

EBC-Guidelines for the Certification of Biochar Based Carbon Sinks Version 2 from 1st January 2021

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1. Basic principles

Plant biomass consists of approximately 50% carbon, which the plant removes during its lifecycle from the atmosphere in the form of CO₂. With the energy from sunlight, the plant separates the carbon (C) from the up-taken CO₂ and builds it into organic molecules such as glucose, cellulose, or lignin.

When plant biomass is burnt or decomposed, the assimilated carbon is re-released as CO₂. However, if the plant biomass is pyrolyzed, only about half of the plant carbon becomes volatile and escapes as combustible gas. The other half is transformed into a very persistent, solid form of carbon (biochar) that degrades extremely slowly under natural conditions. Provided that the biochar is not burned, a comparably large portion of its carbon remains in the terrestrial system for several centuries and thus represents a terrestrial carbon sink (C sink).

If biochar is applied directly to soils or indirectly into agricultural soils via its use in animal feed, livestock bedding, slurry management, compost, or anaerobic digesters, a conservative average degradation rate of 0.3% per year may be assumed for higher temperature biochars with a H : C_{org} ratio below 0.4 (following: Budai et al., 2013; Camps-Arbestain et al., 2015). Thus, 100 years after soil application, 74% of the original carbon in biochar could still be accounted for as sequestered carbon. The annual rate of 0.3% is based on the most conservative metanalytical estimate for biochar carbon degradation published to date. Other sources determined significantly lower degradation rates depending on the degree of pyrolysis and the experimental design (IPCC, 2019; Kuzyakov et al., 2014; Lehmann et al., 2015; Zimmerman and Gao, 2013). In the absence of more reliable methods and long-term experiments, however, it is appropriate to use conservative projections and calculate the climate-relevant effect of C sinks with a sufficient safety margin. Instead of an annual depletion rate, the Intergovernmental Panel on Climate Change defines a proportion of permanent carbon that is not mineralized over 100 years, depending on the pyrolysis temperature (IPCC, 2019). However, this underestimates the climate impact of the biochar-based C-sink in the first decades after its production.

If biochar is used in construction materials as a sand substitute or as an additive in asphalt and plastics, it can also be assumed that the biochar persists and remains a C-sink for as long as the material itself persists. Only when the biochar containing material is disposed of, destroyed, or decomposed may the sequestered carbon be released back to the atmosphere again, causing the C-sink to lose its value and would have to be removed from the C-sink register.

Frame 1: Terminology in regard to carbon and climate effects

C-neutral: A system is considered C-neutral if it removes as much carbon from the atmosphere as it releases over a defined period of time (reference period). The amount of carbon stored in the system remains constant and does not reduce carbon stocks elsewhere. Such a system could be a forest or an agricultural area, or even an entire region including cities, forests, moors, lakes and agricultural land.

Climate-neutral: A system is considered climate-neutral if it does not cause any global warming over a reference period. The sum of all greenhouse gases emitted by the system (CO₂, CH₄, N₂O, etc.) is as large as the removal of greenhouse gases from the atmosphere. The quantity of greenhouse gases emitted or withdrawn is expressed in CO₂ equivalents (CO₂eq).

Climate-positive: A system is considered to be climate-positive if, over a reference period, more CO₂eq is withdrawn from the atmosphere than have been emitted back into the atmosphere. A climate-positive system contributes to the mitigation of global warming during the reference period.

Climate-negative: A system is considered to be climate-negative if, over a reference period, its total emissions of greenhouse gases are greater than the removal of CO₂eq from the atmosphere. The system contributes to global warming.

In the context of the C-sink economy, the use of the terms C-negative, C-positive and negative emissions is confusing and counterintuitive, because the atmosphere is used as the reference point and the assessment as "negative" (as in "negative emissions") refers to the removal (= minus) of CO₂ from the atmosphere. Positive CO₂-emissions would thus refer to a system that leads to an increase in the CO₂ content of the atmosphere, although this would of course be considered negative from a climate protection perspective. To avoid any misunderstandings, the EBC guidelines use the terms C-neutral, climate-positive and climate-negative.

In addition to the degradation rates of biochar applied to soil, all direct and indirect emissions related to biomass production (planting, cultivating, harvesting, transportation, chipping), the pyrolytic transformation of the biomass, post-processing of the biochar (e.g., grinding, mixing, bagging) and its transport and application to soil or materials must be factored into the overall carbon balance. Therefore, it would be overly simplistic and insufficient to only use the carbon content of biochar to assess its value as a C-sink. All greenhouse gas emissions along the biochar value chain must be subtracted as carbon equivalent expenditures from the amount of sequestered biochar carbon to provide an accurate carbon sink accounting.

1.1 Definition and calculation of the C-sink potential

When a packaged unit of biochar (e.g., a big bag or container) passes the factory gate of the production site, the biochar as such does not yet represent a certified C-sink. It only has, at this stage, the **potential to become a certified C-sink**.

Once the biochar is sold, it could be destroyed by fire, or a customer could buy it for co-firing in a biomass power plant or use it as a reducing agent for steel production. In any of these cases, the carbon would be released as CO₂ back into the atmosphere, and the C-sink potential would not be realized.

Biochar only becomes a long-term C-sink when it can no longer be burned or when it is used in products with a long life-cycle. When biochar eventually reaches the soil after it was used as livestock bedding, as a compost additive or as part of similar substrates, or when it becomes a component of concrete or similar non-combustible, or at least long-lasting composite materials, can it be considered a long-term terrestrial C-sink with mathematically/statistically definable life cycle or degradation rates. Until this crucial point in time, when the carbon in the biochar enters a long-term and definable life cycle, the carbon in the biochar only represents a C-sink potential.

The C-sink potential of biochar is calculated from the carbon content of the biochar minus all emissions caused by its production and use.

The C-sink potential is calculated as follows:

1. The carbon content of the biochar is determined according to the EBC method. It indicates the amount of organic carbon stored in the biochar as a mass proportion (in %) based on the biochar's dry weight.
2. All greenhouse gas emissions caused by biochar production are recorded in CO₂eq for the entire EBC production batch (usually the production of one year, see [EBC certification guidelines](#)). This concerns:
 - a) Emissions from the provision of the biomass (cf. Chap. 2)
 - b) Emissions from the storage of the biomass (cf. Chap. 3)
 - c) Emissions from the pyrolysis process and other equipment at the production site (cf. Chap. 5).

