projects

## 1. Applicable Projects

This methodology is applicable for the project which treats the organic substance in the sewerage water[12] under anaerobic condition (anaerobic digestion) and recovery the generated methane gas for utilization.

## 2. Concept and Formula of Emission Reductions

(1) Basic Concept

Emission Reductions of the "methane recovery and utilization project" is calculated as a difference between the emission derived from methane emission into atmosphere (baseline emissions) and the emission after the recovery and utilization of the methane (project emissions). In addition, in the case of the methane is recovered as energy in the project, it is necessary to estimate the emission reductions based on the assumption that the electricity and heat are generated by the standard methods in the country (baseline emissions and project emissions shall be calculated).

(2) Basic Formula

$$ER_y = BE_y - PE_y \quad \cdots\cdots (1)$$

$ER_y$ : Annual emission reduction ($tCO_2$/year)
$BE_y$ : Annual baseline emission ($tCO_2$/year)
$PE_y$ : Annual project emission ($tCO_2$/year)

## 3. Baseline Emissions

(1) Basic Concept

Baseline emission is the emission derived from methane dispersion into atmosphere, which has been generated from the sewerage water and/or its sludge and has not been collected.

[12] In general, sewerage treatment process to treat the organic substances in the sewerage water is categorized as anaerobic digestion, in which volatile organic materials are degraded in the absence of oxygen and produces a methane gas, or aerobic digestion, in which organic substances are degraded by bacteria and generate carbon dioxide. To treat the sludge which is generated in the process of sewerage treatment, carburization process can also be applied. In carbonization process, sewerage sludge is roasted to be utilized as a solid fuel (carbonized sludge).

(2) Basic Formula

$$BE_y = BE_{CH4,y} + BE_{EN,y} \quad \cdots\cdots (2)$$

$BE_y$ : Annual baseline emissions ($tCO_2e/yr$)

$BE_{CH4,y}$ : Annual baseline emissions of Methane from wastewater etc. ($tCO_2e/yr$)

$BE_{EN,y}$ : Annual baseline emissions with electricity generation and heat supply by energy recovery and utilization. ($tCO_2/yr$)

$$BE_{CH4,y} = EF \times TOW \times (1-R) \times GWP_{CH4} \quad \cdots\cdots (3)$$

$BE_{CH4,y}$ : Methane ($CH_4$) emission from sewerage treatment in the baseline ($tCO_2e/yr$)

$GWP_{CH4}$ : Global Warming Potential of methane[13] ($tCO_2/tCH_4$)

TOW : Total organic substance contained in the sewerage water in the baseline (kg-COD/year or kg-BOD/year)

EF : Emission factor of the methane ($kgCH_4$/kg-COD or $kgCH_4$/kg-BOD)

R : Methane recovery rate (%) ; if methane recovery does not have any leakage, R is set as 100%

$$EF = B_o \times MCF \quad \cdots\cdots (4)$$

EF : Emission factor of the methane at sewage treatment facility ($kgCH_4$/kg-COD or $kgCH_4$/kg-BOD)

Bo : Methane generation unit from the sewerage water/sludge ($kgCH_4$/ kg-COD or $kgCH_4$/ kg-BOD)[14]

MCF : Methane conversion factor of sewerage treatment system

$$TOW = W_y \times COD \quad \cdots\cdots (5)$$

$W_y$ : Annual Waste water volume ($m^3$/ yr)

COD : COD concentration or BOD concentration in the sewage water etc. (kg-COD/$m^3$ or kg-BOD/$m^3$)

[13] Refer to Appendix (4. Global Warming Potential of Greenhouse Gas) in this Guidelines.

[14] If there is no general data and/or measured data for Bo of country, default value of Bo=0.6kgCH4 / kg-BOD or Bo=0.25kgCH4 / kg-COD can be applied as an alternative value (Source; 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 5 Waste)

Following value can be applicable as a default value of MCF , if there is no general data and/or measured data in the country.

| | |
|---|---|
| As a common practice, sewerage water/sludge is treated under the aerobic condition in the country. | MCF＝0.1 |
| As a common practice, sewerage water/sludge is treated under the anaerobic condition but methane is not recovered in the country | MCF＝0.8 |
| As a common practice, sewerage water/sludge is uncontrolled in the country | MCF＝0.3 |

$$BE_{EN,y} = BE_{elec,y} + BE_{heat,y} = EG_y \times EF_{elec} + Q_y \times EF_{fuel}/\eta_{facility} \quad \cdots\cdots (6)$$

$BE_{elec,y}$ : Annual baseline emissions with electricity generation ($tCO_2$/yr)

$BE_{heat,y}$ : Annual baseline emissions with heat supply ($tCO_2$/yr)

$EG_y$ : Annual quantity of electricity generation of the project (MWh/yr)

$EF_{elec}$ : Emission factor of the electricity[15] ($tCO_2$/MWh)

$Q_y$ : Annual quantity of heat supply of the project (GJ/yr)

$EF_{fuel}$ : Emission factor of the most used fossil fuel in the country[16] ($tCO_2$/GJ)

$\eta_{facility}$ : Heat efficiency of baseline heat supply facility/equipment (Default value = 0.9)[17]

## 5. Project Emissions

(1) Basic Concept

Project emission is a leakage of the recovered methane. If the methane recovery facility is well managed, the project emission is zero (0). If the methane recovery rate

[15] Refer to "generating end emission factor" or "sending end emission factor" in the "1. Emission Factors for Electricity" of Appendix in this Guideline. However, other emission factor based on F/S report etc. may be applicable if the project substitutes in-house power generation or if the project is implemented in off-grid area inter alia, provided that there is a rational explanation

[16] Emission factor of the most used fossil fuel in the country is either of the following.
1) For the emission factor of the most used fossil fuel in the country, refer to "2. Emission Factors of Fuels" of Appendix in this Guidelines, while the most used fossil fuel in the country shall be defined based on the data of the IEA , or,
2) Specific data in the F/S report etc., provided that there is a rational explanation.

[17] This default value is based on statistical data (source: "Handbook for heating, air-conditioning and sanitary engineering of Japan") of heat efficiency of various types of boilers. If there is any specific data of heat efficiency in the F/S report etc. for the project, it may be applicable, provided that there is a rational explanation.

has been set before the implementation of the project, recovery rate of the methane should be considered for the estimation of project emissions.

(2) Formula of Project Emissions

Basically, project emission is zero (0)

$$PE_y = 0 \quad \text{----------(7)}$$

## 6. Effect outside the Project Boundary (Leakage)

Leakage is not taken into account, it is obviously significant.[18].

## 7. Measurement and Reporting of Emission Reductions after the Completion

The monitoring items are as follows:

| Monitoring items | | Source of Data | |
|---|---|---|---|
| | | Planned Value | Result Value |
| $W_y$ | Annual Waste water volume ($m^3$/yr) | ・F/S report etc. | ・Actual measurement data by measurement machine, etc. |
| COD | COD concentration or BOD concentration in the sewage water etc. （kg-COD or kg-BOD /$m^3$） | | ・Actual measurement data by measurement machine, etc. |
| R | Annual recovery rate of methane from sewage （%） | | ・Actual measurement data by measurement machine, etc. |
| $EC_{PJ,y}$ | Annual consumption of external power (MWh/yr) | | ・Record of electricity meter |
| $FC_i$ | Annual consumption of fuel *i* （t, kl or $m^3$/yr) | | ・Record of fuel consumption in object facility |
| $EG_y$ | Annual electricity generation (MWh/yr) | | ・Record of electricity meter |
| $Q_y$ | Annual heat supply quantity (GJ/yr) | | ・Actual measurement data by calorimeter and flow meter, etc.[19] |

[18] The potential effects outside the Project Boundary are: emissions in the upstream and downstream (lifecycle) of the project activity. These will not be taken into account in this Methodology. However, JBIC will expect borrowers and relevant parties to take appropriate measures when significant source of leakage is found.

