CARBON REMOVALS EXPERT GROUP TECHNICAL ASSISTANCE

Review of certification methodologies for long-term biogenic carbon storage in buildings

by CRETA

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Glossary

Biogenic carbon storage in buildings	This refers to the long-term biogenic carbon storage of buildings.
Stored carbon	In the context of this document, stored carbon refers to the biogenic carbon sequestered by natural processes in materials, which remains locked within bio-based construction products throughout the lifespan of the building. **It's important to clarify that the proposed legislation exclusively focuses on certifying stored carbon.**
Embodied carbon	Embodied carbon denotes the greenhouse gas emissions resulting from the production, usage, and disposal of a construction element over its lifecycle.
Avoided carbon	Avoided carbon refers to the reduction in greenhouse gas emissions achieved when low-carbon products replace materials that are more emission-intensive. This is also known as the substitution effect.
Scale	In this document, "scale" refers to the dimension of the subject being evaluated by the methodology, which may encompass entire buildings, building components, or building materials (as illustrated in Figure 5).
Scope	"Scope" relates to the different stages of the building process defined in standard EN 15804 that the methodology aims to encompass (as depicted in Figure 6).
LCA	A life cycle assessment (LCA) is a systematic methodology that considers all stages of a product's life, from the extraction of raw materials to production, transportation, use, and disposal.
Static LCA	Static LCA is a traditional approach to life cycle assessment (LCA) that assumes that the environmental impacts of a product or system are constant over time. This means that the same input data is used to calculate the environmental impacts for each stage of the life cycle, regardless of when it occurs.
Dynamic LCA	Dynamic LCA is a newer approach to LCA that takes into account the changes in environmental impacts over time. This can be due to a

variety of factors, such as technological advancements, changes in resource availability, and changes in government regulations.

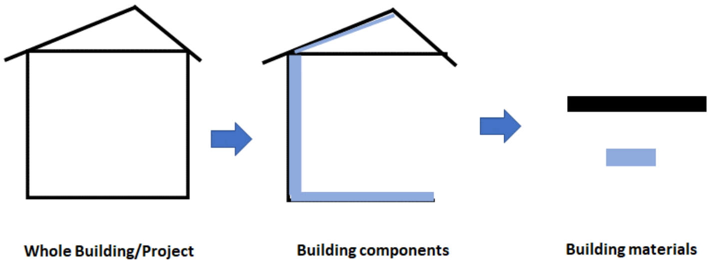


Figure 5 Simple schematic illustrating the scope of assessment[1].

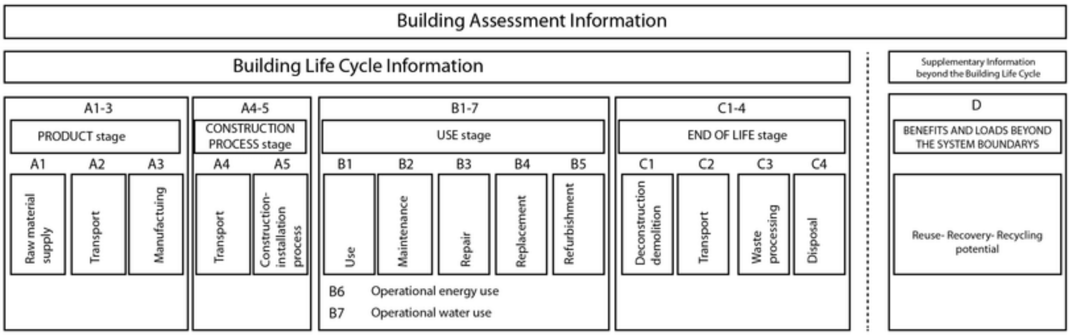


Figure 6 Construction stages in accordance with EN 15804: A1-3 product stage, A4-5 construction process stage, B1-7 use stage, C1-4 end of life stage, and D benefits and loads beyond system boundaries.

[1] Whole building consists of inventories for all building components (e.g., functional components such as insulation or structural components such as internal walls or rooves). These building components are in turn made of raw materials (e.g., structural wood beams). (Adapted from WUR report /Allacker et al. 2018 Environmental profile of building elements)

1. Introduction

This document provides a summary of existing certification and calculation methodologies for long-term biogenic carbon storage in buildings. Specifically, an analysis is made on how existing calculation and certification methodologies deal with aspects mentioned in the Commission's QU.A.L.ITY criteria as proposed in the Carbon Removal Certification Framework regulation proposal (CRCF). It also raises open methodological questions to stimulate meaningful expert discussions.

This summary is prepared by consultants from the CRETA consortium for the Carbon Removals Expert Group of the European Commission. It is based on the submissions from methodology developers and economic operators collected through a public survey that was launched during summer.

To facilitate the comprehension of the findings, it is crucial to clarify fundamental terms frequently referenced throughout this document. Please refer to the glossary on page 14.

