Institute for Energy Economics and Financial Analysis

Debunking Myths about Carbon Capture and Blue Hydrogen Being "Clean"

Hydrogen Hubs Explained

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September 11, 2023

Conclusions

- Capturing ≥90% of carbon dioxide with carbon capture and storage (CCS) is unproven and a big gamble for solving climate crisis
- CCS also will be very expensive
- Making blue hydrogen from natural gas or coal will not be clean or low carbon
- Relying on both will keep the U.S. and rest of the world addicted to fossil fuels for decades and will lead to climate disasters even worse, likely much worse, than those experienced this summer
- Other means for reducing reliance on fossil fuels are proven and available now – wind, solar, storage, energy efficiency

What is CCS and why is it now such a big issue?

- CCS touted as a way to reduce emissions of CO_2 from hydrogen production facilities, fossil-fired power plants and certain large industries
- To do this all, or very nearly all, of the CO_2 produced by these facilities will have to be captured and this must be done for decades
- CCS doesn't include just one technology. Numerous methods are being studied.
- Studying CCS is a good idea - rapid implementation is not

Key questions about CCS

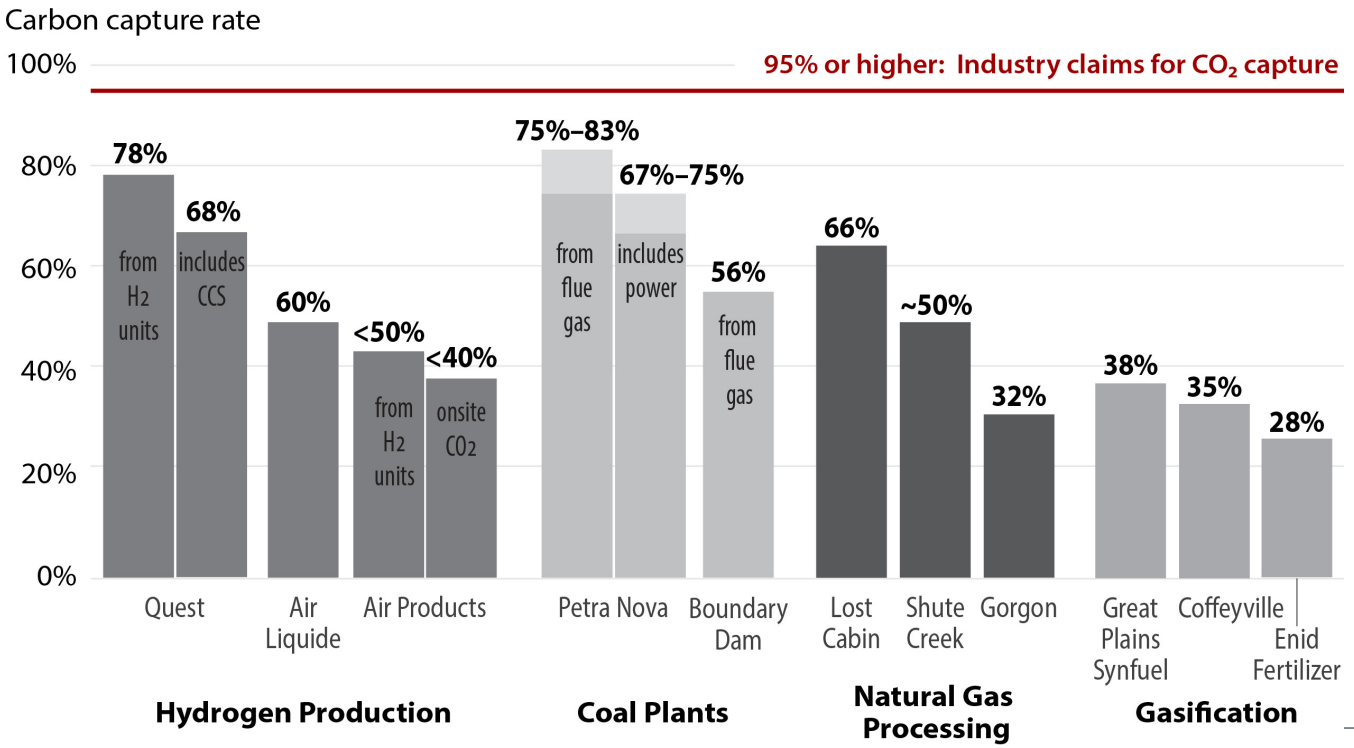
- How much of the CO_2 can CCS reliably capture?
- How effective will it be over the long-term?
- At what cost?

