Appendix3　JCM Manual

Prepared by Oriental Consultants Co., Ltd.

Joint Crediting Mechanism (JCM) Manual

1. Background

The Philippines become the 17th member country of Joint Crediting Mechanism (JCM), which can provide technological and financial support for climate change mitigation projects in member countries. JCM may help facilitate the existing energy efficiency and renewable energy promotion programs in the Philippines such as the Philippine Energy Efficiency Roadmap 2014–2030 and the National Renewable Energy Program (NREP).

The Energy Efficiency Roadmap shall guide the Philippines in building an energy-efficient nation, and in making energy efficiency and conservation a way of life for all Filipinos. The NREP signals the country's big leap from fragmented and halting renewable energy initiatives into a focused and sustained drive towards energy security and improved access to clean energy.

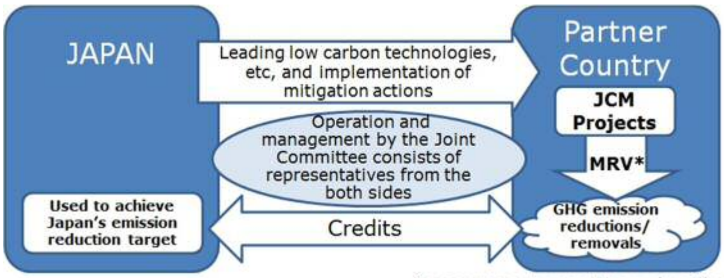
Along with a JCM feasibility study in the field of promoting energy efficiency and renewable energy projects under the City-to-City Collaboration between Osaka and Quezon, the JCM manual was developed for accelerating the development and implementation of JCM projects in the Philippines. It can also promote Quezon Climate Change Action Plan.

The objective of the manual is to provide consice introductionn of the procedures of JCM project implementation, methods of calculationg the amount of greenhouse gas emission reduction for the proposed JCM projects.

2. Introduction of JCM

2.1. Basic Concepts of JCM

The Joint Crediting Mechanism (JCM) is a project-based bilateral offset crediting mechanism initiated by the Government of Japan. JCM aims to facilitate diffusion of leading low carbon technologies, products, systems, services and infrastructure as well as implementation of mitigation actions, and contributing to sustainable development of developing countries. JCM also seeks to contribute to GHG emission reductions or removals by facilitating global actions.



*measurement, reporting and verification

Figure 1 JCM Scheme

The JCM is implemented by Japan and a JCM partner country through bilateral agreements. A JCM project is implemented in the host country using an advanced low carbon technology to reduce GHG emissions.

The JCM was designed to take into consideration robust methodologies, transparency, and environmental integrity of its procedures, rules, and guidelines, while maintaining simplicity and practicality. JCM procedures also address double counting of emission reductions by establishing registries, which track relevant information for the issued credits. The registries will also prevent registered JCM projects from being used under any other international climate mitigation mechanisms.

Emission reductions are calculated as the difference between "reference emissions" defined as emissions estimated below business-as-usual (BaU), and the "project emissions." The reference emissions and the project emissions can be calculated based on an approved methodology

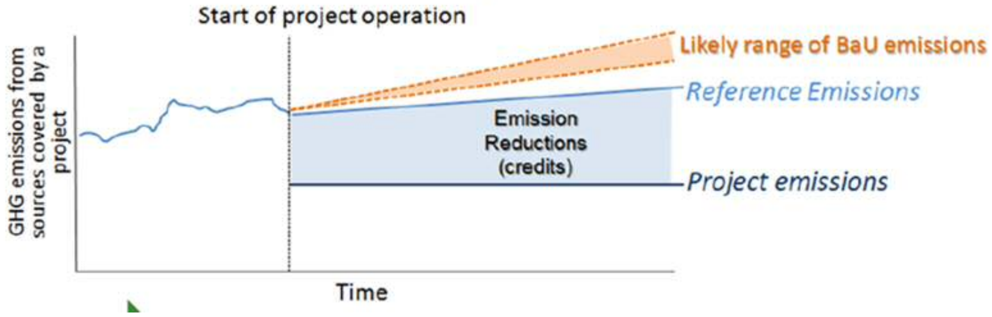


Figure 2 Emission Reduction Calculation Concept[1]

2.2. JCM Stakehloders

Figure 3 below provides an overview of the various stakeholders involved in the JCM and their interface during the implementation of a JCM project.

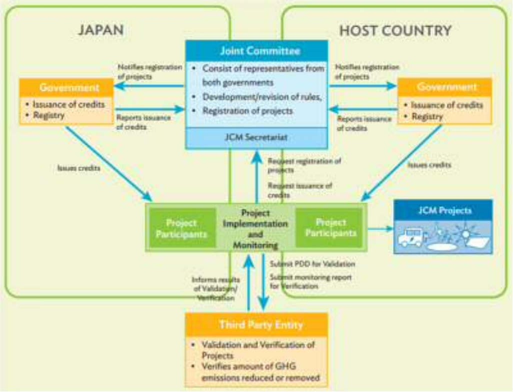


Figure 3 Overview of JCM Stakeholders

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[1] All figures about JCM scheme are reffered to Ministry of Environment, Japan

2.3. JCM Project Cycle

Figure 4 below depicts the project development cycle of of JCM.