Context

The proposed CRCF-regulation aims to contribute to the EU's climate and environmental goals and aligns with other EU initiatives. The EU climate goal includes carbon stock changes in harvested wood products from domestically produced forest biomass and carbon stock changes in the forest. In December 2021, the Commission addressed the importance of developing a standard, robust, and transparent methodology for quantifying the potential carbon storage benefits of construction products in the Sustainable Carbon Cycles Communication.

This commitment is reinforced by various Commission initiatives, such as the 2030 Forest Strategy, the revised Construction Product Regulation, the revised Energy Performance in Buildings Directive, the revised LULUCF Regulation, and the New European Bauhaus. These initiatives all refer to promoting long-lasting carbon storage in construction products.

Simultaneously, stakeholder meetings on buildings and construction products consistently express interest in quantification of carbon storage in construction products. Several Member States are already (working on) incorporating carbon storage in building codes. This collective effort aligns with the EU's vision for a more sustainable and low carbon construction industry.

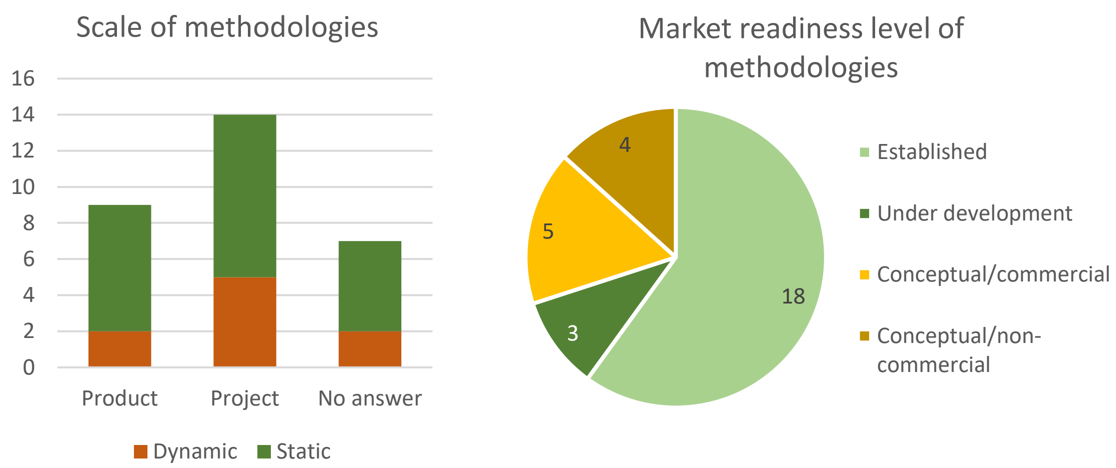
2. Survey results

Between July 20 and September 15, 2023, an online survey was carried out to gather input on certification and calculation methodologies for industrial carbon removals, including long-term biogenic carbon storage in buildings.

It was specifically aimed at experts actively engaged in the development or application of these methodologies. Respondents could propose calculation and certification methodologies that they regarded as best practices, outlining through their answers how elements of these methodologies dealt with aspects of the QU.A.L.ITY criteria.

A total of 12 survey responses were identified to be relevant to the topic of biogenic carbon storage in buildings. Additionally, 18 methodologies were collected by DG CLIMA and CRETA. The majority of these responses came from developers of certification and calculation methodologies, with fewer instances involving economic operators engaged in removal activities and the certification of stored carbon. In annex A the list of reviewed methodologies is given, including by whom they were submitted.

Please be aware that various certification methodologies, including those by Stichting Nationale Koolstofmarkt (Foundation National Carbon Market, NL), and the Timber Finance Initiative (CH), are currently under development. These methodologies may include additional best practices, however, they are not included in this analysis as they have not been published or submitted through the survey.



a) the scale of the methodologies

b) Assessment of methodologies' market readiness

Figure 1: Visualising survey outcomes a) sale of methodology, differentiating dynamic vs. static approaches, b) assessment of methodologies' market readiness.

In the survey, two scales of application were observed – product and project/building (as shown in Figure 1a, see Glossary). In methodologies at product level, emission data related to the production stage tends to be more precise. However, determining the actual lifespan of the product remains challenging as product destinations are not traced. Methodologies at project or building level generally assess the proportion of bio-based building materials within the building that store carbon, e.g., the volume of materials used. In contrast to product-level methodologies, assessing and verifying the lifespan of an entire building can be done with greater confidence. It is foreseen that certification methodologies at this level are mainly to be used by project or building developers.

The carbon storage methodologies varied in their readiness for market implementation (see Figure 1b), which can be classified into the following categories:

- **Conceptual/non-commercial:** Methodologies or tools found in academic literature and only used within academia and not applied in real market cases.
- **Conceptual/commercial:** Methodologies or tools under development, specifically tailored for practical market applications.
- **Under development:** Methodologies or tools that have been developed but are currently not in use in the market.
- **Established**: Methodologies or tools that have been developed and are applied in the market.

Furthermore, a distinction can be made between static and dynamic life cycle assessment[2] (LCA) approaches, as illustrated in Figure 2. Majority of the methodologies that use a dynamic approach fall under the market readiness classification of "conceptual/non-commercial".

