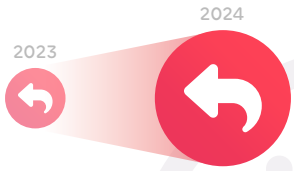
# Carbon Dioxide Removal

## Wrong direction

Carbon Dioxide Removal (CDR) is crucial to compensate for minimal residual emissions. It requires storing carbon in trees and soils and potentially using sustainable technical solutions in the future.

# 4.6 Carbon Dioxide Removal




**Past progress:** The development of Carbon Dioxide Removal (CDR) was still heading in the wrong direction in the period assessed, which means no change to the progress classification of last year. Net removals by natural sinks were decreasing following a declining rate of carbon stored in trees and unreliable data for soils (see 5.2). No large-scale technical removal plants have been deployed in the EU yet. Technical removals are increasingly subject to political attention; however, these technologies are still not mature, and are expensive and associated with substantial risks and trade-offs including high energy needs and pressure on land, water, and biodiversity.

**Policy context:** The EU Climate Law requires that by 2050 total annual removals at least exceed total emissions. The EU's Land Use, Land-Use Change and Forestry (LULUCF) Regulation sets binding EU and national net removal targets for natural CDR. If finalised, the Nature Restoration Law's binding restoration targets for natural sinks should improve forest and soil carbon sequestration and improve adaptability to climate change. The Common Agricultural Policy (CAP) provides financial incentives to sustainably manage forests and soils. The proposed soil and forest monitoring laws aim to improve data availability and quality. The Union certification framework for permanent carbon removals, carbon farming and carbon storage in products, the Certification Framework for Carbon Removals (CFCR), aims at encouraging uptake of both natural and technical CDR. The EC's Industrial Carbon Management Strategy seeks to incentivise technical CDR investments, outlining actions that should complement other existing policies.

**Areas of action:** For natural CDR, there is an urgent need to increase the quantity and health of forest coverage, as well as ecosystem restoration and sustainable management of forests and soils. Good data is a prerequisite for any certification or assessment of implemented subsidies, and to monitor natural CDR. To secure the deployment of sustainable technical CDR post-2030, progress should be made towards R&D funding and a greater focus should be placed on full lifecycle impacts. A legal framework must ensure sustainability compliance and long-term financing options. Technical removals should be deployed with coordinated infrastructure provision powered by renewable energy.

**Table 14: Progress on carbon dioxide removals towards the objective and enablers**

| OBJECTIVE | ENABLERS | | |
|---|---|---|---|
| Enhancing natural sinks and delivering on technical removals | Store more carbon in trees | Storing more carbon in soils | Applying technical removals sustainably |

Note: Large circles show the progress classification of this year and small circles the one from last year's progress assessment. Arrows indicate positive or negative changes in classification. See Table 35 for further information.

Source: ©ECNO.

## Table 15: Details on indicators' past progress and required change

| 2023 2024 › | Historical data | | | Required change | |
|---|---|---|---|---|---|
| | Time period | Relative change p.a. | Absolute change p.a. | Benchmark | Absolute change p.a. |
| **OBJECTIVE: Enhancing natural sinks and delivering on technical removals** | | | | | |
| Net removals from LULUCF [Mt $CO_2$e] | 2017–2022 (EEA, 2023b) | -1.4% per year | -3.4 Mt per year | 310 Mt in 2030 (LULUCF Regulation) | 8.3 Mt per year (2022–2030) → **U-turn** |
| Net technical removals [Mt $CO_2$e] | 2018–2023 (CATF 2024) | 0% per year | 0 Mt per year | 5 Mt in 2030 (EC, 2021r) | 0.7 Mt per year (2022–2030) → **n/a** |
| **ENABLER 1: Storing more carbon in trees** | | | | | |
| Growth in forest area [ha/yr] | 2016–2021 (FAO 2024) | -3.7% per year | -7.200 ha per year | n/a | **n/a** |
| Growth of carbon stock in forest land [Mt C/yr] | 2016–2021 (FAO 2024) | -7.2% per year | -5.9 Mt C per year | n/a | n/a |
| **ENABLER 2: Storing more carbon in soils** | | | | | |
| Soil organic carbon in arable land [g C/kg] | 2009, 2018 (JRC ESDAC 2023) | n/a | n/a | n/a | n/a |
| Net $CO_2$ emissions from crop-, grass-, and wetlands [Mt $CO_2$] | 2016–2021 (EEA, 2023b) | -1.4% per year | -0.8 Mt $CO_2$ per year | n/a | n/a |
| **ENABLER 3: Applying technical removals sustainably** | | | | | |
| Attention to technical CDR | n/a | n/a | n/a | n/a | **n/a** |
| Costs of BECCS and DACCS [EUR/ t $CO_2$e] | n/a | n/a | n/a | n/a | **n/a** |

