Global Construction C-Sink Standard 1.0

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The present standard ~~is planned to be~~was published on 12sth September 2025 following several rounds of public consultation~~ and can be used for pilot certifications as of 9th February 2025~~.

For a transition period until 2026, the Global Construction C-Sink Standard's geographical scope is limited to the EU and EFTA countries. Other global regions will be integrated stepwise.

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Summary

The ~~certification~~ verification of carbon sinks (C-sinks) is a crucial step in scientifically grounded climate change mitigation strategies. While reducing emissions and phasing out the use of fossil carbon are essential to limiting global warming, only active carbon dioxide removal (CDR) from the atmosphere can address the climatic impact of past, current, and future residual emissions.

The Global Construction C-Sink Standard can be used to ~~ertifies~~ verify buildings and civil engineering works that contain biomass-derived C-Sink Materials. Each v~~c~~er~~t~~ified construction is considered a C-Sink Unit and can be registered in the Global ~~Carbon~~ C-Sink Regist~~e~~ry if all GHG emissions that were caused by the production and transportation of the embedded Construction C-Sink Materials were offset.

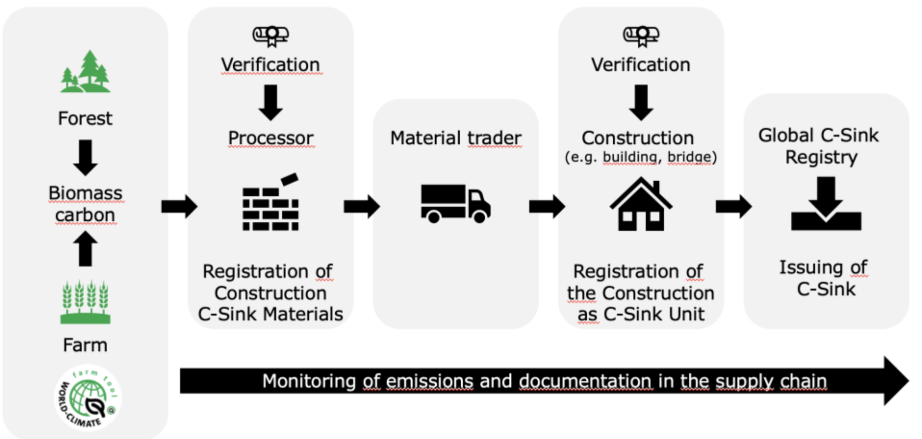

Figure 1: Scheme of ~~certification~~ verification procedures for the Global Construction C-Sink S~~s~~tandard.

The Global Construction C-Sink Standard includes guidelines for rigorous tracking of biomass-derived carbon from biomass production to the construction site, accounting for greenhouse gas (GHG) emissions for all processing steps in the production of Construction C-Sink Materials (i.e., GHG expenditures), and registering the construction lifecycle. The present standard ensures that every unit of carbon sequestered within the construction materials is trackable through endorsed digital monitoring, reporting and verification (dMRV) systems and that its global cooling potential is correctly calculated and publicly registered. The mandatory tracking system guarantees the integrity and transparent quantification of the C-sinks and their time-dependent climate effects. Recycling of construction materials is both an integral part of circular economies and an integral part of determining the long-term fate of the carbon embodied in the C-Sink Materials. Thus, the possible recycling scenarios of construction materials is considered in the verecertification and registration procedures.

The Global Construction C-Sink Standard strongly emphasizes accounting for all direct and indirect GHG emissions associated with biomass cultivation, transportation, processing, storage, trading, and application. By requiring these emissions to be fully offset by registered C-sinks, the standard ensures an accurate representation of the net climate impact of each Global Construction C-Sink.

Construction C-sinks provide temporary C-sinks with a clearly quantified global cooling effect. The usual timespan of a Construction C-sink is the lifetime of the construction, which is generally considered to be 60 years on average. Depending on the method of recycling construction materials, the carbon storage time of Construction C-Sink Materials can be extended.

The emissions caused by the construction process (from land preparation to structural completion) must be assessed by life cycle assessment (according to ISO 14025 and ISO 14044), declared to the CertifierVVB, and registered in the form of an emission portfolio in the Global C-Sinkcarbon Registery.

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Glossary

Processor	A company that uses biomass materials to produce C-sink construction materials. A Processor must be Global Construction C-Sink ~~certified~~ endorsed to register and label its products as Construction C-Sink Materials.
Material trader	A company that trades Construction C-Sink Materials. The trader must be registered at Carbon Standards as part of the tracking process from biomass material to the Construction C-sink (c.f., dMRV)
C-sink trader	An endorsed company or organization that trades the climate effect of a C-sink. Usually C-sink traders are working with the Global Carbon Registry for trading and managing C-sinks.
C-sink	Non fossil derived carbon that is verifiably stored for more than one year (temporary C-sink). The time of carbon dioxide removal and quality and location of the carbon must be registered in the Global ~~Carbon Register~~C-Sink Registry.
C-sink matrix	Mineral substance (e.g., cement paste) to which biomass derived carbon is mixed.
C-sink owner	Owner of a C-Sink Material or, when applied to a construction, owner of the construction.
Construction C-Sink	A Construction C-Sink is a building or work of infrastructure that contain a ~~certified~~ verified amount of biomass-derived carbon that is protected from oxidation to CO2 for ~~verifiable~~ defined periods of time due to its imbedding in the Construction. Every ~~certified~~ verified Construction C-Sink is considered a C-Sink unit and can be registered.
Construction C-Sink Unit	A Construction C-Sink Unit is a building or anon-building structure (a bridge, a scaffolding construction for an agrivoltaics installation, etc.), registered in the Global ~~Carbon Register~~C-Sink Registry. Usually, the minimum size of a C-sink in a Construction C-Sink Unit is 10 t CO_2e.
Construction C-Sink Materials	Materials used in a construction project (i.e., a Construction C-Sink Unit) which contain carbon from non-fossil sources that persists for as long as the material is in use. Each product

	must be registered and listed in the Construction C-Sink Material database hosted by Carbon Standards International.
C-Sink Manager	A company that is endorsed by Carbon Standards International to monitor and digitally track Construction C-Sink Materials from the biomass production and processing site to the construction site, assessing all occurring emissions, potential carbon leakages, and verifying their offsetting. A C-Sink Manager uses an endorsed dMRV system.
Emission portfolio	A list of all GHG emissions caused during the establishment of a C-sink registered in the Global Carbon RegisterC-Sink Registry.
Endorsing agent	The Carbon Standards International AG is the endorsing agent. Carbon Standards (1) endorses dMRV provider, (2) endorses tracking and monitoring tools and IT systems used by the C-Sink manager, (3) endorses C-Sink managers, (4) conducts trainings for the CertifierVVB, (5) endorses the CertifierVVB, (6) verifies the reporting by the C-Sink Manager, (7) endorses laboratories.
Geological C-sink	Non-fossil carbon that was applied to soil, sediments, the oceans, or the lithosphere and presents a persistence of more than 1000 years such as the persistent aromatic carbon (PAC) fraction of biochar.
Global Construction Tool	Reference software of Carbon Standard to assess and manage all data relevant for the certification verification of Construction C-Sink Materials and Constructions C-Sinks. It is no dMRV system.
Global Cooling	The climate impact of any carbon sink over a specified period, quantified as tons of annual CO_2e. An amount of global cooling can compensate an equivalent amount of global warming for the verification period of the respective C-sink.
Global Carbon C-Sink Registery	The Global C-Sinkarbon Registery contains all relevant information about a C-sink to ensure the corresponding climate service and prevent double counting.
Temporary C-sink	Non-fossil carbon that is stored and/or used outside of the atmosphere for a verifiable period of at least one year. Temporary C-sinks are a function of time given in years. The

	carbon contained in the temporary C-sink is calculated for each registered year as annual carbon (aCO_2e). The global cooling effect of the temporary C-sink depends on the year of the initial carbon removal and its expected decomposition.
Methane compensation	Methane is a potent greenhouse gas with limited lifespan in the atmosphere. With a half-life of approximately 8 years, it is oxidized to CO_2 in the atmosphere. The compensation of its global warming effect is possible with temporary C-sinks such as those generated by the Global Construction C-Sink ~~certification~~verification.
Negative Emission Technology (NET) – also CDR technologies	Negative Emission Technologies (NETs) are techniques that remove more carbon dioxide from the atmosphere than they emit, thereby reducing the atmospheric concentration of CO_2 to mitigate the effects of climate change. A NET comprises (1) carbon removal (e.g. photosynthesis in a plant), (2) transformation of the carbon into a storable C-sink material (e.g. converting a trunk into timber or into biochar) and (3) the storage (and use) of the C-sink material.
Non-fossil carbon	Non-fossil carbon refers to carbon originating from the atmosphere. This includes CO_2 assimilated by photosynthesis and, thus, any biomass-derived material or substance. Beyond photosynthesis, non-fossil carbon can be obtained from direct air-capture and similar technologies. It excludes fossil carbon such as coal, lignite, regular plastics and also residues from the treatment of waste materials that were made from fossil carbon (e.g., carbon fibers). Peat is considered as fossil carbon, too. It also excludes carbon in rocks, e.g. CO_2 from calcination.
Persistence	Persistence refers to the duration that a defined fraction of carbon is stable in the environment or in a defined matrix to which it was applied. Sometimes also referred to as "durability".
PyCCS	Pyrogenic Carbon Capture and Storage: The use of carbon transformed by pyrolysis (biochar, pyro-oil, pyro-gas) as carbon sink.
Standard developer & holder	The Global Construction C-Sink Standard was developed and is continuously updated by the Ithaka Institute. The Standard is owned by Carbon Standards International and can only be used under a licensing agreement. Carbon

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	Standards is managing the entire licensing and endorsement process of Construction C-Sink Managers, CertifiersVVBs, dMRV providers, registries, and laboratories.
Validation & Verification Body (VVB)	Independent, internationally accredited organization endorsed by CSI that does validation and verification of the carbon dioxide removal procedures and C-sink values before the issuance of C-sink certificates. In the present standard the Validation & Verification Body (VVB) is synonym to the Certifier.
Issuing of C-sink certificates	After successful certification validation and registration of Construction C-Sinks (C-sink units) following the validation and verification by the Verification BodyCertifier, Carbon Standards International issues the C-sink certificates.

~~3.~~1. Executive Summary: Global Construction C-Sink ~~Certification~~ Verification and Registration

To ~~certify~~ verify a Construction C-sink and its sustainable establishment, to calculate the global cooling effect of the carbon sink, and to assess all emissions that occurred during the carbon sink establishment, the following parameters must be monitored:

- Only Construction C-Sink Materials that will be preserved for as long as the building is preserved can be v~~c~~er~~t~~ified under the present standard.
- The year of the initial biomass CO_2 removal is assessed so that the Annual Global Cooling effect of the C-sink can eventually be calculated (c.f., Chapter 5).
- All fossil-carbon-derived greenhouse gases, N_2O, and CH_4 released during the cultivation of the biomass, its transport and processing, packaging, mixing to a C-sink matrix, and its embedding into the construction are quantified and registered in an emission portfolio (c.f., Chapter 4).
- All emissions in the emission portfolio of the C-sink occurring during production and application of Construction C-Sink Materials must be offset by retiring a corresponding part of a C-sink or C-sink portfolio in the Global C-Sink~~arbon~~ Regist~~e~~ry (c.f., Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**).
- It is controlled that the Construction C-sink does not replace a more carbon-efficient baseline scenario. The use of biomass in the construction must be additional (c.f., Chapter 5.2).
- The C-sink matrix (e.g., concrete) and type (e.g., truss), and the GPS location of the construction site are recorded (c.f., Chapter 9.2).
- The lifecycle of the construction must be estimated and compared to the average lifecycle of the same type of construction. Based on this assessment, the technical audit defines the monitoring method and controlling period of the Construction C-sink (c.f., Chapter 9.2.
- The verified C-sinks are registered in the Global C-Sink~~arbon~~ Regist~~e~~ry run by the Global ~~Carbon Register~~C-Sink Registry Foundation in Switzerland.