There is only limited very experience with carbon capture

CCS has been around for decades, but as of the end of 2022 there were only 27 carbon capture projects in the world – numerous projects have been cancelled or have failed

- Only one coal-fired power plant in the world capturing CO_2, and it's not doing it well.
- Second coal plant captured CO_2 for 40 months as part of a DOE demonstration project. Was then indefinitely mothballed - but current owner says it is intending to restart later this year
- No CO_2 has been captured at a commercial-size gas-fired power plant
- CO_2 has been captured from only a single steel plant (in Dubai) there is no public information on how well this worked. No plant that produces concrete has captured any CO_2
- Only 3 hydrogen production plants have captured CO_2 – none has captured more than 68% of the CO_2 it has produced.

Real-world experience shows CCS not as effective as proponents claim



On what do proponents base claims that ≥90% capture is feasible?

- Results of small-scale technology testing – e.g., the 2 now ongoing "large" pilot scale tests of CCS only targeting capturing ≤ 5% of the total CO_2 produced by 2 commercial-scale coal plants
- A test project described as 'game changer' for capturing CO_2 from gas power plants is designed to capture only 1% of CO_2 from large plant in CA
- Small-scale testing important but not definite proof that ≥90% capture can and will be achieved at commercial-scale projects for decades.
- Unsupported claims by the proponents/developers of CCS projects that have not yet been built and operated. Almost all of which are not yet under construction. And some that have not even been funded yet

On what then do proponents base claims that ≥90% capture is feasible?

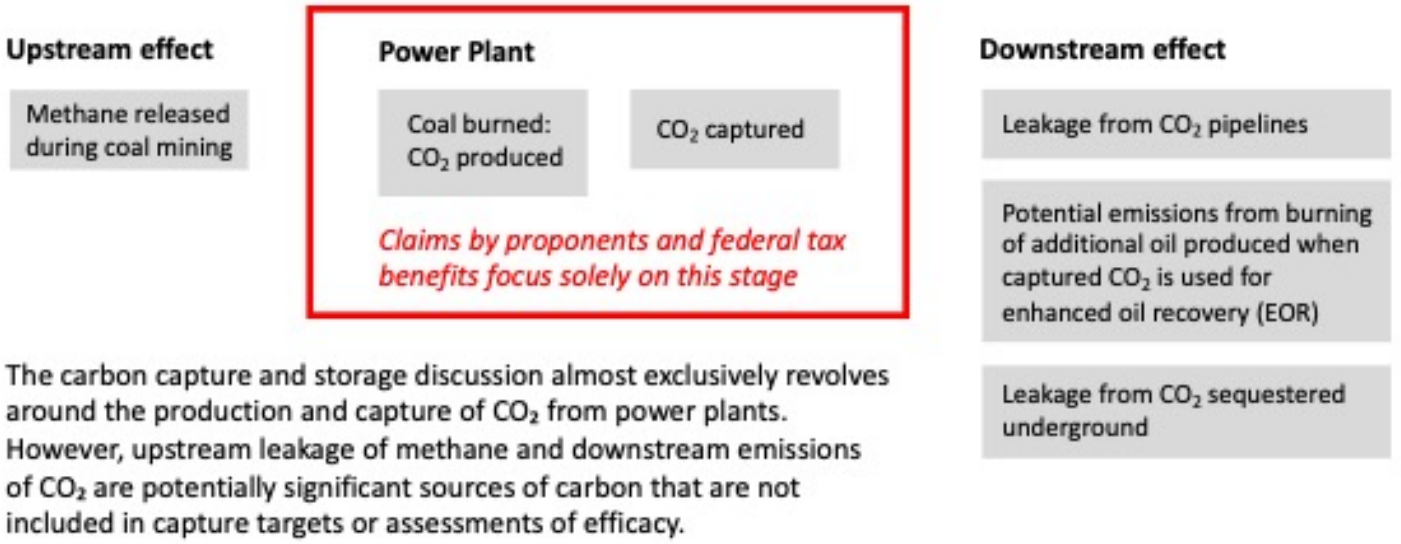
Exhibit 1-4. Hydrogen production with CCUS (operating and planned)