Methane (CH₄) and nitrous oxide (N₂O) emissions are converted into CO₂eq according to their 20-year global warming potential by a factor of 86 and 300, respectively.

3. To include all emissions not covered under point 2, a safety margin of 10% of all greenhouse gas emissions covered under 2) is added (cf. Chap. 6).

4. Using the factor 0.2727 (ratio of the atomic mass of carbon and the molecular mass of carbon dioxide = $12 \text{ u} / 44 \text{ u} = 0.2727$), the total determined amount of CO₂eq is converted into atomic carbon and results in the carbon expenditure. The carbon expenditure of a production batch indicates the "C-costs", i.e., it provides the amount of carbon emitted as CO₂eq to produce the total amount of biochar of a production batch.
5. The carbon expenditure is given as mass proportion based on the dry weight of the biochar. It is calculated by dividing the total amount of carbon expenditure per batch by the dry weight of the total amount of biochar produced per batch.
6. The proportion of carbon expenditure is subtracted from the biochar's carbon content, resulting in the C-sink potential in mass percent of the biochar (DM) – (cf. Frame 4).

Thus, the EBC C-sink potential accounts for the complete CO₂ footprint of the biochar from the origin of the biomass until it leaves the premises on which the EBC-certified pyrolysis plant operates. The C-sink potential indicates the proportion by dry weight of a given amount of biochar that can be converted into a long-term C-sink. Practical calculation examples are provided below in the colored frames (Frame 3 & 4).

1.2 Definition of the C-neutrality of the biomass input material

C-sink certification's overarching goal is to increase the total amount of carbon stored in the terrestrial system and thus reduce the concentration of greenhouse gases in the atmosphere. Therefore, when certifying C sinks, it must be ensured that the certified C sink is not created at the expense of another C sink. Thus, the EBC defines the carbon neutrality of biomass as follows:

A feedstock material (biomass) for the generation of a C-sink is considered C-neutral if it is either the residue of a biomass processing operation or if the biomass removal did not, over the reference period, lead to the reduction of the total carbon stock of the system in which the biomass had been grown.

Biochar produced from biomass whose harvesting resulted in the destruction or depletion of a natural C-sink (e.g., clear-cutting a forest) or has contributed to the disappearance of an existing sink (e.g., inappropriate agricultural practices on bog soil) has no C-sink value and cannot be recognized as a climate service.

For the calculation and certification of the EBC C-sink potential, only C-neutral biomass input materials are permitted.

Frame 2: Examples for the determination of biomass carbon neutrality.

The example of a single tree

If the last remaining tree on an island is felled, chopped and processed into biochar in a pyrolysis plant, 50% of the carbon originally stored in the living tree is lost to the atmosphere by burning bio-oil and pyrogas and 50% is retained in the biochar. If a new tree grows to similar size of the previous tree, the sum of the event would be climate positive. However, if no new tree is planted or regrown, then the sum of the event is climate negative.

Biochar can only have a positive effect on the climate if the production of the biomass used to produce it was at least carbon neutral. In other words, only when the biomass was re-grown where it was harvested, i.e., in the same system, can the biochar that was produced from it be recognized as a carbon sink. This is one of the essential principles of the EBC certification of the C-sink potential.

The example of a Miscanthus plantation

If one hectare of Miscanthus grass is planted and harvested for the first time after a few months and then burned to produce energy, the amount of CO₂ produced during combustion is exactly the same as the amount that the harvested Miscanthus grass had removed from the atmosphere during its first growth cycle. The combustion of the harvested biomass can therefore be considered C-neutral if fertilizer and tractor emissions from planting, harvesting, transportation are discounted. However, if the harvested Miscanthus grass is not burned but pyrolyzed, half of the carbon absorbed by the grass remains in the biochar, rendering the system not merely neutral but climate positive. Thus, the biochar from the harvested Miscanthus grass, which grows back in less than a year, is a C-sink as long as it is not burned or otherwise decomposed. For C-sink certification, all fertilizer and tractor emissions need to be included into the calculation of the C sink potential.

2. Biomass categories

Only biochar produced from either residual materials or biomass provided from other C-neutral sources is eligible for C-sink certification. This results in specific requirements for the following six biomass categories, depending on the biomass's exact origin.

2.1 Agricultural biomasses

If annual biomass is grown on agricultural land specifically for pyrolytic and/or energetic use (see example in Frame 2), it can be assumed that after one year at the latest, the same amount of biomass will have grown again on the same area, which means that approximately the same amount of CO₂ will again be removed from the atmosphere. The harvested biomass can thus be considered C-neutral based on a one-year period (reference period for annuals) so that a C-sink can be created by producing biochar from these biomasses.

The planting of mixed and perennial crops, as well as of agroforestry and meadows, which in addition to biomass production may promote the build-up of soil organic matter, is preferable to the cultivation of monocultures for biomass production. In principle, biomass from crop residues and companion plants should be recognized as a full-fledged tradable agricultural product ("carbon harvest"). The production of food and feed should be synergistic with the production of additional biomass. This would increase farm productivity and enhance biodiversity, soil organic matter, and enable the removal of CO₂ from the atmosphere.

The inclusion of biomass as a full-fledged product of agriculture would also change the definition of agricultural residues. Straw, tomato, potato, cabbage stalks, and leaves, or vine and tree prunings should be considered an essential part of the agricultural carbon crop. The dry weight of any of these biomass types also contains 50 % carbon. Using pyrolysis, more than half of this carbon can be converted into long-term C-sinks instead of being lost as CO₂ in a relatively short period through decomposition or combustion, as is still common practice in some parts of the world. The use of biomass from companion plants and crop residues would be a key component of climate farming and critical to limiting climate change. It is, however, not recommendable to completely remove all crop residues from the field and thus reduce the important ecological function of soil cover and organic matter recycling. Rather, the aim is to integrate biomass as an agricultural product into the field management plan while preserving its central ecological functions and replenishment of soil organic matter.

All biomass from crop residues and companion plants from agricultural activities are considered to be C-neutral input material. However, it has to be ensured that the removal of harvest residues does not decrease soil organic carbon stocks (Whitman et al., 2011).