An endorsed ~~certified~~ C-Sink Manager using an endorsed dMRV system is responsible for (1) tracking the Construction C-Sink Materials, (2) quantifying the emissions caused by their production and transportation, and (3) the lifecycle analysis (LCA) of the entire construction. The C-Sink Manager is also responsible

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for offsetting all emissions that were caused by the production, processing and application of Construction C-Sink Materials.

An accredited ~~Certifier (i.e., v~~Verification and V~~v~~alidation B~~b~~ody (VVB)~~)~~ endorsed by Carbon Standards International must conduct the necessary inspections of the processors, traders and C-Sink Managers. The ~~Certifier~~ VVB conducts random checks at the production, processing and construction sites. Biochar production must be certified under the Global Biochar C-Sink Standard (https://www.carbon-standards.com/en/standards). Dedicated biomass production must be ve~~c~~er~~t~~ified under the World Farm Standard (https://www.carbon-standards.com/en/standards), established by Carbon Standards International to run life cycle analyses of farm operations. Based on the carbon footprint of the farm, the footprint allocation to the products is done and ~~certified~~verified.

Feldfunktion geändert

Feldfunktion geändert

The relevant inspection requirements and calculation templates for ~~certifying~~ verifying the construction C-sinks are detailed in the ~~following pages of the~~present Global Construction C-Sink Standard.

Temporary Construction C-sinks can be used for global warming compensation during the year following the latest control of the ~~certified~~ verified Construction C-Sink. As constructions are usually ~~certified~~ validated for the average lifecycle of the respective construction type, the expected C-sink curve of all future years within the span of the lifecycle can be registered and traded as a C-Sink Option. A C-Sink Option is the right to sell a temporary C-sink in each of the upcoming years, given that the Construction C-sink's continued existence was proven and is ve~~c~~er~~t~~ified ex-post for the respective year.

V~~C~~er~~t~~ified biochar C-sinks, based on Global Biochar C-Sink, embedded in construction materials may be ve~~c~~er~~t~~ified as geological C-sinks and used to offset CO_2 emissions.

1. Introduction to the Global Construction C-Sink Standard

The mass of the built environment surpasses already today the total global biomass (Elhacham et al., 2020). It is expected that the mass of anthropogenic materials will double again within the next 20 years, adding another 1.1 terra tons (1 Tt = 1,000 Gt) of material, and will surpass the global biomass by factor three in 2040. Concrete, steel, and asphalt, all of which have massive carbon footprints, make up the vast majority of anthropogenic materials. However, if those construction materials could be partially substituted by Construction C-Sink Materials, the built environment could become the largest and most relevant C-sink.

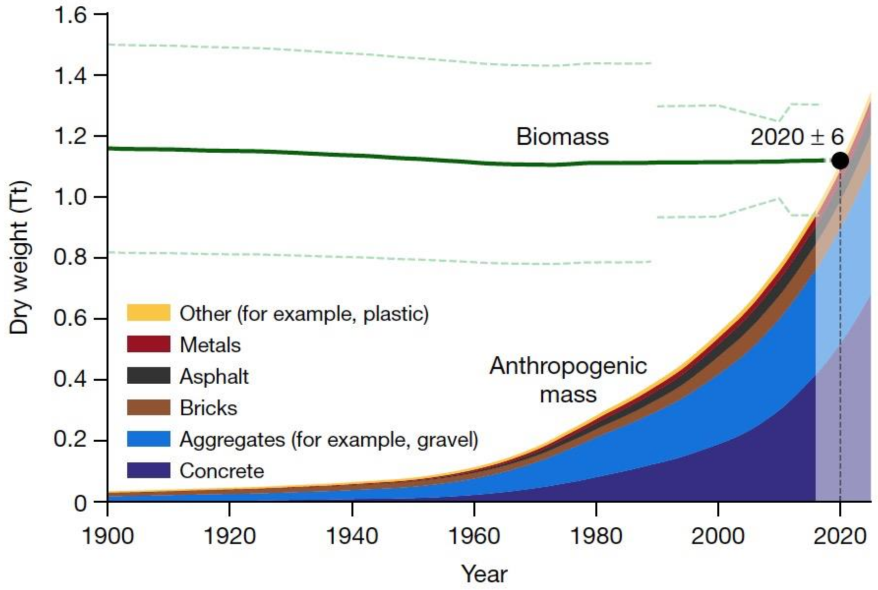

Figure. 1: *Biomass and anthropogenic mass estimates since the beginning of the twentieth century on a dry-mass basis following Elhacham et al., 2020*

If 20% of the anthropogenic material could be replaced by biomass-derived materials and recycled carbon, around (1100 Gt * 20% * 50%[1] * 44/12[2] =) 400 Gt CO_2e could be transferred into C-sinks during the next 20 years, representing around half of the negative emissions required to maintain global warming below 1.5 °C (UNFCCC, 2015) given that GHG emissions were curbed to 10% by 2050 (Smith et al., 2024). Even if only a very feasible 10% of the construction materials would be replaced by Construction C-Sink Materials, a very significant C-Sink increase of 200 Gt CO_2e could be achieved. For this reason, a vcertification standard for construction-related C-sinks is urgently needed and, thus, provided for the first time in the novel Global Construction C-Sink Sstandard presented here.

All biomass contains carbon that was initially removed from the atmosphere by plants or algae. If that biomass is used after mechanical treatment (e.g., wood, straw, cork, etc.) or after further processing (e.g., biochar, cellulose, lignin, caoutchouc, oils, etc.) for building materials, additives, or composites, the biomass carbon would be sequestered for as long as the building material that contains the biomass-derived carbon is preserved or recycled. Given the nature of the construction matrix, significant biological decomposition within the building material can be excluded during the average lifetime of the construction material. Examples are wooden structures like roof trusses, straw insulation, hemp bricks, biochar additives, compressed cellulose panes, pyrolysis oils for bitumen, latex for soundproofing, or carbon fibers as steel armoring replacement.

Biochar embedded in an endorsed C-Sink Matrix may be vcertified as geological C-sinks with a permanence of over 1000 years due to their recyclability and end-of-life as soil deposits (c.f., Annex A1). However, non-biochar organic carbon materials can only form temporary C-sinks, as they may biologically or chemically decompose or be combusted after the end-of-life of the construction material they were embedded in.

Temporary C-sinks provide the same climate service as geological C-sinks for as long as they exist, which is generally for as long as the building material is in use. If the biomass-derived carbon is recycled without loss or leakage or loss and leakage are accounted and compensated for, the sequestration period can be prolonged for as long as the recycled material persists.

[1] Generally, we can assume 50% carbon content in the dry matter of biomass

[2] A CO_2 molecule has the mass of 44 u, the carbon atom 12 u, which is used to convert the mass of carbon into CO_2 equivalents – CO_2e

While traditional carbon dioxide (CO_2) credits mostly certify the reduction of emissions compared to a reference scenario (i.e., emission avoidance), the certificates based on Global C-Sinks guarantee the storage of carbon in the terrestrial system that can be located, verified at any time, and traced back to the year of the initial carbon removal from the atmosphere. This is the case in all Global C-Sink Standards of Carbon Standards International.

Carbon sinks are the result of (1) an active removal of CO_2 from the atmosphere, (2) the transformation of the removed carbon into a storable form, and (3) its verifiable storage outside the atmosphere. In the case of biochar, the removal occurs through biomass growth (photosynthesis), transformation through pyrolysis, temporary storage via adding it to a construction material, and geological storage when the construction debris is applied to landfills or soil. For a wooden beam or straw insulation, the removal occurs equally through biomass growth (photosynthesis), which is followed by mechanical processing, the storage is then provided when including it into a building material (e.g., as truss or insulation or brick additive). It, thus, becomes a temporary C-sink for as long as the building is in place. A geological C-sink might eventually be achieved when pyrolyzing the biogenic parts of construction debris followed by applying the resulting biochar to soil. The latter is not part of the present standard and would have to be veertified under the Global Biochar C-Sink Standard.

Materials of biomass origin that are used in constructions so that their carbon is preserved in the construction matrix are called Construction C-Sink Materials. While all Construction C-Sink Materials are controlled and tracked from the atmospheric CO2 removal via material processing to the construction site, it is not the C-Sink Material but the veertified Construction (i.e., the building, the tunnel, the bridge) itself that is registered as a C-Sink Unit. All Construction C-sinks must be registered in the Global C-Sink Registry to avoid double counting and create the transparency and trust needed in the new carbon economy.

Likewise, all greenhouse gas (GHG) emissions that occurred due to biomass production (i.e., fertilization), processing (e.g., cutting, milling, pelletizing, etc.), transport, and all other activities (e.g., pyrolysis, injection) necessary to provide the Construction C-Sink Material to the Construction must be assessed and registered in an emission portfolio in the Global C-Sinkarbon Registery. All emissions caused by the C-sink production must be balanced before the C-sink can be issued in the Global C-Sink Registry.

The Global Construction C-Sink Standard provides the methodology to verify The Global Construction C-Sink Standard certifies the amount and storage time of carbon that is effectively and measurably embedded in buildings and non-building structures and thus prevented from returning to the atmosphere for the monitored period of the material use. C-sinks veer~~t~~ified under the Global Construction C-Sink Standard are temporary C-sinks. They have a climate effect during the time of their existence. Once the temporary C-sink has been lost, the climate service of the C-sink stops. To continue the climate service, the C-sink must be renewed. Temporary C-sinks must not be used to offset CO_2 emissions but can compensate the global warming potential of a CO_2 emission for the entire time that the temporary C-sink persists.

1.1 Global Construction Carbon Sinks

Plant biomass consists of approximately 50% carbon in its dry matter, which was removed from the atmosphere during the plant's lifecycle in the form of CO_2. Using the energy from sunlight, the plant uses CO_2 and builds it into organic molecules such as glucose, cellulose, or lignin.

When plant biomass is burnt or decomposed, the assimilated carbon is released in the form of CO_2 again. However, if the plant biomass is dried and incorporated into a construction matrix that protects the organic molecules from microbial decomposition and oxidation, such as through fire, the biomass carbon can be preserved for a long time beyond the plant's lifecycle. Thus, the re-emission of the biomass-derived carbon can be delayed for as long as the Construction C-Sink Material is maintained undamaged.

