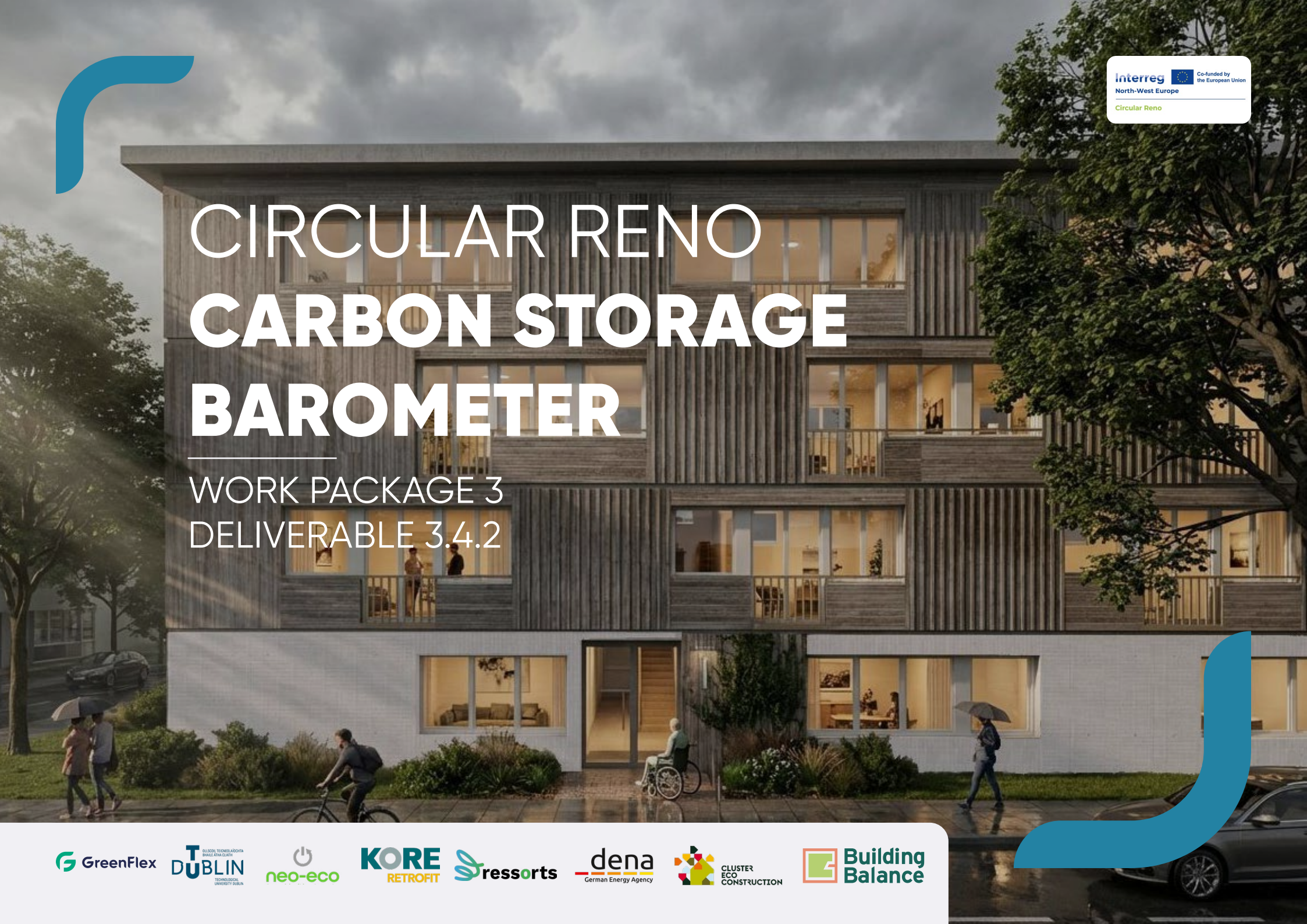

Interreg Co-funded by the European Union
North-West Europe
Circular Reno

CIRCULAR RENO
CARBON STORAGE BAROMETER

WORK PACKAGE 3
DELIVERABLE 3.4.2

GreenFlex · Dublin Technological University · neo-eco · KORE Retrofit · ressorts · dena German Energy Agency · Cluster Eco Construction · Building Balance

CONTENT

CARBON STORAGE BAROMETER

Publishing a market state of the art of biobased solutions carbon footprint, including the associated valuation of carbon credit valuation.

EXECUTIVE SUMMARY

The construction sector is a major contributor to global greenhouse gas emissions, particularly through the use of carbon-intensive materials. As operational emissions decrease due to energy efficiency improvements, **the carbon embodied in materials is becoming a dominant share of a new building's lifecycle emissions,** reaching up to 50 % in low-energy buildings. For older buildings, renovation should be practiced at a steady pace in order to ensure a comfortable living environment for occupants whilst achieving energy savings. Thus, in the 2020s climate context, biobased materials offer a **dual climate benefit for the construction sector: they generally have lower production emissions, and they store biogenic carbon absorbed during plant growth.**

Yet, methodological fragmentation across Europe, particularly regarding end-of-life assumptions and the treatment of biogenic carbon, limits comparability and undervalues biobased materials in many contexts. **Regulations are progressively integrating lifecycle carbon considerations and carbon removal certification, but do not yet provide a harmonised methodology for carbon storage in buildings.** Because of that, different methodologies are spreading across the UE, particularly in France and the Netherlands. At the same time, to offer financial incentives to actors across the value chain, the voluntary carbon market (VCM) emerges as a promising mechanism to monetise stored carbon.

This report analyses the current state of carbon storage in biobased construction materials and explores how this carbon can be measured, regulated, and monetised.

PRESENTATION

The Circular Reno project, funded by Interreg North-West Europe, aims to **accelerate the transition toward a more circular and low-carbon construction sector,** with a strong focus on building renovation. It addresses the high environmental impact of the construction industry by promoting the use of bio-based and recycled materials instead of carbon-intensive conventional resources. Key objectives are to develop scalable deep energy renovation solutions (notably prefabricated façade and roof systems), tools and methodologies to facilitate adoption by stakeholders and local value chains, connecting farmers, manufacturers, construction companies, and social housing providers across several European countries. More broadly, it **aims to support a systemic shift toward circular economy principles in the renovation market.** It is within this context that GreenFlex. Bulding Balance, TUDublin, Kore Retrofit, Neo Eco, Ressorts, Cluster Eco-Construction and Deutshe Energie-Argentur wrote this paper. This report was also developed with the valuable contribution of individuals who kindly agreed to be interviewed, helping to shed light on the realities and complexities of the sector. The Circular Reno team would like to take this opportunity to express its sincere thanks to Julie Poisson from the Fédération bretonne des matériaux biosourcés, Marilyne Rossi from DREAL Hauts-de-France, Nicolas Ferrière from CarbonApp, Grégoire Guirauden from Rainbow Standard, Joël Lagneau and Arno Dignan from Interchanvre and Bastien Bouteloup from Woodeum.

Biobased materials represent a credible and scalable solution to reduce emissions and store carbon in the built environment Unlocking their full potential will depend on aligning measurement, regulation, and finance to create a coherent and robust market framework. It is with these considerations in mind that GreenFlex, with the help of a number of international contributors, has produced this report.

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INTRODUCTION

Climate context – emissions are and will be rising

Ten years after the Paris Agreement was adopted, the growth rate of global greenhouse gas (GHG) is more than four times the average annual increase (1). This concentration of gas reduces the amount of heat escaping into space and leads to a sustained rise in global average temperatures. Scientific evidence shows this mechanism, caused by human activities, is the primary driver of observed global warming (2). Emission coming from combustion of coal, oil and gas in the energy sector and manufacture of metals, cement and others construction materials in the building sector accounts for 69 % of global GHG emissions (3). From material extraction to the end of life through construction processes, the buildings industry represents one of the most significant contributors to global carbon emissions in the world. **Today, it is estimated that concrete, steel and aluminium account for around 23 % of overall global emissions (4).**

These trends are likely to intensify in the years and decades to come. Each year, the global population grows by around 80 million people and is expected to reach 9.7 billion by 2050. Most of this increase will occur in urban areas, intensifying demand for new housing and infrastructure. As long as the construction sector relies on some of the most carbon-intensive materials like cement, steel or clinker, these colossal needs will have a significant impact on the climate (as well as on freshwater consumption and the extraction of sand and gravel) (5). As climate action becomes more urgent, attention is increasingly turning to the carbon footprint of construction activities. Across Europe, governments, industry players, and stakeholders have committed to net zero targets, and the construction sector is pivotal in this transformation.

