CEPS EXPLAINER

RETHINKING MATERIALS, RETHINKING CARBON: HOW THE EU CAN BUILD BETTER TO ACHIEVE CLIMATE NEUTRALITY

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SUMMARY

The role of carbon removals in climate policy is becoming more important as countries move towards achieving their net-zero emissions targets under the Paris Agreement. Greater mitigation efforts are indispensable on the way to net-zero and in many parts of the world, low-carbon technologies are being rolled out. Yet scientific consensus increasingly shows that the UNFCCC's ultimate objective, 'to stabilize greenhouse gas concentrations in the atmosphere at a level that will prevent dangerous human interference with the climate system', can only be met by actively taking carbon out of the atmosphere, i.e. carbon removals.

Carbon removals are seen as essential not only for achieving long-term net-zero targets but also for compensating residual emissions in hard-to-abate sectors. A range of carbon removal approaches are being pursued, including nature-based and technological solutions. Carbon storage in buildings, stemming from upstream removals, is emerging as one such technological solution.

As this CEPS Explainer highlights, buildings can act as long-lived carbon storage units, especially when carbon-storing materials like timber, bio-based products and CO2-cured concrete are used, which are then further enhanced by design choices that extend product lifetimes and reuse cycles. By shifting towards carbon-storing materials, the built environment could store gigatons of CO2 while addressing urban development needs, though its actual contribution to net carbon removals remains uncertain.

The EU has now established a certification framework for high-quality removals, the EU Carbon Removals and Carbon Farming Certification (CRCF) Regulation, which explicitly recognises long-term biogenic carbon storage in buildings. This is a step towards harmonising standards for durable removals, including those related to the built environment.

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Introduction

The buildings sector is one of the EU's most resource- and carbon-intensive sectors, accounting for over a third of energy-related emissions. To meet the EU's 2050 climate neutrality target, the EU's building stock should be transformed into a net-zero emissions building stock. Yet the built environment's decarbonisation pathway is currently fragmented and uncertain, complicated by hard-to-abate materials, the long lifespans of existing stock and slow renovation rates.

Simultaneously, there's a need to provide affordable housing across many EU Member States. Governments are exploring policies to provide affordable housing while still cutting emissions. To avoid locking in carbon-intensive construction practices, emissions from entirely new buildings and renovations need to be reduced now – and not later.

Globally, rising prosperity and increased levels of urbanisation are set to drive a surge in the demand for buildings (new and renovated old) and with it, a rise in materials that would dominate the sector's carbon footprint, including cement, concrete and steel. According to the Intergovernmental Panel on Climate Change (IPCC), buildings are currently responsible for 31 % of global CO2 emissions, with 18 % being embodied emissions. This also provides an opportunity for the EU to lead by example, demonstrating how climate goals can be achieved while still supporting housing needs, by embedding decarbonisation, circularity, material efficiency and sufficiency into its overall built environment strategy.

These challenges are occurring against the backdrop of a broader shift in climate policy, where global mitigation efforts increasingly recognise that deep greenhouse gas (GHG) emission reductions alone won't be sufficient to achieve climate neutrality. Global efforts to mitigate GHG emissions across a wide range of sectors are accelerating and low-carbon technologies are being deployed. As these efforts aren't advancing quickly enough, there's a need to compensate for unavoidable/residual emissions. This means that the role of carbon removals – sometimes referred to as 'negative emissions technologies' – is being increasingly acknowledged.

There's a growing consensus that reaching net-zero will require carbon removals, i.e. actively taking carbon out of the atmosphere. Removals would address overshoot and would be necessary for balancing out residual emissions from sectors that are considered 'hard-to-abate', such as agriculture and food, aviation, maritime and certain energy-intensive industries such as cement, chemicals, non-ferrous metals, and iron and steel.

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The IPCC's assessment of pathways that limit global warming has also confirmed this. Its 2018 Special Report on 1.5°C showed that even the most ambitious mitigation scenarios require some level of carbon dioxide removal (CDR) to compensate for residual emissions that are difficult to eliminate completely. In 1.5°C pathways with none or limited overshoot, cumulative CDR deployment will range from roughly 260 to 1 030 gigatonnes of CO_2 ($GtCO_2$) by 2100. Depending on global ambition, the role of removals will thus vary in terms of its scope and type.