[19] It is advisable to use calorimeter. Depending on the project situation, flow meter, thermometer, pressure meter etc. may be applicable.

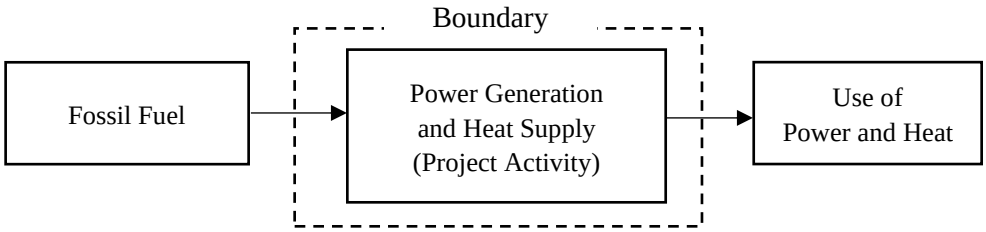
# Methodology for Introducing New Cogeneration Facilities

## 1. Applicable Projects[1]

This methodology is applicable to projects that install new fossil fuel[2] fired cogeneration facilities[3] by generating power and supplying heat simultaneously, which reduce fuel consumption.

## 2. Project Boundary

The project boundary encompasses activities of the applicable project to which JBIC finance is extended.




## 3. Concept and Formula of Emission Reductions

(1) Basic Concept

Emission reductions are defined as the difference between the amount of emissions from power generation and heat supply if the cogeneration project is not implemented (baseline emissions) and the amount of emissions from energy consumption in the project activity (project emissions).

(2) Basic Formula

---

[1] The projects in this methodology include but are not limited to ones newly supplying power and heat for factories, offices, hospitals and commercial buildings, as well as for associated coolers / heaters and industrial processes. As for retrofitting and replacing existing cogeneration facilities, "Methodology for Introducing Energy Efficient Equipment / Facilities" may be applied. For cogeneration projects other than the above, the following methodologies may be applied: "Methodology for Renewable Energy Projects" for cogeneration projects using renewable energy such as biomass; "Methodology for Waste Energy Recovery" for cogeneration projects using waste energy; and "Methodology for Waste Management Projects" for cogeneration projects using waste.

[2] Fossil fuel such as coal, oil, natural gas, diesel fuel, etc.

[3] Cogeneration facilities enable the improvement of overall energy efficiency by generating power and supplying heat simultaneously. In average, cogeneration plant can be expected to improve overall energy efficiency from 51% to 75%, and as a consequence, fuel consumption for generating the same amount of power and heat is reduced by approximately 30% (Reference: Fuel and Carbon Dioxide Emissions Savings Calculation Methodology for Combined Heat and Power Systems, U.S.EPA, 2012)., cogeneration is often referred to as Combined Heat and Power (CHP) in European countries and the United States.

Emission reductions are calculated as the difference between baseline emissions and project emissions.

$$ER_y = BE_y - PE_y \quad \cdots\cdots (1)$$

$ER_y$ : Annual emission reductions ($tCO_2/yr$)

$BE_y$ : Annual baseline emissions ($tCO_2/yr$)

$PE_y$ : Annual project emissions ($tCO_2/yr$)

## 4. Baseline Emissions

### (1) Basic Concept

Baseline emissions,are defined as sum of the baseline emissions from power generation and the baseline emissions from heat supply.

A. Baseline Emissions from Power Generation

Baseline emissions from power generation are defined as the amount of emissions when the same amount of power generated[4] in the project activity was generated by the average emission factor of all power plants in the country[5].

However, if there are constraints regarding fuel supply attributed to energy policies in the country, or economic rationality in the project, the average emission factor of the same fuel type[5] as in the project activity may be applied.

B. Baseline Emissions from Heat Supply

Baseline emissions from heat supply are defined as the amount of emissions when the same amount of heat supplied in the project activity was supplied by the baseline heat supply equipment/facility.

### (2) Basic Formula

$$BE_y = BE_{elec,y} + BE_{heat,y} \quad \cdots\cdots (2)$$

$BE_{elec,y}$ : Annual baseline emissions from power generation ($tCO_2/yr$)

$BE_{heat,y}$ : Annual baseline emissions from heat supply ($tCO_2/yr$)

A. Baseline emissions from power generation

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[4] The amount of net power generation is defined as the difference between the amount of total power generation in the project activity and the amount of power consumed by an auxiliary power unit (APU), etc.

[5] Refer to "generating end emission factor" or "sending end emission factor" in the "1. Emission Factors for Electricity" of Appendix in this Guideline. However, other emission factor based on F/S report etc. may be applicable if the project substitutes in-house power generation or if the project is implemented in off-grid area inter alia, provided that there is a rational explanation

$$BE_{elec,y} = EG_y \times EF_{elec} \quad \cdots\cdots(3)$$

$EG_y$ : Annual power generation in the project activity[4] (MWh/yr)

$EF_{elec}$ : Emission factor for power generation[5] ($tCO_2$/MWh)

B. Baseline emissions from heat supply

$$BE_{heat,y} = Q_y \times EF_{fuel} / \eta_{facility} \quad \cdots\cdots(4)$$

$Q_y$ : Annual heat supply in the project activity (GJ/yr)

$EF_{fuel}$ : Emission factor of fossil fuel, the consumption of which is reduced in the project activity[6] ($tCO_2$/GJ)

$\eta_{facility}$ : Heat efficiency of baseline heat supply equipment/facility (default = 0.9)[7]

## 5. Project Emissions

(1) Basic Concept

Project emissions are defined as the amount of emissions from energy consumption in the project activity.

(2) Basic Formula

$$PE_y = \Sigma(FC_{i,y} \times NCV_i \times EF_{fuel,i}) \quad \cdots\cdots(5)$$

$FC_{i,y}$ : Annual consumption of fossil fuel *i* in the project activity (t, kl /yr)

$NCV_i$ : Net calorific value of fossil fuel *i*[8] (GJ/t, kl)

$EF_{fuel,i}$ : Emission factor of fossil fuel *i* ($tCO_2$/GJ)

## 6. Effects Outside of the Project Boundary (Leakage)

Leakage is not taken into account, unless it is obviously significant.[9]

## 7. Measurement and Reporting of Emission Reductions

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[6] For the emission factor of the baseline fossil fuel, consumption of which is reduced in the project activity, (1) fossil fuel which is the same fuel type as in the project activity is selected and "2. Emission Factors of Fuels" of Appendix in this Guidelines may be applicable, and (2) if the project specific data is described in the F/S report, etc., and is appropriate and reasonable, the type and the emission factor of fossil fuel based on the data can be applied.

[7] This default value is based on statistical data (source: "Handbook for heating, air-conditioning and sanitary engineering of Japan") of heat efficiency of various types of boilers. If there is any specific data of heat efficiency in the F/S report etc. for the project, it may be applicable, provided that there is a rational explanation.

[8] Refer to Appendix (2. Emission Factors of Fuels) in this Guidelines.

