Draft amendment to the approved baseline and monitoring methodology AM0063

"Recovery of CO_2 from tail gas in industrial facilities to substitute the use of fossil fuels for production of CO_2"

I. SOURCE, DEFINITIONS AND APPLICABILITY

Sources

This methodology is based on NM0230 "Methodology for industrial tail gas CO_2 Recovery and Utilization" and its underlying project activity "Recovery and Utilization of CO_2 from Refinery Tail Gas". The baseline study and project design document were prepared by MGM International Ltd, for the underlying project activity "Recovery and Utilization of CO_2 from Refinery Tail Gas" lead by INDURA S.A. and ENAP Refinerías S.A., Chile.

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

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

For more information regarding the proposed new methodology and the tools as well as their consideration by the CDM Executive Board please refer to <https://cdm.unfccc.int/methodologies/PAmethodologies/approved.html>.

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:

Tail gas. A by-product of processes in industrial facilities. It is a mixture of gases including methane, carbon dioxide and other components and can be used as an energy source.

Intermediate gas. A gas produced during a chemical reaction which can be further processed to produce a product and/or by-product.

For example syngas (from synthesis gas) is an intermediate gas and is a gas mixture that contains varying amounts of CO and H2. An example of such a production method is steam reforming of natural gas or liquid hydrocarbons to produce hydrogen.

Off gas. An enriched gas generated by removing CO_2 from the tail gas or the intermediate gas.

Conventional CO_2 production process. A process in which fossil fuels are combusted and CO_2 is captured from the resulting flue gases. The energy generated from the combustion of fossil fuels is not used for purposes other than for the production of CO_2, i.e. no electricity is supplied to the grid or third parties and no heat is generated for production purposes other than CO_2 production. Both the combustion of fossil fuels and the capture processes take place at the same CO_2 production facility.

Integrated industrial facility. An industry which combines processes generally implemented at different locations functioning as a single unit e.g. a Hydrogen (H_2) plant combined with a CO_2 plant.

Applicability

The methodology is applicable to project activities that reduce emissions associated with conventional CO_2 production process by means of extracting CO_2 from the tail gas or the intermediate gas produced at an industrial facility.[1] The off gas, produced as a result of the extraction of CO_2 from the tail gas or the intermediate gas, is supplied back to the industrial facility where it is either utilized as fuel or flared.

The methodology is applicable to the following three cases:

Scenario 1: Use of the tail gas from an existing industrial facility for substitution of the combustion of fossil fuels at a specific existing conventional CO_2 production facility; or

Scenario 2: Use of the tail gas from an existing industrial facility in a new CO_2 production plant established as part of the project activity;

Scenario 3: Use of intermediate gas in a new production facility in a new CO_2 production plant established as part of the project activity.

The following conditions apply to scenarios 1 and 2:

- The tail gas from the industrial facility has been produced for as long as the industrial facility has been in operation;
- Prior to the implementation of the project activity, the tail gas has either been used as fuel in the industrial facility without extraction of the CO_2 or has been flared;
- There are no substantial changes (e.g. product change) in the industrial facility as a result of the project activity;
- If the tail gas was used as fuel prior to the start of the project activity, the off gas has to be used as fuel in the project activity and cannot be flared;
- There exist historical records of at least three years of data related to the operation of the industrial facility from which the tail gas is extracted;
- The project activity does not result in a significant change in the composition of the tail gas ($w_{carbon,TG}$), generated at the industrial facility, i.e. not more than ±5% variation is allowed when comparing the corresponding values before and after the start of the project activity;
- The total amount of CO_2 produced at the project facility has to be sold within the host country;

[1] For example, a refinery for production of hydrogen.

- The methodology is not applicable to project activities where CO_2 is produced for own consumption at the project facility (e.g. for manufacturing of chemicals).[2]

The following conditions apply to scenario 1:

- In order to ensure that the production of CO_2 is justified by a real demand in the market, the end use of the CO_2 is of the same kind (e.g. sale to the food industry) before and after the start of the project activity, which is to be cross checked through sales records;
- The existing conventional CO_2 production facility has an operating history of at least three years as well as three years historical data on the annual fossil fuel and electricity consumption and CO_2 production levels are available.

The following condition applies to scenario 2:

- At the minimum, data on existing CO_2 production facilities, their capacities and technologies used for CO_2 production in these facilities in the host country are available.

The following conditions apply to scenario 3:

- The industrial facility does not utilize CO_2 in the intermediate gas for any other purpose in the production process;[3]
- The methodology is not applicable to project activities where CO_2 is produced for own consumption at the project facility (e.g. for manufacturing of chemicals);
- None of the CO_2 produced should be exported to any Annex I country;
- Data on existing CO_2 production facilities, their capacities and technologies used for CO_2 production in the host country are available in order to determine the baseline.

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

Finally, the methodology is applicable to project activities where the baseline scenario as defined in "Identification of the baseline scenario" is a combination of:

(i) The alternative T3 or T4; or

(ii) The alternative I2; and

(iii) One of the alternatives C2, C3 or C5.

[2] Project participants wishing to produce CO_2 for consumption at a project chemical plant, may use the approved methodology AM0027 "Substitution of CO2 from fossil or mineral origin by CO2 from renewable sources in the production of inorganic compounds" or, if this is not applicable, propose a new methodology.

[3] An example is the production process of urea fertilizer, where CO_2 removed from synthesis gas of Ammonia plant is used in the production process of urea as a reactant.

II. BASELINE METHODOLOGY

Project boundary

As presented in Figure 1 below, the project boundary comprises:

- The CO_2 production facility, including storage equipment;
- The industrial facility where the tail gas or intermediate gas is generated and the returned off-gas is used;
- Blower and pipeline to transport the tail gas or intermediate gas from the industrial facility to the CO_2 production facility and to transport the off-gas back to the industrial facility.

