Approved baseline and monitoring methodology AM0076

"Methodology for implementation of fossil fuel trigeneration systems in existing industrial facilities"

I. SOURCE, DEFINITIONS AND APPLICABILITY

Sources

This baseline and monitoring methodology is based on the following proposed new methodology:

- NM0264 "Baseline and Monitoring Methodology for Heavy Fuel-Oil Trigeneration" prepared by Caracol Knits S.A. de CV.

This methodology also refers to the latest approved versions of the following tools:

- Combined tool to identify the baseline scenario and demonstrate additionality;
- Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion;
- Tool to calculate the emission factor for an electricity system;
- Tool to calculate baseline, project and/or leakage emissions from electricity consumption.

For more information regarding the proposed new methodologies and the tools as well as their consideration by the Executive Board please refer to <http://cdm.unfccc.int/goto/MPappmeth>.

Selected approach from paragraph 48 of the CDM modalities and procedures

"Existing actual or historical emissions, as applicable".

Definitions

For the purpose of this methodology, the following definitions apply:

Trigeneration is the simultaneous production of electricity, heat and cooling from a single heat source such as fossil fuel. Trigeneration is also referred to as CCHP (combined cooling, heating, and power generation).

Industrial facility consists of a single site where the manufacturing of goods is carried out.

Electrical compression chiller is an electrically powered equipment used to produce chilled water (or water/antifreeze mixture) based on the Joule-Thompson effect, in which the refrigeration effect is produced by a refrigerant that is subsequently compressed in an electrical compressor, condensed in a condenser unit, expanded in an expansion valve and evaporated in an evaporator unit.

Absorption chiller is a thermally powered equipment used to produce chilled water (or water/antifreeze mixture) based on an absorption refrigeration cycle, in which the refrigeration effect is produced through the use of two fluids and heat input, rather than mechanical input as in the vapor compression refrigeration cycle. Absorption chillers can be single-effect, double-effect or triple-effect type.

Power consumption function is the relation which correlates the specific electricity consumption of an electrical compression chiller with the chiller output, the inlet temperature of the condensing water and the outlet temperature of the chilled water. This function can be either presented as a mathematical function or as a look-up table.

Load factor-efficiency curve is the relation that expresses the thermal efficiency of boilers as a function of their load factor. This curve can be either presented as a mathematical function or as a look-up table.

Applicability

This methodology is applicable to project activities that implement fossil fuel trigeneration systems, which produce electricity, steam and chilled water as final outputs to supply respectively electricity, heat and cooling demands in an industrial facility.

The following conditions apply:

- The trigeneration system is implemented at an existing industrial facility that, previous to the implementation of the project activity, had all of its electricity, heat and cooling demands respectively supplied with electricity purchased in the electricity grid, steam produced in existing on-site fossil fuel boilers, and chilled water produced in existing on-site electrical compression chillers;
- All steam produced by the trigeneration system is used on-site to supply partially or totally the industrial facility heat demand. Part of the existing on-site fossil fuel boilers may remain operating after the implementation of the project activity to supply the heat demand balance, if the trigeneration system is not able to supply totally the heat demand of the industrial facility;
- All chilled water produced by the trigeneration system is used on-site to supply partially or totally the industrial facility cooling demand. Part of the existing electrical compression chillers may remain operating after the implementation of the project activity to supply the cooling demand balance, if the trigeneration system is not able to supply totally the cooling demand of the industrial facility;
- The electricity produced by the trigeneration system is used on-site to supply partially or totally the industrial facility electricity demand. After the implementation of the project activity the industrial facility remains connected to the electricity grid, which is used to supply the electricity demand balance, if the trigeneration system is not able to supply totally the electricity demand of the industrial facility;
- There has been no cogeneration (CHP) or trigeneration (CCHP) systems operating in the industrial facility before the project activity;
- After the implementation of the project activity, the remaining (old) equipment, i.e. boilers and chillers installed prior to the project activity and not dismantled, must be only used for covering the difference between the heat and cooling output of the trigeneration system and the historical

demand levels of heat and cooling of the industrial facility. In case that increased heat and cooling demand occurs for a cumulative period longer than 3 months during the crediting period, additional to historical levels (up to 10% above the maximum observed in a 3 years period prior to the project activity), and this increased demand is covered by the project trigeneration system and the remaining (old) equipment, project participants cannot claim emission reductions up to the end of the crediting period;[1]

- The crediting period cannot be longer than the end of the remaining lifetime of the existing on-site boilers or electrical compression chillers replaced by the project activity, the one that would occur first, estimated as per the "Procedure for estimating the end of the remaining lifetime of existing boilers and chillers" in this methodology.

In addition, the applicability conditions included in the tools referred to above apply.

Finally, this methodology is only applicable if the most plausible baseline scenario as determined per the "Procedure for selection of the most plausible baseline scenario" is the continuation of the situation existing prior to the implementation of the project activity, i.e. electricity, heat and cooling demands of the industrial facility would be supplied respectively with electricity purchased in the electricity grid, steam produced in on-site fossil fuel boilers and chilled water produced in on-site electrical compression chillers.

Therefore, if the project activity is part of an expansion of electricity, heat (excluding the heat demand of the absorption chillers) or cooling supply to the industrial facility, due to an increase in the industrial facility demand, this methodology is not applicable.

II. BASELINE METHODOLOGY PROCEDURE

Procedure for estimating the end of the remaining lifetime of existing boilers and chillers

As stated in the applicability conditions, the crediting period cannot be longer than the remaining lifetime of the existing on-site boilers and electrical compression chillers replaced by the project activity, i.e. the point in time when those equipments would have been replaced in the absence of the project activity. This point in time should be estimated in a conservative manner by choosing the earliest point in time amongst the estimated ends of the remaining lifetime of each one of the existing boilers and chillers that are being replaced by the project activity, based on:

(1) The typical average technical lifetime of similar boiler(s) and chiller(s) determined on the basis of common practices in the sector and the country (e.g. based on industry surveys, technical literature, manufacturer's specifications, etc.);
(2) The best practices of the industrial facility regarding replacement schedules of that type of equipment (e.g. based on historical replacement records for similar equipment).

[1] In case that project participants wish to expand this methodology to potential capacity expansion projects, a request for revision must be submitted including provisions concerning baseline selection and additionality assessment.

Procedure for selection of the most plausible baseline scenario and demonstration of additionality

Project participants shall identify the most plausible baseline scenario and demonstrate additionality using the latest approved version of the "Combined tool to identify the baseline scenario and demonstrate additionality", agreed by the CDM Executive Board, available at the UNFCCC CDM web site.
In applying Step 1 of the tool, realistic and credible baseline alternatives should be composed of alternatives for how electricity, heat and cooling would be produced and supplied to the industrial facility in the absence of the CDM project activity.

For electricity production, realistic and credible alternatives should include, inter alia:

- The proposed project activity not undertaken as a CDM project activity;
- The continuation of the situation existing prior to the implementation of the project activity, i.e. electricity supplied by the grid;
- The installation of a new cogeneration system;
- Production of electricity in other (on-site/off-site) electricity generating equipments based on fossil fuels or renewable sources of energy.

For heat production, realistic and credible alternatives should include, inter alia:

- The proposed project activity not undertaken as a CDM project activity;
- The continuation of the situation existing prior to the implementation of the project activity, i.e. heat supplied by steam produced in on-site fossil fuel boilers;
- Retrofit of the existing on-site boilers firing the same type or different types of fuels;
- The installation of a new cogeneration system;
- Production of heat in other (on-site/off-site) heat generating equipments or heat sources, such as biomass boilers, geothermal systems, district heating, etc.

For cooling production, realistic and credible alternatives should include, inter alia:

- The proposed project activity not undertaken as a CDM project activity;
- The continuation of the situation existing prior to the implementation of the project activity, i.e. cold supplied by chilled water produced in on-site electrical compression chillers;
- Retrofit of the existing on-site electrical compression chillers;
- Production of cooling in other (on-site/off-site) cooling generating equipments or cooling sources.

During the additionality assessment, all revenues from potential export of electricity to the grid, on ad-hoc basis, shall be included.

Project boundary

The spatial extent of the project boundary encompasses: (1) the fossil fuel based trigeneration system whose outputs are electricity, steam and chilled water supplied to the industrial facility, (2) the electricity grid to which the industrial facility is connected and (3) the boilers and electrical compression chillers which remain operating in the industrial facility after the implementation of the project activity.

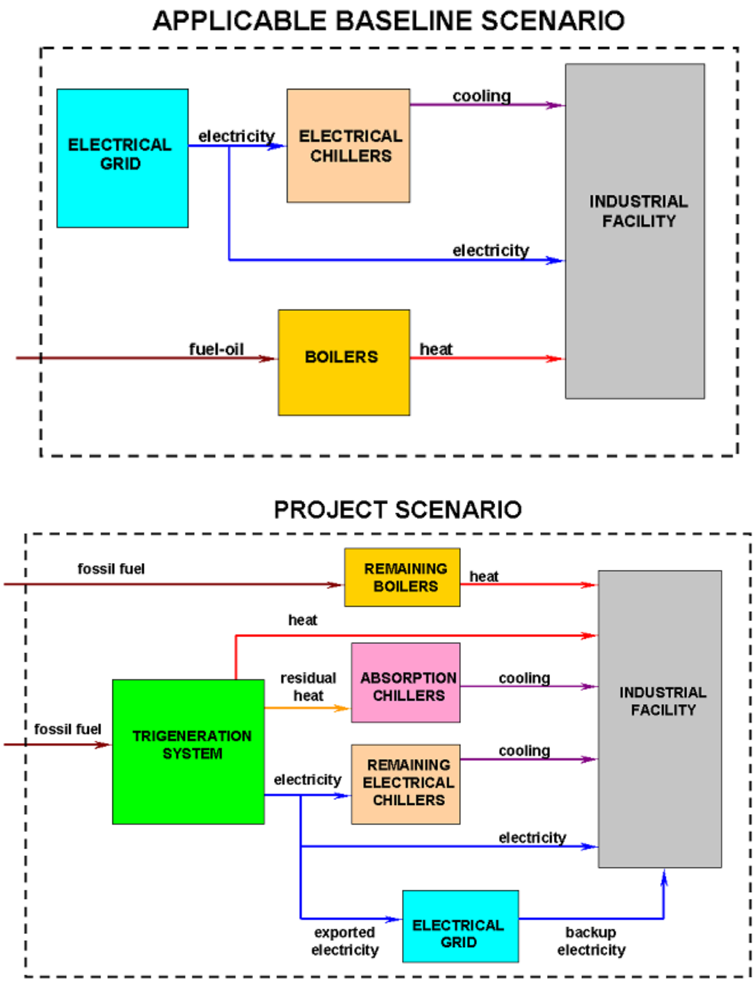

Figure 1: Baseline and Project diagrams

Emissions sources included in or excluded from the project boundary are presented in Table 1.

