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Carbon180

Bioenergy with carbon capture and storage (BECCS)

BECCS is a hybrid carbon removal solution that integrates both land- and tech-based processes. BECCS involves capturing CO_2 in plants, converting it into power, heat, or fuel, and then storing subsequent carbon emissions in rock formations (a process known as dedicated geologic storage) or using them to make carbon-based products. Not all forms of BECCS result in net carbon removal — many factors must be taken into consideration, including the source and type of biomass, transportation requirements, efficiency of conversion processes, and end use of captured carbon.[1]

The carbon removal potential of BECCS is projected to be 3.5–5.2 gigatons per year by 2050.[2] BECCS is a promising solution because of its potential to produce energy, fuel, and other useful byproducts while simultaneously combating climate change by pulling carbon dioxide out of the atmosphere.

Land use and food security considerations

Land requirements for BECCS vary significantly based on the size of the plant and type of biomass being used. In the near term, small-scale BECCS deployment may not require significant land conversion so long as the biomass is sourced from waste biomass and different agricultural residues. However, land dedicated to growing bioenergy crops could compete with land usage for other crops. This could drive both local community displacement and food insecurity by limiting access to food and increasing food prices.[3] This risk can be mitigated by restricting bioenergy crops to marginal and abandoned farmland or prioritizing waste biomass as a feedstock.

KEY TERMS

Gigaton
1 billion tons.

Agriculture residue
Organic materials produced as byproducts from harvesting and processing agricultural crops.

Biomass feedstock
Raw organic material that can be used to produce energy or fuel on an industrial scale.

Waste biomass
Biomass feedstock composed of agricultural, forestry, or municipal waste.

Bioenergy crops
Crops that are intentionally harvested for the production of energy or fuel.

Induced seismicity
Minor earthquakes and tremors (of a low magnitude) caused by human activity.

Ecosystem impacts

Growing bioenergy crops for large-scale BECCS deployment could lead to loss of biodiversity and soil carbon, as well as soil erosion.[4] The high water demand for some forms of bioenergy could also drive or worsen water scarcity for local communities.[5] Additionally, there are ecosystem concerns surrounding the dedicated geologic storage of carbon captured from BECCS, including induced seismicity, water contamination, and carbon leakage.[6] Fortunately, these concerns are very low risk and can be addressed during planning and implementation.[7]

If appropriately and sustainably implemented, BECCS can actually provide ecosystem benefits. Some bioenergy crops act like a "green leaky dam," slowing the flow of water and reducing the impacts of flooding.[8] Some crops like switchgrass can help revitalize depleted and abandoned agricultural lands.[9] Also, sourcing biomass from the leftovers of forest fire management practices (e.g., thinning) may improve the economics of forest management.

Health impacts

Combustion of biomass and biofuels, as well as frequent fertilizer use, can cause local air pollution[10] and increase the risk of water contamination from runoff.[11] Robust regulations are required to address these concerns and ensure BECCS deployments center public health.

Energy demands

Large-scale deployment of BECCS relies heavily on bioenergy crops and can lead to high energy demands throughout the supply chain (e.g., growing crops and transportation). However, net energy production can be maximized by prioritizing agriculture and forest waste biomass as feedstock for BECCS.

Costs

BECCS is a relatively low-cost approach with estimates ranging from $15 to $400 per ton of carbon.[12] Cost variation depends on many factors like biomass supply and transportation, as well as the efficiency of the BECCS plant itself.[13]

Deployment

BECCS operations are beginning to scale up. Between 2022 and 2025, the US is expected to go from hosting three plants to over thirty, with the rate of carbon removed by BECCS more than doubling. Of the three currently active US plants, only one operates at a large scale (i.e., captures 1 megaton, or 1 million tons, of CO_2 per year): The Illinois Basin Decatur plant produces ethanol from corn, capturing the carbon dioxide released from the fermentation process and storing it in rock formations below the facility.[14,15]

In terms of what's to come, a net-negative BECCS project from Clean Energy Systems in Mendota, California plans to use agricultural waste biomass to generate electricity, capturing and permanently storing 99% of CO_2 produced in the process. Charm Industrial, which converts and sequesters biomass as bio-oil in Oklahoma, anticipates expanding to larger-scale operations in Colorado and the Great Plains region. Summit Carbon Solutions, a project made up of 30 small plants, will sequester 1.9 megatons of carbon dioxide per year. These will capture carbon from corn fermentation across the north central US and sequester it underground in North Dakota.

