

**Approved baseline methodology AM0027****“Substitution of CO₂ from fossil or mineral origin by CO₂ from renewable sources in the production of inorganic compounds”****Source**

This methodology is based on the part called "renewable CO₂ activity" of the project activity "Raudi Chemical Salts", proposed by Raudi Indústria e Comércio Ltda., with participation of Coopcana – Cooperativa Agrícola Regional de Produtores de Cana Ltda, whose baseline study and project design document were prepared by Mr. Rodrigo Marcelo Leme, from Ecoinvest, Brazil.

For more information regarding the proposal and its consideration by the Executive Board please refer to case NM0115: “CO₂, electricity and steam from renewable sources in the production of inorganic compounds” on <<http://cdm.unfccc.int/methodologies/PAMethodologies/approved.html>>.

This methodology also refers to the latest version of the “Tool for the demonstration and assessment of additionality”.¹

Selected approach from paragraph 48 of the CDM modalities and procedures

“Emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment”

Applicability

This methodology is applicable generally to industrial production/manufacturing processes of inorganic compounds where fossil or mineral sources of CO₂ are presently used as an input and where renewable sources of CO₂ are available as a substitute input in the project activity case.

The methodology is applicable under the following conditions:

- The residual CO₂ from the processing of biomass was already produced but was not used before the project activity, so that no diversion of CO₂ from other applications is due to the project activity.
- The processing of biomass undergoes no substantial changes in the process with the project activity;
- CO₂ from fossil or mineral sources that is used for the production of inorganic compounds prior to the project activity will not be emitted to the atmosphere with the project activity;
- There are no substantial changes (e.g. product change) in the production process of inorganic compounds as a result of the project activity;
- Production levels of the plant (tons of inorganic compound produced per year) may in general not increase with the project activity over historic maxima;
- No additional significant energy quantities are required to prepare the renewable CO₂ from biomass processing for use in the production of inorganic compounds (related CO₂ emissions are below 1% of total emission reduction);
- All Carbon in the produced inorganic compounds stems from the CO₂ supplied during the production process.

¹ Please refer to: < <http://cdm.unfccc.int/methodologies/PAMethodologies/approved.html>>



This baseline methodology shall be used in conjunction with the approved monitoring methodology AM0027 (Substitution of CO₂ from fossil or mineral origin by CO₂ from renewable sources in the production of inorganic compounds).

Identification of the baseline scenario

The methodology determines the baseline scenario through the following steps:

Step I: Identify alternatives to the project activity;

Step II: Assess project additionality;

Step III: Determine the most likely scenario (baseline scenario) from among the alternatives identified.

Step I: Identify alternatives to the project activity

Project participants shall identify realistic and credible alternatives(s) to each one of the project components in the country where the inorganic compound is produced and consumed. Alternatives should be separately determined regarding:

- How would CO₂ be obtained in the absence of the CDM project activity?
- What would happen to the primary source of renewable energy in the absence of the project activity?
- What would happen to the baseline and project sources of CO₂ in the absence of the project activity?

How would CO₂ be obtained in the absence of the CDM project activity?

The production of some inorganic compounds requires CO₂ as raw material. The gas reacts with other raw material inside a chemical reactor producing the final product.

CO₂ can be obtained from *fossil, mineral* or *renewable* sources.

Alternatives to the renewable CO₂ activity (the project activity) must be identified through the consultation of technical associations and official (country) information, supported by technical literature or market researches, as appropriate. The alternatives are to be identified inside the country where the project is developed.

There is no single standardized source for this type of information, hence, the sources of information must be determined on a project specific basis and evaluated during the validation phase, by the DOE. The sources selected must be well recognized and widespread accepted as a reliable source in the country where the project is developed.

For CO₂, the realistic and credible alternative(s) may include, *inter alia*:

C1: The proposed project activity (use of renewable source of CO₂) not undertaken as a CDM project activity.



C2: The proposed project activity, implemented at a later point in time and not undertaken as a CDM project activity.

