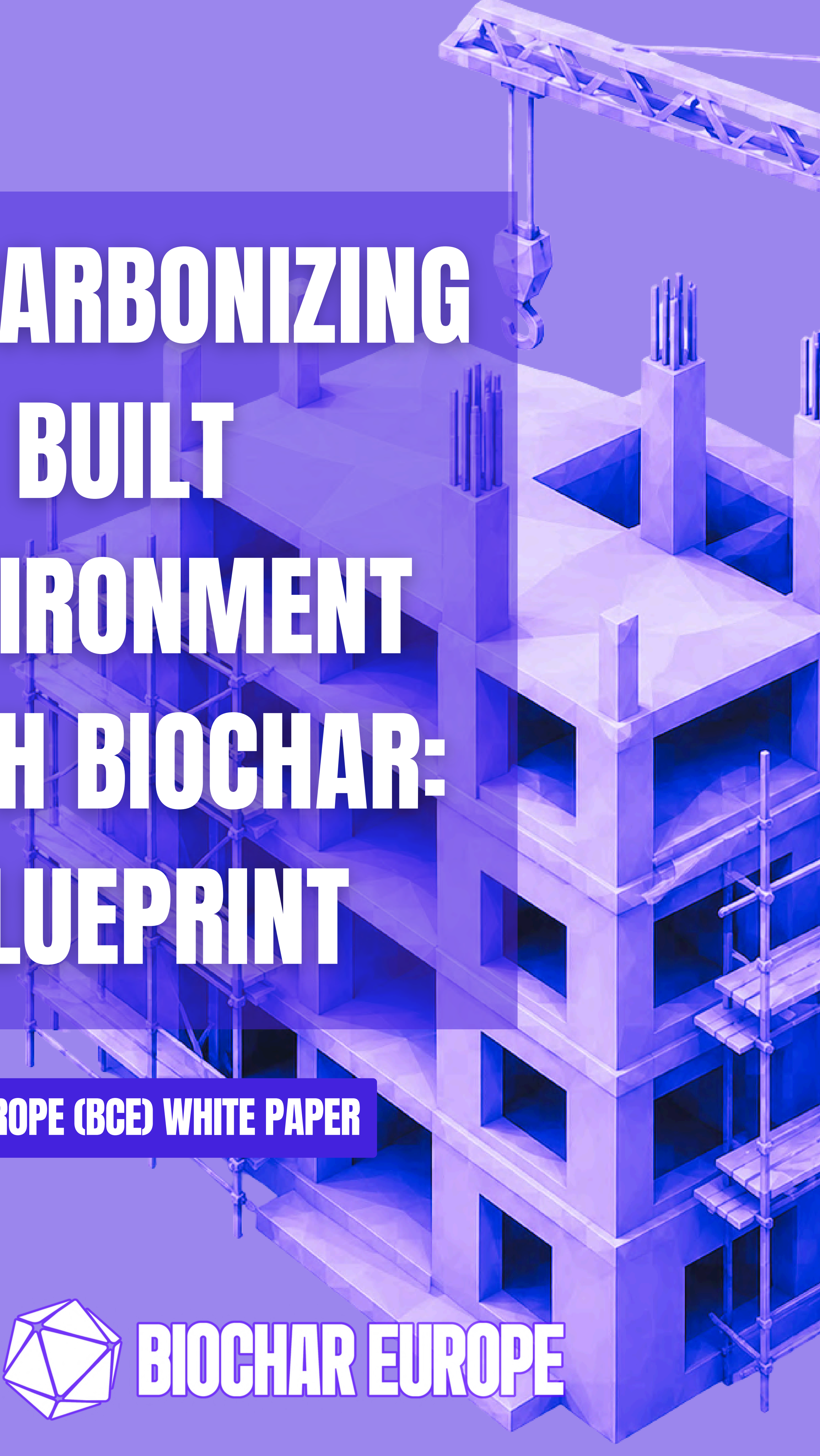

DECARBONIZING THE BUILT ENVIRONMENT WITH BIOCHAR: A BLUEPRINT

BIOCHAR EUROPE (BCE) WHITE PAPER

JUNE 2026

BIOCHAR EUROPE

TABLE OF CONTENTS

TABLE OF CONTENTS

01

EXECUTIVE SUMMARY

The construction sector forms the essential bedrock of modern civilisation, providing vital infrastructure, from residential housing to complex transport networks, that enables global societal growth and economic stability. However, this comes with a cost. **Buildings and construction represent 34% of global emissions, and even with recent innovations, we are not on track to hit 2050 net zero targets.**[1]

Materials like cement and concrete are produced in the billions of tonnes annually to meet development demands and make up 4% of total CO_2 emissions within the EU.[2]

The world is aiming to reduce and use more low carbon and recycled materials, but the facts create a dire picture. **Ongoing climate change requires not only a rapid reduction in greenhouse gas emissions but also the development of reliable carbon sinks.** International assessments, including those by the Intergovernmental Panel on Climate Change (IPCC), indicate that climate targets are hardly achievable without additional forms of carbon removal.[3]

Fortunately, solutions already exist and are already being demonstrated at scale.

Biochar Carbon Removal (BCR) is an effective, practical, and scalable solution for decarbonizing the built environment. It leverages building materials, especially the biggest emitters like concrete, to function as a carbon sink, reducing the harmful impacts of continued growth. This method has been officially acknowledged by the European Union's Carbon Removals and Carbon Farming (CRCF) Regulation[4], meaning integration into materials like concrete, cement, and asphalt qualifies for EU-certified carbon credits on the voluntary carbon market.

[1] United Nations Environment Programme (2025). Global Status Report for Buildings and Construction 2024/2025: Not just another brick in the wall - The solutions exist. Scaling them will build on progress and cut emissions fast. Paris. https://wedocs.unep.org/20.500.11822/47214
[2] Cement Europe. (2025, October 15). Cement Action Plan. https://www.cementeurope.eu/media/ee4a4f4r/cement-action-plan_by-cement-europe_october-2025.pdf
[3] Intergovernmental Panel on Climate Change. (2022). IPCC AR6 WGIII CDR Factsheet. https://www.ipcc.ch/report/ar6/wg3/downloads/outreach/IPCC_AR6_WGIII_Factsheet_CDR.pdf
[4] European Commission. (2026, February 3). Commission delegated regulation (EU) supplementing Regulation (EU) 2024/3012 of the European Parliament and of the Council by establishing the certification methodologies for permanent carbon removals. (2026, final). https://climate.ec.europa.eu/document/download/96845e08-0311-45b4-b6c0-7040e31d9cd0_en?filename=C_2026_553_1_EN_ACT_part1_v5.pdf

This paper will:

- Evaluate the performance of biochar as a **functional additive capable of sequestering atmospheric carbon within long-lasting construction products**, turning buildings and infrastructure into carbon sinks.

- Review the **benefits and gaps of EU-level policies, like EN-12878 and EN-15804,** that provide guidance for the development of biochar construction projects.

- Offer a guide for stakeholders across the entire value chain, including **designers, planning firms, biochar producers, financial institutions, and regulatory bodies** to develop and support projects that benefit from the carbon removal by using known methodologies like the CRCF.

- Move beyond theory by providing empirical evidence from **real projects at scale showing the transitioning from pilot stages to commercial practice.**

About The Authors

This paper was created by Biochar Europe (BCE), the largest network focused on advancing Europe's biochar sector. Through collaboration with industry organisations, scientific experts, and policymakers, we are at the centre of efforts on policy change and application promotion in responsible, circular bio-economies.

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Disclaimer

This document represents a snapshot in time of industry research, technical data, and regulatory knowledge as of June 2026. The information provided is subject to change as technical expertise progresses and new regulatory frameworks come into light. Readers are encouraged to verify the current status of specific standards or regulations with relevant authorities.

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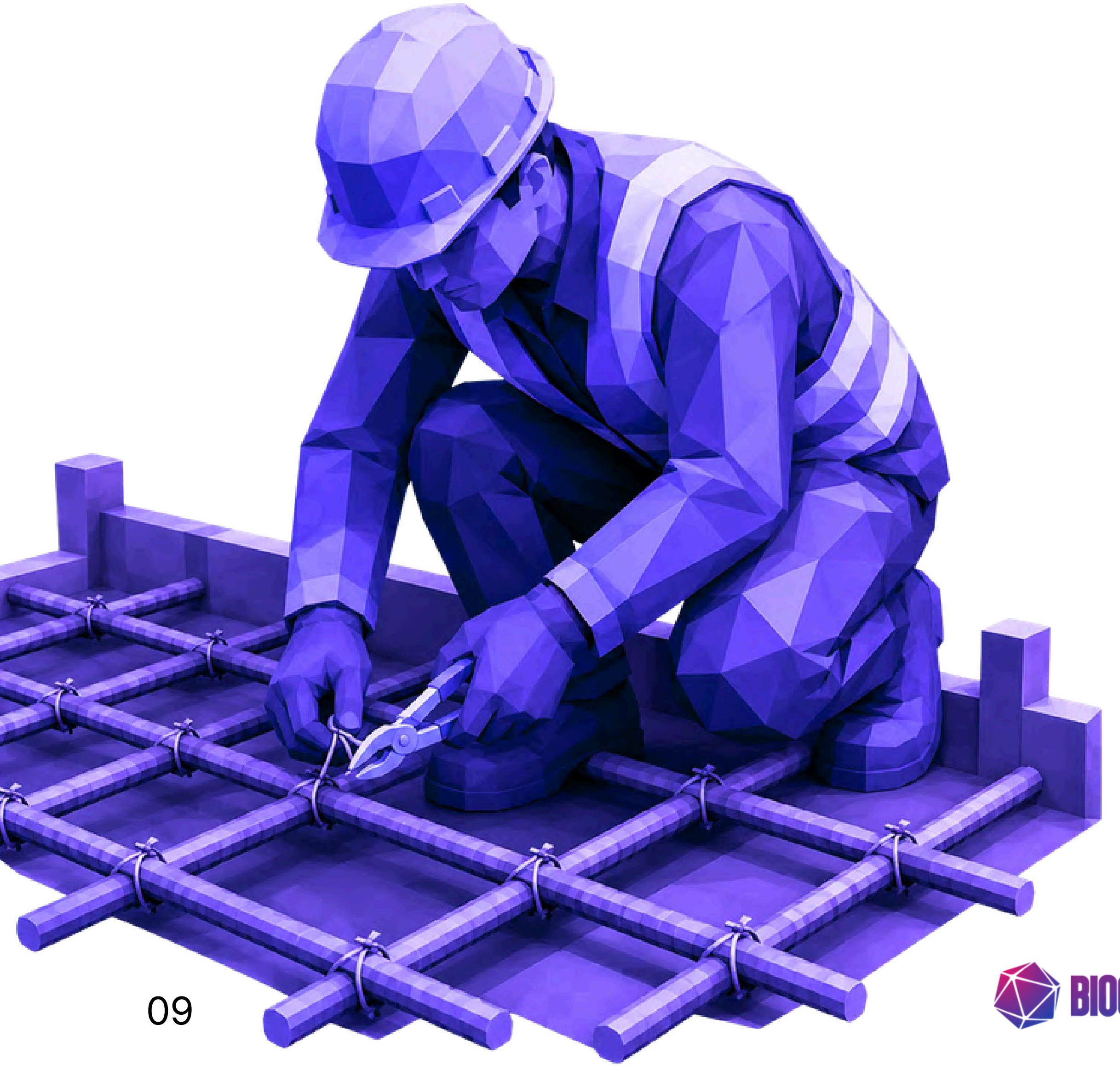
02

CONSTRUCTION'S CLIMATE PROBLEM

This paper focuses primarily on the integration of biochar into cement and concrete but will touch on other construction materials, like asphalt.

Biochar Europe has also written on the use of biochar to reduce the Global Warming Potential (GWP) of steel, another major source of greenhouse gas (GHG) emissions. **Biochar as the Key to a Climate Neutral Competitive Resilient European Economy** provides an extensive view of the industry, where **Defossilising Steel Metallurgy: Biochar's Policy Priorities for the European Union** focuses on specific policy efforts.