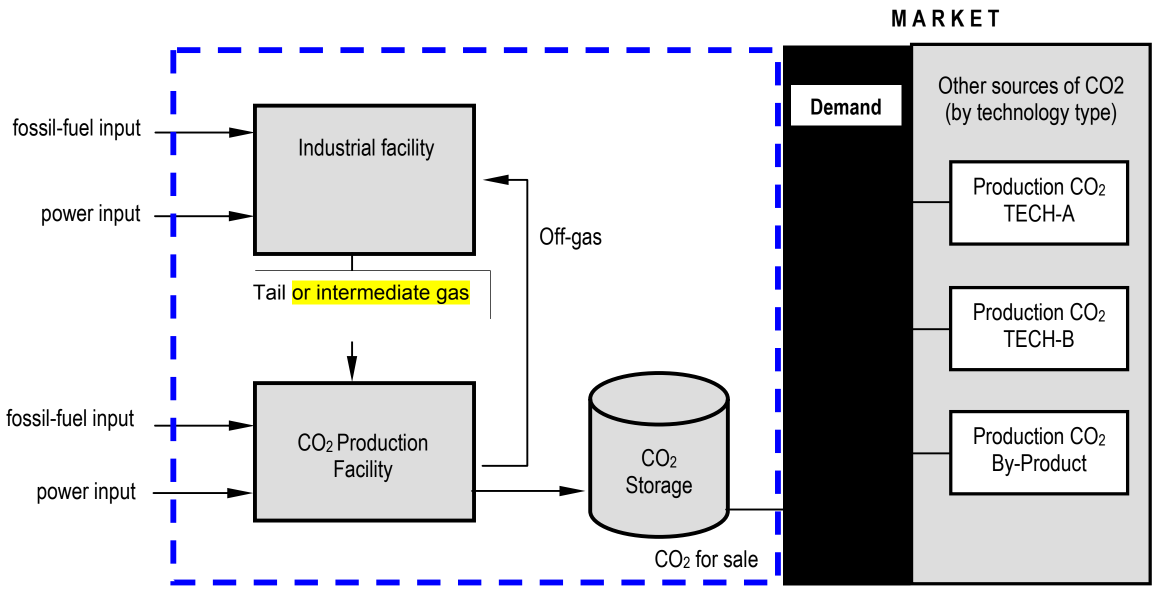

Figure 1: Illustration of the project boundary

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

	Source	Gas	Included?	Justification / Explanation
Baseline	Emissions from the combustion of the tail gas or intermediate gas in the industrial facility process units	CO_2	YES	Main source of emissions in the baseline
		CH_4	NO	It is assumed that all CH_4 is completely oxidized in the combustion process. This is conservative
		N_2O	NO	Assumed negligible
	Emissions from the fossil fuel used at the CO_2 production facility (i.e. existing or new)	CO_2	YES	Main source of emissions in the baseline
		CH_4	NO	Assumed negligible
		N_2O	NO	Assumed negligible
	Emissions from the electricity use at the CO_2 production facility (i.e. existing or new)	CO_2	YES	Main source of emissions in the baseline
		CH_4	NO	Assumed negligible
		N_2O	NO	Assumed negligible
Project Activity	Emissions from the combustion of the off gas in the industrial facility process units	CO_2	YES	Main source of emissions in the project activity
		CH_4	NO	It is assumed that all CH_4 is completely oxidized in the combustion process
		N_2O	NO	Assumed negligible
	Emissions from energy used at the industrial facility to transport the tail gas or the intermediate gas	CO_2	NO	Assumed negligible
		CH_4	NO	Assumed negligible
		N_2O	NO	Assumed negligible
	Fugitive emissions from the tail gas or the intermediate gas transport	CO_2	NO	Fugitive emissions may occur at the installation used to transport tail gas due to CO_2 content. Assumed negligible
		CH_4	NO	Fugitive emissions may occur at the installation used to transport tail gas or intermediate gas due to CH_4 content. Assumed negligible
		N_2O	NO	Assumed negligible
	Fugitive emissions from off gas transport	CO_2	NO	Fugitive emissions may occur at the installation used to transport off gas due to residual CO_2 content after recovery. Assumed negligible
		CH_4	NO	Fugitive emissions may occur at the installation used to transport off gas due to CH_4 content in off gas. Assumed negligible
		N_2O	NO	Assumed negligible
	Fugitive emissions from pipeline accidental events	CO_2	NO	CO_2 fugitive emissions may occur as a result of an accidental event in one or both of the tail gas/intermediate gas/off gas transportation installations. Assumed negligible

	Source	Gas	Included?	Justification / Explanation
Baseline	Emissions from the combustion of the tail gas or intermediate gas in the industrial facility process units	CO_2	YES	Main source of emissions in the baseline
		CH_4	NO	It is assumed that all CH_4 is completely oxidized in the combustion process. This is conservative
		N_2O	NO	Assumed negligible
	Emissions from the fossil fuel used at the CO_2 production facility (i.e. existing or new)	CO_2	YES	Main source of emissions in the baseline
		CH_4	NO	Assumed negligible
		N_2O	NO	Assumed negligible
	Emissions from the electricity use at the CO_2 production facility (i.e. existing or new)	CO_2	YES	Main source of emissions in the baseline
		CH_4	NO	Assumed negligible
		N_2O	NO	Assumed negligible
		CH_4	NO	CH_4 fugitive emissions may occur as a result of an accidental event in one or both of the tail gas/intermediate gas/off gas transportation installations. Assumed negligible
		N_2O	NO	Assumed negligible
	Fugitive emissions at the CO_2 production facility	CO_2	NO	CO_2 fugitive emissions may occur as a result of tail gas, intermediate gas, off gas or product venting or leaks at the CO_2 production facility. Assumed negligible
		CH_4	NO	CH_4 fugitive emissions may occur as a result of tail gas, intermediate gas, off gas or product venting or leaks at the CO_2 production facility. Assumed negligible
		N_2O	NO	Assumed negligible
	Emissions from energy used at the CO_2 production facility	CO_2	YES	Main source of emissions
		CH_4	NO	Assumed negligible
		N_2O	NO	Assumed negligible

Procedure for estimating the remaining lifetime of the existing conventional CO_2 production facility

This step is applicable if scenario 1 corresponds to the project activity. The remaining lifetime of the existing conventional CO_2 production facility should be determined, i.e. the time when the existing conventional CO_2 production facility would have been replaced in the absence of the project activity. For this purpose, the typical average technical lifetime of other conventional CO_2 production facilities may be determined on the basis of common practices in the sector (e.g. based on industry surveys, statistics, technical literature, etc.). The time of replacement of the existing conventional CO_2 production facility in the absence of the project activity should be chosen in a conservative manner, i.e. the earliest point in time should be chosen in cases where only a time frame can be estimated.

Identification of the baseline scenario

Project participants shall apply the following steps to identify the baseline scenario:

Step 1a: Identify plausible alternative scenarios

Under Step 1a project participants shall identify realistic and credible alternatives to both project components. Alternatives should be separately determined regarding:

- What would happen to the tail gas or intermediate gas from the industrial facility in the absence of the project activity; and
- How the CO_2 produced in the project activity would have been produced in the absence of the project activity.

(i) Plausible alternative scenarios for the use of the tail gas in the industrial facility may include, but are not limited to, the following:

T1: The implementation of the proposed project activity, i.e. enrichment of the tail gas (purification of the tail gas and separation of CO_2) for energy purposes, without being registered as a CDM project activity;

T2: Other uses of the tail gas (i.e. as feedstock);

T3: Continuation of the current practice, if applicable, of the use of the tail gas as fuel without separation of CO_2;

T4: Continuation of the current practice, if applicable, of flaring of the tail gas without separation of CO_2.

(ii) Plausible alternative scenario for the use of intermediate gas in the new industrial facility may include:

I1: The proposed project activity (i.e. extraction of CO_2 from the intermediate gas of industrial facility) implemented without being registered as a CDM project activity;

I2: CO_2 in the intermediate gas is used for other uses, than that in the project activity;

I3: Intermediate gas is used for other uses than that in the project activity;

I4: The integrated facility would produce the final product without separation of CO_2 from the intermediate gas.

(iii) Plausible alternative scenarios for the production of CO_2 may include, but are not limited to, the following:

C1: The proposed projet activity (i.e. extraction of CO_2 from the industrial facility tail/intermediate gas) implemented without being registered as a CDM project activity;

C2: The production of CO_2 at a specific existing conventional CO_2 production plant, on-site or off-site;

C3: The construction of a specific new conventional CO_2 production plant, on-site or off-site;

C4: The construction of a specific new non-conventional[4] CO_2 production plant, on-site or off-site; ~~CO_2 production facility, on-site or off-site, using other CO_2 sources than fossil fuels (e.g. by-product of sodium phosphate or ammonia manufacture, processing of biomass, cement production, extraction of CO_2 from natural wells, etc.).~~

C5: The production of CO_2 in existing and/or new CO_2 production plants at other sites;

C6: The production of CO_2 at an existing CO_2 production plant with fossil fuels where the energy generated from fossil fuel combustion is (partly) utilized for purposes other than the production of CO_2;

C7: The construction of a specific new CO_2 production facility, on-site or off-site, in which the CO_2 is generated from fossil fuel combustion but in which the energy generated from fossil fuel combustion is (partly) utilized for purposes other than the production of CO_2 (e.g. electricity exports to the grid, steam generation for other purposes than CO_2 production).

Note: Scenarios C3, C4~~, C6~~ and C7 shall only be included as plausible options if documented evidence is provided to demonstrate a growing demand for commercial CO_2 in the host country, where the project activity will be implemented.[5]

The suggested list of alternatives is only indicative. Project participants may propose other plausible alternatives and/or eliminate some of the listed above, based on documented evidence.

For the purpose of identifying plausible alternative scenarios, provide an overview of the market of the commercial CO_2 production, including the availability of and trends in introduction of new technologies. Provide relevant documentation to support the results of the analysis.

Outcome of Step 1a: List of plausible alternative scenarios to the project activity.

Step 1b: Consistency with applicable laws and regulations

The alternative(s) shall be in compliance with all mandatory applicable legal and regulatory requirements, even if these laws and regulations have objectives other than GHG reductions (this sub-step does not consider national and local policies that do not have legally-binding status).