[9] The potential effects outside the project boundary are: emissions upstream and downstream (lifecycle) of the project activity (emissions from manufacturing cogeneration facilities etc.), or indirect emissions associated with the project activity. These will not be taken into account in this methodology unless they are obviously significant.

The monitoring items are as follows:

| Monitoring Items | | Source of Data | |
|---|---|---|---|
| | | Planned Value | Result Value |
| $EG_y$ | Annual power generation in the project activity (MWh/yr) | ・F/S report etc. | ・Record of electricity meter[10] |
| $Q_y$ | Annual heat supply in the project activity (GJ/yr) | | ・Measured value with calorimeter, flow meter, thermometer, pressure gauge, etc.[11] |
| $FC_{i,y}$ | Annual consumption of fossil fuel *i* in the project activity (t, kl/yr) | | ・Record in the project facility |
| $NCV_i$ | Net calorific value of fossil fuel *i* (GJ/t, kl) | ・F/S report etc.[12] | ・Record in the project facility |

## 8. References

(1) Supplementary Explanation

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(2) Referenced Standards and Methodologies

・AM0014: Natural gas-based package cogeneration

・AM0048: New cogeneration project activities supplying electricity and heat to multiple costumers

・AM0107: New natural gas based cogeneration plant

History of Revisions

・Released, October, 2014

[10] It is preferable to install the electricity meter(s) in locations where net power generation in the project activity can be measured.

[11] Basically, a calorimeter is used. Depending on the circumstances of the project, however, a flow meter, a thermometer, or a pressure gauge, etc. may also be applicable.

[12] Basically, refer to data based on F/S report, environment impact assessment report, etc. However, if such data is not available, default value of Appendix (3. Net Calorific Values of Fuels) in this Guideline may be applicable.

## Methodology for Manufacturing Energy Efficient/Renewable Energy Equipment

### 1. Applicable Projects[1]

This methodology is applicable to projects that manufacture and sell energy efficient or renewable energy equipment/facilities (hereinafter referred to as "Equipment" [2]).

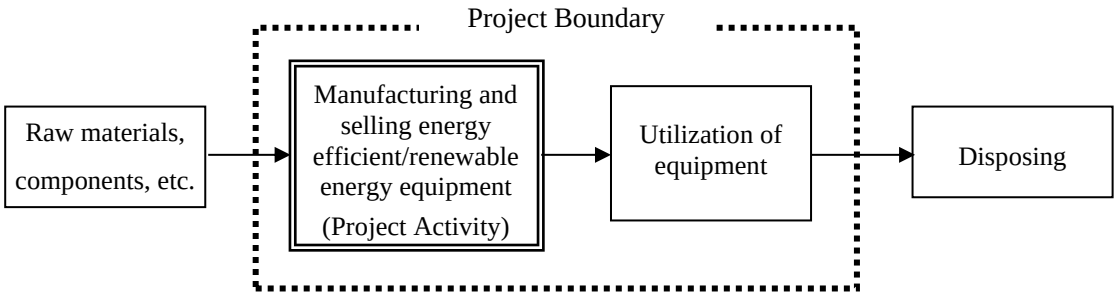
The following table outlines applicable projects.

| Project Type | Outlines |
|---|---|
| Manufacturing and selling energy efficient equipment | Manufacturing and selling energy efficient equipment such as energy efficient refrigerators, inverter air conditioners, LEDs, high efficiency power generators, etc. |
| Manufacturing and selling renewable energy equipment | Manufacturing and selling renewable energy equipment such as solar power generators, wind power generators, hydro power generators, etc. |

### 2. Project Boundary

The project boundary encompasses activities of the applicable projects to which JBIC finance is extended.

It also includes activities in which the equipment manufactured and sold in the project are utilized.




### 3. Concept and Formula of Emission Reductions

(1) Basic Concept

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[1] This methodology can only be applied for projects that manufacture and sell energy efficient/renewable energy equipment. Regarding projects to install and utilize equipment, for renewable energy equipment, the "Methodology for Renewable Energy Projects" can be applied, and for energy efficient equipment, the "Methodology for Introducing Energy Efficient Equipment/Facilities" can be applied.

[2] In principle, "Equipment" in this methodology is limited to finished products which are expected to have emission reduction effect by themselves. However, semi-finished products, such as photovoltaic modules, high-efficient turbines for power generators, etc., are also deemed to be "Equipment", if their specifications and energy efficiency performance are clearly indicated when they are utilized as finished products. The advisory committee may be consulted regarding which kind of semi-finished products shall be deemed as "Equipmet" in this methodology.

A. For energy efficient equipment, emission reductions are defined as the difference between the amount of emissions from average energy consumption when the conventional equipment that has performance/capacity equivalent to the equipment in the project is in utilization (baseline emissions), and the amount of emissions from average energy consumption of the equipment in the project (project emissions).

B. For renewable energy equipment, emission reductions are defined as the difference between the amount of emissions when the same amount of power generation and heat supply from the renewable energy equipment in utilization was generated by the average emission rate of all power plants in the country (baseline emissions), and the amount of emissions from average energy consumption of the equipment in the country (project emissions).

In calculations for the case of A and B above, with taking it into account that cumulative number of equipment in utilization increases every year by manufacturing and selling equipment, annual average emission reductions during calculation period[3] are defined.

(2) Basic Formula

A. Annual emission reductions per unit of equipment[4]

$$ER_{unit,y} = BE_{unit,y} - PE_{unit,y} \quad \cdots\cdots (1)$$

$ER_{unit,y}$ : Annual emission reductions per unit of equipment ($tCO_2$/unit-yr)
$BE_{unit,y}$ : Annual baseline emissions per unit of equipment ($tCO_2$/unit-yr)
$PE_{unit,y}$ : Annual project emissions per unit of equipment ($tCO_2$/unit-yr)

B. Annual average emission reductions in the project

$$ER_{ave} = \left\{ \sum_{y=1}^{y_{max}} \sum_{Y=1}^{y} ER_{unit,y} \times n_Y \times (1 - d_{Y,y}) \right\} \div y_{max} \quad \cdots\cdots (2)$$

[3] Basically, "calculation period" which is subject to length of utilization of equipment is defined as basically 5 years. However, if durable years of equipment is less than 5 years, or if baseline emissions would be changed in line with relevant policy change (such as MEPS described below), calculation period is defined as appropriate period less than 5 years.

[4] In calculating annual emission reductions, equipment manufactured annually in the project is assumed to be all manufactured at the start of each year and to be utilized with immediate emission reduction effect.

$ER_{ave}$ : Annual average emission reductions ($tCO_2$/yr)
$ER_{unit,y}$ : Annual emission reductions per unit of equipment ($tCO_2$/unit-yr)
y : Number of years from beginning of utilization of equipment (yr)
Y : Number of years from beginning of the first shipment of equipment in the project (yr) (However, Y is not extend beyond y)
$y_{max}$ : Calculation period subject to annual average emission reductions (yr)
$n_Y$ : Number of shipments[5] of equipment in year Y (unit/yr)
$d_{Y,y}$ : Cumulative failure rate of equipment until year y[6] regarding the equipment which was manufactured in year Y

## 4. Baseline Emissions

(1) Basic Concept

A. Energy efficient equipment

Baseline emissions are defined as the amount of emissions[7] from average energy consumption[8] when the conventional equipment which has performance/capacity equivalent to the equipment in the project is utilized.

B. Renewable energy equipment

(a) Power generation equipment

Baseline emissions from power generations are defined as the amount of emissions when the same amount of power generated by the renewable energy equipment in utilization was generated by the average emission rate of all power plants in the country.