Renovation is one of the main levers for decar bonising the construction sector

At the European Union (EU) scale, the common framework supervising the decarbonisation of the construction sector is the Energy Performance of Buildings Directive (EPBD). Signed in 2024, it states that all new buildings must be “zero emission buildings” by 2030, and as soon as 2028 for public buildings. In that case, zero emission buildings mean having no on site fossil fuel emissions and very low energy demand, supplied by renewables (6). The directive also states that renovating existing buildings is essential to achieving climate targets. From a carbon perspective, renovation generally results in lower lifecycle emissions than demolition and reconstruction, as it preserves the embodied carbon of existing structures and avoids material and waste-intensive new buildings. While new construction is not prohibited, it represents only a small share of the total building stock (approximately 1 % of buildings are newly built each year in the EU (7)).

As a result, the EPBD **clearly positions renovation as the primary lever for decarbonising the built environment.** 16 % of the worst performing non-residential buildings shall be renovated by 2030, and 26 % by 2033. It will be 22 % for the residential buildings. In Member States, UE’s policies have been declined differently and are more or less advanced. Across the five countries covered in this report, approaches to building decarbonisation vary

significantly. France (8) stands out as the most regulatory-driven, with binding carbon-intensity thresholds per m^2 for new buildings under RE2020, the only country to use this metric. Germany (9) relies more heavily on financial incentives (loans, tax deductions) alongside emission targets, while Belgium's (10) fragmented governance means renovation objectives are set at regional rather than national level. Ireland (9) and the Netherlands (11) broadly follow the EPBD framework without additional binding renovation requirements, relying instead on strategic plans and energy consumption targets. Across all five, renovation is increasingly prioritised over new construction, though current annual renovation rates - around 1 % - remain well below what 2050 targets require.

By the end of 2026, all Member State must prepare a National Building Renovation Plan (NBRP) with quantified targets for 2030 / 2040 / 2050, including investment needs and financing sources (12). The aim is to massively accelerate renovation as the current annual renovation rate (around 1 %) is insufficient to reach 2050 targets.

Biobased materials have a role to play to reach our objectives

To meet the 2030, 2040 and 2050 emissions reductions objectives, the construction sector will need to place greater emphasis on decarbonisation, modernisation, financing, and technical assistance. In this context, **innovative bio based building** materials (cross laminated timber, hemp based concrete, straw insulation panels ...) **play a key role in supporting the transition towards a circular, climate neutral and resilient built environment.** Material choices directly influence a building's upfront GHG emissions, making embodied carbon, i.e. emissions associated with materials and construction processes, a critical component of low carbon construction strategies (13). Because they are wholly or partly derived from biomasses such as plants, animals, microorganisms or their residues, bio based materials are recognised as a lead market within the EU Bioeconomy Strategy. They are characterised by their biogenic carbon content, which reflects the proportion of carbon originating from recently living biological sources rather than fossil resources (14). In France, the market volume for bio based materials has almost doubled since 2016, reaching, for example, 11 % of materials used in insulation works in 2023 (15). By comparison, the share reached 10 % in Germany in 2024 (16), but only 2 % in the Netherlands (17).

For these reasons, this document focuses on how embodied carbon can be taken into account to accelerate the uptake of bio based materials in the European renovation sector. While bio based construction materials also offer a range of additional benefits such as good thermal insulation and regulation, moisture absorption and release, improved indoor humidity control, and effective acoustic performance this document concentrates specifically on their carbon impact.

1 MARKET STATE OF THE ART – CARBON FOOTPRINT

An overview of carbon accounting in the building sector

Reducing emissions in the construction sector requires addressing two distinct types of carbon: *operational carbon* linked to energy use once the building is in use and *embodied carbon* linked to the production, transport, construction and end-of-life of materials. While operational carbon has historically been the primary focus of emissions reduction efforts through policies such as the Energy Efficiency Directive (EED) and the Renewable Energy Directive (RED II), **the decarbonisation of energy grids means that embodied carbon now constitutes a growing share of a building's total lifecycle emissions.** For new low-energy buildings, it may account for up to 50 % of total emissions (18).

Types of Carbon in Buildings

Embodied Carbon
The emissions from manufacturing, transportation, and installation of building materials.

Operational Carbon
The emissions from a building's energy consumption.

Adapted from Carbon Cure, 'What is embodied carbon?' published 22.09.2020

Measuring embodied carbon is therefore increasingly essential for regulators setting carbon thresholds, for developers making material choices, and for companies required to report on their climate impact under frameworks such as the Corporate Sustainability Reporting Directive (CSRD). For manufacturer, constructor, local authorities, project manager, client etc., quantifying carbon enables to identify their main sources of emissions, assess alignment with climate targets, and monitor progress over time. That is why, since mid-2025, the Construction Products Regulation (CPR), that establish a harmonised framework for placing construction products on the European market, defined a norm to declare the environmental impact of a construction product, EN15804+A2.

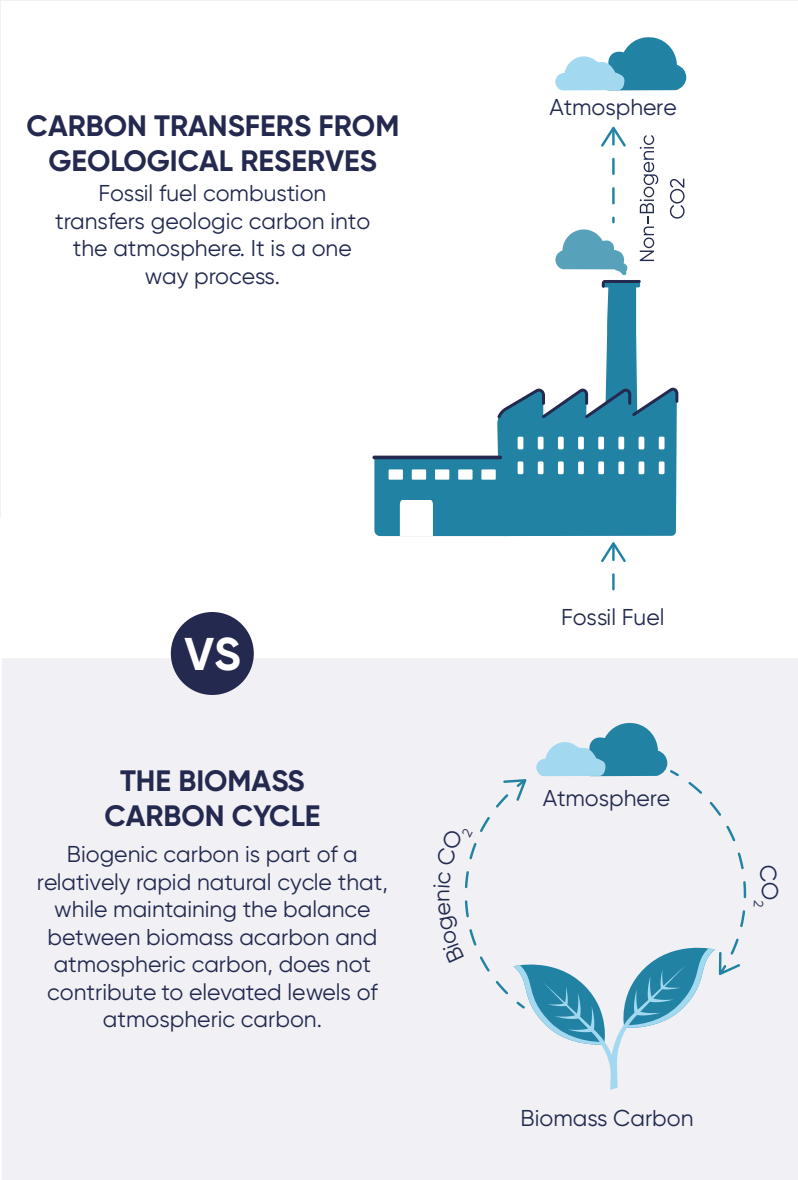
The distinction between conventional carbon and biogenic carbon

The advantage of biobased materials over conventional ones lies in a fundamental difference in how their carbon works.

- **Conventional materials** such as cement and steel require energy-intensive, fossil fuel-based manufacturing processes. The CO_2 emitted during production is long-lasting and contributes **directly to the accumulation of GHG in the atmosphere.**

- **Biogenic carbon,** by contrast, refers to the CO_2 absorbed by plants during their growth through photosynthesis and retained in the material once incorporated into a building. Timber, hemp, straw and flax fibres, seaweed, wool or plant-based concretes thus act as temporary carbon sinks during their service life. Their biogenic carbon content is measured by determining the percentage of carbon in the dry mass of the material, which varies by biological source. In brief, their production not only emits less, but it **also stores carbon that would otherwise remain in the atmosphere (19).**

This advantage is real but conditional, depending on sustainable sourcing, transport-related emissions, and what happens to the material at end of life. For example, incineration releases the stored carbon immediately, landfilling or reuse delays that release. A whole life cycle analysis (LCA) is therefore essential to accurately capture both carbon uptake and subsequent release.

