Institute for Energy Economics and Financial Analysis

CCS: Performance & Cost Risks

David Schlissel, IEEFA Director of Resource Planning Analysis

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Key Messages

1. Carbon capture has been done for decades. But there have been expensive failures and wasted resources.

2. **Most importantly, there is no evidence that the existing and proposed technologies for capturing CO_2 at commercial scale will capture all or almost all of the CO_2 from a facility and will do so year-in and year-out for decades — that is what CCS must do to be an effective tool for decarbonization.**

3. The history of carbon capture began with the processing of natural gases which had high concentrations of CO_2 (~18%-53%). This made it easier to capture and less energy was needed. Today, new technologies are attempting to capture CO_2 from much less concentrated streams in other industries. For example, flue gases from an NGCC contain only 4%-7% CO_2.

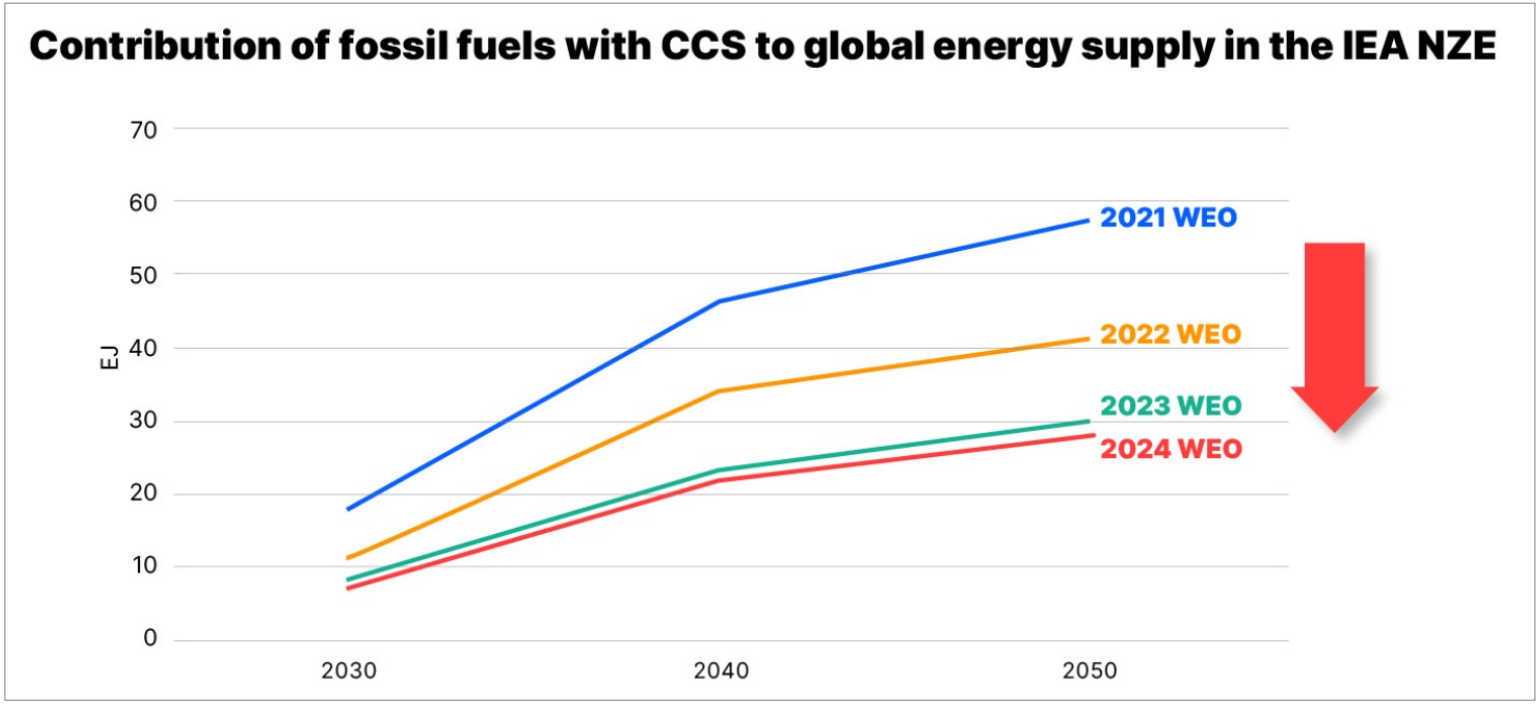
Key Messages

4. It is not true that using captured CO_2 for enhanced oil recovery is an effective means of decarbonization. EOR produces additional oil which, when burned or used as petrochemical feedstock, creates more CO_2.

5. Retrofitting fossil-fired generators for CCS and producing hydrogen from methane (natural gas) will consume large amounts of additional water.