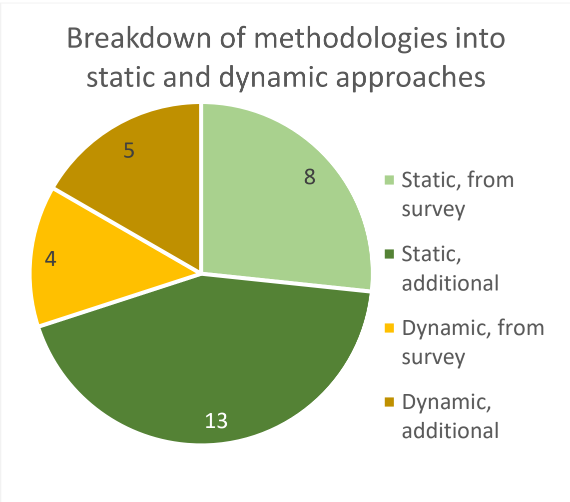


Figure 2: Breakdown of methodologies into static and dynamic approaches, distinguishing between survey submissions and methodologies that were analysed in addition.

3. Findings for QU.A.L.ITY criteria

In this chapter, the preliminary findings will be discussed concerning each QU.A.L.ITY criterion. Each section starts with a short description of the QU.A.L.ITY criterion and guiding questions. Elements on the main convergences and divergences of the analysed calculation and

[2] Static and dynamic Life Cycle Assessment (LCA) are two different approaches for evaluating how a product or process impacts the environment from its inception to disposal. They diverge in their handling of changes over time. Static LCA, resembling a snapshot, offers a one-time assessment based on fixed data, while dynamic LCA considers evolving conditions and delivers a more flexible and accurate representation of a product's environmental performance (please refer to the glossary for further information).

certification methodologies per QU.A.L.ITY will be highlighted, and the best practices identified will be emphasised. Each section will conclude with open questions that still remain.

Overall, it has been found that each of the methodologies contains elements that, when combined, would present a methodology that matches the QU.A.L.ITY criteria.

Quantification

This criterium refers to Article 4 of the proposed regulation. Essentially, a carbon removal activity shall be quantified in a relevant, accurate, complete, consistent, comparable, and transparent manner. The net carbon removal benefit would be quantified using the following formula:

$$\textit{Net carbon removal benefit} = CR_{baseline} - CR_{total} - GHG_{increase} > 0$$

where:

(a) $CR_{baseline}$ is the carbon removals under the baseline;

(b) CR_{total} is the total carbon removals of the carbon removal activity;

(c) $GHG_{increase}$ is the increase in direct and indirect greenhouse gas emissions, other than those from biogenic carbon pools in the case of carbon farming, which are due to the implementation of the carbon removal activity.

The baseline shall correspond to the standard carbon removal performance of comparable activities in similar social, economic, environmental and technological circumstances and take into account the geographical context and shall be periodically updated. Where duly justified, the baseline may be based on the individual carbon removal performance of that activity. In this case, additionality shall be demonstrated through specific tests. Furthermore, the quantification of the carbon removals shall account for uncertainties in accordance with recognised statistical approaches.

Guiding question for the assessment of methodologies:

- How is the net carbon removal benefit calculated? How are $CR_{baseline}$, CR_{total}, and $GHG_{increase}$ defined and measured in the carbon removal activity?
- How does the methodology ensure that carbon removals are quantified in a relevant, accurate, complete, consistent, comparable, and transparent manner?
- What approaches are utilised to account for uncertainties in the quantification of carbon removals?
- How is the data on carbon removals and greenhouse gas emissions collected?
- How is the baseline determined to represent the standard carbon removal performance of comparable activities in similar social, economic, environmental, and technological contexts while considering the geographical context? How is the periodic updating of the baseline carried out?

Consistency with the national GHG inventories

The proposed regulation also stipulates that “the operator or group of operators shall gather data on carbon removals and greenhouse gas emissions in a manner compatible with national greenhouse gas inventories”. The IPCC guidelines give four approaches in which the in and out flow of carbon in the harvested wood products pool (HWP) can be inventoried. To prevent inconsistencies and double counting, under the LULUCF Regulation all EU member states have to use the ‘production’ approach. In this approach the amount of domestically produced wood commodities (semi-finished products) manufactured from domestically harvested wood is added to the HWP pool. This includes products that are exported to other countries, but not products that are imported or produced with imported wood. Four categories of HWP are identified, with default densities and carbon content values. The outflow and emission to the atmosphere from the HWP pool is quantified with a first order decay function using default half-life times per product category. Currently only carbon storage in wood products is reported in this way, other biobased products and materials are excluded.

Key findings from review of methodologies:

Scope of the methodologies

Roughly, two thirds of the survey methodologies included the production stages of bio-based products into their scope as shown in Figure 3. Many of these methodologies focused on the product stages A1-A3, while some also included the disposal stage C4. No methodology considered the circularity-related stage D. Categorising these methodologies under the EN15804 standard posed challenges, as the methodology descriptions often lacked clarity about the intended stages for inclusion, with some rather offering a broader, more conceptual overview.