If an alternative does not comply with all mandatory applicable legislation and regulations, then show that, based on an examination of current practice in the country or region in which the mandatory law or regulation applies, those applicable mandatory legal or regulatory requirements are systematically not enforced and that non-compliance with those requirements is widespread in the country. If this cannot be shown, then eliminate the alternative from further consideration.

Outcome of Step 1b: List of alternative scenarios to the project activity that are in compliance with mandatory legislation and regulations taking into account the enforcement in the region or country and EB decisions on national and/or sectoral policies and regulations.

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[4] Non-conventional CO_2 production plant is a plant that uses other CO_2 sources than fossil fuels (e.g. by-product of sodium phosphate or ammonia manufacture, processing of biomass, cement production, extraction of CO_2 from natural wells, etc.)

[5] If there is no growth in demand a new facility is expected to displace an existing facility. The present methodology does not include any procedures to identify the displaced facility and accordingly estimate the baseline emissions.

Step 2: Eliminate alternatives that face prohibitive barriers

Scenarios that face prohibitive barriers should be eliminated by applying "Step 2 - Barrier analysis" of the latest version of the "Combined tool to identify the baseline scenario and demonstrate additionality" agreed by the CDM Executive Board.

If there is only one alternative scenario that is not prevented by any barrier, and if this alternative is not the proposed project activity undertaken without being registered as a CDM project activity, then this alternative scenario is identified as the baseline scenario.

If there are still several alternative scenarios remaining project participants may choose to either:

- Option 1: go to Step 3 (investment analysis); or
- Option 2: identify the alternative with the lowest emissions (i.e. the most conservative) as the baseline scenario.

Step 3: Comparison of economic attractiveness of the remaining alternatives

Compare the economic attractiveness without revenues from CERs for remaining alternatives by applying "Step 3 - Investment analysis" of the latest approved version of the "Combined tool to identify the baseline scenario and demonstrate additionality" and following the latest Guidelines on the assessment of investment analysis.

The investment comparison analysis shall be applied, using the net present value (NPV) or IRR as indicator, and explicitly stating the following parameters:

- Investment requirements for each alternative scenario (including break-up into major equipment costs, installation, required R&D activities and construction costs);
- A discount rate appropriate to the country and sector (use government bond rates, increased by a suitable risk premium to reflect private investment in fuel switching projects, as substantiated by an independent (financial) expert);
- Current price and expected future price of raw materials, fuels and electricity used as well as the market price of CO_2 and, if applicable, any other products. (As a default, the current prices may be assumed as future prices. Where project participants intend to use future prices that are different from current prices, the future prices have to be substantiated by a public and official publication from a governmental body or an intergovernmental institution);
- Operation and maintenance costs for each alternative scenario, including cost changes at the industrial facility and the CO_2 production facility;
- Any economic benefits at the industrial facility from using the off-gas instead of the tail gas.

The information on all the above factors as well as assumptions shall be explicitly stated in the CDM-PDD.

Outcome of Step 3: Ranking of the short list of alternative scenarios according to their NPV (or IRR) taking into account the results of the sensitivity analysis.

- If the sensitivity analysis is not conclusive, identify the alternative with the lowest emissions (i.e. the most conservative) as the baseline scenario;
- If the sensitivity analysis is conclusive and confirms the result of the investment comparison analysis, then the most economically or financially attractive alternative scenario is considered as baseline scenario.

The methodology is only applicable if a combination of the alternative T3 or T4 or I4 with the alternative C2, C3 or C5 represents the most likely baseline scenario.

Additionality

For Scenario 3 of applicability condition, investment analysis should be applied to demonstrate additionality. The sale price used for the carbon dioxide gas should be justified and its appropriateness should be demonstrated for the type of market supplied by the project proponent. Any other benefits that may result from implementing the project activity to the industrial facility should be identified and quantified where possible and taken into account when applying the investment analysis.

The steps described below may be used to assess additionality. Alternatively, project participants may use the latest approved version of the "Tool for the demonstration and assessment of additionality", applying the additional guidance provided above under "Identification of the baseline scenario".

Step 1: Analysis of outcome of baseline scenario identification procedure

If the proposed project activity is the only alternative amongst the ones considered by the project participants that is in compliance with all mandatory regulations, as identified by applying Step 1 of the baseline scenario identification procedure described in the section above, with which there is general compliance, then the proposed CDM project activity is not additional.

If the barrier analysis is used to identify the baseline scenario, as described in the previous section, then:

(a) If there is only one alternative scenario that is not prevented by any barrier, and if this alternative is the proposed project activity undertaken without being registered as a CDM project activity, then the project activity is not additional;

(b) If the implementation of the proposed project activity without being registered as a CDM project activity is prevented by any barrier, then explain – using qualitative or quantitative arguments – how the registration of the CDM project activity will alleviate the barriers that prevent the proposed project activity from occurring in the absence of the CDM. If the CDM alleviates the identified barriers that prevent the proposed project activity from occurring, proceed to common practice analysis step, otherwise the project activity is not additional.

If the investment analysis step is used to identify the baseline scenario, and if the proposed project activity undertaken without being registered as a CDM project activity is not prevented by any barrier, then:

(a) If the sensitivity analysis confirms the result of the investment comparison analysis, and it cannot be ruled out that the most economically or financially attractive alternative scenario is the "proposed project activity undertaken without being registered as a CDM project activity", then the project activity is not additional;

(b) Otherwise, proceed to common practice analysis step.

Step 2: Common practice analysis

Demonstrate that the project activity is not a common practice in the country and sector by applying Step 4 of the latest version of the "Tool for the demonstration and assessment of additionality" as agreed by the CDM Executive Board.

Baseline emissions

Baseline emissions are calculated as follows:

$$BE_y = BE_{CO2,y} + BE_{IND,y} \quad (1)$$

Where:

BE_y	Baseline emissions during the year y, (tCO_2e~~/year~~)
$BE_{CO2,y}$	Baseline emissions from the production of CO_2 in year y, (tCO_2e~~/year~~)
$BE_{IND,y}$	Baseline emissions from the combustion of the tail gas or intermediate gas at the industrial facility in year y, (tCO_2~~/year~~)
y	Year of the crediting period

<u>Baseline emissions from the production of CO_2</u>

The method of calculation of the baseline emissions from this source depends on whether C2, C3 or C5 has been identified as the baseline scenario.

<u>Baseline scenario C2</u>

Two different cases may apply when the project CO_2 production facility displaces the production of CO_2 in a specific existing conventional CO_2 production plant:

Case A: The existing conventional CO_2 production plant continues to operate after the start of the project activity, but produces less CO_2. In this case, emission reductions from the displacement of CO_2 production in the existing CO_2 production plant can only be claimed to the extent to which the existing plant produces less CO_2.

Case B: The existing conventional CO_2 production plant ceases its operation with the start of the project activity. In this case, the remaining lifetime of the replaced plant has to be determined as specified above and emission reductions can only be claimed against the shortest period between the remaining lifetime and the chosen crediting period.

In both cases, the level of historical CO_2 production in the existing plant before the start of the project activity ($P_{CO2,BL,x}$) has to be determined and documented in the CDM-PDD.

