# Completion aid

The red parts must be overwritten by the project proponent.

The *red parts in italics* give an explanation of what the project proponent has to provide at this place.

The black parts are default entries, which will apply to most projects. The project proponent is free to change them, but must use the track-change-mode if doing so.

# Project Design Document

Logo of the project to be inserted here

Name of project: xxx

Name of quality manager: xxx

Date of issue: xx.xx.xxxx

Methodology: Global Biochar C-Sink 3.0

Project location: xxx

Project start date: XX.XX.XXXX *(Date of contract conclusion with Carbon Standards or registration date for the Global Biochar C-Sink service. Or, in the case of retroactive certification, the production date of the batch.)*

Project period: The project has no end date, but it is verified on an annual basis

Project summary: *(2 sentences about the project)*

The project will increase carbon sequestration by working the produced biochar into different matrixes and in this way create a long-term carbon storage with a persistence of up to 1000 years as according to the Global Biochar C-Sink Standard. Without the project, no C-sink would be created since *feedstock* does not constitute a long-term carbon reservoir.

In the initial 5 years of the project we expect carbon sequestration of approximately xxx CO2eq in total or xxx CO2eq / year.

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# Purpose and general description of project

The project *(projectname)* compromises xx pyrolysis plants for biochar production from *(feedstock).* Biochar is a hyper versatile material with an increasing number of applications in agriculture, environmental engineering, and basic industry. Biochar applied a matrix permitted by the Global C-Sink Standard poses a stable carbon sink (C-sink). Without the project, no C-sink would be created since Pomace does not constitute a long-term carbon reservoir.

*(Write about 2 sentences about baseline.)*

Another objective of the project is to improve the soil quality in xx by marketing biochar as soil amendment. Biochar can improve soil quality significantly because of its impact on the soil pH, its water retention capacity, and its ability to store nutrients.

Furthermore, the biochar may be used as temporary C-sink or as additive in construction materials or consumer products.

## Project location

*(Where will the project take place?)*

*(Provide GPS location of pyrolysis unit)*

The geographical locations of the subsequently installed plants will be documented in the biochar tool *(or other dMRV tool*).

*(Where will biochar sold to)*

*(Provide map indicating the before mentioned regions)*

## Description of baseline scenario

*(Describe Baseline)*

The baseline scenario for carbon removal accounting is the "business as usual", in which no permanent biochar-based carbon sink is generated and is considered as zero. The fact that biomass could have been used differently in the baseline scenario, has no impact on the consideration of the baseline as zero.

## Biochar carbon sinks

When plant biomass is burnt or decomposed, the assimilated carbon is released again in the form of CO2. However, if the plant biomass is pyrolyzed, about half of the plant carbon is transformed into a mixture of predominantly very persistent carbon compounds that form a solid material known as biochar. While in the environment, any carbon compound is subject to degradation; for most components of biochar, this process is extremely slow, and mostly even so slow, that it is hard to measure for thousands of years. Provided that the biochar is not burned, the biochar carbon remains as a C-sink in the terrestrial system.

If biochar with an H to Corg ratio < 0.40 is applied to soil, a major part of its carbon is considered Persistent Aromatic Carbon (PAC, the portion of biochar carbon bound in clusters of more than seven aromatic rings as analyzed by the hydro pyrolysis method) and will constitute a carbon sink for several millennia. A minor though relevant part of the biochar-carbon is less persistent (semi persistent carbon, SPC) and likely to be microbially degraded within decades to centuries, presenting a mean residence time of 50 years. The biochar carbon that may be decomposed within the first 1000 years after the application to soil is called Semi-Persistent Carbon (SPC) and constitutes a temporary C- sink. For biochars presenting an H to Corg ratio < 0.4, the PAC fraction is conservatively fixed by the standard at 75% and the SPC fraction at 25%.

## Project Boundary

Scope 1 and Scope 2 emissions as well as transport emissions from Scope 3 in connection with the production, processing and application of biochar for the creation of a C-sink.

## Eligibility

*(All checkmarks have to be ticked)*

□ Production of biochar according to EBC/WBC criteria in place.

□ Producer is a legal entity and hold an operating license for the entire project region.

□ Social Impact: The project complies with the requirements set by the methodology, see annex 17-0-2EN Self-Assessment Social Responsibility.

## Additionality

The required additionality test consists of 3 steps. The project is deemed additional if it leads to additional carbon removal.

## Assessment of regulatory requirements for biochar production and application as a removal technology

*(Assess whether biochar production and carbon preserving application is required in the country where the producer operates. All relevant permits and regulations need to be presented. A project is only additional, if no legally binding requirements for the production and carbon-preserving application of biochar can be identified.)*

## Additional Carbon Removal

The C-sink efficiency of a pyrolysis facility is a measure of the part of biomass-carbon that is preserved by a technical transformation process as a potential C-sink. According to chapter 4.2.4 of the PDD the producer commits to publish the C-sink efficiency of the production facility annually. This makes the clear objective of transforming a growing proportion of biomass carbon into carbon sinks transparent.

## Biomass Feedstock Additionality

*(Biochar C-sinks must be additional to natural C-sinks that could or would have been realized with the same biomass feedstock in the absence of the biochar C-sink solution. Asses your baseline thoroughly (chapter 1.2 and 3.2 of the PDD) regarding natural C-sinks that could have been realized. Demonstrate that the C-sink potential of the project is superior by showing that your feedstock sourcing complies with the safety measures given in the Global biochar C-sink standard chapter 5.3)*

# Ex-ante estimate of impact

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Year of operation | Amount of feedstock (DM) | C-sink potential (tCO2eq) | Established temporary C-sinks (tC) | Established permanent C-sinks (tCO2eq) |
| 1 | X | X | X | X |
| 2 | X | X | X | X |
| 3 | X | X | X | X |
| 4 | X | X | X | X |
| 5 | X | X | X | X |
| sum | X | X | X | X |

# Technology and business cases

## Production unit

Biochar is produced via pyrolysis technology. Pyrolysis means the thermo-chemical decomposition of the feedstock under the exclusion of oxygen.