	Plant/Project Name	Location	H_2 Production kNm^3/hr (MMSCFD)	H_2 Production Platform	AGR Technology	Overall CO_2 Capture Rate (%)
Operating	Air Products Port Arthur [19]	USA	220 (200)	SMR	VSA	60
	Air Liquide Port Jerome [20]	France	50 (45)	SMR	Membranes, CRYOCAP™ H2	60
	Shell Quest [21] [22]	Canada	210 (191)	SMR	ADIP-X	50
Under Development	H-Vision	Netherlands	700 (636)	ATR	Rectisol™	88.0
	HyNet [23]	United Kingdom	100 (90)	ATR	TBD	97.2
	H21 [24] [25]	United Kingdom	3,200 (2,900) from 9 units	ATR	aMDEA	94.2
	Acorn [26]	Scotland	53 (48)	ATR	Amine	98.7
	H2Teesside [27]	United Kingdom	275 (250)	TBD	TBD	98
	Air Products Alberta [28]	Canada	>695 (>623)	ATR	TBD	95
	Air Products Louisiana [29]	USA	>837 (>750)	ATR/POX	TBD	95

Existing

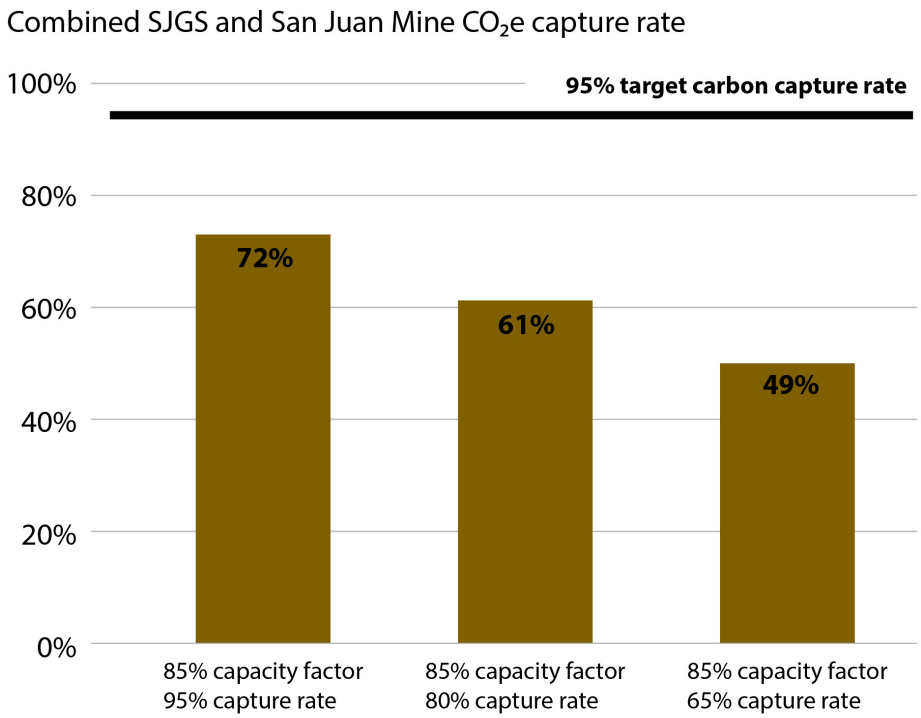
Not yet in operation. Most not even under construction

It is important to consider the entire life cycle of a proposed hydrogen or power plant project with carbon capture



The carbon capture and storage discussion almost exclusively revolves around the production and capture of CO_2 from power plants. However, upstream leakage of methane and downstream emissions of CO_2 are potentially significant sources of carbon that are not included in capture targets or assessments of efficacy.

It is important to consider the entire life cycle of a proposed hydrogen or power plant project with carbon capture



What's been done so far with captured CO_2?

- ~75% of captured CO_2 has been used for Enhanced Oil Recovery (EOR) to produce additional oil that might not otherwise be economical or technically possible to get
- Using captured CO_2 for EOR is a really bad idea
- On average each ton of CO_2 produces 2 to 4 barrels of oil
- When burned, each of these barrels of oil might produce 0.44 tons of CO_2
- As a result, EOR may mean no net reductions in CO_2 emissions – actually could mean higher CO_2 emissions
- Injecting captured CO_2 also produces earthquakes in some areas

Permanent underground storage of captured CO_2 not guaranteed not to leak or work as planned

