Carbon180

Bioenergy with Carbon Capture and Storage (BECCS)

Bioenergy with carbon capture and storage (BECCS) is a hybrid carbon removal solution that integrates both nature- and tech-based processes. BECCS involves capturing carbon dioxide 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.

GLOSSARY

Gigaton
1 billion tons

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

Biomass feedstock
Raw material (plants, residue, or other organic materials) that can be used to produce energy or fuel on an industrial scale

Waste biomass
Biomass feedstock comprised of agricultural, industrial, or municipal waste

Bioenergy crops
Organic sources, such as cottonwood and switchgrass, 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

Considerations

LAND USE AND FOOD SECURITY

Land requirements for BECCS vary significantly based on the size of the plant and type of biomass being used. 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.

ENERGY DEMAND

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, transportation). However, net energy production can be maximized by prioritizing agriculture and forest waste biomass as feedstock for BECCS.

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]

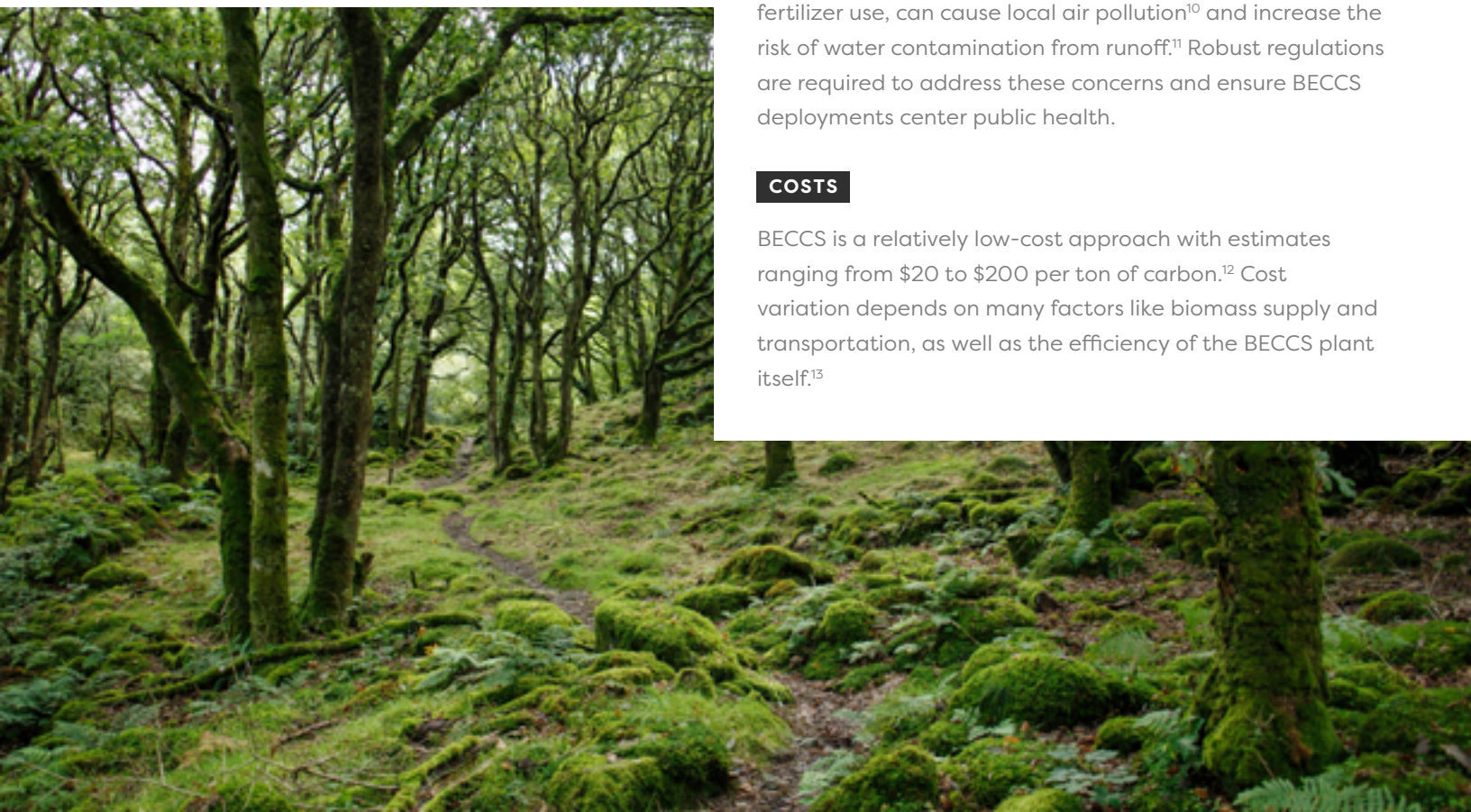
If appropriately and sustainably implemented, BECCS can actually provide ecosystem benefits. Some bioenergy crops act like a "green leaky dam," slowing the flow of water and reducing the impacts of flooding.[8] Some crops like switchgrass can help revitalize depleted and abandoned agricultural lands.[9] 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.

COSTS

BECCS is a relatively low-cost approach with estimates ranging from $20 to $200 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 remains largely undeployed with only five facilities operating worldwide. Of the BECCS plants currently in operation, four are in the US and one is located in Canada. Only one of these plants, an industrial facility located in Illinois, operates at a large scale (i.e. captures 1 Mt CO_2 per year).[14] The Illinois Basin Decatur plant produces ethanol from corn, captures carbon dioxide released from the fermentation process, and stores the captured carbon in rock formations below the facility.[15] There are currently three additional BECCS projects being planned in Japan, the United Kingdom, and Norway.

