Facts and Data About Carbon Capture, Direct Air Capture, and Blue Hydrogen

Mark Z. Jacobson
Stanford University

California Joint Leg. Session
Sacramento, California
May 31, 2022

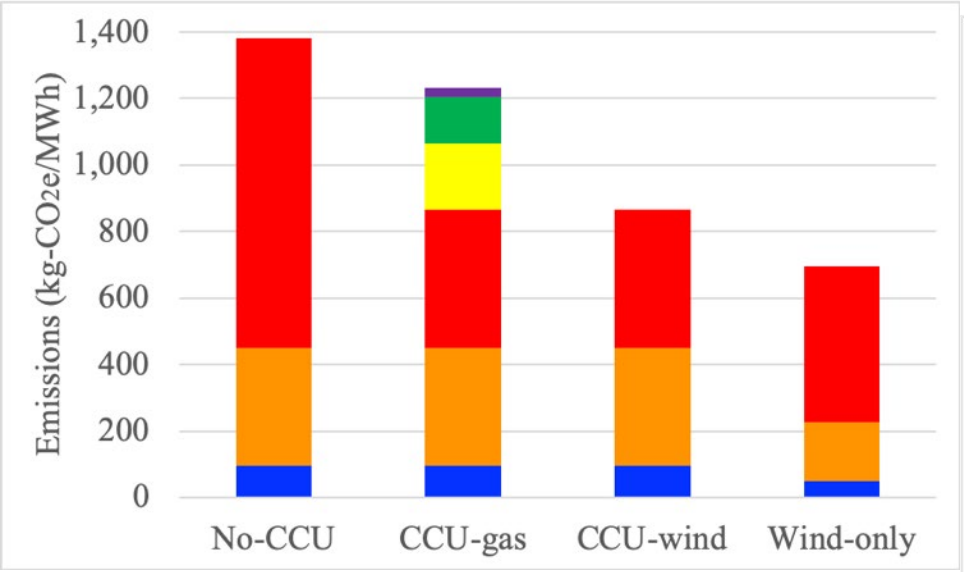
Why Not Carbon Capture?

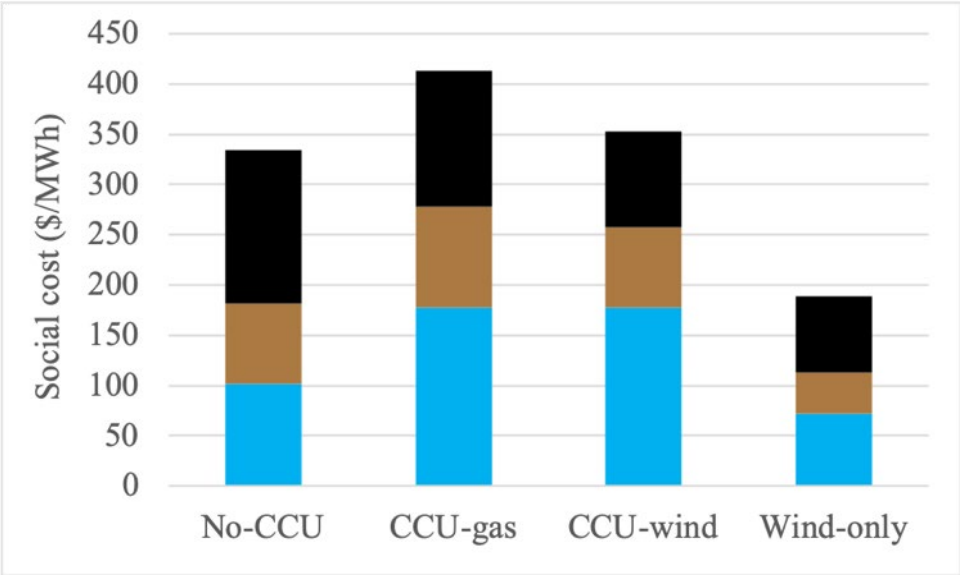
Coal Plant With CCU Powered by Natural Gas