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[5] For the first year, actual value of annual number of shipments, which is derived from monitoring, may be applicable. From the second year on, expected annual number of shipments based on the latest business plan etc. may be applicable.

[6] The failure rate is defined as the ratio of units of equipment (manufactured and sold in the project) that drop below a specified performance/capacity level due to breakdown or other factors associated with equipment aging. The specific failure rate is (1) a reasonable estimate value based on adequate past data from applicable equipment; or (2) a statistical value calculated by Weibull distribution function (refer to Annex). However, if equipment failure can be adequately avoided by having a suitable maintenance contract, or where repair/replacement at no cost is certain to be provided by the manufacturer during a warranty period, it is acceptable to do without consideration of a failure rate.

[7] In the case where the equipment is sold in multiple countries, basically, baseline emissions are calculated based on each country's standards.

[8] Specifically, for setting the baseline, (1) an independently-established standard value such as a Minimum Energy Performance Standard (MEPS) based on domestic energy policy in the country where the equipment is being sold or other standard value of a similar nature (e.g., a domestic standard that conforms with MEPS or an IE-1 (Standard) for energy efficiency set by the International Electrotechnical Commission (IEC)) is applied, or (2) if there is specific data for the project in F/S report etc., and it is appropriate and rational, such data is also applicable.

(b) Heat supply equipment

Baseline emissions from heat supply are defined as the amount of emissions when the same amount of heat supplied by the renewable energy equipment in utilization was supplied by average heat supply equipment/facilities in the country.

(2) Basic Formula

A. Energy efficient equipment

In general, a minimum standard of energy efficiency is set for each type of equipment, and the reference value used in the energy efficiency standard are defined by either "energy consumption" or "energy efficiency" for electricity and fuel consumption. In this methodology, since energy efficient equipment fall into the general classification of electricity using equipment and fuel-using equipment, baseline emissions are calculated by one of the following formulas.

(a) Electricity using equipment

(i) In the case where electricity consumption is set as the minimum standard

$$BE_{unit,y} = EC_{BL,y} \times EF_{elec,y} \quad \cdots\cdots (3)$$

(ii) In the case where energy efficiency is set as the minimum standard

$$BE_{unit,y} = EC_{BL,y} \times EF_{elec,y} \quad \cdots\cdots (4)$$

$$EC_{BL,y} = p_{BL} / \eta_{BL} \times o \quad \cdots\cdots (5)$$

$BE_{unit,y}$ : Annual baseline emissions per unit of the conventional equipment ($tCO_2$/unit-yr)

$EC_{BL,y}$ : Annual power consumption per unit of the conventional equipment (kWh/unit-yr)

$EF_{elec,y}$ : Emission factor for electricity ($tCO_2$/kWh)[9]

$p_{BL}$ : Rated capacity of the conventional equipment (kW/unit)[10]

$\eta_{BL}$ : Energy efficiency of the conventional equipment[11]

[9] Refer to "generating end emission factor" or "sending end emission factor" in the "1. Emission Factors for Electricity" of Appendix in this Guideline. However, other emission factor based on F/S report etc. may be applicable if the project substitutes in-house power generation or if the project is implemented in off-grid area inter alia, provided that there is a rational explanation

[10] The average performance/capacity of the most prevailing conventional equipment in the country is applied. Rated capacity/output etc. may be applicable.

[11] The same as footnote 8.

o : Annual operating hours of the conventional equipment[12] (h/yr)

(b) Fuel-using equipment

(i) In the case where fuel consumption is set as the minimum standard

$$BE_{unit,y} = FC_{BL,y} \times NCV \times EF_{fuel,y} \quad \cdots\cdots (6)$$

(ii) In the case where energy efficiency is set as the minimum standard

$$BE_{unit,y} = Q_{BL,y} \times EF_{fuel,y} \quad \cdots\cdots (7)$$

$$Q_{BL,y} = p_{BL} / \eta_{BL} \times o \quad \cdots\cdots (8)$$

$BE_{unit,y}$ : Annual baseline emissions per unit of the conventional equipment ($tCO_2$/unit-yr)

$FC_{BL,y}$ : Annual fuel consumption per unit of the conventional equipment (t, kl/unit-yr)

NCV : Net calorific value of fossil fuel[13] (GJ/t, kl)

$EF_{fuel,y}$ : Emission factor of the most used fossil fuel in the country[14] ($tCO_2$/GJ)

$Q_{BL,y}$ : Annual heat consumption per unit of the conventional equipment (GJ/unit-yr)

$p_{BL}$ : Rated output of the conventional equipment[10] (GJ/unit-h)

$\eta_{BL}$ : Heat efficiency of the conventional equipment

o : Annual operating hours of the conventional equipment (h/yr)

B. Renewable energy equipment

(a) Electricity generators

$$BE_{unit,y} = EG_{PJ,y} \times EF_{elec,y} \quad \cdots\cdots (9)$$

$$EG_{PJ,y} = \eta_{PJ} \times (365 \times 24 \times p_{BL}) \quad \cdots\cdots (10)$$

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[12] (1) Basically, the mean value that is announced officially or by third parties in the country (e.g., annual number of hours in operation, which is applied for electricity price estimation, etc.) is applied. (2) However, if the project-specific data described in F/S report etc. is appropriate and rational, it is also applicable.

[13] Refer to Appendix (3. Net Calorific Values of Fuels) in this Guidelines.

[14] Emission factor of the most used fossil fuel in the country is either of the following.
1) For the emission factor of the most used fossil fuel in the country, refer to "2. Emission Factors of Fuels" of Appendix in this Guidelines, while the most used fossil fuel in the country shall be defined based on the data of the IEA , or,
2) Specific data in the F/S report etc., provided that there is a rational explanation.

$BE_{unit,y}$ : Annual baseline emissions per unit of the equipment ($tCO_2$/unit-yr)
$EG_{PJ,y}$ : Annual power generation per unit of the equipment (kWh/unit-yr)
$EF_{elec,y}$ : Emission factor for electricity ($tCO_2$/kWh)
$\eta_{PJ}$ : Availability/capacity factor of the equipment[15]
$p_{BL}$ : Rated capacity of the equipment[16] (kW/unit)

(b) Heat supply equipment

$$BE_{unit,y} = Q_{PJ,y} \times EF_{fuel,y} \quad \cdots\cdots(11)$$

$$Q_{PJ,y} = \eta_{PJ} \times (365 \times 24 \times p_{BL}) \quad \cdots\cdots(12)$$

$BE_{unit,y}$ : Annual baseline emissions per unit of the equipment ($tCO_2$/unit-yr)
$Q_{PJ,y}$ : Annual heat supply per unit of the equipment (GJ/unit-yr)
$EF_{fuel,y}$ : Emission factor of the most used fossil fuel in the country ($tCO_2$/GJ)
$\eta_{PJ}$ : Availability/capacity factor of the equipment[14]
$p_{BL}$ : Rated output of the equipment[15] (GJ/unit-h)

## 5. Project Emissions

(1) Basic Concept

A. Energy efficient equipment

Project emissions are defined as the amount of emissions from average energy consumption of the equipment in utilization in the country.

In this methodology, emissions from energy consumption at that stage of manufacturing and selling the equipment are not taken into account, since differences in the amount of emissions from energy consumption at manufacturing and selling stage are not significant between the equipment and conventional ones.