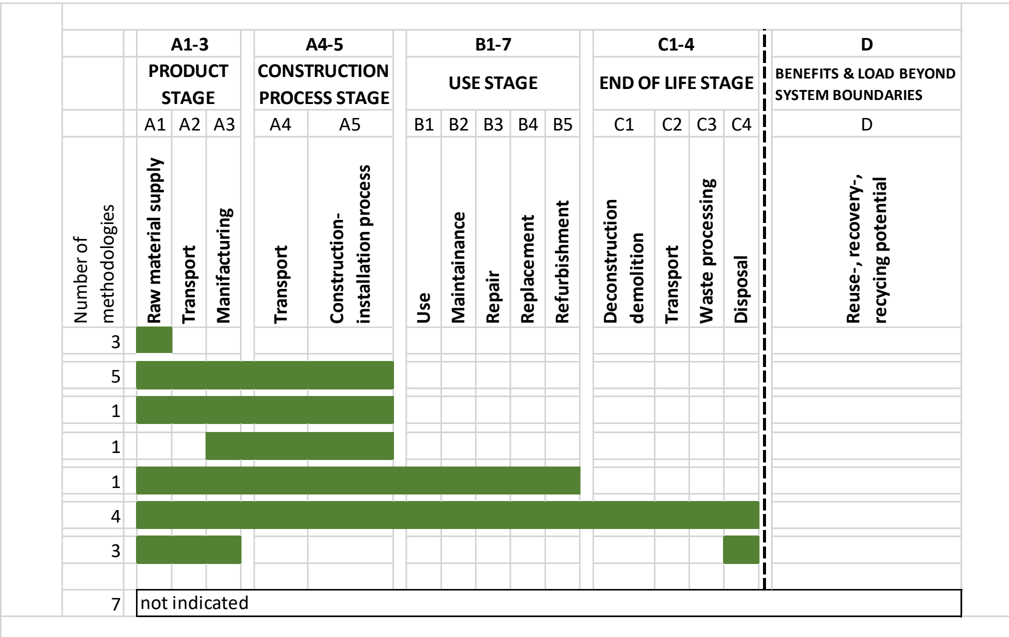


Figure 3: Visualising survey results relative to which building construction stages as defined by EN 15804 are covered by the methodologies.

Quantification of the total carbon removals of the carbon removal activity CR_{total}

The certification methodologies with a static calculation approach are most common in practice. Most static calculation methodologies share a common approach to estimate the amount of stored CO_2 in bio-based materials. Essentially, the mass of the bio-based material is multiplied by its carbon content, and this is multiplied by a conversion factor of (44/12) to convert carbon into carbon dioxide. The carbon content is typically designated as either a standard value, which ranges from 45% to 50% of the dry matter content of the bio-based product, or default values are specified for different tree types. For instance, the following formula is commonly employed:

$$Stored\ carbon = V * \rho * CC * \frac{44}{12}$$

where:
V = volume of the material in a building
ρ = dry matter density of material
CC = biogenic carbon content, which can be sourced from a table specific to the material or can be set as a default value of 0.45 for all wood types.

Several dynamic approaches, especially those focusing on the A1 production stage, integrate the carbon sequestered during forest growth through diverse methodologies. This integration provides a temporal profile, offering insights into the activity of CO_2 removal over time.

Quantification of the direct and indirect GHG emissions due to the implementation of the carbon removal activity $GHG_{increase}$

In most methodologies, both the direct and indirect GHG emissions are taken into account, allowing for a comprehensive assessment of GHG changes resulting from carbon removal activities. However, the project scope for assessing the embodied carbon varies. Methodologies may encompass a range of stages, such as forestry activities, material manufacturing, production of construction elements, and transportation steps to the construction site (refer to Figure 6). This diversity can create challenges when trying to compare certification methodologies. Therefore, it is important to clearly define which stages of the building construction project must be accounted for when calculating the net carbon removal benefit.

Data accessibility and accounting for uncertainties

Most methodologies tend to overlook uncertainties associated with data availability, data usage, and potential carbon leakage. Nevertheless, there are instances where this aspect has been addressed. Broadly, three approaches are identified for managing uncertainties about the data used in the quantification:

Table 1. Example from a subsample of methodologies, outlining the approach to addressing uncertainty about data.

ILCD Handbook (2010) **PAS 2050:2011 (2011)** **SNK (2023)**	Uncertainties in the calculation should be reported with the certification application or LCA report. In some cases, third-party review of the assumptions may be required or strongly recommended.

ONCRA- Construction Stored Carbon concept version for 2024	Uncertainties are disclosed, and in cases where precise data is lacking, conservative assumptions are applied during calculations.
Anrechnung der Senkenleistung von Schweizer Holz als CO2-Kompensationsmassnahme	The applicant must demonstrate that the calculation method and assumptions adopted do not result in overestimation of emission reductions. In case of insufficient precision, the applicant must implement scientific support measures.
Riverse - Bio-based construction materials	Riverse staff might require the applicant to put 5-15% of the credits in a 'buffer pool' to account for uncertainty.