2.1 Setting the Stage for Concrete and Asphalt

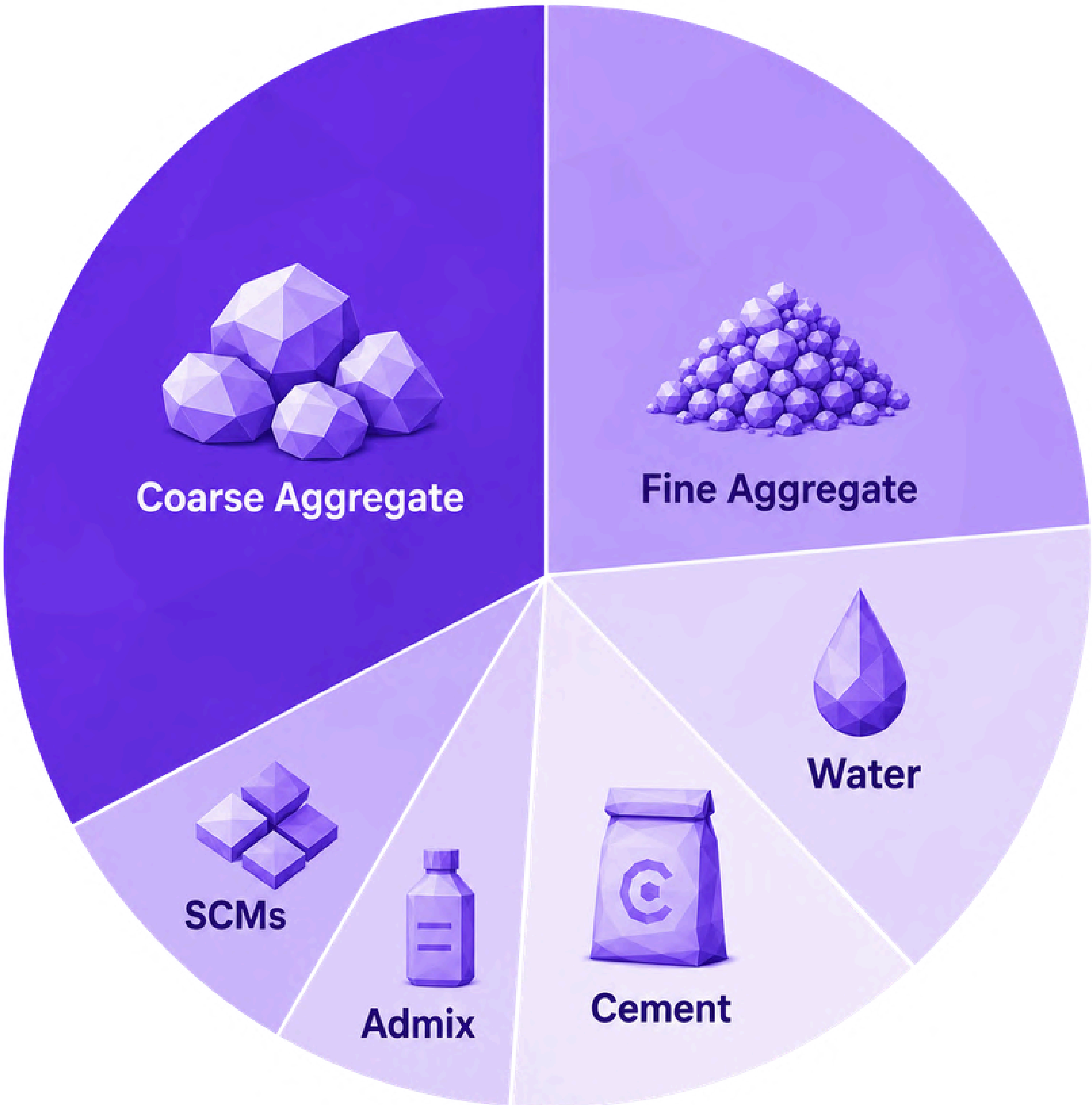
Concrete is the backbone of the built environment, used in everything from residential buildings to bridges and pavements. Within the EU, this sector operates on a massive scale, driving some of the largest material flows in the regional economy.

Concrete is a synthetic rock made of cement, sand, gravel, water, and can include other additives.

The Components of Concrete		
Binder	Cement	Clinker is the main reactive part of cement. It is obtained by heating ground limestone and clay at about 1450°C. It is the most carbon intensive component. Clinker is co-ground with gypsum to obtain cement.
	Supplementary Cementitious Materials (SCMs)	Materials used as clinker substitutes to lower the environmental impact of concrete.
	Water	Water takes part in the hydration process with cement. It also enables the process of pouring or casting.
	Admixtures and Additives	Specialized substances like superplasticizers or air entrainers are often used to modify workability or performance.
Aggregate	Fine Aggregate	Particles like sand that fill in space in the concrete.
	Coarse Aggregate	Gravel particles that make up the bulk of the concrete.

Asphalt is similar to concrete in that it is formed mostly of aggregate and a binding layer often called bitumen. Bitumen is typically made through the distillation of crude oil, and is key to the technical characteristics of asphalt.

Currently, the EU produces and consumes an estimated 171 million tonnes (Mt) of cement annually.[5] When this cement is combined with aggregate materials to create different end-products, like ready-mixed concrete, pre-cast concrete, and plasters and mortars, **the total mass of concrete flowing into EU infrastructure reaches over 1 billion tons each year accounting for an estimated 70Mt of CO_2e emitted.**[5]



A rough proportion by volume of the materials that make up concrete.

[5] Walker, A. M., Albizzati, P. F., Milios, L., Piñero Mira, P., Christis, M. et al., Environmental and SocioEconomic Impacts of the Circular Economy Transition in the EU Cement and Concrete Sector, Publications Office of the European Union, Luxembourg, 2025, https://data.europa.eu/doi/10.2760/6579506, JRC143126

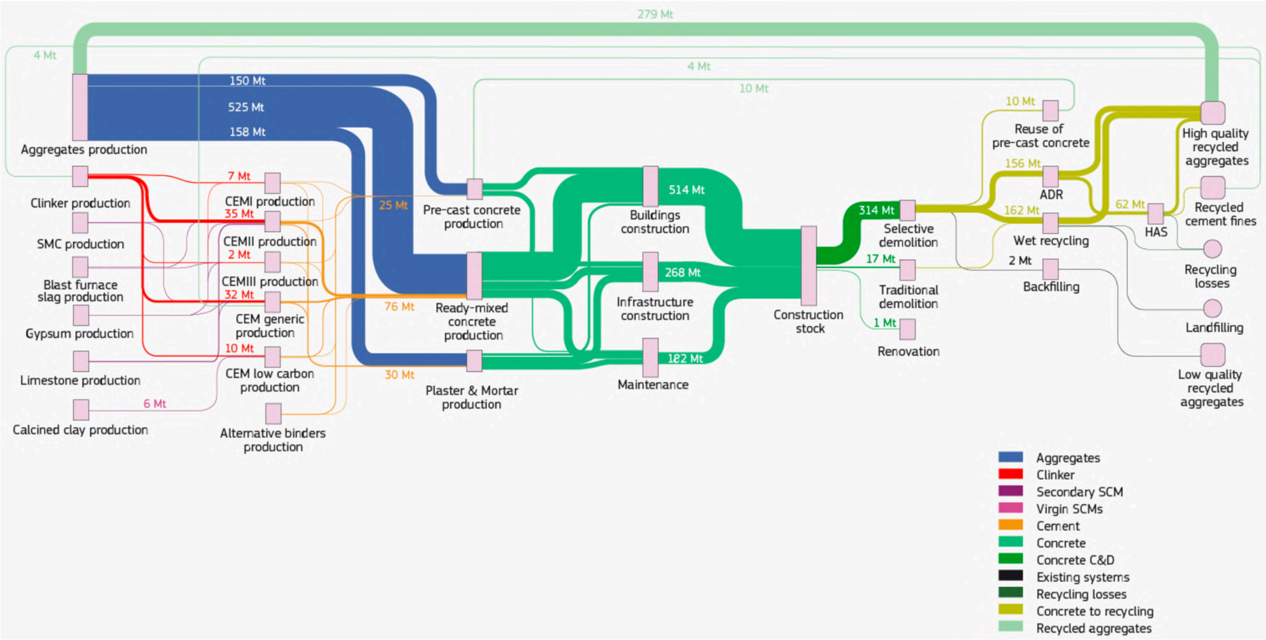
2.2 The Real Carbon Impact

Due to this immense volume and the highly energy-intensive nature of cement production, **the sector is responsible for roughly 4% of the EU's total greenhouse gas emissions**. Because these materials remain undeniably essential for modern civilization and infrastructure, their emissions are widely considered hard-to-abate.

Asphalt production is not as large, but the EU produces around 270Mt of hot and warm mix asphalt every year[6] making asphalt another significant emitter of CO_2.

Although cement typically makes up only 10-15% of the total volume of concrete, it represents more than 80% of its carbon footprint.

About **two-thirds of the emissions come from the thermal decomposition of limestone into calcium oxide (CaO) + CO_2**; carbon dioxide is a major output of this geogenic process. The remaining third is associated with energy use to operate the rotary kiln at about 1450°C.[7]



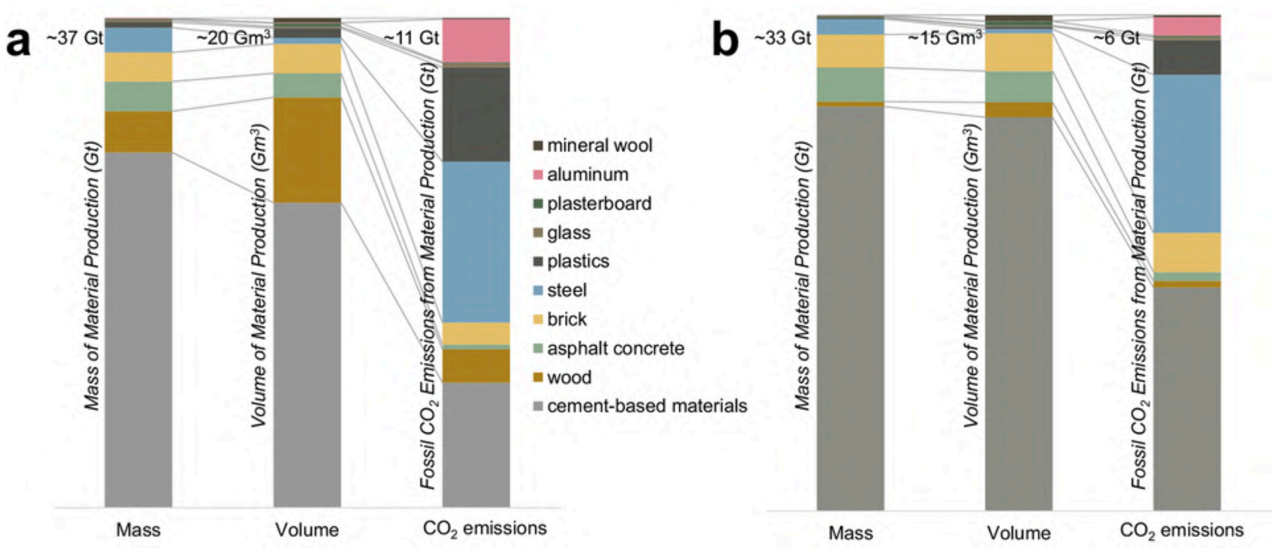
This Sankey diagram shows the inputs and outputs of cement, clinker, and concrete within the EU. Over 1 trillion tons of concrete are produced and used, leading to 4% of total CO_2 emissions. From Environmental and Socio-Economic Impacts of the Circular Economy Transition in the EU Cement and Concrete Sector by Walker, A.M., et al. and used under a CC-BY 4.0 license.

[6] European Asphalt Pavement Association. (2026, February). Asphalt in figures 2024: Key figures of the European asphalt industry in 2024. https://www.eapa.org
[7]Habert, G., Miller, S.A., John, V.M. et al. (4 more authors) (2020) Environmental impacts and decarbonization strategies in the cement and concrete industries. Nature Reviews Earth & Environment, 1 (11). pp. 559-573. ISSN: 2662-138X

For asphalt, the binder, or bitumen, is the component that causes the most GHG emissions. When looking at the material components, the binder makes up 94% of CO_2 equivalent emissions, and the material is a significant percent of the overall GHG emissions.[8]

Tonne for tonne, concrete is not the worst GHG emitter, but the scale at which concrete is used makes its impact the worst for material used in construction, with steel a close second.[9]

Concrete accounts for approximately 70% of the total mass used in construction within Europe and approximately 50% of total embodied CO_2 emissions.



The graph featuring a global estimates demonstrates well that concrete accounts for a significant portion of CO_2 emissions when considering all production (a) and for use in construction (b). From Timely deployment of best-in-class technologies to enable development and decarbonise construction by Dunant C, et al. and used under a CC-BY 4.0 license.

Though they are responsible for gigatons of CO_2 emissions, materials like concrete and asphalt are essential to our built environment - a future without them is not realistic. **Meeting the 2050 net-zero target leaves no room for delay and requires an urgent, comprehensive strategy to integrate significant emission reductions, the rapid deployment of carbon capture and storage (CCS), and scalable carbon dioxide removal (CDR).**[10] CDR is not yet implemented at scale, leaving ample opportunity and need for innovation.