Table 1: Emissions sources included in or excluded from the project boundary

	Source	Gas	Included	Justification / Explanation
Baseline	Combustion of fossil fuels for production of electricity in grid connected power plants	CO_2	Yes	Main emission source in the combustion of fossil fuels.
		CH_4	No	This emission source is negligible compared to CO_2 emissions and disregarded both in project and baseline scenarios
		N_2O	No	This emission source is negligible compared to CO_2 emissions and disregarded both in project and baseline scenarios
	Combustion of fossil fuels for steam production in the existing on-site boilers	CO_2	Yes	Main emission source in the combustion of fossil fuels.
		CH_4	No	This emission source is negligible compared to CO_2 emissions and disregarded both in Project and Baseline scenarios
		N_2O	No	This emission source is negligible compared to CO_2 emissions and disregarded both in Project and Baseline scenarios
Project	Combustion of fossil fuels for electricity, steam and chilled water production in the trigeneration system	CO_2	Yes	Main emission source in the combustion of fossil fuels.
		CH_4	No	This emission source is negligible compared to CO_2 emissions and disregarded both in Project and Baseline scenarios
		N_2O	No	This emission source is negligible compared to CO_2 emissions and disregarded both in Project and Baseline scenarios
	Combustion of fossil fuels for production of electricity in grid connected power plants	CO_2	Yes	Main emission source in the combustion of fossil fuels.
		CH_4	No	This emission source is negligible compared to CO_2 emissions and disregarded both in Project and Baseline scenarios

	Source	Gas	Included	Justification / Explanation
		N_2O	No	This emission source is negligible compared to CO_2 emissions and disregarded both in Project and Baseline scenarios
	Combustion of fossil fuels for steam production in the remaining on-site boilers	CO_2	Yes	Main emission source in the combustion of fossil fuels.
		CH_4	No	This emission source is negligible compared to CO_2 emissions and disregarded both in project and baseline scenarios
		N_2O	No	This emission source is negligible compared to CO_2 emissions and disregarded both in project and baseline scenarios

The general approach for the calculation of emissions reduction in this methodology is to account for total emissions due to the production of electricity, heat and cooling to supply the industrial facility before and after the implementation of the project activity. The methodology does not calculate differential baseline and project emissions due to the implementation of the project activity, i.e. emissions resulting from the portion of electricity, heat and cooling supplies that change due to the implementation of the project activity.

This is required because there is no baseline scenario identification and additionality assessment, which take into account, the additional supply capacity represented by the project activity.

Therefore, project emissions account for all emissions due to the production of electricity, heat and cooling to supply the industrial facility in the project scenario, whereas baseline emissions account for all emissions that would result from the production of electricity, heat and cooling to supply the industrial facility in the absence of the project activity but capped according to historical levels of capacity. Any production of electricity, heat or cooling which surpasses baseline caps, defined in the corresponding sections below, will be attributed a zero emission factor in the baseline and fully taken into account in the project scenario.

If the project activity is part of an expansion of electricity, heat (excluding the heat demand of the absorption chillers) or cooling supply to the industrial facility due to an increase in the industrial facility demand, a revision of this methodology should be requested.

Project emissions

Project emissions account for all emissions due to the production of electricity, heat and cooling to supply the industrial facility. They are calculated as follows:

$$PE_y = PE_{trig,y} + PE_{boilers,y} + PE_{grid,y} \tag{1}$$

Where:

PE_y	=	Project emissions in year y (tCO_2)
$PE_{trig,y}$	=	Project emissions due to the combustion of fossil fuels in the trigeneration system in year y (tCO_2)
$PE_{boilers,y}$	=	Project emissions due to the combustion of fossil fuels in the boilers that remain operating after the implementation of the project activity in year y (tCO_2)
$PE_{grid,y}$	=	Project emissions due to the production of grid electricity used in the industrial facility in year y (tCO_2/year)
y	=	Year of the crediting period

Calculation of $PE_{trig,y}$

$PE_{trig,y}$ should be calculated as the parameter $PE_{FC,j,y}$ in the latest approved version of the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" available in the UNFCCC website, making the element processes j correspond to the combustion of fossil fuels for the main and auxiliary supplies of the trigeneration system in year y.

Calculation of $PE_{boilers,y}$

$PE_{boilers,y}$ should be calculated as the parameter $PE_{FC,j,y}$ in the latest approved version of the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" available in the UNFCCC website, making the element processes j correspond to the combustion of fossil fuels for the main and auxiliary supplies of the boilers that remain operating after the implementation of the project activity, in year y.

Calculation of $PE_{grid,y}$

$PE_{grid,y}$ should be calculated as the parameter $PE_{EC,y}$ in Scenario A in the latest approved version of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" available in the UNFCCC website, making the element j in the parameter $EC_{PJ,j,y}$ of the Tool as the industrial facility.

Baseline emissions

Baseline emissions account for all emissions that would result from the production of electricity, heat and cooling to supply the industrial facility in the absence of the project activity and are capped accordingly as defined in the corresponding sections below. They are calculated as follows:

$$BE_y = BE_{ST,y} + BE_{CW,y} + BE_{EL,y} \quad \textbf{(2)}$$

Where:

BE_y	=	Baseline emissions in year *y* (tCO_2)
$BE_{ST,y}$	=	Baseline emissions due to the production of steam to supply the industrial facility in the absence of the project activity in year *y* (tCO_2/year)
$BE_{CW,y}$	=	Baseline emissions due to the production of chilled water to supply the industrial facility in the absence of the project activity in year *y* (tCO_2/year)
$BE_{EL,y}$	=	Baseline emissions due to the production of electricity to supply the industrial facility in the absence of the project activity (excluding electricity used in the electrical compression chillers) in year *y* (tCO_2/year)
y	=	Year of the crediting period

Baseline emissions due to the production of steam ($BE_{ST,y}$)

Baseline emissions due to the production of steam to supply the industrial facility in the absence of the project activity in year *y* result from the combustion of fossil fuels in the boilers existing in the industrial facility before the implementation of the project activity. Since the project activity is supposed to displace only existing boilers, baseline emissions are capped if the total production of steam in the project scenario surpasses $HG_{BL,CAP}$.

$$BE_{ST,y} = EF_{BL,fuel,boiler} \cdot \sum_{k=1}^{K} \left[\frac{\min\left(HG_{PJ,total,k}, HG_{BL,CAP}\right)}{\eta_{BL,boiler}} \right] \quad \textbf{(3)}$$

Where:

$BE_{ST,y}$	=	Baseline emissions due to the production of steam to supply the industrial facility in the absence of the project activity in year *y* (tCO2)
$HG_{PJ,total,k}$	=	Total amount of steam used to feed the industrial facility heat loads (excluding absorption chillers), which is produced in the trigeneration system and boilers which remain operating after the project activity, during the monitoring interval *k* in year *y* (TJ)
$HG_{BL,CAP}$	=	Maximum amount of steam that could have been produced by all boilers existing on-site prior to the implementation of the project activity during the monitoring interval *k* (TJ)
$EF_{BL,fuel,boiler}$	=	Emission factor of the fossil fuels that would be used for steam production in the boilers existing on-site prior to the implementation of the project activity (tCO_2/TJ)
$\eta_{BL,boiler}(\ldots)$	=	Efficiency from the output-efficiency curve of the boilers existing in the industrial facility prior to the implementation of the project activity (fraction)

Y	=	Year of the crediting period
K	=	Time intervals used for monitoring steam production and steam parameters during the year y. The number of monitoring intervals is equal to $K = 8760/\Delta k$
Δk	=	Length of the monitoring intervals k (hours). This length has to be clearly stated in the CDM-PDD. The default Δk is 1 hour. A different length can be proposed, but has to be justified based on the expected time variation of steam production rate (load factor) and steam parameters

Calculation of $HG_{PJ,total,k}$

The total amount of steam produced by the trigeneration system and boilers which remain operating after the project activity used to feed the industrial facility heat loads (excluding absorption chillers) is calculated as:

$$HG_{PJ,total,k} = HG_{PJ,trig,k} + HG_{PJ,boilers,k} \quad \textbf{(4)}$$

Where:

$$HG_{PJ,trig,k} = SG_{PJ,trig,k} \cdot \left(HS_{PJ,trig,k} - HF_{PJ,trig,k}\right) \quad \textbf{(5)}$$

and

$$HG_{PJ,boilers,k} = \sum_{n}\left[SG_{PJ,boilers,n,k} \cdot \left(HS_{PJ,boilers,n,k} - HF_{PJ,boilers,n,k}\right)\right] \quad \textbf{(6)}$$

Parameters are defined as:

$HG_{PJ,total,k}$	=	Total amount of steam produced in the trigeneration system and boilers which remain operating after the project activity used to feed the industrial facility heat loads (excluding absorption chillers), during the monitoring interval k in year y (TJ)
$HG_{PJ,trig,k}$	=	Total amount of steam produced in the trigeneration system used to feed the industrial facility heat loads (excluding absorption chillers), during the monitoring interval k in year y (TJ)
$HG_{PJ,boilers,k}$	=	Total amount of steam produced in the boilers which remain operating after the project activity used to feed the industrial facility heat loads (excluding absorption chillers), during the monitoring interval k in year y (TJ)
$SG_{PJ,trig,k}$	=	Total amount of steam produced in the trigeneration system used to feed the industrial facility heat loads (excluding absorption chillers, if they are supplied with steam produced in the trigeneration system) during the monitoring interval k in year y (tonnes of steam)
$HS_{PJ,trig,k}$	=	Specific enthalpy of the steam produced in the trigeneration system during the monitoring interval k in year y (TJ/tonne of steam), dependent on the average temperature ($T_{PJ,trig,steam}$) and pressure ($P_{PJ,trig,steam}$) of the steam during the monitoring interval k

$HF_{PJ,trig,k}$	=	Specific enthalpy of the feedwater fed into the trigeneration system during the monitoring interval *k* in year *y* (TJ/tonne of feedwater), dependent on the average temperature ($T_{PJ,trig,feed}$) of the feedwater during the monitoring interval *k*
$SG_{PJ,boilers,n,k}$	=	Total amount of steam produced in boiler *n* which remains operating after the project activity used to feed the industrial facility heat loads (excluding absorption chillers, if they are supplied with steam produced in the boilers) during the monitoring interval *k* in year *y* (tonnes of steam)
$HS_{PJ,boilers,n,k}$	=	Specific enthalpy of the steam produced in boiler *n* which remains operating after the project activity during the monitoring interval *k* in year *y* (TJ/tonne of steam), dependent on the average temperature ($T_{PJ,boilers,steam}$) and pressure ($P_{PJ,boilers,steam}$) of the steam during the monitoring interval *k*
$HF_{PJ,boilers,n,k}$	=	Specific enthalpy of the feedwater fed into the boiler *n* which remains operating after the project activity during the monitoring interval *k* in year *y* (TJ/tonne of feedwater), dependent on the average temperature ($T_{PJ,boilers,feed}$) of the feedwater during the monitoring interval *k*
y	=	Year of the crediting period
k	=	Time intervals used for monitoring steam production and steam parameters during the year *y*. The number of monitoring intervals is equal to $K = 8760/\Delta k$
Δk	=	Length of the monitoring intervals *k* (hours). This length has to be clearly stated in the CDM-PDD. The default Δk is 1 hour. A different length can be proposed, but has to be justified based on the expected time variation of steam production rate (load factor) and steam parameters

Calculation of $HG_{BL,CAP}$

Since the project activity is supposed to displace existing boilers, baseline emissions are capped if the total production of steam in the project scenario surpasses $HG_{BL,CAP}$. This is equivalent to attributing a zero emission factor in the baseline for any production of steam in the project scenario which surpasses $HG_{BL,CAP}$ as no baseline is selected for capacity increases in this methodology.

$$HG_{BL,CAP} = \Delta k \cdot \sum_{n} \left[CAP_{BL,boiler,n} \cdot \left(HS_{BL,boiler,n} - HF_{BL,boiler,n} \right) \right] \quad \textbf{(7)}$$

Where:

$HG_{BL,CAP}$	=	Maximum amount of steam that could have been produced by all boilers existing on-site prior to the implementation of the project activity (TJ)
$CAP_{BL,boiler,n}$	=	Nominal steam output that the boiler *n*, existing in the industrial facility prior to the project activity, would be able to deliver if it would operate at its maximum output capacity during the monitoring interval *k* (tonnes of steam/hour)
$HS_{BL,boiler,n}$	=	Specific enthalpy of the steam produced in boiler *n* existing in the industrial facility prior to the project activity (TJ/tonne of steam), dependent on the historical average temperature ($T_{BL,boilers,steam}$) and pressure ($P_{BL,boilers,steam}$) of the steam produced by boiler *n*

$HF_{BL,boiler,n}$	=	Specific enthalpy of the feedwater fed into boiler *n* existing in the industrial facility prior to the project activity (TJ/tonne of feedwater), dependent on the historical average temperature ($T_{BL,boilers,feed}$) of the feedwater used by boiler *n*
Δk	=	Length of the monitoring intervals *k* (hours). This length has to be clearly stated in the CDM-PDD. The default Δk is 1 hour. A different length can be proposed, but has to be justified based on the expected time variation of steam production rate (load factor) and steam parameters
n	=	Boilers existing in the industrial facility prior to the project activity

Calculation of $EF_{BL,fuel,boiler}$

Considering that a mix of fossil fuels may have been used in the boilers existing on-site prior to the implementation of the project activity, the emission factor $EF_{BL,fuel,boiler}$ used for baseline emissions can be determined as:

Option A: Use a conservative emission factor by choosing the lowest emission factor of all fuels used in the industrial facility in the most recent three years prior to the implementation of the project activity.

Option B: Calculate an equivalent emission factor as the weighted average, on energy basis, of all fuels used in the industrial facility in the most recent three years prior to the implementation of the project activity.

$$EF_{BL,fuel,boiler} = \frac{\sum_i \left(FC_{BL,boilers,i} \cdot NCV_i \cdot EF_i\right)}{\sum_i \left(FC_{BL,boilers,i} \cdot NCV_i\right)} \quad \textbf{(8)}$$

Where:

$EF_{BL,fuel,boiler}$	=	Emission factor of the fossil fuels that would be used for steam production in the boilers existing on-site prior to the implementation of the project activity (tCO_2/TJ)
$FC_{BL,boilers,i}$	=	Amount of fossil fuel *i* used in the boilers existing on-site prior (3 years) to the implementation of the project activity (mass or volume units)
NVC_i	=	Net calorific value of fossil fuel type *i* (TJ/mass or volume units)
EF_i	=	Emission factor for fossil fuel type *i* (tCO2/TJ)

Determination of $\eta_{BL,boiler}(...)$

The output-efficiency curve $\eta_{BL,boiler}(...)$ of the boilers existing in the industrial facility prior to the implementation of the project activity is not a single value, rather it is a relation that expresses the thermal efficiency of the group of boilers existing in the industrial facility, prior to the implementation of the project activity, as a function of their steam output. This curve can be either presented as a mathematical function or as a look-up table.

Given the output-efficiency curve of a boiler, its thermal efficiency is estimated by applying the average values of the output of the boiler, calculated based on the monitored parameters of the boiler during the monitoring intervals *l*, to its output-efficiency curve.

For the purpose of determining output-efficiency curve, project participants should determine and document in the CDM-PDD the maximum range over which the load factor of the boilers can vary. Preferably, historical data records for at least one year should be used for this purpose. The range should reflect the range of year-round ambient conditions and heat demand variations.

The following options can be used to determine the output-efficiency curve of an individual boiler:

Option A: Use on-site measurements, following the procedure provided in the Annex 1 to this methodology.
Option B: Use the manufacturer's specification of load factor-efficiency curves.
Option C: Use a constant conservative default value of 1 irrespective of the output.

If more than one boiler had been operating before the implementation of the project activity, a single equivalent output-efficiency curve should be used by calculating the arithmetic average of the efficiencies of the boilers at each output obtained from the individual output-efficiency curves determined as per one of the options above.

Baseline emissions due to the production of chilled water ($BE_{CW,y}$)

Baseline emissions associated with the production of chilled water to supply the industrial facility in the absence of the project activity in year *y* result from the production of grid electricity that would be required to operate the electrical compression chillers existing in the industrial facility prior to the implementation of the project activity. Since the project activity is supposed to displace only existing electrical compression chillers, if the total production of chilled water in the project scenario surpasses $CG_{BL,CAP}$, baseline emissions are capped.

$$BE_{CW,y} = \Delta l \cdot EF_{grid,y} \cdot \sum_{l=1}^{L} \left[MIN_{CG,l} \cdot PCF_{BL,elechill}\left(MIN_{CG,l}, T_{cond,in,l}, T_{cw,out,l} \right) \right] \quad \textbf{(9)}$$

$$MIN_{CG,l} = 7.9 \times 10^{4} \cdot \frac{\min\left(CG_{PJ,total,l}, CG_{BL,CAP} \right)}{\Delta l} \quad \textbf{(10)}$$

Where:

$BE_{CW,y}$	=	Baseline emissions due to the production of chilled water to supply the industrial facility in the absence of the project activity in year y ($tCO2$)
$MIN_{CG,l}$	=	Minimum between $CG_{PJ,total,l}$ and $CG_{BL,CAP}$ (TR^2)
$7.9x10^4$	=	Conversion factor from TJ/h to TR
$CG_{PJ,total,l}$	=	Total amount of chilled water produced by the trigeneration system (absorption chillers) and electrical compression chillers, which remain operating after the project activity, in the monitoring interval l in year y (TJ)
$CG_{BL,CAP}$	=	Maximum amount of chilled water that could have been produced by all electrical compression chillers existing on-site previous to the implementation of the project activity (TJ)
$PCF_{BL,elechill}(...)$	=	Output from the power consumption function of the electrical compression chillers existing on-site prior to the implementation of the project activity (MW/TR)
$T_{cond,in,l}$	=	Average inlet temperature of the condensing water as it enters the condenser unit in the absorption chillers (trigeneration system) during the monitoring interval l in year y (°C)
$T_{cw,out,l}$	=	Average outlet temperature of the chilled water as it leaves the absorption chillers (trigeneration system) during the monitoring interval l in year y (°C)
$EF_{grid,y}$	=	Emission factor for grid electricity in year y (tCO2/MWh)
l	=	Time intervals used for monitoring chilled water production and chilled water parameters during the year y. The number of monitoring intervals is equal to $L = 8760/\Delta l$
Δl	=	Length of the monitoring interval l. This length has to be clearly stated in the CDM-PDD. The default Δl is 1 hour. A different length can be proposed, but has to be justified based on the expected time variation of chilled water production rate (load factor) and chilled water parameters (hours)
y	=	Year of the crediting period

Calculation of $CG_{PJ,total,l}$

The total amount of chilled water produced by the trigeneration system and electrical compression chillers which remain operating after the project activity is calculated as:

$$CG_{PJ,total,l} = CG_{PJ,trig,l} + CG_{PJ,elechill,l} \quad \textbf{(11)}$$

$$CG_{PJ,trig,l} = CW_{PJ,trig,l} \cdot c_p \cdot \left(T_{cw,trig,in,l} - T_{cw,trig,out,l}\right) \quad \textbf{(12)}$$

$$CG_{PJ,elechill,l} = \sum_m \left[CW_{PJ,elechill,m,l} \cdot c_p \cdot \left(T_{cw,elechill,in,m,l} - T_{cw,elechill,out,m,l}\right)\right] \quad \textbf{(13)}$$

[2] One ton of refrigeration (TR) is the amount of power required to freeze one short ton of water at 0 °C (32 °F) in 24 hours. 1 ton refrigeration = 200 Btu/min = 3.517 kJ/s = 3.517 kW.

