Comparative Analysis of Biomass-Based and Direct Air Capture-Based Technologies for Decarbonization

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Background

The temperature target outlined in the Paris Agreement requires the achievement of a decarbonized society. The transportation and industry sectors are difficult to reduce through electrification, and addressing the emissions from these sectors is a challenge to achieving a decarbonized society. Technologies using biomass and direct air capture (DAC) are expected to play an important role in addressing these difficult-to-abate sectors.

Objective

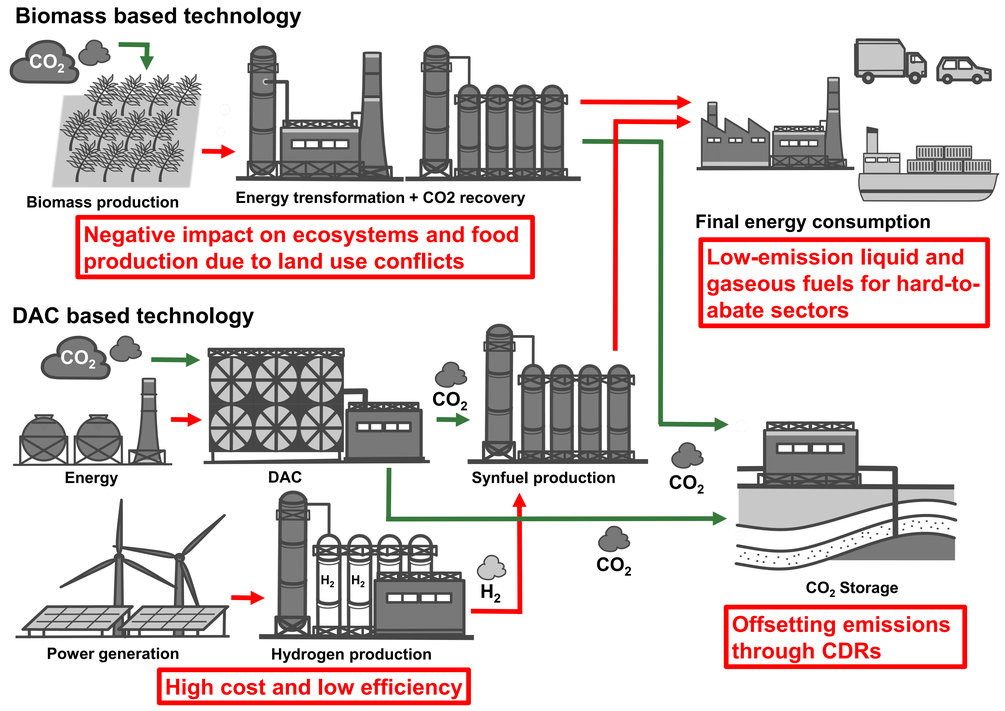
To provide information on developing decarbonization policies considering sustainability, we quantify the differences between biomass and DAC based technologies as a way to address hard-to-abate sectors, in terms of energy, economics, and land use.

Method

We modeled CO2 recovery by DAC, CO2 storage, and CO2 utilization for fuel production In the AIM/Hub, and a mitigation scenario realizing the 1.5-degree Celsius target is estimated.

Two technology constraint scenarios are set up to compare the biomass-based technology with the DAC based technology to address hard-to abate-sectors.

Biomass and DAC based technologies for emission reduction



Overview of the method

Scenario	Emission	Technology
Baseline	-	-
1.5C_BIO	1.5C	2nd gen Biofuel・Biomass electlicity generation(w/woCCS)
1.5C_DAC	1.5C	DACCS・Synfuel (Liquid and gas)

AIM/Hub model (CGE)

Three sectors are modeled based on Keith et al. (2018), IEA(2019)

- DAC
- CO_2 Storage
- Synfuel production (Gas・Liquid)

Result

Two technology scenarios are compared

- Energy system
- Household consumption
- Landuse change
- Commodity price

Conclusion

We compared two mitigation scenarios to achieve the 1.5-degree target. One used biomass-based technologies and another used DAC-based technologies. Results show that DAC based technologies decrease household welfare, fossil fuel consumption and reliance on CO2 removal increases, while forest area increases and food prices decrease, compared to biomass based technologies.

These results indicate that the biomass-based technologies are more efficient from an energy and economic point of view. However, since the difference is small, the adoption of DAC as an alternative technology can be considered as an option considering food production and ecosystems.

Reference: 1) Keith et al., A Process for Capturing CO2 from the Atmosphere, Joule, Vol.2(8), pp.1573–1594, 2018. 2) IEA, CCUS in Clean Energy Transitions, IEA, 2020. 3) Fuhrman et al., Food–energy–water implications of negative emissions technologies in a +1.5 ° C future, Nature Climate Change 2020 10:10, Vol.10(10), pp.920–927, 2020.