6. The actual cost of capturing CO_2 will be far, far higher than currently expected.

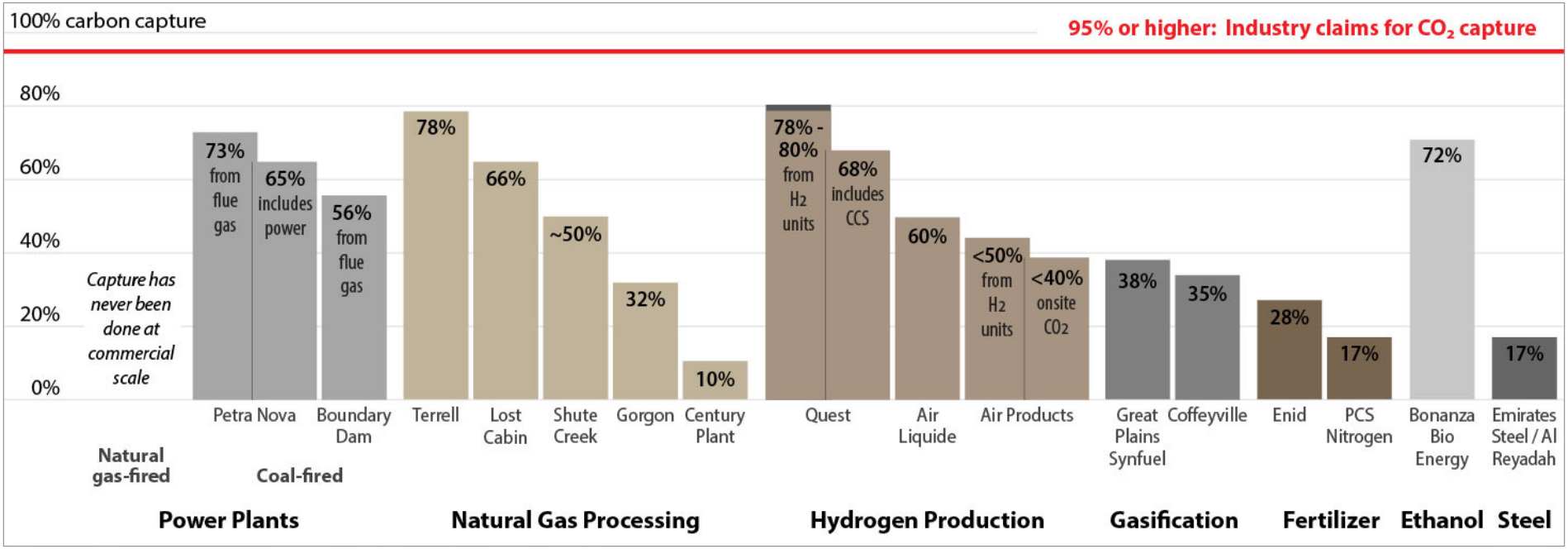
Expectations for How Much CCS Will Contribute to Decarbonization Are Going Down



Source: IEA, World Energy Outlook 2024 (added November 2024) 2023, 2022 & 2021, Net Zero Roadmap, Net Zero Roadmap – 2023 Update. (IEEFA)

Real-World CO_2 Capture

There's no evidence that existing commercial-scale CCS projects have captured anywhere close to 95% of the CO_2 they create year-in and year-out for decades.



Sources: Company reports, IEEFA analysis; updated November 2024.
Originally appeared in Blue Hydrogen: Not clean, not low carbon, not a solution.

Capture Data Highlights: Reality vs. Hype

On what evidence then do the government and CCS promoters decide that carbon capture facilities will achieve CO_2 capture rates ≤95%?

1. Literature reviews and discussions with project developers and capture technology vendors.

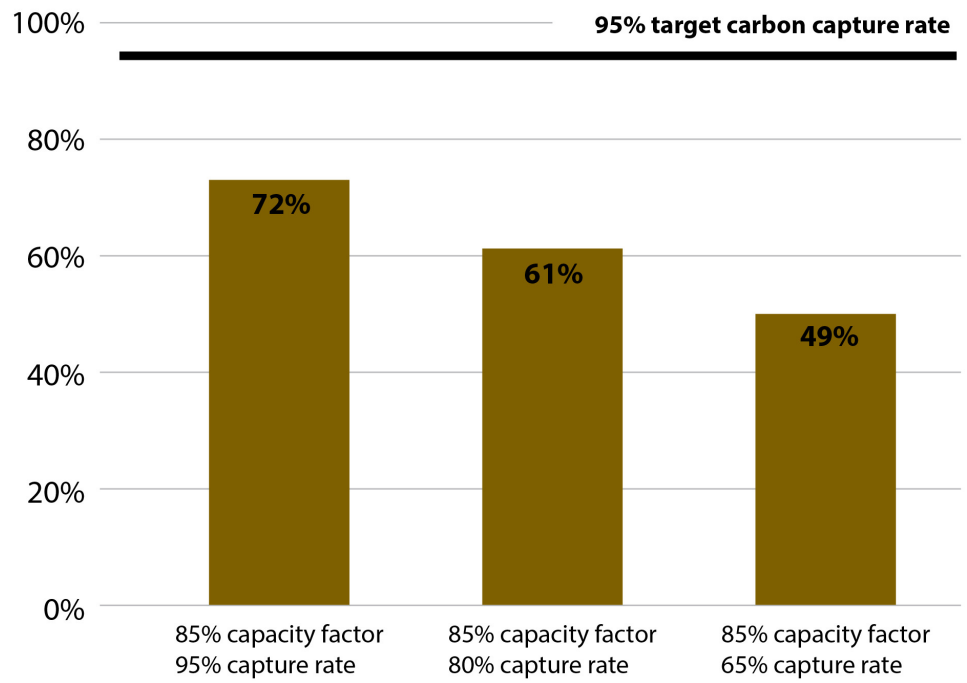
2. The results of small-scale testing of new and evolving capture technologies — on the order of 1%-5% of the CO_2 emissions from commercial-scale projects. ***Actual experience has shown that scaling up is a significant risk.***