[8] Shacat, J., Willis, R., & Ciavola, B. (2024). The carbon footprint of asphalt pavements: A reference document for decarbonization (Special Report No. SIP-109). National Asphalt Pavement Association. https://www.asphaltpavement.org/uploads/documents/Climate/NAPA-SIP109-TheCarbonFootprintOfAsphaltPavements-March2024.pdf
[9]CINARK & Vandkunsten Architects. (n.d.). Byggeriets materialepyramide [The construction material pyramid]. https://www.materialepyramiden.dk/
[10] Global Cement and Concrete Association. (2022). Concrete future: GCCA 2050 cement and concrete industry roadmap for net zero concrete. https://gccassociation.org/concretefuture/wp-content/uploads/2022/10/GCCA-Concrete-Future-Roadmap-Document-AW-2022.pdf

03

BIOCHAR FOR CLIMATE POSITIVE INFRASTRUCTURE

Biochar is a promising solution to the global warming problem of several construction materials, because it:

- **Permanently stores CO_2 by embedding carbon into the built environment**
- **Can be used in favorable cases to reduce clinker content and its associated emissions (detailed in Section 4)**
- **Can improve certain concrete performance metrics (detailed in Section 4)**

The process of pyrolysis, which thermochemically converts biomass into a highly stable form of carbon, locks carbon into a robust state, preventing it from returning to the atmosphere. Industrial grade biochars exhibit high thermal and chemical stability and are the carbon removal technology with the most delivered tons to date.

CDR could develop into a major economic opportunity for the EU, with the market reaching around EUR 110–220 billion per year by 2050 in Europe, creating up to 670.000 jobs.[11] Within this landscape, biochar stands out as one of the most commercially attractive CDR pathways because of its high technological maturity and potential to deliver co-benefits beyond carbon removal, including energy generation and industrial use cases, like those discussed in this paper.

€110-220B

Estimated Market Size for CDR in 2050

670.000

Estimated Jobs Created by 2050

[11] Europe and Germany's Role in Catalyzing a Trillion-Euro Industry BCG, DVNE (2024) https://negative-emissions.bcg.com/home/2024-overview

3.1 The Right Biochar for Construction

Biochar is often known by other terms, such as inertinite biochar, technical carbon, or elemental carbon. To simplify language and to align with the Carbon Removals and Carbon Farming (CRCF) Regulation and other standards, we will use the simple term biochar. However, this paper requires the biochar to be:

- Produced from sustainably sourced biomass
- An industrial-grade carbon material compatible with use in construction materials
- Non-toxic and safe for use in the built environment, including REACH compliance
- Pyrolyzed at a high enough temperature to be considered permanent by nature

3.2 How Organic Materials Become Permanent Carbon Sinks

To qualify for high-value carbon credits and meet strict EU regulatory standards, project developers must prove that the carbon stored in biochar will not degrade. The following metrics are helpful to understand to define that proof:

Hydrogen to Carbon Ratio (H:C ratio)	The measurement of the total amount of elemental hydrogen relative to carbon. The lower the ratio, meaning the less hydrogen, the more permanent the structure.
Random Reflectance	Random reflectance measures the light reflected from a polished surface of biochar. The higher the reflection the more permanent the biochar.
Aromatic Structure	A type of chemical bond that is exceptionally stable due to its unique arrangement, often in a “ring” shape.

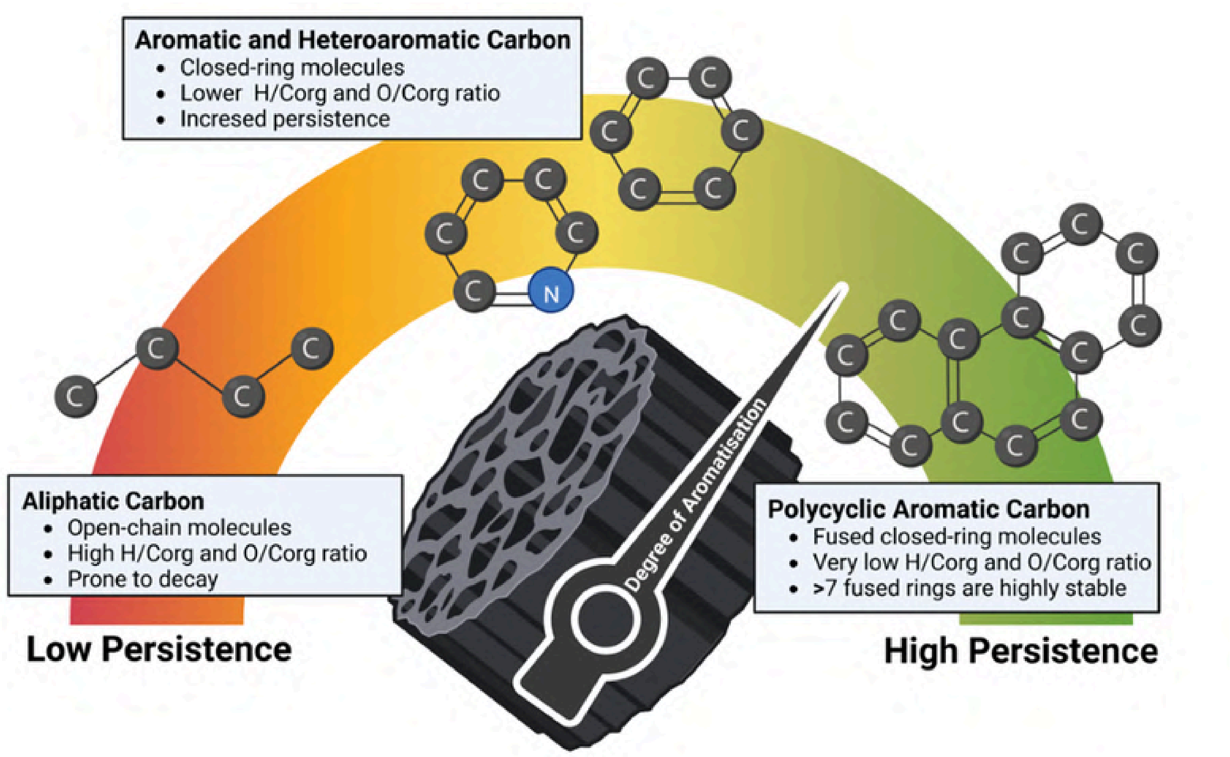
During pyrolysis, biogenic polymers such as cellulose and lignin are transformed into an aromatized carbon framework, becoming persistent to natural degradation.

As process temperature and time-under-temperature increase:

- The hydrogen to carbon ratio (H:C) decreases
- The random reflectance (Ro) increases
- The resulting structures increasingly resemble geologically stable carbon forms

The higher degree of aromatization that comes from a higher pyrolysis temperature and a longer residence time is associated with the carbon becoming more aromatic (ring structure) and less aliphatic (straight chain structure).

The more fused rings and the more the carbon bonds are directly connected to each other, the more difficult it is to break those bonds, and the more persistent the carbon is.[12] **When biochar is created with a high enough temperature, which most industrial processing facilities meet, it resembles inertinite, the most stable maceral, or carbon mineral, that is found in the Earth's crust.** Measurement techniques exist to measure biochar samples and confirm the degree of aromatization is met to be considered permanent on a geologic scale.[13]

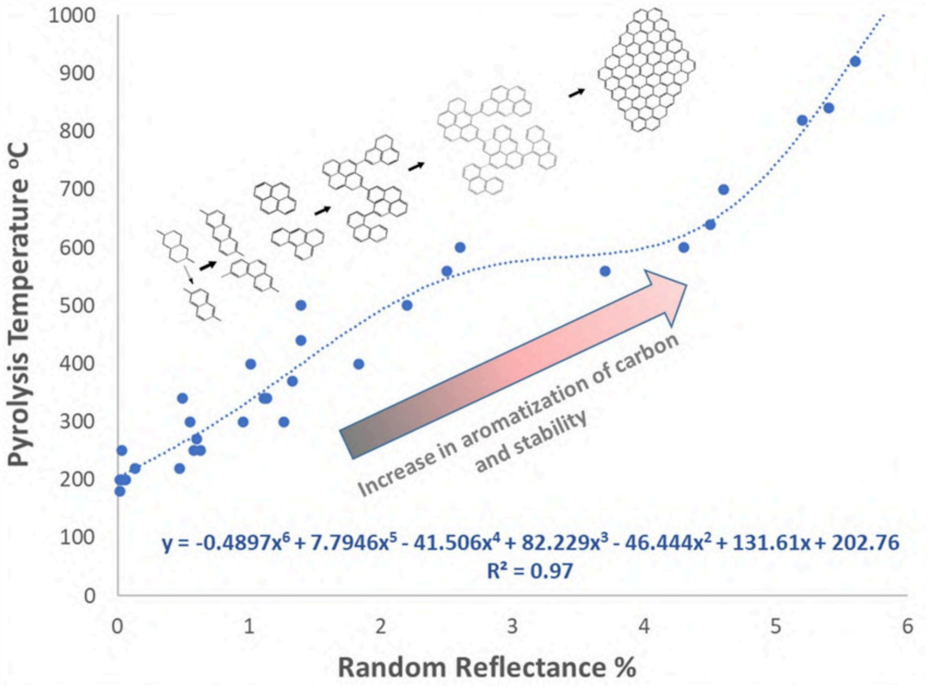


Carbon atoms fuse into rings as they reach a higher degree of aromatization often due to higher pyrolysis temperature. Higher aromatization means higher persistence of the carbon removal. From "Permanence of soil applied biochar" by Schmidt H, et al., shared with approval of the author.

[12] Schmidt HP, Abiven S, Hagemann N, Meyer zu Drewer J: Permanence of soil applied biochar, the Biochar Journal 2022, Arbaz, Switzerland. ISSN 2297-1114 www.biochar-journal.org/en/ct/109. Version of 23rd December 2022. Accessed: 13.05.2026
[13] Hamed Sanei, Arka Rudra, Zia Møller Moltesen Przyswitt, Sofie Kousted, Marco Benkhettab Sindlev, Xiaowei Zheng, Søren Bom Nielsen, Henrik Ingermann Petersen, Assessing biochar's permanence: An inertinite benchmark, International Journal of Coal Geology, Volume 281, 2024, 104409, ISSN 0166-5162, https://doi.org/10.1016/j.coal.2023.104409.

As added protection, **when biochar is encased in a concrete or cement matrix, it is guaranteed that the carbon is permanently bound.** It is no longer separable from the material matrix, and it will cure into solid, durable concrete in less than 28 days. A similar argument can be made about biochar encased in asphalt.

This ensures safe, long-term storage and provides a certifiable carbon removal technology.



Random reflectance increases with increasing pyrolysis temperatures and degree of aromatic structure of carbon atoms. From "Assessing biochar's permanence: An inertinite benchmark" by Sanei H, et al. and used under a CC BY 4.0 license.

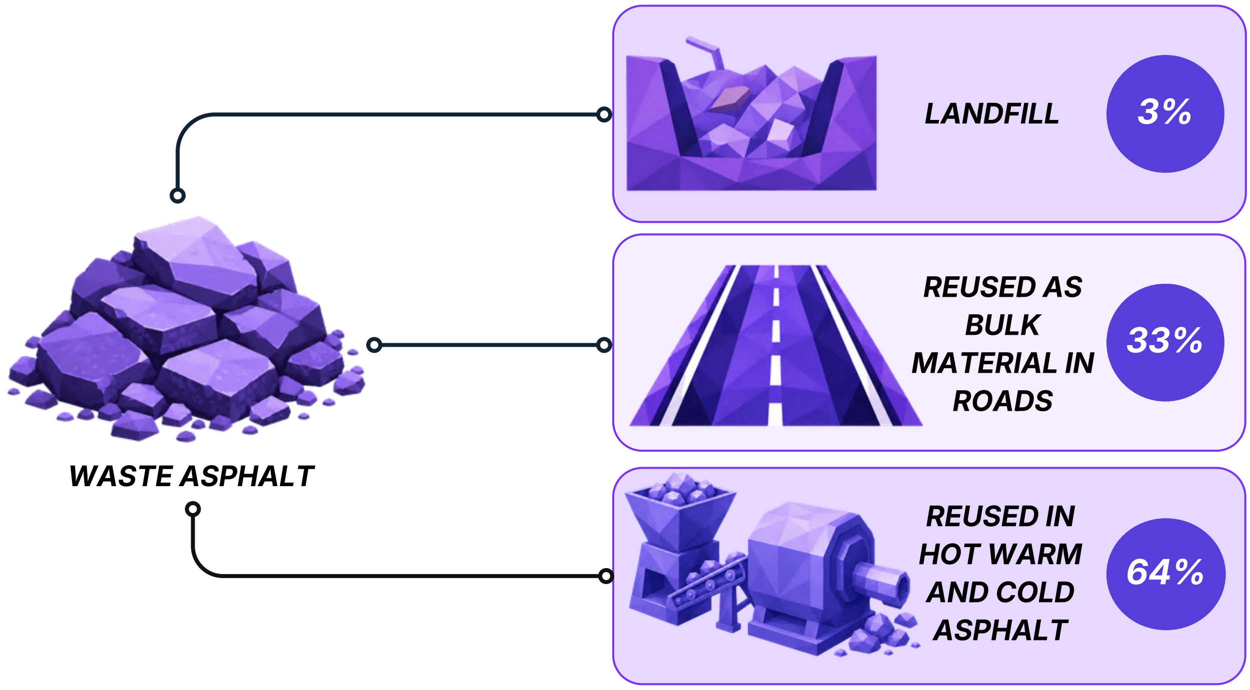
3.3 Safe, Reliable, Irreversible Carbon Storage

Based on scientific evidence, the natural decay of biochar is not the issue, however, the end-of-life of the materials needs to be considered.