B. Renewable energy equipment

Project emissions from the equipment in utilization are considered zero since power generation and/or heat supply using renewable energy sources do not

[15] Availability/capacity factor in the country is determined as follows: (1) The date of the country or the surrounding country described in IEA World Energy outlook 2010 "Assumed investment costs, operation and maintenance costs and efficiencies for power generation in the New Policies and 450 Scenarios" is applied. (2) If there are specific data of the project in F/S report etc., and are appropriate and rational, they are also applicable.

[16] Performance/output of power generation or heat supply per unit of equipment is set by the manufacturer at that stage of designing and manufacturing the equipment.

consume fossil fuel.

In this methodology, emissions from energy consumption at that stage of manufacturing and selling the equipment are not taken into account since differences in the amount of emissions from energy consumption at manufacturing and selling stage are not significant between the equipment and baseline power generators and so on.

(2) Basic Formula

A. Energy efficient equipment

In general, "Energy efficiency" specification of the equipment manufactured and sold in the project activity can be defined by either "energy consumption" or "energy efficiency" for electricity and fuel consumption. In this methodology, since energy efficient equipment fall into the general classification of electricity using equipment and fuel-using equipment, emissions from equipment in utilization are calculated by one of the following formulas.

(a) Electricity using equipment

(i) In the case where energy consumption is set as the specification

$$PE_{unit,y} = EC_{PJ,y} \times EF_{elec,y} \quad \cdots\cdots(13)$$

(ii) In the case where energy efficiency is set as the specification

$$PE_{unit,y} = EC_{PJ,y} \times EF_{elec,y} \quad \cdots\cdots(14)$$

$$EC_{PJ,y} = p_{PJ} / \eta_{PJ} \times o \quad \cdots\cdots(15)$$

$PE_{unit,y}$ : Annual emissions per unit of the equipment in utilization ($tCO_2$/unit-yr)

$EC_{PJ,y}$ : Annual electricity consumption per unit of the equipment (kWh/unit-yr)

$EF_{elec,y}$ : Emission factor for electricity ($tCO_2$/kWh)

$p_{PJ}$ : Rated capacity of the equipment[17] (kW/unit)

$\eta_{PJ}$ : Energy efficiency of the equipment[18]

$o$ : Annual operating hours of the equipment (h/yr)

[17] Performance/capacity of the equipment that is set by the manufacturer is applied. It is indicated by rated capacity/output, etc.

[18] Energy/heat efficiency of the equipment that is set by the manufacturer is applied.

(b) Fuel-using equipment

(i) In the case where fuel consumption is set as the specification

$$PJ_{unit,y} = FC_{PJ,y} \times NCV \times EF_{fuel,y} \quad \cdots\cdots(16)$$

(ii) In the case where heat efficiency is set as the specification

$$PJ_{unit,y} = Q_{PJ,y} \times EF_{fuel,y} \quad \cdots\cdots(17)$$

$$Q_{PJ,y} = p_{PJ} / \eta_{PJ} \times o \quad \cdots\cdots(18)$$

$PJ_{unit,y}$ : Annual emissions per unit of the equipment in utilization ($tCO_2$/unit-yr)

$FC_{PJ,y}$ : Annual fuel consumption per unit of the equipment (t, kl/unit-yr)

NCV : Net calorific value of fossil fuel (GJ/t, kl)

$EF_{fuel,y}$ : Emission factor of the most used fossil fuel in the country ($tCO_2$/GJ)

$Q_{PJ,y}$ : Annual fuel consumption per unit of the equipment (GJ/unit-yr)

$p_{PJ}$ : Rated output of the equipment[16] (GJ/unit-h)

$\eta_{PJ}$ : Heat efficiency of the equipment[17]

o : Annual operating hours of the equipment (h/yr)

B. Renewable energy equipment

In this methodology, emissions from power generation and/or heat supply using renewable energy sources are considered zero since they do not consume fossil fuel.

## 6. Effect Outside of the Project Boundary (Leakage)

Leakage is not taken into account, unless it is obviously significant.[19]

## 7. Measurement and Reporting of Emission Reductions

The monitoring items are as follows:

[19] The potential effects outside the Project Boundary are: emissions in the upstream and downstream (lifecycle) of the project activity, or indirect emissions associated with the project activity (e.g., leakage of refrigerant, etc.). Since it can be considered that the equivalent amount of emissions can be released when the project activity is not conducted, these will not be taken into account in this methodology unless they are obviously significant.

A. Energy efficient equipment

| Monitoring Items | | Source of Data | |
|---|---|---|---|
| | | Planned Value | Result Value |
| $n_Y$ | Number of shipments of equipment in year Y (units/yr) | ・F/S report etc. | ・Record of shipments<br>・expected annual number of shipments based on the latest business plan etc. |
| $p_{PJ}$ | Rated capacity/output of the equipment (kW/unit or GJ/unit-h) | | ・Record of measurement |
| $\eta_{PJ}$ | Energy/heat efficiency of the equipment | | ・Record of measurement |

B. Renewable energy equipment

| Monitoring Items | | Source of Data | |
|---|---|---|---|
| | | Planned Value | Result Value |
| $n_Y$ | Number of shipments of the equipment in year Y (units/yr) | ・F/S report etc. | ・Record of shipments<br>・expected annual number of shipments based on the latest business plan etc. |
| $p_{BL}$ | Rated capacity/output of the equipment (kW/unit or GJ/unit-h) | | ・Record of measurement |

These monitoring shall be conducted for one year period after the manufacturing line of the equipment starts full operation. In the case where conditions affecting the relevant standards in the country are established or changed, the necessity of changing baseline emissions is to be considered.

## 8. References

(1) Supplementary explanation

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(2) Referenced Standards and Methodologies

・Ministerial Ordinance concerning the Useful Life, etc., of Depreciable Assets, Ministry of Finance and National Tax Agency, Japan

・International Electrotechnical Commission

History of Revisions

・Released, October, 2014

ANNEX

## Setting failure rates by using Weibull distribution function etc.

In this methodology, to calculate emission reductions through manufacturing and selling small scale retail equipment such as air-conditioner, refrigerators, etc., where necessary, a failure rate is applied for formulas to calculate emission reductions. The failure rate is defined as the ratio of units of equipment dropping below a certain performance/capacity level due to breakdown, etc., associated with aging. However, since the ratios can differ depending on each manufacturer and type of equipment, it is difficult to obtain specific data which is generally unavailable.

This methodology sets the specific failure rate as (1) a reasonable estimate value based on adequate past data from applicable equipment, or (2) a statistical value calculated by Weibull distribution function.

Weibull distribution is a probability distribution that indicates distribution over the life span of equipment and can be applied to analyse failure rates. Based on durability tests data (e.g. time period until failure of product occurs), Weibull probability sheets are used to obtain parameters defining Weibull distribution function, which can be applied to estimate a future failure rate of the equipment.

In general, the cumulative failure rate $F(y)$ over period of utilization in year $y$ is calculated with the following formula.

$$F(y) = 1 - \exp\left[-\left(\frac{y}{\eta}\right)^{m}\right] \quad \cdots \quad (1)$$

m : Parameter that determines graphical form of probability density function of Weibull distribution (the larger value of m becomes, the more concentrated timing equipment failures in)

η : Parameter that determines a unit of scale of time axis of Weibull distribution function (the larger value of η becomes, the more slowly equipment failures)

In calculating actual cumulative failure rate, data is obtained from durability test on elapsed time until a breakdown occurs, and then, using a Weibull probability sheet, a graphical form parameter $(m)$ and a time scale parameter $(\eta)$ are calculated. The calculated parameters are applied to the above formula to calculate a cumulative failure rate $F(y)$ in year $y$, number of years from beginning of utilization of equipment.