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]

BECCS Technology

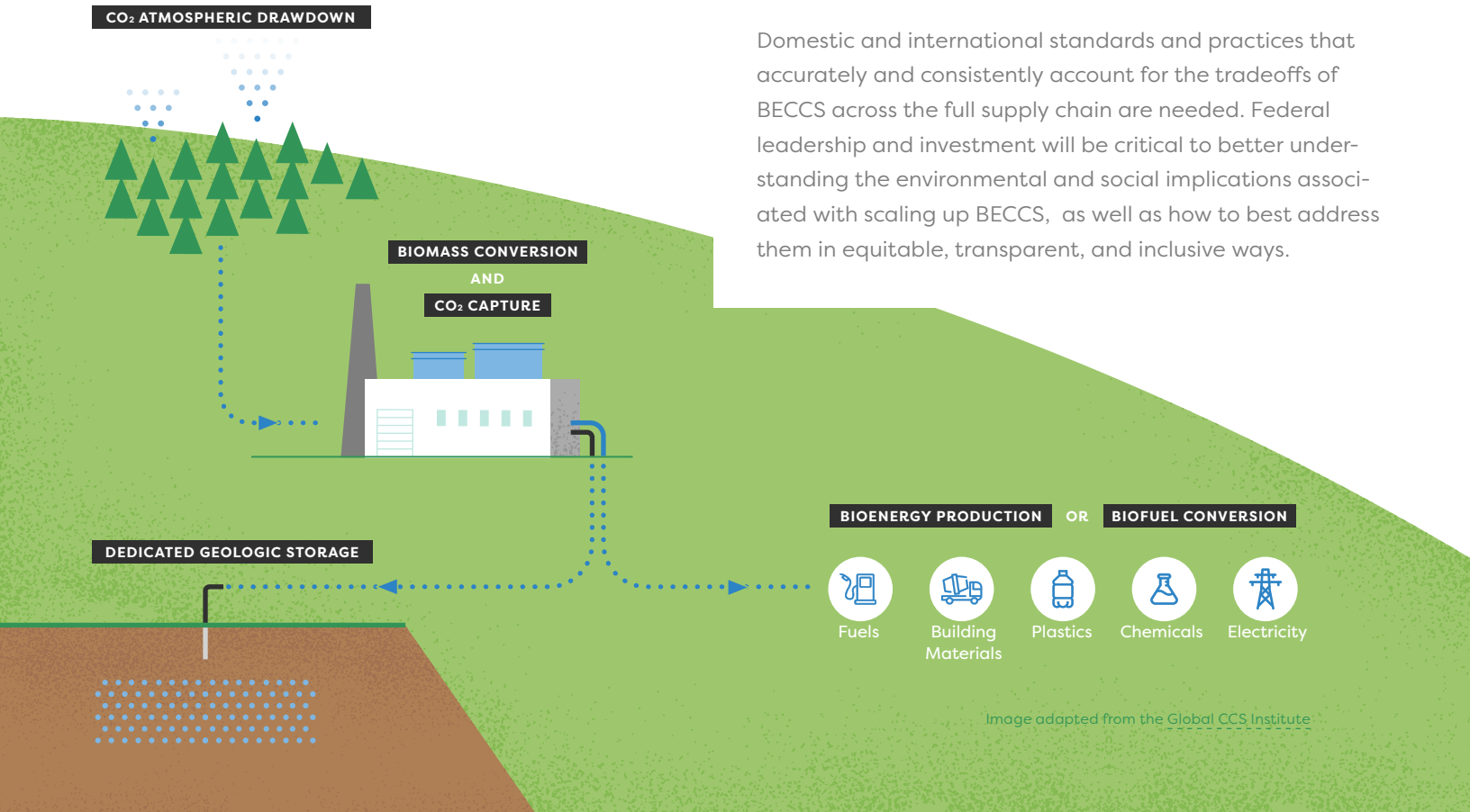


Image adapted from the Global CCS Institute

Government Engagement

The US Department of Energy (DOE) and the US Department of Agriculture (USDA) are the primary federal agencies currently involved in BECCS, but engagement from the 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 Academies of Science (NAS).[17]

DOE — Through a variety of loans, grants, and programs, DOE funds carbon capture and storage (CCS) research, development, and demonstration (RD&D).

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

JOINT — (DOE and USDA) Biomass Research and Development Initiative (BRDI): Supports RD&D for biofuels and bio-based products, but lacks adequate and consistent funding.

EPA — Underground Injection Control (UIC) Program: Oversees permitting of dedicated geologic storage sites, but is underfunded and only two 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

Bioenergy with Carbon Capture and Storage (BECCS)

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

2 Ibid.

3 BECCS Fact Sheet, American University

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

5 BECCS Fact Sheet, American University

6 Health and Safety Risks of Carbon Capture and Storage, John Fogarty and Michael McCally

7 Assessing induced seismicity risk at CO_2 storage projects: Recent progress and remaining challenges, Joshua A.White and William Foxall

8 Bioenergy with Carbon Capture and Storage (BECCS): Finding the win-wins for energy, negative emissions and ecosystem services—size matters, Natural Environment Research Council

9 Vast bioenergy plantations could stave off climate change—and radically reshape the planet, American Association for the Advancement of Science

10 BECCS Fact Sheet, American University

11 The role of large—scale BECCS in the pursuit of the 1.5°C target: an Earth system model perspective, Helene Muri

12 Negative emissions—Part 2: Costs, potentials and side effects, Sabine Fuss, et al.

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

14 Bioenergy and Carbon Capture and Storage, Global CCS Institute

15 Ibid.

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

17 Carbon Removal: Comparing Historical Federal Research Investments with the National Academies' Recommended Future Funding Levels, Bipartisan Policy Center

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