Where:

$CG_{PJ,total,l}$	=	Total amount of chilled water produced by the trigeneration system and electrical compression chillers, which remain operating after the project activity, in the monitoring interval *l* in year *y* (TJ)
$CG_{PJ,trig,l}$	=	Total amount of chilled water produced in the trigeneration system (absorption chiller) during the monitoring interval *l* in year *y* (TJ)
$CG_{PJ,elechill,l}$	=	Total amount of chilled water produced in the electrical compression chillers which remain operating after the project activity during the monitoring interval *l* in year *y* (TJ)
$CW_{PJ,trig,l}$	=	Amount of chilled water produced in the trigeneration system (absorption chillers) during the monitoring interval *l* in year *y* (tonnes of chilled water)
c_p	=	Specific heat of the chilled water (TJ/tonne of chilled water °C)
$T_{cw,trig,in,l}$	=	Average inlet temperature of the chilled water as it enters the absorption chillers (trigeneration system) during the monitoring interval *l* in year *y* (°C)
$T_{cw,trig,out,l}$	=	Average outlet temperature of the chilled water as it leaves the absorption chillers (trigeneration system) during the monitoring interval *l* in year *y* (°C)
$CW_{PJ,elechill,m,l}$	=	Amount of chilled water produced by electrical compression chiller *m* that remain operating after the project activity during the monitoring interval *l* in year *y* (tonnes of chilled water)
$T_{cw,elechill,in,m,l}$	=	Average temperature of the chilled water as it enters the electrical compression chiller *m* that remain operating after the project activity during the monitoring interval *l* in year *y* (°C)
$T_{cw,elechill,out,m,l}$	=	Average temperature of the chilled water as it leaves the electrical compression chiller *m* that remain operating after the project activity during the monitoring interval *l* in year *y* (°C)
m	=	Electrical compression chillers that remain operating after the project activity.
l	=	Time intervals used for monitoring chilled water production and chilled water parameters during the year *y*. The number of monitoring intervals is equal to $L = 8760/\Delta l$
Δl	=	Length of the monitoring interval *l*. This length has to be clearly stated in the CDM-PDD. The default Δl is 1 hour. A different length can be proposed, but has to be justified based on the expected time variation of chilled water production rate (load factor) and chilled water parameters (hours)
y	=	Year of the crediting period

Calculation of $CG_{BL,CAP}$

Since the project activity is supposed to displace existing electrical compression chillers, baseline emissions are capped if the total production of chilled water in the project scenario surpasses $CG_{BL,CAP}$. This is equivalent to attributing a zero emission factor in the baseline for any production of chilled water in the project scenario, which surpasses $CG_{BL,CAP}$ as no baseline is selected for capacity increases under this methodology.

$$CG_{BL,CAP} = \Delta l \cdot \sum_{m} \left[CAP_{BL,elechill,m} \cdot c_p \cdot \left(T_{BL,cw,in,m} - T_{BL,cw,out,m} \right) \right] \tag{14}$$

Where:

$CG_{BL,CAP}$	=	Maximum amount of chilled water that could be produced by all electrical compression chillers existing on-site previous to the implementation of the project activity (TJ)
$CAP_{BL,elechill,m}$	=	Nominal chilled water output that the electrical compression chiller *m*, existing in the industrial facility prior to the project activity, would be able to deliver if it would operate at its maximum output capacity during the monitoring interval *l* (tonnes of chilled water/hour)
c_p	=	Specific heat of the chilled water (TJ/tonne.^{o}C).
$T_{BL,cw,in,m}$	=	Average temperature of the chilled water entering the electrical compression chiller *m*, existing in the industrial facility prior to the project activity (^{o}C)
$T_{BL,cw,out,m}$	=	Average temperature of the chilled water leaving the electrical compression chiller *m*, existing in the industrial facility prior to the project activity (^{o}C)
Δl	=	Length of the monitoring interval *l* (hours). This length has to be clearly stated in the CDM-PDD. The default Δl is 1 hour. A different length can be proposed, but has to be justified based on the expected time variation of chilled water production rate (load factor) and chilled water parameters
m	=	Electrical compression chillers existing in the industrial facility prior to the project activity

Determination of the power consumption function $PCF_{BL,elechill}(...)$

The power consumption function $PCF_{BL,elechill}(...)$ of the electrical compression chillers existing on-site prior to the implementation of the project activity is not a single value, rather it is a relation which expresses the power consumption of the electrical compression chillers as a function of the quantity of chilled water produced, the outlet temperature of chilled water and the inlet temperature of condensing water. This curve can be either presented as a mathematical function or as a look-up table.
Given the power consumption function of a chiller, its power consumption is estimated by applying the average values of chilled water produced, outlet temperature of chilled water and inlet temperature of condensing water, monitored during the monitoring intervals *l*, to the power consumption function of the chiller.

For the purpose of establishing the power consumption function, project participants should determine and document in the CDM-PDD the maximum range over which the three key operating parameters (chilled water produced, the outlet temperature of chilled water and the inlet temperature of condensing water) can vary in the electrical compression chillers. Preferably, historical data records for at least one year should be used for this purpose. The range should reflect the range of year-round ambient temperature and humidity conditions and cooling demand variations. Different ambient conditions (temperature and humidity) are reflected through different inlet temperature of the condensing water (as the operation of the cooling tower depends on ambient temperature and humidity) and different chiller output loads (as the cooling demand usually is influenced by the ambient temperature). The range of the inlet temperature of the condensing water can be determined based on data of the wet bulb and dry bulb temperatures specific to the location of the chillers and information on the variation of humidity and ambient temperature, covering each season in the year and variations during days and nights. In the absence of more precise data, it may be assumed that the inlet temperature of the condensing water is 4 °C higher than the average ambient wet bulb temperature. The range of the outlet temperature of the chilled water should be varied according to the cooling process or air conditioning requirements. However, in some applications the outlet temperature of the chilled water may be kept relatively constant, making the variation of this parameter unnecessary.

The following options can be used to determine the power consumption function of an individual chiller:

Option A: Determination of the power consumption function based on measurements, following the procedure provided in the Annex 2 in this methodology.

Option B: Determination of the power consumption function based on manufacturer's data, following the guidance provided in Step 5 of the Annex 2 in this methodology.

Option C: The power consumption function is assumed to be constant (and not dependent on the quantity of chilled water produced, the outlet temperature of the chilled water and the inlet temperature of the condensing water). In this case, the value for the power consumption function should be chosen as the most conservative value, i.e. the lowest power consumption that is observed over the maximum range of the three operating parameters. This value can either be determined based on measurements or manufacturer's data, following the guidance provided under Option A or Option B above.

If more than one electrical compression chiller had been operating before the implementation of the project activity, a single equivalent value of power consumption should be used by calculating the arithmetic average of the power consumptions of the chillers, obtained from the individual power consumption functions determined as per one of the options above, at each level of chilled water produced, outlet temperature of chilled water and inlet temperature of condensing water.

Baseline emissions due to the production of electricity ($BE_{EL,y}$)

Baseline emissions associated with the production of electricity result from the production of grid electricity that would be required to supply the industrial facility in the absence of the project activity (excluding electricity used in the electrical compression chillers) in year y. Since the project activity is supposed to meet existing demand in the industrial facility, if the total electricity demand in the industrial facility (excluding electrical compression chillers) surpasses $EC_{BL,CAP}$, baseline emissions are capped.

$$BE_{EL,y} = \min\left((EG_{trig,y} + EG_{grid,y} - EC_{elechill,y}), EC_{BL,CAP}\right) \cdot EF_{grid,y} \quad \textbf{(15)}$$

Where:

$BE_{EL,y}$	=	Baseline emissions due to the production of electricity to supply the industrial facility in the absence of the project activity (excluding electricity used in the electrical compression chillers) in year *y* (tCO2)
$EG_{trig,y}$	=	Net electricity produced by the trigeneration system used to supply the industrial facility in year *y* (MWh)
$EG_{grid,y}$	=	Total consumption of grid electricity in the industrial facility in year *y* (MWh)
$EC_{elechill,y}$	=	Total consumption of electricity in the electrical compression chillers that remain operating after the implementation of the project activity in year *y* (MWh)
$EC_{BL,CAP}$	=	Maximum annual amount of electricity that the industrial facility would demand to operate at full load capacity prior to the implementation of the project activity (MWh)
$EF_{grid,y}$	=	Emission factor for grid electricity in year *y* (tCO2/MWh)

Calculation of $EC_{elechill,y}$

The total consumption of electricity in the electrical compression chillers that remain operating after the implementation of the project activity can be determined as per one of the following options:

Option A: Directly monitored in the electrical compression chillers.
Option B: Estimated from the monitored amount of chilled water produced in those chillers and their power consumption function, as per the following equation:

$$EC_{elechill,y} = \Delta l \cdot \sum_{m} \sum_{l=1}^{L} \left[7.9 \times 10^4 \cdot \frac{CG_{PJ,elechill,m,l}}{\Delta l} \cdot PCF_{PJ,elechill,m}\left(CG_{PJ,elechill,m,l}, T_{cond,elechill,in,m,l}, T_{cw,elechill,out,m,l} \right) \right] \quad \textbf{(16)}$$

$$CG_{PJ,elechill,m,l} = CW_{PJ,elechill,m,l} \cdot c_p \cdot \left(T_{cw,elechill,in,m,l} - T_{cw,elechill,out,m,l} \right) \quad \textbf{(17)}$$

Where:

$EC_{elechill,y}$	=	Total consumption of electricity in the electrical compression chillers that remain operating after the implementation of the project activity in year *y* (MWh)
$CG_{PJ,elechill,m,l}$	=	Total amount of chilled water produced in the electrical compression chiller *m* which remain operating after the project activity during the monitoring interval *l* in year *y* (TJ)
$PCF_{PJ,elechill,m}(...)$	=	Power consumption function of the electrical compression chiller *m* which remain operating after the implementation of the project activity (MW/TR).
$T_{cond,elechill,in,m,l}$	=	Average inlet temperature of the condensing water as it enters the condenser unit in the electrical compression chiller *m* during the monitoring interval *l* in year *y* (°C)
$T_{cw,elechill,out,m,l}$	=	Average outlet temperature of the chilled water as it leaves the electrical compression chiller *m* that remain operating after the project activity during the monitoring interval *l* in year *y* (°C)
$7.9x10^4$	=	Conversion factor from TJ/h to TR

$CW_{PJ,elechill,m,l}$	=	Amount of chilled water produced by electrical compression chiller *m* that remain operating after the project activity during the monitoring interval *l* in year *y* (tonnes of chilled water)
$T_{cw,elechill,in,m,l}$	=	Average inlet temperature of the chilled water as it enters the electrical compression chiller *m* that remain operating after the project activity during the monitoring interval *l* in year *y* (°C)
c_p	=	Specific heat of the chilled water (TJ/tonnes.°C)
l	=	Time intervals used for monitoring chilled water production and chilled water parameters during the year *y*. The number of monitoring intervals is equal to $L = 8760/\Delta l$
Δl	=	Length of the monitoring interval *l*. This length has to be clearly stated in the CDM-PDD. The default Δl is 1 hour. A different length can be proposed, but has to be justified based on the expected time variation of chilled water production rate (load factor) and chilled water parameters (hours)
m	=	Electrical compression chillers that remain operating after the project activity
y	=	Year of the crediting period

Calculation of $EC_{BL,CAP}$

Maximum annual amount of electricity that the industrial facility would demand to operate at full load capacity prior to the implementation of the project activity (MWh). This parameter should be either:

Option A: Estimated based on the nameplate electricity demand of all electrical loads existing in the industrial facility prior to the implementation of the project activity, had the industrial facility operated at full load capacity.

Option B: Chosen as the highest electricity consumption that was observed in the industrial facility over the most recent three years previous to the implementation of the project activity.

Determination of the power consumption function $PCF_{PJ,elechill,m}(...)$

The power consumption function for electrical compression chillers which remain operating after the implementation of the project activity can, similarly to $PCF_{BL,elechill}(...)$, be determined as:

Option A: Determination of the power consumption function based on measurements, following the procedure provided in the Annex 2 to this methodology.

Option B: Determination of the power consumption function based on manufacturer's data.

Option C: The power consumption function is assumed to be constant by choosing the most conservative value, i.e. the highest power consumption that is observed, based on measurements or manufacturer's data, following the guidance provided under Option A or Option B above.

Emission factor for grid electricity ($EF_{grid,y}$)

The emission factor for grid electricity in year *y* (tCO2/MWh) should be calculate using the latest version of the "Tool to calculate the emission factor for an electricity system". $EF_{grid,y}$ corresponds to the parameter $EF_{grid,CM,y}$ in the tool referred to above.

Leakage

The only source of leakage considered are upstream emissions due to the supply of fossil fuels. Leakage is conservatively calculated as the difference in fugitive CH_4 emissions associated with the production, transportation and distribution of the fossil fuels used on-site in the baseline and project scenarios, disregarding the impact of the project activity in the use of fossil fuels in grid connected power plants.

$$LE_y = \left[\sum_i FC_{PJ,i,y} \cdot NCV_i \cdot EF_{i,upstream,CH4} - \sum_{k=1}^{K} \left[\frac{\min\left(HG_{PJ,total,k}, HG_{BL,CAP}\right)}{\eta_{BL,boiler}} \right] \cdot EF_{FF,upstream,CH4} \right] \cdot GWP_{CH4} \quad \textbf{(18)}$$

Where:

LE_y	=	Leakage emissions in year y (tCO_{2e})
$FC_{PJ,i,y}$	=	Amount of fossil fuel type i combusted in the industrial facility (trigeneration system and boilers) in year y (mass or volume unit)
NCV_i	=	Net calorific value of fossil fuel type i (TJ/mass or volume unit)
$EF_{i,upstream,CH4}$	=	CH_4 upstream emission factor of fossil fuel type i (tCH4/TJ)
$HG_{PJ,total,k}$	=	Total amount of steam produced in the trigeneration system and boilers which remain operating after the project activity used to feed the industrial facility heat loads (excluding absorption chillers), during the monitoring interval k in year y (TJ)
$HG_{BL,CAP}$	=	Maximum amount of steam that could be produced by all boilers existing on-site prior to the implementation of the project activity (TJ)
$\eta_{BL,boiler}(...)$	=	Efficiency from the load factor-efficiency curve of the boilers existing in the industrial facility prior to the implementation of the project activity (fraction)
$EF_{FF,upstream,CH4}$	=	Highest CH_4 upstream emission factor amongst all fossil fuels type i used in the industrial facility prior to the implementation of the project activity (tCH4/TJ)
GWP_{CH4}	=	Global warming potential of methane valid for the relevant commitment period (tCO2/tCH4)
y	=	Year of the crediting period
k	=	Time intervals used for monitoring steam production and steam parameters during the year y. The number of monitoring intervals is equal to $K = 8760//\Delta k$
Δk	=	Length of the monitoring intervals k (hours). This length has to be clearly stated in the CDM-PDD. The default Δk is 1 hour. A different length can be proposed, but has to be justified based on the expected time variation of steam production rate (load factor) and steam parameters

Where reliable and accurate national data on fugitive CH_4 emissions associated with the production, transportation and distribution of the fuels is available, project participants should use this data to determine average emission factors by dividing the total quantity of CH_4 emissions by the quantity of fuel produced or supplied respectively.[3] Where such data is not available, project participants may use the default values provided in Table 2 below, applying adequate unit conversion factors.

[3] GHG inventory data reported to the UNFCCC as part of national communications can be used where country-specific approaches (and not IPCC Tier 1 default values) have been used to estimate emissions.

Table 2: Default emission factors for fugitive CH_4 upstream emissions

Activity	Unit	Default emission factor	Reference for the underlying emission factor range in Volume 3 of the *1996 Revised IPCC Guidelines*
Coal			
Underground mining	t CH4 / kt coal	13.4	Equations 1 and 4, p. 1.105 and 1.110
Surface mining	t CH4 / kt coal	0.8	Equations 2 and 4, p.1.108 and 1.110
Oil			
Production	t CH4 / PJ	2.5	Tables 1-60 to 1-64, p. 1.129 - 1.131
Transport, refining and storage	t CH4 / PJ	1.6	Tables 1-60 to 1-64, p. 1.129 - 1.131
Total	t CH4 / PJ	4.1	
Natural gas			
USA and Canada			
Production	t CH4 / PJ	72	Table 1-60, p. 1.129
Processing, transport and distribution	t CH4 / PJ	88	Table 1-60, p. 1.129
Total	t CH4 / PJ	160	
Eastern Europe and former USSR			
Production	t CH4 / PJ	393	Table 1-61, p. 1.129
Processing, transport and distribution	t CH4 / PJ	528	Table 1-61, p. 1.129
Total	t CH4 / PJ	921	
Western Europe			
Production	t CH4 / PJ	21	Table 1-62, p. 1.130
Processing, transport and distribution	t CH4 / PJ	85	Table 1-62, p. 1.130
Total	t CH4 / PJ	105	
Other oil exporting countries / Rest of world			
Production	t CH4 / PJ	68	Table 1-63 and 1-64, p. 1.130 and 1.131
Processing, transport and distribution	t CH4 / PJ	228	Table 1-63 and 1-64, p. 1.130 and 1.131
Total	t CH4 / PJ	296	

Note: The emission factors in this table have been derived from IPCC default Tier 1 emission factors provided in Volume 3 of the 1996 Revised IPCC Guidelines, by calculating the average of the provided default emission factor range.

Emission reductions

Emission reductions are calculates as follows:

$$ER_y = BE_y - PE_y - LE_y \quad \textbf{(19)}$$

Where:

ER_y	=	Emissions reductions of the project activity during the year y (tCO_2)
$BE_{,y}$	=	Baseline emissions during the year y (tCO_2)
PE_y	=	Project emissions during the year y (tCO_2)
LE_y	=	Leakage emissions in the year y (tCO_2)
y	=	Year of the crediting period

Data and parameters not monitored

In addition to the parameters listed in the tables below, the provisions on data and parameters not monitored in the tools referred to in this methodology apply.

