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# Carbonated Materials

## Methodology for $CO_2$ Removal

Puro Standard

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## Contents

## Glossary

> **REMARK:** This glossary provides only the most important definitions for the current methodology. Please note that further definitions are listed in the Puro Standard General Rules. The glossary terms appear in *italics* in the text.

**Carbonate mineral** An ionic compound characterized by the presence of the carbonate ion, a polyatomic anion with the chemical formula $CO_3^{2-}$ (e.g. calcium carbonate, $CaCO_3$)

**Carbonated material** Any solid material that is characterized by the presence of metal carbonates (e.g. $CaCO_3$, $MgCO_3$)

**$CO_2$ Removal** A process achieved by a) absorbing $CO_2$ from or b) preventing its entrance to the atmosphere and converting the $CO_2$ to a stabile, durable storage, which for a *Long Term* prevents the $CO_2$ from being released to the atmosphere, see *Net Carbon Dioxide Removal*

**$CO_2$ Removal Certificate** An electronic document, which records the *Attributes* of $CO_2$ *Removal* from registered *Production Facilitys*. Each $CO_2$ *Removal Certificate* represents a *Net Carbon Dioxide Removal* volume of 1 ton of *Long Term* $CO_2$ *Removal*.

**$CO_2$ Removal Supplier** The party authorized to represent the end-to-end supply chain of the carbonated material production activity

**Long Term** A minimum length of 100 years

**Net Carbon Dioxide Removal** 1 Metric ton of $CO_2$ removed from the atmosphere net of any life cycle process emissions and intended to be stored for *Long Term*. Net CDR means that the total removal–emission balance of the $CO_2$ *Removal* activity is net negative.

**Output** The volume of $CO_2$ *Removal* within a certain time period which is eligible to receive CORCs. CORCs are always issued for *Net Carbon Dioxide Removal* in the production process, which means that the total volume of *Output* is determined by subtracting from the $CO_2$ *Removal* volume the $CO_2$ emissions volume generated directly or indirectly due to the production process or materials used according to the *Removal Method* specific *Methodology*.

**Output Audit** An audit performed by a 3rd party for determining that the volume of CORCs *Issuance* corresponds to the *Output* of $CO_2$ *Removal* of that time period from a registered *Production Facility* according to the *Removal Method* specific *Methodology*. In the audit, CORCs issued are compared with the reported *Output* in the *Output Report* for the same period.

**Production Facility** A facility capable of $CO_2$ *Removal* according to one or several *Removal Method* specific *Methodologies*.

**Production Facility Audit** An audit performed by a 3rd party to verify the details and eligibility of a *Production Facility* to be approved into the *System* according to the relevant *Removal Method* specific *Methodology*.

**Production Facility Auditor** An independent 3rd party verifier selected by the $CO_2$ *Removal Supplier* to perform *Production Facility Audits*. A *Production Facility Auditor* may be the same body as the *Output Auditor*. List of *Production Facility Auditors* accredited by the *Issuing Body* is available on the Puro.earth website.

**Removal Method** Method for a) absorbing $CO_2$ from or b) preventing its entrance to the atmosphere and keeping it stored for a *Long Term*. *Removal Methods* include capture, conversion of $CO_2$ to a stabile, durable format, and the *Long Term* storage.

## Acronyms

**CDR** Carbon Dioxide Removal

**CORC** $CO_2$ Removal Certificate, see $CO_2$ *Removal Certificate*

**EIA** Environmental Impact Assessment

**LCA** Life Cycle Assessment

## Chemical species

**$CaCO_3$** Calcium carbonate, see *Carbonate mineral*

**CaO** Calcium oxide

**CaOH** Calcium hydroxide

**$CO_2$** Carbon dioxide

**$MgCO_3$** Magnesium carbonate, see *Carbonate mineral*

**MgO** Magnesium oxide

**MgOH** Magnesium hydroxide

## Note to the reader

**REMARK:** This methodology provides general information as well as actual requirements which must be met by all projects seeking certification under the Puro Standard. Across the entire methodology, the requirements correspond to numbered rules with formatting conforming to the below example.

