Paper critique

The role of direct air capture and negative emissions technologies in the shared socioeconomic pathways towards +1.5 ∘C and +2 ∘C futures

(Fuhrman et al. 2021.)

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Table of contents

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LETTER

The role of direct air capture and negative emissions technologies in the shared socioeconomic pathways towards +1.5 °C and +2 °C futures

Jay Fuhrman[1,2], Andres Clarens[2], Katherine Calvin[1], Scott C Doney[3], James A Edmonds[1], Patrick O'Rourke[1], Pralit Patel[1], Shreekar Pradhan[2], William Shobe[4] and Haewon McJeon[1,*]

[1] Joint Global Change Research Institute, University of Maryland and Pacific Northwest National Laboratory, College Park, MD, United States of America
[2] Department of Engineering Systems and Environment, University of Virginia, Charlottesville, VA, United States of America
[3] Department of Environmental Sciences, University of Virginia, Charlottesville, VA, United States of America
[4] Batten School of Leadership and Public Policy, University of Virginia, Charlottesville, VA, United States of America
[*] Author to whom any correspondence should be addressed.

E-mail: hmcjeon@pnnl.gov

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Supplementary material for this article is available online

1. Introduction
2. Methods
3. Results
4. Summary of the key findings
5. Critique

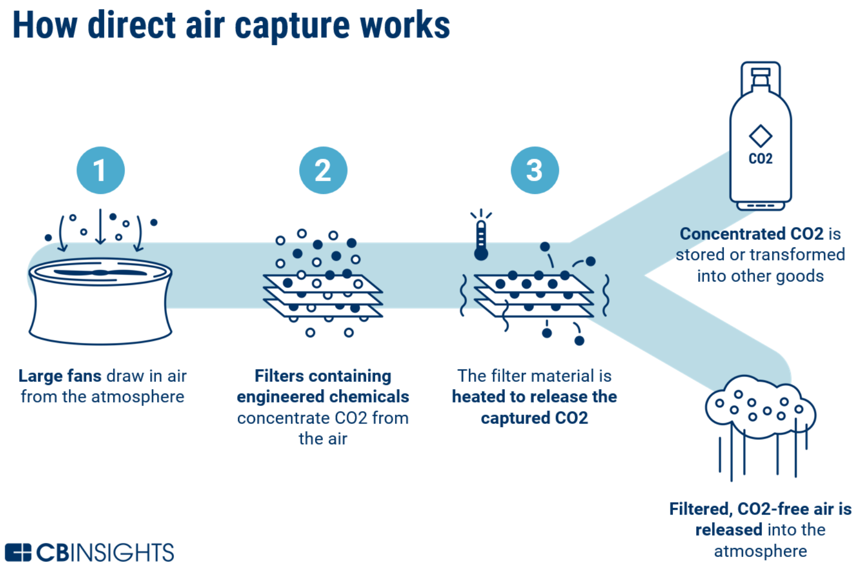
Introduction

- **DACCS as a viable negative emission technology**

  - Several forms of **direct air capture with carbon storage (DACCS)** are in development, with different costs and energy inputs, as well as potential for future cost and performance improvements.

  - Recent progress in **DACCS commercialization** suggests it could be a viable means of removing CO_2 in the near future.

  - DACCS has the advantage of **lower land intensity** than bioenergy with carbon capture or afforestation but requires **higher energy demands.**



Methods

- **Two types of DACCS technology are considered in GCAM 5.4**

  - Assess the **high-temperature** DACCS process that uses heat from **natural gas combustion, electricity, and water** could contribute to both ambitious near-term and delayed mitigation scenarios that limit end-of century warming to below +1.5 ∘C.

  - For **low-temperature DACCS**, this study converted the required low-temperature thermal energy to **electricity** by assuming an electric compression **heat pump** plant with a coefficient of performance equal to 3 and accounted for its additional levelized financial input.