Once the Construction C-Sink Material is recycled, incinerated, or d~~e~~isposed of, e.g., in a landfill, the persistence of the carbon must either be assessed again, or the temporary C-sink must be retired from the Global C-Sink~~arbon~~ Regist~~e~~ry. Retired C-sinks have no global cooling effect anymore and must not be used to compensate for emissions.

If a veer~~t~~ified Construction C-Sink Material is recycled in such a way that (parts of) the carbon is preserved and embedded into a new construction material, preserving the carbon it contains, the initial temporary C-sink can be extended to the new Construction C-Sink Material for the lifecycle of the new material, and for the amount of carbon that was effectively recycled – considering the year of the initial CO_2 removal.

If the biomass of a Construction C-Sink Material is pyrolyzed to biochar at the end of the construction life cycle, the resulting biochar can be veer~~t~~ified as a C-sink made from a carbon-neutral feedstock.

Kommentiert [HPS1]: retired bedeutet, dass der Senke kein Klimaeffekt mehr zugesprochen werden kann, sie also nicht mehr als Offset verwendet werden kann.

1.2 The Emission Portfolio

Before a Construction C-sink can be registered as such, all GHG emissions caused by the production and the processing of the Construction C-Sink Material must be offset.

The GHG emissions caused by the cultivation, harvesting, processing, and transportation of biomass or biomass-derived materials are recorded **by the Construction C-Sink Manager as emission portfolio**. The fossil CO_2 and N_2O emissions of the emission portfolio of the Construction C-Sink Material must be offset with geological C-sinks, CH_4 emission may be offset with temporary C-sinks.

The obligation to offset only concerns the production of the Construction C-Sink Materials (e.g., wood, straw, biochar, lignin powder, hemp, sheep wool, etc.) but not the material into which the organic or pyrogenic carbon is embedded. Modern constructions in civil engineering will certainly not consist exclusively of C-Sink Materials for the foreseeable future. Even a wooden house needs a foundation and possibly a basement, which will most likely be built from concrete, limestone, or burnt bricks. Ideally, all construction-related emissions would be reduced or offset before a given construction can be considered a partial C-sink, but if constructions are not obliged by law to become climate-neutral, it would render the climate action of establishing an embedded Construction C-Sink economically unfeasible.

An alternative to using expensive geological C-sinks would be to compensate for the global warming effect of the construction emissions with Global Cooling claimed from the Global Construction C-sinks integrated into the construction itself (in-setting). Of course, this would only be valid for the lifetime of the construction but given that the average lifetime of construction is around 60 years, it is a significant time of climate neutrality. Once the building is dismantled, the compensation for the original construction emissions would end, which means that the emissions originally caused by the construction and the emissions caused by its dismantling will sum up to a net global warming effect to be compensated by then. Therefore, the building's emissions portfolio must be kept up-to-date for the entire life-cycle of the building.

The emissions portfolio of a building (the C-Sink Unit) is to be regarded as a long-term climate mortgage of the building, which would have to be registered in the cadaster, or the cadaster could be connected to the corresponding Global C-Sink~~arbon~~ Regist~~e~~ry entry (e.g., the building). The climate mortgage of a building or any other construction, which must be redeemed when the temporary C-sink is dissolved (i.e., when the building is dismantled and the Construction C-Sink

Materials are incinerated), would be a decisive conceptual step towards making temporary C-sinks practicable.

The creation of temporary C-sinks is more cost-effective than geological C-sinks. The impact on the climate would nevertheless be fully given, as it is irrelevant to the atmosphere whether the construction emissions are immediately compensated by a geological sink or initially by a temporary C-sink, which is later renewed or replaced by a geological C-sink or another temporary C-sink.

The accounting of Construction C-Sink Materials only becomes economically challenging if neither the construction company nor the residents or owners of the buildings are interested in using the C-sinks to compensate for their own emissions but want to sell the temporary C-sinks of the construction to external companies or individuals. As geological sinks are guaranteed to be long-term, such C-sinks can be sold to external customers to offset CO_2 emissions. Temporary sinks, on the other hand, must be monitored regularly, and as soon as the carbon stored in the temporary C-sink decreases, e.g., due to demolition, the compensation project must be informed accordingly about the loss or decrease of the acquired C-sink's compensation capacity.

The climate service of a temporary carbon sink that is traded outside of the construction project must be checked at defined intervals and can only be traded for a limited time in advance (e.g., the average life cycle of the respective building class). The Global Cooling effect of temporary carbon sinks can only be sold and recognized for periods in which the existence of the carbon sink can be guaranteed. To solve this properly, we have introduced the method of **C-Sink Options** in our Global C-Sink Standards.

1.3 The Global C-Sink ~~arbon~~ Registery

The Global C-Sink~~arbon~~ Registery is a secure digital database for temporary and permanent C-Sinks and construction-related emission portfolios. The registered C-Sink information is publicly available.

All Construction C-Sinks veer~~t~~ified under the present standard as C-Sink Units are registered in the Global C-Sink~~arbon~~ Registery, which is owned and run by the not-for-profit Global ~~Carbon Register~~C-Sink Registry Foundation established under Swiss law. The registry contains all relevant information to evaluate veer~~t~~ified C-Sinks, group them into C-sink portfolios, calculate their global cooling effects, and match them with emission portfolios to compensate for their global warming effect. The amount and type of Construction C-Sink Materials, the year of the original

Formatiert: Schriftfarbe: Text 1, Englisch (Vereinigtes Königreich)

Formatiert: Schriftfarbe: Text 1, Englisch (Vereinigtes Königreich) carbon removal, the construction matrix to which the Construction C-Sink Material was applied to, the average lifetime of the material category, the controlling period, the geo-location of the Construction C-Sink, and the responsible C-Sink Manager and owner are the most important information contained in the registry.

If the construction material is recycled in a carbon-preserving manner following the construction's dismantling, the Construction C-Sink Material-sink certification can be transferred to the new construction (Construction C-Sink unit) or to the disposal storage accordingly.

All GHG emissions caused by the production of the Construction C-Sink Material are registered in the emission portfolio. Also, the GHG footprint of the entire construction of the Construction C-Sink Unit has to be registered. The CO_2 and N_2O emissions caused by the production of the veertified Construction C-Sink Materials must be offset with geological C-sinks (i.e., C-Sink_1000+). CH_4 emissions can be offset with temporary C-sinks (i.e., C-Sink_20). A registered Construction C-sink can only be used for emission compensation when all GHG emissions caused by the Construction C-Sink Materials were previously compensated.

The register allows the conversion of every C-sink and every GHG emission into annual global cooling and annual global warming effects, respectively, to correctly match C-sinks and CO_2 emissions for the annual compensation of climate effects.

2. The Building is the C-Sink

The Construction C-Sink certificate includes only Construction C-Sink Materials that will be preserved for as long as the building is preserved and can, thus, be monitored remotely.

The Construction C-sink vCertification is dedicated forcovers materials that

- contain biomass-derived carbon
- are processed by endorsedcertified producers
- are used in registered constructions,
- protect the embedded carbon from decomposing (biologically, chemically, and by fire),
- will not be replaced or demolished before the end of the **declared** lifetime of the construction.

This includes all statically relevant structures such as walls, beams, pillars, foundations, roof trusses, and the roof cover. It further includes the insulation material, the **fixed** flooring **(but not the floor cover)**, ceilings, and permanent interior walls. However, it does not include quickly exchangeable or mobile materials such as wallpaper, movable walls, decoration, furniture, **parquet, carpets,** doors, window frames, and sills. The latter may be considered temporary material C-sinks, but as their continuous existence cannot be verified with aerial imagery, they cannot be v~~c~~er~~t~~ified under the Global Construction C-Sink Standard.

The existence of a Construction C-sink is controlled remotely at least once per year by satellite, drone, or street view imagery. The images and ~~certificate~~ proof of continued existence must be linked to the Global C-Sink~~arbon~~ Regist~~e~~ry entry to enable verification and renew the temporary C-sink for another year.

If major renovations, extensions, or modifications occur, the registry entry must be updated. The C-Sink Manager is responsible for controlling renovations and alterations. Building inspections are carried out randomly by the ~~Certifier~~ VVB (**0.5**% of registered buildings every **year starting from the tenth year after construction**) and in justified cases of suspicion. If unannounced building alterations have been carried out, the building loses its C-sink ~~certification~~ Certificate **and the Construction C-Sink Manager its endorsement.**

Kommentiert [HPS2]: Das Zertifikat wird von CSI ausgestellt. Hier stimmt der Begriff Certificate.

2.1 The Role of the C-Sink Manager

A Construction C-Sink Manager is an officially registered legal entity (e.g., a company, building association, or non-profit institution) that manages monitoring, data assessment, and recording of the entire process from biomass commissioning to processing, trading and application of Construction C-Sink Materials. Usually, the emissions from the production of Construction C-Sink Materials are offset by the producer and overseen by the Construction C-Sink Manager.

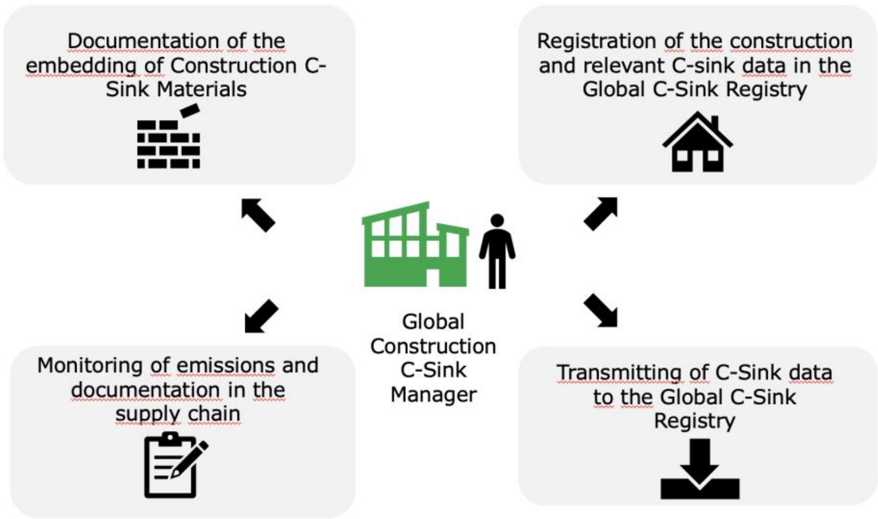

Figure 2: The role of the C-Sink Manager

The C-sink Manager must document the embedding of the Construction C-Sink Materials in the veer~~t~~ified construction, i.e. the Construction C-Sink Unit. The obligation to keep proper proofs and records of the application lies with the C-Sink Manager. Templates for process description and documentation are provided by Carbon Standards International. The construction itself will be registered in the Global C-Sink~~arbon~~ Regist~~e~~ry. All relevant C-Sink data of the construction are also managed by the Construction C-Sink Manager.

The emissions must be assessed and verified until the material has been embedded in the construction. The Construction C-Sink Manager submits the dMRV system for approval and endorsement to Carbon Standards International and is responsible for its correct use. The dMRV system can be provided by a third party.