By converting sustainable biomass into biochar by pyrolysis, a long-term carbon reservoir is created. At the factory gate of the production unit the biochar poses a potential of C-sink (C-sink potential). It could still be burned. By safety measures, such as marketing and labeling the biochar with the aim of becoming ana C-sink and monitoring all distribution channels in a digital Measurement, Reporting and Verification tool (dMRV), it is ensured in the best possible way, that the biochar is used to form a C-sink. C-sink certificates are only issued for those parts of the PC for which it can be proven that they have been put in a matrix. Without the project, no C-sink would be created, as non-pyrolytic biomass does not ensure persistent carbon storage.

The produced biochar is certified under the xx, what guarantees that the biomass feedstock is sustainably procured and produced, biochar fulfils the analytical threshold values so no damage is caused to the environment, emissions limits of the pyrolysis unit are adhered to and storage procedures are environmentally sound.

The biochar production follows the xx standard, which ensures:

* Compliance with laws regarding air pollution control
* Minimization of risks on human health, social and environmental impacts
* Energy and carbon efficiency
* Sustainable origin of the feedstock

Type of pyrolysis unit

Xxx,

Planned operating hours per year: xx

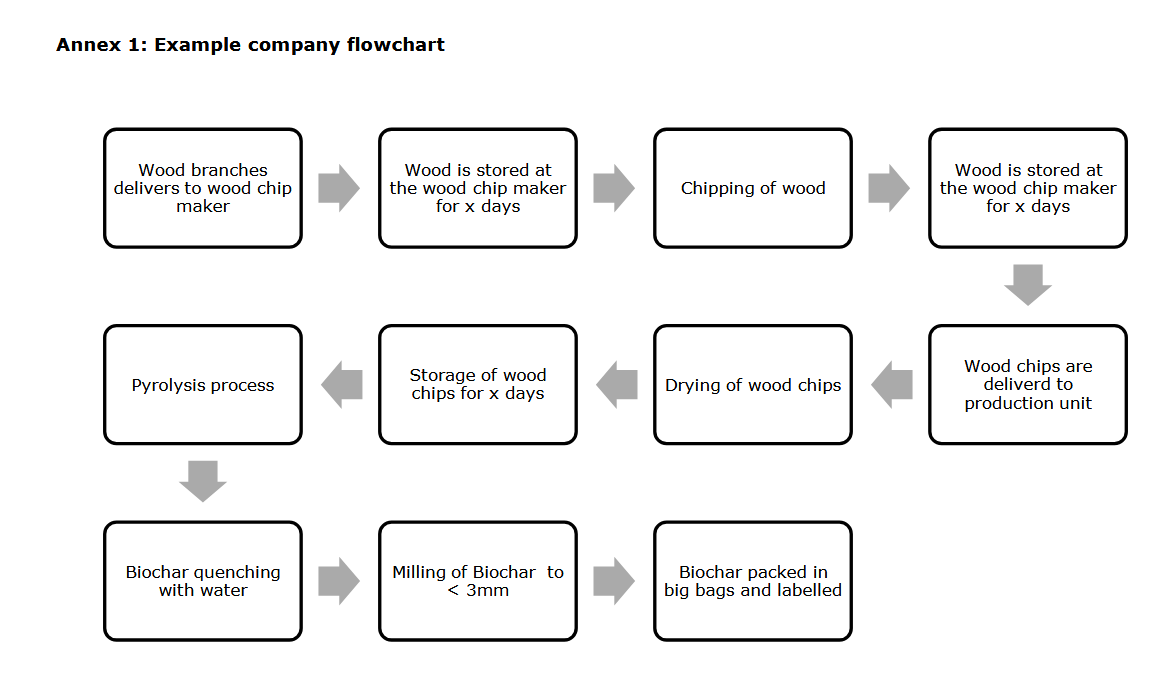
Planned feedstock consumption: xx

Nominal biochar production: xx

Concept for waste energy recovery

*(Provide details on how you plan energy recovery, concerning energy and technical implementation. )*

*(provide company flowchart from technical pre-audit)*



## Feedstock

All used feedstock corresponds to the EBC positive list.

Only C-neutral biomass input materials are permitted for the production of biochar C-sinks. Biochar produced from biomass whose harvesting resulted in the destruction or depletion of a natural C-sink (e.g., clear-cutting of a forest) or has contributed to the disappearance of an existing sink (e.g., inappropriate agricultural practices on bog soil) does not render any positive climate service and must not be used for C-sink-potential certification.

However, it must be ensured that the removal of harvest residues does not decrease soil organic carbon stocks .