C3: The proposed project activity, using the same type of renewable CO₂ but with a lower CO₂ consumption (e.g. CO₂ use efficiency that is common practice in the relevant industry sector).

C4: The use of CO₂ from a particular existing or new plant, on-site or off-site, using other renewable CO₂ sources, such as other biomass sources.

C5: The use of CO₂ from a particular existing or new plant, on-site or off-site, using non-renewable sources of CO₂, such as CO₂ derived from thermochemical processing of fossil hydrocarbons², CO₂ derived from mineral products³, etc. If not used as input for the production of inorganic compounds, the CO₂ would *not* be produced, and would *not* be emitted in the atmosphere.

C6: The use of CO₂ in a particular existing or new plant, on-site or off-site, using non-renewable residual CO₂ sources, such as residual CO₂ from other industrial process that uses fossil or mineral as raw materials, as in the cement industry. If not used as input for the production of inorganic compounds, the CO₂ would accrue *anyway* and would be emitted in the atmosphere.

Note that the alternatives proposed in this Section are only indicative. Project proponents may propose other possible alternatives and/or eliminate some of the proposed above, based on documented evidence.

Step II: Assess the project additionality and select plausible baseline candidates

Project participants, after identifying the alternatives to and building realistic and credible scenarios shall apply the latest approved version of the “Tool for the demonstration and assessment of additionality” for two purposes: (i) to assess project scenario additionality, showing that it is not part of the baseline; and (ii) to identify which one of the alternatives should be excluded from further consideration for baseline determination (e.g. alternatives where barriers are prohibitive or which are clearly economically unattractive). The Tool shall be applied without any modification for the set of alternative scenarios identified.

Step III: Determine the most likely alternative scenario (baseline scenario)

Where more than one credible and plausible alternative scenario remains, project participants shall, as a conservative assumption, use the alternative baseline scenario that results in the lowest baseline emissions as the most likely baseline scenario.

This methodology is only applicable to a project activity if it can be demonstrated through steps I to III above that alternative C5 is the most likely baseline scenario.

² Fossil origin, by thermochemical processing of synthesis gas (methane, for example) or of other hydrocarbons derived from petrochemical industry. CO₂ that is purchased from suppliers of industrial gases normally stems from thermochemical processing.

³ Mineral origin, whether from the calcination of calcium carbonate (CaCO₃), as in the Solvay process, renowned as the most usual fabrication process of sodium bicarbonate worldwide, or directly obtained from mineral ore that contains the inorganic compound.



Additionality

The additionality of the project activity shall be demonstrated and assessed using the latest version of the “Tool for the demonstration and assessment of additionality” agreed by the CDM Executive Board, available at the UNFCCC CDM web site⁴.

Project boundary

For the purpose of determining GHG emissions of the **baseline**, project participants shall include the following emissions sources:

- GHG emissions from on-site production of inorganic compounds (if any) ; and
- GHG emissions from final use of inorganic compounds (if any).

For the purpose of determining the GHG emissions of the **project activity**, project participants shall include the following emission sources:

- Sequestration of CO₂ from the atmosphere (if any);
- GHG emissions from on-site processing of biomass that generates the residual CO₂ (if any); and
- GHG emissions from on-site production of inorganic compounds (if any); and
- GHG emissions from final use of inorganic compounds (if any).

Figure 1 provides an overview on the project activity boundary, **Figure 2** shows the baseline boundary.

