# Net-Zero Commitments Encouraging Growth in Carbon dioxide Removal Technologies

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- Carbon removal may be achieved through nature-based methods or by employing certain technologies, such as CCS and DAC.
- The drive to net-zero has resulted in enhanced interest and investment in CCUS.
- Carbon removal technologies should act as supplements, not substitutes, to emissions reduction goals.

Climate accords have made it abundantly clear that reaching net-zero carbon emissions by 2050 is crucial if we are to keep rising temperatures within 1.5°C, as identified by the Paris Agreement of 2015. While measures to curtail carbon emissions, such carbon taxes, increased deployment of renewables, and improved energy efficiency, are invaluable to the race to net-zero, they are not enough by themselves. Emissions reduction policies must be supplemented by policies that target the removal of carbon dioxide already present in the atmosphere.

Carbon dioxide removal (CDR) involves removing carbon dioxide from the atmosphere and storing it for decades, centuries, or millennia. This process can be carried out in two ways: either through natural means, or by employing certain technologies.

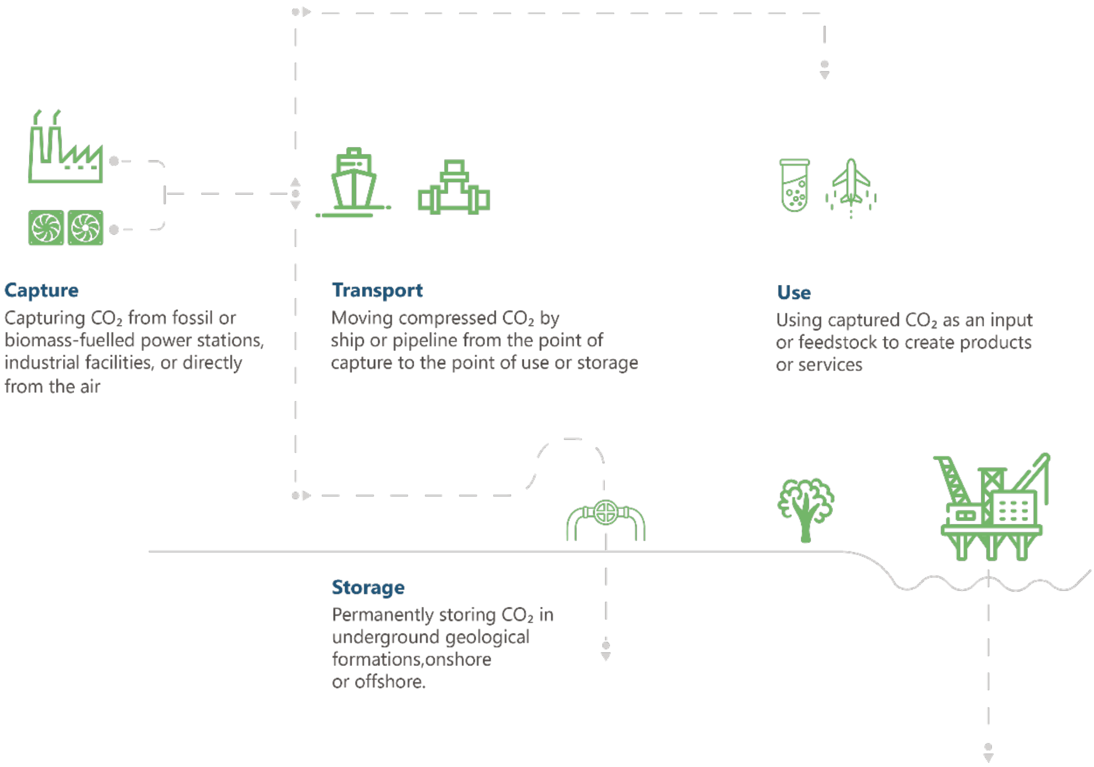


Figure 1: CCUS process

# Natural Carbon Removal Strategies

Removing carbon dioxide from the atmosphere can be done through natural processes that encourage carbon sequestration. Biological carbon sequestration refers to the carbon dioxide that is stored in vegetation and grasslands, as well in the oceans and soil.