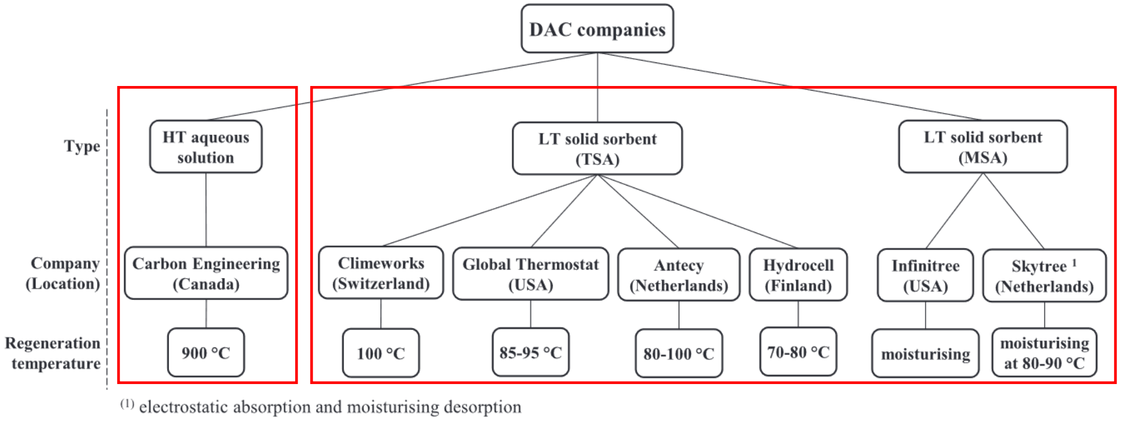


Fig. 1. Companies active in the field of CO_2 DAC. Abbreviations: high temperature, *HT*, low temperature, *LT*, moisture swing adsorption, *MSA*, temperature swing adsorption, *TSA*.

Fasihi et al (2019)

Methods

- **Parametrizations for DACCS technologies**
  - This paper uses GCAM to understand the role of DACCS across **all 5 SSPs for the below 2 ∘C and below 1.5 ∘C** end-of-century warming goals.
  - For parametrizations, generally follow the detailed methodology of **Fasihi et al (2019).**

Table 1. Parametrizations for DACCS Technologies. Values are assumed to remain constant after 2030.

Technology	Scenario	Natural gas (GJ/tCO_2) 2020	Natural gas (GJ/tCO_2) 2030	Electricity (GJ/tCO_2) 2020	Electricity (GJ/tCO_2) 2030	Non-energy cost (2015 $\$/tCO_2$) 2020	Non-energy cost (2015 $\$/tCO_2$) 2030	Water (m^3/tCO_2) 2020	Water (m^3/tCO_2) 2030
High temp. DACCS (natural gas)	SSP1—sustainable development	8.1	5.3	1.8	1.3	$296	$185	4.7	
	SSP2—middle of the road		5.3		1.3		$185		
	SSP3—regional rivalry		8.1		1.8		$296		
	SSP4—inequality		5.3		1.3		$78		
	SSP5—fossil fueled development		5.3		1.3		$78		
High temp. DACCS (fully electric)	SSP1—sustainable development	—		6	5	$384	$186	4.7	
	SSP2—middle of the road				5		$186		
	SSP3—regional rivalry				6		$384		
	SSP4—inequality				5		$101		
	SSP5—fossil fueled development				5		$101		
Low temp. DACCS (electric heat pump)	SSP1—sustainable development	—		5.5	2.5	$402	$235	—	
	SSP2—middle of the road				2.5		$235		
	SSP3—regional rivalry				3.8		$402		
	SSP4—inequality				2.5		$137		
	SSP5—fossil fueled development				2.5		$137		

Results

- **Main results**

  - DACCS could play up to tens of $GtCO_2$ yr^{-1} role in many of these scenarios, particularly those with **delayed climate policy** and/or **higher challenges to emissions mitigation**.