In the project the following feedstock is used which is eligible with the sustainability criteria:

|  |
| --- |
| xxxx |

Origin of feedstock:

*(Describe what feedstock the producer is using and how it was used before the biochar production started.)*

The feedstock mentioned above corresponds to the general feedstock classes:

□ (1) Biomass from annual cropping

□ (2) Biomass from pluriannual and perennial cropping including short rotation

plantations

□ (3) Forest biomass

□ (4) Wood from landscape conservation, agro-forestry, forest gardens, field margins,

and urban areas

□ (5) Wood processing waste and waste wood materials

□ (6) Organic residues from biomass processing

□ (7) Municipal waste and municipal waste digestate

□ (8) Manure and agricultural digestate

□ (9) Biosolids and biosolid digestate

□ (10) Other biogenic residues

To avoid methane emissions during storage of biomass the following principles should be followed:

*(Producers can also get a custom storage plan approved by Carbon Standards. Mandatory for biomass from class (7) and (8).)*

* Wood and other biomass should be chipped only a few days and at a maximum of four weeks before pyrolysis. Log storage is considered unproblematic regarding methane emissions; coarse wood (thinner logs, branches, cuttings, etc.) should be stored as airy as possible and not mixed with green waste.
* If just-in-time chipping is not possible, the wood chips or biomass should be dried as soon as possible, e.g., with the excess heat from pyrolysis and stored dry with a maximum of 20% residual moisture. If the biomass is sufficiently dry, biodegradation does not take place or is slowed down considerably.
* Alternatively, the wood chips or the biomasses can be stored in small, well-ventilated containers such as lattice boxes (max. 2 m3). Due to sufficient ventilation, anaerobic degradation and thus methane emissions can be prevented.

If compliance with these principles cannot be fulfilled, actual practice and parameters according to the monitoring plan will be documented.

## Distribution channels of biochar

The following applications are possible for this project:

* Geological C-sink (biochar applied to soil)
* Temporary C-sink (biochar used in materials)
* Temporary storage of biochar

## Planned business development

*Describe producers plans for business development. E.g. feedstock usage, distribution channels, scale-up.*

# Determination of C-sink potential

## Monitoring plan

All data which are required to calculate the C-sink potential is entered into a dMRV System. The dMRV system is either provided by Carbon Standards or by an external MRV system provider. External MRV systems and tools must be endorsed by Carbon Standards annually. The data will be monitored as mentioned below. Each packaging unit containing more than 1 m3 of biochar must be labeled with a scannable identification code provided by the biochar dMRV System, which shows the following information:

- Biochar producer

- Batch ID

- Biochar analyses

- Date of production

- Year of CO2 removal

- Owner of C-sink material

- Point of departure (GPS) for all kind of transports > 1 km.

- Biochar C-content

- Link to the emission portfolio

Packaging units smaller than 1 m3 biochar may be grouped into a larger unit (e.g., 20 bags of 50 l packed on a palette) where the larger unit is labeled with the scannable identification code, given that all smaller units have the same destination.

### General data

The following general data will be monitored:

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Monitoring frequency** | **Source of data** |
| Batch Start Date | per batch | Internal documentation |
| Batch End Date | per batch | Internal documentation |
| H/Corg ratio | per batch | laboratories endorsed by Carbon Standards, see <https://www.carbon-standards.com/en/standards/service-501~ebc-c-sink.html> section Laboratories |
| C-content of biochar | per batch | laboratory endorsed by Carbon Standards, see <https://www.carbon-standards.com/en/standards/service-501~ebc-c-sink.html> section Laboratories |
| M\_biochar (DM)  (Total biochar production of batch (expected) in t dry matter) | Per batch | Protocols documenting the sampling.  Dry weight and total carbon content per big bag is recorded by means of drying a sample of biochar all 10 m3, according to methods explained in Global Biochar C-Sink Standard, chapter 9.2. |
| Biochar Production (DM) | continous | operation recordings |
| Plan outlining how to reduce fossil GHG emissions of biochar production to less than 100 g CO2eq per ton of biochar until 2030 and to less 20 g CO2eq per ton of biochar until 2035 | The fossil emission reduction plan must be updated annually and include a short progress report. | operation recordings |

The following general conversion rates are fixed ex-ante:

*(If project proponent wants to use different parameters they have to be well justified and accepted by Carbon Standards.)*

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Ex-ante definition; value** | **Source of data** |
| CO2 emissions from diesel | 3.2 kg CO2eq / l diesel | Methodology, Juhrich, 2016 |
| CO2 emissions from heavy fuel | 65 t CO2eq / TJ | Methodology, Juhrich, 2016 |

### Emissions from fossil fuels

#### Feedstock

For the feedstock the following parameters will be monitored:

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Monitoring frequency** | **Source of data** |
| Type of feedstock (with ID of EBC positive list) | continuous | purchase receipts and EBC positive list |
| Average water content of feedstock at delivery | per batch | documentation of frequent measurements |
| Amount of feedstock (DM) processed for the last batch | per batch | production protocols |
| Total amount of feedstock (dry matter) used for the batch | per batch | production planning |
| Year of removal, determined as per the following table | for each feedstock delivery | x |
| Amount of fertilizers used as per the following table in kg N | for each feedstock delivery | x |
| Area on that pesticides were used as per the following table in ha | for each feedstock delivery | x |
| Amount of input of fuels for cultivation and harvest | for each feedstock delivery | x |
| Amount of diesel used for feedstock preparation | continuous | purchase receipts |
| Amount of electricity used for feedstock preparation | continuous | electricity meter |
| CO₂eq of electricity used for the pyrolysis plant in g CO₂eq/kWh |  | electricity provider |
| How do you dry the feedstock? | Continuous | Statement |
| Amount of fuel equivalent used for drying per ton (DM) of feedstock? | continuous | purchase receipts |
| Amount of electric energy used for drying per ton (DM) of feedstock | continuous | purchase receipts |