Baseline emissions from the production of CO_2 are calculated based on a baseline emission index ($BEI_{CO2,BL}$), which expresses the historical GHG emissions of the existing CO_2 production facility per quantity of CO_2 produced, and the quantity of CO_2 that would be produced in the existing CO_2 production facility, as follows:

$$BE_{C02,y} = BEI_{CO2,BL} * \min\{P_{CO2,MAX,y}; P_{CO2,PJ,y} \quad (2)$$

Where:

$BE_{C02,y}$	Baseline emissions in year y, ($t\ CO_2e$~~/year~~)
$BEI_{CO2,BL}$	Baseline emission index from energy use in the existing conventional CO_2 production facility, ($t\ CO_2e/t\ CO_2$)

$P_{CO2,PJ,y}$	Quantity of CO_2 produced at the project CO_2 production facility in year y[6], (tCO_2/year)
$P_{CO2,MAX,y}$	Maximum annual quantity of CO_2 production that is eligible for crediting in year y (tCO_2~~/year~~)

The maximum annual quantity of CO_2 production that is eligible for crediting depends on whether case A or case B applies:

- If case A applies, $P_{CO2,MAX,y}$ is calculated as the difference between the highest historical annual CO_2 production in the existing CO_2 production plant during the most recent three historical years prior to the implementation of the project activity and the annual CO_2 production in the existing CO_2 production plant in year y, as follows:

$$P_{CO2,MAX,y} = \max\{P_{CO2,x}; P_{CO2,x-1;} P_{CO2,x-2}\} - P_{CO2,exist\ plant,y} \quad \textbf{(3)}$$

Where:

$P_{CO2,MAX,y}$	Maximum annual quantity of CO_2 production that is eligible for crediting in year y (tCO_2~~/yr~~)
$P_{CO2,x/x-1/x-2}$	Quantity of CO_2 produced in the existing conventional CO_2 production facility in year $x/x-1/x-2$ (tCO_2~~/yr~~)
$P_{CO2,exist\ plant,y}$	Quantity of CO_2 produced in the existing conventional CO_2 production facility in year y (tCO_2~~/yr~~)
x	Year preceding the start of the project activity
y	Year of the crediting period

- If case B applies, $P_{CO2,MAX,y}$ corresponds to the highest historical annual CO_2 production in the existing CO_2 production plant during the most recent three historical years prior to the implementation of the project activity.

The baseline emission index is calculated as follows:

$$BEI_{CO2,BL} = \frac{BE_{CO2,BL,x}}{P_{CO2,BL,x}} \quad \textbf{(4)}$$

Where:

$BE_{CO2,BL,x}$	Emissions from production of CO_2 at the existing CO_2 production facility during the historical period x (tCO_2), as estimated in equation 5 below
$P_{CO2,BL,x}$	Amount of CO_2 produced at the existing CO_2 production facility during the historical period x, (tCO_2)
x	Period immediately preceding the start of the implementation of the project activity[7]

[6] *Ex ante* estimation of the emission reductions shall be based on prospected levels of CO_2 production at the project CO_2 production facility. In calculating emission reductions for any given year y during the implementation of the project activity, only *ex post* approach, i.e. the monitored quantity of CO_2 produced at the project CO_2 production facility in year y, shall be used.

[7] It is required to use a period comprising enough data to fully represent a regular CO_2 production facility operation (a minimum of three year period is required).

The emissions during the period *x* are estimated on the basis of the total energy requirements (i.e. electricity and fossil fuel consumption) at the existing conventional CO_2 production facility minus the amount of CO_2 produced at this facility during the period *x*. The total energy requirements of the existing facility include both the energy used for generation of CO_2 and the energy used for processing of CO_2.

$$BE_{CO2,BL,x} = EC_{CO2,BL,grid,x} * EF_{CO2,grid,x} + \sum FC_{CO2,BL,i,x} * NCV_{i,x} * EF_{CO2,i,x} - P_{CO2,BL,x} \quad (5)$$

Where:

$EC_{CO2,BL,grid,x}$	Electricity consumption from the grid at the existing conventional CO_2 production facility during the period *x* for generation and processing of CO_2, (MWh)
$EF_{CO2,grid,x}$	Grid emission factor, (tCO_2/MWh). Calculated using the latest approved version of the "Tool to calculate the emission factor for an electricity system"
$FC_{CO2,BL,i,x}$	Quantity of fossil fuel type *i* combusted at the specific existing conventional CO_2 production facility during the period *x* for generation and processing of CO_2, (mass or volume unit)
$EF_{CO2,i,x}$	Emission factor of fossil fuel type *i* during period *x*, (tCO_2/TJ)
$NCV_{i,x}$	Net calorific value of fossil fuel type *i* in the period *x* (TJ/ mass or volume unit)
i	All fossil fuels used at the conventional CO_2 production facility during the period *x*
x	Period immediately preceding the start of the implementation of the project activity[8]

Baseline scenario C3 or C5

In this case, the project facility displaces production of CO_2 from a specific new conventional CO_2 production plant (C3) or from several existing or new CO_2 production plants (C5) that would have been constructed in the absence of the project activity to meet the growing demand of the national or regional market.

Baseline emissions are calculated based on the quantity of CO_2 produced at the project CO_2 production facility and a benchmark emission index related which expresses the GHG intensity of CO_2 production in other CO_2 production facilities, as follows:

$$BE_{CO2,y} = BEI_{CO2,BL,BENCH} * P_{CO2,PJ,y} \quad (6)$$

Where:

$BE_{CO2,y}$	Baseline emissions associated with the production of CO_2 in the absence of the project activity in year *y*, (t CO_2e~~/year~~)
$BEI_{CO2,BL,BENCH}$	Benchmark emission index for the production of CO_2, (t CO_2e/t CO_2)
$P_{CO2,PJ,y}$	Quantity of CO_2 produced at the project CO_2 production facility in year *y*,[9] (tCO_2~~/year~~)

8 It is required to use a period comprising enough data to fully represent a regular CO_2 production facility operation (a minimum of three year period is required).

9 *Ex ante* estimation of the emission reductions shall be based on prospected levels of CO_2 production at the project CO_2 production facility. In calculating emission reductions for any given year *y* during the implementation of the project activity, only *ex post* approach, i.e. the monitored quantity of CO_2 produced at the project CO_2 production facility in year *y*, shall be used.

The baseline emission index ($BEI_{CO2,BL,BENCH}$) is established based on the GHG emission intensity of CO_2 production in other plants that have been constructed during the most recent 10 years prior to the start of the project activity. The following steps shall be performed to determine $BEI_{CO2,BL,BENCH}$:

Step 1: Selection of the geographical area and identification of all CO_2 production plants n in that area

The geographical area should be chosen in a manner that it include at least five facilities that produce CO_2 for commercial use[10] and that have been constructed during the most recent 10 years prior to the start of the project activity. These facilities include both conventional CO_2 production plants and CO_2 production plants using other available technologies (e.g. CO_2 production as by-product in ammonia and hydrogen plants, fermentation, thermal decomposition of CaCO3, sodium phosphate manufacture, capture of CO_2 directly from natural carbon dioxide gas wells). The host country may be used as a default geographical area. If there are less than five plants in the host country that have been constructed during the most recent 10 years prior to the start of the project activity, the geographical area should be extended to all neighboring countries. These plants *(n)* constitute the sample group for the calculation of the benchmark emission index.

Collect and document in the CDM-PDD for each plant *n* the necessary data to determine the emission index. This includes data on the quantities and types of fossil fuels used, the quantity of electricity consumed and the quantity of CO_2 produced during the most recent year for which data are available. In case of conventional CO_2 production plants, this refers to the overall electricity and fuel consumption in the plant. In case of other CO_2 production plants, this refers to the quantity of fossil fuels and electricity needed to capture and process the CO_2.