Few methodologies incorporate to mitigation plans or strategies to address uncertainties associated with potential leakage and risk of reversal.

Table 2. Example from a subsample of methodologies, outlining the approach to addressing uncertainty about risk of reversal.	
Verra VCS Standard	Risk assessment with a 'non-permanence' risk tool is required. The tool determines the number of credits to be deposited in a buffer pool. (For agriculture, forestry, and other land use projects.)
Riverse - Bio-based construction materials	An evaluation of the risk of reversal using a prescribed format is required, outlining potential causes for reversal and their likelihood.
Puro.earth Biobased Construction Materials Methodology (2019)	A 'buffer pool' for uncertainties about loss after production and other losses is included. This buffer is subtracted from the overall amount of stored carbon that is certified.
Puro.earth Woody biomass burial methodology (2023)	Addresses uncertainty within the certification rules rather than in the calculation process. Utilises a risk and mitigation matrix in the certification methodology.
BBCA Label Bas Carbone method for new buildings	All risks that might lead to reversal are combined in a single -10% discount of the total amount.

Baseline $CR_{baseline}$

It is important to note that the proposed regulation specifies the inclusion of a standardised baseline. However, only about 35% of the analysed methodologies included a baseline. A variety of different approaches to determine the baselines was observed. These included scenarios (as part of the dynamic LCA approach), quantified targets (partially dynamic RE2020), and reference buildings (see Table 3 on baseline and additionality below). Very few methodologies used a baseline for stored carbon at building or project scale.

Table 3. Example from a subsample of methodologies, demonstrating the approach to incorporating additionality	
SNK 2023 – Method for storage in hemp	Reference products and an average baseline value (kg CO_2/m^2) are specified, calculated based on material market share, with baseline accuracy checks every 3 years. No region-specific baseline.
Anrechnung der Senkenleistung von	This methodology does not cover only construction materials, but all harvested wood products. Applicants can certify the storage of carbon in wood products that are additional to expected amount of wood products in the market. The

Schweizer Holz als CO2-Kompensationsmassnahme	baseline is determined from the annual volume of harvested wood products in Switzerland, based on historical official data and market trends. The market situation is reassessed annually. In the event of major changes, the baseline is reviewed by an independent panel of experts and adjusted if necessary.
BBCA Label Bas Carbone method for new buildings	There are reference values for stored carbon (in kg CO_2e/m^2) given for the years 2015 and 2035, for three different building types. The reference value for a given year between these dates can be calculated by linear interpolation between the value for 2015 and 2035.
ONCRA - Construction Stored Carbon concept version for 2024	A formula for a baseline scenario is given. This formula is utilized to compute the carbon storage in materials intended for use in the target building over a 100-year period. However, this calculation is performed under the assumption of a fictive scenario where these materials are repurposed for uses other than in the building. The formula includes predefined half-lives for each material type. It's important to note that materials with a market penetration exceeding 20% are ineligible for certification.
Riverse - Bio-based construction materials	Applicants select a reference project and justify their chosen baseline scenario for calculations.

Storage (vs. substitution)

It's important to emphasise that the regulation proposal specifies that only the stored carbon can be certified. However, in the analysis of the certification methodologies, it was observed that some also include the substitution result. This means that not only the stored carbon is calculated, and thus certified, but also the avoided emissions through alternative material choices. Some methodologies provide distinct and separate reporting of storage and substitution results, while others do not make such a clear distinction.

Table 4. Example from a subsample of methodologies, indicating the reporting of stored an embodied carbon	
ILCD Handbook (2010) & PAS 2050:2011	Biogenic carbon storage and embodied carbon should be reported separately.
LCBI label (v 0.1 - not definitive)	Report separately embodied carbon, stored biogenic carbon and operational emissions.
Puro.earth (2019) & ONCRA (2024, proposed)	Only report stored biogenic carbon and embodied carbon associated with the production, construction, and use of biobased materials.
ONCRA (2019)	Only report stored biogenic carbon.
Label Bas Carbone	For new buildings, only report stored biogenic carbon. For renovation projects the avoided carbon from reuse of materials can be reported separately.
TNO (2021)	Combine total embodied and stored carbon per building.

Open Questions

Scope and Scale:

- In the context of certifying biogenic carbon storage in buildings, which stages of building construction should be included in the scope of the calculations of the GHG emissions ($GHG_{increase}$)?
- Should the certification methodology encompass both new constructions and renovations? How should primary and secondary materials be treated in the methodology?

Standardised Baseline:

- What methodologies can be employed to establish a standardised baseline for carbon storage on building level with minimal administrative complexity?
- When determining the baseline, is there a need to distinguish the types of buildings in a representative region? At what regular intervals should the baseline be updated?
- Where should the system boundaries be set to maintain coherence with national inventories and avoid double counting?