# Methodology for Introducing Energy Management System (EMS)

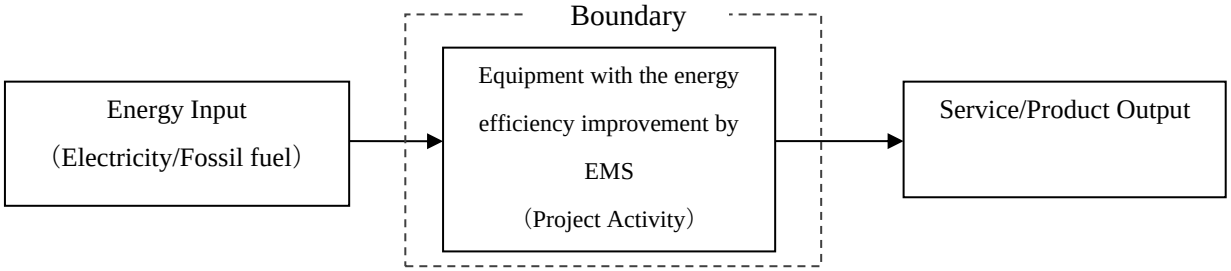
## 1. Applicable Projects

This methodology is applicable to projects that introduce an Energy Management System (hereinafter referred to as "EMS") to facilities or equipment (hereinafter referred to as the "equipment") at plants, buildings or communities. In this methodology, an EMS is a device or system which monitors, analyzes or controls the energy use of the equipment and contributes to its energy efficiency improvement.

This methodology provides the procedure for calculating emission reductions achieved as a result of the EMS implementation. In cases where the project involves the installation of energy efficiency equipment/facilities, or rehabilitation, replacing, or operational improvement for existing equipment/facilities, "Methodology for Introducing Energy Efficiency Equipment/Facilities" shall be applied.

## 2. Project Boundary[1]

The project boundary encompasses activities of the applicable project to which JBIC finance is extended.




## 3. Concept and Formula of Emission Reductions

(1) Basic Concept

Emission reductions are defined as the difference between the amount of emissions from the equipment without the EMS implementation (baseline emissions), and the amount of emissions from the equipment with the energy efficiency improvement through EMS implementation (project emissions).

(2) Basic Formula

Emission reductions are calculated as the difference between baseline emissions and project

[1] The energy efficiency improvement through EMS implementation does not lead to degrade the energy efficiency of equipment outside the project boundary.

emissions.

$$ER_y = BE_y - PE_y \quad \text{---------- (1)}$$

$ER_y$ : Annual emission reductions ($tCO_2$/yr)

$BE_y$ : Annual baseline emissions ($tCO_2$/yr)

$PE_y$ : Annual project emissions ($tCO_2$/yr)

**4. Baseline Emissions**

(1)Basic Concept

Baseline emissions are defined as the amount of emissions from the energy consumption of the equipment without the EMS implementation at the project plants, buildings or communities. The energy consumption of the equipment without the EMS implementation shall be calculated by dividing the project energy consumption after the EMS implementation by the improved efficiency rate achieved through the EMS implementation (hereafter referred to as the "efficiency improvement").[2] In cases where the EMS is introduced to multiple types of equipment[3], the amount of emissions are calculated separately for each application category (i.e. HVAC, lightings, etc.) and shall be aggregated for each energy type (i.e. electricity, fossil fuel).

(2) Basic Formula

$$BE_y = BE_{elec,y} + BE_{fuel,y} \quad \text{---------- (2)}$$

$BE_{elec,y}$ : Annual baseline emissions from electricity consumption ($tCO_2$/yr)

$BE_{fuel,y}$ : Annual baseline emissions from fossil fuel consumption ($tCO_2$/yr)

① Baseline emissions from electricity consumption

$$BE_{elec,y} = \sum_i \sum_j \left( \frac{EC_{PJ,i,j} \times EF_{elec}}{1 - \eta_{EMS,i,j}} \right) \quad \text{---------- (3)}$$

[2] Emission reductions associated with the improved efficiency from the behavioral changes as a result of the EMS implementation shall not be taken into consideration in this methodology.

[3] In cases where the EMS is introduced to multiple types of equipment, estimation based on sampling or theoretical calculation may be used for each application category and energy source, in accordance with Section 2. (7) of this guidelines.

$EC_{PJ,i,j}$ : Annual consumption of electricity by equipment *j* in application category *i*[4] (MWh/yr)

$EF_{elec}$ : Emission factor for electricity[5] ($tCO_2$/MWh)

$\eta_{EMS,i,}$ : Efficiency improvement of equipment *j* in application category *i* achieved through the EMS implementation

② Baseline emissions from fossil fuel consumption

$$BE_{fuel,y} = \sum_i \sum_j \left( \frac{FC_{PJ,i,j} \times NCV_{fuel,i,j} \times EF_{fuel,i,j}}{1 - \eta_{EMS,i,j}} \right) \quad \text{---------- (4)}$$

$FC_{PJ,i,j}$ : Fossil fuel consumption by equipment j in application category i (t or kl/yr)

$NCV_{fuel,i,j}$ : Net calorific value of fossil fuel consumed by equipment j in application category i[6] (GJ/t or kl)

$EF_{fuel,i,j}$ : Emission factor of fossil fuel consumed by equipment j in application category i[7] ($tCO_2$/GJ)

$\eta_{EMS,i,j}$ : Efficiency improvement of equipment j in application category i achieved by EMS implementation

The efficiency improvement of equipment in each application category ($\eta_{EMS,i,j}$) is calculated as below. However, in cases where measurement of the energy consumption neither before nor after the EMS implementation is difficult to conduct, theoretical or estimated values with certain reliability of data such as catalogue values or the values provided by the EMS manufacturers or suppliers may be applicable.

$$\eta_{EMS,i,j} = 1 - \frac{EC_{PJ,i,j}}{EC_{BL,i,j}} \quad \text{or} \quad 1 - \frac{FC_{PJ,i,j}}{FC_{BL,i,j}} \quad \text{---------- (5)}$$

$EC_{PJ,i,j}$ : Annual electricity consumption by equipment *j* in application category *i* after EMS

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[4] Electricity supplied from renewable energy sources shall not be included. In cases where renewable electricity generation is introduced to the plants, buildings or communities where the EMS is installed, emission reductions associated with the implementation of the renewable power generation shall be calculated separately using "Methodology for Renewable Energy Projects".

[5] In principle, the emission factor for electricity refers to " receiving end emission factor" in "1. Emission factor for Electricity" of Appendix in this Guidelines. However, other emission factors based on F/S reports, etc. may be applicable in cases where the project substitutes in-house power generation or the project is implemented in off-grid area *inter alia*, provided that there is a rational explanation for that.

[6] Basically, refer to data in F/S reports or environment impact assessment (EIA) reports. However, if these data are not available, refer to the default values in "3. Net Calorific Values of Fuels" of Appendix in this Guidelines shall be applicable.

[7] Refer to "2. Emission Factors of Fuels" of Appendix in this Guidelines.

implementation[8] (MWh/yr)

$EC_{BL,i,j}$ : Annual electricity consumption by equipment *j* in application category *i* before EMS implementation[9] (MWh/yr)

$FC_{PJ,i,j}$ : Annual fossil fuel consumption by equipment *j* in application category *i* after EMS implementation (t or kl/yr)

$FC_{BL,i,j}$ : Annual fossil fuel consumption by equipment *j* in application category *i* before EMS implementation (t or kl/yr)

## 5. Project Emissions

(1) Basic Concept

Project emissions are defined as the amount of emissions from energy consumption after the EMS implementation at plants, building or communities. In cases where the EMS is introduced to multiple types of equipment[10], the amount of emissions are calculated for each application category (i.e. HVAC, lightings, etc.) and shall be aggregated for each energy type (i.e. electricity, fossil fuel).

