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Carbon Capture and Storage (CCS)

Frequently Asked Questions

Introduction

Carbon capture and storage (CCS) is purported to collect or "capture" carbon dioxide generated by high-emitting activities, and is therefore commonly proposed as a technology to help meet global energy and climate goals. However, CCS does not address the core drivers of the climate crisis or meaningfully reduce greenhouse emissions, and should not distract from real climate solutions. Below you'll find a compilation of some of the most frequently asked questions related to CCS.

Click on a question to jump directly to it.

Questions

What are the different ways of describing carbon capture methods?

The concept of carbon capture encompasses a set of technological processes that trap or "capture" carbon dioxide (CO2) from an emitting source — like a fossil fuel power plant or an ethanol plant — and then compress and transport it for storage, use, or both. The most commonly described process is **carbon capture and storage/sequestration (CCS)**, where carbon dioxide is captured and then injected underground and stored. In **carbon capture and utilization (CCU)**, carbon dioxide is used but not stored, such as in the production of fuels or fertilizers. Finally, **carbon capture, utilization, and storage/sequestration (CCUS)** is a combination of the two. Both CCS and CCUS are used as catch-all terms, although enhanced oil recovery (EOR) is the only activity at scale that involves both utilization and storage.

Is CCS the same as carbon dioxide removal?

Though often conflated, CCS and carbon dioxide removal (CDR) are distinct but related concepts. This FAQ focuses on CCS, which targets carbon dioxide that comes from a point source (an emitting facility or activity). Carbon dioxide removal targets carbon dioxide already in the atmosphere. CCS technology merely prevents a fraction of the emissions from an emitting source from entering the atmosphere, while carbon dioxide removal techniques purport to transfer carbon dioxide already in the atmosphere to some form of storage. However, the wide set of CDR techniques in development are mostly speculative and have significant costs, limitations, or impacts. Some CDR approaches also rely on CCS techniques in whole or in part. Two of the primary proposed methods of engineered CDR — bioenergy with carbon capture and storage (BECCS) and direct air capture (DAC) — combine some or all aspects of CCS with additional technology or processes.

What is enhanced oil recovery?

Enhanced oil recovery (EOR), sometimes called tertiary recovery, is the process of injecting heat, chemicals, or gases into oil fields to stimulate additional oil production. Most EOR uses high-pressure carbon dioxide from natural or anthropogenic sources, and is sometimes referred to as CO2-EOR. The process does not store all injected carbon dioxide — some carbon dioxide remains in the oil reservoir while some returns to the surface with the oil. Critically, the emissions released from the burning of oil produced with CO2-EOR are significantly greater than the carbon dioxide stored in the process, undermining any purported climate benefit from the carbon dioxide storage. Most existing CCS projects in the world are EOR projects.

Return to Top

Is CCS an effective way to reduce carbon emissions?

No. CCS has a decades-long history of overpromising and under-delivering, with projects frequently failing to meet published emission reduction targets. Moreover, CCS also produces its own emissions that often go unaccounted for due to the energy consumed in the capture process (called the "energy penalty"), which dramatically reduces its impact. (One study found, for example, that when accounting for lifecycle emissions, a CCS retrofit on a coal plant in Texas only reduced carbon dioxide-equivalent emissions by 10.8 percent over 20 years.) It may also produce additional emissions downstream via oil produced from enhanced oil recovery (EOR). As noted by the Intergovernmental Panel on Climate Change (IPCC), the ability of CCS to provide meaningful emissions reductions in the next decade is extremely low, while its cost would be extremely high.

What is an 'energy penalty?'

"Energy penalty" is the term used to describe the extra energy necessary to power CCS equipment, drawn either from the plant where the equipment is installed, or from a separate power source. When CCS equipment is added to a facility, it can increase the total amount of energy consumed by the facility, reduce the usable energy output of the facility, or both. Carbon capture's energy penalty can be quite substantial, as noted by the Intergovernmental Panel on Climate Change (IPCC): "the energy penalty increases the fuel requirement for electricity generation by 13–44%."

What does the United Nations Intergovernmental Panel on Climate Change say about the use of CCS?

The Intergovernmental Panel on Climate Change (IPCC) acknowledges that many climate models that employ CCS to meet climate targets assume the availability and efficacy of CCS despite the lack of real-world examples. The IPCC cautions against overreliance on CCS and related technologies, noting their future deployment is uncertain, they face multiple feasibility constraints, and could have adverse impacts on human rights and ecosystems. The modeled pathways that provide the greatest chance of staying below 1.5°C (2.7°F) without overshoot (experiencing global temperature increases beyond 1.5°C) avoid reliance on CCS and BECCS and instead focus on rapid and dramatic phase-out of fossil fuels.