  - Provides 4 different results for different SSP scenarios and target temperature goals.

    - Positive and negative CO_2 emissions by sector

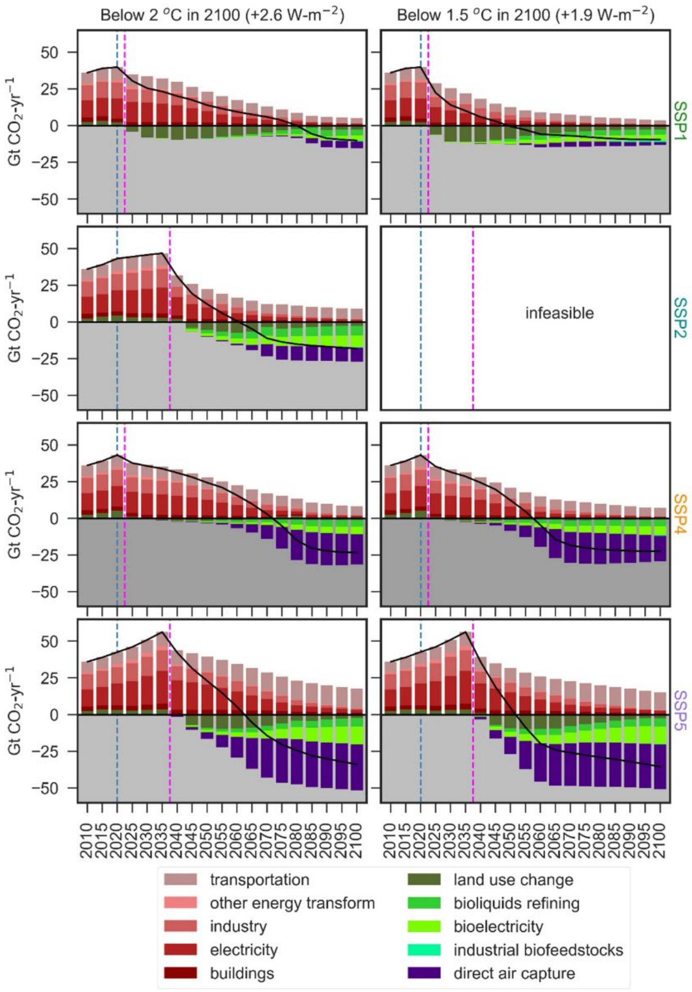
    - Primary energy consumption

    - Global land use

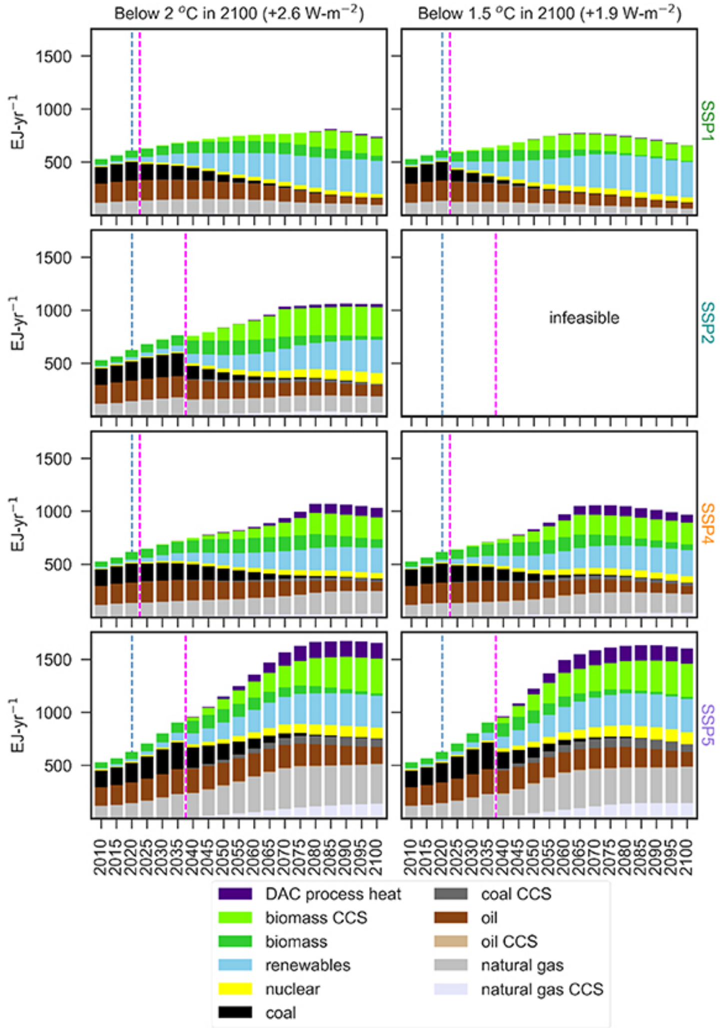
    - Water use

Results

- Positive and negative CO2 emissions by sector

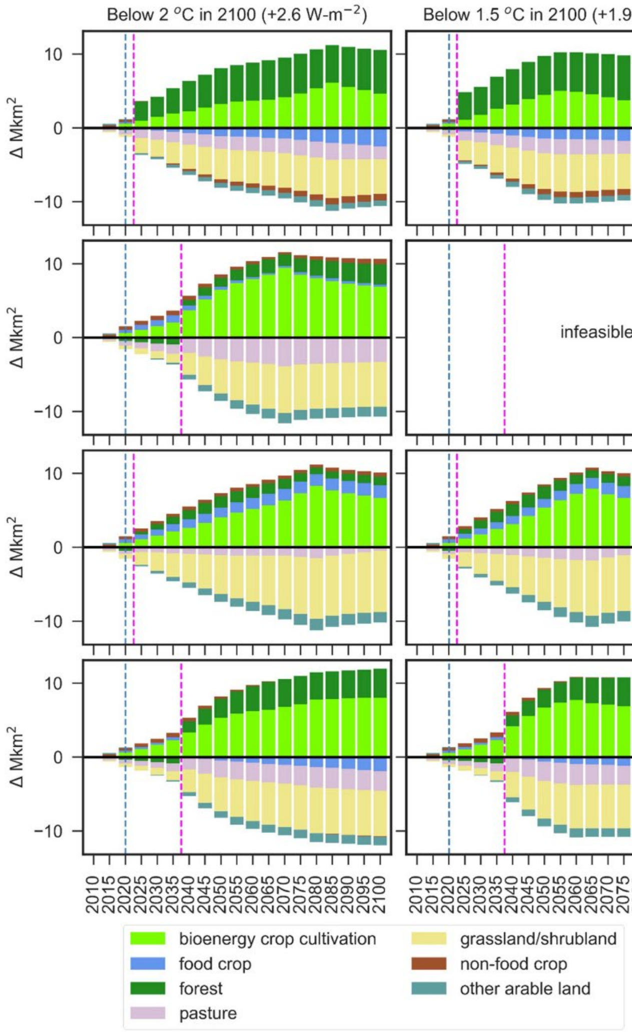


- Primary energy consumption

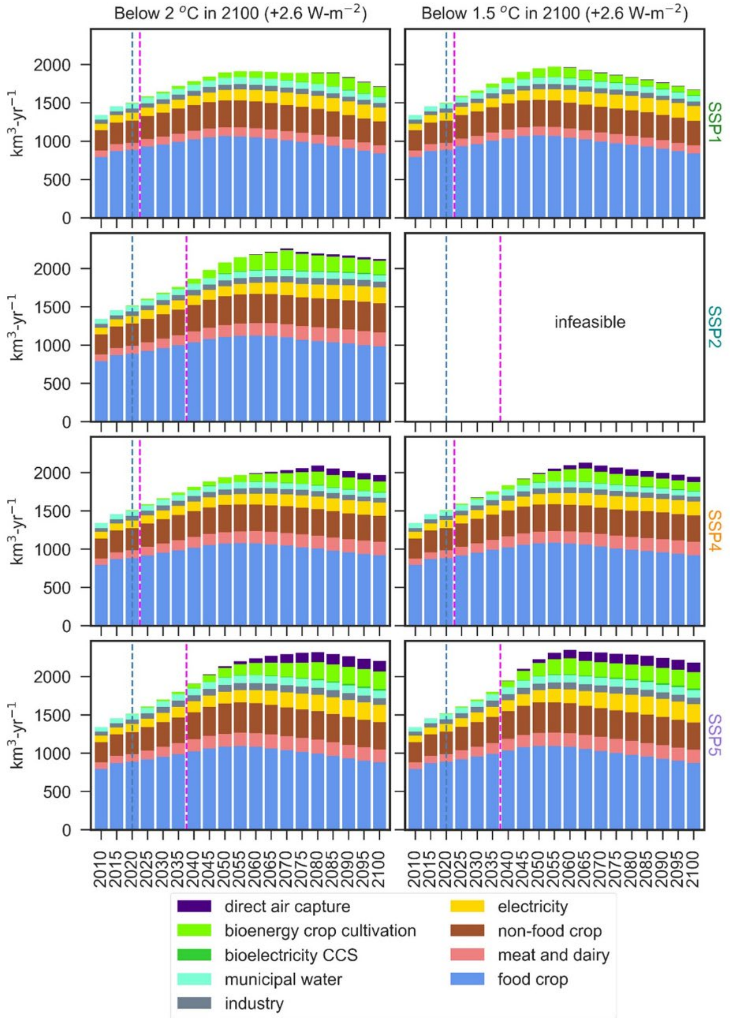


Results

- Global land use



- Water consumption



Summary of the key findings

- ## Comparative summary
  - The **SSP1- 1.5 ∘C -DACCS scenario** shows the least overshoot of the +1.5 ∘C goal.