If biomass was deliberately grown to produce biochar, i.e., it was the single or main product of this field, carbon expenditures need to be accounted for. If mineral nitrogen fertilization was used to produce the biomass, its carbon footprint must be subtracted from the C sink value according to the formula $100 \text{ kg N} = 1 \text{ t CO}_2\text{eq}$ (Zhang et al., 2013). The input of fuels for cultivation and harvest must also be subtracted from the C-sink potential with a conversion factor of $3.2 \text{ kg CO}_2\text{eq}$ per liter diesel (Juhrich, 2016). If the biomass is generally considered a crop residue, no carbon expenditures are accounted for until further notice.

Frame 3: Calculations of the carbon footprint for biomass production

Example for the calculation of the carbon expenditure for the provision of biomass

- On one hectare, 10 t biomass are produced using 50 kg N and 25 l diesel, which are processed into 3 t biochar (dry matter = DM) with a carbon content of 75%.
- The carbon expenditure amounts to $(0.05 \text{ t N} * 100 \text{ t CO}_2\text{eq} * \text{t}^{-1} \text{ N} =) 0.5 \text{ t CO}_2\text{eq}$ for fertilization and $(3.2 \text{ kg CO}_2\text{eq} * 25 \text{ l} =) 0.08 \text{ t CO}_2\text{eq}$ for the diesel used. This results in $(0.5 \text{ t CO}_2\text{eq} + 0.08 \text{ t CO}_2\text{eq} =) 0.58 \text{ t CO}_2\text{eq}$ (0.16 t C).
- The production of 3 t of biochar consumes 0.16 t C for the biomass supply, which corresponds to $(0.16 \text{ t} / 3 \text{ t} =) 5.3 \text{ mass percent}$ (based on the dry substance of the biochar).
- Conditional on the deduction of further emissions caused by pyrolysis and after-treatment (see Frame 4), the C-sink potential of the biochar is therefore $75\% - 5.3\% = 69.7\%$ (meaning 100 kg dry biochar would have a C-sink potential of 69.7 kg Carbon or 255.6 kg CO₂eq).
- The figures are rounded to the nearest 0.1%.

2.2 Organic residues from food processing

Pomace, nutshells, fruit stones, coffee grounds, and other organic residues from food processing are considered C-neutral input materials because the CO₂ footprint of food production has to be credited to the production of primary products (e.g., wine, olive, or any other kind of oil, fruit juice, coffee, etc.).

2.3 Wood from landscape conservation, short rotation plantations, arable forestry, forest gardens, field margins, and urban areas

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, 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 annual regrowth.

If trees have been newly planted on agricultural land for biomass production (e.g., short-rotation coppices, landscape conservation water management, or agroforestry), the harvested biomass can be considered C-neutral at the time of harvest. However, it must be ensured that biomass production is maintained on the corresponding area either through new planting or rejuvenation.

If mineral N fertilization was used to produce the biomass, its carbon footprint must be subtracted from the C-sink potential according to the formula $100 \text{ kg N} = 1 \text{ t CO}_2\text{eq}$ (Zhang et al., 2013). The carbon expenditure for cultivation and harvesting, including the use of pesticides and fuels, must also be deducted from the C-sink potential ($3.2 \text{ kg CO}_2\text{eq} / \text{l diesel}$ (Juhrich, 2016)).

2.4 Biomass from forest management

An area is considered a forest when it presents a canopy density of more than 75%. For efficient control of sustainable forest growth, the forest area units should not exceed 100 ha. The total biomass of an existing commercial forest of max. 100 ha must not decrease when the harvested biomass is used for the development of C-sinks. Therefore, the loss of wood has to be balanced by the growth of forest wood on the referenced area unit. Furthermore, only a maximum of 80% of the harvested biomass must be removed from the forest to maintain the nutrient cycle and forest biodiversity. The degree of canopy cover must not fall below 75% as a result of the timber harvest.

If, for example, the annual regrowth of a 100 ha spruce forest amounts to 650 t (dry matter = DM), only a maximum of 650 t DM per year should be felled, of which a maximum of 520 t DM (80%) should be removed from the forest for wood processing and wood use.

There is currently no comprehensive forest assessment of area units of 100 ha or less in European forestry. The reference area units are considerably larger than 10,000 ha, and the

forest regrowth is extrapolated using regional average values. Suppose in regional forests such as the Black Forest in Germany or the Arlberg in Austria, the forest's standing biomass is higher than the amount of biomass withdrawn. In that case, the withdrawn biomass is regarded as climate neutral according to the European Regulation [2018/841] (EU-Parliament, 2018). Ecologically, it is at least questionable that, e.g., a densifying mountain forest is allowed to compensate for clear-cutting in a more accessible valley. However, until the expected reform of the EU LULUCF regulation (EU-Parliament, 2018), **all wood from forests whose regrowth demonstrably exceeds the removal, independent of its size and structure, is recognized as C-neutral input for the EBC certification of the C-sink potential.**

We want to justify the decision to adhere to European forest legislation primarily because it does not make sense for developing the C-sink economy to make the restrictions too idealistic from the start. If the EU nations promote bioenergy as climate-neutral and allow the regrowth of their forests to be counted as C-sinks, it is not up to the EBC to classify the same biomass as not climate-neutral. Nevertheless, it is our conviction that forests and forest wood should be used more efficiently for the generation of C-sinks than by simply pyrolyzing the extracted biomass (Song et al., 2018). The EBC standard will be updated concerning forest wood use to reflect the technical possibilities and political conditions in the coming years.

If the climate neutrality of a forest is not ensured by the official LULUCF reports of the EU member states or by regional legislation, proof can also be provided by *Program for the Endorsement of Forest Certification* (PEFC) or *Forest Stewardship Council* (FSC) certification. Otherwise, the forest wood is not accepted as biomass input for the production of EBC certified biochar. Accordingly, no EBC C-sink potential of biochar produced from that biomass can be certified.

If during forest establishment denser stands are planted and gradually thinned out as they grow, the wood removed in this way is considered a C-neutral input because this measure accelerates the growth of the remaining trees and increases the total accumulation of carbon.

The CO₂eq expenditure for the wood harvest must be subtracted from the C-sink potential. The amount of diesel fuel required for this is calculated with the conversion factor of 3.2 kg CO₂eq / l diesel (Juhrich, 2016).

It is assumed that no fertilization takes place in the forest, otherwise, the CO₂eq expenditure for fertilization and possible liming would have to be deducted from the C-sink potential.

