BECCS

Bioenergy with Carbon Capture and Storage

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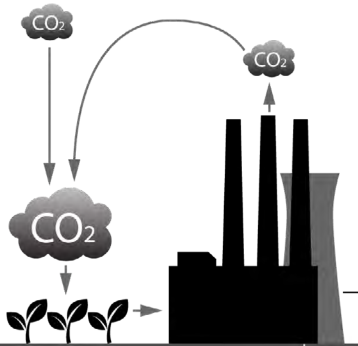
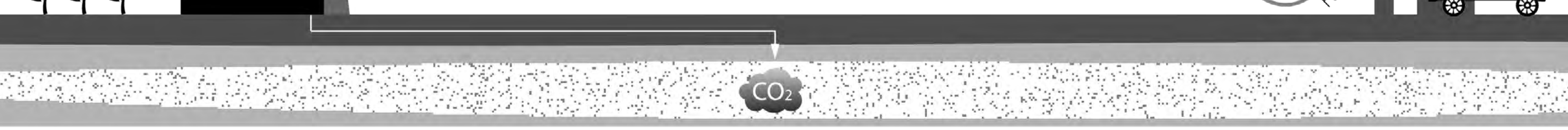


Bioenenergy with Carbon Capture and Storage (BECCS) is a form of climate change mitigation that removes carbon dioxide (CO_2) from the atmosphere while also producing energy (either electricity or fuel). BECCS removes CO_2 first through the production of bioenergy crops, which absorb CO_2 out of the air during photosynthesis. The CO_2 emitted when these crops are harvested and transformed into energy is then captured and injected into geologic formations underground for permanent storage. This could—depending on how and where bioenergy crops are grown and transported—result in more CO_2 being removed from the atmosphere than is released, which is referred to as *negative emissions*.

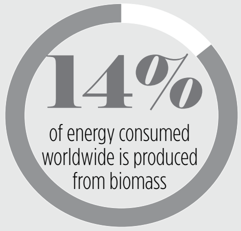


WHY BECCS?

According to the Intergovernmental Panel on Climate Change (IPCC), negative emissions technologies, such as BECCS, are vital to remove enough CO_2 from the atmosphere to prevent the global average temperature from rising more than 2 degrees Celsius, which is projected to be the tipping point above which the world would experience significant consequences. The amount of CO_2 in the atmosphere has been increasing since the Industrial Revolution, largely due to emissions from burning fossil fuels. As the amount of CO_2 particles in the atmosphere increase, more heat is trapped in the earth's atmosphere causing global temperatures to rise.

BIOENERGY

Bioenergy is a renewable energy (in the form of electricity, heat, or fuel) that is generated from living or recently living biological material, called biomass. Biomass, including energy crops, wood, agriculture and forest residue, municipal waste, and algae, are converted into energy through various thermal, chemical, or biochemical processes. For example, burning wood to produce heat is the most basic conversion process. Another common conversion process is fermentation, in which microorganisms consume the sugars in biomass and produce ethanol.



Data from the U.S. Energy Information Administration

CARBON CAPTURE AND STORAGE

Carbon Capture and Storage (CCS) includes a variety of processes that remove CO_2 from the atmosphere, either temporarily or permanently. CCS is the part of the BECCS process that involves capturing CO_2 produced at bioenergy facilities and injecting it into underground geologic formations for permanent storage. This is also sometimes referred to as *geologic carbon capture and storage*.

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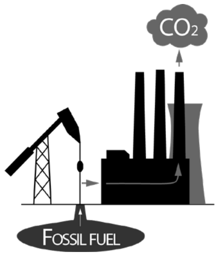
CCS projects are currently capturing and/or injecting CO_2 worldwide

Data from the National Energy Technology Laboratory's CCS Database

BECCS VS. OTHER FORMS OF ENERGY GENERATION

Fossil Fuels

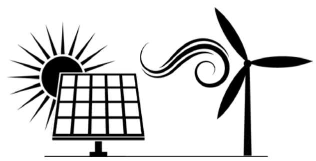
Carbon Positive



Fossil fuel based energies (such as coal, oil, and natural gas) release CO_2 into the atmosphere.

Renewables

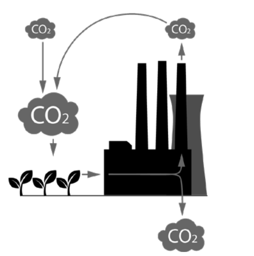
Carbon Neutral



Renewable energies (such as wind, solar, hydropower, and bioenergy) neither release nor remove CO_2.

BECCS

Carbon Negative



BECCS removes more CO_2 from the atmosphere than it releases.

Technological Feasibility

Is it possible to do BECCS with existing technology?