W.A. Parish coal-fired power plant with Petra Nova carbon capture project. (Wikipedia.com)

Combined SJGS and San Juan Mine CO_2e Capture Rate

It is important to consider the entire life cycle of a proposed hydrogen or power plant project with carbon capture. This includes upstream CO_2e emissions

Not just the capture rate at the proposed facility.

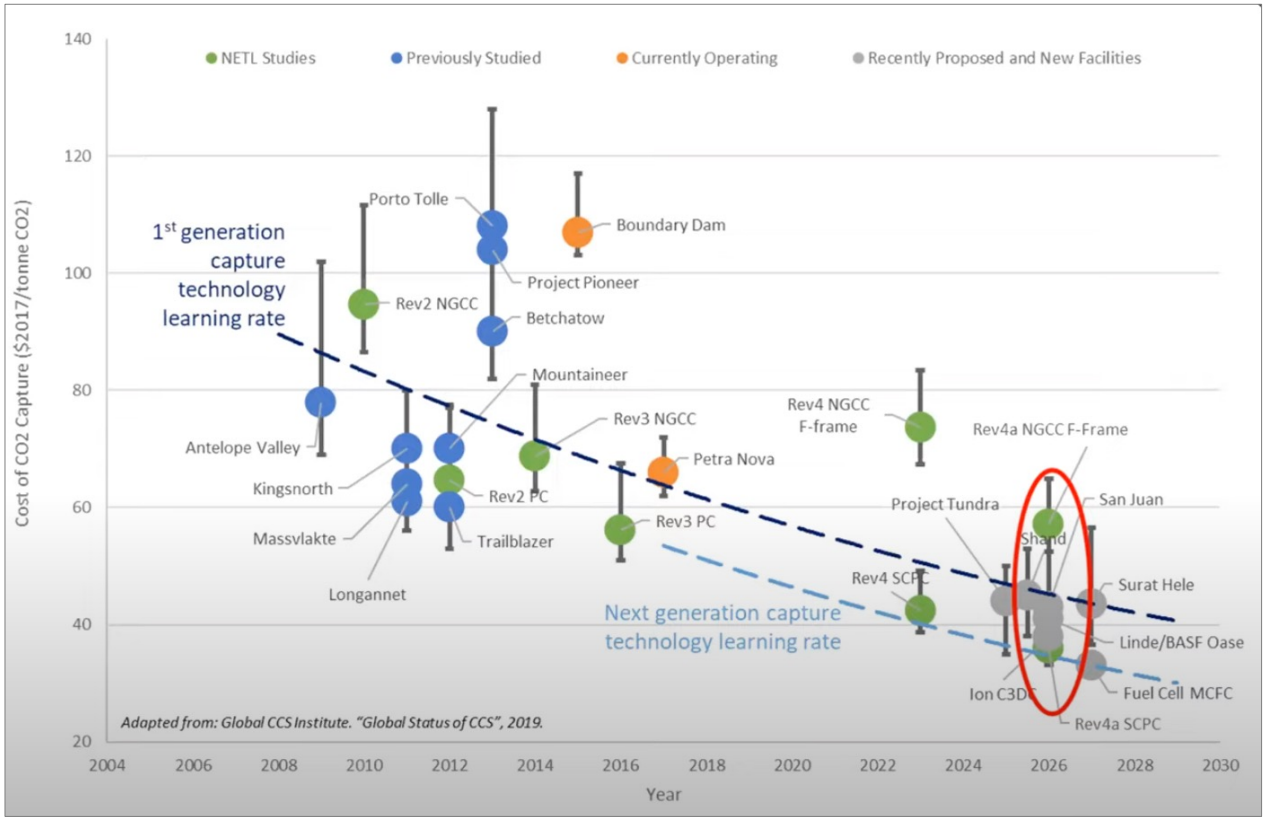


According to DOE:

1st generation capture projects (blue) had actual capture costs between $60 and $110 per tonne, in 2017 dollars.

Next generation projects (gray) anticipated to have capture costs about 50% lower than those 1st generation projects.