- Two projects in Norway are presented as prime examples of how CCS works
- But recent IEEFA study shows that even these projects haven't worked as planned
- Despite extensive and expensive state-of-the-art modeling of underground geology, some of the captured CO_2 has gone where no one expected it would be
- Could be a big problem – injected CO_2 could leak into atmosphere
- Maybe nothing could be done after CO_2 injected underground

Adding CCS to existing plants will take years and will be expensive

- Designing, constructing and connecting a carbon capture facility to a power plant or industry plant will take years
- Adding carbon capture may not be possible at all plants and might require major changes at others
- No one-size or one-design-fits-all for carbon capture facilities
- Not like going to a Home Depot and being told that carbon capture equipment is on aisle 10 - they will have to be designed to fit the space and the layouts of existing plants
- No one should expect to see an operating CCS retrofit or a new plant with CCS until 2028 or later – and still won't know if it operates as projected for years after that
- Estimated cost of $2 billion to retrofit 457 MW coal plant in North Dakota

Blue Hydrogen

Background

- Bipartisan Infrastructure Law (2021) include billions in funding and to establish hydrogen hubs
- DOE has refused to make the applications for funding of regional hubs available to the public
- Inflation Reduction Act (2022) contains tens of billions of additional production subsidies for producing clean hydrogen and CCS

What is blue hydrogen?

- Money from the BIL and the IRA will fund the production of hydrogen from fossil fuels (blue H_2), renewables (green H_2),and nuclear (pink H_2)
- Blue hydrogen would be produced from the methane in natural gas, coal, or maybe renewable natural gas
- Would be combined with the capture of all, or almost all, of the CO_2 created during the production process
- BIL and IRA will mean extended life for fossil fuel facilities and huge profits from government subsidies for the fossil fuel industry

What counts as “clean”?

The IRA and the DOE have established a Federal **Clean Hydrogen Production Standard (CHPS) that defines “clean” hydrogen as that having a life cycle carbon intensity of ≤4.0 of kilograms (kg) of carbon dioxide equivalents (CO_2e) released into the atmosphere per kilogram of hydrogen produced**

But DOE says it will fund projects even if they don’t meet this standard

What then is the purpose of having a standard?

What evidence do proponents have to prove blue hydrogen will be clean and low-carbon?

- **Not much**
- Proponents mostly just repeat the words “hydrogen,” “clean” and/or “low-carbon” as often as possible
- GREET emission model, developed by DOE, is sometimes used to show it is possible to produce hydrogen from a variety of fuels, including methane and coal, that will have carbon intensities that meet the federal CHPS
- But this only true for limited set of very favorable assumptions

Can blue hydrogen meet the “clean” standard?

- We studied default assumptions built into the DOE’s GREET model
- Found many default assumptions are not realistic
- Reviewed scientific literature and other publications to determine more realistic values for key parameters
- Modeled over 100 additional scenarios in GREET to examine whether the carbon intensity of blue hydrogen produced from natural gas could meet the CHPS standard

The only way blue hydrogen can meet the clean standard

- The only way that blue hydrogen can meet or beat the CHPS depends on an extremely favorable, **near-optimal, set of assumptions:**