Leveraging Existing Building Databases:

- What data is available and at what scale to support the establishment and viability of certification schemes at building level?
- How can existing building databases be effectively leveraged to determine the net carbon benefit, especially concerning $GHG_{increase}$ and $GHG_{baseline}$?

Uncertainties

- How can the uncertainties related to potential carbon leakage and the unplanned release of stored carbon be effectively addressed?

Additionality

This criterion refers to Article 5 of the proposed regulation. A carbon removal activity must be "additional", meaning that it must go beyond both Union and national legal requirements and must be driven by the incentive provided by the certification. Meeting the additionality criteria means that the carbon removal activity exceeds the established baseline, as determined by the quantification criterion.

Guiding question for the assessment of methodologies:

- How does the carbon removal activity go beyond both Union and national statutory requirements? How is the activity driven by the incentive effect of certification?
- If the baseline is established, how is additionality considered to be met?

Key findings from review of methodologies:

The methodologies typically integrate additionality into the eligibility rules for certification rather than being a part of the baseline calculation itself. Both regulatory and financial additionality are commonly taken into account. Notably, four methodologies offer a clear approach for demonstrating additionality by estimating the carbon removal benefit against standardised baselines, as listed in Table 3. In contrast, a few methodologies use an alternative approach. In one method, additionality is assumed by default for bio-based construction materials like hemp, straw, or wood as long as the market share of these materials falls below a specific threshold. This assumption is grounded in the notion that the use of materials with such a limited market presence can be considered as an additional carbon storage effort.

Long-term storage

This criterion, as outlined in Article 6 of the proposed regulation, requires that carbon removal activities must secure the long-term storage of carbon. Any risk of release of the stored carbon occurring during the monitoring period must be monitored and mitigated. Effective liability mechanisms must also be put in place to address any such releases. In the context of products, any carbon stored during a carbon removal activity is considered to be released into the atmosphere when the monitoring period concludes. Consequently, for buildings, temporary carbon removal certificates would be issued corresponding to the distinct monitoring period of each building.

Guiding question for the assessment of methodologies:

- How does the methodology ensure that the carbon removal activity is designed to achieve long-term carbon storage?
- How is the monitoring and mitigation of any risk of stored carbon release managed during the monitoring period? What is the chosen monitoring period and why?
- Are mechanisms in place to address the release of stored carbon during the monitoring period?
- End of life: How is the carbon stored by a carbon removal activity handled and considered at the conclusion of the monitoring period?

Key findings from review of methodologies:

The majority of certification methodologies do not impose a specific timeframe for certification. Certification typically ceases when the stored carbon is released, monitoring discontinues, or the reporting period concludes. There was one exception, where certification was time-limited, set to expire on December 31, 2030. In cases where the certification period was bound to the reporting period, it was commonly capped at 100 years.

Monitoring and mitigation of any risk of stored carbon release

Half of the analysed certification methodologies set monitoring requirements for stored carbon. Risk mitigation of carbon release is not commonly included in the methodologies. When it is included, it typically involves the establishment of a 'buffer pool' in which a percentage of the certified carbon is reserved and cannot be traded.

Table 5. Example from a subsample of methodologies, demonstrating the integration of monitoring in the certification process.

Timber Finance Initiative	The lifespan of the certified element is considered to be equal to the lifespan of the building. Lifespan of the building is verified using satellite photographs.
ONCRA- Construction Stored Carbon concept version for 2024.	The monitoring period is 100 years regardless of the (expected) lifespan of the project. The monitoring frequency is once a year.
Riverse - Bio-based construction materials	The monitoring period is equal to the certification period. The certification body determines a monitoring frequency on a case-to-case basis, ranging from 3 months to 1 year.

End of life

End-of-life (EoL) scenarios were often excluded due to significant uncertainties associated with EoL processes. In cases where EoL was considered, the default assumption was typically an immediate release of biogenic carbon. In dynamic life cycle assessment (LCA) methodologies, which were more comprehensive, EoL was considered in most cases. These dynamic methodologies often used various scenarios, such as burning or landfilling, to assess different temporal profiles of emissions and their resulting impact on global warming potentials.

Open questions:

- What is the most effective monitoring frequency (e.g., audits, physical inspections), and could those be integrated with the existing auditing and inspection routines for buildings?
- What is the likelihood of carbon release during the monitoring period, and what measures can be implemented to mitigate this risk?

Sustainability

This criterion, outlined in Article 7 of the proposed regulation, requires a carbon removal activity to achieve not only a net carbon removal benefit but also have a neutral impact or generate positive effects on various sustainability goals. It necessitates compliance with specific sustainability requirements and allows for the reporting of co-benefits. Certification methodologies should encourage the generation of these co-benefits.

Guiding question for the assessment of methodologies:

- How does the carbon removal activity ensure a neutral impact on or generate co-benefits for the specified sustainability objectives?
- What are the sustainability requirements prescribed by the certification methodology?
- Are co-benefits defined?
- Does the certification methodology encourage the generation of co-benefits that surpass the sustainability requirements? How?