Units: kg-CO_2e/MWh	20 yr	100 yr
a) Upstream CO_2 and leaked CH_4 from coal	450	237
b) CO_2 from stack	931	931
c) CO_2 captured from stack by equipment	516	516
Percent of stack CO_2 captured (c/b)	**55%**	**55%**
CO_2e emitted by natural gas mining+combustion	367	283
e) Captured CO_2e not returned to air by natgas (c-d)	149	233
Percent CO_2e reduction realized e/(a+b)	**10.8%**	**20%**

CCU attached to coal plant reduces only 11-20% of CO_2e it is expected to over 20-100 y

Change in CO_2e and Social Cost in 3 CCU Cases





1st case coal-No-CCU; 2nd: Coal-CCU powered by natural gas;

3rd : Coal-CCU powered by wind; 4th: replace coal with wind

Blue=upstream coal non-CH_4 CO_2e; Orange=coal upstream CH_4 CO_2e; Red=coal CO_2; Yellow=nat gas CO_2;

green=Natgas CO_2e from CH_4 leaks; Purple=other natgas upstream CO_2e;

Light blue=elec+CCU cost; Brown=air pol cost; Black=climate cost

Summary of CCS/U

- Using natural gas to run coal-CCU reduces CO_2e only 11.8-20% over 20-100 years while increasing air pollution and mining 25% and incurring a CCU equipment cost

- Using wind to run coal-CCU reduces CO_2e only 34-44% while keeping air pollution and mining the same, while incurring equip cost

- Using same wind to replace coal reduces CO_2 emissions, air pollution emissions, and mining 49.7% and has no CCU equipment cost

Why Not Blue or Gray Hydrogen?

Efficient Applications of Green H_2

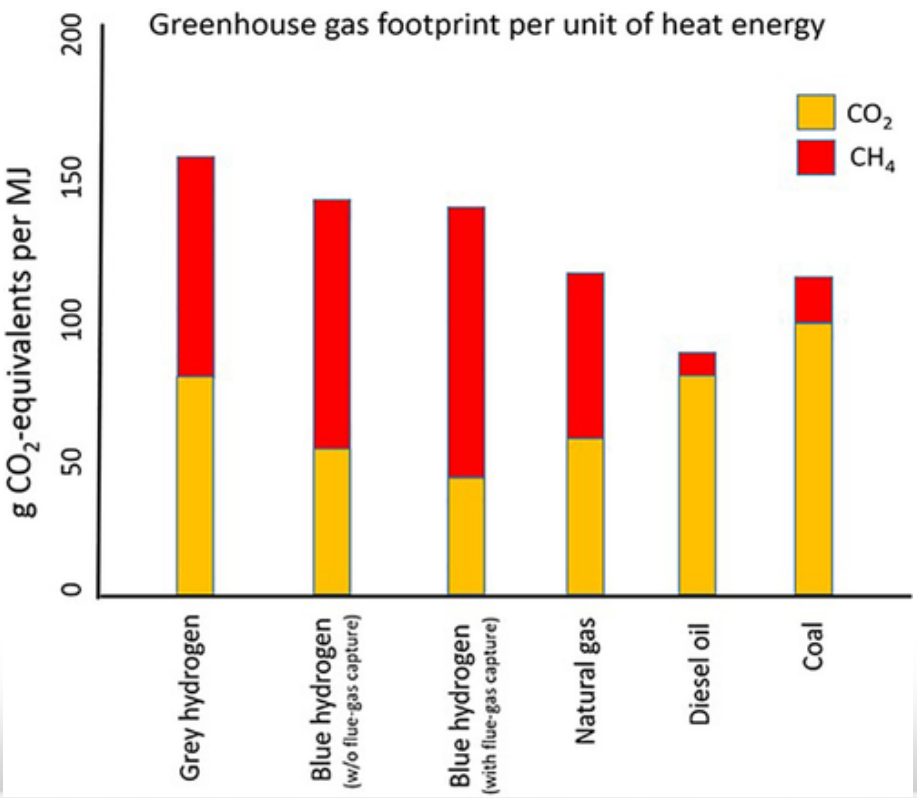
- Long-distance vehicles (airplanes, ships, trains, trucks, military vehicles)
- Steel production, some other industrial processes
- Electricity and heat in remote microgrids
- Not for stationary electricity storage, building heat, or passenger vehicles