For determination of year of CO2 removal and of amount of fertilizers and pesticides the following requirements apply:

|  |  |  |
| --- | --- | --- |
|  | Determination of year of CO2 removal | Determination of amount of Fertilizers and Pesticides |
| (1) Biomass from annual cropping | The time of the CO2-removal to be submitted to the Global C-Sink Registry is the year of harvest. | If biomass was deliberately grown to produce biochar, i.e., when it was the single or main  product of this field, carbon expenditures for fertilization and pesticides need to be accounted for. |
| (2) Biomass from pluriannual and perennial cropping including short rotation plantations | If pluriannual or permanent crops are harvested annually to provide feedstock for biochar production, there is no difference compared to the accounting for biomass from annual crops (i.e., N-fertilizers are accounted annually, the time of CO2 removal is the year of harvest).  If the biomass harvest is only every second, fifth, or twentieth year, the time of CO2  removal must be tracked for every single year of growth and entered accordingly into the Global C-Sink Registry. | If pluriannual or permanent crops are harvested annually to provide feedstock for biochar production, there is no difference compared to the accounting for biomass from annual crops (i.e., N-fertilizers are accounted annually, the time of CO2 removal is the year of harvest).  If the biomass harvest is only every second, fifth, or twentieth year, the carbon expenditures  for fertilizers and fuels must be accounted for the entire growing period. |
| (3) Forest biomass | If the regrowth of last year is harvested and pyrolyzed, the time of removal is set to the year of harvest. If the regrowth of several years is harvested, the time of removal must be distributed proportionally to the growth years and entered accordingly into the Global C-Sink Registry as described in the Global Tree C-Sink Standard. | It is assumed that no fertilization occurs in the forest. |
| (4) Wood from landscape conservation, agro-forestry, forest gardens, field margins, and urban areas | For pruning and landscaping material, the time of CO2 removal is assumed to be the year of cutting. | If trees or hedges on agricultural land are pruned or trimmed but not felled and thus grow  back from their roots, the biomass is considered C-neutral. Biomass from nature conservation, landscape management, including disaster debris removal and roadside greenery, and urban  areas, is also considered C-neutral.  Trees from forest gardens, orchard meadows, tree lines, and hedges for arable farming are  often decades old. They have to be managed so that the amount of wood removed per unit  area does not exceed the amount of the average annual regrowth. |
| (5) Wood processing waste and waste wood materials | The time of CO2 removal is set to the year of pyrolysis. | considered C-neutral |
| (6) Organic residues from biomass processing | The time of CO2 removal is set to the year of pyrolysis. | considered C-neutral |
| (7) Municipal waste and municipal waste digestate | The time of CO2 removal is set to the year of pyrolysis. | Organic waste is considered C-neutral, for other waste radiocarbon analysis of a representative sample is required. |
| (8) Manure and agricultural digestate | The time of CO2 removal is set to the year of pyrolysis. | considered C-neutral |
| (9) Biosolids and biosolid digestate | The time of CO2 removal is set to the year of pyrolysis. | considered C-neutral |
| (10) Other biogenic residues | The time of removal would generally be the year of pyrolysis, though this is verified during the certification procedure. | considered C-neutral |

In case of the usage of forest biomass the following criteria also applies:

If the climate neutrality of a forest is not ensured by the official LULUCF reports of the respective country or by regional legislation, proof can also be provided by *Program for the Endorsement of Forest Certification* (PEFC) or *Forest Stewardship Council* (FSC) certifications and the Global Tree C-Sink certification (cf. chap. 5.4). Alternatively, the carbon balance of the forest could be verified by ISO16064-accredited assessment of CO2 fluxes for the last 20 years.

The following general conversion rates are fixed ex-ante:

*(If project proponent wants to use different parameters they have to be well justified and accepted by Carbon Standards.)*

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Ex-ante definition; value** | **Source of data** |
| CO2 emissions from Nitrogen fertilizer | 1 t CO2eq / 100 kg N | Methodology, Zhang et al., 2013 |
| CO2 emissions from persticides | 94 kg CO2eq per hectare | Methodology, Audsley et al., 2009 |

#### Pyrolysis

For pyrolysis the following parameters will be monitored:

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Monitoring frequency** | **Source of data** |
| Electricity consumption of pyrolyser for the entire batch (in kWh) | per batch | x |
| Source of electric energy for the pyrolysis plant | per batch | x |
| CO₂eq footprint of electricity used for the pyrolysis plant in g CO₂eq/kWh | per batch | electricity provider |
| Energy source to preheat the pyrolysis reactor | per batch | x |
| Amount of fuel which is used to preheat the pyrolysis reactor in t per batch | per batch | x |
| CO₂eq of fuel used for the pyrolysis plant per t | per batch | invoices for purchasing fossil fuels |

If it is assumed that the energy content of the marketable non-biochar output is higher than 50% of the energy contained in the feedstock input (EnonBCoutput / input > 50%), the emission portfolio of the biochar

C-sink may be established using the pro rata approach. Therefore, following parameters will be monitored additionally.

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Monitoring frequency** | **Source of data** |
| Lower heating values (LHV) of feedstock and products (biochar,\_non-biochar\_solid, liquid, gas) | per batch | The LHV of the biochar and charcoal must be analyzed from the EBC/WBC certification sample |
| Dry masses of feedstock and products (biochar,\_non-biochar\_solid, liquid, gas) | per batch | x |
| Produced quantity of electricity per batch | per batch | sales records |

#### Post-treatment

For post-treatment of the biochar the following parameters will be monitored:

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Monitoring frequency** | **Source of data** |
| Amount of diesel used for biochar post-treatment | per batch | purchase receipts |
| Amount of electricity used for biochar post-treatment | per batch | purchase receipts |

#### Compensation of Fossil Emissions

All fossil CO2 emissions, as well as N2O emissions from biomass fertilization, must be offset by long-term carbon sinks before the registration of a biochar C-sink can be validated in the Global C-Sink Registry.