Early 2023 U.S. DOE CO_2 Capture Cost Projections



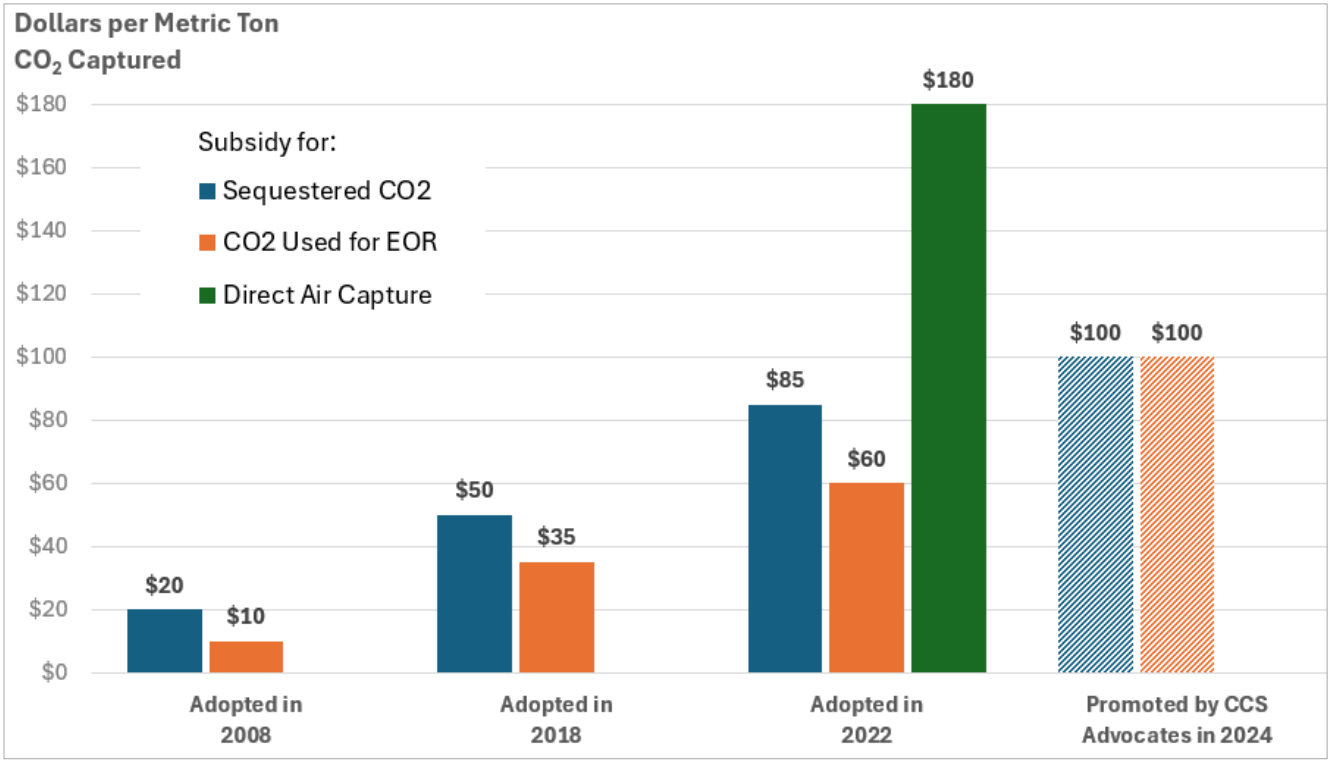
Source: US DOE Office of Fossil Energy and Carbon Management – NETL's Updated Performance & Cost Estimates, Power Generation Facilities Equipped w/Carbon Capture, February 2, 2023.

The Inflation Reduction Act (2022) increased 45Q tax credits significantly.

Despite huge increases, industry and advocates still think the subsidies for carbon sequestration and EOR are not enough to make it feasible financially.

CCS proponents are pushing for further increases in 45Q funding and parity between credits for permanently storing CO_2 and using it to extract more oil and gas.