Forests and grasslands serve as massive carbon sinks, with the process of photosynthesis removing carbon dioxide naturally, which is why afforestation or reforestation is a great way to de-carbonize the environment. Ocean alkalization and ocean fertilization are ways to increase carbon removal in oceans, while employing practices such as no-till agriculture encourage soil carbon sequestration. Enhanced mineralization is another option: crushed rocks are spread over land to absorb carbon dioxide from the air or exposed to carbon dioxide-rich fluids.

However, nature-based carbon removal options have downsides to them. Planting forests takes time and converting fertile areas such as farmlands into forests may come at the expense of decreasing food supplies, leading to forests elsewhere being converted to farmland. Managing oceanic and soil carbon sequestration on a large scale can also prove complicated. Therefore, scientists have come up with innovative technologies to store or remove carbon dioxide from the atmosphere artificially.

# Carbon Removal and Sequestration Technologies

## Carbon Capture and Storage (CCS)

Applied in a number of industries since 1972, CCS is a proven technology in reducing carbon emissions globally. It involves capturing $CO_2$ by separating it from other gases produced at large industrial process facilities, such as coal-fired power plants and steel mills. The separated $CO_2$ is then compressed and transported to a suitable geological site via pipelines, trucks, or ships. Finally, it is stored in rock formations at depths of one kilometer or more.

By 2019, there were 51 large-scale CCS facilities on a global level. 19 of these were in operation, 4 were under construction, and 28 were in various stages of development.

## Direct Air Capture (DAC)

Direct air capture involves technologies that pull $CO_2$ out of the atmosphere using chemical reactions. This method of carbon removal need not be linked to be industrial processes and can, ergo, be applied much more widely than CCS. However, it is also more expensive than CCS, because $CO_2$ in the atmosphere is more diluted than that from industrial processes. After the $CO_2$ is captured from the air, heat is applied to separate it from the solvent and the $CO_2$ is stored underground permanently or used in new products and applications.

Climeworks, Carbon Engineering, and Global Thermostat are the leading names in DAC technologies, with 18 plants of different sizes between the three of them. A total of a little under 8,000 $tCO_2$/year is captured by these plants; around half of the carbon is sequestered underground while the other half is used in a variety of products.

## Bio-energy with Carbon Capture and Storage (BECCS)

BECCS is associated with discussions around "negative emissions". It involves growing biomass, which acts as a carbon sink due to the process of photosynthesis. BECSS extracts bioenergy from the biomass, and captures and sequesters the carbon content, effectively removing the $CO_2$ from the atmosphere and allowing for negative emissions.

As with CCS, challenges surrounding BECCS involve identifying suitable geological locations for combustion plants and storing the captured $CO_2$. Additionally, combustion units must be built close to the biomass sources because transporting biomass emits $CO_2$, so the longer the routes, the more $CO_2$ is emitted.

## Carbon Capture Utilization (CCU)

CCU is different from CCS in that the captured carbon is stored to be re-purposed for use in a range of products. For example, carbon dioxide is a raw material in graphene production, which is used to make screens for devices such as smart phones. Life-cycle analysis (LCA) is an important step determining the net carbon impact of a CCU product. This complicated process considers the everything from start to finish, starting with where the $CO_2$ is sourced and ending with how the carbon product is disposed of and if any carbon is released at that stage.

For example, the $CO_2$ used in cement production locks in carbon for a long time. On the other hand, $CO_2$ used in making liquid fuels that act as substitutes for gasoline and diesel, only sequester carbon until the fuel is combusted, at which point the carbon dioxide is released back into the atmosphere. Such products only recycle $CO_2$ once and then put it back in the atmosphere. However, they still contribute to carbon-neutrality goals because they reduce $CO_2$ emissions relative to traditional fossil fuels.