Data / parameter:	$CAP_{BL,boiler,n}$
Data unit:	tonnes of steam/hour
Description:	Nominal steam output that the boiler *n*, existing in the industrial facility prior to the project activity, would be able to deliver if it would operate at its maximum output capacity during a time interval equal to *k*
Source of data:	Manufacturers data
Measurement procedures (if any):	
Any comment:	

Data / parameter:	$HS_{\mathbf{BL,boiler,n}}$
Data unit:	TJ/tonne of steam
Description:	Specific enthalpy of the steam produced in boiler n existing in the industrial facility prior to the project activity
Source of data:	Historical average measurements (3 years) of temperature ($T_{BL,boilers,steam}$) and pressure ($P_{BL,boilers,steam}$) of the steam produced by boiler n.
Measurement procedures (if any):	
Any comment:	

Data / parameter:	$HF_{\mathbf{BL,boiler,n}}$
Data unit:	TJ/tonne of feedwater
Description:	Specific enthalpy of the feedwater fed into boiler n existing in the industrial facility prior to the project activity
Source of data:	Historical average measurements (3 years) of temperature ($T_{BL,boilers,feed}$) of the feedwater used by boiler *n.*
Measurement procedures (if any):	
Any comment:	

Data / parameter:	$CAP_{\mathbf{BL,elechill,m}}$
Data unit:	tonnes of chilled water/hour
Description:	Nominal chilled water output that the electrical compression chiller m, existing in the industrial facility prior to the project activity, would be able to deliver if it would operate at its maximum output capacity during a time interval equal to *k.*
Source of data:	Manufacturers data
Measurement procedures (if any):	
Any comment:	

Data / parameter:	$T_{BL,cw,in,m}$
Data unit:	°C
Description:	Average temperature of the chilled water entering the electrical compression chiller *m*, existing in the industrial facility prior to the project activity
Source of data:	Historical average measurements (3 years) of temperature $T_{BL,cw,in,m}$ for chiller *m*.
Measurement procedures (if any):	
Any comment:	

Data / parameter:	$T_{BL,cw,out,m}$
Data unit:	°C
Description:	Average temperature of the chilled water leaving the electrical compression chiller m, existing in the industrial facility prior to the project activity
Source of data:	Historical average measurements (3 years) of temperature $T_{BL,cw,out,m}$ for chiller *m*.
Measurement procedures (if any):	
Any comment:	

Data / parameter:	c_p
Data unit:	TJ/tonne of chilled water · ^oC
Description:	Specific heat of the chill water
Source of data:	Use references in standard engineering books or appropriate thermodynamic models
Value to be applied:	
Any comment:	-

Parameter:	$\eta_{BL,boiler}(\ldots)$
Data unit:	
Description	Efficiency of boilers in the baseline scenario
Source of data:	As specified in the baseline methodology.
Measurement procedures (if any):	
Any comment:	

Parameter:	$PCF_{BL,elechill}(...)$
Data unit:	MW/TR
Description	Power consumption function of the electrical compression chillers existing on-site prior to the implementation of the project activity
Source of data:	As specified in the baseline methodology.
Measurement procedures (if any):	
Any comment:	

Parameter:	$PCF_{PJ,elechill,m}(...)$
Data unit:	MW/TR
Description	Power consumption function of the electrical compression chiller *m* which remain operating after the implementation of the project activity
Source of data:	As specified in the baseline methodology.
Measurement procedures (if any):	
Any comment:	

Data / parameter:	$EC_{BL,CAP}$
Data unit:	MWh
Description:	Maximum annual amount of electricity that the industrial facility would demand to operate at full load capacity prior to the implementation of the project activity
Source of data:	Historical measurements (3 years) of electricity consumed by the industrial facility
Measurement procedures (if any):	
Any comment:	

Data / Parameter:	$FC_{BL,boilers,i}$
Data unit:	mass or volume unit
Description:	Amount of fossil fuel *i* used in the boilers existing on-site prior (3 years) to the implementation of the project activity
Source of data:	On-site measurements
Measurement procedures (if any):	Use mass or volume meters
Any comment:	-

<table>
<tr><td>Parameter:</td><td>EF_i</td></tr>
<tr><td>Data unit:</td><td>tCO2/TJ</td></tr>
<tr><td>Description</td><td>Carbon emission factor for fossil fuel type i</td></tr>
<tr><td>Source of data:</td><td>The following data sources may be used if the relevant conditions apply:
<table>
<tr><th>Data source</th><th>Conditions for using the data source</th></tr>
<tr><td>a) Values provided by the fuel supplier in invoices</td><td>This is the preferred source</td></tr>
<tr><td>b) Measurements by the project participants</td><td>If a) is not available</td></tr>
<tr><td>c) Regional or national default values</td><td>If a) is not available

These sources can only be used for liquid fuels and should be based on well-documented, reliable sources (such as national energy balances)</td></tr>
<tr><td>d) IPCC default values at the upper limit of the uncertainty at a 95% confidence interval as provided in table 1.4 of Chapter1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories</td><td>If a) is not available</td></tr>
</table></td></tr>
<tr><td>Measurement procedures (if any):</td><td>-</td></tr>
<tr><td>Any comment:</td><td>-</td></tr>
</table>

Parameter:	$EF_{i,upstream,CH4}$
Data unit:	tCH_4/TJ
Description	Emission factor for upstream fugitive methane emissions from production, transportation and distribution of the fuel type *i* burnt in the trigeneration system and the remaining boilers
Source of data:	As stated in the baseline methodology.
Measurement procedures (if any):	-
Any comment:	-

Parameter:	$EF_{FF,upstream,CH4}$
Data unit:	tCH_4/TJ
Description	Highest CH_4 upstream emission factor amongst all fossil fuels type *i* used in the industrial facility prior to the implementation of the project activity
Source of data:	As stated in the baseline methodology.
Measurement procedures (if any):	-
Any comment:	-

Parameter:	GWP_{CH4}
Data unit:	tCO_2e/tCH_4
Description	Global warming potential of methane valid for the relevant commitment period.
Source of data:	IPCC
Measurement procedures (if any):	Default value for the first commitment period = 21 tCO_2e/tCH_4
Any comment:	-

III. MONITORING METHODOLOGY

All data collected as part of monitoring should be archived electronically and be kept at least for 2 years after the end of the last crediting period. 100% of the data should be monitored if not indicated otherwise in the tables below. All measurements should be conducted with calibrated measurement equipment according to relevant industry standards. In addition, the monitoring provisions in the tools referred to in this methodology apply.

Data and parameters monitored

Data / parameter:	$EG_{trig,y}$
Data unit:	MWh
Description:	Net electricity produced by the trigeneration system used to supply the industrial facility in year *y*
Source of data:	Onsite measurements
Measurement procedures (if any):	Use electricity meters at the outlet of the trigeneration system.
Monitoring frequency:	Continuously, aggregated at least annually
QA/QC procedures:	
Any comment:	

Data / parameter:	$EG_{grid,y}$
Data unit:	MWh
Description:	Total consumption of grid electricity in the industrial facility in year *y*
Source of data:	Onsite measurements
Measurement procedures (if any):	Use electricity meters in the interconnection point with the power grid.
Monitoring frequency:	Continuously, aggregated at least annually
QA/QC procedures:	Cross check measurement results with records or invoices for purchased and sold electricity
Any comment:	

Data / parameter:	$T_{cond,in,l}$
Data unit:	°C
Description:	Average inlet temperature of the condensing water as it enters the condenser unit in the absorption chillers (trigeneration system) during the monitoring interval *l* in year *y*.
Source of data:	Measurements by project participants
Measurement procedures (if any):	
Monitoring frequency:	Continuously, average values to be determined for each time period *l*
QA/QC procedures:	
Any comment:	

Data / parameter:	$T_{cw,out,l}$
Data unit:	°C
Description:	Average outlet temperature of the chilled water as it leaves the absorption chillers (trigeneration system) during the monitoring interval *l* in year *y*
Source of data:	Measurements by project participants
Measurement procedures (if any):	
Monitoring frequency:	Continuously, average values to be determined for each time period *l*
QA/QC procedures:	
Any comment:	

Data / parameter:	$EF_{grid,y}$
Data unit:	tCO_2/MWh
Description:	Grid emission factor in year *y*
Source of data:	As per the latest version of the "Tool to calculate the emission factor for an electricity system"
Measurement procedures (if any):	As per the latest version of the "Tool to calculate the emission factor for an electricity system"
Monitoring frequency:	As per the latest version of the "Tool to calculate the emission factor for an electricity system"
QA/QC procedures:	As per the latest version of the "Tool to calculate the emission factor for an electricity system"
Any comment:	-

Data / parameter:	$SG_{PJ,trig,k}$
Data unit:	tonnes of steam
Description:	Total amount of steam produced in the trigeneration system used to feed the industrial facility heat loads (excluding absorption chillers, if they are supplied with steam produced in the trigeneration system) during the monitoring interval *k* in year *y*
Source of data:	Plant data
Measurement procedures (if any):	Steam meter
Monitoring frequency:	Δk
QA/QC procedures:	Steam meter should be calibrated for temperature and pressure of steam to be monitored as per internal QA/QC procedures of plant
Any comment:	

Data / parameter:	$HS_{PJ,trig,k}$
Data unit:	TJ/tonne of steam
Description:	Specific enthalpy of the steam produced in the trigeneration system during the monitoring interval *k* in year *y*
Source of data:	Plant data
Measurement procedures (if any):	Steam meter for flow measurement. Pressure gauge and Temperature indicator for pressure and temperature measurements respectively. Steam table for enthalpy determination at given average temperature ($T_{PJ,trig,steam}$) and pressure ($P_{PJ,trig,steam}$) of the steam during the monitoring interval *k*.
Monitoring frequency:	Δk
QA/QC procedures:	Regular calibration procedures to be adopted for all monitoring instruments
Any comment:	