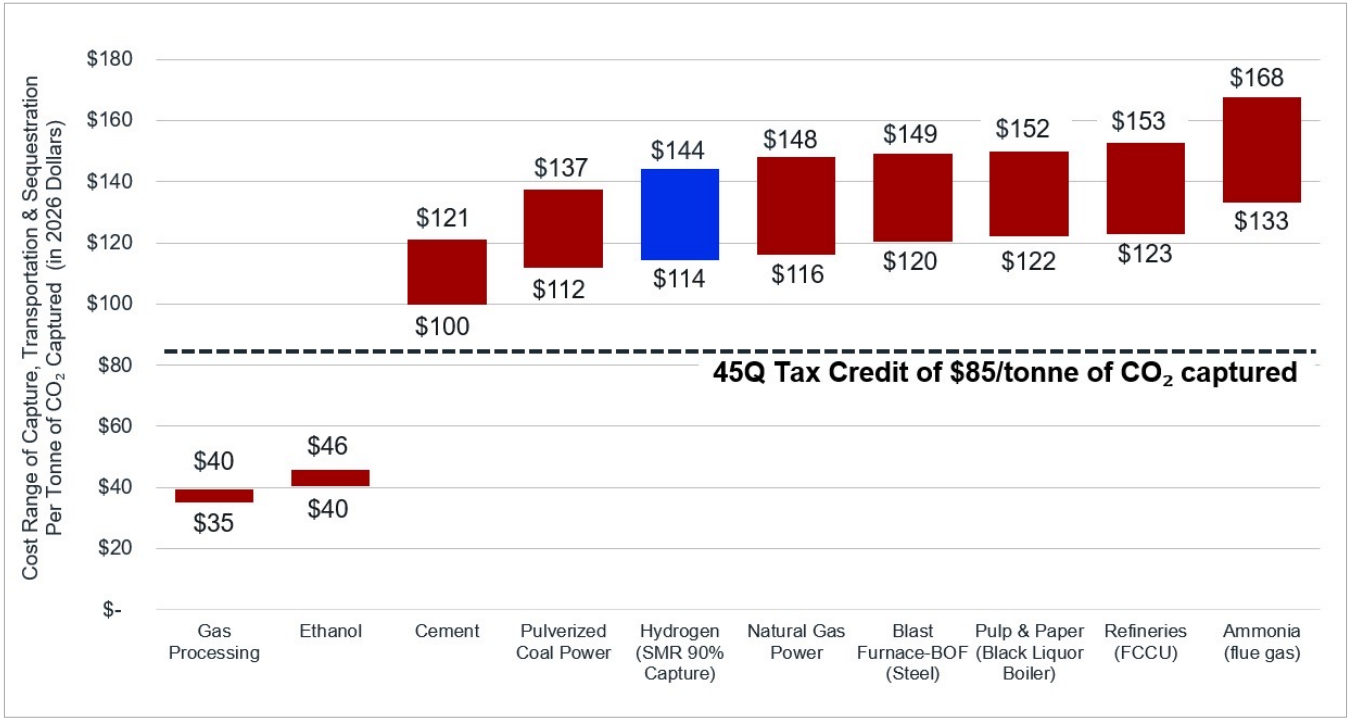
Rising Federal 45Q CCS Tax Subsidies



These estimates are consistent with actual costs of CO_2 capture at projects in Canada and the results of front-end engineering design (FEED) studies funded by the Department of Energy.

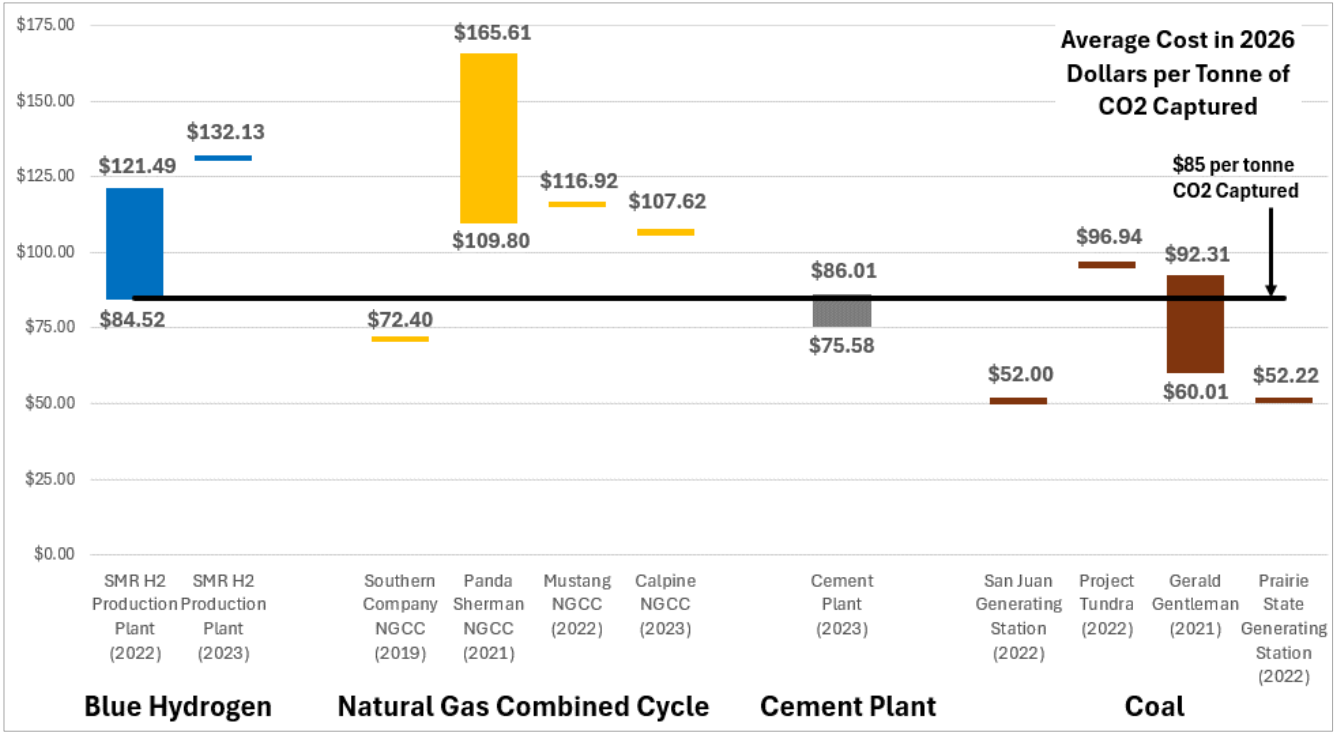
Note: The annual capture costs in the EFI study have been converted from year 2022 to year 2026 dollars to be consistent with the $85/tonne 45Q tax credit.