(2) Basic Formula

$$PE_y = PE_{elec,y} + PE_{fuel,y} \quad \text{---------- (6)}$$

$PE_{elec,y}$ : Annual project emissions from electricity consumption ($tCO_2$/yr)

$PE_{fuel,y}$ : Annual project emission from fossil fuel consumption ($tCO_2$/yr)

① Project emissions from electricity consumption

$$PE_{elec,y} = \sum_i \sum_j \left( EC_{PJ,i,j} \times EF_{elec} \right) \quad \text{---------- (7)}$$

$EC_{PJ,i,j}$ : Annual electricity consumption by equipment *j* in application category *i* after the EMS implementation[11] (MWh/yr)

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[8] Electricity supplied from renewable energy sources shall not be included. In cases where renewable electricity generation is introduced to the plants, buildings or communities where EMS is installed, emission reductions associated with the introduction of the renewable power generation shall be calculated separately by using "Methodology for Renewable Energy Projects".

[9] Electricity supplied from renewable energy sources shall not be included. In cases where renewable electricity generation is implemented to the plants, buildings or communities where EMS is implemented, emission reductions associated with the introduction of the renewable power generation shall be calculated separately by using "Methodology for Renewable Energy Projects".

[10] In cases where EMS is introduced to multiple types of equipment, estimation based on sampling or theoretical calculations may be used for each application category and energy source in accordance with Section 2. (7) of this guidelines.

[11] Electricity supplied from renewable energy sources shall not be included. In cases where renewable

$EF_{elec}$ : Emission factor for electricity ($tCO_2/MWh$)

② Project emissions from fossil fuel consumption

$$PE_{fuel,y} = \sum_i \sum_j \left( FC_{PJ,i,j} \times NCV_{fuel,i,j} \times EF_{fuel,i,j} \right) \quad \text{---------- (8)}$$

$FC_{PJ,i,j}$ : Annual fossil fuel consumption by equipment *j* in application category *i* (t or kl/yr)

$NCV_{fuel,i,j}$ : Net calorific value of fossil fuel consumed by equipment *j* in application category *i*[12] (GJ/t or kl)

$EF_{fuel,i,j}$ : Emission factor of fossil fuel consumed by equipment *j* in application category *i*[13] ($tCO_2/GJ$)

## 6. Effect Outside of the Project Boundary (Leakage)

Leakage is not taken into account, unless it is obviously significant.[14]

## 7. Measurement and Reporting of Emission Reductions

The monitoring items are as follows.

Basically, monitoring option (1) is applied. However, when items under option (1) cannot be monitored, monitoring option (2) may be applicable.

Option (1): Energy consumption before and after the EMS implementation

| Monitoring Items[15] | | Planned Value | Result Value |
|---|---|---|---|
| $EC_{BL,i,j}$, $EC_{PJ,i,j}$ | Annual electricity consumption by equipment *j* in application category *i* before and after the EMS implementation (MWh/yr) | ・F/S report, etc. | ・Record of electricity meters, etc.<br>・Record by the project operator, |

electricity generation is introduced to the plants, buildings or communities where the EMS is implemented, emission reductions associated with the introduction of renewable power generation shall be calculated separately by using "Methodology for Renewable Energy Projects".

12 Refer to "3. Net Calorific Values of Fuels" of Appendix in this Guidelines.

13 Refer to "2. Emission Factors of Fuels" of Appendix in this Guidelines.

14 The potential effects outside the project boundary include emissions upstream and downstream (lifecycle) in the project activity or indirect emissions associated with the project activity. These will not be taken into account in this methodology unless they are obviously significant.

15 In cases where electricity and/or fossil fuel consumptions are measured, the project developer is expected to exclude changes in operating condition and operating pattern before and after the EMS implementation to the extent possible.

| | | | |
|---|---|---|---|
| | | | etc. |
| $FC_{BL,i,j}$、$FC_{PJ,i,j}$ and the type of fossil fuel consumed | Annual fossil fuel consumption by equipment *j* in application category *i* before and after the EMS implementation (tons or kl/yr), and the type of the fossil fuel consumed. | ・F/S reports etc. | ・Record by the project operator etc. |

Option (2): Efficiency improvement and energy consumption after the EMS implementation

| Monitoring Items | | Planned Value | Result Value |
|---|---|---|---|
| $\eta_{EMS,i,j}$ | Efficiency improvement of the EMS equipment | ・Catalogue values and other values provided by the EMS manufacturer or suppliers | |
| $EC_{PJ,i,j}$ | Annual electricity consumption by equipment *j* in application category *i* after the EMS implementation (MWh/yr) | ・F/S reports, etc. | ・Record of electricity meters, etc. |
| $FC_{PJ,i,j}$ and the type of fossil fuel consumed | Annual fossil fuel consumption by equipment *j* in application category *i* after the EMS implementation (tons or kl/yr), and the type of the fossil fuel consumed. | ・F/S reports, etc. | ・Record by the project operator, etc. |

8. References

(1) Supplementary explanations

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(2) Referenced standards and methodologies

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Histories of Revisions

・Released, August, 2015

## 1. Emission Factors for Electricity

Appendix

・The emission factors for generating end, sending end, and receiving end[16] in the chart below are based on "EMISSIONS FACTORS" and "WORLD ENERGY BALANCES" by IEA.
・The formula for each emission factors are as follows:

Average for All Power Sources = Amount of emission from all power plants serving the grid /Amount of power generated by all power plants serving the grid

Fuel = Amount of emission from a certain type of fossil fuel / Amount of power generated by the certain type of fossil fuel

1. Average for All Power Sources (Unit:kgCO2/MWh)

BLANK

[16] Basically, (1) use "generating end" in the case where the project activity serves the grid, and station service power (auxiliary power etc.) is NOT deducted from power generation in the project activity. (2) Use "sending end" in the case where the project activity serves the grid, and station service power is deducted from power generation in the project activity. (3) Use "receiving end" in the case where the project activity reduces power consumption by customers in the grid.

2. Fuel (Coal・Oil・Gas)　(Unit:kgCO2/MWh)

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## 2. Emission Factors of Fuels