0.0.1 This is an example of a numbered rule. The requirements set within numbered rules must be followed by all projects seeking certification under the Puro Standard.

# 1 Introduction

This methodology quantifies the net $CO_2$ *Removal* achieved over the time horizon of **100 years** by the production of *carbonated materials*. The $CO_2$ *Removal* results from the chemical binding of $CO_2$ into the materials. More precisely, $CO_2$ *Removal* is achieved through **carbonation**, which is a chemical reaction between $CO_2$ and metal hydroxides or oxides (e.g., CaOH, MgOH, CaO, MgO) in the presence of water, leading to the formation of ionic *carbonate minerals* (e.g., $CaCO_3$, $MgCO_3$). The $CO_2$ *Removal* is considered **permanent**, with very unlikely risk of reversal due to the above-stated chemical process.

This methodology is applicable to certificates issued for the Puro Standard.

# 2 Eligible activity type

An **eligible activity** is an activity capable of producing as output *carbonated material* which is net $CO_2$ negative as per the system boundaries defined in this methodology, and which possesses a low risk of reversal as understood in the *IPCC Special Report on Carbon Dioxide Capture and Storage* [1].

## 2.1 Requirements for activities to be eligible

2.1.1 To be counted as removal, the carbon dioxide ($CO_2$) mineralised in the carbonated material shall be of **biogenic origin** or from **direct capture from the ambient atmosphere**. $CO_2$ originating directly from fossil fuels or lithospheric carbon (e.g. cement production) is therefore not eligible.[1] In case the captured $CO_2$ contains mixed sources, the fossil or lithospheric $CO_2$ is not eligible.

2.1.2 The **raw materials** used in the carbonated material production must be of eligible types, and EU or national legislation must be followed in the sourcing and extraction of the raw materials used.

2.1.3 The **eligibility** of the *Production Facility* is determined in the *Production Facility Audit* (see section 2.2).

## 2.2 Requirements for the *Production Facility Audit*

The *Production Facility Audit* is a process where a *Production Facility Auditor* inspects the *Production Facility* of the carbonated material to determine its eligibility under the requirements of the present methodology. The specific requirements of the audit are detailed below.

2.2.1 The *Production Facility Auditor* inspects the *Production Facility* against the requirements for activities to be eligible under the methodology (section 2.1), and the proofs needed from the $CO_2$ *Removal Supplier* (section 6).

2.2.2 The *Production Facility Auditor* checks that the *Production Facility* is capable of metering and quantifying the output in a reliable manner for the **quantification** of $CO_2$ *Removal*. The purpose of this procedure is to ensure that:

- The **quantity** of the carbonated material produced is quantified and documented in a reliable manner.
- Relevant **meters** are in place and calibrated.
- The **energy use** of the *Production Facility* can be quantified and the emissions from the process calculated.

[1] Although any source of carbon dioxide would lead to carbon storage, the requirement made here is to distinguish between carbon removals and avoided emissions. Restricting the scope to biogenic carbon and direct air capture allows to not incentivize fossil fuel consumption. See further distinctions in figure 1 of *The Oxford Principles for Net Zero Aligned Carbon Offsetting* (2020) [2, p. 7].

- The emissions from the **extracting** and **transporting** of the raw material are estimated and calculated in a reliable manner.
- The auditor cross checks the quantification of $CO_2$ *Removal* requirements with the $CO_2$ *Removal Supplier* so that the $CO_2$ *Removal Supplier* can independently calculate the $CO_2$ *Removal* in future periodic output reports.

This check also prepares the $CO_2$ *Removal Supplier* for producing periodic output reports.