The IPCC's 6th assessment report reinforces this message. It emphasises that removals play a dual role – balancing unavoidable emissions in the near term and helping to reduce atmospheric CO2 concentrations in the long term.

To support policymaking, the IPCC is developing a Methodology Report on carbon dioxide removal technologies and carbon capture utilisation and storage to provide detailed methodologies on how to remove GHG from the atmosphere.

THE EU POLICY FRAMEWORK AT A GLANCE

The EU's approach to carbon removals is rapidly evolving. Article 2 of the 2021 Climate Law sets the aim to achieve negative emissions after 2050. Under the revised LULUCF (Land Use, Land-Use Change, and Forestry) Regulation[1], the EU aims to increase its net carbon sink to 310 megatonnes of CO_2 equivalent ($MtCO_2e$) by 2030, contributing to the overall 2030 climate target set under the Fit for 55 package. The contribution of carbon dioxide removals has been limited to a maximum of 225 $MtCO_2e$.

Meanwhile, the 2040 Target Communication from 2024 recommends a target of 90 % net GHG emissions reduction compared to 1990 levels. The Communication also suggests that removals from land-based sectors (such as agriculture) and industry should contribute up to 400 $MtCO_2$. It stresses that industrial carbon removals would complement land-based carbon removals in biomass (rather than replace them) and should be used for unavoidable emissions.

[1] The LULUCF Regulation sets rules for how Member States account for emissions and removals from land use, which includes forests, soils, wetlands and harvested wood products. It establishes binding targets to maintain and enhance the EU's land-based carbon sink.

The final 2040 climate target and the role of carbon removals are still being negotiated, with the latest Communication from July 2025 including a reflection on the role of domestic removals under the EU ETS.

The EU's Industrial Carbon Management Strategy, also from 2024, outlines a framework to scale up carbon capture, transport and storage infrastructure, and also calls for permanent removals. For later, it will be crucial to create a more integrated framework and – ultimately – a single market for carbon as a commodity for storage or use. Of course, the precondition for any kind of removals strategy would be a commitment to high environmental integrity.

Such a framework for high environmental integrity has been developed in more detail through the 2024 Carbon Removals and Carbon Farming Certification (CRCF) Regulation, a voluntary framework for certifying high-quality carbon removals. It avoids, for example, double counting, ensures that removals go beyond simply 'business as usual' and prevent claims of removals that are unreliable, hard to verify or non-permanent.

Consequently, the CRCF establishes standardised rules for certifying different types of CDR activities, covering both the nature-based and technology-based options by introducing four criteria, known as the QU.A.L.ITY criteria:

1) Quantifying where removals must be measured in an accurate, transparent and consistent way.
2) Additionality, where the activity goes beyond requirements and 'business as usual'.
3) Long-term storage, where removals must ensure that carbon storage is permanent or geared towards storing carbon long-term while minimising the risk of reversal.
4) Sustainability, where activities don't significantly harm the environment and – where possible – deliver co-benefits such as biodiversity protection, soil health or contributing to the circular economy.

Carbon storage in long-lasting products is explicitly recognised as a certified category if it meets the QU.A.L.ITY criteria. This covers practices and processes that capture and store atmospheric or biogenic carbon for at least 35 years in long-lasting products, including construction materials used for buildings.

For certification, the framework also foresees 'robust' monitoring, reporting and verification methodologies for each of the CDR technologies. The first methodologies were adopted at the end of 2025 through implementing regulations.

The European Commission is being supported by an Expert Group on Carbon Removals, which consists of a broad group of stakeholders who advise on developing tailored certification methodologies. The group has had meetings on different types of CDR technologies, themed by permanent removals, carbon farming and carbon storage in buildings. For monitoring removals, an EU registry is also being established to ensure public accessibility and transparency to the certification process.

The revised Energy Performance of Buildings Directive (EPBD) requires Member States to address carbon removals associated with carbon storage in or on buildings. It also allows for indicators on carbon removals in buildings being included through energy performance certificates. Draft National Building Renovation Plans, which every Member State must submit by 31 December 2025, should also detail if and how carbon removals are adopted by the construction sector.