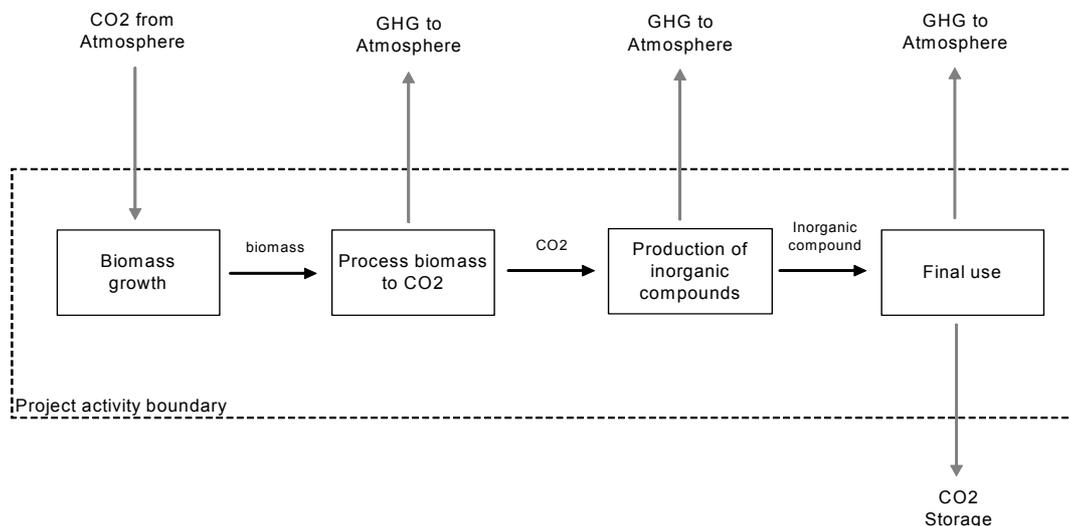


Figure 1: Project activity boundary

⁴ Please refer to: < <http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html> >

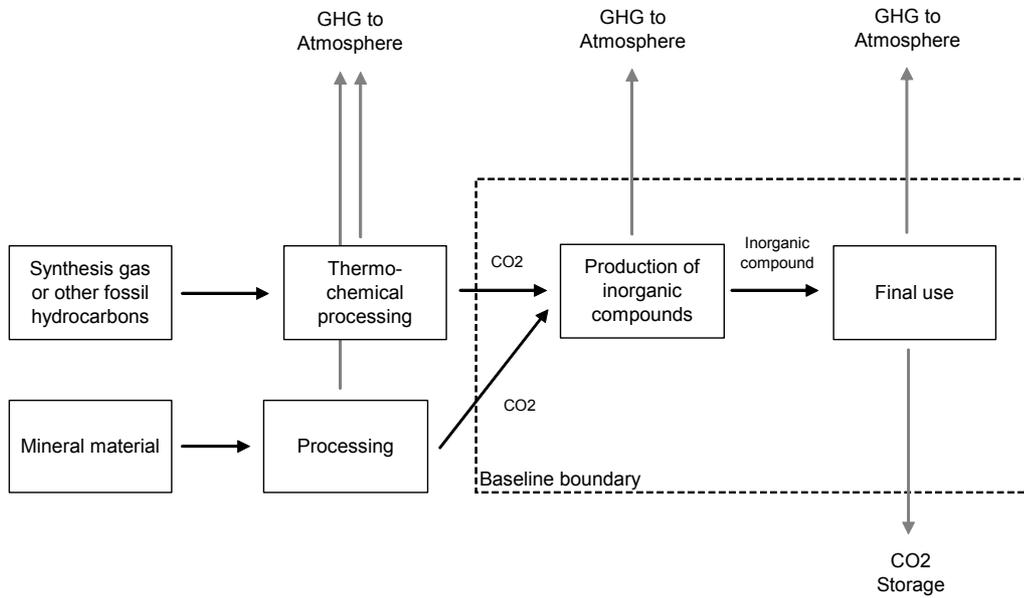


Figure 2: Baseline boundary

Table 1 illustrates in detail which emissions sources are included and which are excluded from the project boundary for determination of both baseline and project emissions.