CO2 must only be offset with geological C-sinks, such as the persistent aromatic carbon (PAC) fraction of soil-applied biochar, that are registered in the Global C-Sink Registry.

The emission offsets can be realized with the registered permanent biochar C-sink whose production had caused the emission.

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Monitoring frequency** | **Source of data** |
| Proof of compensation | annually | emission portfolio |

### Methane emissions

#### Storage of biomass

When biomass is stored, methane emissions can be produced, which need to be included in the C-sink potential calculation. This is why the storage period needs to be monitored. Not only the storage on the premises of the pyrolysis plant is considered, but the entire storage period of the biomass, be it at the harvest site or the site of any biomass processor or trader. *(Caution: For biomass type (7) and (8) project proponent needs to adopt this monitoring and storage plan and get it confirmed by Carbon Standards)*

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Monitoring frequency** | **Source of data** |
|  | continuous | operation recordings |
| A) Is storage duration less than a month? Yes/No | continuous | operation recordings |
| If Answer to A) is no:  B) Is biomass stored well ventilated? Yes/No | continuous | operation recordings |
| If Answer to B) is no:  C) Is moisture content below 20%? Yes/No | continuous | operation recordings |
| core temperature of the biomass for all sites where biomass is stored for more than one month | annually | measurement during on-site inspection |

If at least one Point A) to C) is answered with yes: methane emissions are negligible.

If all points A) to C) are answered with no or temperatures of more than 5°C above ambient temperature is measured during on-site inspection: methane emissions are included in the C-sink potential calculation.

#### Pyrolysis

During pyrolysis, the pyrolysis gases are usually oxidized in a suitably designed combustion chamber. Usually, the gaseous combustion products pass a filtration step and are then emitted mostly as CO2. If the pyrolysis process is well-adjusted and the combustion chamber correctly designed, non-CO2 GHGs and other pollutants can be kept at very low levels in the exhaust. However, CH4, NOx, CO, and particulate matter (PM) are, as in all combustion processes, never completely absent and must be controlled. Concerning the net climate impact, methane emission is particularly important to measure. CO, NOx, SOx, and PM are also harmful to the environment, but according to the IPCC, they do not have a clear greenhouse gas effect (IPCC, 2013) and are therefore not accounted for the emission portfolio, while CH4 is included.

Measuring methane emissions below 5 ppm is technically complex. Continuous measurement over an entire production year is not possible with currently available technology. Therefore, either at least two CH4-emission tests per pyrolysis unit with the same feedstock representing the typical operation of the unit are required, or the pyrolysis unit must have a system certification according to EBC or WBC.

The average methane emission of a type of system is then set to be the mean value plus one standard deviation. If an emission measurement for methane or CxHx is below the measuring accuracy of the instruments, the limit of quantification (LOQ) is used. The assessed methane emissions are thus higher than the calculated average and provide a sufficiently high safety margin to cover any potential emission peaks, e.g., during start-up and shutdown of operation.

|  |  |
| --- | --- |
| □ | Default: Pyrolysis unit used in the project has a system certification, see system certification. |
| xxx |

Accordingly, ex-ante definition of the following parameter:

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Ex-ante definition; value** | **Source of data** |
| [CH4\_emissions\_pyrolysis] | 0.1 kg CH4/t DM feedstock | system certification |

|  |  |
| --- | --- |
| □ | Pyrolysis unit used in the project has no system certification. A detailed measurement strategy with precise details of the measurement technology, measurement intervals, and measurement for CH4 emission tests will be provided to Carbon Standards and approved. Methane emissions factor of the pyrolysis unit is calculated as the mean of the two measurements plus one standard deviation as the margin of security.  *Provision of details on testing strategy required.* |

Accordingly, following parameter will be monitored once during first monitoring period:

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Monitoring frequency** | **Source of data** |
| [CH4\_emissions\_pyrolysis] in kg CH4/t DM feedstock | At least 2 measurements during first monitoring period | measurements |

#### Compensation of CH4 Emissions

Methane compensation is defined as creating a carbon sink for 20 years that has a climate cooling effect equal to the climate warming effect of a methane emission over 100 years after the emission occurred. Thus, the total climate forcing of a methane emission must be compensated within 20 years after the initial emission.

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Monitoring frequency** | **Source of data** |
| Proof of compensation | per batch | Emission portfolio |

### Energy flows

In order to determine the energy efficiency of the pyrolysis unit the following parameters have to be monitored:

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Monitoring frequency** | **Source of data** |
| LHV\_feedstock | per batch | *(If the feedstock is clearly defined, the LHV can be taken from literature and a list will be prepared for the Global C-Sink webpage. Mixed and not clearly defined biomass and feedstock known for its high energy content variability (e.g., sieving residues from composting) must be analyzed in a laboratory endorsed by Carbon Standards.)* |
| M\_feedstock (DM) (Total amount of feedstock (dry matter) used for the batch) | per batch | Is equivalent to “Total amount of feedstock (dry matter) used for the batch” monitored in 4.1.2.1 |
| LHV\_biochar | per batch | The LHV of the biochar and charcoal must be analyzed from the EBC/WBC certification sample |
| M\_biochar (DM) | per batch | Is equivalent to “M\_biochar (DM)” in 4.1.1 |
| Supply of (Produced quantity of electricity per batch) | per batch | Is equivalent to “Produced quantity of electricity per batch” monitored in 4.1.2.2 |
| E\_expenditure (energy used for the production) | per batch | Sum of all sources of energy used for the production |
| Supply of E\_thermal (Produced quantity of heat per batch) | per batch | If thermal energy is supplied to district heating or industry, the actual amount used must be metered. |
| If thermal energy from reactor is used for feedstock drying: | | |
| Water content of biomass at delivery | per batch | measurement |
| Mass of biomass at delivery | per batch | operation recordings |
| Water content of biomass after drying | per batch | measurement |
| Mass of biomass after drying | per batch | operation recordings |
| If relevant: | | |
| LHV\_pyrooil |  | *(The LHV of the pyro-oil must be analyzed in a laboratory endorsed by Carbon Standards. If different fractions of the pyro-oil are produced, the LHV of each fraction has to be analyzed.)* |
| M\_pyrooil (Mass of pyrooil) | per batch | operation recordings |
| E\_fuel\_products (energy contained in all fuel products) | per batch | sales records  *(LHV of each fraction has to be analyzed.)* |
| Mass of CO2 seperated | per batch | metered data |