The Construction C-Sink Manager is mandated to retain the comprehensive, non-aggregated datasets for a minimum of 10 years. Carbon Standards and the third-party ~~Certifier~~ VVB may request access to the complete dataset or specific sections of it as deemed necessary. Once the required data are transmitted to the Global ~~Carbon Register~~C-Sink Registry, these are ~~validated and~~ verified; only then can the respective C-sinks ~~can~~ be officially registered.

The emission portfolio of the Construction C-Sink Materials must be registered under the name of the C-Sink Manager, who is responsible that all emissions of the portfolio and the allocated products were offset.

The Construction C-Sink Manager is required to prepare the project design document (PDD), and submit it to Carbon Standards International for approval. A template for PDD is available from Carbon Standards. The PPD includes a project description and a monitoring plan that details the methods and schedule for monitoring the Construction C-Sink Material processing, trading, and transportation between the processing and trading sites and to the final construction site. Additionally, the plan must elucidate the process of transmitting data to the Global ~~Carbon Register~~C-Sink Registry, typically via electronic data exchange (API's), and outline solutions to challenges like data quality, data losses, or hacking. Each construction and C-Sink Unit has its own PDD. However, it is possible to group identic constructions built in the same year (e.g., terraced houses in the same street) under one PDD.

The PDD must further include an Internal Control System (ICS) for quality management covering both the physical product and related documentation and data. The ICS plays a pivotal role in ensuring and upholding the project's quality (e.g., measuring of production quantities) as well as the integrity of the data collected. This is achieved through systematic quality checks, conflict-of-interest resolutions, and imposing sanctions and corrective actions where needed. Guidelines for Construction C-Sink Managers to establish ICS fit for purpose are provided by Carbon Standards.

3. Temporary C-Sinks and C-Sink Options

To offset CO_2 emissions, the same amount of carbon must be removed from the atmosphere or the ocean and permanently stored for more than a thousand years. However, reducing and offsetting CO_2 emissions are not the only way to limit climate change. Every greenhouse gas (GHG) emission causes a defined global warming effect over defined periods of time. The global warming effect is calculated via the radiative forcing that an emitted GHG causes every single year since the initial emission. Using the currently accepted reflux function (Jeltsch-Thömmes and Joos, 2019), it is simple to calculate how much radiative forcing (related to global warming) is caused by a specific GHG emission in the first, second, tenth, or hundredth year. The absolute global warming effect over a certain number of years is the sum of the global warming effect of every year within the considered timespan.

To compensate for the global warming effect that a distinct emission has next year, in ten years or a hundred years, an equal global cooling effect (negative radiative forcing due to GHG removal) in every respective year is needed. If 100 t CO2e were emitted in the year 2020, 100 t CO2e must be removed and stored in 2020 to compensate for the global warming effect of the emission for this one year. If in 2021, the removed and stored CO_2e is reemitted, no compensation can be accounted for in 2021 or any following year. However, if the C-sink can be preserved for 10, 20, or 58 years, the compensation for the emission's global warming effect can be accounted for 10, 20, or 58 years, respectively. For the year that the global warming effect of an emission is compensated, positive and negative radiative forcing are balanced, and no net climate warming is prompted.

The significant difference between a geological and a temporary C-Sink is the future. The effect of a geological C-sink can be extrapolated into the far future (> 1000 years), while the future of a Construction C-sink cannot be guaranteed in advance, and its existence must be verified regularly. However, the climate effect during the verified and guaranteed period of existence of a temporary C-sink is the same as that of a geological C-sink during the same period.

If organic materials are embedded in construction materials, it can be assumed that the entire carbon content of the construction material remains a C-sink for as long as the material itself persists. Only when the organic carbon-containing material is dismantled, recycled, pyrolyzed, or incinerated can the sequestered carbon potentially be released back into the atmosphere, causing the C-sink to lose its climate value. A temporary C-Sink that got lost must be retired from the Global Carbon Registry.

The prospective value of a temporary C-sink is given as the annual average mass of carbon in carbon dioxide equivalents (t aCO_2) over the ~~certified~~ defined period in years, e.g., C-Sink_35, C-Sink_50, or C-Sink_100. The prospective value is the base for the C-Sink Option introduced below.

To ensure that the global cooling effect of a temporary C-sink is effectively delivered, the Global Cooling effect can only be claimed for the past (i.e., ex-post). **Only when it is validated that the registered temporary C-sink has existed during a control period can the global cooling effect of the C-sink be used for emission compensation.** The global cooling effect veer~~t~~ified for the last year can be used to compensate for the global warming effect that an emission has in the present year or had in the past (legacy emissions).

Example: A building was erected in 2020 with a GHG footprint of 100 t CO_2e. The building has a wood truss presenting 20 t CO_2e, compressed straw fiber insulation (15 t CO_2e), and biochar used in the concrete for the foundation (50 t CO_2e) and for the walls (15 t CO_2e). The organic and pyrogenic carbon embedded in the construction materials constitutes a temporary C-sink of 100 t CO_2e. For as long as the building persists, the temporary C-sinks will exist without decay. The GHG footprint of the construction (100 t CO_2e) can, thus, be entirely compensated by the embedded C-sink of the woody-, straw-, and biochar materials for as long as the construction is unmodified.

Once a C-sink is ~~activated~~ issued in the register, it can be used to compensate for the global warming effect of an emission, e.g., for the GHG caused by the construction itself, or, if not used for in-setting, also for external emissions.

The global cooling effect of the construction C-sink for future years (e.g., from today until the end of the expected lifecycle of the construction) is shown as the expected C-sink curve in the ~~Carbon Register~~C-Sink Registry. The expected C-sink curve can be traded and registered as a "C-Sink Option." The yearly values of a registered C-Sink can be ~~activated~~ issued and veer~~t~~ified annually following the automated monitoring of the construction's existence.

The recommended maximal duration of a C-Sink Option is the average lifecycle of the respective building type (35 years for functional buildings and 60 years for housing and infrastructure (Omrany et al., 2020). However, as the C-Sink Option is not the C-sink itself nor the climate effect of the potential C-sink but only the right to use the remaining C-sink in the future after annual validation, the declaration of other construction lifetimes is possible. It is the responsibility of the C-Sink Manager to carry out a plausibility check to determine whether a specific construction is designed for a service life of > 35 years (functional buildings), > 60 years (housing and infrastructure), or any other declared service life span.

While the fate of most organic compounds embedded in construction becomes highly uncertain once the construction is demolished, embedded biochar carbon represents long-term persistent C-sinks. Biochar-containing building materials such as cement-, lime-, or geopolymer-based concrete, clay, or gypsum are usually recycled into aggregates or deposited in land or road fills at the end of the product life. When deposed in land- or other soil-located fills, the biochar may become a geological C-sink. Eventually, biochar-containing building materials will enter the soil and, thus, become a geological C-sink depending on the material properties of the biochar. Large-scale oxidative recycling of concrete materials is unlikely (c.f., Annex A1). Biochar carbon embedded in construction materials and veertified under the Global Biochar C-Sink Standard can be registered as a geological C-sink and retired for CO_2 offsets (see also Annex A1, which reprints the detailed chapter on "Biochar-Concrete Construction Materials" of the Global Biochar C-Sink Standard (Schmidt HP et al., 2024)).

4. Emission Portfolio and Offsetting

The carbon expenditures of Construction C-sinks include the biomass production, transport, material processing, trading and application of the resulting Construction C-Sink Material (e.g., wood, straw, biochar, etc.). It presents the complete carbon footprint of the carbon material from the initial capture of atmospheric carbon (i.e., by plants or algae) to its material use at the registered and ve~~e~~r~~t~~ified construction site.

The emissions are calculated by summarizing all the listed emissions as CO_2e. For N_2O, the GWP100 of 298 t CO_2e t^{-1} and for methane, the GWP20 of 82.5 and GWP100 of 29.8 are used as conversion factors, respectively (IPCC, 2022).

The carbon expenditures of the construction-embedded C-sinks do not include the emissions caused by the production and use of other construction materials such as those from cement and steel production, site excavation, machine use, etc. All those construction-related emissions must, however, be declared and visible in the Global ~~Carbon Register~~C-Sink Registry.

The carbon expenditures of the Construction C-Sink Materials and the entire construction must be electronically assessed, tracked, and monitored (c.f., Chapter 7). The endorse~~certifi~~ed C-Sink Manager is responsible for this and must use an endorsed dMRV system.

All production emissions of the Construction C-Sink Materials are registered in the *emission portfolio* of the C-Sink Manager. If the construction owner wants to register the C-sinks and the emissions himself, he must register as C-Sink Manager. The C-Sink Manager is responsible for offsetting and compensating for GHG emissions caused by the production and set-up of construction C-sinks.

4.1 Offsetting of C-Sink Material Emissions

All fossil CO_2 emissions from biomass production to C-sink application must be offset with geological C-sinks that result, e.g., from DACCS, BECCS, enhanced rock weathering, and PyCCS. The same must be done for N_2O emissions from biomass cultivation (e.g., from fertilizer application) using a GWP of 298 (Aamaas et al., 2016; Allen et al., 2016; IPCC, 2022; Myhre et al., 2013). Biochar applied to a concrete matrix and used in a ve~~e~~r~~t~~ified construction can be used to offset fossil CO_2 and N_2O emissions.

The global warming potential (GWP100) of methane (CH_4) emissions can be compensated by an equally sized global cooling effect (i.e., negative global warming). However, given that most of the warming caused by CH_4 emissions occurs in the first two decades, the compensation of the GWP100 must be delivered during the first 20 years following the CH_4 emission.

4.2 The Emission Portfolio of the C-Sink Unit

Established system boundaries define how to account for and calculate the emissions embedded in constructions. It is mainly standardized today how to assess emissions and perform a life cycle assessment (ISO 14025, ISO 14044). For buildings and infrastructure, it includes the production of materials and their transport, the machines used in the construction process, land preparation, etc. (EN 15978, EN 15804 Modules A1-A3 and A4+A5). Also, the emissions caused by maintaining the construction over the years and using it, are standardized (Modules B1-B7). The present standard does not assess, monitor, and veertify those emissions but requires third-party assessed LCA according to ISO EN15804 (Modules A1-A3, B4, C1-C4) of the entire construction, from sourcing materials and preparing the site to completing the shell construction. However, they must be declared, presenting the ISO-accredited LCA of the entire construction, from sourcing materials and preparing the site to completing the shell construction.

The Construction C-Sink Unit has its own emission portfolio in the Global C-Sink registry. All construction life cycle emissions can be recorded there and presented as part of the registered C-sink. This leads to a new kind of transparency in the external presentation of carbon sinks and the carbon industry itself.

The emissions caused by using the construction (e.g., tenants' consumption of electricity, heating, air conditioning, water use, renovating, etc.) can be updated annually in the ~~Carbon Register~~C-Sink Registry as the construction's lifetime emissions. The global warming effects of those emissions could then be (partially) compensated by global cooling effects of the C-sinks embedded in the building. The building's entire lifetime emissions could thus be set climate-neutral for as long as the building exists. However, the valid~~certific~~ation of the lifetime emissions of a construction and their compensation is not part of the present standard.