Recently Estimated CO_2 Capture Costs



Data Source: Energy Futures Initiative (EFI), Turning CCS projects in heavy industry & power into blue chip financial investments. February 2023.

Results of DOE-Funded Pre-FEED and FEED Studies on Carbon Capture



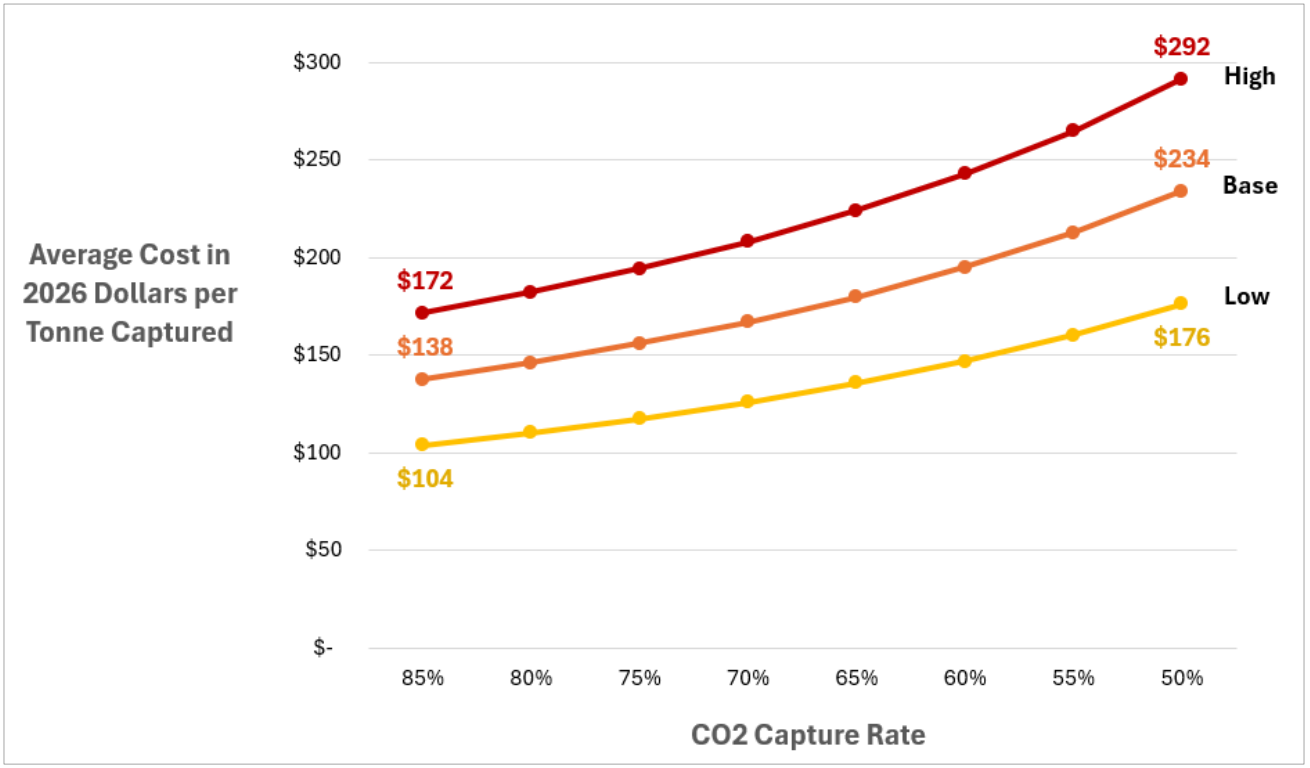
Note: Some studies did not include costs for transport and storage of captured carbon dioxide.

High capital and O&M costs result in higher cost per metric ton CO_2 captured.

Coupled with lower capture rates, the cost per metric ton can rise steeply.

The “high” and “low” cases represent cost estimates +/- 15% of the base case for annual capital cost and +/- 50% for O&M.

Potential Volatility in CO_2 Capture Costs — Natural Gas Combined Cycle Power Plant



Why CCS Costs Are Going Up

1. Increasing construction costs due to delays and rising commodity prices (e.g. structural steel, concrete, etc).
2. Increasing O&M expenses including higher power prices due to natural gas price spikes
3. Lower-than-expected CO_2 capture rates leads to higher costs per tonne of CO_2 captured.