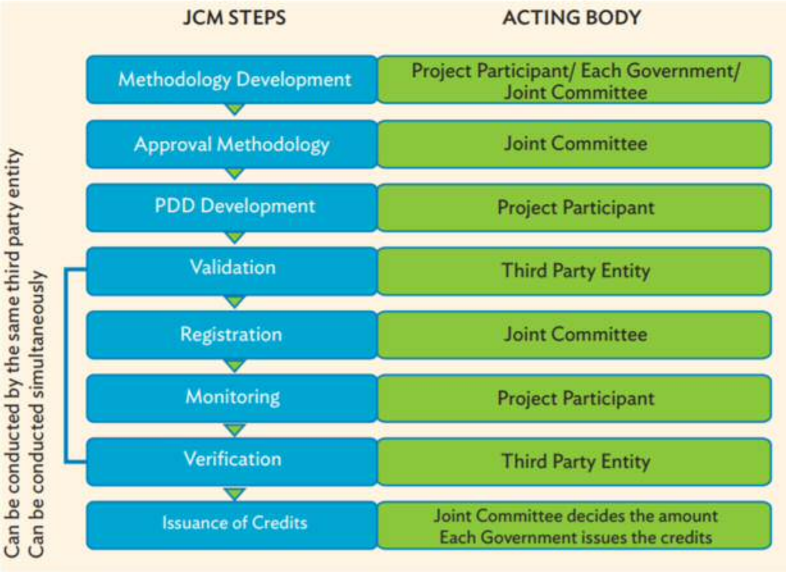


Figure 4 JCM Project Developmet Cycle

PDD:Project design document

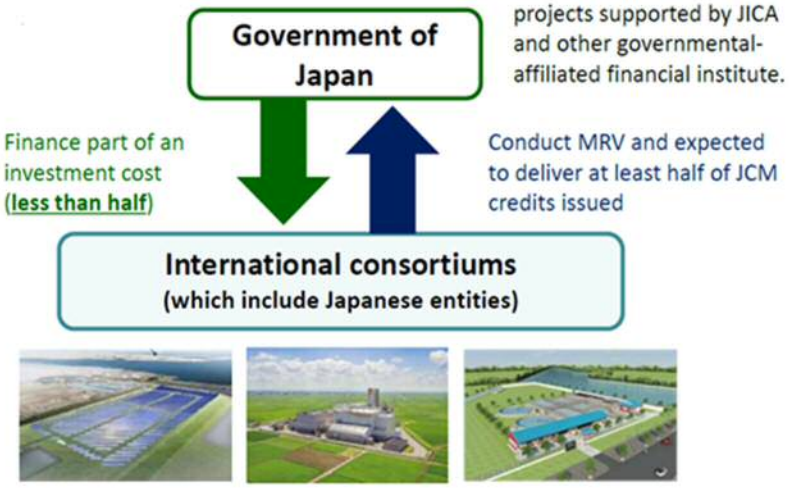
2.4. Eligible Projects under the JCM

There are 15 sectors under the JCM which are based on the CDM sectoral scopes. A JCM project may fall within more than one sectoral scope.

(i) Energy industry (renewable and nonrenewable sources) (ii) Energy distribution (iii) Energy demand (iv) Manufacturing industries (v) Chemical industry (vi) Construction (vii) Transport (viii) Mining/mineral production (ix) Metal production (x) Fugitive emissions from fuel (solid, oil, and gas) (xi) Fugitive emissions from production and consumption of halocarbons and sulphur hexafluoride (xii) Solvent use (xiii) Waste handling and disposal (xiv) Afforestation and reforestation15 (xv) Agriculture

2.5. JCM Model Projects

Japanese Government facilitate JCM model projects by providing subsidy up to 50% of the investment cost of a JCM model project. The subsidy covers contruction and cost of facilities, equipment, vehicles, etc which directly contribute to reduction of CO_2 emission reduction. Model projects should complete installation and contruction of systems within 3 years.



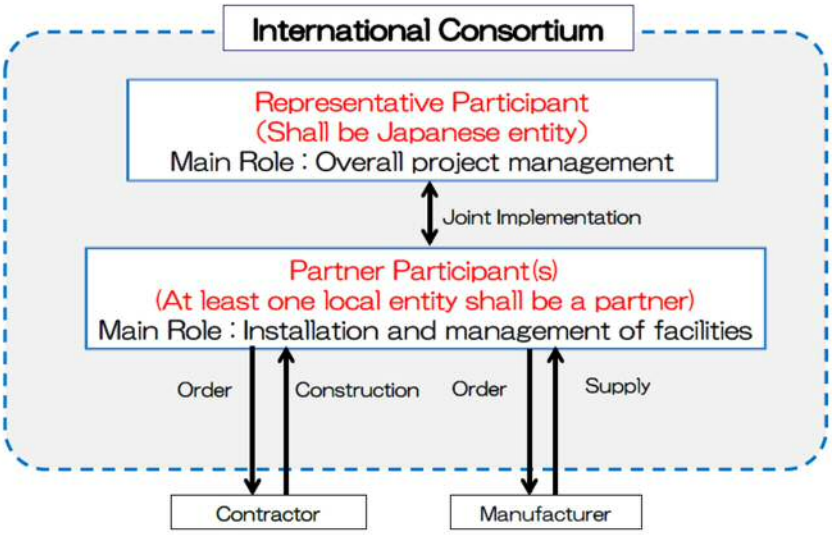


Figure 5 Example of International Consortium

The functions of Japanese participant are as follows:

- Applying for the model project;
- Project management and coordination;
- Introducing technology;
- Purchasing, installing facilities using the construction period and managing the facilties during the project period (life time of the technology stipulated by Japanesse law); and
- Return and compensate the finance resulting from any violation of financial regulation by any of the project participants.

3. Technologies Examples

3.1. Waste Heat Recovery (WHR)

In most cases, a WHR system generates electricity through the recovery of exhaust heat from production facilities such as textile, cement, and other type of industries. In the case of textile or food processing factories, it is possible to recover heat from waste water from dyeing processes.

Table 1 Charateristics of Textile Industry Energy Consumption

	Spinning	Knitting	Dyeing	Sewing
Electric energy	◎	◎	○	○
Heat energy	×	×	◎	×

In the textile industry, electric energy is mostly consumed by motors and compressors (partly). On the other hand, dyeing process also consumes a large amount of heat energy, which is provided by boilers. Dyeing process also generates a huge amount of heated wastewater.

From the perspective of energy saving potentiality in textile factories, introducing energy saving technologies or practices to dyeing and finishing process promises significant energy saving results.

Heat exchangers are the technology for recovering and applying waste heats from waste water generated in dyeing processes. Recovered waste heat is used to heat up the temperature of supply water (clean water) to the dyeing process or boilers. Generally, the temperature of the supply water is increased if necessary by using steam from boilers.