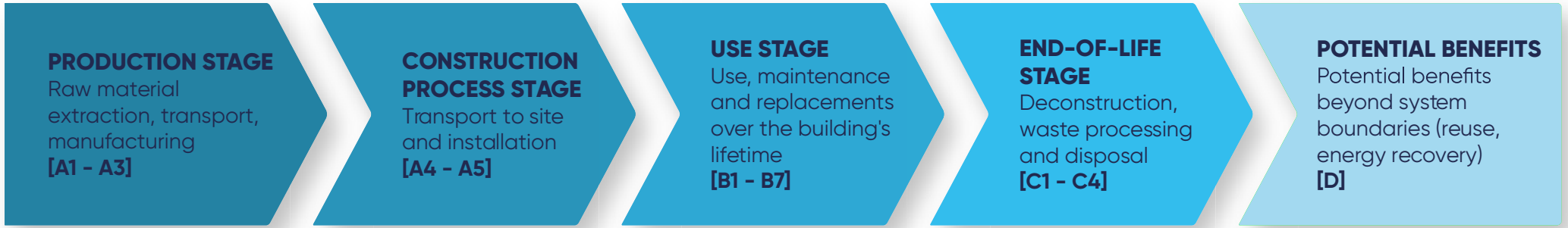


Adapted from https://pbpc.com/carbon-emissions-plant-based-products/

How stored carbon is measured : the life cycle analysis (LCA) methodology

LCA is a systematic process for evaluating the environmental impacts of a product, process, or system across its entire lifecycle. It includes assessing the extraction and processing of raw materials, manufacturing, distribution, use, maintenance, and disposal or recycling. Once a LCA is completed, it can be use within an Environmental Product Declaration (EPD), which is a standardized and third-party verified document (20).

LCA can be carried out at **product level,** assessing a specific material from extraction to end of life or at **building level,** covering the full structure including all technical systems such as heating, ventilation and equipment. In both cases, the assessment is structured around standardised lifecycle stages (labelled by European standards as A1-A3, A4, B1-B7, C1-C4 and D to organize enviromnetal impact), which together form the system boundary within which a material or building's carbon footprint is calculated :



At the European level, methodological guidance on LCA is provided by standards for environmental product declarations, most notably EN 15804+A2, which introduces explicit requirements for reporting biogenic carbon flows across lifecycle modules. The standard establishes separate indicators for biogenic carbon removal and emissions, thereby improving transparency. However, despite this harmonised framework, applying these rules consistently remains challenging in practice, particularly due to assumptions related to end-of-life scenarios and data availability (21).

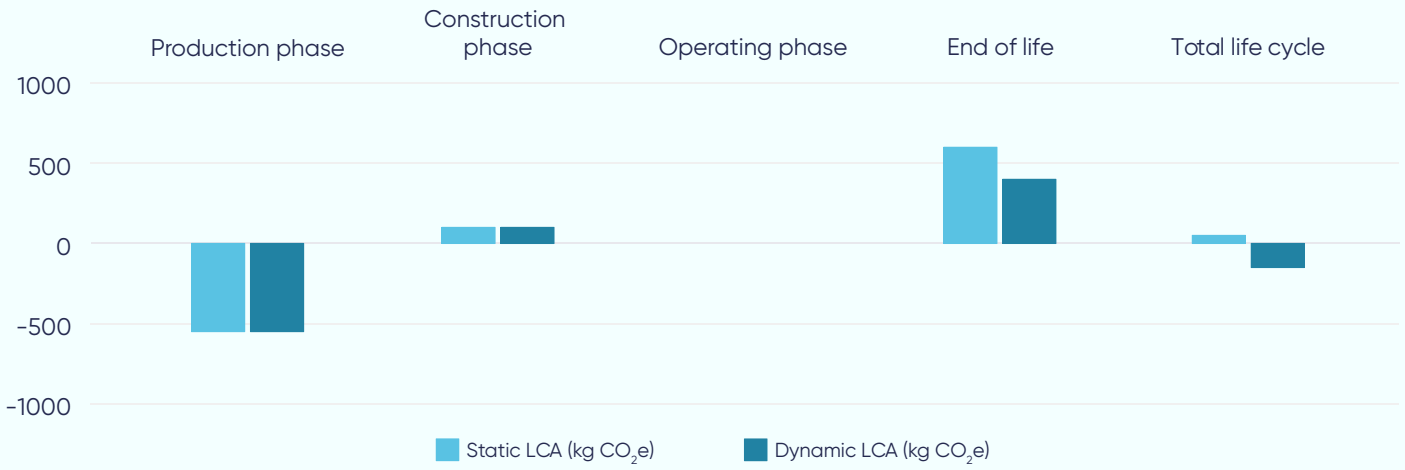
The data used to conduct these assessments comes from national environmental databases, whose coverage of biobased materials and stored carbon varies significantly across the countries covered by this white paper.

COUNTRY - MAIN DATABASE(S)	COVERAGE OF BIOBASED MATERIALS & STORED CARBON
 **INIES (FDES sheets), Base Empreinte**	Most comprehensive: all FDES include biogenic carbon content by plant species (e.g. flax 43.9%, hemp straw 48%, softwood 50%)
 **ÖKOBAUDAT, WECOBIS, IBU**	EN 15804-compliant with high verification standards
 **TOTEM, B-EPD**	19 environmental indicators. Static methodology End-of-life assumptions often penalise biobased products
 **NMD (Nationale Milieudatabase)**	No national open LCA database: environmental impacts aggregated into a single cost indicator (MKI) Embodied carbon is not separately visible
 **EPD Ireland (IGBC)** **SEAI (Sustainable Energy Authority of Ireland)**	Verified national EPDs Coverage of biobased materials still developing
 **Ecoinvent, SimaPro, ELCD**	Background databases used in LCA tools across all countries

FOCUS :
FRENCH CASE WITH DYNAMIC LIFE CYCLE ANALYSIS (LCA)

LCA can be conducted using either a static or a dynamic approach. The latter is required in the French main building regulation, the RE2020. Dynamic LCA accounts for the timing of emissions and the effects of carbon storage, while static LCA treats all emissions as occurring at the same moment, regardless of when they actually occur in the building's life cycle (22). Temporary carbon storage has no effect on the calculated impact. In a dynamic LCA, the weighting coefficient decreases over time, reflecting that GHG emitted later will remain in the atmosphere for a shorter period over a 100-year horizon. **This approach values temporary carbon storage, which benefits biobased materials and encourages their use in new buildings.**

Example : a wooden beam with a 50-year lifespan with a GHG emissions weighting coeficient of 0,57



According to a study published by the Carbon Removals Expert group Technical Assistance (CRETA) in 2023, out of 30 methodologies analysed, only 30 % use a dynamic approach (23).

This illustrative example was developed by GreenFlex.

Which biobased materials perform best, and where ?

Each bio-based material used in renovation performs differently in terms of embodied carbon and biogenic carbon storage, depending on their own characteristics as well as the methodologies used to assess their performance. In other words, the amount of carbon that can be stored varies between bio-based materials. It depends on the carbon content of the plant in its dry state, also referred to as the «fractional carbon share». This content is approximately 45 % for wheat straw, between 47 % and 48 % for hemp, flax and miscanthus, and between 48 % and 50 % for wood fibres. The higher this content, the greater the plant's capacity to store carbon (24).

The carbon storage performance of a bio-based material is therefore shaped by a combination of factors: the material's own biogenic carbon content, whether biogenic carbon accounting is included in the assessment, the norm version applied (particularly whether Module D is mandatory), and the country context including national energy mixes and typical end-of-life scenarios. Standard calculation methods, by excluding biogenic storage, tend to systematically undervalue bio-based insulation materials relative to conventional alternatives.

The main takeaway : **the same material can appear climate-positive in one country and carbon-neutral or even negative in another,** depending solely on whether a static or dynamic LCA is used and what end-of-life scenario is assumed. This methodological fragmentation is one of the key barriers to a level playing field for biobased materials across Europe.