Within Europe, concrete is typically recycled to be reused as an aggregate or downcycled and used as an affordable and sustainable filler for the substructure of roads.[14] Though country dependent, the average portion across the EU of construction demolition waste, which is predominantly concrete, is approximately 80%, with very small portions going to landfills.[15]

[14] Hradil, Petr & Talja, Asko & Wahlström, Margareta & Huuhka, Satu & Lahdensivu, Jukka & Pikkuvirta, Jussa. (2014). Re-use of structural elements; Environmentally efficient recovery of building components. 10.13140/2.1.1771.9363.
[15] Cristóbal García, J., Caro, D., Foster, G., Pristerà, G., Gallo, F., Tonini, D. Techno-economic and environmental assessment of construction and demolition waste management in the European Union, Publications Office of the European Union, Luxembourg, 2024, doi:10.2760/721895, JRC135470

When concrete is downcycled into roads or put into a landfill, it is buried and effectively protected even further from any thermal or oxidative degradation. The carbon remains permanently bound and the removal safely protected.

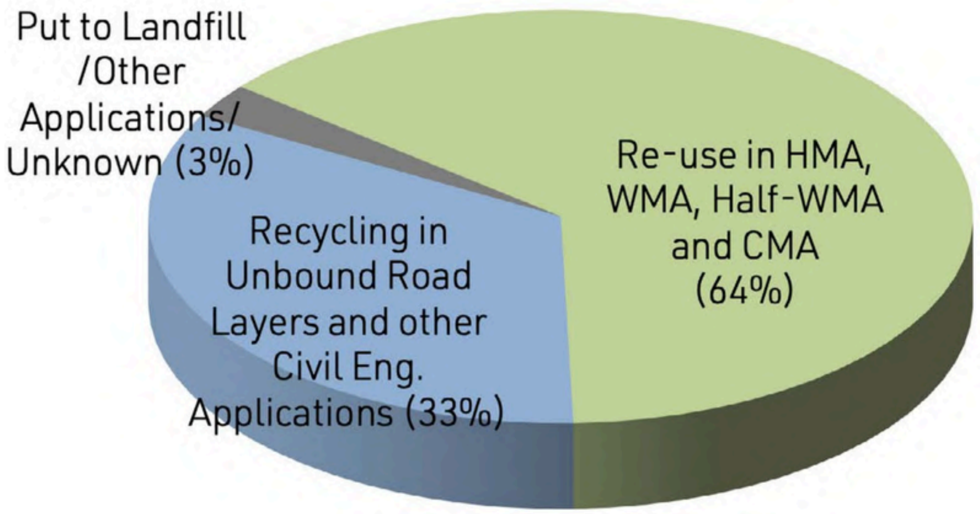


An example of the percentage breakdown of end-of-life of materials based on data from Hradil, P. et al (2014).[16]

Only if the crushed concrete sand is used as a secondary raw material in the clinker re-calcination process, the permanence of the carbon would be affected, however, this practice is not at all common. Carbon credit standards and verifiers, like Isometric, specifically call out that closed-loop recycling technology is nascent and does not need to be considered at this time.[17] However, in order to maintain the high degree of integrity associated with biochar credits, it will be important to adjust if this process is adopted in the mainstream.

The same can be said for asphalt, where it is most often re-used or recycled, and only on rare occasions put to a landfill.[18]

[16] Hradil, Petr & Talja, Asko & Wahlström, Margareta & Huuhka, Satu & Lahdensivu, Jukka & Pikkuvirta, Jussa. (2014). Re-use of structural elements; Environmentally efficient recovery of building components. 10.13140/2.1.1771.9363.
[17] Isometric. (2025, August). Biochar storage in the built environment (Version 1.0). https://registry.isometric.com/module/biochar-storage-built-environment/1.0
[18] European Asphalt Pavement Association (EAPA). The Circular Economy of Asphalt. EAPA Technical Review (2022) 34 pages. https://eapa.org/ download/15684/



European Asphalt Pavement Association (EAPA). The Circular Economy of Asphalt by the European Asphalt Pavement Association (EAPA) used under a CC BYNC-ND 4.0 license

Regardless of the end outcome, the biochar and carbon locked within the concrete or asphalt matrix would not be exposed to high enough temperatures that would convert the carbon in biochar back to atmospheric CO_2. This ensures the security of the environmental benefit.

For a more detailed analysis on this topic, Biochar Europe published a previous position paper on this topic. The Permanence of Biochar in Concrete can be read here.

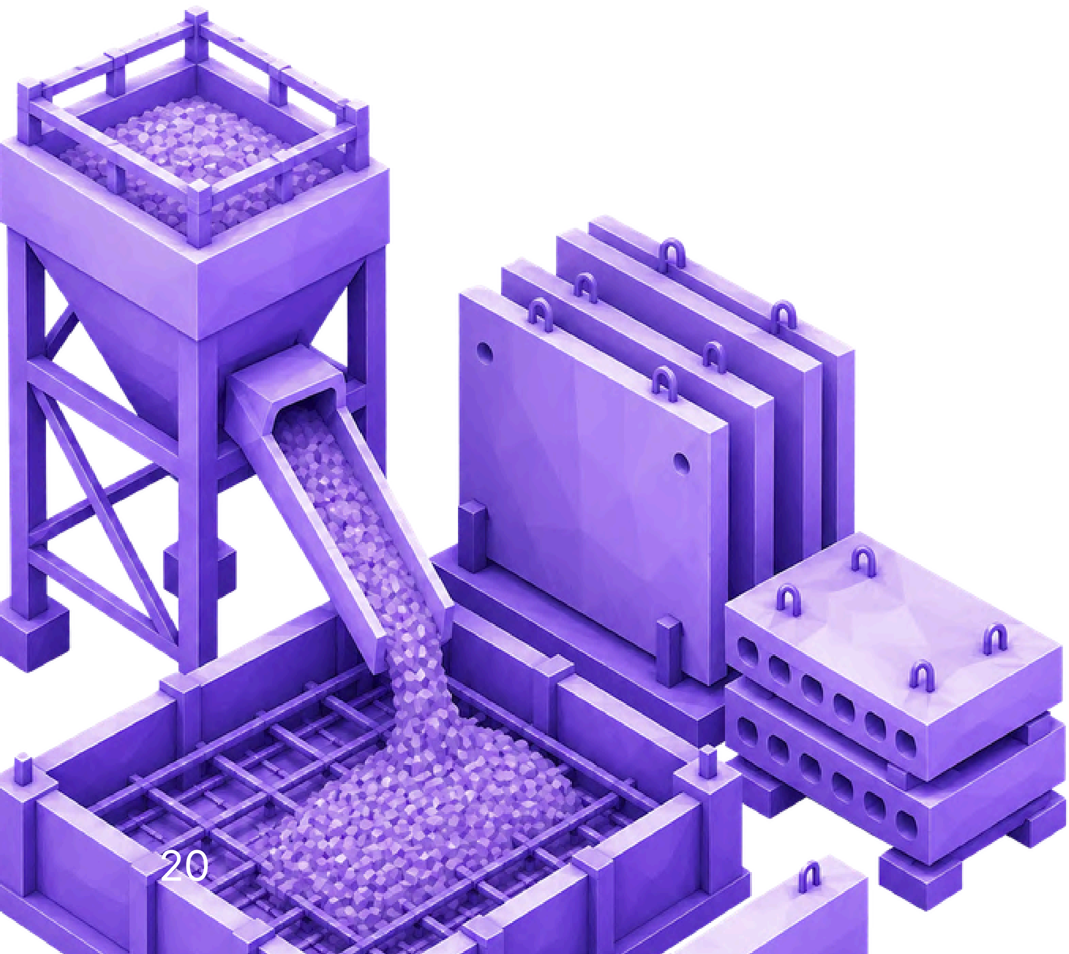
04

TECHNICAL PATHWAYS FOR BIOCHAR-ENHANCED CONSTRUCTION

Translating biochar's sequestration potential into structural reality requires precise engineering and a commitment to rigorous performance standards. The following overview outlines the most promising pathways for biochar integration in concrete and asphalt as they stand at the time of publication.

Because our understanding of these carbon-negative materials is continuously expanding, this section serves as both a technical guide and a call to action for the industry to maintain high standards of evidence-based development.

We invite the reader to utilize these findings as a springboard for their own rigorous testing.



4.1 How to Create a Low Embodied Carbon Concrete Mix

When companies look to incorporate biochar into their production lines, they generally target one of two distinct phases within the concrete mix: the binder or the aggregates.

As the binder is the most carbon-intensive part, replacing this means not just storing carbon, but also reducing emissions - a primary focus of all climate change strategies. For the binder phase, biochar is typically processed into a fine powder and used to replace a portion of the cement or SCMs. These replacement ranges are often around 5% by cement weight, but researchers and concrete mix companies have shown high-performing concrete with mixes ranging from 0,25 to 20%.[19],[20],[21]

In addition, biochar is often added into the fine aggregate portion of the concrete mix. **Because the aggregate portion is a much higher percentage of mass of the overall mix, replacing this portion is a much quicker way to increase the carbon storage amount.** The addition of biochar here can also be used to increase the packing density and be used to fine tune the pore structure.

Caption: Ready-mix concrete with biochar is being poured from a concrete truck. Image used with permission of Holcim.

Furthermore, biochar can be considered a pigment and functional additive, as it can adjust the color or surface appearance, while lowering the embodied carbon of the end product and improving the material's properties.

There are a number of methods of integrating biochar into cement and concrete materials. These methods focus on following standard industry practices to limit added effort by the production teams.

[19] Murali, G., Wong, L.S., 2024. A comprehensive review of biochar-modified concrete: Mechanical performance and microstructural insights. Constr. Build. Mater. 425, 135986. https://doi.org/10.1016/j.conbuildmat.2024.135986
[20] Ling, Y.; Wu, X.; Tan, K.; Zou, Z. Effect of Biochar Dosage and Fineness on the Mechanical Properties and Durability of Concrete. Materials2023, 16, 2809. https://doi.org/10.3390/ma16072809
[21] Mahmoud, A.A., El-Sayed, A.A., Fathy, I.N. et al. Evaluation of rice husk biochar influence as a partial cement replacement material on the physical, mechanical, microstructural, and radiation shielding properties of ordinary concrete. Sci Rep 15, 27229 (2025). https://doi.org/10.1038/s41598-025-11987-8

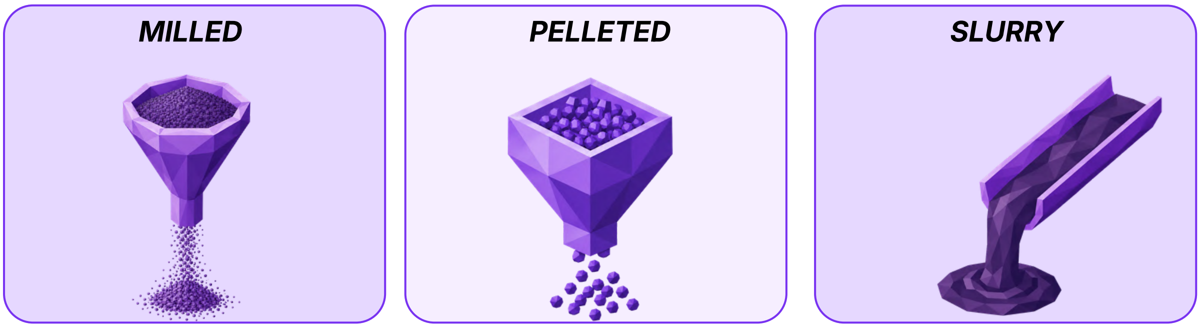
One method involves the direct addition of milled biochar during the batching process. This is a simple and straightforward method that fits well with existing manufacturing processes of cement and concrete. Because biochar is a highly porous material, when added in larger volumes, it can absorb water, which can lead to a reduction in workability. To mitigate this, biochar can be shipped with an elevated water content that is ideal for processing, or water/superplasticizers can be adjusted in the mix.[22]

To improve material handling and mitigate dust generation and clumping associated with ultrafine carbon powders, additional manufacturing approaches to transform the material as pellet, granulate or slurry have been developed and demonstrated. These processes typically involve the use of specific binders, superplasticizers, and/or other proprietary additives to enhance product stability and handling performance.

Alternatively, biochar can be processed through cold-bonding methods to produce lightweight aggregates suitable for construction applications.[23]

Whether used as a pigment, supplementary cementitious material, or a bulk aggregate replacement, biochar's success in concrete depends on creating a mix that properly balances the water content, superplasticiser amount and, where applicable, air-entraining agents to consistently achieve the specified concrete properties. It is imperative not to increase cement dosage to offset any potential biochar-related performance loss as this would be counterproductive to decarbonization.