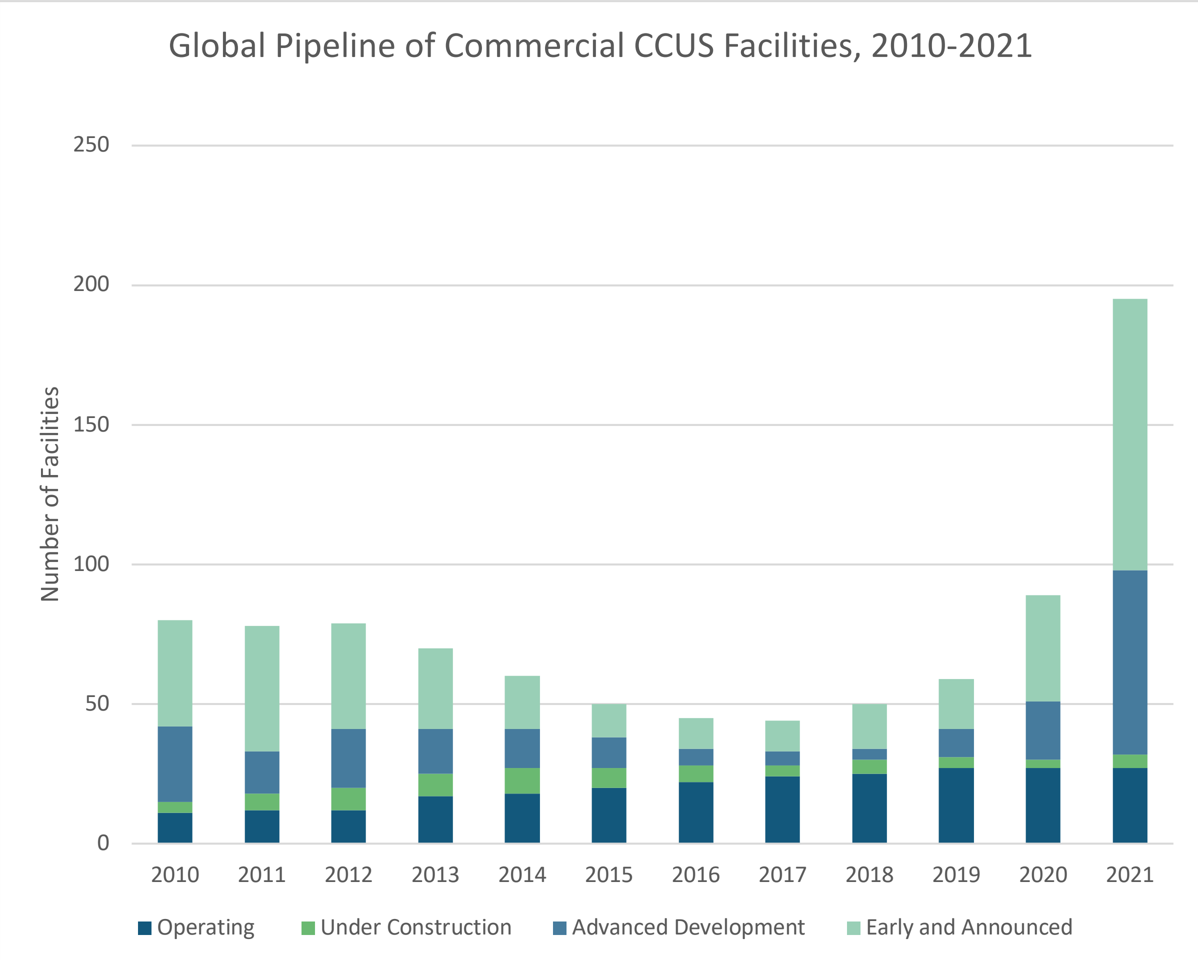


Figure 2: Global Pipeline of Commercial CCUS Facilities Operating and in Development.
Source: International Energy Agency (IEA)

# Looking Ahead

Altogether, Carbon Capture Utilization and Storage (CCUS) technologies have gained unprecedented traction because of bolstered climate goals. More than a hundred new facilities for CCUS were announced in 2021 alone. Similarly, DAC has also been identified as a key technology for achieving net zero targets. However, such technologies must not take away from companies' emissions reduction goals; they should act as supplements. Not only are there very high costs associated with carbon removal technologies, but there is also the possibility of carbon leakages during transportation. Additionally, there is no certainty surrounding how the land and oceans will respond to the shifting atmospheric chemistry, which is why controlling their carbon emissions should remain companies' primary focus. Worryingly, however, a number of companies are using tree planting, and soil management schemes to balance out emissions instead of addressing the root problem. Shell is one giant example of this: installing CCS and DAC systems, in addition to planning a huge Brazil-sized afforestation program.

In order to achieve climate goals, a range of de-carbonization technologies should be deployed alongside effective strategies to decrease carbon emissions altogether.

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