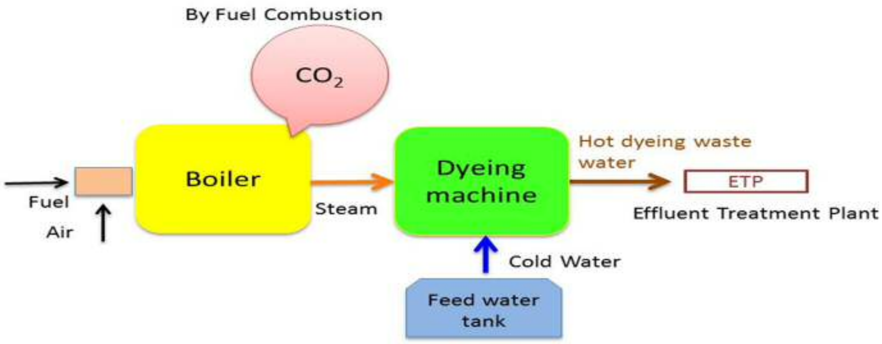


Figure 6 Situation without Waste Heat Recovery

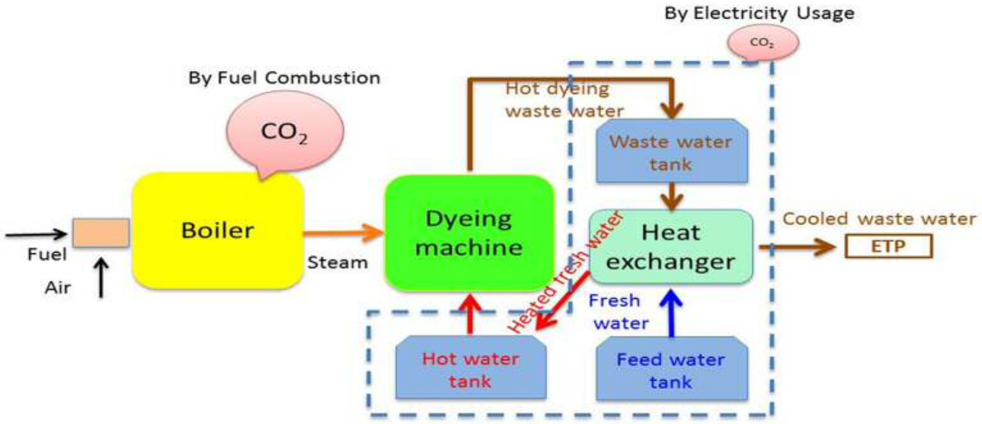


Figure 7 A Case of Introduction of Waste Heat Recovery

There are several types of heat exchangers such as tube types, plate types and spiral types. The comparison of different type of heat exchangers is given in the table below.

Table 2 Comparison of Different Types of Heat Exchangers

	Advantages	**Disadvantage**
Shell & Tube type	Long history High temperature & pressure	Low efficiency Large space Easy to be fouled and clogged.
Plate type	High efficiency Low initial cost Compact	Easy to be fouled and clogged. Expensive rubber packing & maintenance.
Spiral type	High efficiency Suitable for dirty fluid Low cost for maintenance Compact	Pressure drop of the spiral flow is slightly high.

As depicted in the table above, the spiral type heat exchangers are suitable for recovering waste heat from fluids containing suspended solids such as hairs, threads and films. Therefore, for projects which try to recover waste heat from waste dyeing water in textile industries, the spiral type heat exchangers are recommended to be applied.

This type of heat exchangers can also be applied to recover and apply heat from edible oil used for frying foods in restaurants and plants.

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3.2. The GHG Emission Reduction Estimation Methodology for Waste Heat Recovery and Utilization in Textile Industries

3.2.1.Terms and Definitions

Textile dyeing and finishing: The processes from pre-treatment to finishing in yarn and garment dyeing houses. Including main procedures of pre-treatment, dyeing and finishing (washing/rinsing) of yarns or fabrics that is the chemical and physical treatments of yarn and fabrics by consuming heat (steam).

Waste heat: Heat energy from boiler exhaust air and/or waste water from dyeing machines.

3.2.2. Summmary of the Methodology

Items	Summary
GHG emission reduction measures	Recovered waste heat is used for preheating feed-water to boilers and dyeing machines so that reduce the fossil fuel consumption of boilers which provide steam for dyeing and finishing process.
Calculation of reference emissions	Reference emission is calculated based on the amount of waste energy/heat utilized, boiler efficiency and CO_2 emission factor of the fossil fuel that is used in boilers for providing energy to the dyeing process. Conservative values of the parameters are used to ensure the reference emission are lower than BaU emissions.
Calculation of project emissions	The project emission is calculated based on the electricity consumption of waste heat recovery system and CO_2 emission factor of the electricity
Monitoring parameters	The following parameters need to be monitored. The temperature and the amount of feed-water for dyeing machines and/or boiler in the project. The amount of electricity consumed by the waste heat recovery system.

This methodology is applicable to the projects of recovering heat from waste water generated in the processes of yarn and fabric dyeing in the textile factories or food processing factories.

3.2.3. Establishment of Reference Emissions

The reference emission is the emission from the consumption of fossil fuel to gain the same amount of waste energy utilized.

3.2.4. Calculation of Reference Emissions

$$RE_y = (T_P - T_{Re}) \times \mathrm{W}_{th} \times \mathrm{F_w} \times \frac{1}{\mathrm{Ef}} \times \mathrm{EF_{CO2,fuel}} \times 10^{-6}$$

$\mathrm{RE_y}$: Reference emission [tCO_2/y]

$\mathrm{T_P}$: Temperature of feed-water to the heat exchanger the project (°C)

$\mathrm{T_{Re}}$: Temperature of feed-water from the heat excher to dyeing machines in the case of project (°C)

$\mathrm{W_{th}}$: The specific heat of water (kJ/kg °C)

$\mathrm{F_w}$: The amount of the feed-water in the project (t/y)

Ef: Boiler efficiency (ratio)

$\mathrm{EF_{CO2,fuel}}$: CO_2 emission factor the fossil fuel that is used to provide energy for dyeing or other production processes (tCO_2/TJ)