MATERIAL*	INIES	TOTEM	EPD Ireland	ÖKOBAUDAT	BUILDING BALANCE (25)
Hemp wool insulation	Hemp wool partitions [R=2.5 m^2·K/W] Total lifecycle**: 4,41 $kgCO_2eq/m^2$ Production: -0,46 $kgCO_2eq/m^2$	/	/	Insulation materials / Hemp / 2.13.02 Total lifecycle: 44,39 $kgCO_2eq/kg$ Production: -20,26 $kgCO_2eq/kg$	Hemp wool insulation Production: -0.41 kg CO_2eq/m^2
Grass wool panels	For wall, GRAMITHERM ® 120 Total lifecycle: 6,11 $kgCO_2eq/m^2$ Production: -3,95 $kgCO_2eq/m^2$	/	/	/	/
Wood-based clad panels	Wood clad panels Total lifecycle: 4,82 $kgCO_2eq/m^2$ Production: -12,8 $kgCO_2eq/m^2$	Softwood timber frame (with stone wool and plasterboard) Total lifecycle: 173,98 kg CO_2eq/m^2	/	Solid wood panel Total lifecycle: 148,86 $kgCO_2eq/m^3$ Production: -665,4 $kgCO_2eq/m^3$	/
Hempcrete	Biosys BCE, 30cm thick Total lifecycle: 40,9 $kgCO_2eq/m^2$ Production: -15,2 $kgCO_2eq/m^2$	Blocks Hempcrete (600x150x300mm) Total lifecycle: 273,29 kg CO_2eq/m^2	/	/	/
Blown-in straw insulation	Ielo Phi chopped straw 221 and 400mm Total lifecycle: 6,12 $kgCO_2eq/m^2$ Production: -62,6 $kgCO_2eq/m$	/	/	Straw insulation Total lifecycle: 50,41 $kgCO_2eq/m^3$ Production: -98,03 $kgCO_2eq/m^3$	Blown-in straw insulation Production: -19.26 kg CO_2eq/m^2

** Due to the diversity of construction materials and the way databases operate, construction techniques as well as calculation assumptions may vary from one product to another. The purpose of this table is to provide orders of magnitude and to highlight the current lack of harmonisation in practices. Circular Reno recommends that it should not be used as such to compare the environmental performance of materials. ** 50 years, not taking into account the phase D*

IS STORED CARBON VALUED IN REGULATIONS?

2

European regulations on the integration of carbon stored in buildings

Carbon accounting between countries is fragmented because **there are no Europe wide building regulations, and regulatory frameworks across the EU remain highly heterogeneous.** In fact, most regulations are integrated into national regulations through transposition, where each Member State adapts the Directive's objectives into its domestic legal and regulatory systems. Consequently, local building regulations have evolved from historical and national codes developed over the past century, reflecting local materials, construction methods, architectural traditions and planning practices. Nevertheless, a degree of harmonisation has emerged in recent decades, particularly in relation to testing standards. **If none of these regulations clearly defines a harmonised methodology for accounting for biogenic carbon in construction products, manufacturers face growing expectations to ensure data consistency and traceability.**

The Ecodesign for Sustainable Products Regulation (ESPR), into force since July 2024, establishes a horizontal framework aimed at improving the environmental sustainability of products placed on the EU market, with product specific requirements such as durability, reparability, recycled content, and environmental footprint. These requirements will be rolled out progressively by product group over time. For producers, this implies a gradual shift towards eco design principles, including material optimisation, substitution of high impact inputs, and increased use of secondary raw materials. They will also have to provide structured, standardised product information, potentially through a Digital Product Passport (DPP), which will reinforce the need for robust data collection systems, including traceability of raw materials and quantified environmental data (27).

The evolutions of the ESPR will also support downstream requirements under the EPBD and building level LCA. **In its most recent revision from 2024, the EPBD's role has been extended to introducing renovation passports and the integration of whole-building LCA as an assessment criterion.** Through this framework, the EPBD not only harmonises performance standards across the EU but also acts as a driver of national regulatory reform, accelerating investment in sustainable construction, renovation, and building decarbonisation. However, the use of LCA is mandatory only for new buildings, and the Directive does not yet propose a complete and detailed, uniform LCA methodology. The operational detailing of the modules (e.g. A1–A5, B, C) is not fully defined but is instead referred to existing European standards and to delegated acts of the Commission (28). The CPR, that require to declare the environmental impact of a construction product, does not define a LCA method either.

At the project developers scale, since 2017, the Environmental Impact Assessment (EIA) Directive, that requires the assessing of the environmental effects of certain projects before development consent is granted, will integrate environmental and climate considerations into decision making at an early stage. While it does not directly

regulate construction product manufacturers, it increases demand for reliable environmental data on materials used in projects. As a result, manufacturers are indirectly encouraged to provide transparent life cycle and environmental information to support project assessments. Furthermore, it **encourages project developers to favour materials with lower environmental impacts, indirectly influencing market demand and procurement practices (29).**

As a result, many national building regulations across Europe share common features while also retaining distinct national characteristics. Circular Reno's analysis shows that France is at the forefront of fairly valuing the environmental performance of circular biobased materials, notably through the dynamic LCA and the application of GWP limit values. By contrast, the Netherlands, Ireland, Germany and Belgium demonstrate varying degrees of shortcomings in terms of effective limit values, calculation requirements and methodologies that properly recognise circular biobased materials.

National regulations on the integration of carbon stored in buildings

Since **January** 2022, France has implemented an ambitious regulatory framework for new buildings through the **Environmental Regulation 2020** (RE2020). The objective of this regulation is to reduce the impact of energy use by promoting energy efficiency and the decarbonisation of energy sources, to limit the environmental impact of construction, and to ensure occupant comfort under extreme weather conditions. The main methodological innovation is the introduction of a dynamic LCA, calculated over a 50 year reference period and expressed in $kgCO_2/m_2$ of usable floor area, that allows bio-based materials to be one of the solutions for achieving the mandatory carbon thresholds. This assessment aggregates the estimated carbon impacts of all materials and equipment used in the building, as well as GHG emissions associated with the construction site. **Based on a best in class approach, labelling schemes and bonuses are planned for buildings that perform better than regulatory thresholds, while the maximum allowable carbon thresholds are designed to become progressively more stringent over time :** it is currently 530 $kgCO_2e/m_2$ for individual buildings and 650 $kgCO_2e/m_2$ for residential buildings and will be 475 $kgCO_2e$ and 580 $kgCO_2e$ by 2028 and 415 $kgCO_2e$ and 490 $kgCO_2e$ by 2031 (30). To date, there are not regulations similar to the RE2020 in France concerning building renovation.

The Netherlands has already integrated environmental performance requirements into its building regulations through the **Environmental Performance of Buildings** (Milieuprestatie Gebouwen, MPG). This indicator assesses the environmental impact of new residential and office buildings across their life cycle, based on a life cycle assessment (LCA) methodology and expressed as a single aggregated score combining multiple environmental indicators. The calculation relies on verified environmental data from the National

Environmental Database (Nationale Milieudatabase), which provides standardised datasets for construction materials. Unlike regulatory frameworks based on explicit carbon thresholds expressed in $kgCO_2/m_2$, **the Dutch approach currently uses a multi-criteria indicator that integrates global warming potential alongside other environmental impacts (33).**

Germany does not yet have a dedicated regulatory framework comparable to the French RE2020 that explicitly integrates dynamic LCA and mandatory carbon thresholds for buildings. Static LCA according to EN 15804+A2 remains the standard approach within certification and sustainability assessment systems. Regulatory efforts have historically focused on operational energy performance through the Building Energy Act (GEG), while embodied carbon and whole-life assessment are gaining importance through European legislation, sustainability certification systems (DGNB, BNB, QNG) and public funding schemes. Methodologies based on DIN EN 15978 and EN 15804 are increasingly applied, supported by ÖKOBAUDAT as the central national LCA database. Although biogenic carbon flows can already be included in current LCA methodologies, the practical recognition and economic valorisation of stored carbon remain limited. Static assessment approaches and differing assumptions regarding end-of-life scenarios continue to create uncertainties for the consistent evaluation of biobased construction materials. **However, increasing attention to embodied carbon, circular construction and resource efficiency is expected to strengthen the role of bio-based materials within the German construction sector in the coming years.**

In **Belgium,** the sustainable construction sector and the timber construction sector joined forces in April 2025 to raise concerns with the authorities regarding how biogenic carbon is calculated in LCA under Belgian regulations. The **stakeholders commissioned a scientific study from the Katholieke Universiteit Leuven.** The results will soon be finalised and presented to the three regions to press for a review of the standard norms currently applied in the TOTEM tool, the data from which is unfavourable to bio-based building materials. **The methodology applied in France has been used as a model.**

Finally, **Ireland** does not yet have a dedicated regulatory framework that sets mandatory embodied carbon thresholds for construction or renovation. Current building regulation is primarily based on the Irish Building regulations which focuses on improving operational energy efficiency and reducing emissions from building use. Since 2024, Ireland has been preparing the implementation of EPBD, which introduces whole-life carbon assessment requirements across the building sector. This includes the development of a national methodology for calculating Life Cycle Global Warming Potential (LC-GWP), typically assessed over a 50-year reference period and covering emissions from materials, construction, maintenance, replacement, and end-of-life processes. **The Sustainable Energy Authority of Ireland (SEAI) is currently developing a national Life Cycle Global Warming Potential (GWP) methodology including a carbon database and calculation tools, which represents a transition toward the integration of whole-life carbon in building assessment,** although it is not yet fully implemented in regulatory practice (31).

European standards and labels that encourage carbon storage in buildings

Labels and certifications can concentrate on the biobased product, the entire building or both.