Step 2: Calculation of the benchmark emission index

The benchmark emission index is calculated as follows:

$$BEI_{CO2,BL,BENCH} = \sum_{n} BEI_{CO2,BL,n} * w_{n,z} \quad \textbf{(7)}$$

Where:

$BEI_{CO2,BL,n}$	Baseline emission index of plant *n* (t CO_2e/t CO_2)
$w_{n,z}$	Share of CO_2 production of the plant *n* in year *z* as a fraction total CO_2 production of all plants identified in step 1 to estimate the benchmark
n	CO_2 production plants identified in Step 1
z	Year prior to the start of the project activity or the most recent year for which data are available

$$w_{n,z} = \frac{P_{CO2,n,z}}{\sum_{n} P_{CO2,n,z}} \quad \textbf{(7a)}$$

Where:

$P_{CO2,n,z}$	Quantity of CO_2 produced at the plant *n* in the year *z* (t CO_2~~/year~~)

[10] Exclude facilities that produce CO_2 for their own use only (e.g. breweries) without selling CO_2 at the market

The baseline emission index for the plant *n* is calculated as follows:

$$BEI_{CO2,BL,n} = \frac{BE_{CO2,BL,n,z}}{P_{CO2,n,z}} \qquad \textbf{(8)}$$

Where:

$BE_{CO2,BL,n,z}$	Emissions relating to CO_2 production at the plant *n* in year *z* (t CO_2~~/year~~)

The calculation of emissions relating to CO_2 production at each plant *n* depends on the type of plant:

(a) If *n* corresponds to a conventional CO_2 production plant:

$$BE_{CO2,BL,n,z} = EC_{CO2,grid,n,z} * EF_{CO2,grid,z} + \sum_i FC_{CO2,i,n,z} * NCV_{i,z} * EF_{CO2,i,n,z} - P_{CO2,n,z} \qquad \textbf{(9)}$$

Where:

$EC_{CO2,grid,n,z}$	Electricity consumption from the grid in the conventional CO_2 production plant *n* in year *z* for generation, extraction and processing of CO_2 (MWh)
$EF_{CO2,grid,z}$	Grid emission factor for the electricity used at the CO_2 production facility *n* in year *z* (tCO_2/MWh). Calculated in accordance with the latest approved version of the "Tool to calculate the emission factor for an electricity system"
$FC_{CO2,i,n,z}$	Quantity of fossil fuel type *i* combusted in the CO_2 production plant *n* in year *z* for generation, extraction and processing of CO_2 (t)
$EF_{CO2,i,n,z}$	Emission factor of fossil fuel type *i* at the CO_2 production facility *n* in year *z* (tCO_2/TJ)
$NCV_{i,z}$	Net calorific value of fossil fuel type *i* in year *z* (TJ/t)
$P_{CO2,n,z}$	Quantity of CO_2 produced at the plant *n* in year *z* (t CO_2~~/year~~)
i	All fossil fuels used in the CO_2 production plant *n* in year *z*

<u>Note</u>: If plant specific data on the electricity and fossil fuel consumption are not available, the project participants may use Annex I manufacturer's specifications for a modern conventional CO_2 production plant to estimate $BEI_{CO2,BL,n}$.

(b) If *n* corresponds to a CO_2 production facility using other technology than conventional CO_2 production processes:

$$\mathrm{BE_{CO2,BL,n,z} = EC_{CO2,grid,n,z} \cdot EF_{CO2,grid,z} + EC_{CO2,capt,n,z} \cdot EF_{CO2,capt,n,z} + \sum_i FC_{CO2,i,n,z} \cdot NCV_{i,z} \cdot EF_{CO2,i,n,z}} \qquad \textbf{(10)}$$

$$EF_{CO2,capt,n,z} = \frac{EF_{CO2,i,n,z}}{Eff_{capt,n,z}} \times \frac{3.6}{1000} \qquad \textbf{(10a)}$$

Where:

$EC_{CO2,grid,n,z}$	Electricity from the grid used in the plant *n* for extraction and processing of CO_2 in the year *z* (MWh). Electricity consumption in the process where CO_2 is generated as by-product is not included
$EF_{CO2,\ grid,n,z}$	Grid emission factor for the electricity used at the CO_2 production facility *n* in the year *z* (tCO_2/MWh). Calculated in accordance with the latest approved version of the "Tool to calculate the emission factor for an electricity system"
$EC_{CO2,capt,n,z}$	Electricity from a captive power plant used in the plant *n* for extraction and processing of CO_2 in the year *z* (MWh). Electricity consumption in the process where CO_2 is generated as by-product is not included.
$EF_{CO2,\ capt,n,z}$	Emission factor for the captive electricity generation at the CO_2 production facility *n* in the year *z* (tCO_2/MWh).
$Eff_{capt,n,z}$	Efficiency of the captive power generation plant in the CO_2 production facility *n* in the year *z* (%)
$FC_{CO2,\ i,n,z}$	Quantity of fossil fuel type *i* used in the plant *n* for extraction and processing of CO_2 in the year *z* (t). Fossil fuel consumption in the process where CO_2 is generated as by-product is not included.
$EF_{CO2,i,n,z}$	CO_2 emission factor of fossil fuel type *i* in the year *z* (tCO_2/TJ)
$NCV_{i,z}$	Net calorific value of fossil fuel type *i* in year *z* (TJ/t)
i	All fossil fuels used in the plant *n* for extraction and processing of CO_2 in the year *z*

Note: If plant specific data on the electricity and fossil fuel consumption are not available, the project participants may use documented Annex I manufacturer's specifications for a modern CO_2 production plant, using corresponding technology, to estimate $BEI_{CO2,BL,n.}$ In the case where manufacturer's specifications are not available for a CO_2 production plant, using a technology other than fossil fuel combustion without energy generation, the project participants must apply $BEI_{CO2,BL,n}$=0 as a conservative assumption.

Note: As the Step 1 above requires that if there are less than five plants in the host country that have been constructed during the most recent 10 years prior to the start of the project activity, the geographical area should be extended to all neighboring countries. If the data to calculate the emission factor of the plants identified outside the host country is not available, the benchmark emission index ($BEI_{CO2,BL,BENCH}$) should be calculated as the minimum between the emission index of the existing production facilities in the country (to be calculated using the procedure in Step 2 above) and a conservative estimate of emission index based on: (i) CO_2 manufacturer's specification for a Greenfield CO_2 production plant; and/or (ii) the industry standard for CO_2 production plants of similar capacity.

Baseline emissions from the combustion of the tail gas at the industrial facility

In calculating baseline emissions from combustion of the tail gas at the industrial facility, it is assumed that all carbon in the tail gas (i.e. in methane and other gases including other hydrocarbons, CO, and CO_2) is completely oxidized to carbon dioxide and that all flue gases are released into the atmosphere.

$$\cancel{BE_{IND,y} = \min\{V_{TG,y}, V_{TG,hist}\} \cdot w_{carbon,TG,y} \cdot 44/12} \qquad \textbf{\cancel{(11)}}$$

$$BE_{IND,y} = \min\{V_{TG,y}, V_{TG,x}\} \cdot w_{carbon,TG,y} \cdot 44/12 \qquad \textbf{(11)}$$

Where:

$BE_{IND,y}$	Baseline emissions from combustion of the tail gas in the year y (t CO_2e~~/year~~)
$V_{TG,y}$	Volume of the tail gas utilized in year y, i.e. volume of the tail gas delivered to the project CO_2 production facility for extraction of CO_2 (m^3)
$V_{TG,\cancel{hist},x}$	Average annual volume of the tail gas generated in the period x (m^3)
$w_{carbon,TG,y}$	Average carbon content of the tail gas in the year y, (tC/m^3)
$^{44}/_{12}$	Weight conversion factor to provide for fully oxidized carbon content in the tail gas, (tCO_2/tC)
x	Period immediately preceding the start of the implementation of the project activity[11]

All data used to establish the baseline emission index should be documented transparently in the CDM-PDD. The calculation should be documented in a manner that it can be reproduced.

Baseline emissions from the intermediate gas at the integrated facility

In calculating baseline emissions from the intermediate gas at the integrated facility, it is assumed that all carbon in the intermediate gas (i.e. in methane and other gases including other hydrocarbons, CO and CO_2) is completely oxidized to carbon dioxide and that all flue gas is released into the atmosphere.

$$BE_{IND,y} = V_{IG,y} \cdot w_{carbon,IG,y} \cdot 44/12 \qquad \textbf{(12)}$$

Where:

$BE_{IND,y}$	Baseline emissions from the intermediate gas in the year y (t CO_2e)
$V_{IG,y}$	Volume of intermediate gas utilized in year y, i.e. volume of the intermediate gas delivered to the project CO_2 production facility for extraction of CO_2 (m^3)
$w_{carbon,IG,y}$	Average carbon content of the intermediate gas in the year y, (tC/m^3)
44/12	Weight conversion factor to provide for fully oxidized carbon content in the intermediate gas, (tCO_2/tC)

All data used to establish the baseline emission index should be documented transparently in the CDM-PDD. The calculation should be documented in a manner that it can be reproduced.