4.3 Margin of Safety

In the calculation of carbon footprints of a material producer, the emissions accounted for are usually divided into Scope 1 (direct emissions at the production site, e.g., gas combustion for wood drying or methane emissions during biomass storage, heating with fuel oil), Scope 2 (indirect emissions from externally purchased energy, in this case mainly electricity, e.g., for running the sawmill, heating, cooling) and Scope 3 (further indirect emissions, e.g., emissions from producing the sawing machine, electricity for external computer server maintenance, traveling of business representatives, fertilizers production, transport of biomass which mainly constitute the scope I + II emissions of other entities.

For the Global Construction C-Sink, the emissions from Scope 1 and 2 of each involved and registered organization (producers and processors) are fully recorded and assigned to the final Construction C-Sink produced. If the conditions for the pro-rata approach (c.f., Chapter 7) are met (e.g., when the sawmill also cuts wood for non-veertified C-sink uses, the emissions are proportionally allocated to the C-sink product and non-C-sink products.

For Scope 3 emissions of involved organizations, only the emissions from biomass production (including fertilizer and pesticide application, land-use change, and tractor fuel) and Construction C-Sink Material transport to the production, trading, and construction sites 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 to account for the whole value chain. This includes, for example, the emissions caused by:

- Production and disposal of plastic bags for the transportation and storage of biomass materials,
- Potential methane emissions during 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 biomass processing equipment, transport vehicles, warehouses, and other machinery.

- The loss of small amounts of C-Sink Materials once delivered to the construction site, including waste, cut-offs, and redirected/ repurposed surplus material.
- The margin further accounts for unavoidable imprecisions in sampling, packaging, volume, and dry mater analysis, etc.

To account for all these GHG emissions that are not directly quantified, a flat margin of safety is defined. The margin of safety generally amounts to 1% of the natural carbon embedded in theof the certified Construction C-Sink Material. This is an industry-standard margin for the inherent uncertainty of the overall process that allows Carbon Standards to keep the validation and verificationcertification process lean and efficient without misappropriating emissions.

The size of the margin will be verified and, if necessary, adapted at least every second year by Carbon Standards International according to the evolution of global GHG emissions and the average footprint of scope 3 emissions.

Example: If a company produces 260 tons of wood beams on a dry matter base with a C-content of 48%, the GHG margin would be (260 t wood * 0.48 C-content * 1% =) 1.25 t C or 4.6 t CO_2e. This margin of safety covers all indirect emissions not quantified in the system and unavoidable imprecisions in measuring and analyzing the produced Construction C-Sink Material.

5. Biomass Feedstock for Construction C-Sink Materials

The overarching goal of the C-sink veertification is to increase the total amount of carbon stored in the terrestrial system, including the anthroposphere, and thus reduce the concentration of greenhouse gases in the atmosphere. When veertifying C-sinks, it must be ensured that the establishment of the veertified C-sink does not reduce the total terrestrial carbon sink. The C-sink must be additional to the total terrestrial carbon sink at the moment of CO_2 removal.

The evaluation of a Construction C-Sink does not start with the production of the material (e.g., brick, insulation panel, biochar, or wooden beam) or with the transport of the feedstock to the factory but with the growing the biomass, thus the time of CO_2 removal from the atmosphere. The climate effect of the carbon sinks is caused by the reduced atmospheric CO_2 concentration while preserving the removed carbon in the carbon sink avoids its re-emission.

The Global Construction C-Sink ~~certification~~ Standard verifies that the use of biomass does not deplete a long-term natural or otherwise registered carbon sink (e.g., forests). It further evaluates the climate neutrality of the feedstock production and provision following specific criteria for the different feedstock types outlined in Chapter 6 (Feedstock Classes for Construction C-Sink Materials).

5.1 Carbon Neutrality of Biomass Feedstock

Feedstock to be used for Construction C-Sink Materials must be carbon neutral under the following definition of feedstock carbon neutrality:

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 harvest did not reduce the total carbon stock of the system's baseline *(e.g., a field before the crop cultivation started or a forest before last years growth).*

Only C-neutral biomass input materials are permitted for the production of Construction C-Sink Materials. Construction C-Sink Materials 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) do not render any net positive climate service and must not be veertified as C-sink.

Fossil CO_2 emissions resulting from biomass cultivation (i.e., fuel consumption for land preparation and harvest, fertilizer, irrigation, etc.) do not in themselves challenge feedstock carbon neutrality but are included as carbon expenditures. They are part of the Construction C-Sink Material emission portfolio and must be offset with registered long-term C-sinks.

5.2 Carbon Leakage and Additionality

Biomass cultivation for C-sink production may lead to activity shifts (e.g., from wheat production to industrial hemp biomass) or market transformations (e.g., when biomass used as material feedstock can no longer be used in biomass power plants and is replaced by fossil fuels) which may cause a system-wide negative carbon balance (i.e., carbon leakage).

It is the duty of the C-Sink Manager to assess the risk of activity shifts and market transformation. The risk assessment must be submitted as part of the PDD, evaluated by Carbon Standards during the technical pre-audit, and validated and verified by the ~~Certifier~~VVB. A re-evaluation can be requested as a consequence of the annual inspection. The emissions resulting from activity shifts and market transformations in the C-sink activity must be incorporated into the emission portfolio of the Construction C-Sink Materials and offset with registered geological C-sinks. Carbon from biomass shall be preserved as much and for as long as possible. Given the limited surface area of the planet on which plants can grow, natural carbon dioxide removal is limited, and the available biomass must be used responsibly. Construction C-sinks must be additional to natural C-sinks that could or would have been realized with the same biomass in the absence of the construction C-sink solution. However, transforming annual or pluriannual crops into long-lasting materials also liberates land surface area for new biomass growth and, thus, additional CO_2 removal. The overall balance between natural carbon accumulation, e.g., in unmanaged forests, and biomass use combined with enhanced carbon uptake, e.g., by replacing felled trees in managed forests, must include soil organic carbon which is directly associated with the aboveground biomass (Peng et al., 2023).

As the Construction C-Sink Material preserves the entire carbon, there is no other more carbon-efficient use. However, in the manufacturing of Construction C-Sink Materials, significant amounts of biomass waste may be produced (e.g., when producing wood beams from tree trunks, wood waste may exceed 50%). If the material waste is not used in a carbon-preserving or emission-abating way (e.g., producing biochar or bioenergy, respectively), but is burnt or left for (anaerobic) decomposition, the total climate balance of the Construction C-Sink product may become negative.

To assess the carbon efficiency of the Construction C-Sink Material, the biomass waste streams must be assessed and submitted in the PDD. It must be proven that no biomass waste is burnt without adequate energy use or left for uncontrolled decomposition. **If less than 80% of biomass transformation wastes are used for energy generation, material applications, or biorefinery, the emissions caused by the inadequate waste treatment must be offset with geological C-sinks to meet the principle of additionality.**

Respecting the preceding factors, it is reasonable to consider that wood sourced from sustainable forest management and biomass residues collected in accordance with the following guidelines (c.f., chapter 6), should not be dismissed as biomass feedstock for Construction C-Sink Materials on the ground of additionality considerations.

5.3 Approved Biomasses and Carbon Expenditures for their Production

Only Construction C-Sink Materials produced from carbon-neutral biomass are eligible for C-sink ~~certification~~validation. Nevertheless, providing biomass for construction materials results in energy consumption and emissions that must be included in the carbon expenditure of Construction C-Sink Materials. Depending on the type of biomass and the way it is produced, specific criteria for carbon expenditures apply.

Global Construction C-Sink defines the following **eight general feedstock classes:**

(1) Biomass from annual cropping systems
(2) Biomass from pluriannual and perennial cropping systems including short rotation tree plantations
(3) Forest biomass
(4) Biomass from landscape conservation, agro-forestry, forest gardens, field margins, and urban areas
(5) Wood processing residues and waste timber
(6) Animal Byproducts
(7) Biochar

(8) Organic residues from the processing of food, municipals waste, digestate, biosolids, and others

The cultivation of biomass may cause emissions that need to be accounted for as follows:

- If mineral nitrogen fertilization was used to produce the biomass, its carbon footprint, including soil borne N_2O emissions, must be accounted for according to the formula 100 kg N = 1 t CO_2e (Zhang et al., 2013).
- If pesticides were used, a flat value of 94 kg CO_2e per hectare (Audsley et al., 2009) is applied for their production-related emissions.
- The input of fuels for cultivation, harvest, and transport to the processors, traders, and construction sites must be added to the emission portfolio with a conversion factor of 3.2 t CO_2e per ton or 2.7 t CO2e per m^3 diesel (Juhrich, 2016).

To keep the C-sink validation and veertification process lean and appropriate to the developmental stage of the nascent C-sink industry, average values for field cultivation and harvest emissions are used and included in the margin. Still, fertilization, pesticides, and transportation of the biomass from its origin to the site where the biomass is transformed into construction materials and from there to the construction site must be monitored, quantified, certified under the World Farm Standard, and accounted for as carbon expenditures.

If the footprint of biomass was calculated with the World Climate Farm Tool, the corresponding calculation is used directly to determine the emissions.

An overview of the accounting of carbon expenditures for the eight general feedstock classes is given in Chapter 6.

5.4 Storage of biomass feedstock

If moist biomass is stored for too long in too large piles, uncontrolled self-heating occurs. In this process, the biomass is microbially degraded, similar to composting, which results in the loss of carbon as CO_2. Depending on the biomass composition and storage conditions, emissions of CH_4 and N_2O may also occur.

Given that organic construction materials are generally used dry and that wet storage deteriorates their properties, prolonged storage (> 30 days) of wet biomass (> 20% water content) is not considered a risk under the present standard. Still, the

C-Sink Manager must present a risk assessment in the PDD explaining how prolonged wet storage of biomass is effectively avoided.

6. Feedstock Classes for Construction C-Sink Materials

6.1 Biomass from annual cropping systems (under the World Climate Farm Standard)

If annual crops are grown on agricultural land, it can be assumed that after one year, at the latest, the same amount of biomass will have grown again in the same area, which means that approximately the same amount of CO_2 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 Construction C-Sink Materials from cropping residues or the entire annual biomass production. Crop rotations may result in differences in annual CO_2 removals, though over the years, those differences even out.

Today, materials like straw, the stalks of tomatoes, potatoes, cabbages, and other plants, leaves, and pruning wood are considered agricultural residues. Including biomass carbon as a full-fledged product of agriculture would change this perception and the definition of agricultural residues. Carbon, which is now considered a residue or even waste, would become an essential part of the agricultural product range. The dry weight of any of these biomass types contains roughly 50 % carbon. Manufacturing those feedstocks into Construction C-Sink Materials converts the labile biomass carbon into temporary C-sinks instead of being lost as CO_2 in a relatively short period through decomposition or combustion, as is still common practice in most parts of the world. Using biomass from companion plants and crop residues should become a key component of climate farming and critical to mitigating climate change. However, it is not recommended to completely remove all crop residues from the field and, thus, reduce the important ecological function of soil cover, organic matter recycling, and prompt a continuous export of soil nutrients. Rather, the aim is to integrate biomass as an agricultural product into the field management plan while preserving its central ecological functions and replenishing soil organic matter.