At the European level, **the Level(s) framework** complements existing certification schemes by providing a common methodology. Developed by the European Commission, it is a voluntary assessment and reporting framework that **establishes a shared language for measuring the sustainability performance of buildings across their full life cycle.** It relies on a set of core indicators covering key dimensions such as GHG emissions, resource efficiency, water use, indoor environmental quality, climate resilience, and life cycle cost and value. Unlike certification systems, Level(s) does not define performance thresholds but instead supports consistency, comparability, and transparency in sustainability assessment, while facilitating alignment with EU policy objectives and circular economy principles (34).

On 8 March 2024, the Council of the European Union and the European Parliament reached a provisional political agreement to establish the first EU level certification framework for carbon removals. Known as the **Carbon Removals and Carbon Farming Regulation** (CRCF), this framework **aims to harmonise methodologies and scale up carbon removal activities across Member States.** It advances decarbonisation by shifting the focus away from stored carbon towards avoided carbon. Avoided carbon refers to the reduction in GHG achieved when low carbon products substitute for more emission intensive materials, a mechanism commonly described as the substitution effect. The framework is voluntary: certification schemes may apply for EU recognition but are not required to do so. It is designed to stimulate investment in sustainable carbon removal activities (32).

All emission reductions certified under the CRCF are intended to contribute to the EU's climate objectives. To ensure this, the CRCF methodology quantifies avoided emissions against a baseline representing the standard performance of comparable practices, while also accounting for any increase in greenhouse gas emissions attributable to the activity itself. Any additional emission reductions resulting from implementation are considered co benefits. Under the CRCF proposal, carbon removal activities must deliver measurable climate benefits while safeguarding or enhancing other environmental objectives. Activities must comply with four QU.A.L.ITY (QUantification, Additionality, Long term storage, SustainabilITY) criteria in order to issue CO_2 certificates on the voluntary carbon market (32). The analysis of CRCF focuses on the building scale, but it can also be carried out at the level of construction materials.

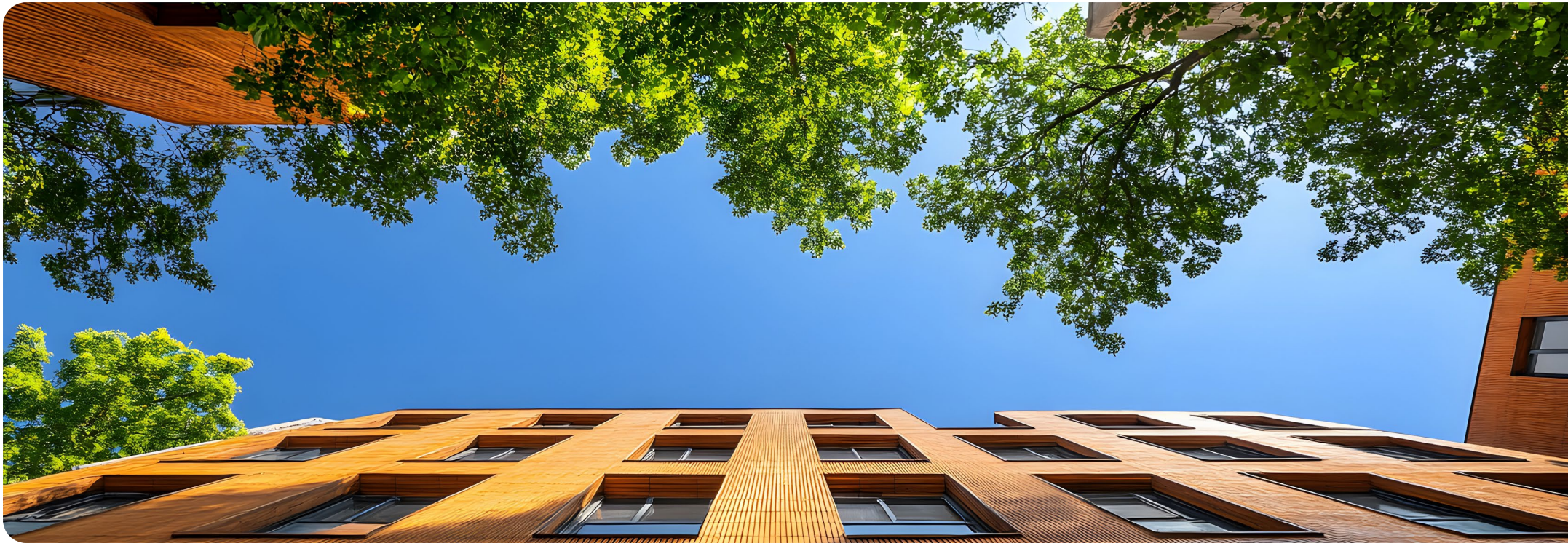
National standards and labels that encourage carbon storage in buildings

COUNTRY	LABEL OR CERTIFICATION	SCALE	RENOVATION ?	METHODOLOGY
NL	National Carbon Market Foundation (SNK)	Products	/	Provides certification for verified carbon emission reductions within the Dutch voluntary carbon market
NL	Climate Cleanup Foundation's Open Natural Carbon Removal Accounting (ONCRA)	Products and Buildings	Yes	Defines an open framework to measure and verify carbon removal in products and buildings
IE	REDcert[2]	Products	/	Certifies compliance with sustainability criteria for products derived from biomass
IE	Forest Stewardship Council (FSC) Certification	Products	/	Ensures that wood of wood-based construction materials (timber, plywood, flooring) comes from responsibly managed forest
IE	Life Carbon Farming project	Products	/	Develops methods to quantify and certify carbon sequestration in agricultural practices
BE	Natureplus	Products	/	Certifies products with a minimum of 85% bio-based or mineral raw materials, without harmful substance

BE	Biobased product label	Products	/	Certifies biobased materials incorporating a significant proportion of biomass with transparency about the origin of the product
DE	DIN Geprüft Biobasiert	Products	/	Certifies biobased materials incorporating a significant proportion of biomass
DE	Natureplus quality label	Buildings	/	Promotes the traceability, the composition and the sustainable raw material extraction of products composing a building
FR	AFNOR	Products	/	Defines standard for biobased materials, according to their type. These standards specify a single methodology for what is meant by the term “biobased materials” and serve as a reference for the majority of label
FR	Biobased product label	Products	/	Certifies biobased materials incorporating a significant proportion of biomass (more than AFNOR’s standards), with an EPD and transparency about the origin of the product
FR	Bio-sourced Building	Buildings	No	Defines threshold of minimum quantity per unit area of biobased construction products incorporated into the building throughout its lifetime, expressed as a quantity of biogenic carbon stored per square meter
FR	Rainbow Standard	Products and Buildings	Yes	Evaluates avoided carbon with: › Static LCA › Baseline chose by applicants Long term storage of 100 years
FR	Low carbon label	Buildings	The renovation methodology only deals with reused materials	Evaluates avoided carbon with: › Dynamic LCA › Baselines define by references values for stored carbon given for the years 2015 and 2035 Long term storage of 70 years

According to CRETA, that made an analysis in 2023 of 30 existing methodologies calculating long-term biogenic carbon storage in buildings, only 35 % of them include a strong baseline. Moreover, in most methodologies, minimum sustainability requirements are lacking or not well-defined (23). Yet, from 2026 onwards, the use of CRCF approved certificates is expected to become mandatory within the European voluntary carbon market. Certificates that do not comply with the CRCF framework will no longer be accepted beyond that date. As a result, we can estimate a change in some of those methodologies in years to come (32).