CARBON STORAGE IN BUILDINGS

To date, the EU has been focusing on decarbonising its building stock to help it to eventually reach net-zero by 2050. Policies like the EPBD or the Energy Efficiency Directive (EED) have successfully reduced emissions by contributing to the EU's 37 % reduction in emissions since 1990. Most of this action focused on so-called operational emissions and on technologies such as heat pumps, district heating and improved insulation for buildings.

With the EPBD's latest revision, however, a major shift has started. While the previous focus was on addressing only operational emissions, it has now switched to a whole-life carbon approach, which includes embodied emissions (i.e. emissions embodied in materials).

The Commission has now presented a package introducing guidelines for national roadmaps with limit values for new buildings. Limit values are the maximum allowable levels of emissions that a building may produce over its life cycle and Member States need to set these values for new buildings by 2027. They apply across the whole life cycle of buildings, thus complementing the move from operational to embodied emissions by providing a concrete regulatory framework for Member States.

The embodied emissions in building materials such as cement, concrete and steel have a large carbon footprint. This means that dealing with them requires additional policies and tools to those that focus on operational emissions. Existing mitigation options, including efficiency and circularity, have inherent limits when it comes to global supply chains and a building's full life cycle.

WHILE THE BUILT ENVIRONMENT CURRENTLY REPRESENTS A LARGE SHARE OF APPROXIMATELY 39 % OF GLOBAL EMISSIONS, IT CAN ALSO POTENTIALLY BE USED AS A CARBON SINK AND, IMPORTANTLY, FOR 50 TO 100 YEARS – OR MORE.

While using bio-based construction materials or other CO2-negative options[2] can lower embodied emissions, their climate benefits haven't yet been fully captured in conventional life-cycle assessments. While the built environment currently represents a large share of approximately 39 % of global emissions, it can also potentially be used as a carbon sink and, importantly, for 50 to 100 years – or more. The revised EPBD lays the groundwork by requiring whole-life carbon assessment and limit values, allowing for the growth of incentives for low- and negative-carbon building materials.

Given the massive – and still growing – worldwide demand for construction materials, the buildings sector will need to become a significant carbon sink, alongside natural systems such as forests and oceans. Unlocking this potential will require not just technological progress but also robust policies. In the EU, this means further aligning EU policies and regulation with innovation and funding.

NEW AND INNOVATIVE MITIGATION OPTIONS FOR BUILDING MATERIALS

The IPCC has identified several measures that can further reduce emissions coming from cement and concrete, from carbon capture and storage to switching to low carbon fuels but also using cement and clinker more efficiently. The built environment can also act as a carbon sink by integrating materials and processes that store carbon. The IPCC has noted that carbon stored in buildings is less vulnerable and has a longer storage time than carbon stored in vegetation or soil carbon sequestration.

Substituting construction materials with biobased alternatives can already be scaled up. Switching from mineral-based (brick and concrete) to biomass-based materials could reduce carbon emissions from the production phase and increase carbon storage during the building's lifetime. Storage potential depends on the type of material used and which part of the building is replaced (ceiling, wall or roof). Materials such as wood fibre, hemp, straw and wool can be used as insulation, as their thermal performance is similar to conventional insulation materials. Atmospheric carbon capture takes place when the materials are physically grown, which is then stored in the building over its lifetime.

[2] Options to reduce buildings' carbon footprint via CDR include biobased construction materials (e.g. wood, bamboo or hemp), using biochar in construction materials (as an additive) or by using captured carbon for CO2-cured concrete.

Stakeholders, including scientists, have raised concerns about the sustainability of increased wood use in construction, arguing that extensive logging in countries such as Austria, Sweden and Finland has weakened forests as carbon sinks. They've also argued that storing biomass in buildings doesn't necessarily enhance removals, as benefits depend on baselines, alternative biomass uses and regional life-cycle contexts.

The net climate effect also depends on whether forest regrowth compensates for immediate carbon losses. Established carbon accounting frameworks already consider timber harvesting's climate impact across all forest carbon stocks, including harvested wood products, with 'stock' being the quantity of carbon held throughout a forest (trees, soil, etc.) at any given moment. To be effective, EU policies will need to ensure that by focusing on end-use storage in products, important stock changes aren't overlooked.

Initially, biobased materials seem to offer more immediate scalable opportunities. To achieve scale, other technologies should be explored, such as solutions that focus on improving mineral-based materials so they can absorb or incorporate carbon.