To be effective, biochar must be added to already optimized low-carbon mixes, serving as the catalyst to reach near/net zero carbon levels. By treating biochar as a functional additive rather than just a passive filler, the construction industry can achieve both the permanent sequestration of atmospheric carbon dioxide and a measurable improvement in the durability of the built environment.



While multiple options exist, the correct option for integrating biochar will depend on the product and process used.

[22] Hylton, J., Hugen, A., Rowland, S.M. et al. Relevant biochar characteristics influencing compressive strength of biochar-cement mortars. Biochar 6, 87 (2024). https://doi.org/10.1007/s42773-024-00375-6
[23] Mateusz Wyrzykowski, Nikolajs Toropovs, Frank Winnefeld, Pietro Lura, Cold-bonded biochar-rich lightweight aggregates for net-zero concrete, Journal of Cleaner Production, Volume 434, 2024, 140008, ISSN 0959-6526, https://doi.org/10.1016/j.jclepro.2023.140008.

4.2 Balancing Technical Benefits and Carbon Removal

The integration of biochar influences strength development, deformation behavior, and cracking characteristics of the final concrete product in defined and controllable patterns. For industrial manufacturing, biochar dosage, particle geometry, and its interaction with the cement matrix must be treated as fixed parameters within the formulation to ensure consistent product quality.

A biochar-concrete block is being tested for compressive strength. Image used with permission of ecoLocked GmbH.

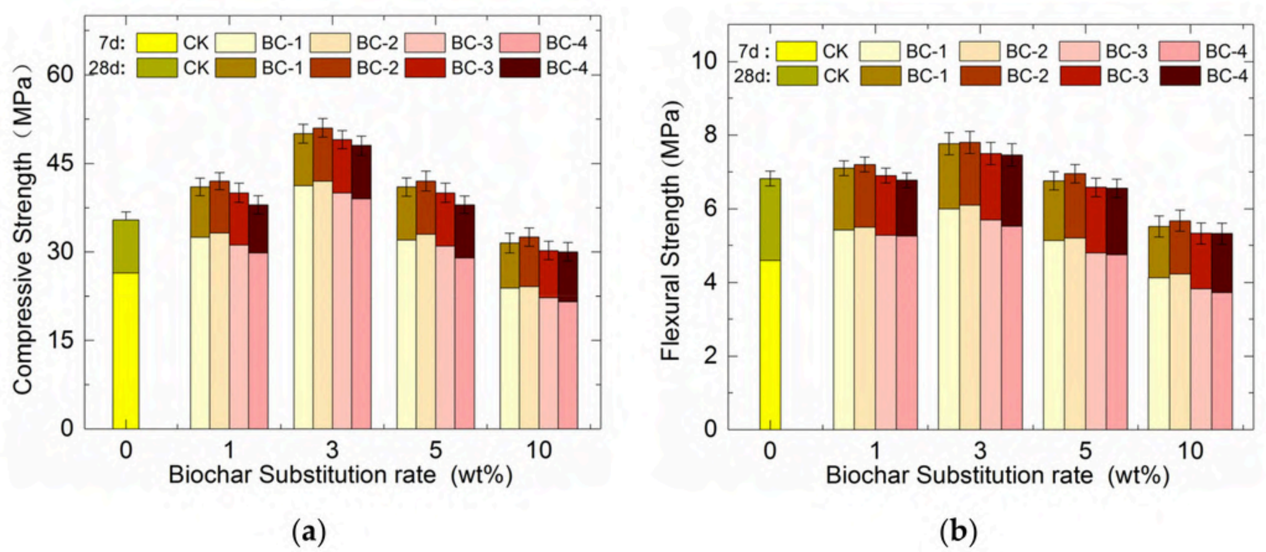
4.2.1 Mechanical Performance and Strength Optimization

Compressive strength is a very important performance metric as it defines its reference class and suitability for structural applications, particularly in high-load scenarios such as high-rise construction.

Flexural strength, another often measured parameter, determines the load at which unreinforced concrete may bend and break.

Substituting cement or aggregate with biochar can lead to fluctuations in both compressive and flexural strength, and can improve performance for specific replacement rates.[24] This requires optimizing the specific dosage rate of biochar to meet the strength class required by that product. Once a specific recipe is established, the compressive and flexural strength properties remain fixed, ensuring reliability for structural engineers.

[24] Ling, Y.; Wu, X.; Tan, K.; Zou, Z. Effect of Biochar Dosage and Fineness on the Mechanical Properties and Durability of Concrete. Materials 2023, 16, 2809. https://doi.org/10.3390/ma16072809



Compressive and flexural strength data are shown for samples with varying biochar per cement wt %. BC-1 to BC-4 denotes different particle size distributions. The authors showed performance improvements with 3% added biochar. From "Effect of Biochar Dosage and Fineness on the Mechanical Properties and Durability of Concrete" by Ling, Y, et al. and used under CC BY 4.0 license.

Young's modulus also must be evaluated and not negatively impacted, especially for structural applications. At cement volume replacements of approximately 5%, biochar will have no discernable impact on Young's modulus, while higher dosages (e.g. 25%) may decrease performance[25], as expected from the inclusion of a lower stiffness component. Biochar particle size will also impact properties with two competing mechanisms. First, the biochar particles will absorb and retain water, reducing the free water content in the binder phase and subsequently boosting the paste's strength and elastic modulus. Second, the inclusion of these low-modulus porous biochar particles will inherently lower the composite's overall effective modulus[26]. **However, through smart concrete mix design, formulations can be optimized to limit Young's modulus reduction to a minor level that does not impact structural design.**

Ultimately, these findings confirm that **biochar-enhanced mixes can maintain, and in some configurations, exceed,** the rigorous mechanical standards required for modern structural engineering, proving that carbon sequestration does not have to come at the cost of performance.

[25] Renata Lorenzoni, Tobias Fritsch, Sabine Kruschwitz, Giovanni Bruno, Wolfram Schmidt, Mechanical analysis of cement-biochar composites using in-situ X-ray microtomography and digital volume correlation, Construction and Building Materials, Volume 490, 2025, 142511, ISSN 0950-0618, https://doi.org/10.1016/j.conbuildmat.2025.142511.
[26] Souradeep Gupta, Harn Wei Kua, Sze Dai Pang, Biochar-mortar composite: Manufacturing, evaluation of physical properties and economic viability, Construction and Building Materials, Volume 167, 2018, Pages 874-889, ISSN 0950-0618, https://doi.org/10.1016/j.conbuildmat.2018.02.104.

4.2.2 Improving on Durability Metrics

Outside of strength, metrics focused on concrete's durability are very important to consider, especially for buildings that last decades.[27]
The table below covers three key areas of durability that this paper will review.

Permeability	Biochar replacement, typically at 1-3 wt%, can reduce porosity by nearly 28%, significantly lowering capillary adsorption and total water absorption.[27]
Chloride Ingress	This refined microstructure is particularly effective at slowing chloride ions. Chloride is corrosive to the steel rebar often used for structural concrete. Optimal biochar dosages can reduce the chloride diffusion coefficient by up to 32%.[28]
Freeze-Thaw Resistance	Biochar's porous structure stores water, promoting a more uniform hydration that resists the expansion pressures of ice during freeze-thaw cycles. Though dosages under 5% are needed to ensure the denser structure remains resistant to frost damage.[27]

Durability is a definitive parameter for the structural application of concrete. The physical structure dictates the density and transport behavior of water, gases, and ions, ensuring the concrete mix complies with rigorous exposure classes required for modern infrastructure. As with mechanical strength, these parameters must be measured and confirmed for each specific product as different dosage rates and characteristics influence performance.

4.2.3 Maintaining Workability and Operations

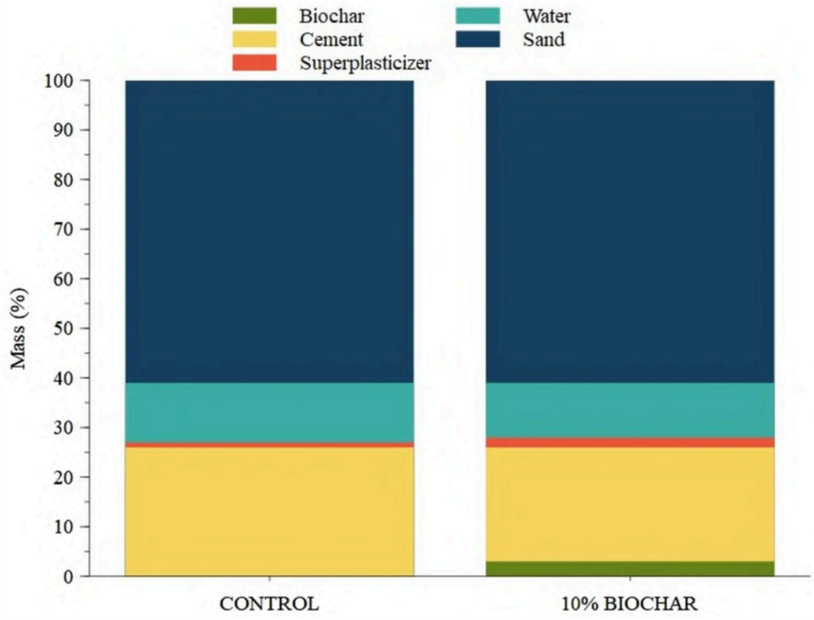
Concrete mixes containing biochar are engineered to be produced, transported, placed, and cured using standard concrete industry methods.

Because biochar has a high specific surface area and porosity, leading to water absorption, the mix design is typically adjusted. Through **using off-the-shelf superplasticizers and making adjustments to the water-cement (w/c) ratio and overall packing density of concrete, biochar-enhanced concrete achieves the necessary slump and flow to ensure pumpability** and ease of placement for normal site conditions.[29]

[27] Xuqun Lin, Wengui Li, Yipu Guo, Wenkui Dong, Arnaud Castel, Kejin Wang, Biochar-cement concrete toward decarbonisation and sustainability for construction: characteristic, performance and perspective, Journal of Cleaner Production, Volume 419, 2023, 138219, ISSN 0959-6526, https://doi.org/10.1016/j.jclepro.2023.138219. (https://www.sciencedirect.com/science/article/pii/S0959652623023776)
[28] Ling, Y.; Wu, X.; Tan, K.; Zou, Z. Effect of Biochar Dosage and Fineness on the Mechanical Properties and Durability of Concrete. Materials 2023, 16, 2809. https://doi.org/10.3390/ma16072809
[29] Hylton, J., Hugen, A., Rowland, S.M. et al. Relevant biochar characteristics influencing compressive strength of biochar-cement mortars. Biochar 6, 87 (2024). https://doi.org/10.1007/s42773-024-00375-6

Air voids, air entrainment behavior, and surface quality are managed through the specific composition, along with chemical admixtures. This ensures the final product meets defined structural and aesthetic qualities.

These mix designs are engineered to be robust, maintaining performance regardless of minor fluctuations in raw material quality or environmental conditions, such as temperature and humidity.



An example showing ratios of how a mortar mix may be adjusted in order to maintain workability. This example shows a 10% addition of biochar, maintaining a 0,45 water-to-cement mass ratio with approximately 1% of superplasticizer. From Relevant biochar characteristics influencing compressive strength of biochar-cement mortars by Hylton J, et al. and used under A CC BY 4.0 license.

When designed properly, biochar-based concrete is a drop-in solution for construction crews. It behaves like conventional concrete, utilizing familiar control parameters for testing and installation, while offering significant carbon removal benefits.

An engineer is conducting a slump flow test on a biochar concrete mix. Image used with permission of Holcim.