Table 1: Overview on emissions sources included in or excluded from the project boundary

	Source	Gas		Justification / Explanation
Baseline	Processing of fossil or mineral hydrocarbons	CO ₂	Excluded	Excluded for simplification. This is conservative.
		CH ₄	Excluded	
		N ₂ O	Excluded	
	Production of inorganic compounds	CO ₂	Included (but cancelled out)	Due to applicability criteria, the process of the production of inorganic compounds is not changed with the implementation of the project activity, and potential baseline and project emissions are the same.
		CH ₄	Excluded	
		N ₂ O	Excluded	
	Final use	CO ₂	Included	CO ₂ is either emitted to the atmosphere or stored
		CH ₄	Excluded	Excluded for simplification
		N ₂ O	Excluded	Excluded for simplification
Project Activity	Uptake of CO ₂ by biomass growth	CO ₂	Included (but included elsewhere)	CO ₂ uptake in biomass growth is covered by the fact that renewal CO ₂ is treated climate-neutral.
	Processing of biomass, producing residual CO ₂	CO ₂	Included (but cancelled out)	May be an important emission source. However, due to applicability criteria, the biomass processing is not changed with the implementation of the project activity, and baseline and project emissions are the same.
		CH ₄	Excluded	
		N ₂ O	Excluded	
	Production of inorganic compounds	CO ₂	Included (but cancelled out)	Due to applicability criteria, the process of the production of inorganic compounds is not changed with the implementation of the project activity, and potential baseline and project emissions are the same.
		CH ₄	Excluded	
		N ₂ O	Excluded	
	Final use	CO ₂	Included	CO ₂ is either emitted to the atmosphere or stored
		CH ₄	Excluded	Excluded for simplification.

**Final use and emission reductions**

The project activity reduces net CO₂ emissions to the atmosphere or leads to C sequestration by substituting CO₂ from fossil or mineral origin by CO₂ that originates from the processing of biomass as input for the production process of inorganic compounds.

In the final use, the inorganic compounds may either (i) thermally dissolve or (ii) not dissociate:

(i) Assuming that the inorganic compound molecules thermally dissolve in the final use. Hence, if a project activity uses renewable CO₂ instead of non-renewable CO₂ of fossil or mineral origin, emissions of non-renewable CO₂ during the final use of the compound are avoided.

(ii) On the other hand, in the case the inorganic compound molecules do not dissociate during the final use, the result of the project activity is carbon sequestration, because CO₂ is continuously sequestered from the atmosphere by the production of inorganic chemical. Hence, the project activity leads to the permanent removal of CO₂ from the atmosphere (or "negative" emissions).

It is important to note, however, that the main objective of the "renewable CO₂ activity" is not to sequester CO₂ from the atmosphere. The point about sequestration is to demonstrate that, even in the case some portion of the chemical doesn't dissociate during the final use phase, the activity continues to lead to emissions reductions.

The renewable CO₂ may be obtained from the processing of biomass, e.g. from the waste CO₂ stream, which was previously released to the atmosphere, generated in the fermentation of sugar cane juice for the production of ethanol.



In Table 2, representations of both situations, with and without dissociation in the final use, are presented.

Table 2 – Emissions balance in the “renewable CO₂ activity”

		Does the compound release CO₂ in the final use?	What happens to emissions in the project activity scenario?	What would happen to emissions in the baseline scenario?	Emissions balance, from the difference between baseline and project emissions
Project scenario with renewable CO ₂ and baseline scenario with non-renewable CO ₂	SITUATION 1 With dissociation	Yes, compound molecule dissociates and CO ₂ is emitted to the atmosphere in the final use	CO ₂ emissions occur and are renewable (net emission is zero)	Fossil or mineral CO ₂ emissions would occur (net emission would be positive)	Emissions reductions occur due to the avoidance of non-renewable CO ₂ emissions
	SITUATION 2 Without dissociation	No, compound molecule does not dissociate and CO ₂ is not emitted to the atmosphere in the final use	Atmosphere CO ₂ is sequestered by the chemical molecule (net emission is negative)	Fossil or mineral CO ₂ would be sequestered by the chemical molecule (net emission would be zero)	Emissions reductions occur due to the sequestration of atmosphere CO ₂ by the chemical molecule

Please note that, switching from one situation to the other does not affect the net emission reductions of the project, as it may be assumed that the final use of the product in the baseline would be the same as in the project activity. It means that, if in the project activity scenario CO₂ is released in the final use, it would also happen in the baseline scenario and vice-versa, and the emissions reductions would be the same, independently of the situation describing the final use.