Data / parameter:	$HF_{PJ,trig,k}$
Data unit:	TJ/tonne of feedwater
Description:	Specific enthalpy of the feedwater fed into the trigeneration system during the monitoring interval *k* in year *y*
Source of data:	Plant data
Measurement procedures (if any):	Water flow meter for flow measurement and temperature indicator for temperature measurements respectively. Enthalpy to be estimated based on the average temperature ($T_{PJ,trig,feed}$) of the feedwater during the monitoring interval *k*.
Monitoring frequency:	Δk
QA/QC procedures:	Regular calibration procedures to be adopted for all measuring instruments
Any comment:	

Data / parameter:	$SG_{PJ,boilers,n,k}$
Data unit:	tonnes of steam
Description:	Total amount of steam produced in boiler *n* which remains operating after the project activity used to feed the industrial facility heat loads (excluding absorption chillers, if they are supplied with steam produced in the boilers) during the monitoring interval *k* in year *y*
Source of data:	Plant data
Measurement procedures (if any):	Steam meter
Monitoring frequency:	Δk
QA/QC procedures:	Steam meter should be calibrated for temperature and pressure of steam to be monitored as per internal QA/QC procedures of plant
Any comment:	

Data / parameter:	$HS_{PJ,boilers,n,k}$
Data unit:	TJ/tonne of steam
Description:	Specific enthalpy of the steam produced in boiler *n* which remains operating after the project activity during the monitoring interval *k* in year *y*
Source of data:	Plant data
Measurement procedures (if any):	Steam meter for flow measurement. Pressure gauge and Temperature indicator for pressure and temperature measurements respectively. Steam table for enthalpy determination at given average temperature ($T_{PJ,boilers,steam}$) and pressure ($P_{PJ,boilers,steam}$) of the steam during the monitoring interval *k*.
Monitoring frequency:	Δk
QA/QC procedures:	Regular calibration procedures to be adopted for all monitoring instruments
Any comment:	

Data / parameter:	$HF_{PJ,boilers,n,k}$
Data unit:	TJ/tonne of feedwater
Description:	Specific enthalpy of the feedwater fed into the boiler *n* which remains operating after the project activity during the monitoring interval *k* in year *y*
Source of data:	Plant data
Measurement procedures (if any):	Water flow meter for flow measurement and temperature indicator for temperature measurements respectively. Enthalpy to be estimated based on the average temperature ($T_{PJ,boilers,feed}$) of the feedwater during the monitoring interval *k*.
Monitoring frequency:	Δk
QA/QC procedures:	Regular calibration procedures to be adopted for all measuring instruments
Any comment:	

Data / parameter:	$CW_{PJ,trig,l}$
Data unit:	tonnes of chilled water
Description:	Amount of chilled water produced in the trigeneration system (absorption chillers) during the monitoring interval *l* in year *y*
Source of data:	Plant data
Measurement procedures (if any):	Flow meter applying required conversion factor for units
Monitoring frequency:	Δl
QA/QC procedures:	Flow meter should be calibrated for temperature and pressure of chilled water to be monitored as per internal QA/QC procedures of plant
Any comment:	

Data / parameter:	$T_{cw,trig,in,l}$
Data unit:	°C
Description:	Average inlet temperature of the chilled water as it enters the absorption chillers (trigeneration system) during the monitoring interval *l* in year *y*
Source of data:	Measurements by project participants
Measurement procedures (if any):	
Monitoring frequency:	Continuously, average values to be determined for each time period *l*
QA/QC procedures:	
Any comment:	

Data / parameter:	$T_{cw,trig,out,l}$
Data unit:	°C
Description:	Average outlet temperature of the chilled water as it leaves the absorption chillers (trigeneration system) during the monitoring interval *l* in year *y*
Source of data:	Measurements by project participants
Measurement procedures (if any):	
Monitoring frequency:	Continuously, average values to be determined for each time period *l*
QA/QC procedures:	
Any comment:	

Data / parameter:	$CW_{PJ,elechill,m,l}$
Data unit:	tonnes of chilled water
Description:	Amount of chilled water produced by electrical compression chiller *m* that remain operating after the project activity during the monitoring interval *l* in year *y*
Source of data:	Plant data
Measurement procedures (if any):	Flow meter applying required conversion factor for units
Monitoring frequency:	Δl
QA/QC procedures:	Flow meter should be calibrated for temperature and pressure of chilled water to be monitored as per internal QA/QC procedures of plant
Any comment:	

Data / parameter:	$T_{cw,elechill,in,m,l}$
Data unit:	°C
Description:	Average temperature of the chilled water as it enters the electrical compression chiller *m* that remain operating after the project activity during the monitoring interval *l* in year *y*
Source of data:	Measurements by project participants
Measurement procedures (if any):	
Monitoring frequency:	Continuously, average values to be determined for each time period *l*
QA/QC procedures:	
Any comment:	

Data / parameter:	$T_{cw,elechill,out,m,l}$
Data unit:	°C
Description:	Average temperature of the chilled water as it leaves the electrical compression chiller *m* that remain operating after the project activity during the monitoring interval *l* in year *y*
Source of data:	Measurements by project participants
Measurement procedures (if any):	
Monitoring frequency:	Continuously, average values to be determined for each time period *l*
QA/QC procedures:	
Any comment:	

Data / parameter:	$T_{cond,elechill,in,m,l}$
Data unit:	°C
Description:	Average inlet temperature of the condensing water as it enters the condenser unit in the electrical compression chiller *m* during the monitoring interval *l* in year *y*
Source of data:	Measurements by project participants
Measurement procedures (if any):	
Monitoring frequency:	Continuously, average values to be determined for each time period *l*
QA/QC procedures:	
Any comment:	

Data / Parameter:	$FC_{PJ,i,y}$
Data unit:	mass or volume unit
Description:	Amount of fossil fuel type *i* combusted in the industrial facility (trigeneration system and boilers) in year *y*
Source of data:	On-site measurements
Measurement procedures (if any):	Use mass or volume meters
Monitoring frequency:	Continuously
QA/QC procedures:	The consistency of metered fuel consumption quantities should be crosschecked by an annual energy balance that is based on purchased quantities and stock changes. Where the purchased fuel invoices can be identified specifically for the CDM project, the metered fuel consumption quantities should also be cross-checked with available purchase invoices from the financial records.
Any comment:	-

<table>
<tr><td>Data / parameter:</td><td>NCV_i</td></tr>
<tr><td>Data unit:</td><td>TJ per mass or volume unit</td></tr>
<tr><td>Description:</td><td>Net calorific value of fossil fuel type i</td></tr>
<tr><td>Source of data:</td><td>The following data sources may be used if the relevant conditions apply:
<table>
<tr><td>Data source</td><td>Conditions for using the data source</td></tr>
<tr><td>a) Values provided by the fuel supplier in invoices</td><td>This is the preferred source if the carbon fraction of the fuel is not provided (Option A).</td></tr>
<tr><td>b) Measurements by the project participants</td><td>If a) is not available</td></tr>
<tr><td>c) Regional or national default values</td><td>If a) is not available

These sources can only be used for liquid fuels and should be based on well documented, reliable sources (such as national energy balances).</td></tr>
<tr><td>d) IPCC default values at the upper limit of the uncertainty at a 95% confidence interval as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories</td><td>If a) is not available</td></tr>
</table></td></tr>
</table>

Measurement procedures (if any):	For a) and b): Measurements should be undertaken in line with national or international fuel standards.
Monitoring frequency:	For a) and b): The NCV should be obtained for each fuel delivery, from which weighted average annual values should be calculated For c): Review appropriateness of the values annually For d): Any future revision of the IPCC Guidelines should be taken into account
QA/QC procedures:	Verify if the values under a), b) and c) are within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. If the values fall below this range collect additional information from the testing laboratory to justify the outcome or conduct additional measurements. The laboratories in a), b) or c) should have ISO17025 accreditation or justify that they can comply with similar quality standards.
Any comment:	

IV. REFERENCES AND ANY OTHER INFORMATION

Not applicable.

Annex 1

Procedure to determine the output-efficiency curve of the boilers existing in the industrial facility prior to the implementation of the project activity

The output-efficiency curve should be determined for each individual boiler existing in the industrial facility prior to the implementation of the project activity. Establish load – efficiency function by conducting efficiency tests on the equipment[4] and applying a regression analysis on the test results. The efficiency tests shall be conducted following the guidance provided in relevant national / international standards such as ASME PTC-6 1996 or IEC 60953-3 2001, ASME PTC-4 or BS 845 or EN 12952-15-2003 etc., preferably using direct methods (i.e dividing the net output by the sum of all inputs) and not indirect methods (i.e. based on losses), for a range of loads that is representative of the operational conditions during the project activity. All the measurements should be conducted in the presence of an independent party (e.g. the DOE, equipment manufacturer, an independent relevant technical expert/consultant). All measurements shall be conducted immediately after scheduled preventive maintenance has been undertaken and under normal good operation conditions (optimal load, optimal operating conditions, representative or favorable ambient conditions for the best efficiency of the equipment, etc). During the measurement campaign, the load is varied over the whole operation range and the efficiency of the boiler is measured for different steady-state load levels. Document the measurement procedures and results transparently in the CDM-PDD.

Two successive load points at which the tests are conducted in the load range shall at least have an increment of 5% of the equipment rated capacity. At each load point in the selected load range, at least 10 efficiency tests/measurements shall be conducted[5]. All efficiency tests shall be conducted for a predetermined discrete time interval e.g. 1 hour using direct method or indirect method as prescribed in the relevant national/international standards. All tests shall be conducted for the same duration.
Each efficiency test provides a pair of data i.e. (1) load on the equipment and (2) the efficiency of energy equipment at the particular load point. Based on the data collected at all load points under normal operation conditions, the load-efficiency function shall be established using regression analysis, in the form of the definite relation as given below.

$$\eta_{BL,boiler}(...) = \eta$$

and

$$\eta = f(L) = a + b_1 L + b_2 (L)^2 + ... + b_n (L)^n \quad \textbf{(1)}$$

[4] Tests shall be conducted before implementation of retrofits that are part of the project activity.