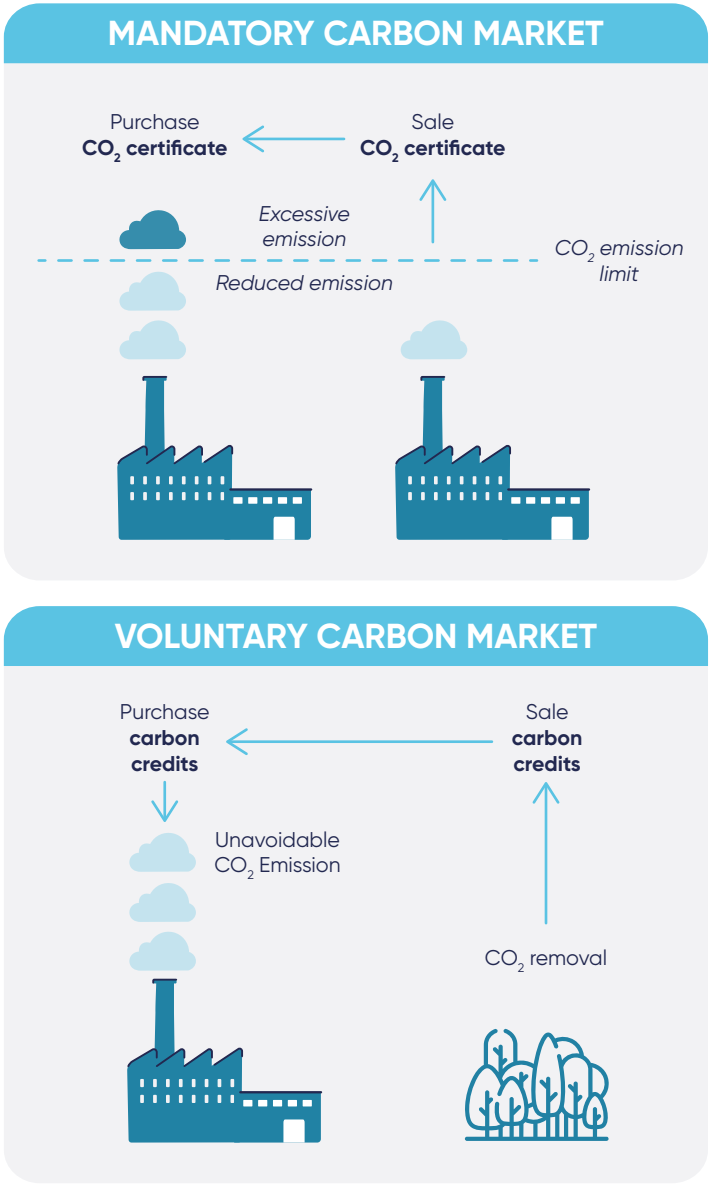
Overall, while the regulatory landscape is evolving rapidly, stored biogenic carbon remains largely absent from binding building regulations across Europe. Only France has integrated it into a mandatory framework through the dynamic LCA methodology of RE2020. Elsewhere, its recognition is confined to voluntary labels and certification schemes, which, despite their growing number, do not yet create the market signals needed to systematically reward bio-based materials for their carbon storage potential. The coming years, particularly with the full implementation of the CRCF and the transposition of the EPBD across Member States, are likely to mark a turning point.



3 FINANCING BIOBASED MATERIALS IN THE CONSTRUCTION SECTOR

Quantifying stored carbon is not only a regulatory requirement but also a source of economic value for manufacturers and developers of biobased materials. Several mechanisms now exist to translate this stored carbon into tangible financial incentives, while emerging regulations are progressively defining how such storage should be measured and rewarded. Understanding these mechanisms and their limits is essential for any actor looking to integrate biobased materials into their business model or investment strategy.

The mandatory carbon market (ETS) vs. the voluntary carbon market (VCM)



Adapted from Building Balance

A clear distinction exists between mandatory and voluntary carbon markets.

The mandatory carbon market, also known as the EU Emissions Trading System (ETS), focuses on capping and progressively reducing emissions. The number of available allowances decreases annually, and companies can trade their remaining emission rights among themselves. In 2027, the ETS market is going to grow with ETS-2, opening the market to smaller emitters, including buildings owners for their energy use, but not for stored carbon in material. This is why we'll focus specifically on **the voluntary carbon market, which is the relevant framework for biobased construction materials.**

The voluntary carbon market (VCM) operates without legal regulation and is designed to enable additional investment in carbon reduction from private actors. Different roles have been defined: a certification scheme, managed by an independent party, sets the rules and quality criteria for issuing CO_2 certificates; a certification body audits and certifies parties; operators (farmers, forest managers, construction companies) issue certificates based on their activities; and market intermediaries (sales platforms, rating agencies, insurers, buyers) facilitate trading.

How does the VCM works ? Five-step process of the Voluntary Carbon Market (VCM) : project development, certification, credit issuance, credit sale, credit retirement

A project developer must follow five steps in order to monetise their CO_2 savings on the voluntary carbon market :

1

PROJECT DEVELOPMENT :
The operator (farmer, manufacturer, or developer) defines the project scope, selects a certification methodology applicable in their country, and drafts a project plan.

2

CERTIFICATION :
The project plan is submitted to an accredited validation and verification body (VVB), which independently verifies that the project meets the methodology's requirements and that the carbon removals are real and measurable.

3

CREDIT ISSUANCE :
Once validated, carbon certificates are issued on the relevant registry, with one certificate per tonne of CO_2 stored. The certificate explicitly states the duration of storage and distinguishes between temporary and permanent storage.

4

CREDIT SALE :
Certificates are sold to buyers through trading platforms, direct agreements, or public procurement schemes. Credits can in some cases be pre-sold before the project is even completed, providing upfront financing. Buyers can be companies (for example the large ones under the EU Green Claims Directive), public bodies and government funds (to meet their climate commitments or support local activity) or ESG investors.

5

CREDIT RETIREMENT :
The operator (farmer, manufacturer, or developer) defines the project scope, selects a certification methodology applicable in their country, and drafts a project plan.

FOCUS :
TEMPORARY VS. PERMANENT CARBON STORAGE : WHAT DOES IT MEAN FOR BIOBASED MATERIALS ?

The distinction between temporary and permanent storage is central to how biobased construction materials are valued in carbon markets and is now formally defined under the CRCF. Temporary carbon storage (35 to 100 years) applies to the biogenic carbon contained in biobased construction materials (hemp, straw, wood and flax store) for the duration of the building's life, but this carbon may be re-released at end of life. Permanent carbon removal (100 years+) applies to geological storage and other engineered solutions. **For biobased materials, the duration of storage and the end-of-life scenario both directly affect the value of the credits which is why a whole-life-cycle approach is essential.**

Who can generate carbon credits ? A review of the value chain

Carbon credits from biobased construction materials can be generated and claimed at multiple points along the value chain. However, a critical rule applies : **only one actor can claim the credits for a given tonne of stored CO_2.** The ownership of certificates must therefore be clearly defined contractually between parties before any project is launched.

The farmer / raw material producer can generate credits based on the biogenic carbon stored in the fibre crops they grow. Certification can be initiated at farm level, and credits can even be sold in advance (before the crop is harvested) providing upfront income to support the agricultural transition.

The manufacturer / industrial processor can claim credits linked to the carbon stored in the finished product (hemp concrete block, wood panel, straw insulation board, ...), in exchange for a share of the revenue returned to the farmer. This model works well when the manufacturer has the administrative capacity to manage certification and annual reporting on volumes delivered to the construction sector.

The project developer or building owner can valorise the long-term carbon storage at building scale, using a certified LCA methodology to quantify and certify the total stored carbon across all biobased materials incorporated in the building. This approach generates the highest per-project volumes but requires the most comprehensive documentation.

To facilitate access to the voluntary carbon market, project aggregator or carbon developer work as intermediary who handles the methodology, the certification process, the monitoring and credit issuance on behalf of farmers or developers in exchange of a commission or fixed fee. This model lowers the barrier to entry for smaller actors with limited administrative resources.

How much does it cost ? (LCA, carbon modelling, certification, registration and verification fees)

Certification costs and expected revenues vary significantly depending on the methodology chosen and the scale of the project. The three schemes presented below (SNK and ONCRA, both Dutch, and Rainbow Standard, French) illustrate the range of models available, from per-credit fees suited to smaller producers to fixed annual costs better suited to larger projects (35).

	SNK	ONCRA (CLIMATE CLEANUP FOUNDATION)	RAINBOW STANDARD
Registration, admin & validation	€2,500 (one-off) + €0.75/credit	€3/credit	€5,000 year + ~€2 /credit
Verification	€2,500 + €550/year (est.)	€4/credit (est.)	€2,500 year
Own admin costs	✓	✓	✓

* The prices shown are indicative estimates prepared by the Circular Reno team at a given point in time. These prices are not contractually binding and may not be used as a basis for discussions or negotiations with any of the organisations concerned.