Ex-ante definition of following parameters:

*(If project proponent wants to use different parameters they have to be well justified and accepted by Carbon Standards.)*

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Ex-ante definition; value** | **Source of data** |
| Energy to evaporate water | 810 kWh per ton of evaporated water (2.44 kJ per gram of water + 20% margin) | methodology |
| Energy per captured CO2 | 1000 kWh t-1 CO2 | methodology |

## Calculation of C-sink potential at factory gate

The C-sink potential at factory gate reflects the remaining C-content of the biochar at factory gate, for which all fossil emissions have been offset against a permanent sink. Preferably the permanent portion of the biochar itself.

### Emissions from fossil fuels

Emissions from fossil fuels are calculated based on the following formulas:

#### Feedstock

The production of biomass usually causes emissions that need to be accounted for as carbon expenditures of the C-sink. Emissions are calculated in t CO2eq.

* If mineral nitrogen fertilization was used to produce the biomass, its carbon footprint, including soil borne N2O emissions, must be accounted for according to the formula 100 kg N = 1 t CO2eq (Zhang et al., 2013). This represents a consideration of the GWP100 for N2O and the production emissions for nitrogen fertilizer.
* If pesticides were used, a flat value of 94 kg CO2eq per hectare (Audsley et al., 2009) is applied for their production-related emissions.
* The input of fuels for cultivation and harvest or preparation of feedstock must also be added to the emission portfolio with a conversion factor of 3.2 kg CO2eq per liter diesel (Juhrich, 2016).
* The fuel for trucks for transporting the biomass from the source to the biochar production facility must be calculated with the conversion factor of 3.2 kg CO2eq per liter diesel and the road distance according to google maps. If the truck returns back empty, the distance will be multiplied by 2.
* Emissions for drying feedstock are calculated, fuel and electricity are considered. The fuel for drying feedstock is calculated with a conversion factor of 3.2 kg CO2eq per liter diesel.

The total biomass related GHG emissions without Methane per batch is calculated according to the following formula:

#### Pyrolysis

Emissions which are produced during the pyrolysis process contain electricity consumption and fuel for preheating the pyrolysis reactor. The emissions are calculated in **tCO2eq.**

Note: If renewable energy is used, a CO2eq footprint of zero is assumed. If the pyrolysis plant itself generates at least as much electricity on an annual average as is consumed in the production facility, a CO2eq of zero is assumed for electricity consumption.

The total production emissions are calculated with the formula:

A pro-rata approach was decided for the project:

|  |  |
| --- | --- |
| □ | No |
|  |

|  |  |
| --- | --- |
| □ | Yes |
| *(1) Einput = LHVfeedstock \* mfeedstock(DM)*  *(2) EnonBCoutput = LHVnonBCsolid \* mnonBCsolid(DM) + LHVliquid \* mliquid + LHVgas \* mgas + Eelectric / 40%*  *(3) Ebiochar = LHVbiochar \* mbiochar (DM)*  The energy content of the marketable non-biochar output is higher than 50% of the energy  contained in the feedstock input (*EnonBCoutput / Einput >* 50%), C-sink may be established using the pro rata approach.  To calculate the GHG attribution of the biochar product, the total emissions assessed for the  entire process from biomass production to biochar output are multiplied by the ratio of *Ebiochar*  to the total *Eoutput (=EnonBCoutput + Ebiochar).*  (4) *BCemission = [production emission] \* Ebiochar/(EnonBCoutput + Ebiochar)* |

#### Post-treatment

If the biochar will be post-treated, the emissions are calculated according to the following formula:

#### Leakage emissions

The Global C-Sink Standard prohibits non-sustainable biomass cultivation, land use change and soil organic carbon depletion - thus, leakage in sense of carbon expenditure outside of the project boundaries is avoided as much as possible. It is assumed that activity shifts to biochar production causes only minimal leakage emissions.

For the Global Biochar C-Sink, the emissions from Scope 1 and 2 are fully recorded. As per project boundary, from Scope 3, only the emissions from biomass production and its transport are directly quantified. Other indirect emissions from Scope 3 are not recorded individually due to their comparatively low volume but are instead included in the calculation with a flat margin of safety.

This includes, for example, the emissions caused by:

- Production and disposal of polypropylene bags,

- Electricity for the operation and cooling of the company's external computer servers,

- Potential methane emissions during the first month of storage of the biomass,

- Fuel consumption by employees for commuting to work and for business trips,

- Marketing and management activities including trade shows and conference attendance,

- Operation of chainsaws or harvesters for felling and peeling trees and for digging up roots,

- Emissions from machine fuels during cultivation of agricultural land and plant protection measures,

- Production, maintenance, repair, and disposal of pyrolysis equipment, transport vehicles, warehouses, and other machinery.