3.2.5. Calculation of Project Emissions

Project emission is calculated based on the amount of electricity consumed by the waste heat recovery system and electricity CO_2 emission factor.

$$\mathrm{PE_y} = \mathrm{EC_{PJ,y}} \times \mathrm{EF_{elec}}$$

$\mathrm{PE_y}$: Project emissions (tCO_2/y)

$\mathrm{EC_{PJ,y}}$: Electricity consumption by the waste heat recovery system (MWh/y)

$\mathrm{EF_{elec}}$: CO_2 emission factor of electricity (tCO_2/MWh)

3.2.6. Calculation of Emissions Reduction

$$\mathrm{ER_y} = \mathrm{RE_y} - \mathrm{PE_y}$$

RE_y: Reference emissions (tCO_2/y)

$\mathrm{PE_y}$: Project emissions (tCO_2/y)

3.2.7. Data and Parameters Fixed Ex-ante

Parameter	Description of data	Source
Ef	Boiler efficiency	Factories (100% is used for conservativeness)

$EF_{CO2,fuel}$	CO_2 emission factor of the fuel used for steam generation Natural gas:54.3 t CO_2/TJ (54.3–58.3) Coal:87.3 t CO_2/TJ (87.3–101) Heavy oil:71.1 t CO_2/TJ (71.1–75.5)	2006 IPCC Guidelines for National Greenhouse Gas Inventories. Table 1.4, Chapter 1, Volume 2.
EF_{elec}	CO_2 emission factor of electricity In the case of grid: 0.508 tCO_2/MWh In the case of captive power plant (diesel): 0.8 tCO_2/MWh	In the case of grid (Combined margin emission factor for Philippine) (IGES's List of Grid Emission Factors). In the case of diesel captive power plant (Table I.F.1, Small Scale CDM Methodology: AMS I.F. ver.2).

3.3. Energy Efficient Boiler

Boiler is an important equipment of the most industrial facilities and power plants.Boiler is a closed pressure vessel used to produce high pressure or low pressure steam or to produce hot water, heat for industrial or domestic use. Industrial steam boilers are classified in too many ways like. According to type of fuel used, there are coal fired boilers, oil fired boilers, gas fired boilers, biomass boilers and electric boilers and waster heat recovery boilers; according to steam pressure, there are low pressure boilers, medium pressure boilers and high pressure boilers.

Nippon Thermoener is a manufacturer of boilers and provides high efficient boilers, such as steam boilers, hot-water heaters, and heat medium boilers, and other energy-saving and environmentally friendly equipment and systems. As a boiler needs a huge amount of investment, the feasibility of replacement of exisiting boilers with high effiency boilers relies on the timing, condition of existing boilers and type of fuel used for the boiler.

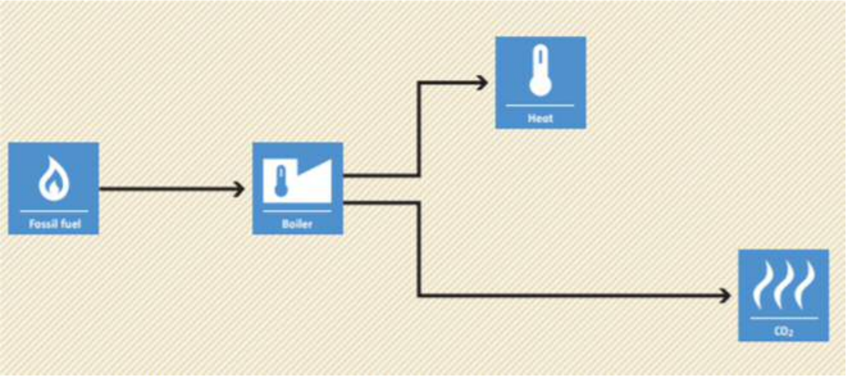

Figure 8 Reference Scenario (without project)

Without introduction of high efficiency boilers (HOB), boiler(s) with lower efficiency will continue to operate at multiple locations, thereby consuming high amounts of fossil fuel.

Employing HOBs through their rehabilitation or replacement will result in a reduction of fossil fuel consumption and related CO2 emissions.

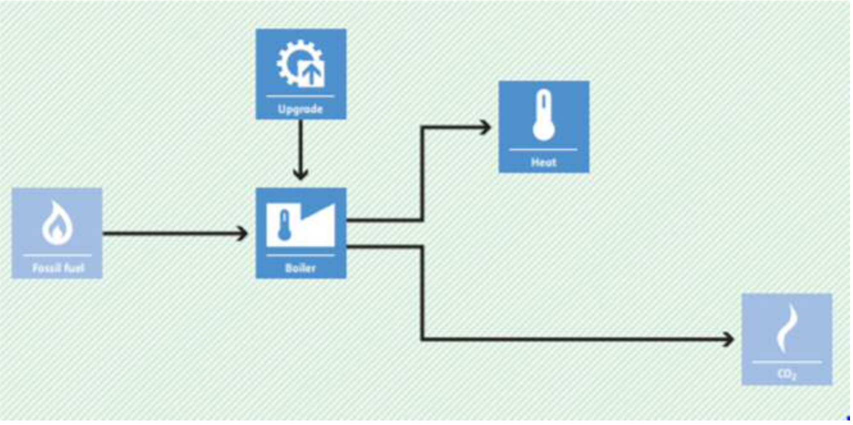

Figure 9 Project Sceneario

3.4. The GHG Emission Reduction Estimation Methodology for High Efficiency Boilers

3.4.1.Terms and Definitions

HOB: The HOB is defined as a boiler to supply steam or heat or hot water.