Note: Icons indicate progress classification of this year's progress assessment and coloured lines the change in classification; See Table 35 for further information. n/a indicates that data are not available.

Source: ©ECNO.

## Objective: Enhancing natural sinks and delivering on technical removals

**Indicators:**
- Net removals from LULUCF
- Net technical removals

**Past progress:** Even though net natural removals increased from 230 Mt $CO_2e$ in 2021 to 244 Mt $CO_2e$ in 2022, the 5-year trend line is still pointing in the **wrong direction** and signifies a declining sink. Removals must increase by 8.2 Mt$CO_2e$ each year to reverse the trend and meet the 310 Mt $CO_2e$ net natural removal goal from the EU's LULUCF Regulation (see Table 15). In addition, the EU Climate Law requires that by 2050 total annual removals at least exceed total emissions. No technical options in the EU removed $CO_2$ from the atmosphere on a large scale in the period assessed, meaning that progress was **far too slow** to align with the EC's objective for technical CDR of at least 5 Mt $CO_2e$ in 2030 (EC, 2021r). However, the first Bioenergy with carbon capture and storage (BECCS) plants are under development in Sweden and Denmark (CATF, 2024).

**Policy context:** The LULUCF Regulation sets EU- and Member State-specific natural CDR targets and provides accounting rules. Until 2026, it requires Member States to compensate emissions from land use with at least an equivalent quantity of removals; after that it enforces binding EU and national net removal targets. Still, insufficient attention has been paid to the declining land sink and its resilience. To reach LULUCF targets, it is still possible to trade removals between Member States and use surplus emissions allocations under the Effort Sharing Regulation. The CFCR (EC, 2022i) aims to incentivise removals through voluntary certification. The environmental integrity of this policy strongly depends on the additionality of certified removals and how it ensures long-term storage, the specific rules for which are still under development (Meyer-Ohlendorf et al., 2023). The proposed Net Zero Industry Act includes a target of 50 Mt $CO_2$ injection capacity per year by 2030 (EC, 2023e). The EC's Industrial Carbon Management Strategy (ICMS) promotes technical CDR by outlining upcoming initiatives to support the development of BECCS and Direct air carbon capture and storage (DACCS), with the aim of creating a single market for $CO_2$ (EC, 2024c).

**Areas of action:** The environmental integrity of natural and technical removals must be ensured to enhance carbon sequestration without negative side effects on biodiversity, land and resource use, especially associated with technical CDR (IPCC, 2022b, 2023). This focus on environmental integrity must be respected in policies for incentivising CDR under development, such as ensuring that the CFCR regulation rules deliver robust quantification, additionality, storage, monitoring, and liability. It is crucial to provide support, including public funding and guidance for sustainable natural and technical removal, particularly promoting the growth and restoration of forests and soil organic carbon, while ensuring climate adaptation (see enabler 1 and 2). Technical CDR must demonstrate its positive climate effect and that it does not lead to the use of unsustainable biomass or excessive energy (see enabler 3).