- The margin further contains unavoidable imprecisions of the C-sink accounting such as sampling, packaging, volume and dry mater analysis, etc.

- Unlikely loss of c-sink material e.g. by burning small portions of diffuse C-sinks in waste incineration plants

The margin of safety generally amounts to 20 kg CO2eq per ton of biochar which corresponds to roughly 0.7 % of the biochar carbon. The margin of safety is applied per ton of biochar and thus not affected by pro-rata accounting.

### Methane emissions

During biomass storage and pyrolysis process methane emissions are produced. They are calculated according to the following formula:

#### Emissions from the storage of the biomass

If methane emissions are negligible according to section 3.1.3.1.: 0 tCH4

If methane emissions are included in the C-sink potential calculation: Emissions are calculated in **tCH4**:

Default values given in the methodology are used:

|  |  |
| --- | --- |
|  | 0,13% of C-content for woody biomass  0,25% of C-content for non-woody biomass |
|  | 48% for woody biomass 50% for non-woody biomass |

#### CH4 Emissions from Pyrolysis reactor

Emissions are calculated in **tCH4.**

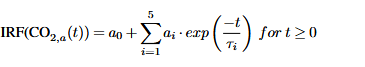
#### Compensation of CH4 Emissions

To compensate methane emissions, the GWP100 of the emitted amount of methane is calculated using the factor 25 kg CO2eq per kg CH4. We then calculate the absolute global warming potential (AGWP) over 100 years using Jeltsch-Thömmes & Joos (2019). The AGWP must then be compensated by a same-sized absolute global cooling potential (AGCP) over a maximum of 20 years. The compensating global cooling must start in the same year as the CH4 emission occurred, provide annual global cooling in every following year, and finalize the compensation latest 20 years after the methane emission.

With GWP100\_CH4 = 25 CO2eq

Greenhouse gases decay in the atmosphere. The quantities of CO2 still present in the atmosphere each year are added up over the 100 years, resulting in the absolute global warming potential (AGWP) over 100 years.

CO2 decay is described by:



With the values

|  |  |  |
| --- | --- | --- |
| i | ai | ti |
| 0 | 0.008 |  |
| 1 | 0.044 | 68521 |
| 2 | 0.112 | 5312 |
| 3 | 0.224 | 362 |
| 4 | 0.31 | 47 |
| 5 | 0.297 | 6 |

If SPC fraction of biochar is used for compensation AGCP(20) is calculated as the cumulated sum of:

)

with

|  |  |
| --- | --- |
| Sf | 0.045341876 |
| kf | 0.5134 |
| Ss | 0.212136124 |
| ks | 0.009451 |
| P | -0.007478 |

In order to claim that methane emissions where compensated it must be proven that

.

### Value of C-sink potential

The C-sink potential at factory gate reflects the remaining C-content of the biochar at factory gate, for which all fossil emissions have been offset against a permanent sink. Preferably the permanent portion (PAC) of the biochar itself.

For biochars with H/Corg ratio ≥ 0,4 no maximum value for the SPC fraction can be given. Therefore, for respective biochar cannot be used for creation of a permanent C-sink and is treated as if it consists out of 100% SPC and can only serve as a temporary C-sink. This in turn leads to the fact that GHG emissions cannot be set off against the potential permanent C-sink value of the biochar.

Under the condition that the GHG emissions from production are offset against long-term carbon sinks, the C-sink potential can be calculated as:

Note: It is mandatory to label biochar with its H/Corg ratio.

### C-Sink efficiency

If the non-biochar fraction of the pyrolysis products is used for energy production or as raw material for chemical or other industries, the biomass-carbon is considered as having been used meaningfully.

The total amount of used electrical and thermic energy, and the heating value of the marketed pyrolysis products is divided by the sum of the energy content of the biomass feedstock and the external energy used to produce the entire batch. The value is given as a percentage.

In most cases of today’s pyrolysis facilities, some summands are zero, the formula then simplifies to:

With:

If applicable:

# Determination of C-sink

Once the C-sink potential of the biochar has been determined and the label has been applied to the packaging units in accordance with the requirements in chapter 3.1, the further fate of the biochar is only indirectly influenced by the producer. In the further chain up to the final C-sink, there are processors and users. It is incumbent on all of them to play their part in quality assurance and monitoring as well as reporting on their emissions. The final C-sink is registered by the first C-sink owner.

## Biochar processing

If the biochar is delivered to a processing company who makes new biochar-based products from the biochar, the receiving company must be EBC or WBC certified as a processing company and/or trader. This allows the verification of the climate relevant processes as part of annual on-site inspection. All processing steps must be recorded with their CO2eq footprint.

Once the products are repackaged, they must be registered as new product and C-sink unit providing the following information:

- Product processor

- Biochar production batch ID and/or QR code to access EBC/WBC biochar analysis.

- Date of biochar production

- Year of CO2 removal

- Owner of C-sink material

- Point of new departure (GPS)

- Biochar C-content of product

- C-sink matrix, if mixed to one

- Emission that occurred during processing

- Link to the emission portfolio of the C-sink unit and/or company

### Monitoring of processing parameters

Processors are obliged to monitor the following data:

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Monitoring frequency** | **Source of data** |
| Amount of diesel used for transportation | continuous | distance and amount of trucks |
| Amount of diesel used for biochar processing | continuous | operation recordings |
| Amount of electricity used for biochar processing | continuous | operation recordings |
| Input biochar and output biochar based-product documentation | continuous | operation recordings |
| Any other GHG emitting process | continuous | operation recordings |

### Calculation of processing emissions

The calculation of the processing emissions is done with the following formula:

# Registration of C-sink

Biochar carbon sinks must be registered with the geo-localized area where the biochar or its derived products have been applied. This encompasses scenarios where biochar serves as a soil amendment or finds application in various contexts, such as construction for residential, infrastructural, or road-related purposes.