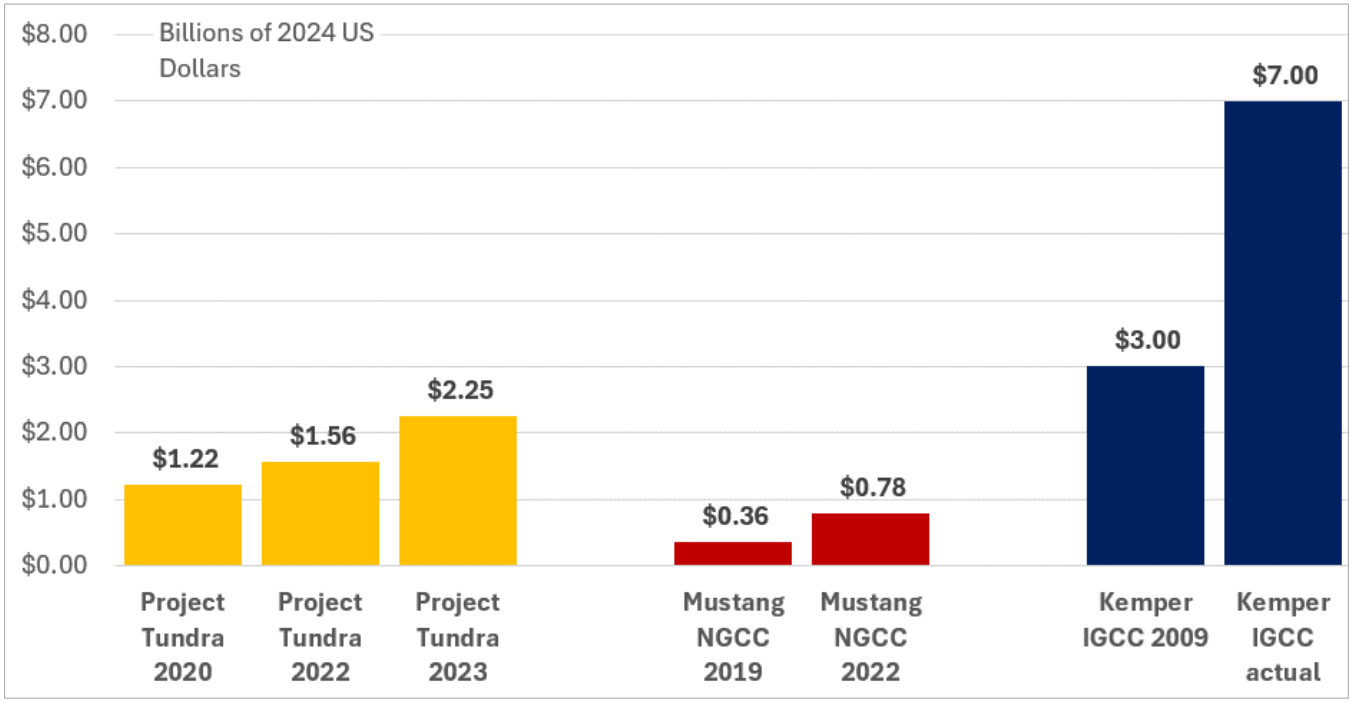
Examples:

Project Tundra and SJGS (San Juan Generating Station: Coal-fired power plants with proposed post-combustion CO_2 capture.

Mustang: Natural gas-fired combined cycle power plant which studied adding post-combustion CO_2 capture.

Kemper Project: Pre-combustion CO_2 capture. Never worked properly. Carbon capture portion of plant demolished in 2021.

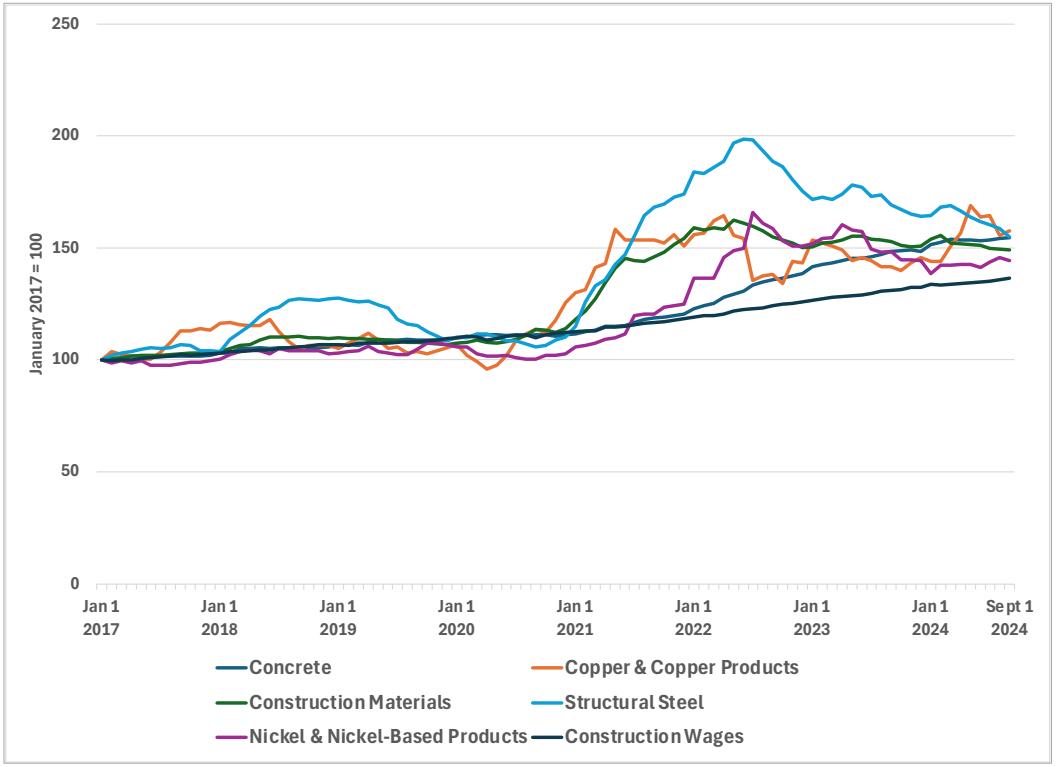
Carbon Capture's Soaring Estimated Construction Costs