2.2.3 The *Production Facility Auditor* collects and checks the **standing data** of the *Production Facility* and the $CO_2$ *Removal Supplier*. The data to be collected by the auditor includes:

- The $CO_2$ *Removal Supplier* registering the *Production Facility*. A certified **trade registry** extract or similar official document stating that the organization is validly existing and founded under the laws of the designated country.
- **Location** of the *Production Facility*.
- **Volume** of *Output* during the full calendar year prior to registration.
- **Removal Method** for which the plant is eligible to receive $CO_2$ *Removal Certificates* (CORCs).
- **Date** on which the *Production Facility* becomes eligible to receive CORCs.
- Whether the *Production Facility* has benefited from **public support or grants**.

2.2.4 The $CO_2$ *Removal Supplier* shall be able to demonstrate **Environmental and Social Safeguards** and that the *Production Facility* activities[2] do no significant harm to the surrounding natural environment or local communities. This may be done through one or several of the following:

- *Environmental impact assessment* (EIA).
- Environmental permit.
- Other documentation[3] approved by the Issuing Body on the analysis and management of the environmental and social impacts.
- When applicable, the *Production Facility* activities shall be developed with informed consent from local communities and other affected stakeholders and have a policy in place to address potential grievances.

2.2.5 The $CO_2$ *Removal Supplier* shall be able to demonstrate **additionality**, meaning that the project must convincingly demonstrate that the $CO_2$ *Removals* are a result of carbon finance. Even with substantial non-carbon finance support, projects can be additional if investment is required, risk is present, and/or human capital must be developed. To demonstrate additionality, the $CO_2$ *Removal Supplier* must provide full project financials and counterfactual analysis based on *Baselines* that shall be project-specific,

[2] It shall be noted that the responsibility of the *Production Facility* operator extends to the imminent environmental and human health related impacts of the use of manufactured product as far as concerned in the Environmental Impact Assessment or environmental permit.

[3] The provided documentation shall robustly address all material environmental and social impacts that could potentially materialize both within and outside the activity boundary. For environmental matters, the documented information should consider, where applicable, effects on human health, biodiversity, fauna, flora, soil, water and air, inter alia. For social matters, the documented information should consider, where applicable, effects on local communities, indigenous people, land tenure, local employment, food production, user safety, and cultural and religious sites, *inter alia*.

conservative, and periodically updated. Suppliers must also show that the project is not required by existing laws, regulations, or other binding obligations.[4]

[4] See the Microsoft criteria for high-quality carbon dioxide removal [3].

# 3 Point of creation of the $CO_2$ *Removal Certificate* (CORC)

## 3.1 Point of creation

3.1.1 The point of creation of the $CO_2$ *Removal Certificate* (CORC) is the **production of the carbonated material** that has absorbed $CO_2$ at the eligible *Production Facility*.

3.1.2 The producer of the **carbonated material** is the $CO_2$ *Removal Supplier*.

# 4 Assessment of life cycle greenhouse gas emissions

4.0.1 The $CO_2$ *Removal Supplier* shall conduct a *life cycle assessment* (LCA) for the carbonated material production activity including disaggregated information on the emissions arising at different stages. $CO_2$ *Removal Supplier* shall provide the results of the assessment in the form of an LCA report.

4.0.2 For the purpose of CORC determination, the *life cycle assessment* shall follow the rules for product LCA,[5] and the general guidelines of the **ISO standard 14040**.

4.0.3 For the purpose of CORC determination, the **system boundary** is set to **cradle-to-gate** of the facility, as illustrated in figure 1. The system boundary shall include emissions from production and supply of the materials (excluding e.g. the production of waste or other secondary materials, see rule 4.0.4), the sourcing of $CO_2$, and the production of the carbonated material.