Blue vs. Gray Hydrogen: Main Assumptions

- Use of steam methane reforming, SMR (vs. autothermal reforming, ATR)
- Leakage rate 3.5 (1.54 to 4.3)%
- Carbon dioxide capture rate for pure stream from SMR: 85 (78.8-90)%; flue gas: 65%
- 20-year GWP (100-year also examined)

Howarth and Jacobson (2021)

Base Case Results



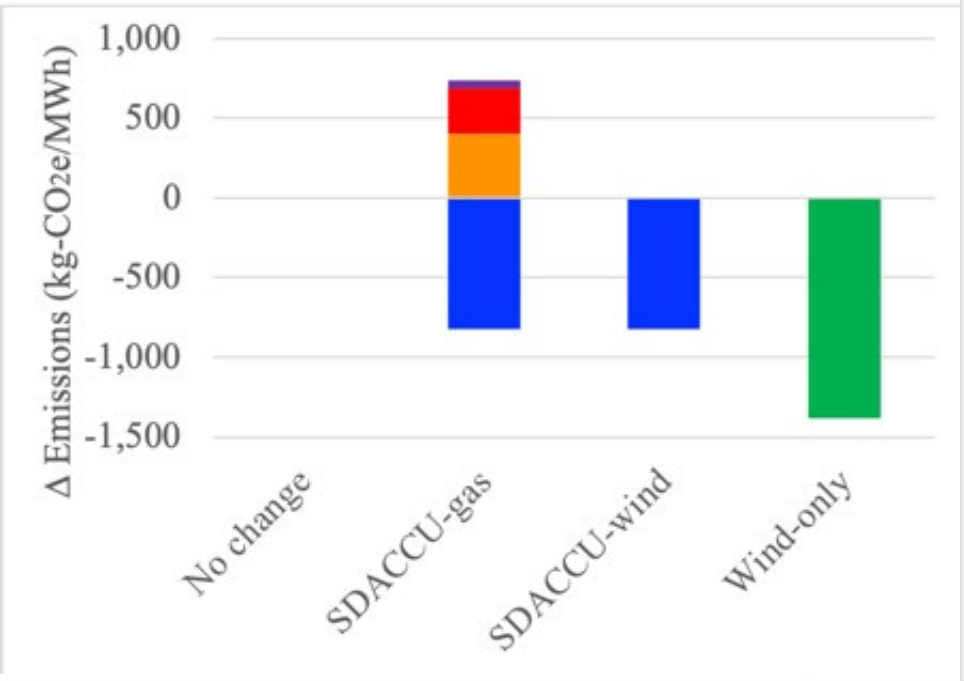
Why Not Synthetic Direct Air Carbon Capture and Storage?