1
Use of **100-year GWP** for methane and no GWP for hydrogen

2
Very low **methane emissions**

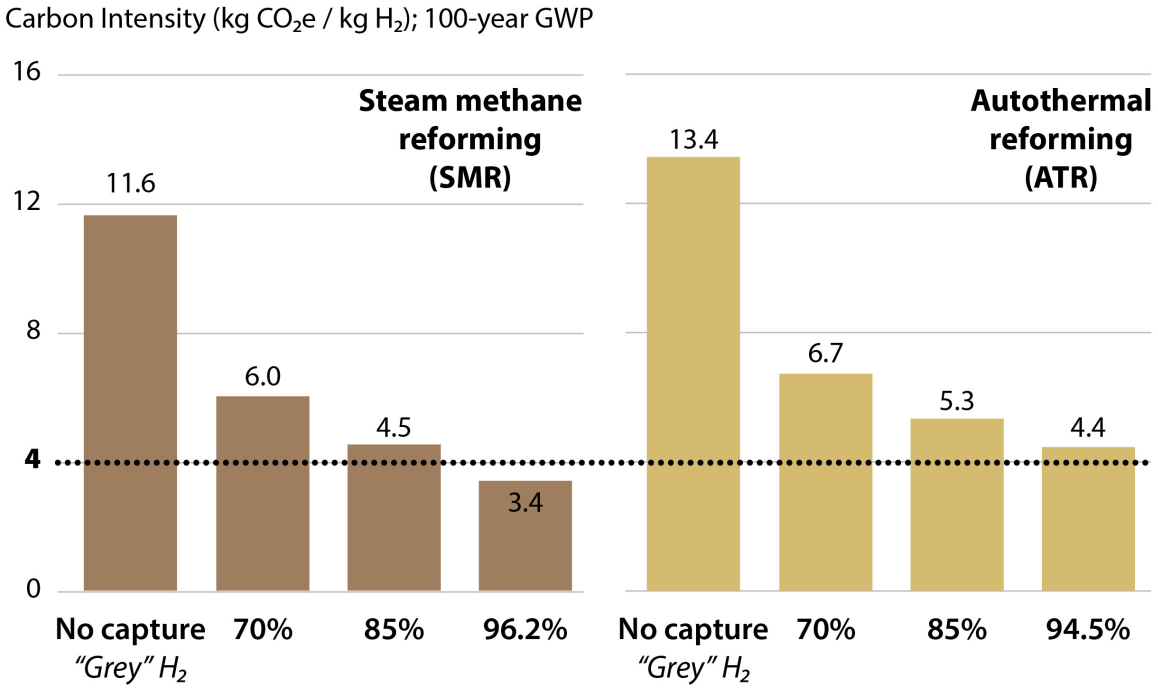
3
Nearly complete **CO_2 capture** in the production process

4
Exclusion of all downstream **hydrogen-related emissions**

Can CCS make blue hydrogen "clean" even with very favorable assumptions?

Not with ATR
Close with SMR

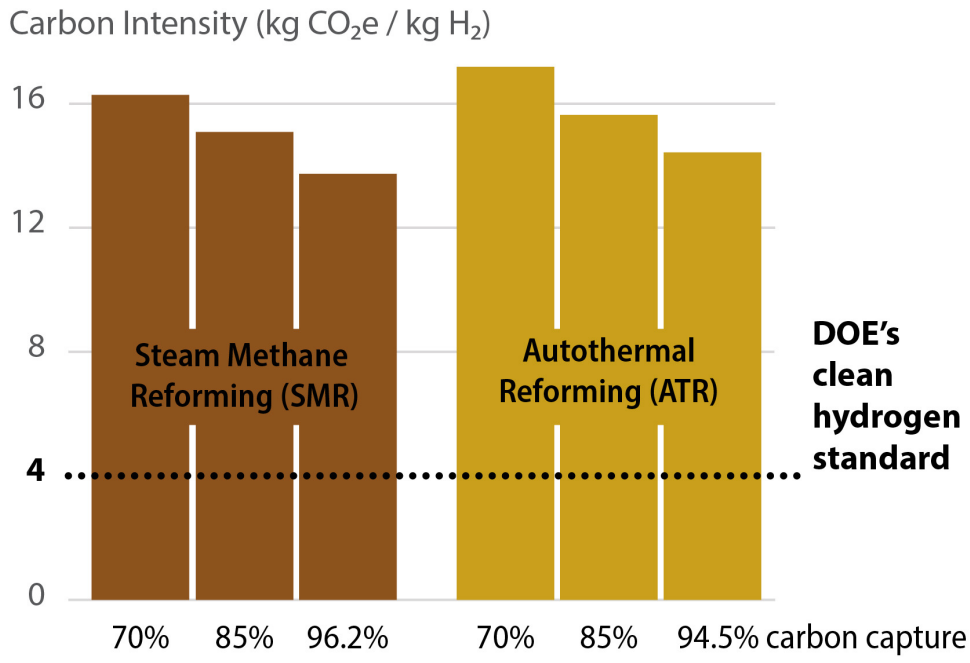
But DOE says it will fund blue H2 projects even if they're not clean under CHPS



With more reasonable assumptions blue H_2 is not clean or low-carbon, even with very high CO_2 capture rates

With higher **assumptions**, carbon intensity of blue hydrogen will be **three to four times** as high as the clean standard

Blue hydrogen is not clean or low-carbon and never will be



For More Information

- Contact David Schlissel at dschlissel@IEEFA.org
- IEEFA “Blue Hydrogen: Not clean, not low carbon, not a solution” report to be released September 12th
- Webinar at 1pm ET on September 14th
- Check out reports on blue hydrogen and CCS on IEEFA’s website
- Sign up with IEEFA to get new research from IEEFA available