Project emissions

Emissions of greenhouse gases related to the operation of the project activity will include the following:

- Combustion or flaring of the off gas at the industrial facility. After the tail/intermediate gas is treated at the project CO_2 production facility, the off gas is sent back to the industrial facility for fuelling purposes or flaring;
- Energy requirements at the industrial facility. Electricity consumption (i.e. self generated or grid imported) for tail gas transportation and other services provided to the project CO_2 production facility;
- Energy requirements (i.e. electricity and heat) at the project CO_2 production facility for processing of CO_2.

[11] It is required to use a period comprising enough data to fully represent a regular CO_2 production facility operation (a minimum of three year period is required).

Project emissions are calculated as follows:

$$PE_y = PE_{IND,y} + PE_{CO2NEW,y} \quad \textbf{(13)}$$

Where:

PE_y	Project emissions during year *y*, (tCO_2e~~/year~~)
$PE_{IND,y}$	Project emissions at the industrial facility during year *y*, (tCO_2e~~/year~~)
$PE_{CO2NEW,y}$	Project emissions at the project CO_2 production facility during year *y*, (tCO_2e)

Project emissions at the industrial facility

$$PE_{IND,y} = PE_{IND,OG,y} + PE_{IND,ELEC,y} \quad \textbf{(14)}$$

Where:

$PE_{IND,OG,y}$	Project emissions from the combustion of the off gas during year *y*, (tCO_2e~~/year~~)
$PE_{IND,ELEC,y}$	Project emissions from the electricity consumption at the industrial facility for the transportation of tail/intermediate gas and other services provided to the project CO_2 production facility during year *y*, (tCO_2e). This may include electricity generated by a captive plant(s) at the industrial facility and/or electricity imported from the grid by the industrial facility

Project emissions from the combustion of the off gas in case of intermediate gas used at an integrated facility or in the case when the tail gas was flared in the baseline scenario:

$$PE_{IND,OG,y} = V_{OG,y} \cdot w_{carbon,OG,y} \cdot 44/12 \quad \textbf{(15)}$$

Where:

$V_{OG,y}$	Volume of off gas combusted at the industrial facility during year *y*, (m^3)
$w_{carbon,OG,y}$	Average carbon content of off gas in year *y*, (tC/m^3)
$44/12$	Weight conversion factor to provide for fully oxidized carbon content in off gas, (tCO_2/tC)

Project emissions from the combustion of the off gas in the case when the tail gas was used for energy generation in the baseline scenario are calculated as follows:

$$\cancel{\text{If } V_{OG,y} * NCV_{OG,y} < V_{TG,hist} * NCV_{TG,hist}}$$

$$\text{If } V_{OG,y} * NCV_{OG,y} < V_{TG,x} * NCV_{TG,x}$$

$$\cancel{PE_{IND,OG,y} = V_{OG,y} * w_{carbon,OG,y} * 44/12 + (V_{TG,hist} * NCV_{TG,hist} - V_{OG,y} * NCV_{OG,y}) * EF_{coal,y}} \quad \cancel{\textbf{(16)}}$$

$$PE_{IND,OG,y} = V_{OG,y} * w_{carbon,OG,y} * 44/12 + (V_{TG,x} * NCV_{TG,x} - V_{OG,y} * NCV_{OG,y}) * EF_{coal,y} \quad \textbf{(16)}$$

Where:

$V_{OG,y}$	Volume of off gas combusted at the industrial facility during year y, (m^3)
$NCV_{OG,y}$	Net calorific value of off gas in year y, (GJ/m^3)
~~$V_{TG,hist}$~~ $V_{TG,x}$	Average annual volume of the tail gas generated in the period x, (m^3)
~~$NCV_{TG,hist,}$~~ $NCV_{TG,x}$	Average net calorific value of tail gas in the period x, (GJ/m^3)
$w_{carbon,OG,y}$	Average carbon content of off gas in year y, (tC/m^3)
$44/12$	Weight conversion factor to provide for fully oxidized carbon content in off gas, (tCO_2/tC)
$EF_{coal,y}$	CO_2 emission factor of coal in year y, ($tCO2e/GJ$)
x	Period immediately preceding the start of the implementation of the project activity[12]

As a conservative simplification, it is assumed that the efficiency of energy generating unit using tail/off gas is the same as the efficiency of the unit using coal.

~~If $V_{OG,y} * NCV_{OG,y} \geq V_{TG,hist} * NCV_{TG,hist}$, use equation14.~~

If $V_{OG,y} * NCV_{OG,y} \geq V_{TG,x} * NCV_{TG,x}$, use equation~~14~~ 15.

Project emissions $PE_{IND,ELEC,y}$ should be calculated using the latest approved version of the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”.

Project emissions at the project CO_2 production facility

$$PE_{CO2NEW,y} = PE_{CO2NEW,ELEC,y} + PE_{CO2NEW,FF,y} \tag{17}$$

Where:

$PE_{CO2NEW,ELEC,y}$	Project emissions from the electricity consumption at the project CO_2 production facility, including the transportation of off gas back to the industrial facility, during year y, (tCO_2e~~/year~~). This includes both electricity generated by a captive plant(s) at the industrial facility and electricity imported from the grid by the project CO_2 production facility
$PE_{CO2NEW,FF,y}$	Project emissions from the use of fossil fuels at the project CO_2 production facility during year y, (tCO_2e~~/year~~)

Project emissions $PE_{CO2NEW,ELEC,y}$ and $PE_{CO2NEW,FF,y}$ should be calculated using the latest approved versions of the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption” and the “Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion” respectively.

All data for gas volumes in all equations should be converted to common standard temperature and pressure values.

[12] It is required to use a period comprising enough data to fully represent a regular CO_2 production facility operation (a minimum of three year period is required).

Leakage

Leakage emissions need to be accounted for if scenario 2 in the applicability conditions and baseline scenarios C3 or C5 apply:

$$LE_y = P_{CO2,PJ,y} * w_{non-conv} \tag{18}$$

$$w_{non-conv} = \sum_n w_{n,z} \tag{19}$$

where *n* corresponds to plants using other technologies than the conventional CO_2 production process

Where:

$P_{CO2,PJ,y}$	Amount of CO_2 produced at the project CO_2 production facility in year *y,* (tCO_2)
$w_{non\text{-}conv}$	Share of CO_2 produced by CO_2 production facilities using other technologies than the conventional process in year z preceding the start of the project activity

Emission Reductions

Emission reductions for any given year of the crediting period can be obtained by subtracting project and leakage emissions from baseline emissions:

$$ER_y = BE_y - PE_y - LE_y \tag{20}$$

Where:

ER_y	Emissions reductions of the project activity during the year *y*, (tCO_2e~~/year~~)
BE_y	Baseline emissions during the year *y*, (tCO_2e~~/year~~)
PE_y	Project emissions during the year *y*, (tCO_2e~~/year~~)
LE_y	Leakage emissions during the year *y*, (tCO_2e~~/year~~)

In case of scenario 1, baseline scenario C2 and case A (under baseline emissions), emission reductions can only be claimed as long as (a) the existing conventional CO_2 production plant is operating and (b) has not reached the end of its technical lifetime.

In case of scenario 1, baseline scenario C2 and case B (under baseline emissions), emission reductions can only be claimed as long as the existing conventional CO_2 production plant would not have reached the end of its technical lifetime.

Changes required for methodology implementation in 2nd and 3rd crediting periods

Consistent with guidance by the CDM Executive Board, project participants shall assess the continued validity of the identified baseline scenarios and update the baseline parameters. Similarly, the benchmark for the production of CO_2 should be updated at the renewable of the crediting period.