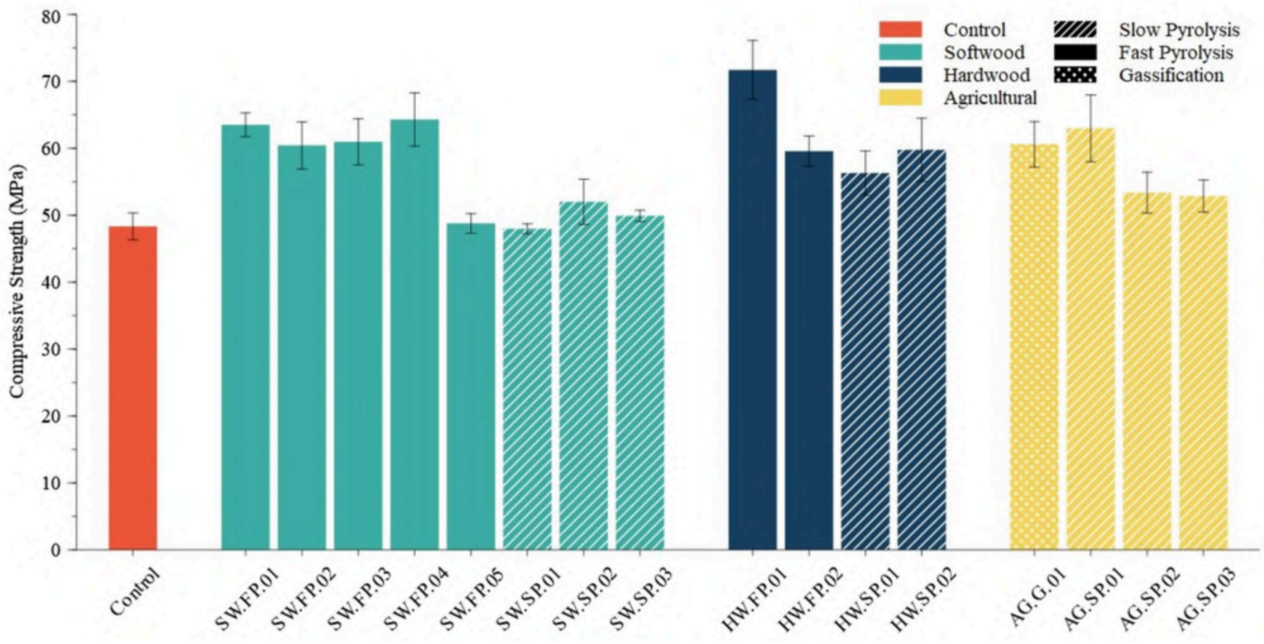
4.3 Unlock the Potential to Scale with Biomass Diversity

Biochar offers a promising solution for the long-term sequestration of carbon, especially when it is derived from sustainable residual biomass and used in durable applications.[30] It is important for the input biomass to not be purpose-grown, and to focus on residues that would otherwise be burned or decompose.

In fact, **one of biochar's greatest assets is its versatility, as it can be made from various types of biomass**, such as forestry or agricultural residues.

Many material characteristics of biochar, like carbon content, specific surface area, and density, can impact the final end product performance of the concrete mix.[31]

However, research has demonstrated that **with proper processing and mix design, cement mortar samples can be made from biochars across various biomass** and still out perform control samples with respect to compressive strength.[32]

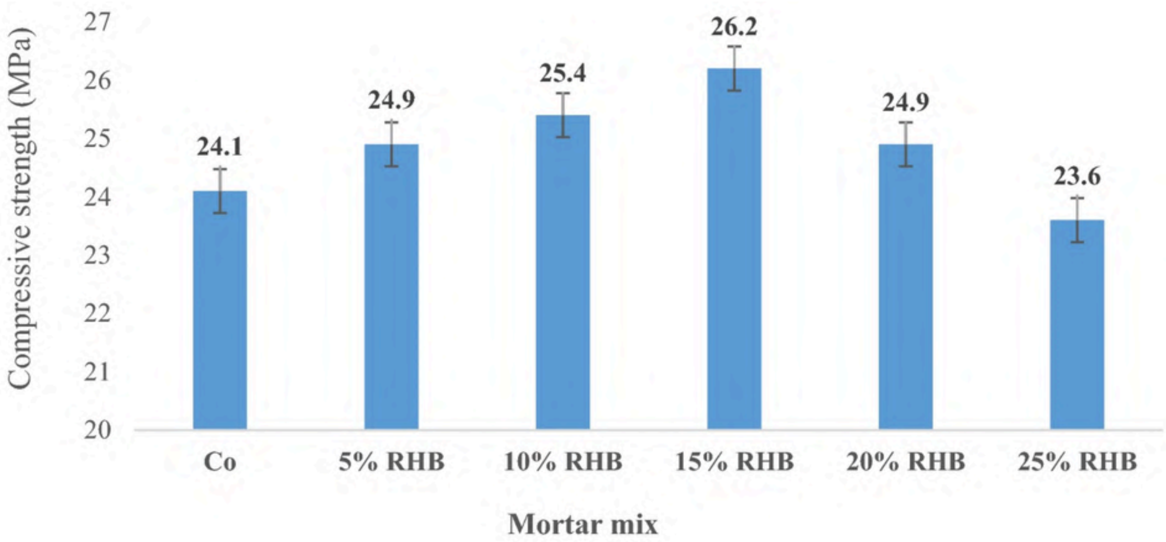


Almost all cement mortar samples made from various biomass biochars outperform the control for compressive strength, demonstrating feasibility to create concrete samples from many different biomass. From Relevant biochar characteristics influencing compressive strength of biochar-cement mortars by Hylton J, et al. and used under A CC BY 4.0 license

[30] Woolf, D., Amonette, J., Street-Perrott, F. et al. Sustainable biochar to mitigate global climate change . Nat Commun 1, 56 (2010). https://doi.org/10.1038/ncomms1053
[31] Hamid Maljaee, Rozita Madadi, Helena Paiva, Luis Tarelho, Victor M. Ferreira, Incorporation of biochar in cementitious materials: A roadmap of biochar selection, Construction and Building Materials, Volume 283, 2021, 122757, ISSN 0950-0618, https://doi.org/10.1016/j.conbuildmat.2021.122757.
[32] Hylton, J., Hugen, A., Rowland, S.M. et al. Relevant biochar characteristics influencing compressive strength of biochar-cement mortars. Biochar 6, 87 (2024). https://doi.org/10.1007/s42773-024-00375-6

One of the more impactful characteristics of biochar to cement performance is the ash content. The feedstock is the primary driver of the ash content in a biochar. Woody biomass typically yields very low ash, whereas agricultural residues, animal manures, and waste materials can produce biochars with ash contents up to 50% or more.

The ash content contains non-carbon elements and can dictate chemical reactivity in cementitious systems by pozzolanic activity. However, this can lead to a benefit. Biochars derived from agricultural residues such as rice husks are rich in reactive amorphous silica.[33] In a cement matrix, this reactive silica exhibits pozzolanic activity and contributes to long term strength.



Compressive strength can be seen increasing at high biochar loadings, peaking at 15%, using a rice husk biochar. From Evaluation of rice husk biochar influence as a partial cement replacement material on the physical, mechanical, microstructural, and radiation shielding properties of ordinary concrete by Mahmoud, A.A., et al. and used under a CC BY-NC-ND 4.0 license.

Given different biomass can be utilized to make concrete, the reach of biochar has potential for immense scale to reduce emissions and store carbon.

This operationalizes the cascading use of biomass principle by ensuring biogenic residues are transformed into a permanent, circular sink rather than being lost to immediate energy recovery.

By harnessing the vast diversity of biogenic residues, biochar empowers the construction industry to turn localized waste into high-performance, carbon negative infrastructure.

[33] Mahmoud, A.A., El-Sayed, A.A., Fathy, I.N. et al. Evaluation of rice husk biochar influence as a partial cement replacement material on the physical, mechanical, microstructural, and radiation shielding properties of ordinary concrete. Sci Rep 15, 27229 (2025). https://doi.org/10.1038/s41598-025-11987-8

4.4 How Roads Can Also Decarbonize

Biochars are also integrated into other building material systems, including mortar, screeds, grouting compounds, asphalt and polymer-bound materials. Depending on the product, it can act as a filler, functional additive, or pigment.

In asphalt, biochar is typically applied as part of the bitumen, but may also be applied as an aggregate, the choice depending on the end goal of the mix. The addition of biochar can enhance resistance to aging, increase high temperature resistance, reduce susceptibility to cracking, and improve resistance to moisture.[1]

Similar to concrete, ratios of the core components must be adjusted and tests must be conducted to confirm the performance of the end material to key regulatory specifications.

Carbon neutral asphalt is being laid by Gieseke GmbH. Image used by permission of Gieseke GmbH.

[19] Murali, G., Wong, L.S., 2024. A comprehensive review of biochar-modified concrete: Mechanical performance and microstructural insights. Constr. Build. Mater. 425, 135986. https://doi.org/10.1016/j.conbuildmat.2024.135986
[20] Ling, Y.; Wu, X.; Tan, K.; Zou, Z. Effect of Biochar Dosage and Fineness on the Mechanical Properties and Durability of Concrete. Materials2023, 16, 2809. https://doi.org/10.3390/ma16072809
[21] Mahmoud, A.A., El-Sayed, A.A., Fathy, I.N. et al. Evaluation of rice husk biochar influence as a partial cement replacement material on the physical, mechanical, microstructural, and radiation shielding properties of ordinary concrete. Sci Rep 15, 27229 (2025). https://doi.org/10.1038/s41598-025-11987-8

05

LEVERAGING EXISTING REGULATIONS FOR SAFE INNOVATION

Concrete is a high-stakes material. Because structural failure can be catastrophic, concrete is, understandably, one of the most heavily regulated materials in the world.

EN 12878, or “Pigments for the colouring of building materials based on cement and/or lime - Specifications and methods of test,” is an accepted standard for tests designed to ensure the safety of a final concrete mix. Other standards for concrete properties, like EN 206 (EU-level) and DIN 1045-2 (Germany), reference EN 12878.

Traditionally, the deep grey and black hues in concrete are achieved using iron oxide or carbon black. EN 12878 classifies elemental carbon as inorganic pigment. Biochar serves as a direct, net carbon-negative pigment alternative, where laboratory testing has demonstrated that biochar additives behave as stable elemental-carbon reservoirs.[35]

By subjecting biochar to this standard, manufacturers ensure that the carbon-sequestration benefits do not come at the cost of durability or structural safety.

[35]Test report CarStorCon® Technologies, VBE-P24763 EP, 22092025, Clim@Add® Granulates according to EN 12878:2006, VBE – Association for Building Materials Testing and Development (Pöchlarn; accredited in Austria, BMWFW 92.714/0381-I/12/2014) issued (reinforced concretes)

In order to satisfy EN 12878, the essential tests required are:

Parameter	Test method	Comment	Compliant
Setting time	EN 196-3	Tested to ensure the biochar does not significantly accelerate or retard the hydration of the cement	✓
Compressive strength	EN 196-1	A key parameter where the addition of pigment or biochar must not reduce the concrete's strength by more than 8%, for reinforced concrete	✓
Water-soluble substances	EN ISO 787-3	Validates the concrete remains chemically stable in the highly alkaline environment of concrete	✓
Soluble chloride	EN ISO 787-13 / ISO 1158	important for reinforced concrete to prevent the internal steel rebar from corroding	✓
Loss on ignition	EN 450-1	Confirms existence of a minimal amount of organic compounds that may impact strength	✓
Moisture content	EN 12570	An important measure that can affect everything from end product strength to workability	✓

Biochar mixes have already been demonstrated to be compliant with all of the above tests. This is crucial, as not only is the new product safe, but it will also be workable and meet the performance requirements of the project.

By anchoring biochar innovation in the rigor of EN 12878, it is an admissible constituent of cementitious materials and can be CE-marked under the Construction Products Regulation, building the foundation of uncompromised structural safety.

06

MEET CLIMATE GOALS WITH LOW-CARBON INCENTIVES

Permanent carbon removals are a critical and complementary solution to avoiding the worst effects of climate change. **The IPCC states that carbon removals are required as part of all modelled scenarios to limit global warming to 2°C or lower by 2100.**[36]

Both emission reductions and high-quality, verified, permanent carbon removals are needed.

In order for these solutions to scale and become an effective tool to fight climate change, clear regulatory or monetary incentives are required.

Incentives for the benefits and credits of carbon removals can show up in 3 ways:

- **The voluntary carbon market, further regulated by the CRCF**
- **LCA calculations of specific products, recorded in Environmental Product Declarations**
- **Green building codes that promote sustainable solutions**

Additionally, it is critical that the removals calculated are accurate, transparent, tracked, and consistent across the project developers. In Europe, regulations help align calculation rules for products, and registries are used to track the removal. This will be even more essential when the EU's Emission Trading System (ETS) is fully implemented.