Baseline emissions (non-renewable CO₂ activity)

If the baseline scenario C.5 is identified (see Section "Identification of baseline scenario"), i.e. the production of the inorganic compound with fossil or mineral CO₂ sources, then emissions of the baseline due to the final use of the inorganic compounds are calculated as below.

When the final use of the inorganic compound emits CO₂ to the atmosphere, the emissions from the final use of the inorganic compounds are *N* moles of CO₂ for each mol of inorganic compound used. Hence, the following emission factor for the “CO₂ activity” results [in tCO₂/t of inorganic compound]:

$$EF_{CA} = 44 (N/M)$$



where:

- 44 is the molecular weight of CO₂, [g/mol].
- N is the carbon content of the inorganic compound, i.e., the number of carbon atoms in the inorganic compound molecule that would thermally dissociate in the final use of one molecule of the compound. N is a fixed parameter that depends on the inorganic compound involved, [non dimensional].
- M is the molecular weight of the inorganic compound, a fixed parameter that depends on the inorganic compound involved. It is calculated straightforwardly by summing the atomic weights of the compound constituents, in [g].

This is based on the assumption that all Carbon in the produced inorganic compounds stems from the CO₂ supplied during the production process (applicability criterium).

The calculation of the baseline emissions (B) consists of three parts, the GHG emission (BE) and sequestration (BS) parts during final consumption, as well as possible emissions related to the activity, e.g. from the production of inorganic compounds (BI). It is calculated as follows:

$$B = BE - BS + BI \quad (1)$$

The emissions of non-renewable CO₂ are

$$BE = EF_{CA} m_1(1-k_b) \quad (2)$$

Thus,

$$BE = 44 (N/M) m_1(1-k_b) \quad (3)$$

The sequestration in the baseline is

$$BS = EF_{CA} m_2 k_b \quad (4)$$

Thus,

$$BS = 44 (N/M) m_2 k_b \quad (5)$$

Definition of parameters and variables is provided at the end of the project emissions section below.

Project Emissions (Renewable CO₂ activity)

The calculation of the project emissions (P) also consists of three parts, the GHG emission (PE) and sequestration (PS) parts during final consumption, as well as other possible emissions related to the activity, e.g. from the production of inorganic compounds (PI). It is calculated as follows:

$$P = PE - PS + PI \quad (6)$$



The emissions of non-renewable CO₂ are

$$PE = EF_{CA} m_1 (1-k_p) \quad (7)$$

Thus,

$$PE = 44 (N/M) m_1 (1-k_p) \quad (8)$$

The sequestration in the project activity is

$$PS = EF_{CA} m_2 k_p \quad (9)$$

Thus,

$$PS = 44 (N/M) m_2 k_p \quad (10)$$

where:

- m_1 is the amount of the inorganic compound that releases CO₂ in the final use, in [t].
- m_2 is the amount of the inorganic compound that does *not* release CO₂ in the final use, in [t].
- $m = m_1 + m_2$ is the total amount of the inorganic compound produced, in [t].
- k_b and k_p are non-dimensional correction factors for renewable CO₂ in the baseline and project activity and are calculated as follows:

$$k_b = m_{br} / (m_{br} + m_{bnr}) \quad \text{and} \quad k_p = m_{pr} / (m_{pr} + m_{pnr}),$$

where

- m_{br} is the total amount of renewable CO₂ used in the baseline scenario.
- m_{bnr} is the total amount of non-renewable CO₂ used in the baseline scenario.
- m_{pr} is the total amount of renewable CO₂ used by the project.
- m_{pnr} is the total amount of non-renewable CO₂ used by the project.