Data and parameters not monitored

Parameter:	$V_{TG, x}$
Data unit:	m^3
Description:	~~Average volume of tail gas generated in the industrial facility during three years prior to the implementation of the project activity~~ Average annual volume of the tail gas generated in the period *x*
Source of data:	Historical records (minimum 3 years)
Measurement procedures (if any):	Flow meter totalizer data (to be obtained from industrial facility process unit control system records)
Any comment:	Applied to calculate $BE_{IND,y.}$ tail gas flow meters shall be calibrated according to the suppliers' specifications and following the industrial facility QA/QC procedures. In order to comply with the applicability conditions DOEs should verify records or evidence of the generation of the tail gas in accordance with the years the industrial facility has been in operation as well as its use (i.e. fuel purposes or flared)

Parameter:	$w_{carbon, TG, x}$
Data unit:	tC/m^3
Description:	Carbon content in tail gas stream generated in the industrial facility during three years prior to the implementation of the project activity
Source of data:	Historical records
Measurement procedures (if any):	Chemical analysis (e.g. gas chromatograph)
Any comment:	Applied to verify compliance with the applicability conditions. Gas analyzing equipment shall be calibrated according to the suppliers' specifications and following the industrial facility QA/QC procedures

Parameter:	$EC_{CO2,BL, grid, x}$
Data unit:	MWh
Description:	Electricity consumption from the grid at the baseline CO_2 production facility during period *x*
Source of data:	Plant historical data
Measurement procedures (if any):	As per electricity supplier standard measurements, supporting documents and plant records
Any comment:	Applied in equation for estimation of $BE_{CO2,BL, x}$

Parameter:	$EF_{CO2, grid, x}$
Data unit:	tCO_2/MWh
Description:	Grid emission factor for the period *x*
Source of data:	Calculated in accordance with the latest approved version of the "Tool to calculate the emission factor for an electricity system"
Measurement procedures (if any):	None
Any comment:	Applied in equation for estimation of $BE_{CO2,BL, x}$

Parameter:	$FC_{CO2,BL,i,x}$
Data unit:	T
Description:	Amount of fuel type *i* combusted at the baseline CO_2 production facility during period *x*
Source of data:	Plant historical data
Measurement procedures (if any):	As per fuel supplier standard measurements, supporting documents and plant records
Any comment:	Applied in equation for estimation of $BE_{CO2,BL,x}$

Parameter:	$EF_{CO2,i,x}$
Data unit:	tCO_2/TJ
Description:	Fuel emission factor for the period *x* (per fuel type)
Source of data:	The source of data should be the following, in order of preference: project specific data, country specific data or IPCC default values. As per the guidance from the Board, IPCC default values should be used only when country or project specific data are not available or difficult to obtain
Measurement procedures (if any):	None
Any comment:	Applied in equation for estimation of $BE_{CO2,BL,x}$

Parameter:	$EC_{CO2,grid,n,z}$
Data unit:	MWh
Description:	Electricity consumption from the grid at the CO_2 production facility *n* in year *z*
Source of data:	Plant historical data (benchmark analysis data)
Measurement procedures (if any):	As per electricity supplier standard measurements, supporting documents and plant records
Any comment:	Applied to calculate $BE_{CO2,BL,n,z}$

Parameter:	$EF_{CO2,grid,n,z}$
Data unit:	tCO_2/MWh
Description:	Grid emission factor for the electricity used at the CO_2 production facility *n* in year *z*
Source of data:	Calculated in accordance with the latest approved version of ACM0002
Measurement procedures (if any):	None
Any comment:	Applied to calculate $BE_{CO2,BL,n,z}$.

Parameter:	$FC_{CO2,i,n,z}$
Data unit:	t
Description:	Amount of fuel type i combusted at the CO_2 production facility *n* in year *z* (per fuel type)
Source of data:	Plant historical data (benchmark analysis data)
Measurement procedures (if any):	As per fuel supplier standard measurements, supporting documents and plant records
Any comment:	Applied to calculate $BE_{CO2,BL,n,z}$.

Parameter:	$EF_{CO2,i,n,z}$
Data unit:	tCO_2/TJ
Description:	Fuel emission factor for the fuel type i at the CO_2 production facility *n* in year *z* (per fuel type)
Source of data:	The source of data should be the following, in order of preference: project specific data, country specific data or IPCC default values. As per the guidance from the Board, IPCC default values should be used only when country or project specific data are not available or difficult to obtain
Measurement procedures (if any):	None
Any comment:	Applied to calculate $BE_{CO2,BL,n,z}$. IPCC guidelines/Good practice guidance provide for default values where local data are not available

Parameter:	$P_{CO2,BL,x}$
Data unit:	tCO_2
Description:	Amount of CO_2 produced at the existing CO_2 production facility during period *x* (applied in the estimation of the $BE_{CO2,BL,x}$)
Source of data:	Plant historical data
Measurement procedures (if any):	CO_2 production facility methods (volumetric and weight measurements and product inventory records)
Any comment:	Applied in the estimation of the $BE_{CO2,BL,x}$

Parameter:	~~$P_{CO2,x}$~~ $P_{CO2,x/x-1/x-2}$
Data unit:	tCO_2
Description:	Quantity of CO_2 produced in the existing conventional CO_2 production facility in year *x/x-1/x-2* (tCO_2/yr)
Source of data:	Plant historical data
Measurement procedures (if any):	CO_2 production facility methods (volumetric and weight measurements and product inventory records)
Any comment:	Year *x* is the year preceding the start of ~~implementation of~~ the project activity

Parameter:	$P_{CO2,n,z}$
Data unit:	tCO_2
Description:	Quantity of CO_2 produced at the CO_2 production facility *n* in year *z*
Source of data:	Plant historical data
Measurement procedures (if any):	CO_2 production facility methods (volumetric and weight measurements and product inventory records)
Any comment:	Applied to calculate $BE_{CO2,BL,n,z}$.

Parameter:	$NCV_{(i,x), (i,z), (OG,y), (TG,x)}$
Data unit:	Joules/mass or volume unit
Description:	Net calorific value of fossil fuel type *i* in the period *x* Net calorific value of fossil fuel type *i* in year *z* Net calorific value of off gas in year *y* Net calorific value of tail gas in the period *x*
Source of data:	Preferably invoices from fuel supplier or use accurate and reliable local or national data where available. Where such local or national data are not available, IPCC default emission factors (country-specific, if available) may be used if they are deemed to reasonably represent local circumstances
Measurement procedures (if any):	Use mass or volume meters. Measurements according to best international practices
Any comment:	*i* = index for fossil fuel type. *x* = index for minimum three year period prior to the start of the project. *z* = index for the year before the start of the project activity or the most recent year for which data are available. *y* = index for the project year. The NCV for period *x* should be calculated as the average

Parameter:	$EF_{coal,y}$
Data unit:	t CO_2/GJ
Description:	CO_2 emission factor of coal in year y
Source of data:	The source of data should be the following, in order of preference: project specific data, country specific data or IPCC default values. As per the guidance from the Board, IPCC default values should be used only when country or project specific data are not available or difficult to obtain
Measurement procedures (if any):	none
Any comment:	

Parameter:	GWP_{CH4}
Data unit:	tCO_2e/tCH_4
Description:	Global Warming Potential for methane
Source of data:	IPCC
Measurement procedures (if any):	21 for the first commitment period, shall be updated according to any future COP/MOP decisions
Any comment:	None

Parameter:	$SALES_x$
Data unit:	Tons of CO_2
Description:	CO_2 actually sold and delivered to customers before the start of the project activity. These records should include *inter alia*: Amount purchased Contact information of customers Type of customer according to end use of the CO_2 Date of delivery
Source of data:	Management records. Historical records from three years prior to the start of the project activity
Measurement procedures (if any):	None (from archives)
Any comment:	Applied to verify compliance with the applicability conditions. These data have to be collected in order to ensure that the production of CO_2 is justified by a real demand in the market. The end use of the product should not differ significantly after the start of the project activity implementation

III. MONITORING METHODOLOGY

Monitoring procedures

The monitoring methodology involves monitoring of the following:

- The composition and quantity of tail gas or intermediate gas produced by the industrial facility process unit;
- The quantity and carbon intensity of any additional energy source used for transportation purposes;
- The composition and quantity of off gas returned to the industrial facility from the project CO_2 production facility;
- The quantity and carbon intensity of any energy source used at the project CO_2 production facility and for off gas transportation purposes;
- Any fugitive emissions of methane or CO_2 at the project CO_2 production facility;
- Any fugitive emissions of methane or CO_2 along the tail gas and off gas transportation pipeline system (including those from accidental events).

