NEGEM

Quantifying and Deploying Responsible Negative Emissions in Climate Resilient Pathways

BIOMASS WITH CARBON CAPTURE AND STORAGE

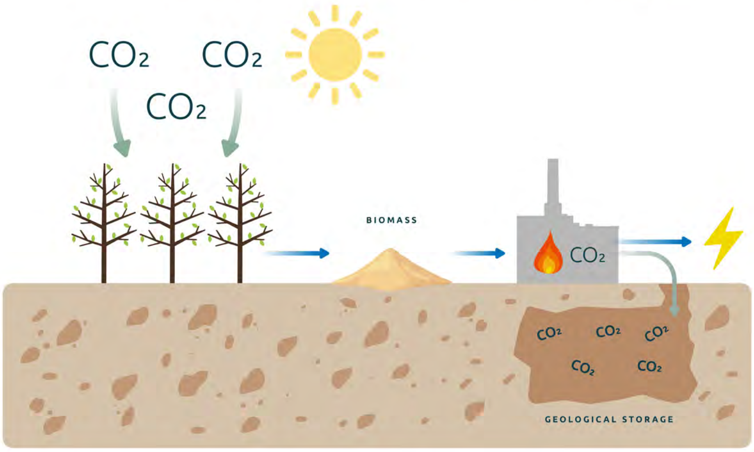
Facts figures and recommendations

In a biomass with carbon capture and storage (**BIO-CCS**) system, growing biomass sequesters CO_2 from the atmosphere; the **biomass** is then converted into **energy,** fuels, or other uses, during which the **CO_2 is captured and stored in permanent geological storages.**

If more CO_2 is stored than is released during each of these steps including all associated supply chains, and indirect impacts on ecosystems and natural sinks, then BIO-CCS can provide carbon dioxide removal (CDR) or **negative emissions.**

BIO-CCS can be applied to different uses of biomass, including electricity and/or heat generation, biogas, biofuel production, bioenergy with carbon capture and storage and non-energy uses, such as pulp and paper production and biorefineries.

SIMPLIFIED SCHEME OF A BIO-CCS SYSTEM



Advantages of BIO-CCS

- BIO-CCS can be applied to **existing point sources** of biogenic CO_2, such as paper mills, ethanol plants, and biomass power/CHP plants.
- The **costs** of BIO-CCS can be **moderate to low** compared to other CDR solutions, particularly when high concentration CO_2 streams are available (e.g., in biorefineries, biogas upgrading units, bioethanol plants).
- BIO-CCS can **contribute to energy security** while removing CO_2. BIO-CCS power, heat, and CHP plants can help to balance the energy system and thus support increased use of intermittent renewables such as wind and solar.
- The storage of CO_2 in geological formations, done correctly, is **permanent**, unlike other biomass-based CDR options, such as afforestation/reforestation, biochar, or soil carbon sequestration.

Challenges of BIO-CCS

- The main challenge of BIO-CCS is to ensure that the biomass–whether from forestry or agriculture—is **sourced sustainably**, in full **compliance with EU and international regulations**, regardless of where it is produced, and without generating indirect land use change or decreasing carbon sinks.
- Since sustainable biomass is limited, it should be used in **resource-efficient** conversion processes, following the **cascading principle** of biomass use.
- BIO-CCS requires a careful **assessment** of its **impacts** on natural resources, ecosystem, biodiversity, nutrient flows, and soil carbon stocks.
- Planning BIO-CCS deployment at scale needs to consider the possible **tradeoffs** with the **planetary boundaries**, and the effects on the whole spectrum of the **Sustainable Development Goals**.

Cost range of different BIO-CCS systems ($/t CO_2-eq)[1]					
Hydrothermal liquefaction	583-1,365	Anaerobic digestion	235-557	Oxy-combustion	155
Gasification-FT	368-524	IGCC	175-364	Combustion	224-266
Fast pyrolysis	404	Chemical looping combustion	171-200	Ethanol fermentation	21-185