  - DACCS could play **a large role in mitigation and reduce the sharpest tradeoffs** of land and irrigation-intensive negative emissions deployments.

Table 2. Comparative summary of DACCS and no-DACCS scenarios.

		SSP1		SSP2	SSP4		SSP5	
	Scenario	2 °C	1.5 °C	2 °C	2 °C	1.5 °C	2 °C	1.5 °C
Peak temperature, °C (year of peak)	DACCS	1.89 (2075)	1.63 (2045)	2.07 (2060)	2.15 (2075)	1.96 (2060)	2.26 (2075)	2.12 (2055)
	No-DACCS	1.87 (2075)	1.65 (2045)	2.02 (2055)	2.03 (2070)	1.80 (2055)	2.07 (2055)	—
2050 gross CO_2 removal ($GtCO_2\ yr^{-1}$)	DACCS	9.1	13	10	3.6	8.5	17	27
	No-DACCS	8.7	11	12	4.2	8.9	21	—
2050 CCS deployment ($GtCO_2\ yr^{-1}$)	DACCS	5.6	8	9.8	5.7	14	15	30
	No-DACCS	2.9	6.5	12	7.9	17	21	—
2050 primary energy consumption ($EJ\ yr^{-1}$)	DACCS	737	716	834	803	831	1150	1225
	No-DACCS	735	711	835	783	817	1088	—
2050 water consumption for bioenergy + DACCS ($km^3\ yr^{-1}$)	DACCS	70	121	151	78	127	144	225
	No-DACCS	71	107	182	104	202	236	—
2050 land use for bioenergy crop cultivation (Mkm^2)	DACCS	3.2	4.5	6.5	4.1	5.4	5.3	6.7
	No-DACCS	3.2	4.1	7.4	5.2	8.7	8.4	—
First year of global CO_2 pricing (exogenously assumed)		2025		2040	2025		2040	
Initial CO_2 emissions price (2020 $/tCO_2$)	DACCS	51	110	118	36	58	87	118
	No-DACCS	53	98	98	56	101	160	—
DAC deployment in 2030 ($MtCO_2\ yr^{-1}$)	DACCS	3	14	—	90	180	—	—
DAC deployment in 2050 ($GtCO_2\ yr^{-1}$)	DACCS	0.01	0.4	0.24	0.68	4.2	4.7	12
Peak DAC y/y scaling rate after first reference plant	DACCS	24%	25%	97%	14%	20%	68%	102%