If the main crop is used for food, animal feed, or biomaterials, no carbon expenditures for the cultivation must be accounted for the C-sink made from its residues. Harvest residues (waste biomass) from annual cropping (i.e., the main crop, residues, companion plants) are, thus, considered to be C-neutral input material. The time of the CO_2-removal to be submitted to the Global ~~Carbon Register~~C-Sink Registry is the year of harvest. It must, however, be outlined in the

PPD that the removal of harvest residues does not decrease soil organic carbon stocks (Whitman and Lehmann, 2015).

If biomass was deliberately grown to produce Construction C-Sink Materials, i.e., when it was the single or main product of the field, carbon expenditures for cultivation and fertilization need to be accounted for. The farm operations must be certified under the World Climate Farm Standard and the carbon footprint of the crop dedicated to Construction C-Sink Materials must be provided and included in the emission portfolio. Average emission factors for laboring, cultivation, and harvesting for specific crops in specific regions and specific cultivation methods may be used as specified in the World Climate Farm Standard (e.g., 25 l diesel per ha in industrial hemp production in Germany). Additional cultivation-related GHG emissions are included in the margin of safety (c.f., chapter 4.3).

World-Climate Farm Tool – For the calculation of carbon footprints in agriculture

Use the World-Climate Farm Tool to calculate your farm's carbon footprint and generate reports on its climate performance. In addition to the carbon footprint of the farm, measures for improvement can be selected and the emissions for individual products can be calculated. Data-illustrated reports and online visualizations provide information on emissions, sink performance and implemented measures.

Individual farm certificates and product certificates confirm the results of carbon footprint calculation and climate services.

6.2 Biomass from pluriannual and perennial cropping systems, including short rotation plantations (under the World Climate Farm Standard)

If pluriannual or perennial crops are harvested/pruned annually to provide feedstock for Construction C-Sink Material production, there is no difference compared to the accounting for biomass from annual crops (i.e., N-fertilizers are accounted for annually, the time of CO_2 removal is the year of harvest). The farm operations must be certified under the World Climate Farm Standard, and the emissions portfolio of the crops dedicated to Construction C-Sink Materials must be provided.

If the biomass harvest occurs only every second, fifth, or twentieth year, the carbon expenditures for fertilizers and fuels must be accounted for the entire growing period. The time of CO_2 removal must be calculated for every single year of growth or averaged over the reference period and entered accordingly into the Global C-Sink Registry to correctly calculate the global cooling effect of the resulting biochar carbon sink.

The cultivation of mixed and perennial crops, 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, i.e., the carbon crop. The Global Tree C-Sink Standard~~certification~~ may support and facilitate this process. Food and feed production should be synergistic with the production of additional biomass. This would increase farm productivity in terms of land-equivalent-ratios, enhance biodiversity, soil organic matter, and enable the removal of CO_2 from the atmosphere.

Box 2: Calculations of the emission portfolio for dedicated biomass production

Example for the calculation of the emission portfolio of a Construction C-Sink Material produced from dedicated annual biomass production

- On one hectare, 12 t (DM) of industrial hemp was produced, presenting (12 t * 48% $C_{content}$ * 44/12 =) 21.1 t CO_2e captured.
- For the field production, 100 kg N fertilizer and 25 kg (30.1 l) diesel were used.
- Another 20 kg (24.1 l) of diesel is used per 10 t of feedstock for chipping, mixing, and transportation to the manufacturing and then to the construction site.
- No pesticides and herbicides were applied.
- The biomass is used as an additive to bricks where the entirety of the carbon is conserved for the lifetime of the bricks.

- The feedstock production emissions amount to (0.1 t N * 10 t CO_2e + 0.025 t_{diesel} * 3.2 t CO2e/ t_{diesel} + 0.02 t_{diesel} * 12 t / 10 t *3.2 t CO2e/ t_{diesel} =) 1.16 t CO_2e per ha producing 12 t feedstock (DM).
- This is equivalent to (1.16 t CO_2e / 12 $t_{feedstock}$ =) 97 kg CO_2e expenditures per ton of feedstock or (1.16 t CO_2e / 21.1 t $CO_2e_{captured}$ =) 55.0 kg CO_2e expenditures per ton of captured CO_2e.
- Given that the C content of the Construction C-Sink Material (hemp bricks) is 20% (0.2 t CO_2e *12 / 44 / 48% $C_{content}$ = 113 kg hemp per brick), one ton of hemp bricks contains 200 kg CO_2e and the carbon expenditures would be (55 kg CO_2e / t * 0.2 t =) 11.0 kg CO_2e per ton of hemp bricks.
- 11 kg CO_2e per ton of hemp bricks must thus be offset with geological C-sinks before the C-sink of the Construction C-Sink Material can be registered as such.

- Considering a 150 € per t CO_2e price for geological C-sinks, the offset price per ton of hemp bricks would be (150 €/tCO2e * 0.011 t CO2e =) 1.65 €.
- The temporary C-sink of 200 kg CO_2e per ton of hemp bricks would have an estimated value of (0.2 t CO_2e * 3 €/taCO2e * 50 y =) 30 €, which can easily cover the offset cost, even considering the cost for dRMV, ~~certification~~validation and verification, registration, taxes, marketing, trade margin for C-sink traders, and prefinancing the 50-year service (C-sink option) are not yet included here.
- Organic hemp farming, omitting the GHG burden for mineral N fertilization, would massively reduce CO_2e expenditures and make the C-sink significantly more profitable.

6.3 Forest biomass

Unlike agricultural land, a forest is characterized by a high stock of carbon in the above-ground and below-ground biomass. Thus, a forest's living biomass is a C-sink that must be maintained and not compromised when biomass is sourced for the production of Construction C-Sink Materials.

If the climate neutrality of a forest is not ensured by the official LULUCF reports of the respective country or designated responsible organization 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 certification according to the Global Tree C-Sink Standard. Alternatively, the carbon balance of the forest could be verified by ISO16064-accredited assessment of CO_2 fluxes for the last 20 years. Otherwise, the forest wood is not accepted as biomass input for Construction C-Sink Materials. Accordingly, no C-sink of construction material produced from that biomass can be validated~~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.

Forest wood damaged by wind, fire, drought, or pests is considered a C-neutral input provided that a climate-change-adapted reforestation plan is submitted to Carbon Standard for approval.

The overall very low CO_2e expenditures for forest maintenance and timber harvesting is included in the overall balance via the safety margin for scope 3 emissions (c.f., Chapter 4.3).

It is assumed that no fertilization and pesticide spraying occur in the forest; otherwise, it would be considered a plantation under chapter 6.2 and not a forest.

6.3.1 Forest Biomass and Nationally Determined Contribution (NDC)

Forestry biomass is currently registered as carbon stock under the Nationally Determined Contributions (NDC) in the EU, in Switzerland, and many other countries.

Using forestry biomass as C-sinks to compensate or offset emissions outside of the country of the forest biomass origin, would result in double accounting. As products from forest biomass (wooden beams, flooring wood, etc.) are equally registered under the NDCs, Construction C-Sink Materials from forest wood can only be registered as C-sink within the country of the forest biomass origin and may not be used to compensate for emissions having occurred outside of the reference country. For as long as the C-Sink and the emission to be compensated are assigned to the same geospatial unit, here national boundaries, there may be parallel-, but no double counting of C-Sinks in respect to NDCs.

6.4 Biomass from landscape conservation, agro-forestry, forest gardens, field margins, and urban areas

If trees or hedges on agricultural land are pruned or trimmed (including coppicing), but not irreversibly felled and thus grow back, 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. It should be monitored at the farm level (c.f., Chapter 5.3).

If trees, hedges, reeds, and others have been newly planted on agricultural land for their ecosystem services and biomass production as co-benefit (e.g., landscape conservation, water management, buffer areas around ponds and streams, 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 in the corresponding area either through new planting or rejuvenation.

For pruning and landscaping material, the time of CO_2 removal is assumed to be the year of cutting.

6.5 Wood processing residues and waste timber

Traceability of wood processing residues is often challenging, especially in larger sawmills. Still, it is desired that wood waste is used to build up C-sinks instead of being wasted. However, primary waste wood amounts to more than 50% of the harvested forest biomass and must, when used for C-sink and energy production, be considered a raw material and not a waste. Therefore, when using sawdust, bark, and lumber residues (primary wood waste) from a sawmill or directly from pre-processors in the forest or on the way to a sawmill, the wood must be veertified as required under 6.3. The more primary waste wood gains prominence as a reliable economic asset, the more it influences secondary wood processors to encourage forestry managers to adopt climate-positive and sustainable management practices.

Secondary wood waste from recycled wood products (e.g., recycled construction and service wood such as lumber, pallets, furniture, etc.), often also referred to as waste timber, are considered C-neutral. The time of CO_2 removal is set to the year of pyrolysis.

6.6 Animal Byproducts (Wool)

While manure and other animal waste products are not considered feedstock for Construction C-Sink Materials except when having been transformed into biochar, animal wool and feathers are valuable insulation products. Assuming wool and feathers are a secondary product (in many cases, wool is considered waste and disposed of in waste incineration), the wool and feather feedstock is considered climate neutral. However, when wool and feather operations become more significant, and income from them becomes proportionally relevant compared to the main animal products (i.e., meat, milk, eggs, etc.), a pro-rate sharing of the animal farming's emission portfolio will be introduced.

6.7 Organic residues from the processing of food, municipal waste, digestate, and others

Currently, there is no need to set detailed rules for using organic residues, as mentioned in the chapter title, for the veertification of Construction C-Sink Materials. As of today, no construction materials are on the market yet using such unprocessed residues. If these residues are used as feedstock for biochar production, the biochar C-sink veertification would address and compensate for their emission portfolio.

However, if producers of construction materials intend to use such biomass, the present chapter and list can be updated. Pomace, nutshells, fruit stones, coffee grounds, and other organic residues from food processing are considered C-neutral input materials. Also, other industrial biomass processing residues such ~~us~~

as paper sludge, bio fiber washing, fresh palm fruit bunches, digestate, biosolids, or manure can generally be considered C-neutral.

New feedstock categories will be added for C-sink vcertification as required or requested.

6.8 Biochar

Biochar is one of the most versatile Construction C-Sink Materials and can be used as a cement additive, sand replacement, insulation material, bulk material for the foundation, and landscaping. Biochar that is used in Construction C-Sink Material must be EBC certified and registered under the Global Biochar C-Sink Standard (https://www.carbon-standards.com/en/standards). All GHG emissions for the production and transport of such certified biochar must be offset before being registered as C-sink as required by the Global Biochar C-Sink Standard. Only biochar certified under the Global Biochar C-Sink can be registered in the C-Sink Material Index. Please refer especially to the Chapter 12.3 (Application in Construction Materials) of the Global Biochar C-Sink Standard (Schmidt HP et al., 2024) that can also be found in Annex A below.

Feldfunktion geändert

7. Biomass Processing and Trading of Construction C-Sink Materials

Generally, specific treatment or manufacturing is needed before biomass can be used for construction. Therefore, biomass is delivered to a processor (i.e., the Construction C-Sink Material Processor) before being delivered to the construction site. Only in exceptional cases, such as for log houses, is biomass directly delivered to a construction site.

If the biomass is delivered to a processing company that treats it and/or transforms it into a refined construction material, the receiving company must be endorsedcertified as a processing company. All processing steps must be recorded with their CO_2e expenditures. The annual inspection controls that the processing company supplies the data into the dMRV system regularly for all materials that were handled. The veertified Construction C-Sink Materials must be registered in the Construction Material database provided by Carbon Standards International.