2.5 Wood waste

Wood waste from forestry (e.g., bark, crowns, branches, roots), wood processing (e.g., sawdust, offcuts), and recycled construction and service wood (e.g., lumber, pallets, furniture) are considered C-neutral. Strictly speaking, it would also be necessary to ensure that the wood used for these wood waste materials and wastes originally comes from sustainable forestry with third-party verification such as PEFC or PFC. However, traceability is not always possible in these cases. Moreover, it is, of course, better if the wood waste is used to build up C-sinks instead of being combusted.

2.6 Other biogenic residues

For the other biomass on the EBC positive list, a C-neutral initial value can generally be assumed. This is, however, considered individually during the certification procedure depending on the feedstock used. New feedstock categories will be added for C-sink certification as required or requested.

Animal manures and sewage sludge become increasingly important as biomass feedstock for pyrolysis and, thus, for the creation of pyrogenic C-sinks. The EBC certification of these feedstock classes is in preparation. In the meantime, C-sink potentials based on the pyrolytic products from animal manures and sewage sludge can already be assessed and certified.

3. Storage of biomass feedstock

If moist biomasses are stored for too long in piles that are too large, uncontrolled self-heating occurs. In this process, the biomass is microbially degraded, similar to composting, which results in the loss of carbon as CO₂. Depending on the biomass and storage conditions, emissions of CH₄ and N₂O may also occur.

Especially in biomass power plants, it is common practice that the self-heating of wood chips is used to dry them. A review of 14 scientific studies on the C-degradation of woodchips during storage has shown that depending on storage conditions, wood species, and wood moisture content, between 0.6 to 4.3% of the biomass carbon is degraded per month (Whittaker et al., 2016a). For wood chip piles larger than 1 m³, biodegradation of the wood leads to oxygen consumption inside the pile, which eventually leads to anaerobic degradation (fermentation) and thus methane emissions. How high the actual methane emissions are, depends on factors such as temperature, humidity, type and age of the wood, and its C:N ratio. Measurements have shown that up to 20% of the carbon released during storage is emitted as methane (Pier and Kelly, 1997). However, scientific studies on this are still incomplete, and generalizations can only be made cautiously.

For the storage of non-woody biomasses such as straw, crop residues, pomace, etc., data on methane emissions during uncontrolled composting can be applied. According to the IPCC methodology, 10 g of CH₄ emissions are generated per kilogram of biomass (DM) during complete composting (Pipatti et al., 2006).

To prevent or reduce GHG emissions from biomass storage, it is generally recommended:

- Chop wood and other biomass only a few days before pyrolysis. The storage of logs is considered unproblematic. Coarse wood (thinner logs, branches, cuttings, etc.) should be stored with as much air flow as possible.
- If prompt chipping is not possible, the wood chips or biomass should be dried as soon as possible with the waste heat from pyrolysis and stored dry with a maximum of 20% residual moisture. In case of sufficient dryness, biodegradation does not take place or is significantly slowed down.
- Pelletizing biomass also results in stable biomass suitable for storage.
- Alternatively, the wood chips or other biomass can be stored in small, well-ventilated containers such as wire mesh boxes (max. 2 m³). Thanks to sufficient ventilation, anaerobic degradation, and thus methane emissions can be prevented.

If none of the above measures can be implemented, the methane emissions resulting from storage must be included in the carbon footprint with a sufficient safety margin. For this, the EBC accounts as follows:

- A monthly C-loss of 2% (Whittaker et al., 2016a, 2016b) is assumed for the storage of biomass with a water content of more than 25% for more than two weeks without active ventilation.
- It is further assumed that 20% of the C loss from biomass storage is emitted in the form of CH₄, the climate impact of which must be subtracted from the sink potential (Cao et al., 2019; Pier and Kelly, 1997; Pipatti et al., 2006; Whittaker et al., 2016a).

For example, if the wood chips that are used as feedstock for pyrolysis have a water content above 25% and are stored in a large pile for an average of two and a half months prior to pyrolytic processing, a C loss of (2.5 * 2% =) 5% is assumed. 20% of the 5% C loss occurs as CH₄ emission, which is equivalent to (20% * 5% * 12u/16u =) 0.75% of the total C of the biomass used.

Methane has a global warming potential (GWP100) 34 times higher than CO₂ over a 100-year period CO₂ (Myrhe et al., 2013). However, inasmuch as the critical period for limiting global warming is the coming decades to 2050, the climate warming potential over the 20-year period (GWP20) should be used instead of GWP100 to promote avoidance of these critical emissions. The GWP20 of methane is 86, so within the first 20 years of emission, the climate-warming effect of methane is 86 times greater than that of CO₂ over the same period.

For an annual processing of 4000t (DM) of biomass with a C-content of 48%, the methane emissions to be estimated for a 2.5-month storage period would correspond to (4000t * 48% * 0.75% =) 14.4t CH₄, whereby (14.4t CH₄ * 86 tCO₂eq/tCH₄=) 1238 t CO₂eq would have to be credited as GHG emissions for the storage effect.

For the storage period, 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 at the site of any biomass processor or trader. For example, for processing of pomace, the start time of storage is considered to be the emptying of the wine press. For wood chips, the moment of chipping applies. During control, the logistics of biomass processing and its transport must be fully traceable.

During the EBC on-site control visit, the core temperature of the biomass has to be measured. In case of temperatures of more than 5°C above ambient temperature, which cannot be plausibly explained e.g., by diurnal fluctuations, the above formula is applied for the calculation of the accruing GHG emissions. The instruction manual may also specify an

in-house temperature monitoring of the stored biomasses (e.g., daily measurement of the core temperature of one or more biomass storage facilities).

4. Deductions for production-related emissions

4.1 Energy and fuel carbon expenditures for transportation, provision of the biomass and post-treatment of the biochar

The energy and fuel-related carbon expenditure for the entire process chain from the provision of the biomass to the packaging of the biochar is calculated in CO₂eq and deducted from the C-sink value of the biochar. This concerns in particular:

- (1) Transportation of the biomass to the pyrolysis plant,
- (2) Chipping, homogenization, pelletizing, and drying of the biomass,
- (3) Post pyrolysis treatment of the biochar (e.g., grinding, pelletizing),
- (4) Transport of the biochar to the collection depot (factory gate).

During certification, accounting for electricity and fuel consumption for all these individual steps is requested. The conversion of electricity consumption into CO₂eq is based on the specific information provided by the contractual energy provider or the average CO₂eq value of the regional electricity mix used. If renewable energy is used, a CO₂eq footprint of zero is assumed. The latter also applies if the pyrolysis plant itself generates electricity and feeds at least the amount of electricity equivalent to its consumption into the grid.