Future deployment of BECCS must consider both biomass supply and potential sites for dedicated geologic storage. Also, complete supply chain monitoring, reporting, and verification (MRV) will be necessary to account for emissions and removals at all stages.[16]

Government engagement

The Department of Energy (DOE) and Department of Agriculture (USDA) are the primary federal agencies currently involved in BECCS, but engagement from the Environmental Protection Agency (EPA) will also be needed. Federal funding for BECCS over the last decade has remained low and piecemeal; in 2018, estimated DOE funding was $203 million — only a fifth of the funding level recommended by the National Academy of Sciences (NAS).[17]

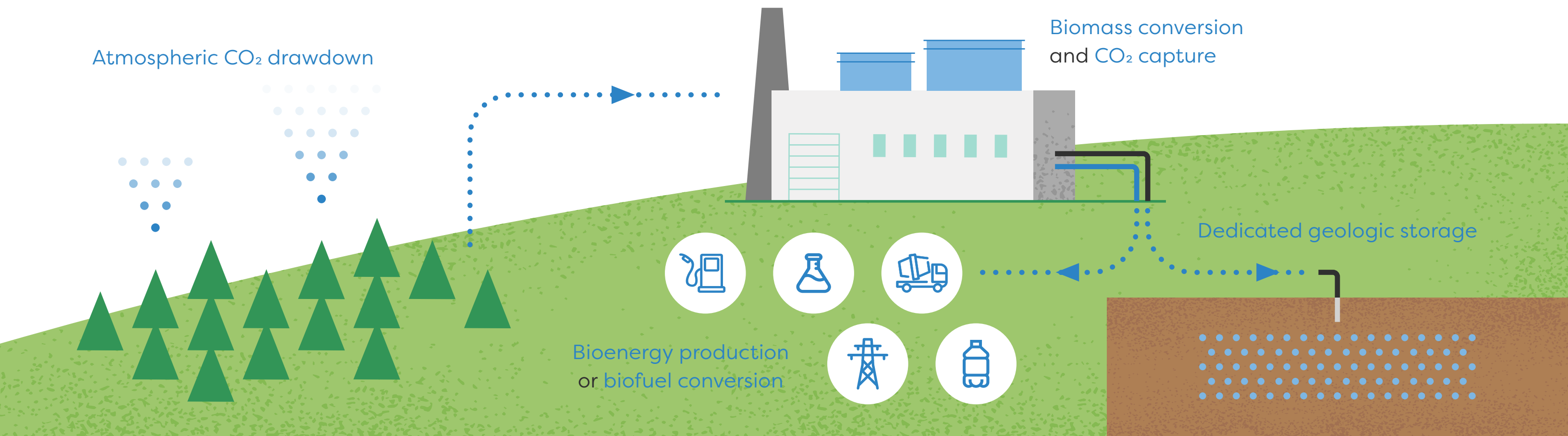
DOE advances carbon removal solutions and enabling infrastructure through a variety of programs that improve technologies, lower costs, fill knowledge gaps, and maximize community benefits.

USDA supports biofuel, bioenergy, and biomaterial industries, especially in rural communities, through loans, grants, and production-based payments. However, USDA does not offer credit for the capture and storage of carbon emissions from these industries.

The Biomass Research and Development Initiative (BRDI) is a joint effort from DOE and USDA that supports RD&D for biofuels and bio-based products, but lacks adequate and consistent funding.

EPA's Underground Injection Control (UIC) program oversees permitting of dedicated geologic storage sites, but is underfunded and only two Class VI permits have ever been issued.

Domestic and international standards and practices that accurately and consistently account for the tradeoffs of BECCS across the full supply chain are needed. Federal leadership and investment will be critical to better understanding the environmental and social implications associated with scaling up BECCS, as well as how to best address them in equitable, transparent, and inclusive ways.



Endnotes

1 Negative Emissions Technologies and Reliable Sequestration: A Research Agenda, The National Academies of Sciences

2 Ibid.

3 Fact Sheet: BECCS, American University

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