Empirical evidence for the potential climate benefits of decarbonizing light vehicle transport in the U.S. with bioenergy from purpose-grown biomass with and without BECCS

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Abstract

Climate mitigation scenarios limiting global temperature increases to 1.5 °C rely on decarbonizing vehicle transport with bioenergy production plus carbon capture and storage

(BECCS), but climate impacts for producing different bioenergy feedstocks have not been directly compared experimentally nor for ethanol vs. electric light-duty vehicles. A field experiment at two Midwest U.S. sites on contrasting soils revealed that feedstock yields of seven potential bioenergy cropping systems varied substantially within sites but little between. Bioenergy produced per hectare reflected yields: miscanthus > poplar > switchgrass > native grasses ≈ maize stover (residue) > restored prairie ≈ early successional. Greenhouse gas emission intensities for ethanol vehicles ranged from 20 to -179 g CO_2e MJ^{-1}: maize stover >> miscanthus ≈ switchgrass ≈ native grasses ≈ poplar > early successional ≥ restored prairie; direct climate benefits ranged from ~80% (stover) – 290% (restored prairie) reductions in CO_2e compared to petroleum, and were similar for electric vehicles. With CCS, reductions in emission intensities ranged from 204% (stover) – 416% (restored prairie) for ethanol vehicles, and from 329 – 558% for electric vehicles, declining 27% and 15%, respectively, once soil carbon equilibrates within several decades of establishment. Extrapolation based on expected U.S. transportation energy use suggests that, once CCS potential is maximized with CO_2 pipeline infrastructure, negative emissions from bioenergy with CCS for light-duty electric vehicles could capture >900 Tg CO_2e yr^{-1} in the U.S. In the future, as other renewable electricity sources become more important, electricity production from biomass would offset less fossil-fuel electricity, and the advantage of electric over ethanol vehicles would decrease proportionately.

Methods

Data collected as described in materials and methods.

Usage Notes

See the readme file for a description of data in "dataset_gelfand_es&t.xlsx". The file "calculations_gelfand_es&t.xlsx" shows the assumptions, calculations, and extrapolations of these data and their location in the paper and supplemental information.

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References

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Keywords

soils, Carbon capture and storage, Bioethanol, Fossil fuels, biomass

Files

3 files for this dataset

calculations_gelfand_est.xlsx	61.49 kB	application/vnd.openxmlformats-officedocument.spreadsheetml.sheet
dataset_gelfand_est.xlsx	155.75 kB	application/vnd.openxmlformats-officedocument.spreadsheetml.sheet
readme_gelfand_est.txt	4.06 kB	text/plain

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