Technologies to produce bioenergy are well-established, widely implemented, and have been proven feasible. However, technologies for geologic CCS, though they have existed for more than 40 years, are less proven. Much of the outstanding uncertainty about the feasibility of CCS concerns determining if individual geologic formations have the structural integrity to safely and permanently store enough CO_2 to significantly contribute to climate change mitigation. If a formation lacks the necessary structural integrity, injecting too much CO_2 too quickly may increase the likelihood of seismic activity or result in CO_2 leakage. Many test projects are currently researching the technological feasibility of CO_2 storage in various geologic formations. For example, the Regional Carbon Sequestration Partnerships, created in 2003 with support from the US Department of Energy, are assessing CCS capacity across the country and developing best practices for safe and permanent geologic storage of CO_2.

Economic Feasibility

Do current economic incentives encourage the adoption of BECCS?

While economic incentives exist to encourage a prevalent bioenergy industry in the US, there are currently insufficient economic incentives to encourage widespread adoption of CCS by bioenergy facilities. CCS would increase costs for these facilities (including capital investments in equipment and technology, operating costs, and transportation costs) without providing additional revenue. This has discouraged CCS from being adopted by all but a small number of facilities that are receiving additional revenue, either from grants for CCS research and development or from selling the captured CO_2 for use in enhanced oil recovery (EOR)* or other CO_2 markets. However, CCS could be incentivized by the newly expanded Section 45Q tax credits, which are available for facilities that capture and store CO_2. Revised as part of the 2018 budget package, 45Q tax credits will gradually increase until 2026, from $10 to $35 per metric ton of CO_2 captured and used for enhanced oil recovery (or other industrial uses), and from $20 to $50 per metric ton of CO_2 captured and stored geologically. This increasing credit could make BECCS economically feasible in the near-term, especially for ethanol biorefineries for which the cost of capturing CO_2 is relatively low.

It is worth noting that widespread CCS would also require significant expansion of CO_2 transportation infrastructure. This would most likely be in the form of an extensive pipeline system, connecting emissions sources (like bioenergy facilities) to geologic storage locations. Currently there is only a small network of CO_2 pipelines in the US, crossing just a few states, and being used primarily for EOR. Expanding this pipeline would require not only additional economic investments but also the political will and capacity to organize its construction across state lines.

*Some of the CO_2 used for EOR is recovered for re-use, some may remain stored underground, and some may leak back into the atmosphere.

Potential Implications

If BECCS is widely adopted, what would be the regional implications?

Though BECCS could have far-reaching worldwide benefits by mitigating climate change, it could also have significant consequences in the regions where it is adopted. While it would reduce atmospheric CO_2, it would also require transformations in agriculture, land-use, and energy production systems, creating trade-offs among food, water, energy, biodiversity, and economic opportunities. For example, bioenergy crops could displace food crops, threatening local food security. CCS practices and bioenergy production could require changes in water use, affecting water quality and quantity. Grasslands, wetlands, and forests could be converted to intensive bioenergy crops, altering wildlife habitat and biodiversity. These land-use conversions could also cause the release of large amounts of CO_2 currently stored in native ecosystems, incurring a carbon debt so large it could take generations for BECCS to repay it. Transitions from fossil fuels to bioenergy industries could impact employment opportunities and local and state tax revenue, affecting regional economic development. These potential trade-offs could have significant implications for local people, communities, cultures, and ecosystems.

Is anyone doing BECCS now?

Despite assertions that BECCS is vital for climate change mitigation, it has not yet been widely adopted. In 2017, an ethanol refinery in Decatur, Illinois, became the first large-scale, operational BECCS facility when it received a grant from the US Department of Energy for CCS research and development. Called the Illinois Industrial Carbon Capture and Storage Project, the facility has the capacity to store up to 1.1 million tons of CO_2 per year by injecting it into a saline reservoir in the Illinois Basin, at a depth of 7,000 ft. Over five years, the project is expected to store a total of 5.5 million metric tons of CO_2 and demonstrate safe and effective commercial-scale CCS in a saline reservoir. However, compared to the 100 - 1,000 billion metric tons of CO_2 the IPCC projects will need to be removed from the atmosphere in the remaining part of the 21st century, the expected volume of CO_2 to be stored at the Illinois Industrial Carbon Capture and Storage facility is relatively small.

For more information about BECCS, Bioenergy, or CCS, please see: the IPPC's Fifth Assessment (https://www.ipcc.ch/report/ar5/), the U.S. Department of Energy (https://www.energy.gov/), and Big Sky Carbon Sequestration Partnership (https://www.bigskyco2.org/).

WAFERx is a research collaboration supported by the National Science Foundation (Cooperative Agreement No. OIA-1632810). Our objective is to evaluate the implications of adopting Bioenergy with Carbon Capture and Storage in the Upper Missouri River Basin as a form of climate change mitigation.