For the consumption of diesel or benzine fuel for transportation, chipping, drying, etc., the conversion factor of 3.2 kg CO₂eq / l fuel used by the German Ministry of the Environment is applied (Juhrich, 2016).

4.2 External energy for operating the pyrolysis plant (control and regulation technology, preheating, heating, conveyor technology)

Even though the production of biochar usually produces a surplus of energy from the combustion of the pyrolysis gases, external energy is always required to operate pyrolysis plants. Thus, electrical energy is required for the control and regulation technology as well as for conveying the biomasses and biochar. Depending on the type of plant, (fossil) fuel gas or electricity is also required to preheat the reactors.

Besides biochar, certain pyrolysis equipment can also produce pyrolysis oil and pyrolysis gas. When not using the pyrolytic gases to heat the reactors, external energy is required, and its carbon footprint needs to be subtracted. The EBC does not allow the use of fossil fuels to drive the pyrolytic reactions except for preheating the reactor.

To calculate the CO₂ footprint of a pyrolysis plant, it is, therefore, necessary that each plant is equipped with its electricity meter. By means of the electricity meter, the effective electricity consumption per production batch is determined and converted into CO₂eq via the CO₂ emissions per KWh of the electricity mix used.

In a case where the energy balance of a biochar production facility is positive, meaning that measurably more electrical energy or fuel products are generated than are consumed, the positive energy balance may be attributed to renewable energy as emission reduction under appropriate governing agencies. However, the positive energy balance cannot serve to increase the C-Sink value and can only be used to potentially nullify C-Sink deductions where appropriate (e.g. electricity needed to run the pyrolysis) (cf. Chap. 7).

The amount of fuel used to heat the pyrolysis reactors must be specified per batch and is converted into CO₂eq by fuel type (65 t CO₂eq per TJ (Juhrich, 2016)).

4.3 Methane emissions during the pyrolysis process

During pyrolysis, the pyrolysis gases are usually oxidized in a suitably designed combustion chamber. The combustion products, consisting mainly of CO₂, are emitted. If the pyrolysis process is well adjusted and the combustion chamber is of high quality, the pollutants in the exhaust gas stream can be kept very low. Concerning the net climate impact, the emission of methane is particularly important to measure. The other combustion products of the pyrolysis gas, such as CO, NO_x, SO_x, particulate matter, etc., 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 in the calculation of the C-sink potential, at least not for the time being.

As explained in chapter 3, for the conversion of the global warming effect of methane, the GWP₂₀ is credited with a factor of 86. Within the first 20 years after emission, the climate-warming effect of methane is thus 86 times greater than that of CO₂ over the same period.

Due to this very high GWP₂₀ of methane, even very small methane emissions during the pyrolysis process have a major impact on the carbon footprint of biochar production. In pyrolysis plants without controlled post-combustion of the pyrolysis gases (e.g. Kon-Tiki or traditional charcoal kilns), the global warming effect of methane emissions can even exceed the climate-positive effect of biochar for the first 20 years. For this reason, it is particularly important to systematically control and reduce methane emissions wherever possible.

The measurement of low methane emissions below 5 ppm of a given flue gas is technically very complex. A continuous measurement over an entire year of production would involve costs that would be significantly higher than the projected revenue for the development of

C-sinks. As the emissions from individual plants cannot be adequately monitored and a few individual measurements are not representative enough, pyrolysis equipment type certification has been introduced to assess the climate balance of pyrolysis plants.

Frame 4: Calculation of pyrolytic carbon expenditures.

Example for the calculation of the carbon expenditure of pyrolysis (continued)

- With an annual production of 500 t of biochar (dry substance = DM) with a carbon content of 75%, **50,000 kWh of electricity** are used to operate the pyrolysis plant. The local electricity mix emits 450 g CO₂eq per kWh. Thus, the carbon expenditure for the electricity consumption is $50,000 \text{ kWh} * 0.45 \text{ kg CO}_2\text{eq (kWh)}^{-1} = 22.5 \text{ t CO}_2\text{eq}$ per year. Converted to one ton of biochar, this results in $(22.5 \text{ t CO}_2\text{eq} / 500 \text{ t}) = 45 \text{ kg CO}_2\text{eq}$ per ton of biochar produced.
- Emission measurement of pyrolysis results in a **methane content of 10 ppm** (6.6 mg CH₄ m⁻³) in the flue gas. At a daily production of 3 t biochar the exhaust gas volume flow is 45,000 m³. This results in methane emissions of $45,000 \text{ m}^3 * 6.6 \text{ mg CH}_4 / \text{m}^3 = 0.3 \text{ kg CH}_4$ per day. Using the GWP₂₀ of 86 CO₂eq for methane, a daily CO₂eq of $(0.3 \text{ kg CH}_4 * 86 =) 25.5 \text{ kg}$ results, corresponding to a carbon expenditure of $(25.5 \text{ kg} / 3 \text{ t}) = 8.5 \text{ kg CO}_2\text{eq}$ per t of biochar (DM).
- To preheat the pyrolysis reactors, **5 t of liquefied petroleum gas (LPG)** with a CO₂eq of 3 t CO₂eq t⁻¹ are consumed per year. This results in a carbon expenditure of 15 t CO₂eq per year or 30 kg CO₂eq per t biochar (DM).
- The total **carbon expenditure for the pyrolysis** is converted from $(45 \text{ kg} + 8.5 \text{ kg} + 30 \text{ kg}) = 83.5 \text{ kg CO}_2\text{eq}$ to $(83.5 \text{ kg CO}_2\text{eq} / 44\text{u} * 12\text{u}) = 22.8 \text{ kg C}$ per t biochar (DM). This results in $(22.8 \text{ kg C per } 1000 \text{ kg biochar}) = 2.3 \text{ mass percent}$.
- Including the carbon expenditure for the provision of biomass (see Frame 3), this results in a **C-sink potential** of biochar at the factory gate of $(75\% \text{ (carbon content)} - 5.3\% \text{ (biomass expenditure)} - 2.3\% \text{ (pyrolysis expenditure)}) = 67.4\%$.
- A big bag with 1.3 m³ biochar, a bulk density (based on DM and a particle size < 3 mm) of 0.22 t m⁻³ would have a C-sink potential of $(1.3 \text{ m}^3 * 0.22 \text{ t m}^{-3} * 67.4\%) = 193 \text{ kg carbon}$ or $(193 \text{ kg} * 44\text{u} / 12\text{u}) = 707 \text{ kg CO}_2\text{eq}$. The C-sink potential can also be determined by the weight and water content of the packaging unit. A 381 kg big bag with a water content of 25% would therefore have a C-sink potential of $(381 \text{ kg} * (100\% - 25\%) * 67.4\%) = 193 \text{ kg carbon}$ or $(193 \text{ kg} * 44\text{u} / 12\text{u}) = 707 \text{ kg CO}_2\text{eq}$.