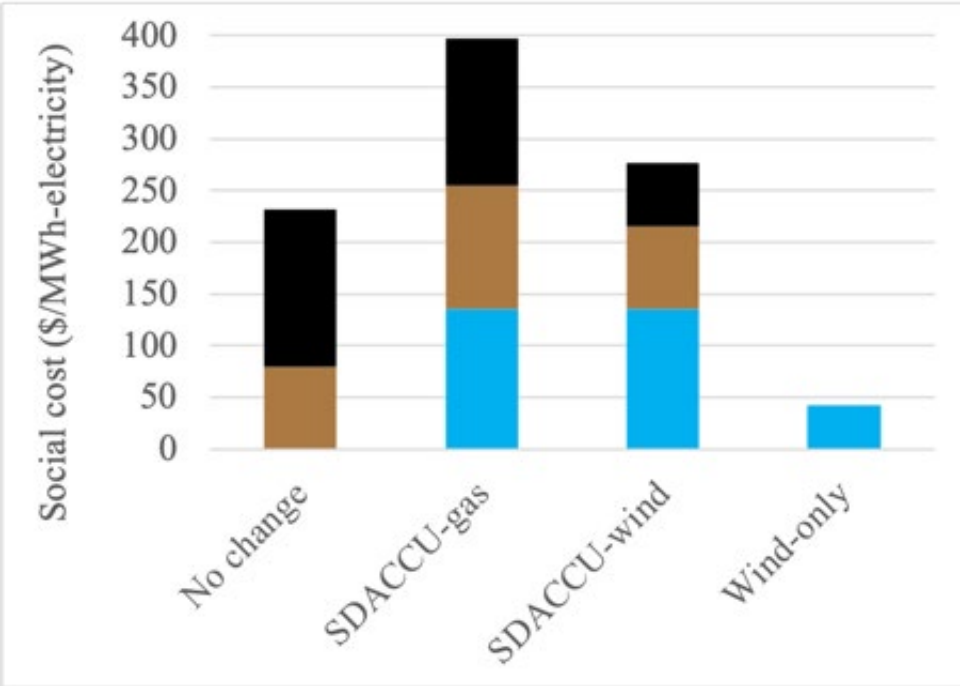
Direct Air Capture Powered by Natural Gas

Units: kg-CO_2e/MWh	20 yr	100 yr
a) CO_2 removed from air	825	825
b) CO_2e from natural gas upstream returned to air	334	165
c) CO_2 from natural gas combustion returned to air	404	404
d) Net CO_2e reduced due to natural gas (a-b-c)	87	256
Percent of removed CO_2e that stays removed (d/a)	11%	31%

→Natural gas-powered DAC reduces a net of only 11-31% of CO2e that is captured over 20-100 years.

Change in CO_2e and Social Cost in 3 DAC Cases





1st case: no change; 2nd: Use SDACCU powered by natural gas;

3rd : Use SDACCU powered by wind; 4th: replace coal with wind

Direct Air Capture is an Opportunity Cost

Preventing CO_2 from getting into air has the exact same impact as removing it

So, the social cost of DAC powered by fossils is 8x that of using renewables to replace fossils.

The social cost of DAC powered by renewables is ~6x that of using renewables to replace fossils.

When renewable replace fossils, they not only eliminate CO2, but they also reduce

a) non-CO_2 air pollutants from fossils
b) upstream fuel mining and pollution
c) pipeline, refinery, gas station, and other fossil infrastructure
d) oil spills, oil fires, gas leaks, gas explosions
e) international conflicts over energy

Conclusion

CCS/U, DAC, and blue H2 are all opportunity costs that increase air pollution, mining, infrastructure, carbon dioxide, and social costs relative to spending the same money on replacing fossil fuels with renewables.

Any government support for CCS/U, DAC, and blue H2 IS A FOSSIL-FUEL SUBSIDY that will keep the fossil-fuel industry in business.

Any non-subsidized cost of these technologies will be paid by ratepayers thus is a TAX ON RATEPAYERS

Book on 100% WWS

https://web.stanford.edu/group/efmh/jacobson/WWSBook/WWSBook.html

Paper on Carbon Capture and Direct Air Capture

https://web.stanford.edu/group/efmh/jacobson/Articles/Others/19-CCS-DAC.pdf

Paper: How Green is Blue Hydrogen

https://onlinelibrary.wiley.com/doi/full/10.1002/ese3.956

Twitter: @mzjacobson