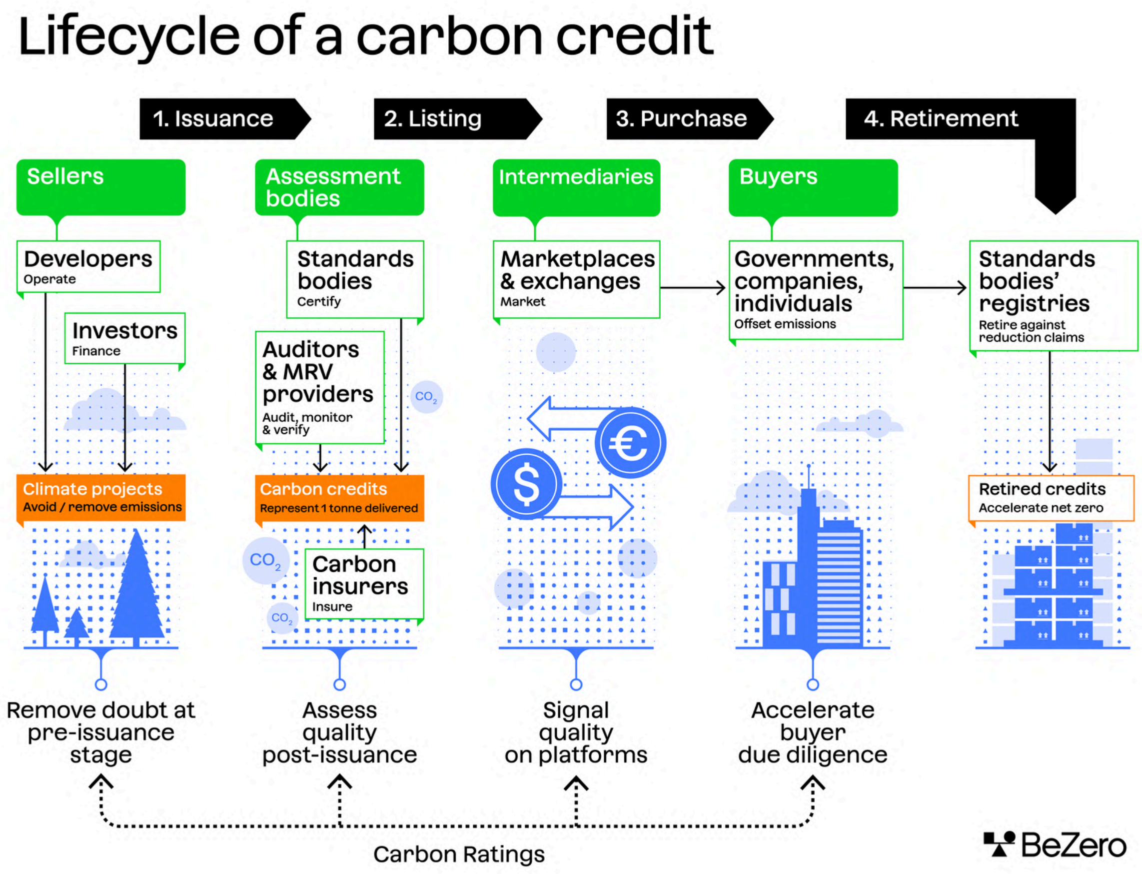
[36] Intergovernmental Panel on Climate Change. (2022). IPCC AR6 WGIII CDR Factsheet. https://www.ipcc.ch/report/ar6/wg3/downloads/outreach/IPCC_AR6_WGIII_Factsheet_CDR.pdf

6.1 Carbon Credit Trading on the Voluntary Carbon Market

The voluntary carbon market (VCM) acts as a catalytic financial engine for scaling carbon removal technologies.

By signaling long-term demand through offtake agreements, VCM buyers provide the price certainty required for developers to secure project financing and build industrial-scale pyrolysis plants. For the construction sector, this demand is transformative. It covers the green premium, allowing biochar to compete with traditional, high-carbon additives.

The VCM has a robust ecosystem ensuring the validity and transparency of carbon removal projects, including independent, third-party standards bodies, auditors, and insurers. The credit is typically registered on an exchange that ensures the credit is never double counted.



A carbon credit requires an entire ecosystem to ensure the removal was produced safely, effectively, and is additional to a baseline. From "[Climate projects and carbon credits: climate action, today]" by BeZero Carbon and used with their permission.

The growing acceptance of biochar in the construction industry is reflected in the new, dedicated methodologies established by several standards bodies.

Methodology	Detail	Link for More Info
Isometric	Released their "Biochar Storage in the Built Environment" standard in August 2025, that allows for credit durability of 1,000 years.	https://registry.isometric.com/module/biochar-storage-built-environment/1.0
Carbon Standards International	Released their Global Construction C-Sink Standard for various CDR solutions in the built environment. This also references their Global Biochar C-Sink Standard for specifics of biochar projects.	https://www.carbon-standards.com/en/standards/service-501~global-biochar-c-sink.html https://www.carbon-standards.com/en/standards/service-538~global-construction-c-sink.html
Rainbow	Their "Biomass carbon removal and storage" methodology was released Jan 2026, and explicitly calls out the use of biochar in construction as a permanent solution.	https://docs.rainbowstandard.io/methodologies/biomass-carbon-removal-and-storage-bicrs
Puro.earth	Their Biochar Carbon Removal methodology specifically calls out biochar used in concrete, and states that these removals have a very low risk of reversal.	https://puro.earth/biochar

Additional carbon removal credit methodologies do exist, and each have their pros and cons depending on buyer confidence, ease of access, jurisdiction, fees, and more. Project developers should consider these prior to choosing a methodology and may look for expert services to refine the path forward.

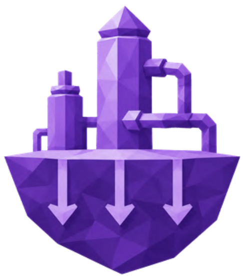
The integration of biochar into construction materials represents one of the most scalable solutions for global decarbonization. By utilizing the voluntary carbon market, project developers can bridge the gap between high-cost innovation and industrial-scale adoption.

6.2 EU's Landmark Carbon Removal Certification Framework

The EU's Carbon Removals and Carbon Farming (CRCF) Regulation[37] represents a pivotal shift in how the construction industry can valorize its sustainability efforts. By building consensus and establishing rigorous quality criteria, **the CRCF provides the clear market signal that biochar-based removals are safe, effective, and scientifically robust.** This framework is instrumental in addressing greenwashing, thereby unlocking high-value carbon credits for operators who can demonstrate compliance with the EU's permanent carbon removal standards.

The CRCF has three pillars: permanent carbon removal, carbon storage in products, and carbon farming. BCR is classified under the permanent carbon removal methodology, rather than within carbon storage in products. This is a crucial distinction for construction projects: while the broader regulation allows for temporary carbon storage in products, **the CRCF methodology recognizes that the stable fraction of biochar persists for at least several centuries.** Currently, for construction, eligibility is strictly limited to biochar incorporated into cement, concrete, or asphalt. Due to end-of-life scenarios, other construction materials are not currently considered permanent removals.

Carbon Removal and Carbon Farming Framework



Permanent Carbon Removal

Provides standard requirements for industrial technologies like DACCS and BioCCS and BCR, that capture CO2 and store it permanently

Carbon Storage in Products

Focuses on methods to store carbon in products that are inherently more temporary, like the use of timber or agricultural fibers

Carbon Farming

Establishes a framework for certifying various land-based activities that enhance carbon sequestration in soils and biomass or reduce emissions from agricultural practices

Biochar in cement, concrete, asphalt

The three major buckets of carbon accounting in the CRCF are permanent carbon removal, carbon storage in products, and carbon farming.

[37] European Commission. (2026, February 3). Commission delegated regulation (EU) supplementing Regulation (EU) 2024/3012 of the European Parliament and of the Council by establishing the certification methodologies for permanent carbon removals. (2026, final). https://climate.ec.europa.eu/document/download/96845e08-0311-45b4-b6c0-7040e31d9cd0_en?filename=C_2026_553_1_EN_ACT_part1_v5.pdf

To turn sequestered carbon into tradable units, the CRCF requires a precise calculation of the net carbon removal benefit. The most critical variable for construction projects is the permanence fraction, F_{perm}, which accounts for the long-term stability of the carbon. This is determined through either a random reflectance assessment using microscopy or a decay function based on the biochar's H/C_{org} ratio.

By establishing these rigorous, science-based benchmarks, **the CRCF transforms biochar from an experimental additive into a verified option to fight climate change for the European construction sector**. New projects should feel certain that using biochar scales low-carbon infrastructure and aligns the building industry with the EU's 2050 net zero goal.

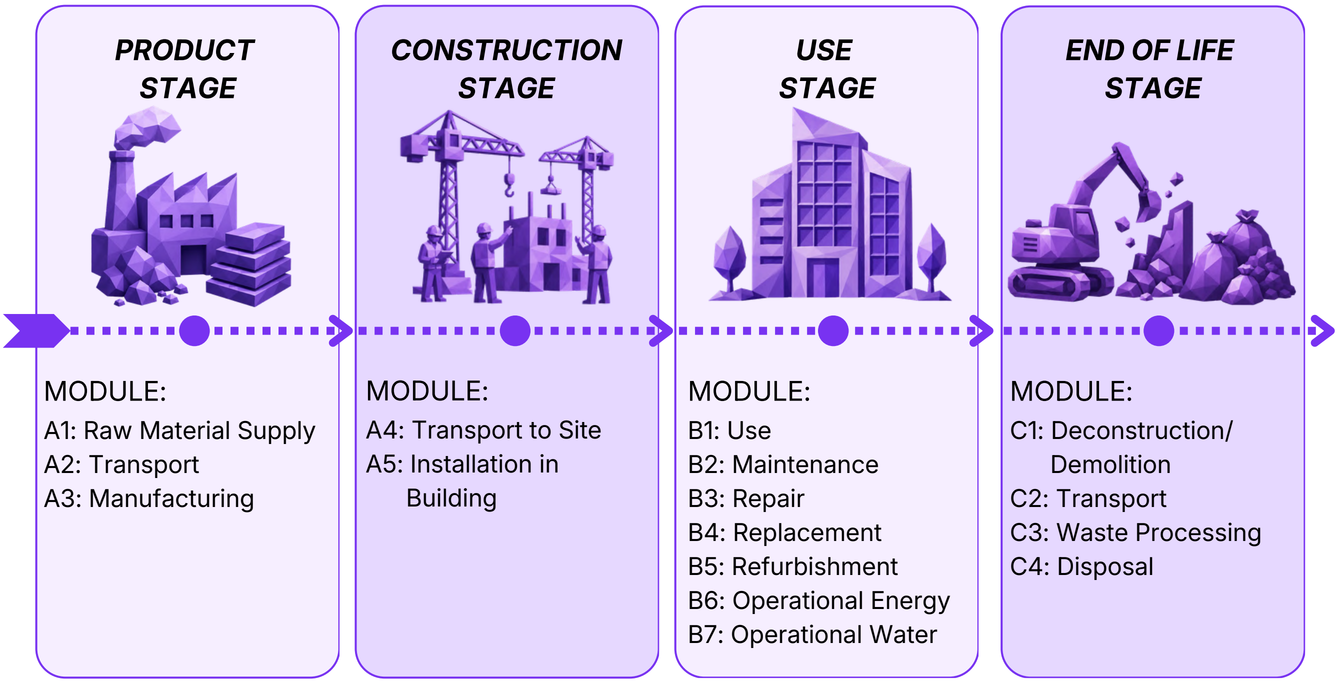
6.3 Today's Gap between Removals and Environmental Product Declarations

As of 2026, all construction products in the EU are required to produce verified Environmental Product Declarations (EPDs) to differentiate the carbon footprint of various construction materials.

EPDs are standardized, third-party verified documents that communicate the global warming potential (GWP) of products, based on rigorous life cycle assessments (LCAs).

It is important to note that while the EPD is a document that communicates the embodied carbon or GWP of a product, **EPDs are not sufficient to generate carbon removal credits, as a registry and tracking technology must be used to confirm every ton of removed CO2** claimed for a particular project was delivered and properly assigned.

In the EU, EN 15804+A2 harmonizes GWP calculations across distinct modules: A1–A3 (Production), A4-A5 (Construction), B1–B7 (Use), and C1–C4 (End-of-life). This modularity allows professionals to aggregate data for an assessment of the whole building.



Life cycle stages according to EN 15804.

Currently, the standard treats removals differently based on their source.

- Fossil Sources are treated as permanent and allowed as a negative impact (-1) in Module A. An example is carbonation, where concrete chemically reabsorbs CO_2 over time.
- Biogenic Sources are conventionally treated as temporary. Carbon is recorded as a removal (-1) in the manufacturing stage (A1–A3) but must be recorded as a re-release (+1) at end-of-life (Module C).

Scientific consensus and the standards reviewed like CRCF and those from the VCM agree that biochar removals in concrete and asphalt are permanent. However, the EPD standards like EN 15804 have yet to catch up to the science.

The EN 15804 standard was designed with raw biomass, such as timber, in mind. Because timber eventually degrades, the standard mandates that effects of permanent biogenic carbon storage shall not be included in GWP calculations for the entire life-cycle.

However, biochar defies this logic. Unlike timber, biochar is a highly stable, permanent carbon sink. When embedded in concrete or asphalt, that carbon remains sequestered even if the material is recycled or landfilled at end-of-life.

For now, companies should follow current regulations of the EN-15804 standard, requiring that removals from biochar be included in Module A, but released in Module C. **Groups like Biochar Europe (BCE) and our member companies are working actively to correct this misalignment between the standard and science.**

6.4 How Building Codes Accelerate Decarbonization

Green building codes are structured frameworks designed to evaluate and certify the environmental performance of a building throughout its lifecycle. They can additionally influence the bidding cycle by providing verifiable climate benefits. **Adding carbon removal elements especially biochar technology to green building codes would have significant impacts to the development and use of more climate-friendly materials.**

The codes range from mandatory national regulations (such as France's RE2020) to voluntary but highly influential labels like DGNB (Germany), BREEAM (UK/EU), Minergie (Switzerland), and LEED.