Project emissions:

All the procedures to monitor and measure parameters needed to calculate project emissions shall be integrated into the plant quality control process, according to the plant quality certifications. The monitoring frequency varies from one parameter to another according to their variability grade over time and their importance in the project emissions calculations. All the measurements shall be done with meters calibrated according to the suppliers' specifications and following the facility QA/QC procedures. All data collected as part of monitoring should be archived electronically and be kept at least for two years after the end of the last crediting period.

For guidance on the monitoring of project emissions from consumption of electricity and fossil fuels please refer to the latest approved versions of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" and the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion".

Data and parameters monitored

Data / Parameter:	$V_{TG,y}$
Data unit:	m^3
Description:	Volume of tail gas delivered to the project CO_2 production facility in year y
Source of data:	Flow meter totalizer data (to be obtained from industrial facility process unit control system records)
Measurement procedures (if any):	Data is to be measured using accurate and calibrated flow meters. Measurements shall be taken at the point where tail gas enters the pipeline to transport it to the tail gas recovery CO_2 production facility
Monitoring frequency:	Continuous
QA/QC procedures:	Tail gas flow meters shall be calibrated according to the suppliers' specifications and following the industrial facility QA/QC procedures
Any comment:	Applied to calculate $BE_{IND,y}$

Data / Parameter:	$V_{IG,y}$
Data unit:	m^3
Description:	Volume of intermediate gas delivered to the project CO_2 production facility in year *y*
Source of data:	Flow meter totalizer data (to be obtained from industrial facility process unit control system records)
Measurement procedures (if any):	Data is to be measured using accurate and calibrated flow meters. Measurements shall be taken in the pipeline that transports it to the intermediate CO_2 production facility
Monitoring frequency:	Continuous
QA/QC procedures:	Intermediate gas flow meters shall be calibrated according to the suppliers' specifications
Any comment:	Applied to calculate $BE_{IND,y}$

Data / Parameter:	$V_{OG,y}$
Data unit:	m^3
Description:	Volume of off gas combusted at the industrial facility during year *y*, (m^3)
Source of data:	Flow meter totalizer data (to be obtained from industrial facility process unit control system records)
Measurement procedures (if any):	Data is to be measured using accurate and calibrated flow meters. Measurements shall be taken at the point where off-gas enters the burners at the industrial facility process unit ~~tail gas enters the pipeline to transport it to the tail gas recovery CO2 production facility~~
Monitoring frequency:	Continuous
QA/QC procedures:	~~Tail~~ Off gas flow meters shall be calibrated according to the suppliers' specifications and following the industrial facility QA/QC procedures
Any comment:	Applied to calculate $PE_{IND,y}$

Data / Parameter:	$w_{carbon, TG, y}$
Data unit:	tC/m^3
Description:	Carbon content in tail gas stream
Source of data:	Chemical analysis (e.g. gas chromatography)
Measurement procedures (if any):	Analysis can give direct results or data to estimate tail gas carbon content
Monitoring frequency:	Weekly
QA/QC procedures:	Gas analyzing equipment shall be calibrated according to the suppliers' specifications and following the industrial facility QA/QC procedures
Any comment:	Applied to calculate $BE_{IND,y}$

Data / Parameter:	$w_{carbon, IG, y}$
Data unit:	tC/m^3
Description:	Carbon content in intermediate gas stream
Source of data:	Chemical analysis (e.g. gas chromatography)
Measurement procedures (if any):	Analysis can give direct results or data to estimate intermediate gas carbon content
Monitoring frequency:	Weekly
QA/QC procedures:	Gas analyzing equipment shall be calibrated according to the suppliers' specifications and following the industrial facility QA/QC procedures
Any comment:	Applied to calculate $BE_{IND,y}$

Data / Parameter:	$w_{carbon, OG, y}$
Data unit:	tC/m^3
Description:	Carbon content in off gas stream
Source of data:	Chemical analysis (e.g. gas chromatography)
Measurement procedures (if any):	Analysis can give direct results or data to estimate ~~tail~~ off gas carbon content
Monitoring frequency:	Weekly
QA/QC procedures:	Gas analyzing equipment shall be calibrated according to the suppliers' specifications and following the industrial facility QA/QC procedures
Any comment:	Applied to calculate $PE_{IND,y}$

Data / Parameter:	$P_{CO2, PJ,y}$
Data unit:	tCO_2
Description:	CO_2 produced at the project CO_2 production facility in year *y*
Source of data:	Control system or plant inventory records
Measurement procedures (if any):	Level or weight metering tanks and truck scales
Monitoring frequency:	Daily
QA/QC procedures:	Level or weight metering equipment shall be calibrated according to the suppliers' specifications and following the tail gas recovery CO_2 producer QA/QC procedures
Any comment:	Applied in the calculation of $BE_{CO2,y}$

Data / Parameter:	$P_{CO2,exist\ plant,y}$
Data unit:	tCO_2
Description:	Quantity of CO_2 produced in the existing conventional CO_2 production facility in year *y* (tCO_2/yr)
Source of data:	Control system or plant inventory records
Measurement procedures (if any):	Level or weight metering tanks and truck scales
Monitoring frequency:	Daily
QA/QC procedures:	Level or weight metering equipment shall be calibrated according to the suppliers' specifications and following the tail gas recovery CO_2 producer QA/QC procedures
Any comment:	Applied to determine $P_{CO2,MAX,y}$

Data / Parameter:	$SALES_{CO2,y}$
Data unit:	Tons of CO_2
Description:	CO_2 actually sold and delivered to customers after the start of the project activity. These records should include *inter alia*: Amount purchased Contact information of customers Type of customer according end use of the CO_2 Date of delivery
Source of data:	Management records
Measurement procedures (if any):	Audits
Monitoring frequency:	Monthly
QA/QC procedures:	Cross cutting checks against sales records and deliveries receipts
Any comment:	These data have to be collected in order to ensure that the production of CO_2 is justified by a real demand in the market. The end use of the product should not differ significantly from the baseline use

Data / Parameter:	$P_{MP,y}$
Data unit:	Tons or m3
Description:	Quantity or volume of main product actually produced in year *y*
Source of data:	Control system or plant inventory records
Measurement procedures (if any):	Audits
Monitoring frequency:	Monthly
QA/QC procedures:	Cross cutting checks against sales records and deliveries receipts
Any comment:	These data have to be collected in order to ensure that the production of the main product is justified by a real demand in the market

Data / Parameter:	$SALES_{MP,y}$
Data unit:	Tons or m3
Description:	Quantity or volume of main product actually sold and delivered to customers. These records should include *inter alia*: • Amount purchased; • Contact information of customers; • Date of delivery
Source of data:	Flow meter totalizer data (to be obtained from industrial facility process unit control system records)
Measurement procedures (if any):	Data is to be measured using accurate and calibrated flow meters. Measurements shall be taken in the pipeline that transports it to the intermediate CO_2 production facility
Monitoring frequency:	Monthly
QA/QC procedures:	Cross cutting checks against volumes or quantities of main product actually produced
Any comment:	These data have to be collected in order to ensure that the production of the main product is justified by a real demand in the market

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History of the document

Version	**Date**	**Nature of revision**
01.2.0	EB 61, Annex # 3 June 2011	Amendment to expand the applicability of the methodology to new integrated industrial facilities recovering CO2 from the intermediate gas and reducing emissions associated with CO2 production in other conventional CO2 production facilities and provide editorial improvements.
01.1	EB 39, Paragraph 22 16 May 2008	"Tool to calculate baseline, project and/or leakage emissions from electricity consumption" replaces the withdrawn "Tool to calculate project emissions from electricity consumption".
01	EB 36, Annex 4 30 November 2007	Initial adoption.