However, measuring methane emissions below 5 ppm is technically very complex. Continuous measurement over an entire production year would incur costs that would be significantly higher than the projected revenues for setting-up C-sinks. Since emissions from individual plants can only be poorly monitored and a few individual measurements may not be representative enough, type certification has been introduced to assess the carbon footprint of pyrolysis plants.

To carry out a pyrolysis equipment type certification, at least three pyrolysis plants of the same type from the same manufacturer must be in commercial operation at different sites. For each of these three plants, at least two independent, state-accredited emission measurements including CH₄ or C_xH_x must be available. From these measurements, a statistical mean value with standard deviation is calculated. The average methane emission of this type of plant is then set to be the mean value plus the standard deviation. If the emission measurement for methane or C_xH_x is below the measuring accuracy of the instruments, the limit value is taken as the average methane emission. The methane emissions included in the calculation are thus higher than the calculated average and provide a sufficiently high safety margin to cover any potential emission peaks, e.g. in start-up and shut-down of operation. The measured values for methane emissions are given in ppm of the flue gas (i.e., combusted pyrolysis gas) and converted into g CH₄ per ton of biochar via the waste gas flow per mass unit of biomass input.

Upon request, individual measurements of methane emissions from individual installations may also be available. For this purpose, a detailed measurement strategy with precise details of the measurement technology, measurement intervals, and measurement accuracy must be submitted in advance to the EBC for review.

5. Mandatory data for the certification of the C-sink potential

Due to the EBC certification, which usually precedes the C-sink certification, the QR code of the respective EBC batch must be printed on each packaging unit. This QR code refers to the EBC website, which documents the most important analytical data of the corresponding biochar batch. The certified C-sink potential is also printed there. Since the C-sink potential refers to the fresh weight of the biochar, the dry weight of the biochar must also be indicated for each packaging unit. The dry weight is the mass of the dry substance.

5.1 On-site measurement of the dry matter content of biochar

It should be noted that both the water content and the bulk density of biochar can be subject to considerable fluctuations. While the water content varies primarily as a result of varying intensity of quenching at the discharge, absorption of air humidity, or air drying, the bulk density changes primarily as a result of abrasion during transfer and transport.

For factory determination of the dry weight of the biochar, the EBC allows the use of the following two methods, both of which have advantages and weaknesses, but which, when carefully performed, provide an accuracy of at least 95% ($\pm 5\%$ deviation).

The reliable determination of the dry weight is a basic condition to be able to indicate the C-sink potential of a packaging unit of biochar. For the producers of biochar it represents a considerable effort, which is, however, unavoidable in order to maintain verifiability and thus the confidence in this C-sink method.

The dry weight must be determined at least once for each production quantity of maximum 10 m³ and at least once a week by one of the two following methods. Deviations from this requirement may be addressed in the EBC instruction manual. Such a case may occur, for example, if an operation can demonstrate that the dry weight does not change by more than $\pm 2\%$ over longer periods and production quantities, or if the determination of the dry weight is reliably determined and verified by methods other than those specified herein.

5.2 Determination of dry weight via drying and weight loss

For each sub-quantity of max. 10 m³ of biochar, at least 20 individual sub-samples must be taken using a sampling drill stick. Combining at least 20 sub-samples must yield at least a combined sample of 10 liters of biochar. The individual sub-samples can be taken either from a collected pile or container of max. 10 m³ of biochar or from each of several big bags presenting a total amount of max. 10 m³. The combined sample is then weighed using a balance with a precision of at least 1 gram. The biochar is then dried at 110 °C for at least 8

hours and weighed again. The dry substance (DM) content is calculated by dividing the weight after drying with the weight before drying.

$$DM [\%] = \frac{\text{weight after drying}}{\text{weight before drying}}$$

If, for example, big bags of 1.3 m³ are used for storing the biochar, a maximum of seven big bags may be combined for one sampling. At least three sub-samples have to be taken with the sampling drill stick from each of the seven big bags. All 7x3 subsamples are then combined and weighed as described above, dried, and then weighed again. If the 10-liter sample weighs 3.057 kg before drying and 2.139 kg after drying, a DM content of (2.139 kg / 3.057 kg =) 69.970% is present rounded to full percentages for further calculations (here: 70%). The DM content determined in this way must then be multiplied by each big bag's individually balanced weight (see example in Table 1). This results in each big bag's respective dry weight, with which each big bag must then be labeled. For instance, if a big bag weighs 200 kg (fresh weight) and has a determined DM content of 70%, the dry weight is (200 kg * 70% =) 140 kg. It is expressed in whole kilograms.

For the described DM determination via drying of a representative sample, a relatively large drying oven and correspondingly accurate balances are required. Still, the effort for 10 m³ or seven big bags is manageable. Weighing of the big bags should be done on the same day as the sampling.

Serial number of big bag	Volume	Weighed weight	Dry matter content	Dry weight
Big bag 2020-490	1,3 m3	195 kg	70%	137 kg
Big bag 2020-491		200 kg		140 kg
Big bag 2020-492		200 kg		140 kg
Big bag 2020-493		210 kg		147 kg
Big bag 2020-494		195 kg		137 kg
Big bag 2020-495		200 kg		140 kg
Big bag 2020-496		200 kg		140 kg

The following method is similarly robust and easy to perform:

5.3 Determining the dry weight via volume shrinkage measurement

If biochar is ground to smaller than 3mm and the water content is below 40%, the bulk density remains largely constant regardless of the water content (< 40%) and regardless of the particle size (< 3mm). On the one hand, this is due to the fact that at a water content of less than 40%, the water is bound within the pore system, does not lead to swelling of the biochar, and thus does not cause any changes in volume. On the other hand, it can be explained by the fact that although finer grinding should allow denser storage of the particles, the electrostatic charge of the charcoal particles during grinding causes the small particles to repel each other, thus counteracting densification of the bulk density. Comprehensive measurements by the Ithaka Institute using a wide variety of biochars with different water contents and particle sizes have confirmed this volume constancy at a particle size of less than 3 mm. They will be published soon.