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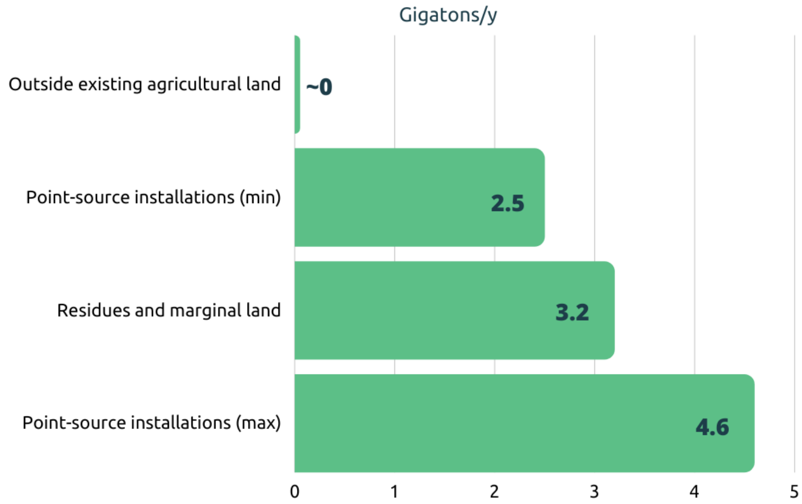
What is the sustainable scale for BIO-CCS deployment globally?

Most of the 1.5° or 2°C compatible scenarios of the IPCC rely on BIO-CSS deployment, with median CDR rates of ~9 Gt CO_2 per year by 2100. These "demand-driven" scenarios varyingly assume that the biomass for BIO-CCS could be produced from energy crops cultivated on natural land, currently unused marginal land, pastures or cropland. They may assume that agricultural land can be dedicated to biomass production due to reductions in land use due to potential global yield increases and/or reduced meat consumption.

In NEGEM, three parallel modelling studies explored different scenarios about the global potential of BIO-CCS. Although the results of these works vary depending on the baseline assumptions and models used, **they all indicate more conservative figures than those expressed by IPCC scenarios.**

BIO-CCS global potential from different NEGEM scenarios*



*Preliminary results

1. A "supply-driven" assessment of the global BIO-CSS potential that excludes further transgression of planetary boundaries and assumes no expansion on current forest areas finds that there is almost no potential for deployment of plantations for BIO-CCS outside existing agricultural areas[2].
2. A second model that assumed the use of both agricultural **residues** and biomass from dedicated energy crops grown on marginal agricultural land indicates a global BIO-CCS potential of 3.2 Gt per year[3].
3. A third study assuming the deployment of BIO-CCS in **point-source installations** and the use of **biomass from forest residues** and energy crops, indicated a global BIO-CCS potential **of 2.5 to 4.6 Gt per year until 2050[4]**.

Policy recommendations

- **Biomass plantations for BIO-CCS should be deployed only on existing agricultural land, there is very limited potential at global scale** for growing energy crops outside the current agricultural areas, without further transgressing the planetary boundaries and ensuring that forest ecosystems are not converted to biomass plantations.
- The sustainable global deployment of BIO-CCS from energy crops to the scale suggested by IPCC scenarios, will require a significant transformation of the agricultural sector, to **more efficiently yet sustainably use current agricultural land**, including crop yield increases, innovative farming practices (e.g., intercropping, double cropping, cover cropping, agroforestry), and the use of waste and residue streams across all agricultural value chains for BIO-CSS.
- **Dietary changes** (reducing meat consumption) could help to release pastures and feed crop lands for energy crop cultivation.
- A **portfolio approach** that prioritises deep emission reduction while deploying both BIO-CCS and other negative emission technologies and practices is needed to ensure effective carbon dioxide removal while safeguarding the planetary boundaries and the Sustainable Development Goals.
- **At EU level** the deployment of BIO-CCS requires a careful assessment of the full **compliance with biomass sustainability** criteria already applied for bioenergy and biofuels by RED2 and LULUCF regulation.
- A cascading approach to the use of residual biomass from forestry in existing point sources of biogenic CO2 emissions should be prioritized.
- Cooperation between Member States for CO_2 transport and storage is needed to enable CDR deployment at scale.

References

1 - Cobo S. et al., 2023 - Sustainable scale-up of negative emissions technologies and practices: where to focus
2 - D.3.2 - Global NETP biogeochemical potential and impact analysis constrained by interacting planetary boundaries
3 - Chiquier S., Fajardy M. et al. 2022 - CO2 removal and 1.5 °C: what, when, where, and how?
4 - D8.6 - Quantitative assessments of NEGEM scenarios with TIMES-VTT, preliminary results

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