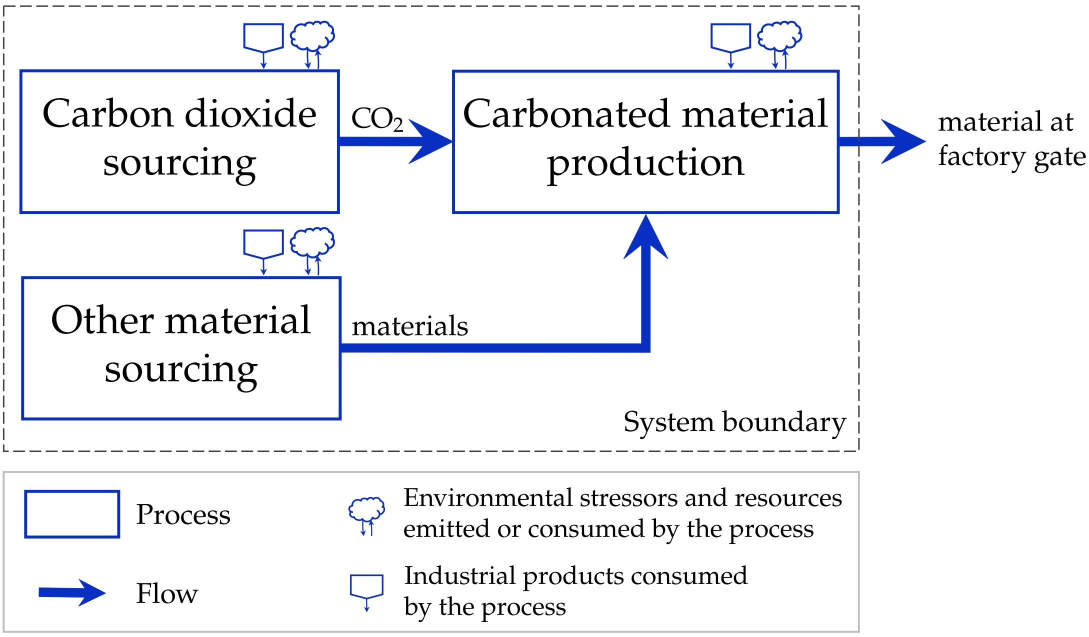


Figure 1: Flowchart describing the main processes involved in the production and distribution of carbonated material.

4.0.4 In the event that waste or secondary materials (such as e.g. mine tailings or other alkaline wastes) are being utilized in the production of the carbonated material, it is permissible and recommended to apply the cut-off approach for waste, recycled, and secondary products. Specifically, **the burdens from production of e.g. waste feedstock material can be excluded** from the system boundary, but the supply and

[5] In other words, the LCA shall be a product stand-alone LCA. If relevant, the results of the product stand-alone LCA can also be compared to an alternative reference product to provide additional perspective (e.g., climate change mitigation by substitution of the alternative product).

handling of the waste feedstock material must be included.[6]

4.0.5 In the event that by-products generated during the production of the carbonated material and that these by-products have a use (i.e. not sent for treatment or disposal), an allocation of the production burdens can be made between the co-products. Determination of an appropriate allocation rule shall follow principles from ISO 14040/44.

4.0.6 For the purpose of CORC determination, the system boundary **excludes** the distribution of the material, the use phase and the end-of-life of the material. These life cycle stages are considered to not affect the carbon removal, because:

- During the use phase, re-emission of $CO_2$ from the finished product does not occur in normal use conditions.
- At the end of life of the material, the $CO_2$ remains stored in the material, and removal is hence *a priori* permanent.

The material must also **not be exposed to conditions where reversal might occur** (see rule 6.4.4).

[6]Description of the cut-off system model is available on the website of the ecoinvent life cycle database: https://ecoinvent.org/the-ecoinvent-database/system-models/#!/allocation-cut-off. Under the cut-off approach "recyclable materials are available burden-free to recycling processes, and secondary (recycled) materials bear only the impacts of the recycling processes"

# 5 Calculation methodology for the quantification of $CO_2$ *Removal Certificates* (CORCs)

This section details how to **calculate** the amount of $CO_2$ *Removal Certificates* (CORCs) resulting from the production activity over a given reporting period, i.e. for a given amount of carbonated material produced. First, the **overall equation** and its parameters are presented, after which the details about the calculation of each term are summarized.

