

## **Carbon Footprint and Economics of Integrating Biogas Upgrading Process and Carbon Capture Technologies in Cellulosic Biorefineries**

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**Project Goals: Establish the scientific knowledge and new technologies to transform the maximum amount of carbon available in bioenergy crops into biofuels and bioproducts.**

Gaseous streams in biorefineries have been historically undervalued and underutilized. Biogas produced in existing biorefineries is assumed to be combusted directly on-site to generate process heat and electricity along with lignin. However, biogas can alternatively be upgraded to biomethane, which can be used as a transportation fuel. Biogenic CO<sub>2</sub> generated in biorefineries can also play a critical role in climate change mitigation due to the large amount (45 Mt annually from fermentation). With economic incentives, cellulosic biorefineries could be redesigned to make better use of biogas and concentrated CO<sub>2</sub> streams. To date, the trade-offs associated with biogas upgrading, bioenergy with carbon capture technologies and biogas on-site combustion in cellulosic biorefineries have not been thoroughly investigated. Here, we explore the economic and environmental impacts of upgrading biogas and capturing carbon at cellulosic biorefineries and identify opportunities to maximize value and environmental benefits. The results indicate that biorefineries using biogas upgrading technologies resulted in a similar minimum ethanol selling price as the base case. The amount of carbon captured in biorefineries could be ~90 Mt per year in the U.S. with a maximum 10% conversion of pastureland and cropland to biomass sorghum in future scenarios.

### **References**

1. Sanchez, D. L.; Johnson, N.; McCoy, S. T.; Turner, P. A.; Mach, K. J. Near-term deployment of carbon capture and sequestration from biorefineries in the United States. *Proc. Natl. Acad. Sci. USA* 2018, 115(19), 4875–4880. DOI: 10.1073/pnas.1719695115

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