What would a large-scale buildout of CCS look like?

Scaling CCS to operate at the level suggested by some proponents would require a massive buildout of pipelines and associated infrastructure. In the United States, it is estimated that to capture a quarter of current emissions by 2050, the industry would need to manage nearly two-and-a-half times more carbon dioxide than the total volume of current US oil production, and construct over 60,000 miles of pipelines. And critically, because the needs for carbon dioxide pipelines are different from oil or gas pipelines, the existing pipeline network cannot simply be used for carbon dioxide. A buildout of this size and scale is not only unrealistic; it is dangerous for the many communities through which carbon dioxide pipelines would run and where capture and storage facilities would be built.

Does capturing carbon also reduce other toxic air emissions?

No, CCS does not alleviate harmful air pollutants, and may actually lead to additional emissions at the point of capture. Because of carbon capture's energy penalty, burning fossil fuels to power the process increases pollutant emissions on site. Moreover, CCS increases the upstream impacts of fossil fuel production and refining in proportion to the additional energy consumed. The use of amine-based chemicals (such as monoethanolamine (MEA)) for CCS can lead to significant releases of ammonia as well. And, because CCS relies on underlying facilities by design, CCS retrofits risk exacerbating pollution and environmental injustice in communities already burdened by existing polluting facilities. This is in part why the White House Environmental Justice Advisory Council flagged CCS; carbon capture, utilization, and storage (CCUS); and direct air capture (DAC) as examples of projects that will not benefit a community.

Return to Top

What about CCS for 'hard to abate' emissions from heavy industry like plastics, steel, and cement?

High-emitting industrial activities, particularly plastics, steel, and cement manufacturing, are increasingly used to justify the reliance on — and public subsidies for — CCS. Yet even advocates of the technology acknowledge that CCS is infeasible, uneconomic, or unnecessary for most industrial sector emissions. In reality, the bulk of industrial emissions can be eliminated through demand reduction, reuse of materials, and electrification with renewable energy. To the degree that a small amount of residual emissions exist, CCS has only a limited ability to reduce those emissions given its expense, energy consumption, and limited capture rate. Such residual emissions are insufficient to justify the massive infrastructure buildout (and public subsidies) required to address them. In the United States, for example, CCS proponents routinely cite cement process emissions as a justification for massive CCS deployments (and subsidies), even though those emissions account for less than 1 percent of total US emissions. Moreover, cement emissions are among the most expensive carbon dioxide point sources to capture through CCS, and in the US, are scattered across roughly 100 facilities in thirty-four states and Puerto Rico. Applying CCS to cement facilities would require constructing a massive pipeline network at great expense and risk with little, if any, climate benefit.

Is CCS important for hydrogen production?

CCS is key to the push to portray hydrogen (virtually all of which is produced from fossil fuels) as an alternative energy source for the future rather than a way to prolong dependence on oil, gas, and coal. Despite commonly promoted myths, "blue hydrogen" — hydrogen made from fossil gas or coal with CCS — is nothing more than a tether to the fossil fuel economy. Blue hydrogen fails as a climate solution: Its lifecycle emissions can be greater than if the gas used to make it were burned directly. While hydrogen produced from electrolysis and renewable energy — "green hydrogen" — may have a modest but valuable role to play in a small subset of industrial and heavy transport applications, those applications are limited and often overstated. Nonetheless, the narrow role for green hydrogen is often used to justify and greenwash a broad push for all hydrogen, including fossil hydrogen. Such arguments largely ignore the drawbacks of using any kind of hydrogen, including the significant limitations, challenges, and risks of green hydrogen. Hydrogen of any kind is both extremely flammable and an indirect greenhouse gas (it does not trap heat itself but it extends the atmospheric life of other GHGs). And because hydrogen has the smallest particle size of any gas, it is exceptionally prone to leaks.

Return to Top

What about the jobs potential in building out CCS?

Claims about the economic benefits of deploying CCS technology and infrastructure are often overstated. Delivering a just transition away from fossil fuels has a greater jobs potential than attempts to prop up the fossil economy. In the US, the clean energy sector employed 3 million people in 2020, and is the biggest job creator in the energy sector, with nearly three times more workers employed than in fossil fuel extraction and generation. Wind and solar jobs are among the fastest growing jobs in the country. Additionally, the clean energy sector offers good-paying union jobs. There is further potential for job creation doing things like weatherizing homes, plugging and remediating old oil and gas wells, reconfiguring existing infrastructure to be more climate resilient, and restoring natural ecosystems that can help sequester carbon. All of these provide good jobs with co-benefits, such as reducing energy consumption, reducing the cost of energy, reducing local pollution, and more. As the Labor Network for Sustainability warns: "People threatened with job loss as a result of reduction in fossil fuel burning should not expect carbon capture to help protect their jobs any time in the next 10–20 years."