In the case of carbonated materials, the IPCC [1] has concluded that:

> "The fraction of $CO_2$ stored through mineral carbonation that is retained after 1000 years is virtually certain to be 100 %. As a consequence, the need for monitoring the disposal sites will be limited in the case of mineral carbonation."

This methodology hence possesses a very low risk for reversal, provided that the risk for exposure to e.g. high temperatures during end use is adequately mitigated (see also rules 6.4.2 and 6.4.4).

## 5.1 Overall equation

The **overall equation** to calculate the number of CORCs is illustrated in figure 2. It includes three **(3) variables**:

- $E_{\text{stored}}$ describes the **amount of $CO_2$ sequestered** over a 100-year time horizon by the carbonated material produced. Guidelines for the calculation of $E_{\text{stored}}$ are given in section 5.2.
- $E_{\text{production}}$ describes the **life cycle greenhouse gas emissions** arising from the production of the carbonated material and its constituents. Guidelines for the calculation of $E_{\text{production}}$ are given in section 5.3.
- $E_{\text{baseline}}$ describes describes the amount of $CO_2$ that the feedstock material **would have sequestered naturally** (in the absence of project activities) **in 50 years** following the commencement of the accelerated carbonation activity. Guidelines for the estimation of $E_{\text{baseline}}$ are given in section 5.4.

$$\text{CORCs} = E_{\text{stored}} - E_{\text{production}} - E_{\text{baseline}}$$

| | CORCs | $E_{\text{stored}}$ | $E_{\text{production}}$ | $E_{\text{baseline}}$ |
|---|---|---|---|---|
| Description | Amount of net $CO_2$-eq removed by the production of carbonated material over the reporting period | Amount of $CO_2$ sequestered in carbonated material by the project over the reporting period | Life cycle emissions arising from the production of the carbonated materials during the reporting period | Amount of $CO_2$ that would be sequestered in the material under baseline conditions |
| Units | Tonnes of $CO_2$-eq | Tonnes of $CO_2$ | Tonnes of $CO_2$-eq | Tonnes of $CO_2$ |

Figure 2: Overall equation to calculate the amount of CORCs supplied by the production activity over a given reporting period. The tonnes unit refers to metric tonnes (i.e. 1000 kg). All terms are counted as positive.

> **REMARK ON SIGN CONVENTIONS:** In the equation shown in figure 2, the amount of CORCs and the three (3) terms are positive numbers. The amount of CORCs supplied is equal to the amount of $CO_2$ sequestered **minus** life-cycle emissions from the production process.

## 5.2 Carbon stored in material ($E_{\text{stored}}$)

The term $E_{\text{stored}}$ is calculated as a product of the **amount of carbonated material produced** over the reporting period ($Q_{\text{CM}}$, in tonnes) and the actual amount of $CO_2$ sequestered per tonne of product ($A_{CO_2}$, in tonnes of $CO_2$ per tonne of product). Specifically,

$$E_{\text{stored}} = Q_{\text{CM}} \times A_{CO_2}, \tag{1}$$

where:

- $Q_{\text{CM}}$ is the **amount of carbonated material produced**, in metric tonnes, produced by the supplier over the reporting period. It is calculated by the supplier based on appropriate documentation (see rule 5.2.1).
- $A_{CO_2}$ is the **actual amount of $CO_2$ sequestered**, in tonnes of $CO_2$ per tonne of product. It is determined by the supplier based on laboratory measurements or other scientifically sound methods (see rule 5.2.2).

5.2.1 The $CO_2$ *Removal Supplier* is responsible for the determination of the amount of carbonated material produced ($Q_{\text{CM}}$), and appropriate documentation in support of the determination (e.g., number of units produced, weight of units produced) must be available.