Key findings from review of methodologies:

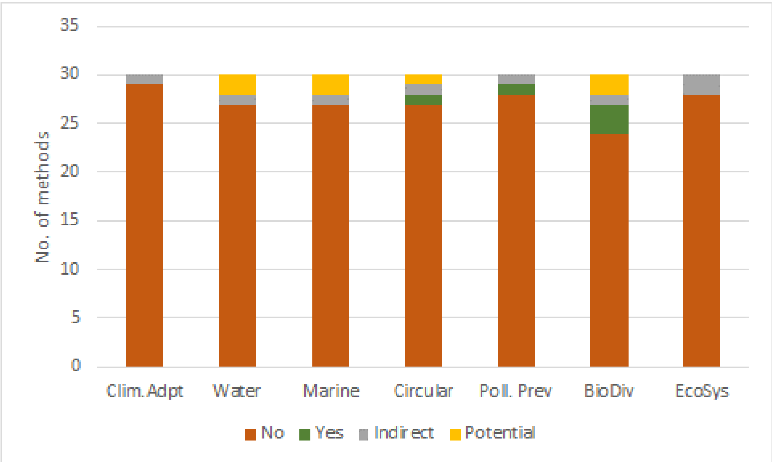


Figure 4: Visual overview of how the methodologies addressed sustainability and co-benefit considerations. 'No' indicates not included, 'yes' signifies inclusion, 'indirect' implies that an external

sustainability certification is necessary, and 'potential' suggests possible inclusion in future methodologies[3].

Minimum sustainability requirements

In many cases, explicit and well-defined minimum requirements are lacking. The assessment of sustainability is frequently indirect, with certification eligibility criteria relying on the availability of sustainable harvesting certification schemes for wood products like PEFC or FSC, which inherently presuppose forest regrowth.

Leveraging sustainability criteria from existing regulations, such as RED III, could provide a valuable starting point for defining the requirements for sustainable harvesting. Moreover, mandating a specific energy performance rating for the building would help ensure that only sustainable buildings are certified.

Consideration of Co-benefits

The main co-benefit is regarding circularity and material reuse, while they can often be reported, there are usually no specific minimum requirements defined.

Table 6. Example from a subsample of methodologies, outlining the integrations of circularity.

LCBI Label	In the calculation of the embodied carbon (which is reported separately from the stored carbon), reused products are allocated 0% of initial emissions, i.e. reused products have to be reported on but emissions can be left out of the calculation.
Riverse - Bio-based construction materials	The material footprint and tons of avoided waste per year must be provided in the certification application but will not be included in the calculation.
B2C carbon sequestration tool (FP Innovations, 2013)	Recycling rates for the materials should be entered in the calculator and will be incorporated into the calculation as an extended lifespan.

Open Questions:

- Which sustainability requirements should be mandatory, and at what level should they be defined?
- Are current certifications for sustainably harvested wood adequate, or do they require additional criteria?
- How can such criteria be incorporated into an auditing process which aims to monitor overtime?
- How can sustainability criteria be set to prevent rebound effects?
- What measures can be taken to promote sufficiency, circularity, and cascading use as co-benefits?
- How can certification methodologies be designed to stimulate and incentivise the creation of co-benefits?

[3] Clim. Adapt= climate adaptation, water=fresh water, marine = marine waters, Circular= circular economy, Poll. Prev=pollution prevention, BioDiv=Biodiversity , EcoSys=Ecosystems

4. Conclusion

In conclusion, this document offers a comprehensive yet not exhaustive overview of the existing certification and calculation methodologies for long-term biogenic carbon storage in buildings. While several methodologies are under development, this analysis focused on those that were publicly available or submitted through the survey. The survey results revealed valuable insights into the current landscape of certification methodologies for biogenic carbon storage in buildings, serving as a valuable starting point for ongoing discussions.

Annex A – Included methodologies

Study / Methodology	Link to publication	Respondent	Type of respondent
Anrechnung der Senkenleistung von Schweizer Holz als CO2-Kompensationsmassnahme	https://www.bafu.admin.ch/bafu/de/home/themen/klima/fachinformationen/verminderungsmassnahmen/kompensation/inland/registrierte-projekte/9-1.html	Anonymous response	
Athena Impact Estimator for Buildings	http://www.athenasmi.org/our-software-data/impact-estimator/	*from CRETA review*	
Aureus Earth - Mass Timber Building Protocol	Not publicly available	*from CRETA review*	
B2B and B2C carbon sequestration tools (FP Innovations, 2013)	https://library.fpinnovations.ca/en/permalink/fpipub8139	*from CRETA review*	
BayFHolz - Bayern Wood building subsidy scheme	https://www.stmb.bayern.de/buw/bauthemen/gebaeudeundenergie/foerderprogramme/bayfholz/index.php	Thuenen Institute, later through feedback round	Developer of methodology
Carbon calculator of the Canadian Wood council	https://cwc.ca/en/design-tools/carbon-calculator/	*from CRETA review*	
CCI tool (LCIA) (Tiruta-Barna, 2021)	na	University of Toulouse	Developer of methodology
Centralised per year carbon removal payments for timber and other biobased products	https://www.nature.com/articles/d41586-023-02649-8 and https://link.springer.com/article/10.1023/A:1009697625521	Anonymous response	
Conceptual issue of the dynamic GWP indicator and solution (Ventura, 2023)	https://link.springer.com/article/10.1007/s11367-022-02028-x#citeas	*from CRETA review*	
Concrete CO2 uptake model - IVL (2021)	https://www.ivl.se/projektwebbar/co2-concrete-uptake/calculation-models/tier-2-calculation-model.html	IVL Swedish Environmental Research Institute	Developer of methodology
Dynamic greenhouse gas life cycle inventory and impact profiles of wood used in Canadian buildings (Head et al., 2020)	https://www.sciencedirect.com/science/article/pii/S0360132320301098	*from CRETA review*	