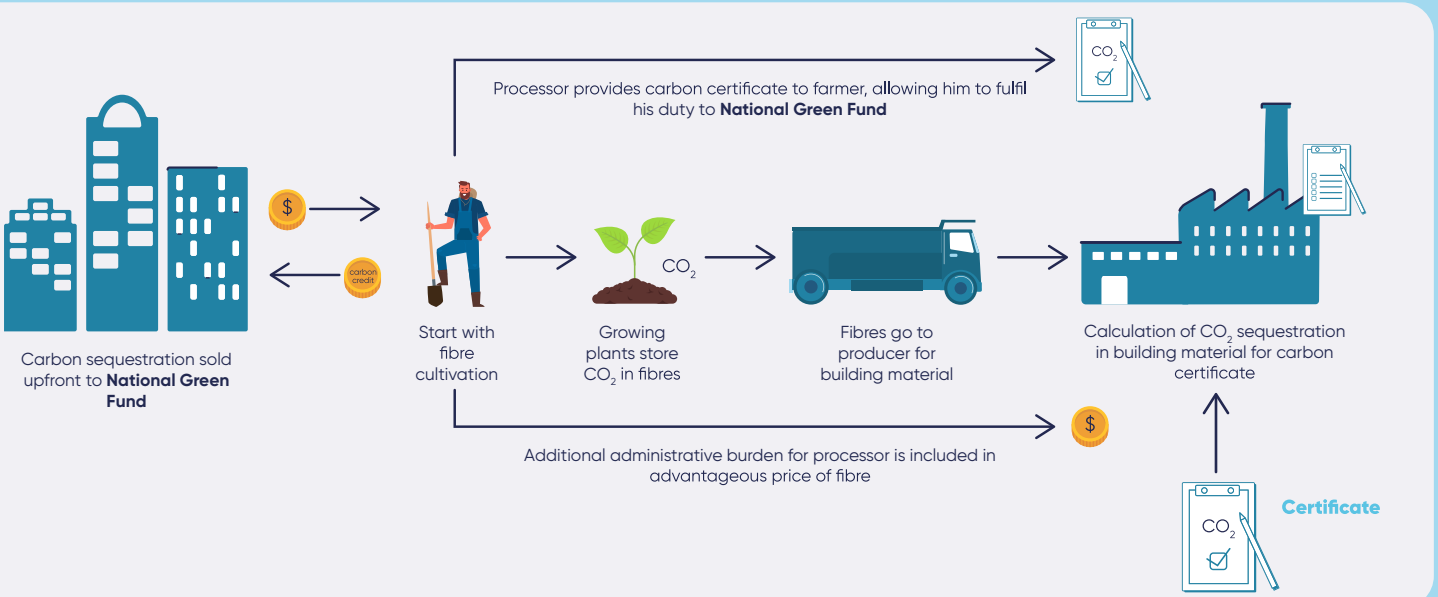
For comparison, the cost of biogenic carbon capture via fibre crops incorporated into building materials is estimated at €75–90 per tonne of CO_2 (35), well below engineered carbon capture technologies such as Direct Air Capture, which currently range from €200 to over €2 400 per tonne (36). However, standardised project blueprints, developed for specific product types (blow-in straw, flax insulation, hemp-lime, willow shoring), significantly reduce the administrative burden and entry cost for manufacturers making certification more accessible to SMEs.

CASE STUDY :
THE DUTCH INCENTIVE SCHEME

What makes the Netherlands stand out is not just the existence of carbon credits for biobased materials, but the use of public procurement as a market-making tool. Through the National Green Fund, the government pre-purchases carbon credits from farmers before crops are even grown, providing the upfront financial security that makes investing in biobased value chains viable. Only above-ground carbon stored in long-lasting construction products is eligible. Farmers must provide proof of delivery to a certified manufacturer, ensuring traceability from field to building.

A first pilot involving the Ministry of Agriculture saw 82 companies participate, with 30,000 credits pre-purchased across 1,131 hectares, predominantly hemp. A second pilot run by the Water Board Vallei & Veluwe added regionality and biodiversity criteria, with credits priced at €80–120/tCO_2.

By committing to purchase credits in advance, the Dutch government removed the market risk that had previously prevented farmers and manufacturers from scaling up. The model is already being studied as a replicable template across the EU (35).



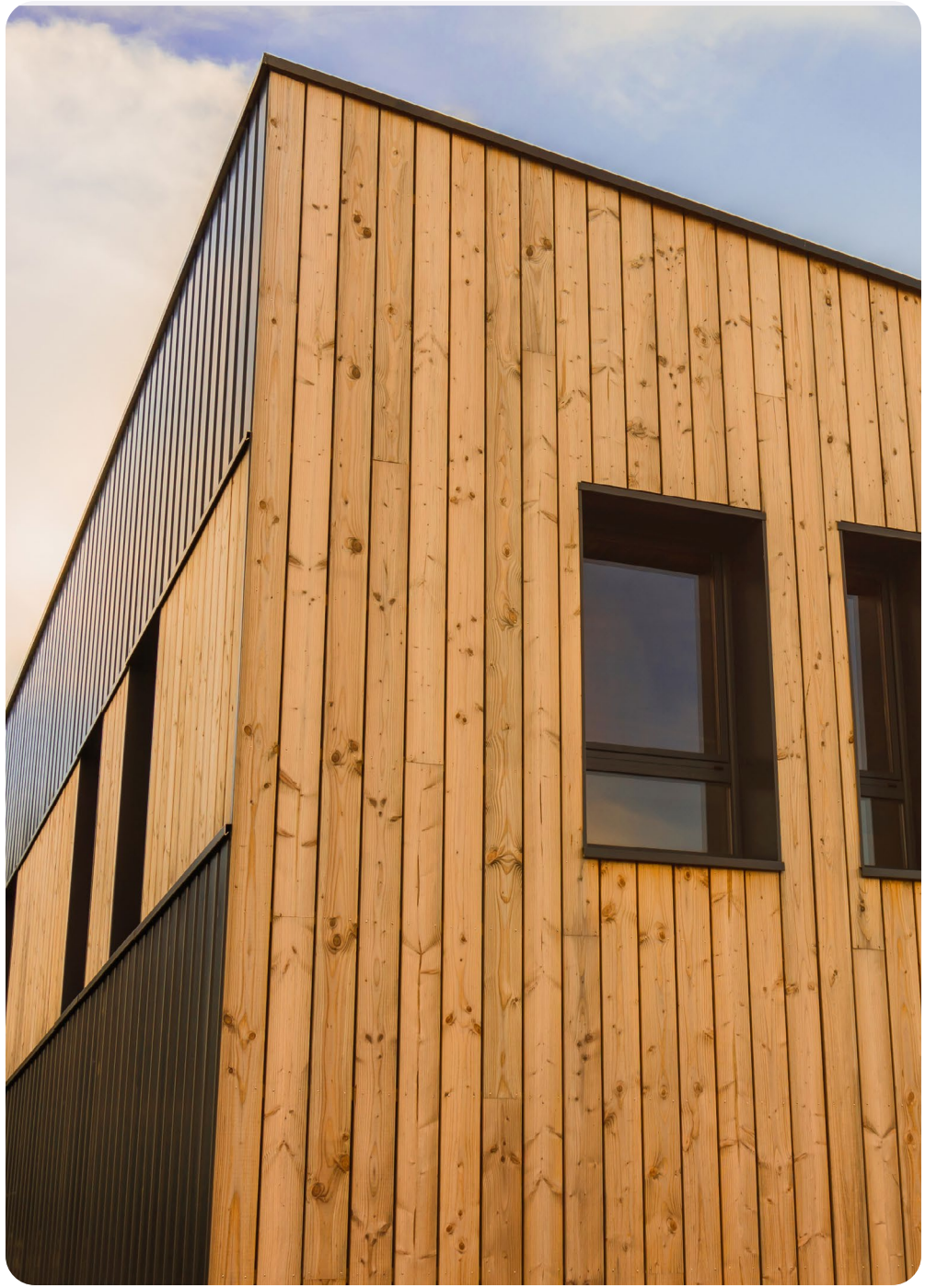
Adapted from ...

Where does the market stand today ?

The voluntary carbon market is undergoing a structural shift : avoidance credits (linked to reforestation projects, often in the Global South) are declining in credibility following several high-profile methodology scandals. At the same time, biogenic removal and storage credits are gaining traction, with strong acceleration expected toward 2030 as frameworks such as the CRCF mature. That said, several practitioners interviewed for this report noted that **voluntary demand alone is unlikely to drive the transition at scale,** as long as EU regulations restrict how companies can use carbon credits to substantiate climate claims.

For biobased construction materials, the certified project pipeline remains small. The Netherlands leads with an active public procurement pilot (82 companies, 30,000 credits pre-purchased, 1,131 hectares). In France, Rainbow Standard has certified several biobased material producers and is now working with real estate developers on new biobased buildings. The Low Carbon Label has seen limited uptake in construction despite its official recognition (around ten projects currently undergoing certification since 2023) because of long administrative processes that allows to certify only one building at a time. Practitioners estimate the true economic value should be closer to €150/tCO_2 (35) to meaningfully offset the cost premium of biobased materials, and current prices fall short of this threshold.

A key unresolved tension concerns who claims the credits between the building owner or the material producer. Directing credits to producers would have greater impact on the industrial transition, as carbon revenue represents a meaningful share of a manufacturer's business model, whereas for a real estate developer it amounts to a marginal gain. **This question is at the heart of ongoing CRCF discussions.**



CONCLUSION

The construction sector is one of the largest contributors to global GHG emissions, from the extraction of raw materials to the end of a building's life. Biobased construction materials such as hemp, flax, straw or wood offer a distinctive response to this challenge. First, their production emits significantly less CO_2 than conventional materials, whose manufacturing processes are among the most carbon-intensive in the world. Second - and this is what makes them unique - plants absorb CO_2 from the atmosphere through photosynthesis as they grow, and this carbon remains locked in the building material for the entire lifetime of the structure, sometimes several decades. **A building constructed with biobased materials therefore not only emits less carbon to build, but it also retains carbon that would otherwise remain in the atmosphere.** Quantifying, recognising and financially rewarding this stored carbon is what this white paper has set out to map.