5.2.2 The $CO_2$ *Removal Supplier* is responsible for the determination of the actual amount of $CO_2$ sequestered in the carbonated material ($A_{CO_2}$). The determination must be based on laboratory measurements or other scientifically sound method of quantification verified by a qualified third-party auditor.[7]

[7] Such quantification methods might consist of e.g. thermogravimetric analyses or analyses based on acid

**NUMERICAL EXAMPLE**

Company A has produced over one (1) year, 200 000 tonnes of carbonated material, which has been shown to store 35 kg of $CO_2$ per every tonne of material.

$$Q_{CM} = 200\,000\,\text{t}$$
$$A_{CO_2} = 35\,\text{kgCO}_2/\text{t}$$
$$E_{\text{stored}} = 200\,000\,\text{t} \times 0.035\,\text{tCO}_2/\text{t} = 7000\,\text{tCO}_2$$

## 5.3 Production of material ($E_{\text{production}}$)

5.3.1 The term $E_{\text{production}}$ must be derived from the *life cycle assessment* of the carbonated material. This term must include all greenhouse gas emissions from the activities involved in the production of the material. For transparency, the activities involved may be grouped in the following three **(3) groups**:

- Sourcing of the $CO_2$.
- Sourcing of other materials (e.g., aggregates, water, slag).
- Production of material.

5.3.2 For any activity included, a **full scope of emissions** must be included (i.e., including all life cycle stages (manufacturing, use, and disposal) of the processes involved.[8] Any material input, energy input, or waste output must be included.

In the case of a **multifunctional process** (i.e., another useful product is generated in addition to the carbonated material), then burdens should be allocated between the two products. The choice of allocation factors should be justified (see rule 4.0.5).

## 5.4 Baseline emission reductions and removals ($E_{\text{baseline}}$)

Certain **reactive materials**, such as ultramafic mine tailings and some alkaline wastes, possess the capacity to naturally sequester significant amounts of $CO_2$ from the atmosphere through **spontaneous mineral carbonation**. This is exemplified by the precipitation of carbonate minerals within mine tailings and the formation of carbonate crusts at their surface [6].

The term $E_{\text{baseline}}$ describes the amount of $CO_2$ that the feedstock material **would have sequestered naturally** (in the absence of project activities) **in 50 years** following the commencement of the accelerated carbonation activity. The purpose of its inclusion is to ensure that the $CO_2$ *Removal* credited as CORCs is a result of human intervention, additional to Earth's natural processes in the short term.

5.4.1 The $CO_2$ *Removal Supplier* must present a **scientifically justified estimate of the baseline sequestration** amount ($E_{\text{baseline}}$). Specifically, the $CO_2$ *Removal Supplier* must present an estimate of the **amount of $CO_2$ (in tonnes)** that, in the absence of the project activities, would have been naturally sequestered by the specific material utilized in the project **over a time period of 50 years** following the commencement of the

digestion. It is also permissible to utilize e.g. the Steinour formula (originally presented in [4]; see e.g. [5, eq. 6] for a more easily accessible reference) or other theoretical composition-based quantification formulas provided that an appropriate buffer is included to account for the inherent uncertainties related to such formulas.

[8] For example, use of solar electricity in the process should not be considered to have a null climate impact, rather its climate impact should include the emissions from production, installation, maintenance, and disposal of the panels. Likewise, equipment and infrastructure needed for the project ought to be included.

accelerated carbonation activity. The estimate must be **conservative** and be based on information gathered from either the $CO_2$ *Removal Supplier*'s own scientific research or peer-reviewed scientific publications.

5.4.2 The estimate shall consider at least the effect of **three (3) factors** to the sequestration rate: **mineralogy**, **physical form** (including particle size) and **likely storage conditions**. The sequestration amount shall be estimated based on the physical form of the material (e.g. solid mineral, ground particles, or fine dust) it would have been in without the project's activities.[9]

5.4.3 To perform the estimate, it is permissible to utilize e.g. **average sequestration rates from scientific literature**, if such values are available and applicable to the external conditions under consideration. A full chemical kinetics simulation is not required.