Since the bulk density determination of anhydrous biochar ground to < 3mm provides a quasi-constant reference value, this constant value can be used to calculate the dry matter content of undried, unground biochar.

If the bulk density in the anhydrous state was determined for a particle size < 3mm in an EBC laboratory, a sample quantity of at least 20 liters of biochar from the production of one week or a maximum amount of 10 m³ (as described in 4.1.1) should be taken at the production site. The bulk density is determined from the composite sample by placing a sub-sample of 4 to 5 L in a measuring jug and reading the volume to the nearest 0.1 L without prior compaction. The weight of this amount of biochar is determined to the nearest ±5 g and finally recombined with the rest of the sample. This entire sample is ground to a particle size < 3mm using a suitable mill.

Four to five liters of the ground sample is placed back into the measuring flask, which is then tapped ten times onto a solid base so that the material is compacted in a standardized manner. The volume is then read to the nearest 0.1 L and the weight of this quantity of biochar is determined to the nearest ±5 g.

The ratio of the bulk density of the ground sample to the bulk density of the unground sample gives the shrinkage measure.

$$\text{shrinkage} = \frac{\text{bulk density of the unground sample}}{\text{bulk density of the ground sample}} = \frac{\text{unground weight} * \text{groundvolume}}{\text{unground volume} * \text{ground weight}}$$

For example, if a volume of 4.4 l and a weight of 1.205 kg are determined for the unground sample, and 5.2 l of the ground sample weighs 2.430 kg, the shrinkage measure is calculated as follows, rounded to two decimals:

$$\text{shrinkage} = \frac{1,205 \text{ kg} * 5,2 \text{ l}}{2,360 \text{ kg} * 4,4 \text{ l}} \approx 0.6034 \approx 0.60$$

Using the shrinkage measure and the bulk density (DM, <3mm), the dry mass can now be determined from the volume of any packaging unit as follows.

$$\text{Dry weight} = 1,3 \text{ m}^3 * 0,60 * 180 \text{ kg m}^{-3} = 140,4 \text{ kg} \approx 140 \text{ kg}$$

Provided that the type and particle size of the pyrolyzed biomass is not subject to significant changes and the shrinkage remains relatively constant over the course of the production batch, it is usually sufficient to measure and record the shrinkage at the factory only once a week.

6. Margin of Safety

In the calculation of carbon footprints, the emissions to be recorded are usually divided into Scope 1 (direct emissions at the production site, in this case, combustion of pyrolysis gas, methane emissions during biomass storage, combustion of natural gas for preheating the reactors), Scope 2 (indirect emissions from externally purchased energy, in this case mainly electricity) and Scope 3 (further indirect emissions, in this case, e.g., production of purchased biomasses and transport). For the EBC C-sink potential, the emissions from Scope 1 and 2 are fully recorded. In contrast, 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 small scale but are calculated using a flat safety margin. This relates, for example, to emissions from the following areas:

- Production and disposal of polypropylene big bags,
- Electricity for the operation and cooling of the company's external computer servers,
- Fuel consumption by employees for commuting to work and for business trips,
- Marketing department activities including trade shows and conference attendance,
- Operation of chainsaws or harvesters for felling and peeling trees and for digging up roots,
- The greenhouse gases produced in growing the food served in the cafeteria,
- Production, maintenance, repair, and disposal of pyrolysis equipment, transport vehicles, warehouses, and other machinery.

There are many small, indirect scope 3 emissions that need to be included when creating a perfect carbon footprint. Compared to the total amount of CO₂eq from Scope 1 & 2 as well as from biomass provision in Scope 3, and to the vast amount of carbon accumulated in biomasses, the indirect emissions remaining in Scope 3 play only a minimal role. To not underestimate all these GHG emissions that are not directly quantified and transparently map them, a flat margin of safety is set. The margin of safety generally amounts to 10% of the total emissions from biochar production deducted from the C-sink value. This is a high, industry-standard margin for the inherent uncertainty of the overall process that allows EBC to be sure to keep the certification process lean and efficient without misappropriating emissions.

Thus, if the biomass provision (5.3% - see Box 3) and the pyrolysis process (2.3% - see Box 4) result in total GHG input that equals 7.6% of the C-content of the produced biochar, the safety margin for the indirect emissions not quantified in the system is $(10\% * 7.6\% =)$ 0.76% of the C-content of the biochar and is additionally subtracted from the C-sink potential accordingly.

7. Climate neutral energy

When determining the C-sink potential, the total amount of GHG emissions caused during the biomass production, storage, and pyrolysis process is recorded as CO₂eq. The corresponding amount of carbon is subtracted from the C-content of the biochar. This means that all other products of the pyrolysis process (pyrolysis oil, pyrolysis gas, or the thermal energy and electricity obtained from it) are to be regarded as climate-neutral since all GHG emissions have already been accounted for with the biochar. The total power generated as heat or electricity during pyrolysis is therefore climate neutral.

The European Emissions Trading Scheme (EU-ETS), through which CO₂ emission allowances are traded, is based on the assumption, as are most platforms for voluntary CO₂ compensation, that fossil energy will be replaced by climate-neutral energy, thereby indirectly reducing CO₂ emissions. Based on this idea, which is anchored in the Kyoto Protocol as well as in the Paris Climate Treaty, CO₂ certificates are generated for the production of climate-neutral energy, with which companies or private individuals can offset their emissions, i.e., obtain quasi climate pollution rights. The general hope of policymakers is that this will provide market-based leverage to make fossil energy more expensive and climate-neutral energy cheaper to reduce emissions overall.

Thus, there is a fundamental difference between C-sinks and emission reductions/pollution rights. C-sinks, such as those created by the production and application of biochar, have actively removed CO₂ from the atmosphere and stored it in the terrestrial system over the long term. This climate service has been documented and can also be physically verified through various means. On the other hand, the generation of climate-neutral energy only avoids emissions compared to a reference scenario, e.g., a coal-fired power plant. Only through such a reference scenario can a value for the emission reduction be determined, while it cannot be measured physically. The atmosphere's CO₂ content is not reduced by the generation of climate-neutral energy but ensures at best that less anthropogenic greenhouse gases are released into the atmosphere.