Once the manufactured products are packaged for delivery to the construction site, to a trader, or to another manufacturer, the following information must be provided:

- Processor ID
- Construction C-Sink Material ID
- Weight of Construction C-Sink Material per unit
- C-content of Construction C-Sink Material unit
- Date of Construction C-Sink Material production
- Year of CO_2 removal
- Owner of Construction C-Sink Material
- Point of departure for next delivery (GPS)
- C-sink matrix, if mixed to one (e.g., cement, clay)
- Emissions that occurred during the processing of the C-Sink Material unit

Biomass processors treating Construction C-Sink Materials presenting less than 1000 t CO_2e per year do not require an annual on-site inspection visit of the CertifierVVB. They are controlled by the Construction C-Sink Manager, who takes responsibility for correct data acquisition and transfer to the dMRV system.

7.1 Energy and Fuel Consumption for Processing of Biomass into Construction C-Sink Materials

To calculate the carbon footprint of biomass treatment and manufacturing, the processing machinery and production sites must be equipped with meters for electricity and, if applicable, natural gas and fuel.

The energy and fuel-related carbon expenditure for the entire process chain, from the biomass delivery to the packaging of the Construction C-Sink Material, is calculated in CO_2e and must be included in the emission portfolio of the processing company. Larger scale biomass processors (> 1000 t CO_2e per year) may group their production of Construction C-Sink Materials into annual product-specific production batches and assess the emissions per batch.

The emission portfolio must be offset before the Construction C-Sink Materials can be registered. The Construction C-Sink Manager is responsible for the complete offset. The following emissions must be included:

(1) Transportation of the biomass from the production site to the processor (including all intermediaries).

(2) Chipping, homogenization, pressing of the biomass.

(3) Drying and other thermal treatments

(4) Treatment with conservation agents, pesticides, sterilization, impregnation, etc.

5) GHG emissions of thermal processing plants (i.e., electricity, heat, and fuel consumption).

(6) Electricity, thermal energy, used for the entire production chain including, e.g., milling, aggregation, surface treatment, painting, etc.

(7) Packaging of the Construction C-Sink Material

The conversion of electricity consumption into CO_2e is based on the specific information provided by the contractual energy provider or the average CO_2e value of the regional electricity mix used. If renewable energy is used, the CO_2e footprint can be close to zero. However, some greenhouse gas emissions occur also for solar, wind, biomass, and hydropower and must thus be declared and included in the emission portfolio. In the case that the energy provider cannot provide a reliable footprint assessment, average literature values will be used by the VVB ~~Certifier~~ (IPCC, 2022; Kadiyala et al., 2016; Nugent and Sovacool, 2014).

The amount of fuel used for thermal treatment of the biomass should be reported per production unit and are converted to CO_2e by fuel type (usually 65 t CO_2e per TJ (Juhrich, 2016))

For the consumption of diesel or benzine fuel for transportation, chipping, drying, etc., the conversion factor of 2.7 kg CO_2eq per liter of diesel fuel is applied (Juhrich, 2016).

If the processor's life-cycle emissions were assessed under ISO 14044 and all GHG emissions were offset with geological C-sinks (CH_4 emissions can be offset with temporary C-sinks), the production would be considered climate neutral, and no production emissions would be added to the emission portfolio of the Construction C-Sink Material.

However, if the processor is not climate-neutral and produces a wide spectrum of products, it may be difficult to separate the emissions caused by the processing of the Construction C-Sink Materials and products of the processing company. Here, the C-Sink Manager is responsible for assessing all scope 1 and scope 2 emissions caused by the processing of the Construction C-Sink Materials by each registered processor in the production chain between the biomass harvest to the delivery at the construction site.

The C-Sink Manager is required to submit their monitoring plan for the assessment of the GHG emissions of the processors to Carbon Standards; it is part of the PDD.

All processors producing Construction C-sink Materials presenting a total of> 1000 CO_2e per year must be controlled annually by the Certifier on-site and in person.

7.2 Dry Matter and Carbon Content of the Organic Carbon Material

The size of a C-sink is defined by its mass and carbon content. Here, mass refers to dry mass, and it is a true challenge to measure it regularly on-site. While the dry matter content of wood can be measured relatively reliably with handheld infrared devices, other and more heterogenous biomass dry matter must be calculated from the fresh weight and gravimetric water content determined via sample drying (>24 h at 105 °C). Generally, this will be done at the Construction C-Sink Material manufacturing site, monitored by the C-Sink Manager.

The C-Sink Manager must set up a dry matter monitoring system for all their Construction C-Sink Material processors and submit it to Carbon Standards International.

The carbon content of plant biomass (including wood) varies only in a small range of 45 to 50% and is generally assumed to be 48% on average. The Construction C-Sink Material manufacturer must analyze the total carbon content of biomass feedstock for at least every 1000 t of feedstock (DM).

7.3 Trading of Construction C-Sink Materials

All Construction C-Sink Material traders that trade C-sink quantities > 1 t CO_2e must be registered at Carbon Standards and receive their company ID. Traders that only sell small quantities (e.g., individual bags of straw-clay or insulation panels) do not need to register.

Construction C-Sink Material traders who do not repack the packaging units only need to scan the ID and add the storage location and date of arrival to the registered data. Once it leaves the premises again, the date of departure must be registered.

If the Construction C-Sink Materials are repackaged, the new packaging units must be registered and linked to the former registered packaging unit and all material and transportation data.

8. Labeling of Construction C-Sink Materials and Constructions

8.1 C-Sink Labeling

If a Construction C-Sink Material is verified according to the Global Construction C-Sink S~~s~~tandard, the following information must be provided on each packaging and on delivery bills:

A unique ID of the Construction C-Sink Material and a QR code. This QR code refers to the **Global Construction Tool**, which documents the corresponding analytical data, the C-sink value per unit, sourcing and production conditions, persistence, and recycling information.

The specifications for the labeling of products can be found in the Design Manual of Carbon Standards and are accessible to registered ~~certified~~ clients of Carbon Standard International.

The product QR code must also serve the dMRV system to track the Construction C-Sink Material from the production to the construction site.

The following Global Construction C-Sink Label must be used on all packaging units or as branding on larger modules and the corresponding delivery bills:

Figure 3: The Global Construction C-Sink Label.

9. dMRV of the Construction C-Sink Material

Tracking carbon from the atmosphere to biomass (timestamp of the CO_2 removal), from harvest to various processors, maybe to a trader, and then eventually to the construction site is a complex task. If not organized efficiently and reliably, it may become more burdensome and costly than the economic benefit of registering temporary construction C-sinks. Also, minimizing the GHG emissions along the C-sink generation track is imperative to further reduce the cost of the C-sinks due to offsetting those emissions.

All Construction C-Sink Materials must be tracked by a digital Monitoring, Reporting and Verification (dMRV) system. The dMRV system tracks all transports (i.e., from biomass provision to processors to the construction), the carbon conservation rate (i.e., how much of the initial feedstock carbon is lost between harvest and construction embedding), includes emission data from dedicated biomass production from the World Climate Farming Standard, and assesses the processing emissions (i.e., emissions caused by manufacturing the Construction C-Sink Material). It further treats material quality data such as dry matter, volume, and carbon content.

The C-Sink Manager may develop and use his own dMRV system, employ third-party dMRV systems, or engage third-party dMRV providers. All dMRV employed under the Global Construction C-Sink Standard must be endorsed annually by Carbon Standard.

The ~~Certifier~~ VVB controls the C-Sink Manager for the correct implementation of the dMRV and the complete data recording and verification. The C-Sink Manager is responsible for the complete dMRV assessment and execution.

9.1 The dMRV at the Processors and Traders up to the Construction Site

The principal entry point of biomass materials into the dMRV system is the site of the first Construction C-Sink Material processor. The biomass must be delivered to the processing site either climate-neutral (c.f. chapter 6) or with a veertified carbon footprint (c.f. chapters 6.1, 6.2, 6.8). Here, the following date must be entered into the dMRV system:

- Construction C-Sink Material ID

- IDs of processor and of the C-Sink Manager
- Type of biomass (code of feedstock positive list)
- Weight (DM), volume, water content
- C-content
- C-Sink content
- Place of origin (GPS of e.g., field site, sawmill, etc.)
- Carbon footprint of feedstock
- Year of carbon removal (i.e., CO_2 uptake from the atmosphere)

At the processing site (or sites, if there are several), **the endorsed dMRV must assess all emissions related to the Construction C-Sink Material processing (c.f., chapter 4), Construction C-Sink Material mass, mass losses, dry matter, and carbon content**. The C-Sink Manager must prove that all emissions for processing and transportation to the following site, be it another processor, the trader, or the construction itself, are offset. Offsetting the emissions can be done by the processor, the trader, the construction company, the C-Sink Manager, or any other identity based on their project-specific contractual relations. However, it is the C-Sink Manager who is responsible for the emissions being offset entirely and reliably.

Based on this principle, the Construction C-Sink Material is always set climate neutral when arriving at the following site and eventually at the construction site, where it is embedded into the construction.

9.2 The dMRV at the Construction Site

The C-Sink Manager must ensure that the dMRV system verifiably registers the amount of each Construction C-Sink Material built into a veertified construction. If biochar is used in concrete slabs, the mass and quality of the biochar must be registered for each slab, as well as the total amount of slabs (the biochar quality parameters are those registered through the Global Biochar C-Sink Standard~~certification~~). If clay bricks with straw additives are used, the quantity of bricks and their organic C content must be registered. If sheep wool is used for insulation, the total mass of a specific sheep wool and the surrounding matrix material must be registered. All registrations must always be made with a link to the Construction C-Sink Material ID.

Each construction must be registered with the complete list of veertified Construction C-Sink Materials contained and used in the construction.

As it is practically impossible to electronically localize every Construction C-Sink Material within a construction, visual or technical verification of each Construction C-Sink Material inside the construction is also impossible. Therefore, the primary monitoring and verification documents are the construction plans, material inventory, material-order bulletins, and invoices, which are reliable proofs in those countries where the present standard will be introduced (i.e., EU and EFTA countries in 2025). While all v~~e~~er~~t~~ification-relevant data are collected by the C-Sink Manager and its endorsed dMRV system, the ~~Certifier~~ VVB is obliged to control at least 10% of the validated~~certified~~ constructions during the construction period to verify that the C-Sink Manager and his dMRV tool are correctly assessing the construction process. Following a thorough statistical data assessment of the control reports, the requirement to control at least 10% of the validated~~certified~~ construction sites could be lowered in upcoming standard updates.

Once the Construction C-Sink Materials are integrated into a construction and the construction becomes v~~e~~er~~rt~~ified under the Global Construction C-Sink Standard, the construction C-sink can be registered. The emissions caused by the Construction C-Sink Material from the feedstock production to using the material in a v~~e~~er~~t~~ified construction must be offset. The construction's emission portfolio must be registered in the Global ~~Carbon Register~~C-Sink Registry.