[5] For example, if 20 load points were considered in the load range of the equipment and considering 10 measurements at each load point, the total number of efficiency tests shall be 200.

Where:

η	=	Efficiency of the energy equipment, expressed as a function of the load of the equipment
L	=	Load of the energy equipment (MW)
$A, b_1, b_2, ..., b_n$	=	Parameters of regression equation estimated using the regression analysis

For the regression analysis, project participants may choose any standard regression software to determine the load-efficiency function. While applying the regression analysis to the test results, project participants may choose an appropriate regression equation. For example, the equation (1) above applies for a polynomial function. The equation (1) becomes linear when n=1. In case of polynomial function, the terms of polynom may be restricted to 3 or 4 i.e. n<=3 in the above equation (1). If the regression analysis does not fit polynomial or linear model, appropriate transformations such as logarithmic, anti-logarithmic, or any other models supported by the regression software may be used.

In order to ensure that the results of the regression analysis are conservative, the efficiency function derived above shall be adjusted for the upper bound of uncertainty of the result of load-efficiency function at a 95% confidence level by introducing the standard error SE (*f(L)*). The standard error shall be determined for each load point *t*. It is recommended that project participants use the standard software to determine the standard error SE(*f(L)*). The adjusted efficiency at a particular load point, after introducing the standard error is as follows:

$$\eta = f(L) + 1.96 \cdot SE(f(L)) \qquad \textbf{(2)}$$

Where:

L	=	Load of the energy equipment
f(L)	=	Load-efficiency function of the energy equipment, determined through regression analysis, as described above.
SE(f(L))	=	Standard error of the result of the load-efficiency function '*f(L)*'

In case of a linear regression equation i.e. if n=1 in equation (3) above, the standard error can be determined as follows:

$$SE(f(L)) = \sigma \cdot \sqrt{\left(1 + \frac{1}{N_x} + \frac{(L_X - L)^2}{\sum_{x=1}^{N_x}(L_x - L)^2}\right)} \qquad \textbf{(3)}$$

with

$$\sigma = \frac{1}{N_x - 2} \cdot \sqrt{(1 - R^2) \cdot \left[\sum_{x=1}^{N_x}(\eta_x - \eta)^2\right]} \qquad \textbf{(4)}$$

and

$$L = \frac{\sum_{x=1}^{N_x} L_x}{N_x} \qquad \textbf{(5)}$$

and

$$R = \frac{b_1^2 \cdot \sum_{x=1}^{N_x} (L_x - L)}{\sum_{x=1}^{N_x} (\eta_x - \eta)} \qquad \textbf{(6)}$$

Where:

$SE(f(L_{xt}))$	=	Standard error of the result of the load-efficiency function '$f(EG_{PJ,t})$'
$f(L_x)$	=	Load-efficiency function of the equipment, determined through the regression analysis, as described below.
Σ	=	Standard error of regression equation
L_x	=	Load on the equipment during the time interval *t* (TJ)
L	=	Mean load on the equipment during the time length *T* of all measurements *x*
(η_x, L_x)	=	Pair of data recorded from measurement *x* at a defined load factor
η_x	=	Efficiency of the equipment at measurement *x*
η	=	Mean efficiency of the equipment of all measurements *x*
R	=	Adjusted R^2
x	=	Measurements undertaken at defined load factors
N_x	=	Number of measurements undertaken to establish the load-efficiency function
t	=	Discrete time interval of duration 'T' *hrs* for which the test is conducted.
T	=	Duration of discrete time intervals *t* (h)

Annex 2

Procedure to determine the power consumption function of chillers

The power consumption function is established, for each individual electrical compression chiller, prior to its replacement and should be based on measurements, as outlined below.

Two power output functions are required in the methodology:

(1) The power consumption function $PCF_{BL,elechill}(...)$ for the baseline electrical compression chillers.
(2) The power consumption function $PCF_{PJ,elechill,m}(...)$ for the project scenario electrical compression chillers.

The power consumption function (*PCF)* or baseline efficiency profile of chiller, is established under different chiller outputs (OUP_m), inlet temperatures of the condensing water ($T_{cond,in}$) and outlet temperatures of the chill water ($T_{cw,out}$) to reflect the representative range of year-round ambient temperature and humidity conditions. The power consumption function should be measured through the steps outlined below. The measurement results and the derivation of the power consumption function should be documented transparently in the CDM-PDD or the first monitoring report.

Step 1: Ensure chiller is maintained properly before experiment

Ensure that the chiller is filled with the correct quantity of refrigerant and the scaling in the condenser unit and evaporator unit is removed. In addition, preventive maintenance of the chiller should be done prior to carrying out the measurements.

Step 2: Define the operating conditions for which measurements are carried out

The measurements for the chiller should be carried out for the maximum range of variation of the chiller output (OUP_m), the inlet temperatures of the condensing water ($T_{cond,in}$) and the outlet temperatures of the chill water ($T_{cw,out}$). For this purpose, project participants should identify discrete operation points for which steady-state measurements are carried out. For example, if the chiller output (OUP_m) varies from 0 to 100 TR, discrete measurement points may cover chiller outputs of 20, 40, 60, 80 and 100 TR. The discrete measurement points should cover applicable combinations of the three parameters (OUP_m, $T_{cond,in}$ and $T_{cw,out}$).

Step 3: Install the necessary measurement equipment

Install the necessary measurement equipment to measure the following parameters:

- Power consumption of the chiller (*PC*);
- Inlet temperatures of the condensing water ($T_{cond,in}$);
- Outlet temperatures of the chill water ($T_{cw,out}$);
- Flow of the chill water (q).

The guidance provided in the monitoring methodology should be followed when measuring these parameters.

Step 4: Carry out measurements

Measure the parameters identified in step 3 for each discrete operation point identified in step 2, by operating the chiller at the discrete operating conditions. The discrete operating points can, *inter alia*, be generated by the following means:

- The chilled water flow may be varied with the help of a valve or variable speed drive or starting or stopping the number of pumps distributing the chilled water to consumers.
- The different inlet temperatures of the condensing water ($T_{cond,in}$) can be generated by installing a water conditioning device (including chiller/heater) at the inlet of the condenser unit to produce the desired cooling water temperature. This conditioning device may, inter alia, work on following principles:
    - Electric heaters (or hot water) and chilled water pipes are installed;
    - The device can also be a type of mixer, which can facilitate addition of small amount of chilled water in the inlet condensing water.

In the case that several chillers operate in parallel, having a common condensing water and/or chilled water circuit, isolating one chiller for the purpose of the experiment can influence the operation of other chillers. In such cases, either the chiller under experiment will require a separate water circuit or will have to be isolated from the other chillers for the time of experiment.

Step 5: Establish the power consumption function

Calculate the chiller output (*OUP*) in TR for each discrete operation point. Establish for each discrete operation point all four parameters (*PC*, *OUP*, $T_{cond,in}$ and $T_{cw,out}$) of the power consumption function in a table. An example is provided Table 3 below.

Table 3: Example of data collected to establish the power consumption function

Specific power consumption (*PC* in MW/TR)	Chiller output (OUP in TR)	Inlet temperature of the condenser water ($T_{cond,in}$ in °C)	Outlet temperature of the chill water ($T_{cw,out}$ in °C
0.00088	100	40 °C	6 °C
0.00078	100	40 °C	8 °C
0.00073	100	40 °C	10 °C
0.00070	100	40 °C	12 °C
0.00075	100	30 °C	6 °C
0.00073	100	30 °C	8 °C
0.00070	100	30 °C	10 °C
0.00066	100	30 °C	12 °C
0.00069	100	20 °C	6 °C

0.00066	100	20 °C	8 °C
0.00063	100	20 °C	10 °C
0.00062	100	20 °C	12 °C
0.00088	100	40 °C	6 °C
0.00080	100	40 °C	8 °C
	...	...	...

The power consumption function may be established by the following two ways:

- Use a look-up table, as the one provided in Table 3, as the power consumption function. To ensure a conservative approach, for each period *t* the more conservative should be selected if the monitored data operating parameters $(OUP_t, T_{cond,in,t}, T_{cw,out,t})$ are between the discrete operation points provided in the look-up table. For example: If the monitored chiller output is 90 TR, the inlet temperature of the condenser water is 35°C and the outlet temperature of the chill water is 7°C, the lowest value for the specific electricity consumption among the following eight data sets should be used:
    - $OUP = 100\ TR;\ T_{cond,in} = 40°C;\ T_{cw,out} = 6°C$
    - $OUP = 100\ TR;\ T_{cond,in} = 40°C;\ T_{cw,out} = 8°C$
    - $OUP = 100\ TR;\ T_{cond,in} = 30°C;\ T_{cw,out} = 6°C$
    - $OUP = 100\ TR;\ T_{cond,in} = 30°C;\ T_{cw,out} = 8°C$
    - $OUP = 80\ TR;\ T_{cond,in} = 40°C;\ T_{cw,out} = 6°C$
    - $OUP = 80\ TR;\ T_{cond,in} = 40°C;\ T_{cw,out} = 8°C$
    - $OUP = 80\ TR;\ T_{cond,in} = 30°C;\ T_{cw,out} = 6°C$
    - $OUP = 80\ TR;\ T_{cond,in} = 30°C;\ T_{cw,out} = 8°C$
- Develop a mathematical expression $(PCF = f(OUP_t, T_{cond,in,t}, T_{cw,out,t}))$ that correlates the three operating parameters, OUP_t, $T_{cond,in,t}$, $T_{cw,out,t}$, with the electricity consumption. In doing so, conservativeness should be ensured by requiring that the result of the function, when applied to the discrete operation points, is on average the same or lower than the specific electricity consumption measured.

- - - - -

History of the document

Version	Date	Nature of revision(s)
01	EB 45, Annex 3 13 February 2009	Initial adoption.