Emission Reduction

The applicability criteria (see above) require that neither the processing of biomass (generating waste renewable CO₂) nor the production process (for inorganic compounds) undergo substantial changes with the project activity. With this, it may be assumed that potential GHG emissions from the biomass processing and the production process remain the same in the baseline (*BI*) and in the project activity (*PI*) case:

$$BI = PI \quad (11)$$

The total emission reduction which covers direct emissions of GHG and sequestration can be written as:

$$ER = B-P = (BE-PE) + (PS-BS) + (BI-PI) \quad (12)$$

$$ER = (BE-PE) + (PS-BS) \quad (13)$$



$$ER = 44 (N/M) (m_1+m_2) (k_p-k_b) \quad (14)$$

$$ER = 44 (N/M) m (k_p-k_b) \quad (15)$$

Leakage

The main potential source of leakage for this project activity lies in an increase in emissions due to diversion of CO₂ from other users to the project as a result of the project activity.

This source of leakage is zero if the conditions under which the methodology is applicable are satisfied:

- The residual CO₂ from the processing of biomass was already produced but was not used before the project activity, so that no diversion of CO₂ from other applications is due to the project activity.

Project participants must provide adequate evidence of this condition during the validation of the project activity.



Approved monitoring methodology AM0027

“Substitution of CO₂ from fossil or mineral origin by CO₂ from renewable sources in the production of inorganic compounds”

Source

This methodology is based on the part called "renewable CO₂ activity" of the project activity "Raudi Chemical Salts", proposed by Raudi Indústria e Comércio Ltda., with participation of Coopcana – Cooperativa Agrícola Regional de Produtores de Cana Ltda, whose baseline study and project design document were prepared by Mr. Rodrigo Marcelo Leme, from Ecoinvest, Brazil.

For more information regarding the proposal and its consideration by the Executive Board please refer to case NM0115: “CO₂, electricity and steam from renewable sources in the production of inorganic compounds” on <<http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html>>.

This methodology also refers to the latest version of the “Tool for the demonstration and assessment of additionality”⁵.

Applicability

This monitoring methodology shall be used in conjunction with the approved baseline methodology AM0027 (Substitution of CO₂ from fossil or mineral origin by CO₂ from renewable sources in the production of inorganic compounds). The same applicability conditions as in baseline AM0027 apply.

This methodology is applicable generally to industrial production/manufacturing processes of inorganic compounds where fossil or mineral sources of CO₂ are presently used as an input and where renewable sources of CO₂ are available as a substitute input in the project activity case.

The methodology is applicable under the following conditions:

- The residual CO₂ from the processing of biomass was already produced but was not used before the project activity, so that no diversion of CO₂ from other applications is due to the project activity.
- The processing of biomass undergoes no substantial changes in the process with the project activity;
- CO₂ from fossil or mineral sources that is used for the production of inorganic compounds prior to the project activity will not be emitted to the atmosphere with the project activity;
- There are no substantial changes (e.g. product change) in the production process of inorganic compounds as a result of the project activity;
- Production levels of the plant (tons of inorganic compound produced per year) may in general not increase with the project activity over historic maxima;
- No additional significant energy quantities are required to prepare the renewable CO₂ from biomass processing for use in the production of inorganic compounds (related CO₂ emissions are below 1% of total emission reduction);
- All Carbon in the produced inorganic compounds stems from the CO₂ supplied during the production process.

⁵ Please refer to: <<http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html>>



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 differently in the comments in the tables below.

**Project emissions parameters**

The following table illustrates the data to be collected or used in order to monitor emissions from the project activity.