5.4.4 The $CO_2$ *Removal Supplier* must utilize reasonable, **conservative assumptions** for variable factors such as likely storage conditions during the estimation period.[10]

5.4.5 The baseline estimate shall include a discussion of the level and sources of uncertainty in the amount of $CO_2$ sequestered.

5.4.6 The **baseline estimate** shall only consider the effect of **natural $CO_2$ sequestration** of the feedstock material. Specifically, no deductions due to e.g. avoided emissions or any other project activities may be included.[11] The baseline sequestration amount can hence never be negative.

5.4.7 For inert feedstock materials, the baseline estimate and its effects on the amount of CORCs can be ignored in cases where it is **scientifically reasonable** to assume that the amount of $CO_2$ sequestered naturally by the material would be 1 % or less of the total amount sequestered by the project. However, it shall be the responsibility of the $CO_2$ *Removal Supplier* to present scientific evidence to support such an assumption.

5.4.8 The $CO_2$ *Removal Supplier* must present its baseline estimate and the underlying assumptions and sources thereof to Puro experts for review. The reliability of the estimate shall be at the discretion of Puro experts.

5.4.9 Projects, where the **baseline sequestration** amount is estimated to be 50 % or more of the total amount sequestered are **not eligible** to be credited under the Carbonated Materials methodology.

[9] For example, projects aiming to utilize existing mine tailing storages must base the estimate on the type and size of particles typically found in such tailings.

[10] It is noted that predicting the future is inherently inaccurate, as there might be e.g. unforeseen changes in storage conditions during the estimation period. Nevertheless, the $CO_2$ *Removal Supplier* should strive to account for such uncertainties to the best of their ability.

[11] For a specific example, if the feedstock material were transported from a mine to the reactor site via diesel truck, it is not permissible to deduct the $CO_2$ emissions from the baseline sequestration amount on the basis that such emissions would not have occurred in the absence of the project's activities.

# 6 Proofs needed from the $CO_2$ *Removal Supplier*

## 6.1 Principle

6.1.1 The *Output* of a *Production Facility* is eligible for **issuance** of $CO_2$ *Removal Certificates* (CORCs) once the facility has undergone a process of **third-party verification** by an auditor against the specific methodology for the carbonated material. This verification is done in a *Production Facility Audit* (see section 2.2). During the *Output Audit*, the verification ensures that the corresponding $CO_2$ *Removal* has taken place.

6.1.2 The $CO_2$ *Removal Supplier* is responsible for producing the various **proofs needed to ensure the eligibility** of the $CO_2$ *Removal* activity under the present methodology. The necessary proofs are further detailed in sections 6.2–6.5.

## 6.2 Raw materials used

6.2.1 The $CO_2$ *Removal Supplier* must present information on:

- The raw materials used and their composition.
- The assumed emission factors for the supply (extraction and manufacturing) of the raw materials.
- The scope of emissions included in the emission factors.

The information may be presented in the form of a product LCA.

6.2.2 The raw materials (e.g., sand, gravel, binder, $CO_2$, water, slag) should be **sustainably sourced** and sourced in accordance to local regulations.

## 6.3 Production process and product quality

6.3.1 The $CO_2$ *Removal Supplier* must present a **proof of net $CO_2$ negativity**, i.e. that the product stores more $CO_2$ than has been emitted within the system boundaries defined in this methodology. The proof can take the form of an LCA report (see rule 4.0.3).

6.3.2 The $CO_2$ *Removal Supplier* must present **laboratory test results** (or other scientifically reliable analyses by a trusted third party) quantifying the amount of $CO_2$ sequestered by the material (see also rules 5.2.1 and 5.2.2).

## 6.4 End of use or disposal

6.4.1 The $CO_2$ *Removal Supplier* must provide a **statement of end use** for the carbonated material. The statement must at least specify:

- The intended end use of the carbonated material (e.g. whether utilized in construction materials or other products, or stored permanently).