For the reasons explained above, the EBC only issues certificates for C-sink potentials but does not issue CO₂ certificates for the generation of climate-neutral energy. The EBC only certifies the amount of carbon that has been effectively and measurably stored and thus prevented from returning to the atmosphere.

The EBC certificate nevertheless indicates the amount of climate-neutral thermal and electrical energy generated in MWh per year as well as the amount of pyrolysis oils produced in tons (DM) per year, if applicable.

8. Use and trading of biochar-based C-sinks by accredited brokers and trading platforms

The C-sink potential of the EBC certificate is the prerequisite for generating marketable C-sink certificates. However, it only represents the status of the C-sink at the factory gate.

From the moment a delivery unit filled with biochar (e.g., a big bag = super sack) leaves the factory site, many things can happen that may reduce or eliminate the C-sink potential of the traded biochar. If fossil fuels are burned for the transport of biochar or electricity is consumed in a pelleting process, the C-sink potential is reduced by the greenhouse gas emissions that result from these activities. If the biochar is burned, for example, as charcoal, processed into activated carbon, or used as a reducing agent in steel production, a significant amount of carbon would be lost to the atmosphere. Therefore, only when the biochar is eventually applied to soil or included in measurable long-lasting materials can it be assumed that the C sink will be preserved in a calculable and controllable way in the long term.

To generate a full C-sink certificate, an accredited tracking system is required to record all carbon losses from the factory gate to incorporation into the soil or a long-term stable material and to deduct them from the certified C-sink potential. The tracking system to be accredited by the EBC can be developed and implemented by C-sink brokers, trading platforms, or even the biochar producers themselves. The following basic principles must be observed:

- 1) For as long as the packaging unit is stored closed and protected on the factory premises, the C-sink potential remains unchanged.
- 2) After leaving the site of biochar production, any greenhouse gas emissions that occur during transport, further processing (e.g., grinding, blending), and placement in a final storage site (e.g., soil, concrete, asphalt, etc.) must be deducted from the C-sink potential.
- 3) Incorporating biochar into substrates such as compost, litter, feed, fertilizer or cement, sand, clay, and lime is considered a creation of a carbon sink. From this moment on, the combustion of the biochar and thus the loss of carbon can be practically excluded.
- 4) To prevent duplicate certifications, the final location and the owner of the site where the C-sink is created should be registered. Ideally, this would be done using a central C-sink registry. This applies to agricultural applications where the specific land surface where the biochar or biochar containing substrate was placed must be recorded by GPS. It equally applies to material uses where, e.g., the particular house where the biochar was used as part of the building materials would have to be registered with address or GPS data.

- 5) Recording the location data and owner of the C-sink is essential both for subsequent monitoring (e.g., measuring the biochar content of the soil) and for rewarding the climate service that the owner ensures over the long term by maintaining and preserving the C-sink (e.g., managing the soil in a C-friendly manner, maintaining the house intact).
- 6) If the registration of the geographical location and the owner, respectively, caretaker of the C-sink is not possible or practicable, but if it can be proven that the biochar was introduced into a matrix that excludes combustion (e.g., compost, biogas slurry, cement, etc., see above), the carbon sink has to be defined as a diffuse C-sink whose local whereabouts cannot be verified and double certification cannot be excluded in principle. Nevertheless, it can be assumed that the carbon introduced in this way remains as a terrestrial C-sink and is only subject to the natural degradation rate (see point 8ff). As long as there are no C-sink certificates for soil organic matter in place, and as biochar is usually applied at maximum rates of only two t per hectare and year, which can hardly be measured using usual methods for measuring soil carbon, the risk of double certification is currently considered to be low.
- 7) In the present version 2.0 of the EBC guidelines for C-sink certification, C-sinks' geographic localization is not yet regulated in a mandatory manner, and no qualitative distinction is made between diffuse and localized C-sinks. The tracking systems of the few existing brokers and traders of C-sinks are not yet prepared for this. Moreover, there is not yet sufficient consensus on the theoretical and technical basis. Therefore, the EBC is defining a transitional period until June 2022 for the implementation of the geographical localization of C-sinks.
- 8) If a packaging unit of biochar or a product containing biochar is traded whose C-sink value has already been sold or traded elsewhere, the packaging and delivery bill must state that the C-sink value of the biochar has already been compensated. The product can, therefore, no longer be declared or traded as a C-sink or CO₂ certificate. For example, suppose a farmer purchases 10 m³ of biochar whose C-sink value has already been sold by the distributor or manufacturer to a C-sink broker. In that case, the farmer cannot again use the C-sink value of the purchased biochar to offset emissions from, for example, his potato production or livestock and advertise the potatoes as climate positive. The sale of biochar without its C-sink value is subject to declaration and should be confirmed in writing by the buyer.
- 9) The life cycle of the final C-sink or the degradation of the biochar in the final C-sink must be factored in. When incorporated into soils or blended into substrates and feeds that will eventually be incorporated into agricultural or urban soils, the annual rate of biochar degradation must be applied according to the H/C_{org} ratio of the biochar (Camps-Arbestain et al., 2015; IPCC, 2019) and must be at least 0.3%. In this

way, the C sink's annual evolution can also be specified over more extended periods of 100 or 250 years or traded in annual tranches.

- 10) When biochar is incorporated into industrial materials such as plastics or asphalt, appropriate monitoring methods (e.g., electronic tracking, satellites, or even statistically validated lifetime averages) must be used to ensure what proportion of the material containing biochar is still in use and has not been converted to CO₂ by combustion. From these data, an appropriate degradation rate should be formulated.
- 11) For incorporating biochar into building materials such as concrete, mineral plasters, gypsum, or clay, a permanent sink can be assumed. Building materials make incineration impossible, thermal waste treatment is not provided for and thus protects embedded biochar against biological and chemical degradation far better than the soil. For periods of 100 - 250 years, no degradation rate must be considered for this purpose.

To ensure that the tracking system works without leakage and that only high quality, verifiable C-sinks are sold as a climate service, the EBC has introduced an accreditation protocol of C-sink traders and trading platforms.

Manufacturers of biochar are advised to sell the EBC-certified C-sink values only to EBC-accredited C-sink dealers. This is the only way to guarantee that only the amount of carbon actually removed from the atmosphere in the form of CO₂ is certified and sold as a sink.

Of course, a biochar manufacturer can also become accredited as a C-sink trader and thus sell CO₂ certificates to farmers or building contractors, for example, or to third parties, or offset its own emissions.

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