## Enabler 1: Storing more carbon in trees

**Indicators:**
- Growth in forest area
- Growth of carbon stock in forest land

**Past progress:** Forests are the key land solution for removing $CO_2$ from the atmosphere. But progress was still moving in the wrong direction in the assessed period. The carbon stock in forest land was increasing, but at a decreasing rate, from a 119 Mt increase in 2016 to a 73 Mt increase in 2021, with widely varying situations across Member States. The same applies to forest areas, which increased slightly from 181,600 ha in 2020 to 182,300 ha in 2021 but with a declining growth rate of 7,180 ha per year. This suggests a deteriorating ability of the EU's forests to sequester carbon due to temperature effects, natural disturbances worsened by climate change, harvesting practices, and mismanagement (ESABCC, 2024; Hyyrynen et al., 2023). At the same time, current data may not reflect the changes in forest carbon sequestration due to a lack of harmonised monitoring across the EU. For a more detailed analysis of this enabler see also 5.2.

**Policy context:** The LULUCF Regulation target for net removals and the Nature Restoration Law's goal to restore 20% of the EU's land areas by 2030 should improve forest carbon sequestration. The Forestry Strategy (EC, 2021g) lays out a plan to protect existing forests and provide financial incentives to increase forest cover, hence also CDR, including the goal to plant at least 3 billion trees by 2030. The CAP delivers subsidies for afforestation, reforestation, improved forest management, but also prevention of natural disasters and support for forest ecosystem services. The EC (2023c, 2023s, 2023u) provides voluntary guidelines and financial support for forestry measures but has few competencies for imposing binding obligations for carbon sequestration in tree biomass. In addition, the CFCR aims at incentivising forest planting by certifying carbon removals. The proposal for a Forestry Monitoring Law (EC, 2023x) aims to improve knowledge of forests, including by harmonising data from satellites and Member States. The Renewable Energy Directive (RED) strengthens sustainability criteria for forest biomass with new limits on its use for burning.

**Areas of action:** Forest restoration, afforestation, and sustainable forest management needs further promotion and support e.g., by providing guidance that also enhances biodiversity and the resilience of existing forests to climate change. The CAP could better facilitate sustainable forest practices through capacity building to help landowners implement appropriate measures (see e.g., Carbon Gap, 2022). Building on the '3 billion trees' initiative, the EU could consider using degraded or unused lands for the expansion of forests to new areas. In this context, it is important that EU policies on agriculture and bioenergy reflect the necessity to maintain and expand the area of forests for carbon sequestration (ESABCC, 2024). For any certification of forest carbon removals, such as under the CFCR, it is crucial that removals are of high integrity, ensuring quantification, additionality, long-term storage, and liability (Meyer-Ohlendorf et al., 2023). The EU's knowledge and database needs to be improved for forests based on a strong adoption and implementation of the proposed Forest Monitoring Law (EC, 2023ag).

## Enabler 2: Storing more carbon in soils

**Indicators:**

- Soil organic carbon in arable land
- Net $CO_2$ emissions from crop-, grass-, and wetlands

**Past progress:** Healthy soils provide several ecosystem services, including food production, water purification, carbon storage, but also offer potential for additional carbon sequestration (Rodrigues et al., 2021). However, soils are currently a net source of emissions as they are under significant pressures including land cover change, high-intensity land use, and erosion (EEA, 2023h). The concentration of organic carbon in arable land, including both organic soils such as peatlands and the more prevalent mineral soils, decreased slightly by 0.01% between 2009 and 2018 with no more recent data available. Linked to this, croplands, grasslands, and wetlands are still a net source of emissions (63 Mt $CO_2e$), with roughly even shares from each respectively (23, 20, 21 Mt $CO_2e$) (EEA, 2023b), despite wetlands representing only 4% of the land area (Eurostat, 2021). Although net emissions decreased by 1.4% per year between 2016 and 2021, these reductions are far too slow if soils are to positively contribute towards the LULUCF net removal target. It is important to note that data quality for soil carbon storage is poor due to measurement challenges (Bellassen et al., 2022).

**Policy context:** The proposed EU Nature Restoration Law would establish legally binding objectives for Member States to restore agricultural organic soils, including introducing restoration measures on at least 30% of drained peatlands by 2030. The proposal for a Soil Monitoring Law (EC, 2023ad) will introduce a harmonised methodology and rules for monitoring. The CAP provides subsidies for improved soil management via the good agricultural and environmental conditions (GAEC) standard, the 'eco-schemes', and the voluntary agri-environmental-climate measures (EC, 2024n). However, some measures within the CAP indirectly degrade soils by promoting intensive farming practices (Carbon Gap, 2023a).