3.4.2. Summmary of the Methodology

Items	Summary
GHG emission reduction measures	Installation of new HOB for steam or heat or hot water supply system and the replacement of existing coal or gas

	or oil fired boiles.The boiler efficiency of the reference HOB is typically lower than that of the project HOB. Therefore, the project activity leads to the reduction of coal consumption, resulting in lower emission of GHGs as well as air pollutants.
Calculation of reference emissions	Reference emissions are calculated by the net heat quantity supplied by the project HOB, boiler efficiency of the reference HOB and CO_2 emission factor of the fuel
Calculation of project emissions	The sources of project emissions are the fuel consumption and electricity consumption of project HOB.Project emissions are calculated by the net heat quantity supplied by the project HOB, boiler efficiency of the project HOB and CO_2 emission factor of coal. In addition, project emissions due to auxiliary electricity consumption are included, on the basis of electricity consumption and CO_2 emission factor of the grid
Monitoring parameters	The quantity of fule used by the project HOB. Total hours of the project HOB operation during the monitoring period

3.4.3. Establishment of Reference Emissions

Reference emissions are calculated by the amount of the reference fuel consumption and CO_2 emission factor. The amount of fuel consumption in the reference scenario is calculated by dividing “net heat quantity supplied by the project HOB” by “boiler efficiency of the reference HOB”. This is because the net heat quantity of the reference HOB is equal to the net heat quantity of the project HOB. Both “CO2 emission factor” and “boiler efficiency of the reference HOB” are set as default values. The reference emissions are calculated as follows.

3.4.4. Calculation of Reference Emissions

$$RE_p = FC_{P,y} \times NCV_{P,fuel} \times \eta_{P,HOB}/\eta_{RE,HOB} \times EF_{CO2,coal}$$

Where;

RE_y : Reference emissions during the period y (tCO_2/y)

$FC_{P,y}$: Quantity of fuel used by the project HOB during the period y (t/y)

$NCV_{P,fuel,y}$: Net calorif value of the fuel used by the project HOB during the period y [GJ/t]

$\eta_{\mathrm{RE,HOB}}$: Boiler efficiency of the reference HOB (-)

$\eta_{\mathrm{P,HOB}}$:Boiler efficiency of the project HOB (-)

$\mathrm{EF}_{\mathrm{CO2,coal}}$: CO_2 emission factor of coal (tCO_2/GJ)

The reference HOB may use electricity,but it is not counted to ensure conservativeness (less reference emission).

3.4.5. Calculation of Project Emissions

Project emissions are calculated by "the amount of the project fuel consumption" and "CO_2 emission factor of the fuel". Both "CO_2 emission factor" and "boiler efficiency of the project and reference HOB" are set as default values. Additionally, electricity consumption of the project HOB is calculated in a conservative manner.
Therefore, the project emissions are calculated as follows.

$$\mathrm{PE_y} = \mathrm{FC_{P,y}} \times \mathrm{EF_{CO2,fuel}} + \mathrm{EC_{P,y}} \times \mathrm{EF_{CO2,grid}}$$

Where;

$\mathrm{PE_p}$: Project emissions during the period y (tCO_2/y)

$\mathrm{PC}_{P,y}$: Quantity of fuel used by the project HOB during the period y (t/y)

$\mathrm{EF_{CO2,fuel}}$: CO2 emission factor of fuel (tCO_2/GJ)

$\mathrm{EC_{P,y}}$:Electricity consumption of the project HOB during the period p (MWh/y)

$\mathrm{EF_{CO2,grid}}$:CO2 emission factor of the grid electricity consumed by the project HOB (tCO_2/MWh)

$$EC_p = \mathrm{RPC}_{PJ,HOB} \div 1000 \times HMP_p$$

Where;

$\mathrm{EC_y}$: Electricity consumption of the project HOB during the period y (MWh/y)

$\mathrm{RPC_{PJ,HOB}}$: Rated power consumption of the project HOB (kW)

$\mathrm{HMP_y}$: Total hours of the project HOB operation during the monitoring period y (h/y)

3.4.6. Calculation of Emissions Reduction

$$\mathrm{ER_y} = \mathrm{RE_y} - \mathrm{PE_y}$$

RE_y: Reference emissions (tCO_2/y)

$\mathrm{PE_y}$: Project emissions (tCO_2/y)

3.4.7. Data and Parameters Fixed Ex-ante

The source of each data and parameter fixed ex ante is listed as below.

Parameter	Description of data	Source
$\eta_{RE,HOB}$	Boiler efficiency of the reference HOB calculated from published information and measured data	Actual measured values.
$\eta_{P,HOB}$	Boiler efficiency of the project HOB calculated from published information and measured data	Actual measured values.
$EF_{CO2,coal}$	CO_2 emission factor of fuel Natural gas:54.3 t CO_2/TJ (54.3–58.3) Coal:87.3 t CO_2/TJ (87.3–101) Heavy oil:71.1 t CO_2/TJ (71.1–75.5)	2006 IPCC Guidelines for National Greenhouse Gas Inventories. Table 1.4, Chapter 1, Volume 2.
$EF_{CO2,\mathrm{grid}}$	CO_2 emission factor of the grid electricity consumed by the project HOB. In the case of grid: 0.508 tCO_2/MWh In the case of captive power plant (diesel): 0.8 tCO_2/MWh	The most recent value available at the time of validation is applied and fixed for the monitoring period thereafter. In the case of grid (Combined margin emission factor for Philippine) (IGES's List of Grid Emission Factors)). In the case of diesel captive power plant (Table I.F.1, Small Scale CDM Methodology: AMS I.F. ver.2).
$\mathrm{RPC}_{PJ,HOB}$	Rated power consumption of the project HOB	Catalog value provided by the manufacturer of the project HOB

3.5. Regenerative Burner System

Burners are indispensable for the factories using industrial furnaces. Especially, regenerative burners are equipped with a conventional reheating furnace to reduce fuel consumption of the reheating furnace in the factory. Regenerative burner systems are equipped with a pair of burners that each have a regenerator. These burners fire alternately to recover the sensible heat from waste gas for the preheating of combustion air. Regenerative burner system generally ignites a pair of burners (A and B) integrated with the heat reservoirs alternately at intervals of several tens of seconds. While one (A) burner is burning, the exhaust gas passes through and heats the other burner's (B) heat reservoir to recover the energy of the exhaust gas. Then, when the other burner burns (B), the air for combustion in turn passes through the preheated heat reservoir to recover the exhaust gas energy which had conventionally been wasted so that the system is able to provide high efficient combustion and secure at least 1,000℃ preheated air.