Table 1 sets out some of the different types of carbon storage methods that are relevant for the built environment, indicating their timescale, whether they are nature-based or technology-based, and how they enhance existing natural processes that remove carbon from the atmosphere or, alternatively, how they use chemical processes.

In the longer term, chemical processes that bind CO2 into new materials could offer greater storage potential and scalability, with the principle being to remove CO2 from the atmosphere and use it as a feedstock for carbon-containing materials. This can be used in closed cycles for a long time, before they end up in final sinks. In theory, such materials could store carbon for decades – or even centuries.

For example, the Swiss Federal Laboratories for Materials Science and Technology (EMPA) is investigating several technologies in this field that have shown promising results for large-scale, durable carbon storage in construction materials. One approach that uses carbon as a feedstock for construction products is mixing biochar with concrete. Biochar, a plant-based charcoal produced through pyrolysis, can negatively impact concrete due to its high absorptivity, but this can be addressed by processing it into pellets. Mixing the pellets with concrete can – depending on the ratio – achieve net-zero emissions concrete, with early research suggesting that the concrete's material strength is not critically affected. Biochar can also be bound to building insulation.

Another emerging technology is based on the cement carbonation process, also known as the 'sponge effect', which currently accounts for an estimated 0.6 to 1 gigatonnes of carbon uptake per year. This process re-binds carbon over the space of many years after the cement is put into place. The rate of carbon uptake can be increased by altering the degree of exposure and the casting method. While the process passively reabsorbs some of the carbon emitted during cement production, it doesn't provide additional carbon removal. This means that carbonation's contribution to global decarbonisation efforts will remain limited.

Building on the same process, circular economy strategies offer ways to actively harness carbonation. CO2, which must first be captured, can be bound to crushed concrete material by flooding the concrete with carbon dioxide, all of which happens in a factory setting. This creates concrete that permanently stores captured carbon while reducing the need for virgin cement.

Technologies such as biochar incorporation and CO2 mineralisation in cement are still mostly in the testing phase, with their carbon removal potential still to be verified. Alas, questions remain regarding the scalability, permanence and the feasibility of commodifying such storage.

THE NEXT STEPS FOR BETTER BUILDINGS

The CRCF Regulation's guidelines include different categories of carbon storage, one being carbon storage in products, defined as any practice or process that captures and stores atmospheric or biogenic carbon for at least 35 years in long-lasting products.

This duration represents a minimum threshold, which means that methodologies (when finalised) may set longer storage periods. Storage is expected to be monitored on-site and certified throughout the monitoring period. At the end of the monitoring period, storage units expire unless the operator commits to prolonging the monitoring period. The development of methodologies for this category is already underway as technological advances continue. The Regulation prioritises methodologies for wood-based and bio-based construction materials.

A next step is to align CRCF methodologies with whole-life carbon reporting, for example under the EPBD, ensuring that embodied carbon accounting includes certified removals. Incentives such as public procurement, funding, liability frameworks or innovation support can also contribute to the scaling-up of bio-based materials in the short to mid-term and carbon-binding materials over the longer term.

A useful tool would be product-level traceability as far as practically possible. It will also be important for carbon accounting to monitor the impacts of biomass use on the LULUCF sink.

To further increase carbon storage in buildings, Member States can begin integrating circular economy principles into their building strategies, for example by extending carbon storage beyond a single building's lifespan.

Conclusions

Buildings are central to the EU's climate transition. Their operational emissions have been a focus of decarbonisation, but embodied emissions are now coming into focus. This opens the door to transforming the built environment into a long-lived carbon sink using carbon-storing materials. This would turn a major source of emissions (a liability) into a carbon sink (a climate asset).

The framework for this shift has already been created. The CRCF Regulation explicitly recognises carbon storage for buildings as a certified storage pathway. Emerging technologies could help reduce the cement and concrete sectors' large carbon footprints alongside existing policies.

Carbon removals in buildings can represent a scalable climate solution, especially if the co-benefits are considered. With the right policy support, in the form of regulatory clarity, financial incentives and standardised and accurate methodologies, the growing ecosystem of innovators, researchers and policymakers could make carbon-storing construction a mainstream element of the EU's climate strategy. This would deliver durable carbon storage alongside sustainable urban development – as well as the affordable housing that so many Europeans are crying out for.

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