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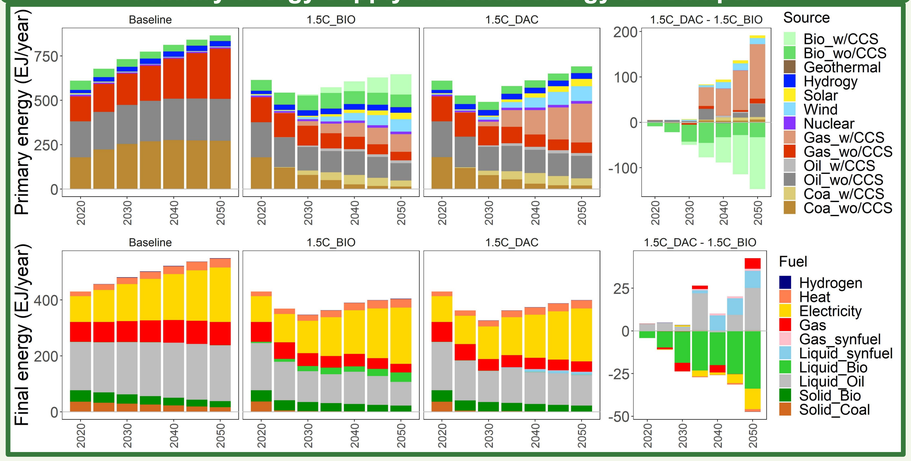
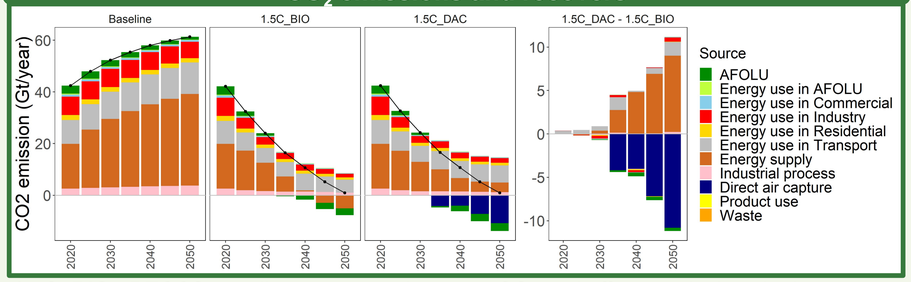
Result

Primary energy supply and Final energy consumption



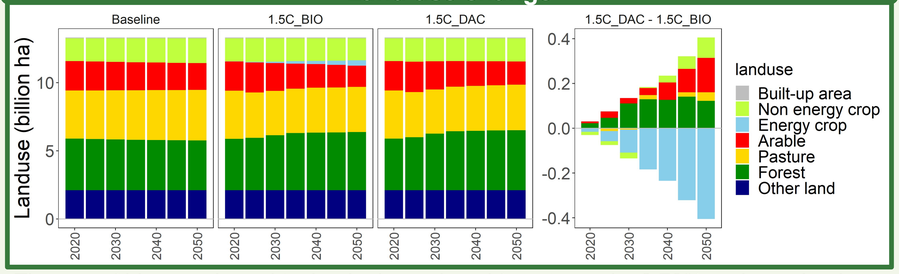
1.5C_BIO: Biomass supplies 185 EJ and 34.1 EJ of biofuels consumed in 2050.
1.5C_DAC: DAC consumed 101 EJ and 11.2 EJ of synthetic fuels were produced in 2050.

CO_2 emissions and recovers



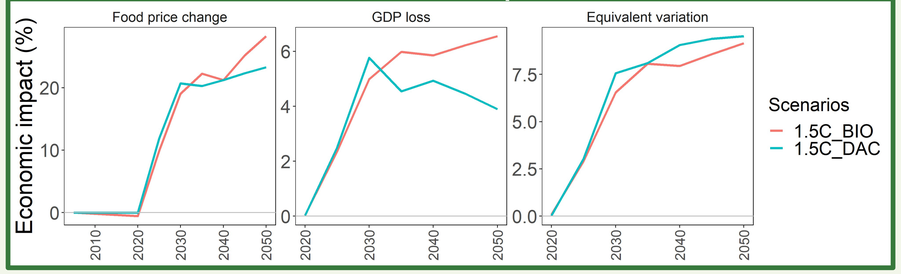
1.5C_BIO: BECCS supplies energy and capture CO_2 and offsets emissions in the industry and transportation sectors.
1.5C_DAC: DACCS removes 10.8 Gt CO_2 in 2050, offsetting emissions in the energy supply, industry, and transportation sectors

Land use change



The use of biomass-based technologies reduced forest area by 2.79% and crop land area by 7.19% in 2050 compared to the use of DAC.

Economic impact



The use of biomass-based technology increased the GDP loss by 68.6% and food prices by 3.99%, while the level of household welfare, increased by 4.05%.