Is carbon dioxide storage safe?

Underground storage of carbon dioxide poses significant safety risks, such as potential leakage, contamination of drinking water, and stimulation of seismic activity. As one study states, "geological storage is associated with a string of side-effects." The US Department of Energy acknowledges the risk of carbon dioxide leakage, noting for example that carbon dioxide stored in deep geologic reservoirs could leak through cracks during periods of natural seismic activity and reach groundwater sources. The US Bureau of Ocean Energy Management similarly acknowledges that leakage risk is especially significant for abandoned wells in areas with a long history of oil and gas drilling, including offshore environments like the US Gulf of Mexico.

Return to Top

If carbon dioxide is safe to drink in carbonated water and soft drinks, why are carbon dioxide pipelines dangerous?

Though harmless in carbonated drinks, carbon dioxide is an asphyxiant that can be toxic and even fatal at high concentrations. Unlike fossil gas and oil pipelines, the greatest risk with carbon dioxide pipeline leakage and rupture is not ignition, but inhalation. Carbon dioxide is categorized as a hazardous liquid when transported through pipelines. It is transported in a high-pressure "supercritical" state, so pipelines operate under extremely intense conditions. Consequently, when there's a leak or rupture, a huge amount of carbon dioxide can be released very quickly. Controlled ruptures of carbon dioxide pipelines, like this experiment conducted in the United Kingdom, show just how severe the explosion could be. An accidental release of highly compressed carbon dioxide poses substantial danger, as demonstrated when a carbon dioxide pipeline ruptured in Satartia, Mississippi, in February 2020, sending over forty people to the hospital and requiring over 300 people to evacuate. Moreover, because carbon dioxide displaces air, leaks can prevent internal combustion engines in nearby vehicles from working properly, potentially stranding those exposed and stymying emergency response.

Is CCS important for the Global South?

CCS faces the same obstacles and presents the same problems in the Global South as it does in the Global North. Renewables are already cheaper than fossil fuels in the majority of the world, so the financial rationale for building additional fossil fuel-fired power plants is rapidly deteriorating. Moreover, even where such plants do exist, it will still be a more effective use of money to build renewables than to try to install CCS to reduce or replace sources of emissions.

How many CCS and carbon removal projects exist in the world?

As of December 2022, there are twenty-nine active CCS projects and one active direct air capture (DAC) project operating globally, according to the Global CCS Institute. Eight CCS and two DAC projects are currently under construction, and more than 150 projects are in early or advanced development in more than twenty countries. Finally, there are two suspended CCS projects globally, both located in the United States. One of these is the flagship Petra Nova project at a coal-fired power plant in Texas. Many more projects have been proposed but never completed, and either maintain a dormant status or have been subsequently abandoned. Of the 42.6 million tonnes per year (mtpa) of operational global capture capacity, half (19.8 mtpa) is located in the United States. Nearly three-quarters (31 mtpa) of global capacity is connected to enhanced oil recovery projects and almost 70 percent (29.5 mtpa) is applied to natural gas processing. Only a single active project, the Boundary Dam project in Alberta, Canada (1 mtpa), is applied to power generation. Compared to the 38 gigatons of carbon dioxide emitted from fossil fuels and other industry globally, total capture capacity represents just over 0.1 percent of those emissions.

What public subsidies have been provided to build CCS infrastructure in the United States?

The primary subsidy for CCS in the United States is the 45Q tax credit. The Inflation Reduction Act (IRA), passed in August 2022, significantly enhanced the value of the 45Q credits. Captured carbon now garners 85 USD per tonne of carbon dioxide sequestered, and 60 USD per tonne utilized (including for enhanced oil recovery (EOR)). Direct air capture (DAC) projects separately qualify for 180 USD per tonne of carbon dioxide sequestered, and 130 USD per tonne utilized (including for EOR). The IRA also loosened other requirements for credits and extended the window during which projects can qualify. Moreover, the Infrastructure Investment and Jobs Act of 2021 (IIJA) included funding for DAC and hydrogen hubs, as well as funding for carbon dioxide pipelines. An analysis of the impact of IRA and IIJA on CCS and fossil fuels is available here.

Return to Top

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