DyPLCA Tool /Method (Negishi et al. 2018, 2019 - applied)	https://www.sciencedirect.com/science/article/pii/S0959652615018739 https://link.springer.com/article/10.1007/s11367-019-01696-6 https://www.sciencedirect.com/science/article/abs/pii/S0360132319305876	University of Toulouse	Developer of methodology
Forestry carbon budget models to improve biogenic carbon accounting in life cycle assessment (Head et al., 2019)	https://www.sciencedirect.com/science/article/pii/S0959652618338320#appsec1	*from CRETA review*	
FRESCOS tool	https://www.frescos.earth/_files/ugd/cff30d_02aaeeb9c7d84a94a1aa65e2ced569e3.pdf	*from CRETA review*	
ILCD Handbook (2010)	https://eplca.jrc.ec.europa.eu/uploads/ILCD-Handbook-General-guide-for-LCA-DETAILED-GUIDANCE-12March2010-ISBN-fin-v1.0-EN.pdf	*from CRETA review*	
LCBI label (v 0.1 - not definitive) by Association BBCA	https://www.lowcarbonbuilding.com/methodology/	*from CRETA review*	
Nova Institute 2023 - Carbon Storage in Hemp and Wood raw materials for Construction Materials	https://eiha.org/wp-content/uploads/2023/07/Carbon-Storage-in-Hemp-and-Wood-raw-materials-for-Construction-Materials.pdf	*from CRETA review*	
ONCRA- Construction Stored Carbon (2021)	https://climatecleanup.org/wp-content/uploads/2022/01/Construction-Stored-Carbon-V8-11-2021-5.pdf	*from CRETA review*	
ONCRA- Construction Stored Carbon concept version for 2024.	Not publicly available	Climate Cleanup	Developer of methodology
Parisa et al 2022 - The time value of carbon storage	https://www.sciencedirect.com/science/article/pii/S1389934122001538	*from CRETA review*	
PAS 2050:2011	https://www.bsigroup.com/globalassets/localfiles/en-th/carbon-footprint/pas-2050-2011-guide.pdf	*from CRETA review*	
Puro.earth Biobased Construction Materials Methodology (2019)	https://connect.puro.earth/biobased-construction-materials-carbon-removal	Hasslacjer Norica Timber	Economic operator

Puro.earth Carbonated Materials Methodology (2022)	https://connect.puro.earth/carbonated-materials-carbon-removal-methodology		
Puro.earth Woody biomass burial methodology (2023)	https://connect.puro.earth/woody-biomass-burial	Carbon Lockdown	Economic operator
Label Bas Carbone	https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000043936431	l'Association pour le Développement du Bâtiment Bas Carbone & French Ministry of Energy Transition	Economic operator & Governmental organisation
Riverse - Bio-based construction materials	https://app.hubspot.com/documents/20406207/view/484655743?accessId=3f7e8b and https://www.riverse.io/standard/bio-based-construction-materials	Riverse	Developer of methodology
SNK 2023 - Method for determining CO2 emission reduction and storage in hemp	https://nationaleco2markt.nl/wp-content/uploads/2023/05/04042023-SNK-methodedocument-hennep-langdurige-opslag.pdf	Stichting Nationale Koolstofmarkt	Developer of methodology
Temporalis (Cardellini and Mutel, 2018)	https://www.sciencedirect.com/science/article/pii/S0048969718325257?via=ihub#s0060	*from CRETA review*	
Timber finance initiative	https://cdm.unfccc.int/methodologies/PAmethodologies/tools/	Timber Finance	Developer of methodology
TNO 2021 (Dutch only) - Een verkenning van het potentieel van tijdelijke CO2-opslag bij houtbouw	https://www.tno.nl/nl/newsroom/2021/01/onderzoek-co2-opslag-houtbouw/	*from CRETA review*	
Verra VCS - REDD+ VMD0005 Module: Estimation of carbon stocks in the long-term wood products pool	https://verra.org/methodologies/vmd0005-estimation-carbon-stocks-long-term-wood-products-pool-cp-w-v1-1/	*from CRETA review*	