Summary of the key findings

- **Strengthened near-term policy ambition is needed**

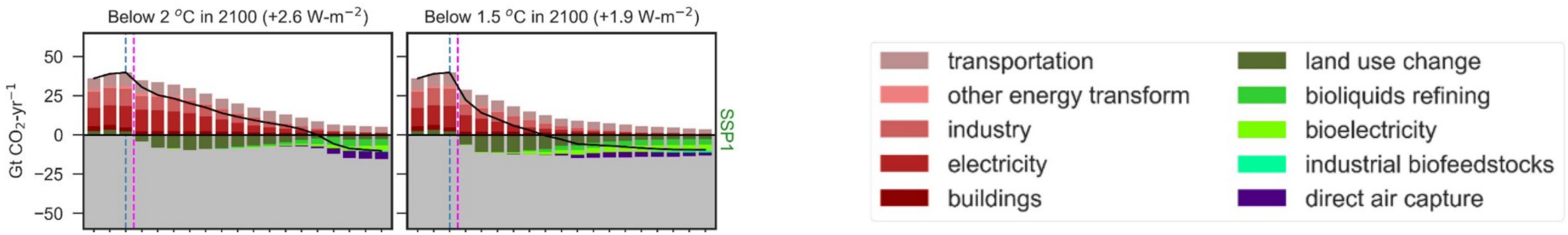
  - **SSP1 scenario is the only one of the below +2 ℃ scenarios** that did not temporarily overshoot this warming target, and all scenarios temporarily overshot the +1.5 ℃ target.

  - This highlights **the importance of strengthened near-term policy ambition** in case negative emissions prove unable to scale up quickly enough to reverse the overshoot of a less ambitious goal.

  - Given the emerging emphasis on DACCS in deep negative emissions scenarios, this study propose that the **IAM community more fully integrate DACCS into future SSP scenarios** such that opportunities to reduce reliance on future negative emissions can be highlighted.

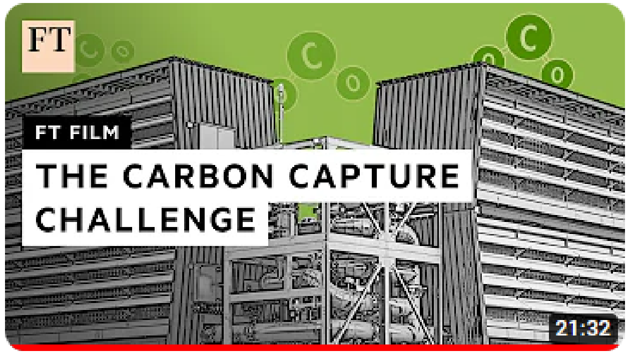
Critique

- I suggest 3 strengths and 1 weakness of this research as critique
  - **Comparative summary** allows us to see clearly the main results of the research.
  - The data that support the findings of this study are available online, so **GCAM modeler and other IAM communities can easily access the configuration of the analysis.**
  - **Urge people to avoid the risks of delaying mitigation policies** and thus further deepening the reliance on large-scale negative emissions, or else failing to meeting the goals of the Paris Agreement.
  - **Some figures can be stylistically improved**, such as a color scheme for legend properties or using different plots to show what the authors want to point out.



Thank you for listening

For those who wants know more about carbon capture



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