ID number	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/paper)	Comment
1. <i>N</i>	Carbon content of the inorganic compound, i.e., the number of carbon atoms in the inorganic compound molecule that would thermally dissociate in the final use of the compound.	Technical literature, such as, chemical engineers handbooks.	Non dimensional	C	Once, at the validation	100%	Electronic and paper	This is a fixed parameter that needs to be demonstrated through the chemical dissociation equation in the final use of each compound produced.
2. <i>M</i>	Molecular weight of the inorganic compound.	Technical literature, such as, chemical engineers handbooks.	g/mol	C	Once, at the validation	100%	Electronic and paper	This is a fixed parameter calculated from the summation of the atomic weights of the compound constituents.
3. <i>m</i>	Total amount of chemical produced.	Company books, sales documents	t	M	Monthly	100%	Electronic and paper	This variable is monitored directly in the site. It is the total amount of production. For instance, the sales receipts that contain the quantity sold



ID number	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/paper)	Comment
								may be used for monitoring.
4. m_{pnr}	Total amount of non-renewable CO ₂ used in the process.	Local measurements through field instruments	t	M	Monthly	100%	Electronic and paper	The amount of non-renewable CO ₂ eventually used in the project needs to be monitored directly in the project site. The means of monitoring depends on each specific project. For instance, if CO ₂ is purchased from external suppliers, then, this variable can be monitored from the amount of CO ₂ purchased. The purchase receipts may be used for this purpose.
5. m_{pr}	Total amount of renewable CO ₂ used in the process.	Local measurements through field instruments	t	C	Monthly	100%	Electronic and paper	This variable is calculated from m and m_{pnr} . The calculation depends on the chemical produced and the stoichiometric equation that represents its production. With the stoichiometric equation, and the monitored variables m and m_{pnr} , the calculation is performed as a conventional stoichiometric calculation.

**Baseline emission parameters**

The following table illustrates the data to be collected or used in order to estimate emissions from the baseline activity.

ID number	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/paper)	Comment
6. m_{bnr}	Total amount of non-renewable CO ₂ used in the process before the start of the project activity.	Project site records	t	M	Monthly, over three years before the start of the project activity	100%	Electronic and paper	The amount of non-renewable CO ₂ eventually used in the baseline needs to be monitored directly in the site before the start of the project activity. The means of monitoring depends on each specific project. In case that no renewable CO ₂ has been used before the start of the project activity, m_{bnr} has not to be monitored.



ID number	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/paper)	Comment
7. m_{br}	Total amount of renewable CO ₂ used in the process before the start of the project activity.	Project site records	t	C	Monthly, over three years before the start of the project activity	100%	Electronic and paper	This variable is calculated from m and m_{bmr} . The calculation depends on the chemical produced and the stoichiometric equation that represents its production. With the stoichiometric equation, and the monitored variables m and m_{bmr} , the calculation is performed as a conventional stoichiometric calculation. In case that no renewable CO ₂ has been used before the start of the project activity, m_{br} is 0.
8. <i>Product</i>	Type of inorganic compound produced	Plant operator	Description of chemical substance	M	Annually after start of project activity	100%	Electronic and paper	The type of inorganic compound produced is monitored to assure that the product does not change and that the methodology remains applicable.

Leakage

The main potential source of leakage for this project activity lies in an increase in emissions due to diversion of CO₂ from other users to the project as a result of the project activity. This condition is checked in the validation of the project.



Quality Control (QC) and Quality Assurance (QA) Procedures

All measurements should use calibrated measurement equipment that is maintained regularly and checked for its functioning. QA/QC procedures for the parameters to be monitored are illustrated in the following table.

Data	Uncertainty Level of Data (High/Medium/Low)	Are QA/QC procedures planned for these data?	Outline explanation how QA/QC procedures are planned
1., 2.	low	Yes	Check consistency with literature.
3.	Low	Yes	Any direct measurements with mass or volume meters at the plant site should be cross-checked with an annual energy balance that is based on purchased quantities and stock changes.
8.	Low	Yes	Type of inorganic compound well known to producers.

Monthly, project participants should provide the stoichiometric balance of the process or database of measured quantities. Field instruments must be regularly checked, calibrated, and maintained. The amounts monitored should be cross-checked with the legal purchase receipts of these products.