In general, 35-50% of energy can be saved by adopting the regenerative burner system, though depending on the furnace temperature, air ratio, and operating patterns of the installed unit. Moreover, regardless of high temperature preheated air, the system is able reduce NOx emission under 150ppm. The main features of the system are as follows.

- Automatically controlling air ratios according to fuel condition and the temperature of air.
- Applicability for various type of fuels such as diesel and fuel oil (bunker oils).
- Low NOx emission

3.6. The GHG Emission Reduction Estimation Methodology for Regenerative burner system

3.6.1. Terms and Definitions

Regenerative burner : Burner systems which absorb exhaust gas heat to a reservoir and preheat combustion air using the absorbed heat in the reservoir to improve energy efficiency.

Conventional burner : Burner systems which do not have combustion air preheating facility.

3.6.2. Summary of the Methodology

Items	Summary
GHG emission reduction measures	By replacing conventional burners with regenerative burners in reheating furnaces, consumption of fossil fuels can be reduced, which leads to reduction of GHG emissions.
Calculation of reference	Reference emissions are the CO_2 emissions from the use of

emissions	reheating furnaces with reference burners, which are calculated based on the amount of production in the project and the energy intensity of the reference furnaces
Calculation of project emissions	The project emission is calculated based on the fuel and electricity consumption of the furnaces in the project and the CO_2 emission factors of the electricity and fuel.
Monitoring parameters	The following parameters need to be monitored. 1) The quantity of fuel consumed by furnaces in the project. 2) The quantity of steel produced in the project. 3) The quantity of electricity consumed by the project furnace

3.6.3. Establishment of Reference Emissions

The reference emission is the emissions from consuming fossil fuels to produce the same amount of steel bars in the project under the reference condition. In this methodology, the energy intensity of the reference condition is determined ex-ante as a default value through a survey before project implementation.

CO_2 emissions from electricity consumption of reference furnaces are not considered for conservatives.

3.6.4. Calculation of Reference Emissions

$$\mathrm{RE_y} = \mathrm{FC} \times P_y \times \mathrm{NCV} \times EF_{co2}$$

$\mathrm{RE_y}$	Reference emissions (tCO_2/y)
FC	Energy intensity of a reference furnace (l/t)
P_y	The quantity of steel bars produced in the project (t/y)
NCV	Net caloric value of furnace fuel (TJ/Gg)
EF_{co2}	CO_2 emission factor of furnace fuel (tCO_2/TJ)

3.6.5. Calculation of Project Emissions

Project emissions are calculated based on the quantity of electricity and fuel consumed by a project furnace and the respective CO_2 emission factors

$$\mathrm{PE_y} = \mathrm{EC_{PJ,y}} \times \mathrm{EF_{e,co2}} + FC_y \times NCV \times EF_{\ 2}$$

$\mathrm{PE_y}$	Project emissions tCO_2/y)
$\mathrm{EC_{PJ,y}}$	Electricity consumption by a project furnace (MWh/y)
$\mathrm{EF_{e,co2}}$	CO2 emission factor of electricity (tCO_2/MWh)
FC_y	Fuel consumption by a project furnace (t/y)
NCV	Net caloric value of furnace fuel (TJ/Gg)
EF_{co2}	CO_2 emission factor of furnace fuel (tCO_2/TJ)

3.6.6. Calculation of Emissions Reduction

$$\mathrm{ER_y} = \mathrm{RE_y} - \mathrm{PE_y}$$

$\mathrm{PE_y}$	Emission reduction (tCO_2/y)
RE_y	Reference emissions (tCO_2/y)
$\mathrm{PE_y}$	Project emissions (tCO_2/y)

3.6.7. Data and Parameters Fixed Ex-ante

The source of each data and parameter fixed *ex ante* is listed as below.

Parameter	Description of data	Source
FC	Energy intensity of a reference furnace (liter/ton)	The most steel bar manufacturing plants in Philippine have fuel intensity over 450Mcal/t. For this project, 43 l/ton (411 Mcal/ton) is applied
$\mathrm{EF_{RE,i}}$	CO_2 emission factor of electricity In the case of grid: 0.670 tCO_2/MWh	In the case of grid (Official data from Philippine Government). ((IGES's List of Grid Emission Factors updated in August 2017)).

	In the case of captive power plant (diesel): 0.8 tCO_2/MWh	In the case of diesel captive power plant (Table I.F.1, Small Scale CDM Methodology: AMS I.F. ver.2).
NCV	Net caloric value of furnace fuel (TJ/Gg) Residual fuel oil: 39.8 TJ/Gg Coking Coal: 24 TJ/Gg Natural gas:40.9 TJ/Gg (lower case of default value)	2006 IPCC Guidelines for National Greenhouse Gas Inventories. Table 1.2, Chapter 1, Volume 2.
EF_{co2}	CO_2 emission factor of furnace fuel (tCO_2/TJ) Residual fuel oil: 75.5 tCO_2/TJ Coking Coal: 87.3 tCO_2/TJ Natural gas:58.3 tCO_2/TJ (lower case of default value)	2006 IPCC Guidelines for National Greenhouse Gas Inventories. Table 1.4, Chapter 1, Volume 2.

3.7. Solar Photovoltic Power Generation

A photovoltaic system, also PV system or solar power system, is a power systemdesigned to supply usable solar powerby means of photovoltaics. It consists of an arrangement of several components, including solar panels to absorb and convert sunlight into electricity, a solar inverter to change the electric current from DC to AC, as well as mounting, cabling and other electrical accessories to set up a working system. It may also use a solar tracking system to improve the system's overall performance and include an integrated battery solution, as prices for storage devices are expected to decline. Strictly speaking, a solar array only encompasses the ensemble of solar panels, the visible part of the PV system, and does not include all the other hardware. Moreover, PV systems convert light directly into electricity and shouldn't be confused with other technologies, such as concentrated solar power or solar thermal, used for heating and cooling.

PV systems range from small, rooftop-mounted or building-integratedsystems with capacities from a few to several tens of kilowatts, to large utility-scale power stations of hundreds of megawatts. Nowadays, most PV systems are grid-connected, while off-grid or stand-alone systemsonly account for a small portion of the market.