The following information about the construction and its embedded Construction C-Sink Materials must be transferred from the dMRV system to the Global ~~Carbon Register~~C-Sink Registry:

- ID of C-Sink Construction Unit (linked to:
    - Name and address of the construction
    - A GPS point within the construction
    - Year of construction
    - Owner of the construction
    - Building plans
    - Third party ISO verified LCA of construction
- ID of Construction C-Sink Materials (linked to attributes as per Chapter 7.2)
    - Proof that production and transport emissions were offset
- Mass (DM) per material ID used in the construction
- Code of construction type where the Construction C-Sink Material was used (i.e., foundation, supporting wall, non-supporting separation, insulation).
- The average lifetime of Construction C-Sink Material when used with the respective code of construction
- Minimum controlling period

- Method of expected recycling
- PDD of the construction
- Report of the verification and validation body

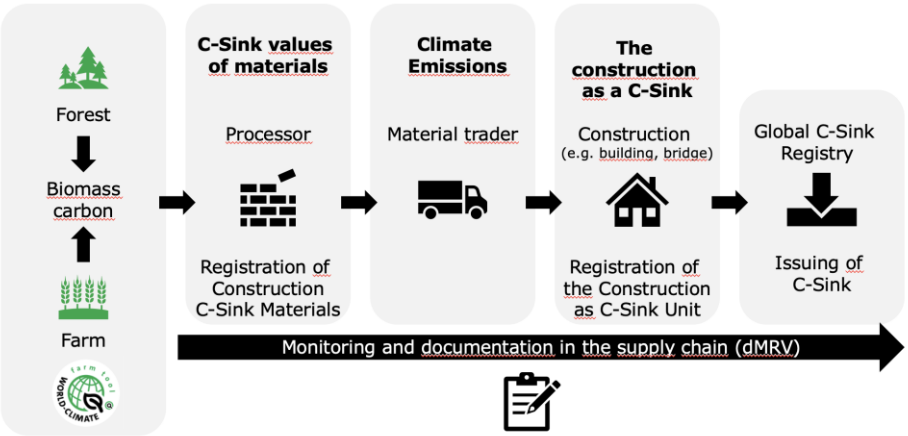

Figure 4: General scheme of dMRV procedures.

Construction C-sinks can be registered for all constructions containing Construction C-Sink Materials representing at least 10 t CO_2e.

The C-Sink Manager must ensure the completeness and correctness of the data, which is controlled annually by the ~~Certifier~~VVB.

The right to use the "registered C-Sink" seal (c.f., Figure 5), owned by the Global ~~Carbon Register~~C-Sink Registry Foundation, is acquired by registration of the corresponding C-sink in the Global C-Sink Registry.

All logos can be downloaded from the Carbon Standards International website.

Figure 5: C-Sink registered seal to label v~~c~~er~~t~~ified Global Construction C-Sinks.

9.3 Trading of Carbon Sinks (C-sinks)

Developers of C-sink-containing constructions ~~certified~~ endorsed by the present standard are advised to sell the registered C-sink effects only through Carbon Standards' endorsed C-sink traders. This is the only way to guarantee that exactly the amount of carbon actually removed from the atmosphere in the form of CO2 and the respective global cooling effects are v~~c~~er~~t~~ified and sold as a function of time.

Construction developers and C-Sink Managers may become endorsed as C-Sink Traders and thus sell C-sink effects (global cooling services or CO_2e offsets) to third parties or compensate and offset their own emissions.

For more detailed information, please refer to the Global ~~Carbon Register~~C-Sink Registry Foundation (www.global-c-registry.org). Carbon Standards collaborates with the independent Global ~~Carbon Register~~C-Sink Registry and the C-Sink Registry. Carbon Standards' Construction C-Sink Tools provides direct data exchange with the Global ~~Carbon Register~~C-Sink Registry and support its methodology. However, Carbon Standards and its endorsed C-Sink Managers are free to collaborate also with other registries given they provide the same data security and science-based calculations of annual cooling and warming effects.

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Annex A

A1. Biochar Concrete Construction Materials

Biochar incorporated into cement-, lime-, clay-, or geopolymer-based construction materials is considered a carbon sink.

Structures like the Roman Colosseum, the Egyptian pyramids, and the old city of Fulda show that buildings may last longer than empires and constitutions. However, the average life cycle of reinforced cement-based concrete constructions is specified by various standards and publications, such as LEED v4.1 and Minergy/SNBS, to be approximately 60 years (35 years for logistic and production structures). These relatively short life cycles are primarily due to steel corrosion and urban planning. While extending the lifetime of these materials is both possible and desirable, given the current state of the global building industry, an average lifespan of 60 years for buildings and urban infrastructures and 35 years for logistics and production facilities is representative.

During the building's existence, the concrete matrix protects the biochar, e.g., from water, air, and chemicals, so it does not decay. For the duration of the average construction life cycle of 35 to 60 years, depending on the construction type, the carbon sink can be registered with 100% carbon persistence. No biochar carbon is lost when incorporated into the construction material for as long as the building exists. This holds true regardless of the binder used in the construction material, whether cement, lime, clay, or geopolymers.

While the preservation of biochar carbon during a building's lifetime is undisputed, the end-of-life scenario becomes crucial for certifying it as a permanent carbon sink. Different scenarios must be considered at this stage:

1) **Landfill**: Demolished building materials are often deposited in landfills and, thus, indirectly applied to the soil or at least exposed to conditions that are comparable to those in the soil, especially concerning moisture and biological activity. Still, concrete fragments are typically relatively large (centi- to decimeters), and the biochar particles within these pieces remain protected from microbial and chemical attacks for many decades to centuries. However, depending on the soil's pH, the biochar carbon will eventually be exposed to environmental conditions. Thus, the standard decay curve of soil-applied biochar applies once the rubble is deposited in

a landfill, with the year of landfill deposition marking the starting point of the biochar decay curve.

2) **Conventional concrete recycling**: Demolished concrete is increasingly recycled into new construction materials or fillers. To achieve this, the rubble must be crushed. During the crushing process, the biochar remains within the resulting pebbles. Depending on the size and quality of the crushed materials, these pebbles are used as filler, such as in road construction, or as aggregate for new construction materials. Both scenarios are distinguished in regard to the C-sink registration:

   2.1 When used as filler for roadbeds, retaining walls, or landscaping gravel where no binder is applied, the biochar carbon remains protected within the crushed concrete matrix for many decades. However, it will eventually be released into the soil matrix. The application of the filler material is considered the entry point to geology and marks the starting point of the decay curve for soil-applied biochar.

   2.2 When used as aggregate for new construction material, i.e., the aggregate is mixed with a binder, a new life cycle as building material begins, with an average lifetime of 60 years and no decomposition of biochar carbon (100% persistence during the second use as construction material). This cycle of reuse in building materials can continue many more times before reaching its end-of-life as filler in roadbeds (scenario 2.1) or landfills (scenario 1).

3) **Thermo-oxidative cement recycling:** A new process developed at laboratory scale aims to recycle cement from concrete materials and reuse it as a cement binder. To do this, the concrete is ground very finely and sieved to separate the used binder (fine material) and aggregates (oversized particles). The sieved oversize can be reused as aggregate, which is particularly important as sand is a non-renewable, limited resource (Wang et al., 2021). The fines, i.e., hydrated and aged cement, can then be reactivated by thermal treatment at 1400 °C under an oxidative environment (Bogas et al., 2021; Carriço et al., 2020; Dunant et al., 2024; Mostazid and Sakai, 2023). It can be assumed that biochar would predominantly end up with the fines and thus would be oxidized during the thermal treatment.
   While this procedure is theoretically possible, thermo-oxidative cement recycling will not be implemented at scale and thus not become an end-of-life scenario for biochar-amended concrete. Reactivation requires the same temperature level as conventional cement production from limestone, which is abundantly available in the earth's crust, inexpensive and its use and

quality assurance is well established. Additionally, cement-based concrete captures significant amounts of atmospheric CO_2 during aging, transforming it into highly stable carbonates. When concrete or recycled cement paste is deposited in non-acidic landfills, these carbonates form a very stable, long-term carbon sink. Aged concrete contains more than 20 kg CO_2e per m^3 in the form of carbonates formed with CO_2 captured from the atmosphere and/or industrial sources (Monkman and MacDonald, 2017; Pae et al., 2024; Zhao et al., 2024), which may even have been vcertified as a carbon sink (Puro Earth, 2022). If biochar were added as a cement additive or sand replacement, the carbon content could exceed 10% (m/m).

If the cement paste were thermo-oxidatively recycled, the captured and concrete-sequestered carbon would be released as CO_2. Given that by 2050, all industrial emissions must be equipped with CC-SINK, the additional cost of recycling cement paste would make it comparatively more expensive than sequestering the cement paste in a soil matrix and producing new cement from limestone with CC-SINK already in place. Maintaining the carbon sink long-term by sequestering hydrated and aged cement without thermal treatment is the most sustainable and economical recycling option.

Dunant et al. (2024) investigated combining steel and cement recycling by using recycled cement paste as flux in the melting of waste steel. Although this approach appears promising, many questions remain regarding the industrial scale-up with highly heterogeneous cement pastes. While steel melting does not cause major CO2 emissions if conducted in electric furnaces, the thermo-oxidative treatment of carbonate and biochar-containing cement pastes would release significant amounts of CO2. This would necessitate CC-SINK, further increasing recycling costs.

If human civilization succeeds in limiting climate change, which is the primary goal of establishing the carbon sink economy, it is clear and unavoidable that by 2085—sixty years from now and the average life cycle of concrete buildings—no industrial CO2 emissions will enter the atmosphere but will instead be recycled for carbon materials or sequestered geologically. Given that CC-SINK of emissions from industrial processes will become legally mandatory in the coming decades, conventional limestone-based cement companies will not only produce cement but also purified CO2 for the carbon cycling economy (Schmidt and Hagemann, 2024). Cement production will become carbon neutral by then.

As landfill application of waste cement paste is accepted as carbon sequestration (for both carbonate and biochar carbon contained in the paste), recycling the heterogeneous paste with mandatory CC-SINK would clearly be at an economic, energetic, and environmental disadvantage compared to its carbon-sequestering landfill application and fresh cement production with CC-SINK.

It can thus be concluded that thermo-oxidative cement recycling is highly unlikely to develop due to both economic and physical considerations. According to the EU definition of permanent carbon removal as *any practice or process that, under normal circumstances and using appropriate management practices, captures and stores atmospheric or biogenic carbon for several centuries* (Eur-Lex, 2024), thermo-oxidative cement recycling can be excluded as an end-of-life scenario for biochar-containing concrete materials.

Biochar applied in construction materials, such as buildings, urban constructions, and infrastructure, is typically pre-mixed at a processor's site. In most cases, these pre-mixed materials are transported as bulk material, measured by weight or volume, rather than in packaging units. Depending on the individual systems in place, appropriate tracking of the materials to the construction site, and thus to the carbon sink site, must be developed and submitted to Carbon Standards for approval. Only when the tracking to the construction site is verified, and the building itself is registered as the carbon sink location can the biochar carbon sink be registered without decay for the expected average lifetime of the construction and potentially longer if material use in new constructions is tracked (c.f., scenario 2.2). If no tracking from the concrete mixing site to the construction site can be provided, the biochar contained in the concrete will be registered with the same degradation curve as soil-applied biochar.