- The storage conditions of any carbonated material intended for permanent storage (e.g. the type, location, and general properties of the permanent storage site)
- A description of any products where the carbonated material is intended to be utilized, including the estimated lifetime and end of life use of the products.

Specifically, the statement of end use must detail how the permanence of the $CO_2$ storage is ensured by the end use conditions (see also rules 6.4.2–6.4.4 about risk assessment and mitigation, major risks to permanence of sequestration, and long-term storage planning).

6.4.2 The $CO_2$ *Removal Supplier* must provide a **risk assessment and mitigation plan** for the risks related to the permanence of the $CO_2$ sequestration and potential re-emission of $CO_2$. The risk assessment must be comprehensive and specific to the intended end use of the carbonated material. The risk assessment and mitigation plan must at least address:

- Risks for exposure to chemical or physical conditions affecting storage permanence (see also rule 6.4.4).
- Risks related to the destruction, re-purposing, or other end of life use of any product(s) where the carbonated material is intended to be utilized.[12]
- Risks related to any potential major changes in the storage conditions of any carbonated material intended for permanent storage, such as due to e.g. decommissioning or destruction of the storage site (see also rule 6.4.3).

Furthermore, the risk assessment and mitigation plan shall include at least a qualitative estimation of the likelihood of each of the risks identified, and an outline of the measures in place to mitigate the effects to re-emission of the sequestered $CO_2$.

6.4.3 The $CO_2$ *Removal Supplier* must provide a **long-term storage plan** for any carbonated material intended for permanent storage. The long-term storage plan must specify the measures in place to ensure the permanence of the carbonated material during storage, taking into account the identified risks (see rule 6.4.2). Furthermore, the long-term storage plan must also specify how the permanence of the carbonated material is ensured in cases where:

- The $CO_2$ *Removal Supplier* ceases to exist as a legal entity.
- The ownership of the storage site and/or the stored carbonated material is transferred to a third party.
- The storage site is destroyed or decommissioned (e.g. as a part of mine remediation or similar).

6.4.4 The carbonated material **must not be exposed** to conditions resulting in the **reversal of $CO_2$ sequestration**, nor utilized for purposes where exposure to such conditions can occur. Such conditions include e.g. high temperatures[13] where carbonates start to

[12] Specifically, it is noted that in cases where the carbonated material is utilized in construction materials, the demolishing of such materials at end of life does not under normal circumstances lead to the re-emission of the stored carbon dioxide. The crushed material can be reused e.g. in road construction or in new carbonated products without the sequestered $CO_2$ being re-emitted to the atmosphere.

[13] The precise thermal decomposition range for metal carbonates varies by species, but is usually several hundred degrees centigrade for the carbonates relevant to this methodology, e.g. around 750 °C for $CaCO_3$ [7].

thermally decompose, or exposure to strong acids.[14]

## 6.5 Proof of no double counting

6.5.1 Double counting is avoided by the use of the Puro Registry, with a system of unique identification of each CORC that guarantees it is only used once. Each CORC in the registry contains information on *Production Facility* registration and crediting period dates, verification, issuance and retirement transactions as well as the title and ownership over time.

6.5.2 No marketing and branding claims can be made by the end-user (user of the carbonated material) indicating that the material is a carbon storage, when the decoupled $CO_2$ *Removal Certificate* (CORC) has been sold to and accounted by another stakeholder. The proof can be a statement, an offtake agreement, or documentation of the sale or shipment of the product, indicating the title to the CORC.

6.5.3 A **disclaimer** is required if the $CO_2$ *Removal Supplier* and the end user in marketing and branding claims choose to include the carbon net-negativity, carbon removal, carbon drawdown or carbon sink aspects of the product. The disclaimer should state that the carbon credit associated with the physical product is managed in Puro.earth's carbon removal registry.

[14] As a specific example, the utilization of e.g. calcium carbonate as a filler or coating in paper or board applications is not allowed, as such material might be incinerated at the end of use, resulting in the re-emission of $CO_2$.

## References


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