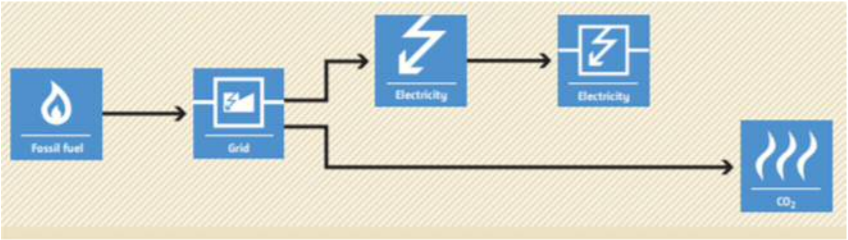

Figure 10 Reference Scenario (without project)

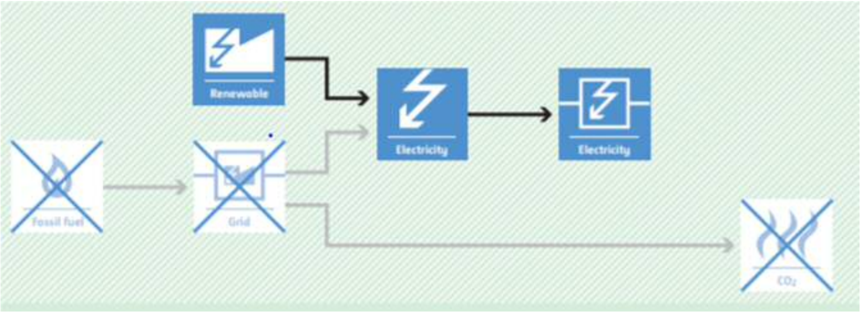

Figure 11 Project Sceneario

A complete PV system includes different components that should be selected taking into consideration your individual needs, site location, climate and expectations. Grid-connected PV systems are designed to operate in parallel with and interconnected with the electric utility grid. The primary component is the inverter, or power conditioning unit (PCU). The inverter converts the DC power produced by the PV array into AC power consistent with the voltage and power quality required by the utility grid. The inverter automatically stops supplying power to the grid when the utility grid is not energized. A bi-directional interface is made between the PV system AC output circuits and the electric utility network, typically at an on-site distribution panel or service entrance. This allows the power produced by the PV system to either supply on-site electrical loads, or to back feed the grid when the PV system output is greater than the on-site load demand. During periods when the electrical demand is greater than the PV system output (night-time), the balance of power required is received from the electric utility This safety feature is required in all grid-connected PV systems, it also ensures that the PV system will not continue to operate and feed back onto the utility grid when the grid is down for service or repair.

3.8. The GHG Emission Reduction Estimation Methodology for Solar PV System Introduction

3.8.1.Terms and Definitions

Solar photovoltaic (PV) system:An electricity generation system which converts sunlight into electricity by the use of photovoltaic (PV) modules. The system also includes ancillary equipment such as inverters required to change the electrical current from direct current (DC) to alternating current (AC).

3.8.2. Summmary of the Methodology

Items	Summary
GHG emission reduction measures	Displacement of grid electricity and/or captive electricity by installation and operation of solar PV system(s).
Calculation of reference emissions	Reference emissions are calculated on the basis of the AC output of the solar PV system(s) multiplied by either; 1) the conservative emission factor of the grid, or 2) conservative emission factor of diesel power generator.
Calculation of project emissions	Project emissions are the emissions from the solar PV system(s), which are assumed to be zero.
Monitoring parameters	The quantity of the electricity generated by the project solar PV system(s).

3.8.3. Establishment of Reference Emissions

The reference emission is the emission from the grid or a captive disel generator to generate the same of amout of electricity as the PV system in the project.
In the case of grid, a combined margin emission factor (IGES's List of Grid Emission Factors)) of host country is used. Foe example, 0.508 tCO_2/MWh for Philippine.
In the case of diesel captive power plant (Table I.F.1, Small Scale CDM Methodology: AMS I.F. ver.2), 0.8 tCO_2/MWh is used.

3.8.4. Calculation of Reference Emissions

$$\mathrm{RE_y} = \sum_{\mathrm{i}} \left(\mathrm{EG_{i,y}} \times \mathrm{EF_{RE,i}}\right)$$

REy :Reference emissions during the period y (tCO2/y)
EGi,y :Quantity of the electricity generated by the project solar PV system i during the period y (MWh/y)
$EF_{RE,i}$: CO_2 emission factor of grid or a captive generation which is replaced by the project solar PV i (tCO2/MWh)

3.8.5. Calculation of Project Emissions

Project emissions are the emissions from electricity consumption of PV system installed. However, in the case of small scale PV projects in the size of less than megawatt. The project emission can be neglected as follows.

$PEy = 0$

PEy : Project emissions during the period y (tCO_2/y)

Otherwise, project emissions are calculated based on the amount of electricity consumed by project PV systems and the CO_2 emissio factor of electricity. Electricity consumption in the project needs to be monitored.

3.8.6. Calculation of Emissions Reduction

$ER_y = RE_y - PE_y$

RE_y: Reference emissions (tCO_2/y)

PE_y: Project emissions (tCO_2/y)

3.8.7. Data and Parameters Fixed Ex-ante

Parameter	Description of data	Source
EF_{elec}	CO_2 emission factor of electricity or a captive generator. In the case of grid: 0.508 tCO_2/MWh In the case of captive power plant (diesel): 0.8 tCO_2/MWh	In the case of grid (Combined margin emission factor for Philippine) (IGES's List of Grid Emission Factors). In the case of diesel captive power plant (Table I.F.1, Small Scale CDM Methodology: AMS I.F. ver.2).

3.9. Diesel-Duel-Fuel (DDF) system

DDF is a system, which injects diesel and Liquefied Petroleum Gas (LPG) at the same time by controlling the portion of each through an electronic control for reducing diesel fuel consumption, CO_2 emission and other roadside air pollutant emissions as well.

DDF can be developed through introducing additional kits to a regular diesel engine. Main parts include a LPG tank, Engine Control Unit (ECU) and regulator.