In certain specific instances where marginal quantities of biochar are applied or utilized in products, the registration of so-called diffuse carbon sinks (i.e., non-geo-localized) is permitted.

The following information are registered for biochar carbon sink:

1. C-sink owner (e.g. owner of the land where the C-sink is established, owner

of the material that contains the biochar, producer of biochar containing

products).

2. KLM-file of land or area where the C-sink was established.

3. Date of C-sink establishment.

4. Year of CO2-removal (date of carbon uptake of biomass that was pyrolyzed).

5. EBC/WBC batch number.

6. Biochar analysis

7. Type of C-sink (geo-localized or diffuse).

8. C-sink matrix.

9. Amount of biochar in dry tons.

10. Amount of carbon in CO2eq.

11. Persistence curve of C-sink (depending on C-sink matrix).

12. Controlling period (depending on C-sink matrix).

13. C-sink project design document

14. validation report of the validation body

15. verification report of the verification body

16. Monitoring plan of the operation

17. Confirmation of the compensation of the emission portfolio of the biochar

### Monitoring of transport parameters until final location

First C-sink owners are obliged to monitor the following data:

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Monitoring frequency** | **Source of data** |
| Amount of diesel used for transportation from last processor to application site | continuous | Distance and amount of trucks; in case of diffuse C-sink: statistically determined mean distance |
| Amount of diesel used for application | continuous | operation recordings |
| Any other GHG emitting process | continuous | operation recordings |
| Emission reports from Producer and Processors | per C-sink | Producer and Processors |

### Calculation of C -sink

The C-sink is registered in the Global C-sink Registry.

If H/Corg ratio is < 0,4, the calculation of the C-sink at day of application is :

For biochars with H/Corg ratio ≥ 0,4 no maximum value for the SPC fraction can be given. Therefore, for respective biochar cannot be used for creation of a permanent C-sink and is treated as if it consists out of 100% SPC and can only serve as a temporary C-sink. This in turn leads to the fact that GHG emissions cannot be offset against the permanent C-sink value of the biochar.

Under the condition that the GHG emissions from processing and application are offset against permanent carbon sinks, the C-sink potential can be calculated as:

Note: It is mandatory to label biochar with its H/Corg ratio.

However, every biochar C-sink underlies a time-dependent evolution, and the C-sink is a measure of the mass of carbon that is physically present in the C-sink matrix at any given moment in time since the establishment of the C-sink. The size of a biochar C-sink is, thus, a function of the type of biochar determining its specific persistence in a specific C-sink matrix and the time since the application to the C-sink matrix.

### Geological C-sink

Biochar which is applied to soil can be registered as geological C-sink. EBC and WBC certified biochar with an H/Corg ratio < 0.4 that was applied to soil is therefore registered with a PAC fraction of 75% and SPC fraction of 25% in the Global C-Sink Registry. Soil-applied biochars with an H/Corg ratio ≥ 0.4 that was applied to soil, are registered with an SPC fraction of 100%, and no PAC fraction can be registered.

The remaining carbon for soil-applied biochar with an H/Corg ratio < 0.4 is calculated with the

following conservative approximation:

*=[ ]/1000 \* Ccontent \* ( 750 + 45 \* e-0.5232 \* year + 205 \* e-0.009966 \* year)*

Biochars with an H/Corg ratio ≥ 0.4 that was applied to soil, are registered with an SPC fraction of 100%, and no PAC fraction can be registered.

When C-sinks are sold to offset CO2 emissions only the PAC fraction must be used.

The SPC-fraction of biochar can be used for methane emission offsets (see section 3.1.3.3).

### Temporary C-sink

Biochar which is used in materials can be registered as temporary C-sink.

#### Monitoring plan for materials

For consumer products:

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Monitoring frequency** | **Source of data** |
| lifetime | one-time | Average lifetime from statistics for specific products can determine an average lifetime |

For stationary infrastructure:

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Monitoring frequency** | **Source of data** |
| lifetime | *(frequency to be proposed by Project Proponent and accepted by CS)* | Proof of existence of the permanent infrastructure, e.g. by satellite imagery |

#### Calculation of temporary C-Sink for materials

if year < [lifetime];

Temporary material C-sinks are registered with their statistically validated lifetime or their

controlling period. If the control at the end of the defined controlling period confirms the

continued presence of the C-sink, the registry entry of the temporary C-sink is prolonged until

the end of the next controlling period. The duration of the new controlling period is updated

at the end of each controlling period.

### Temporary Storage of Biochar

Biochar can be stored to preserve it for later years when, e.g., demand and prices increase.

For as long as the biochar is stored under controlled conditions and with regular verification,

such as in containers, below ground protected from water and biologically active matrices,

and in ancient salt or coal mines, it can be considered a temporary C-sink during the controlled

storage time.

#### Monitoring plan for temporary storage:

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Monitoring frequency** | **Source of data** |
| C loss | continuous | remote control of temperature and/or CO2 concentration |
| amount of carbon in temporary storage | annually | calculated |

#### Calculation of temporary C-sink for temporary storage

# Public consultation

During public consultation the following comments were raised:

|  |  |  |
| --- | --- | --- |
| **Comment** | **Was comment taken into**  **account (Yes/ No)?** | **Explanation/ justification (Why? How?)** |
| xx | xx | xx |
| xx | xx | xx |

# Annexes

1. Social Responsibility