**Areas of action:** Carbon stored in wetlands, croplands, and grasslands needs to be preserved and restored. Additional support and guidance should be provided to promote the regeneration of soil health and carbon sequestration, also to ensure resilience of ecosystems. The CAP should be improved with stricter conditionality requirements and 'eco-scheme' and agri-environmental-climate incentives that result in increased removals (ECA, 2021; ESABCC, 2024). The inherent risk of reversals of soil organic carbon needs to be acknowledged and a holistic approach to addressing the multiple ecosystem services provided by soils should be taken. It should be a priority to promote the fast adoption and implementation of the Soil Monitoring Law proposal, establishing the knowledge base and ensuring easily accessible and regularly updated data. It is crucial that any certification of soil carbon removals is based on a solid database to ensure 'real' removals.

## Enabler 3: Applying technical removals sustainably

**Indicators:**

- Attention to technical CDR
- Costs of BECCS and DACCS [EUR/ t $CO_2$e]

**Past progress:** Data is limited for checking progress towards enabling technical removals. Yet, technical CDR is increasingly receiving political attention to achieve long-term targets and net-negative emissions thereafter (EC, 2024b). However, it is important to acknowledge the risks and trade-offs with its upscaling regarding high energy needs and pressure on land, water, and biodiversity. Technical CDR is not yet mature, with a few BECCS demonstration plants being built in Scandinavia, and costs are still high. For DACCS, estimates range from USD 400–1,000 (Bednar et al., 2023), decreasing to USD 200–400 by 2050 (Al-Juaied & Whitmore, 2023). The IPCC (2022b) estimates costs of USD 15–400 for BECCS, with the higher end more likely (Bednar et al., 2023). Costs depend on the technology, related resource and energy needs and prices, and costs for transport and storage. They are likely to decrease quicker for DACCS than BECCS as the latter is subject to potential cost increases for land biomass (Fuss et al., 2018). While BECCS and DACCS offer significant $CO_2$ removal potential, other solutions are also being developed and deployed at small scales, such as biochar, with own risks and potentials (Smith et al., 2023).

**Policy context:** The ICMS (EC, 2024c) aims at boosting technical CDR amongst other objectives. It highlights the need for national policies and strategic infrastructure planning at EU level and foresees industrial carbon management to be an 'integral part of EU's economic system' after 2040 and the creation of a single EU market for $CO_2$. For this, the EC plans to increase incentives for investing in CDR across the entire value chain, including the EU CFCR and considering the potential for including CDR in the EU Emissions Trading System (ETS) Directive, which will be assessed by 2026. Additional actions will complement the existing policies including the Carbon Capture and Storage (CCS) Directive as well as already existing funding under Horizon Europe and the Innovation Fund, which both finance technical CDR projects as part of the CCS funding category (Carbon Gap, 2023c, 2024a; EC, 2022g). Regulating technical CDR is picking up speed on a Member State level with 23 Member States having formal CDR strategies in place (Carbon Gap, 2024b) and others, including Germany, additionally having a strategy for long-term negative emissions (BMWK, 2024).

**Areas of action:** To develop the potential of technical removals within the EU and broaden the deployment of technical CDR post-2030, additional funding for research, development, and demonstration (RD&D) is called for. This funding should focus on the sustainable application of CDR, ensuring that the full lifecycle emissions are lower than the $CO_2$ captured, that technical CDR is powered by renewable energy, and that it does not exert pressure on water or food security (IPCC, 2023). Any funding of CDR should require monitoring of these sustainability criteria (see e.g. Carbon Gap, 2024c). Looking forward, a comprehensive legal framework based on the CFCR and the CCS Directive should be set up to incentivise the sustainable deployment of technical CDR in the longer-term. In addition, coordinated and co-operative planning and development of infrastructure such as pipelines and storage sites are needed within and between Member States.