3.9. The GHG Emission Reduction Estimation Methodology for diesel- duel- fuel (DDF) system

3.9.1. Terms and Definitions

Diesel Duel Fuel (DDF) engine : The engine, which uses both conventional diesel fuel and liquefied petroleum gas (LPG) fuel, is referred to as 'LPG–diesel dual fuel engines'. Diesel engines are modified to engines, which use primary fuel as diesel and secondary fuel as LPG.

Overhaul : An overhauled engine is an engine which has been removed, disassembled (torn down), cleaned, inspected, and repaired as necessary and tested using factory service manual approved procedures.

3.9.2. Summary of the Methodology

Items	Summary
GHG emission reduction measures	DDF helps improve in fuel efficiency, reduce the quantity of fossil fuel consumption and partly replace diesel with LPG, which has a lower CO_2 emission factor than diesel.
Calculation of reference emissions	Reference emission is calculated based on the distance of a target truck travelled, the fuel efficiency of the truck before retrofitted and the CO_2 emission factor of diesel used by the truck.
Calculation of project emissions	The project emission is calculated based on the quantity of fuel consumed by a truck and the CO_2 emission factors of the fuels.
Monitoring parameters	The following parameters need to be monitored. 1) The quantity of fuel consumed by a truck in the project. 2) The distance traveled by a target truck in the project.

3.9.3. Establishment of Reference Emissions

The reference emission is the emissions from diesel consumption of target trucks for travelling the same distance as happened in the project.

3.9.4. Calculation of Reference Emissions

$$RE_y = \sum_i RE_{i,y} \quad (1)$$

$$RE_{i,y} = PD_{i,y}/FE_{RE,i,diesel} \times De_{diesel} \times NCV_{diesel} \times EF_{\ 2\ ,diesel} \times 10^{-6} \quad (2)$$

RE_y	Reference emissions (tCO_2/y)
i	Target vehicle
$RE_{i,y}$	Reference emission of a target vehicle i (tCO_2/y)
$FE_{RE,i,diesel}$	Fuel efficiency of a target vehicle i (Km/l)
$PD_{i,y}$	Distance travelled by a target vehicle i (Km)
De_{diesel}	Density of diesel (Kg/l)
NCV_{diesel}	Net caloric value of diesel (TJ/Gg)
$EF_{co2,diesel}$	CO_2 emission factor of diesel (tCO_2/TJ)

3.9.5. Calculation of Project Emissions

Project emissions are calculated based on the quantity of fuel consumed by target vehicles and the CO_2 emission factors of the fuels

$$PE_y = \sum_i PE_{i,y} \quad (3)$$

$$PE_{i,y} = (FC_i \times Ra_{diesel,i} \times NCV_{diesel} \times EF_{\ 2\ ,diesel} \times 10^{-3}) + ((FC_i \times Ra_{LPG,i} \times NCV_{LPG} \times EF_{\ 2\ ,LPG} \times 10^{-3}) \quad (4)$$

PE_y	Project emissions (tCO_2/y)
i	Target vehicle
FC_i	The quantity of fuel consumed by a target vehicle i (t/y)
$Ra_{diesel,i}$	Ratio of diesel in the fuel of a vehicle i in the project
NCV_{diesel}	Net caloric value of diesel（TJ/Gg)
$EF_{co2,diesel}$	CO_2 emission factor of diesel (tCO_2/TJ)

$Ra_{LPG,i}$	Ratio of LPG in the fuel of a vehicle i in the project
NCV_{LPG}	Net caloric value of LPG（TJ/Gg）
$EF_{co2,LPG}$	CO_2 emission factor of diesel (tCO_2/TJ)

3.9.6. Calculation of Emissions Reduction

$\mathrm{ER_y} = \mathrm{RE_y} - \mathrm{PE_y}$

$\mathrm{RE_y}$: Reference emissions (tCO_2/y)

$\mathrm{PE_y}$: Project emissions (tCO_2/y)

3.9.7. Data and Parameters Fixed Ex-ante

The source of each data and parameter fixed *ex ante* is listed as below.

Parameter	Description of data	Source
$FE_{RE,i,diesel}$	Fuel efficiency of a target vehicle	Field survey data (calculated based on the measured distance and fuel consumption of a target vehicle)
$EF_{co2,diesel}$ $EF_{\ 2\ ,LPG}$	CO_2 emission factor of fuels consumed by vehicles: Diesel: 72.6 tCO_2/TJ LPG:61.6 tCO_2/TJ	2006 IPCC Guidelines for National Greenhouse Gas Inventories. Table 1.4, Chapter 1, Volume 2. (Table 1.4) Lower
NCV_{diesel} NCV_{LPG}	Net caloric values of fuels consumed by vehicles Diesel: 41.4 TJ/Gg LPG: 44.8 TJ/Gg	2006 IPCC Guidelines for National Greenhouse Gas Inventories. Table 1.4, Chapter 1, Volume 2. (Table 1.2)
De_{diesel}	Density of diesel (Kg/liter) Diesel: 0.832 Kg/liter (Average density)	Philippine National Standards on Petroleum, Department of Energy (DOE) Density at 15 °C: 0.820-0.860 Kg/liter

4. Key Points for JCM project implementation

The following points need to be determined to implement a JCM model project. These are also seen as challeneges to realize JCM model projects.

- Determination of a representative project participant early
- Confirmation of local participants an their decision
- Conclusion of international consortium agreement
- Confirmation of the budget adjustment of local participants
- Financing plan
- Profitability analysis
- Project schedule
- Confirmation of law, regulations and licenses.

5. Future Prospects

5.1. Expansion of JCM Project

JCM model project supports initial investment cost and contribute to CO_2 reduction.However, recognition of JCM is still insufficient in Philippines. Therefore, it is important to introduce technologies to potential counterparts such as industrial parks, hotels, hospitals, schools, and public buildings with huge energy consumption. Introduction of successful JCM model projects into an overall country is a key challenge forward.

5.2 Promotion of JCM

JCM scheme has been evolved into a win-win scheme which requires various players participation and open to different business models such as ESCO, lease and PPP. Therefore, it is important to activate industrial association groups to encourage their members to benefit from JCM through applicable business models.