The methods to measure stored carbon are maturing fast. Life cycle assessment tools now make it possible to calculate, for any given building, how much carbon is stored in its materials and for how long. Environmental product databases are progressively integrating biogenic carbon data, giving architects, developers and policymakers the information they need to make informed choices. France stands out as the most advanced country in this regard, with a calculation method that explicitly accounts for the timing of carbon storage, giving biobased materials a tangible advantage over conventional ones. Other Member States are still catching up, but the direction of travel is clear.

Regulatory recognition is following, though at different speeds across Europe. Some countries like France have already integrated carbon storage into their building performance requirements, creating a direct incentive to build with biobased materials. At European level, new regulations are beginning to require whole-lifecycle carbon assessments for buildings, and a dedicated certification framework for carbon storage is under development. The rules still vary significantly from one country to another, meaning that the incentive to use biobased materials currently depends too heavily on where you build, a gap that European harmonisation will need to close.

Turning stored carbon into a financial return with voluntary carbon markets is the most promising option and the one with the most ground still to cover, especially because current credit prices do not yet fully cover the cost premium of biobased over conventional material. The Dutch public procurement scheme, where the government pre-purchases carbon credits to stimulate local biobased supply chains shows a way and what becomes possible when public policy steps in to bridge that gap.

Beyond carbon accounting and financial mechanisms, the transition toward biobased construction materials should be understood as part of a broader systemic transformation of the built environment and regional economies. **Sustainably managed biobased value chains can strengthen links between agriculture, manufacturing and the construction sector while contributing to wider ecosystem services such as soil protection, biodiversity enhancement, water retention and more resilient landscapes.** In this context, biobased construction materials are not only a climate mitigation solution, but also a lever for regenerative and circular regional development. Looking ahead, such ecosystem services could increasingly become additional evaluation criteria within sustainability assessment and policy frameworks, further broadening the recognition of the environmental value of biobased construction materials.

The priority now is to align measurement methods across Member States, extend regulatory incentives to renovation, and scale carbon market mechanisms to the point where they meaningfully offset the cost premium of building with biobased materials. The anticipated rise in biomass use will need to be accompanied by sustainable agricultural management, biodiversity protection, avoidance of harmful land-use changes and a prioritisation of long-lived material uses.

GLOSSARY

CPR – CONSTRUCTION PRODUCTS REGULATION :
establish a harmonised framework for placing construction products on the European market, replacing the earlier Construction Products Directive. Its main aim is to ensure the free movement of construction products across the EU by creating a common technical language for assessing and declaring product performance. Under the CPR, manufacturers must provide a Declaration of Performance (DoP) and CE marking based on harmonised European Standards (hENs) or European Assessment Documents (EADs), ensuring transparency and comparability of product characteristics such as fire resistance, thermal performance, or mechanical strength.

CRCF – CARBON REMOVALS AND CARBON FARMING REGULATION :
adopted in 2024 (EU/2024/3012), the CRCF establishes the first EU-wide harmonised framework for certifying carbon removals, carbon farming, and carbon storage in long-lasting products — including biobased construction materials. Its significance lies less in creating a new market than in providing the common regulatory foundation on which certification schemes and methodology developers can build, with the aim of standardising and scaling up the use of carbon credits across these sectors at European level. A certification methodology specifically for carbon storage in buildings is expected in 2026.

CRETA – CARBON REMOVALS EXPERT GROUP TECHNICAL ASSISTANCE :
was a support mechanism established by the European Commission that provided independent technical and scientific expertise on carbon removal activities. The assistance supported the work of the Carbon Removals Expert Group. Its role was to inform the development of methodologies, monitoring and certification rules. It contributed to the design of the EU Carbon Removal Certification Framework (CRCF). It was a time-limited support mechanism that is now ended, but the Carbon Removals Expert Group itself continues to exist.

CSRD – CORPORATE SUSTAINABILITY REPORTING DIRECTIVE :
adopted in December 2022 (EU/2022/2464), the CSRD is an EU directive requiring large companies to publicly report on their environmental, social and governance (ESG) performance according to a harmonised standard — the European Sustainability Reporting Standards (ESRS). It replaces the previous NFRD, significantly expanding its scope to cover around 50,000 companies across the EU. For biobased construction materials, it is relevant as a demand driver: companies subject to the CSRD must report on their embodied carbon and supply chain emissions, creating a financial incentive to choose lower-carbon materials and document their climate impact — including temporary carbon storage.

EIA - ENVIRONMENTAL IMPACT ASSESSMENT DIRECTIVE :
(amended by Directive 2014/52/EU) ensure that the environmental effects of certain public and private projects are identified, assessed and taken into account before development consent is granted. The Directive applies to projects likely to have significant effects on the environment due to their nature, size or location, including major construction and infrastructure projects.

EPD - ENVIRONMENTAL PRODUCT DECLARATION :
standardized, third-party verified document that provides transparent, quantifiable information on the environmental impacts of a product throughout its lifecycle. EPDs are based on Life Cycle Assessment (LCA) results and follow specific standards, allowing for consistent comparison of environmental data between similar products.

EPDB - ENERGY PERFORMANCE OF BUILDINGS DIRECTIVE :
first introduced as Directive 2002/91/EC and later recast as Directive 2010/31/EU and Directive (EU) 2018/844, it is the key EU policy instrument aimed at improving the energy efficiency and decarbonisation of buildings. It establishes a common framework for calculating building operational energy performance and requires EU members to set minimum energy performance standards (MEPS) for both new and existing buildings. The EPBD also mandates Energy Performance Certificates (EPCs), regular inspections of heating and cooling systems, and the progressive transition toward nearly zero-emission buildings (nZEBs), ensuring that new buildings meet strict energy demand and renewable integration criteria. Integration of the EPBD into national building regulations occurs through transposition, where each Member State adapts the Directive's objectives and requirements into its domestic legal and regulatory systems.

ESPR - ECODESIGN FOR SUSTAINABLE PRODUCTS REGULATION :
replaces the Ecodesign Directive (2009/125/EC) and establishes a binding, horizontal framework aimed at improving the environmental sustainability of products placed on the EU market. The Regulation enables the introduction of product specific requirements such as durability, reparability, recycled content, environmental footprint and the Digital Product Passport through subsequent delegated acts.

EU BIOECONOMY STRATEGY :
published in 2025 and building on earlier strategies from 2012, 2018 and 2022, the EU Bioeconomy Strategy is a European framework aimed at developing the bioeconomy — that is, the production of biomass and its conversion into food, materials, products and bioenergy — as a lever for a more circular and carbon-neutral economy. Biobased construction materials are explicitly identified as a priority market, recognising their dual potential for economic growth and environmental benefits, with demand to be stimulated through binding targets in relevant legislation.

GHG – GREENHOUSE GASES :
refers most often to all greenhouse gases listed in the Kyoto Protocol (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride).

NBRP - NATIONAL BUILDING RENOVATION PLANS :
required under the revised Energy Performance of Buildings Directive, NBRPs are national strategic documents in which each EU member state must plan the renovation of their entire building stock — residential and non-residential, public and private — into a highly energy-efficient and decarbonised stock by 2050. For biobased construction materials, they represent a key policy lever: as countries define their renovation pathways and investment needs for 2030, 2040 and 2050, the material choices embedded in these plans will shape demand at scale. Draft plans were due by end of 2025, with final versions expected by end of 2026.

UNEP - UNITED NATIONS ENVIRONMENT PROGRAMME :
the United Nations' authority on the environment, founded in 1972

ELCD - EUROPEAN LIFE CYCLE DATABASE :
a European Commission life-cycle inventory database used as background data in LCA software and studies across Europe.

INIES - INFORMATIONS SUR LES IMPACTS ENVIRONNEMENTAUX ET SANITAIRES :
(French National Database for Environmental and Health Information on Construction Products) France's national reference database containing environmental and health data for construction products and equipment, widely used for RE2020 assessments.

FDES - FICHE DE DÉCLARATION ENVIRONNEMENTALE ET SANITAIRE :
(Environmental and Health Product Declaration) a Type III environmental declaration for construction products in France, based on Life Cycle Assessment (LCA) results and published in the INIES database.

IBU - INSTITUT BAUEN UND UMWELT E.V. :
(Institute Construction and Environment) the German organization managing the national Environmental Product Declaration (EPD) programme for construction products.

MILIEUKOSTENINDICATOR :
(Environmental Cost Indicator) a Dutch environmental indicator that aggregates environmental impacts into a single monetary score, used within the Nationale Milieudatabase (NMD).

IGBC - IRISH GREEN BUILDING COUNCIL :
Ireland's leading sustainable construction organization, which manages the national EPD Ireland programme.

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