Default value on Intergovernmental Panel on Climate Change (IPCC) Guideline

(Unit: kg GHG／TJ)

| DEFAULT EMISSION FACTORS FOR STATIONARY COMBUSTION IN MANUFACTURING INDUSTRIES AND CONSTRUCTION[1] | | |
|---|---|---|
| **Fuel** | | **Default Emission Factor (CO2)** |
| Crude Oil | | 73 300 |
| Orimulsion | | r 77 000 |
| Natural Gas Liquids | | r 64 200 |
| Gasoline | Motor Gasoline | r 69 300 |
| | Aviation Gasoline | r 70 000 |
| | Jet Gasoline | r 70 000 |
| Jet Kerosene | | 71 500 |
| Other Kerosene | | 71 900 |
| Shale Oil | | 73 300 |
| Gas/Diesel Oil | | 74 100 |
| Residual Fuel Oil | | 77 400 |
| Liquefied Petroleum Gases | | 63 100 |
| Ethane | | 61 600 |
| Naphtha | | 73 300 |
| Bitumen | | 80 700 |
| Lubricants | | 73 300 |
| Petroleum Coke | | r 97 500 |
| Refinery Feedstocks | | 73 300 |
| Other Oil | Refinery Gas | n 57 600 |
| | Paraffin Waxes | 73 300 |
| | White Spirit and SBP | 73 300 |
| | Other Petroleum Products | 73 300 |
| Anthracite | | 98 300 |
| Coking Coal | | 94 600 |
| Other Bituminous Coal | | 94 600 |
| Sub-Bituminous Coal | | 96 100 |
| Lignite | | 101 000 |
| Oil Shale and Tar Sands | | 107 000 |
| Brown Coal Briquettes | | n 97 500 |
| Patent Fuel | | 97 500 |
| Coke | Coke Oven Coke and Lignite Coke | r 107 000 |
| | Gas Coke | r 107 000 |
| Coal Tar | | n 80 700 |
| Derived Gases | Gas Works Gas | n 44 400 |
| | Coke Oven Gas | n 44 400 |
| | Blast Furnace Gas | n 260 000 |
| | Oxygen Steel Furnace Gas | n 182 000 |
| Natural Gas | | 56 100 |
| Municipal Wastes (non-biomass fraction) | | n 91 700 |
| Industrial Wastes | | n 143 000 |
| Waste Oils | | n 73 300 |
| Peat | | 106 000 |
| Solid Biofuel | Wood / Wood Waste | n 112 000 |
| | Sulphite lyes (Black Liquor)a | n 95 300 |
| | Other Primary Solid Biomass | n 100 000 |
| | Charcoal | n 112 000 |
| Liquid Biofuels | Biogasoline | n 70 800 |
| | Biodiesels | n 70 800 |
| | Other Liquid Biofuels | n 79 600 |
| Gas Biomass | Landfill Gas | n 54 600 |
| | Sludge Gas | n 54 600 |
| | Other Biogas | n 54 600 |
| Other non-fossil fuels | Municipal Wastes (biomass fraction) | n 100 000 |

(a) Includes the biomass-derived CO2 emitted from the black liquor combustion unit and the biomass-derived CO2 emitted from the kraft mill lime kiln.
n indicates a new emission factor which was not present in the 1996 Guidelines
r indicates an emission factor that has been revised since the 1996 Guidelines

Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories

## 3. Net Calorific Values of Fuels

Default value on Intergovernmental Panel on Climate Change (IPCC) Guideline

(Unit: TJ/Gg)

| Fuel type | | Net Calorific Value |
|---|---|---|
| **Crude Oil** | | 42.3 |
| **Orimulsion** | | 27.5 |
| **Natural Gas Liquids** | | 44.2 |
| **Gasoline** | Motor Gasoline | 44.3 |
| | Aviation Gasoline | 44.3 |
| | Jet Gasoline | 44.3 |
| **Jet Kerosene** | | 44.1 |
| **Other Kerosene** | | 43.8 |
| **Shale Oil** | | 38.1 |
| **Gas/Diesel Oil** | | 43 |
| **Residual Fuel Oil** | | 40.4 |
| **Liquefied Petroleum Gases** | | 47.3 |
| **Ethane** | | 46.4 |
| **Naphtha** | | 44.5 |
| **Bitumen** | | 40.2 |
| **Lubricants** | | 40.2 |
| **Petroleum Coke** | | 32.5 |
| **Refinery Feedstocks** | | 43 |
| **Other Oil** | Refinery Gas | 49.5 |
| | Paraffin Waxes | 40.2 |
| | White Spirit & SBP | 40.2 |
| | Other Petroleum Products | 40.2 |
| **Anthracite** | | 26.7 |
| **Coking Coal** | | 28.2 |
| **Other Bituminous Coal** | | 25.8 |
| **Sub-Bituminous Coal** | | 18.9 |
| **Lignite** | | 11.9 |
| **Oil Shale and Tar Sands** | | 8.9 |
| **Brown Coal Briquettes** | | 20.7 |
| **Patent Fuel** | | 20.7 |
| **Coke** | Coke Oven Coke and Lignite Coke | 28.2 |
| | Gas Coke | 28.2 |
| **Coal Tar** | | 28 |
| **Derived Gases** | Gas Works Gas | 38.7 |
| | Coke Oven Gas | 38.7 |
| | Blast Furnace Gas | 2.47 |
| | Oxygen Steel Furnace Gas | 7.06 |
| **Natural Gas** | | 48 |
| **Municipal Wastes (non-biomass fraction)** | | 10 |
| **Industrial Wastes** | | NA |
| **Waste Oil** | | 40.2 |
| **Peat** | | 9.76 |
| **Solid Biofuels** | Wood/Wood Waste | 15.6 |
| | Sulphite lyes (black liquor) | 11.8 |
| | Other Primary Solid Biomass | 11.6 |
| | Charcoal | 29.5 |
| **Liquid Biofules** | Biogasoline | 27 |
| | Biodiesels | 27 |
| | Other Liquid Biofuels | 27.4 |
| **Gas Biomass** | Landfill Gas | 50.4 |
| | Sludge Gas | 50.4 |
| | Other Biogas | 50.4 |
| **Other non- fossil fuels** | Municipal Wastes (biomass fraction) | 11.6 |

Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories

## 4. Global Warming Potential (GWP) of Greenhouse Gas (GHG)

| Type of Greenhouse Gas (GHG) | | | GWP |
|---|---|---|---|
| Carbon dioxide | | CO2 | 1 |
| Methane | | CH4 | 25 |
| Nitrous oxide | | N2O | 298 |
| HFCs | | | |
| | HFC-23 | CHF3 | 14,800 |
| | HFC-32 | CH2F2 | 675 |
| | HFC-41 | CH3F | 92 |
| | HFC-43-10mee | CF3CHFCHFCF2CF3 | 1,640 |
| | HFC-125 | CHF2CF3 | 3,500 |
| | HFC-134 | CHF2CHF2 | 1,100 |
| | HFC-134a | CH2FCF3 | 1,430 |
| | HFC-143 | CH2FCHF2 | 353 |
| | HFC-143a | CH3CF3 | 4,470 |
| | HFC-152 | CH2FCH2F | 53 |
| | HFC-152a | CH3CHF2 | 38 |
| | HFC-161 | CH3CH2F | 12 |
| | HFC-227ea | CF3CHFCF3 | 3,220 |
| | HFC-236cb | CH2FCF2CF3 | 1,340 |
| | HFC-236ea | CHF2CHFCF3 | 1,370 |
| | HFC-236fa | CF3CH2CF3 | 9,810 |
| | HFC-245ca | CH2FCF2CHF2 | 693 |
| | HFC-245fa | CHF2CH2CF3 | 1,030 |
| | HFC-365mfc | CH3CF2CH2CF3 | 794 |
| PFCs | | | |
| | PFC-14 | CF4 | 7,390 |
| | PFC-116 | C2F6 | 12,200 |
| | PFC-218 | C3F8 | 8,830 |
| | PFC-3-1-10 | C4F10 | 8,860 |
| | PFC-c318 | c-C4F8 | 10,300 |
| | PFC-4-1-12 | C5F12 | 9,160 |
| | PFC-5-1-14 | C6F14 | 9,300 |
| | PFC-9-1-18 | C10F18 | >7,500 |
| Sulphur hexa fluoride | | SF6 | 22,800 |
| Nitrogen trifluoride | | NF3 | 17,200 |

Source: IPCC Fourth Assessment Report: Climate Change 2007