Though most often voluntary, these standards can be required in two main cases:

- Where specific national or local laws, often in more dense urban areas, make certification a condition for planning permission or land sales
- For developers to comply with EU Taxonomy reporting to secure green financing, or lower interest rates

Though these cover a wide range of topics, like energy efficiency and renewable energy, they are recently including topics like embodied carbon and carbon removals, as these technologies are becoming more prominent.

Building Code	Date of CDR Inclusion	Handling of Carbon Removals for Embodied Carbon
DGNB	Aug 2025	Recognizes biogenic carbon storage and permanent removals through its "Climate Positive" award. It uses the EU Taxonomy framework to allow "negative emissions" from materials to offset the building's initial carbon debt.
LEED v5	Early 2025	Introduces a dedicated "Reduce Embodied Carbon" credit rewarding "Engineered Carbon Removals" and bio-based materials, using EPDs to verify the carbon sequestered in the product during manufacturing.
BREEAM V7	Sep 2025	Shifts to a Whole-Life Carbon (WLC) assessment model. It allows for the inclusion of biogenic carbon storage in materials (Modules A1-A3) within the LCA, favoring permanent sinks, like biochar, over temporary offsets to achieve "Outstanding" ratings.
Minergie	2023-2024	Projects using bio-based or biochar-infused materials receive credits in the "Building Ecology" module, helping the project reach net-zero for both operation and construction.
RE2020	Jan 2022	A national requirement in France – this uses Dynamic Life Cycle Assessment (dLCA) to apply a higher weight to carbon sequestered at the beginning of the building's life, making biochar highly advantageous for meeting strict national carbon caps.
Nordic Swan	2023-2024	Focuses on circularity and renewable materials. It sets strict thresholds for embodied carbon and provides bonus points for materials that demonstrate high biogenic carbon content, effectively incentivizing biochar-based additives.

Of these building codes, it is important to note that, as of 2026, Minergie's Netto-Null standard allows for the full deduction of the permanent CO_2 removals from biochar as well as compensating for residual emissions through certified biochar projects outside the building's scope. However, in order to take advantage of the removal benefits, buildings need to meet the highest efficiency standards, ensuring that carbon reductions are a required first step. Biochar Europe encourages more standards to take this type of approach.

Green building codes have moved beyond mere energy efficiency to focus on the entire life cycle of the materials being used. This focus is further underscored by the CRCF, which officially recognizes BCR as a permanent carbon sink. This regulatory shift confirms biochar as a premier, sustainable solution for decarbonizing the building sector.

07

LANDMARK PROJECTS ARE THE BLUEPRINTS FOR CHANGE

The integration of biochar in the built environment is no longer theoretical. Across the EU, **forward-thinking developers are successfully deploying biochar-enhanced concrete and asphalt, proving their viability as a tool to slash embodied carbon,** and in some cases, achieve carbon neutrality. Biochar-concrete mixes maintain strict workability standards and are effective across pumpable ready-mixes, pre-cast elements, and advanced techniques like slip-forming.

The following use cases represent a curated sampling of landmark EU projects, providing empirical proof that high-performance, low-carbon infrastructure is possible now.

7.1 Apartment Complex De Nieuwe Defensie Utrecht, Netherlands

A new sustainable residential area, "De Nieuwe Defensie," is being built just minutes from the historic city center in Utrecht, Netherlands. ERA Contour is handling the construction of the 150-unit apartment building, and are using a precast concrete product from Voorbij Prefab, with Clim@Add® from CarStorCon® Technologies, as interior walls. In the first phase of construction, 275m^3 of the concrete was used, permanently removing 30 tons of CO_2.

One of the pre-cast wall elements used in the building. Image used by permission of Voorbij Prefab

Construction ongoing at the apartment complex in Utrecht, Netherlands. Image used by permission of Voorbij Prefab.

7.2 Reduced Carbon Concrete Walls in Kemnath, Germany

In an innovative collaboration, the construction company MARKGRAF partnered with ecoLocked to construct a new training and education center in Kemnath, Germany, integrating carbon-storing biochar into precast concrete walls.

A total of 5,3 tonnes of ecoLocked’s eLM Zero were incorporated as precast elements in the building's non-load-bearing partition walls. This application effectively stored 10,7 tonnes of CO_2 while also positively influencing the early strength development of the precast concrete elements. Ultimately, by turning local biomass residues into a permanent carbon sink, the project reduced the overall carbon footprint of the affected prefabricated components by more than 60%.

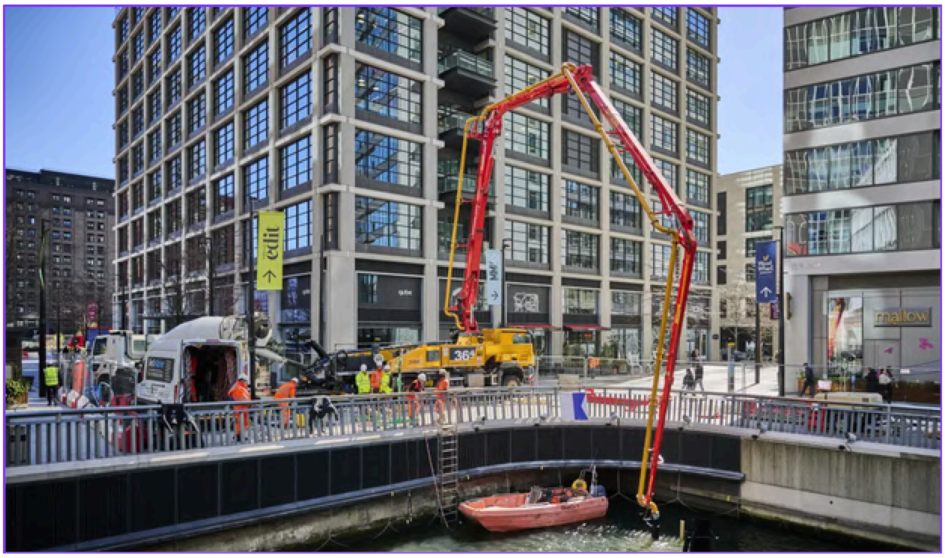
Biochar-concrete precast walls are assembled into a holding structure of a new training and education center in Kanmath, Germany. Image used by permission of ecoLocked.

Concrete-biochar mix is being poured over a rebar form to create a precast wall element. Image used by permission of ecoLocked.

7.3 The Whale on the Wharf in London, UK

Holcim UK, Canary Wharf Group, along with Holcim's Innovation team in Lyon, collaborated to develop an innovative biochar concrete mix to serve as the underwater foundation for StudioKCA's 12-meter high blue whale sculpture, "The Whale on the Wharf" in London.

The bespoke mix utilized biochar derived from fast-growing UK hardwoods and spent coffee grounds collected from local cafes, securely trapping carbon that would otherwise decompose and release greenhouse gases into the atmosphere. 32 cubic meters of the concrete-biochar mix were pumped beneath the water's surface to anchor the installation. Ultimately, this circular construction method achieved a projected net GWP as low as 69 kg CO_2e/m^3 (A1-A3), representing a total carbon reduction of about 79%.



32m3 of pumpable biochar-concrete laid the foundation for "The Whale on the Wharf" sculpture. Image used by permission of Holcim.

"The Whale on the Wharf" is a showcase sculpture at Canary Wharf, highlighting the global issue of plastic waste. The foundation was made with a biochar-concrete mix with a 79% reduction of embodied carbon. Photo by and used from permission of Canary Wharf Group.

7.4 Climate-Friendly Energy Plant in Dornbirn Wallenmahd, Austria

CO_2 is being permanently removed across a variety of concrete parts at the new construction of a modern heating plant in Dornbirn Wallenmahd. Project Developer EnergieWerk Ilg already prioritized sustainability during the construction phase, storing 164 tons of CO_2 in a total of over 4.300 m3 3 of concrete. From pile supports to walls to stairs and columns were all built with Cilm@Add® from CarStorCon® Technologies. In the foundation, the biochar-concrete mixes were demonstrated to be pumpable, and more remarkable, the material was used in the walls that were built with an innovative slip form technology, proving the drop-in nature of the biochar additive Clim@Add®.

A biochar-concrete mix is being pumped to build the foundation of the new energy plant at Wallenmahd. Image used by permission of CarStorCon® Technologies.

A biochar-concrete mix is being used in a slipform construction, marking the first time in the world this has been accomplished. Image used by permission of CarStorCon® Technologies.

7.5 A NetZero Foundation at Johanniskirche

In Eberswalde, Germany, a unique construction project is bridging historic architecture with future-ready climate solutions. Partnering with Berger Holding SE in Spring 2026, ecoLocked introduced its carbon-neutral technology to the construction of a modern extension building for the landmark Johanniskirche church.

By infusing biochar into the building's most critical structural components, including the exterior walls, interior columns, and load-bearing reinforced beams, the concrete achieved a 100% net carbon footprint reduction.

Currently under construction, this extension serves as a permanent, physical vault that safely traps more than 30 tonnes of atmospheric carbon dioxide directly inside its structural framework.

The new, net zero foundation of Johanneskirche as it is being poured. Imaged provided by permission of ecoLocked.

Biochar concrete is being poured at Johanniskirche. Image used by permission of ecoLocked.

7.6 Gieseke GmbH realises CO2-neutral asphalt pilot in Duisburg, Germany

By using a thinner construction, a high percentage of recycled materials, and a low mix temperature, Gieseke was able to drastically reduce the carbon footprint of their asphalt. For the hard-to-abate emissions that were unable to be avoided, they worked with CarStorCon® Technologies to utilize biochar to remove the residual CO_2, making the project climate neutral overall. Of the 4.464m2 of asphalt used, 30 tons of CO_2 were safely, and permanently stored.

Carbon neutral asphalt is being laid by Gieseke GmbHImage used by permission of Gieseke GmbH.

08

POLICY CHANGES TO SCALE LOW-CARBON BUILDINGS

The details in this paper show not a vision for the future, but a documented, operational, certified pathway for projects to happen today.

The road forward is one of methodological alignment and the eventual consolidation of a dedicated standard. The horizons below are sequential, not alternative.

Caption: Precast concrete walls made with biochar admix from ecoLocked are being installed in Kemnath, Germany with construction and engineering company Markgraf. Image used by permission of ecoLocked GmbH.

Today — Operational

Pathway: EN 12878 pigment route (CE-mark under CPR 305/2011) + PCR 2019:14 v2.0.1 EPD reporting + CRCF certification.

Current Status: *This path is documented and verified, able to be adopted by any manufacturer or producer.*

2027–2029 — Better Regulatory Alignment

Demand: Revision of EN 15804+A2 to recognise permanent biogenic carbon in concrete and asphalt as a permanent sink to align with scientific consensus and the CRCF.

Why: *Methodological alignment will bring additional value for the construction ecosystem to integrate removals from biochar into their projects, aiding efforts needed for removals to combat global warming.*

2030+ — Verified, Safe, and Transparent Scale

Demand: A dedicated European standard for biochar in building materials that covers material specification, test methods, permanence verification, and harmonised EPD reporting across major norms, such as EN 15804, EN 206, EN 197-1, and EN 13108.

Why: *A single, harmonised standard will accelerate scale, reduce certification cost, and prevent national fragmentation*

09

CONCLUSION AND ACTION

Biochar can play a major role in the decarbonization of the built environment and aid in actively removing CO_2 from the atmosphere, reducing rates of global warming. A depth of research, deployed products, and successful projects exist to prove the maturity of this technology. It is only a matter of awareness and adoption to further scale and have a positive impact across the EU.

Biochar can replace cement (emission reductions) or be added as a sink (carbon removals) to concrete mixes	**The CRCF has already recognized biochar in concrete and asphalt as a safe and permanent CO2 removal solution with low risk of reversal**
Biochar-concrete mixes have been created that meet workability requirements and improve on technical performance	**Clear regulatory pathways exist to safely integrate biochar, though more policy work is needed to fully realize the climate benefits**

With standards and frameworks increasingly aligning on how to demonstrate permanent carbon sinks, the path is clear for deploying biochar at scale today.

So, what can you do?

Construction Companies and Architects	Reduce embodied carbon in your next project by implementing a biochar solution. Concrete and cement companies already have products that are ready for your building.
Concrete and Cement Producers	Work with biochar producers to build the capacity needed to scale this already validated solution
Policy makers	Work with the TC 350 Working Group to align EN15804 with the CRCF to allow for permanent removals from biochar in construction materials Help Biochar Europe develop biochar-specific standards within EN 206 and EN13108 Incentivize the use of carbon-sequestering materials by mandating that verified storage metrics that are aligned with the CRCF receive significantly higher weight in building codes and public infrastructure tenders
Biochar producers	Create EPDs with biochar, aligned with industry standards, that help drive adoption further down the value chain Collaborate to ensure market trust by building best practices and consistency in carbon accounting and product quality

Join Biochar Europe today and be involved in the changes needed to build a sustainable, clean, and safe environment for all.

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BIOCHAR EUROPE

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