Between January 2017 and September 2024:

- Construction material producer price index rose by 49%
- Structural steel producer price index by 55%
- Concrete producer price index by 55%
- Construction wage index rose by 36%
- Copper and copper product producer price index rose by 58%
- Nickel and nickel-based project producer price index rose by 44%

Why Are Construction Costs Going Up? Rising Commodity Prices and Wages



Source: *Federal Reserve Bank of St. Louis*.

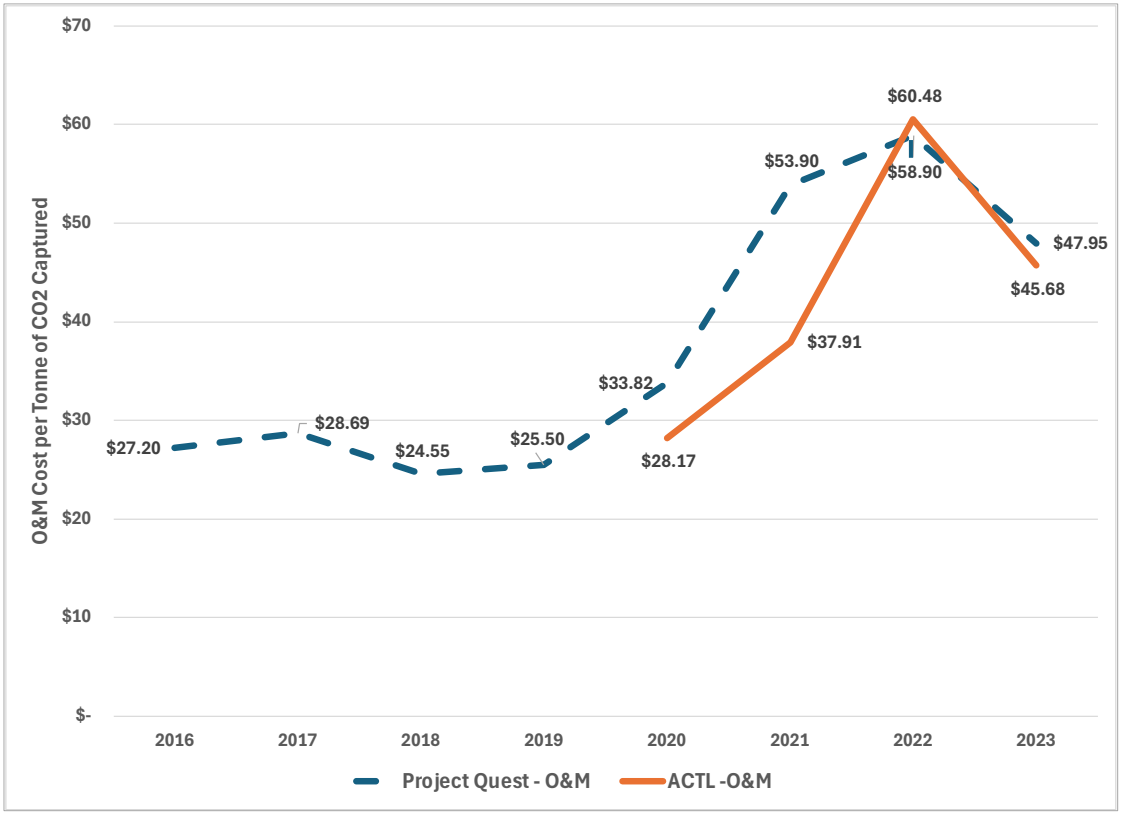
Most CCS projects, including all those in the U.S., don't reveal capture costs.

Two projects in Canada must file detailed annual reports in order to get subsidies from Province of Alberta.

Project Quest's annual O&M per tonne increased by 76% from 2016 to 2023.

Alberta Carbon Trunk Line's annual O&M per tonne increased by 62% from 2020 to 2023.

Rising Operating and Maintenance Costs — Canadian CCS Projects



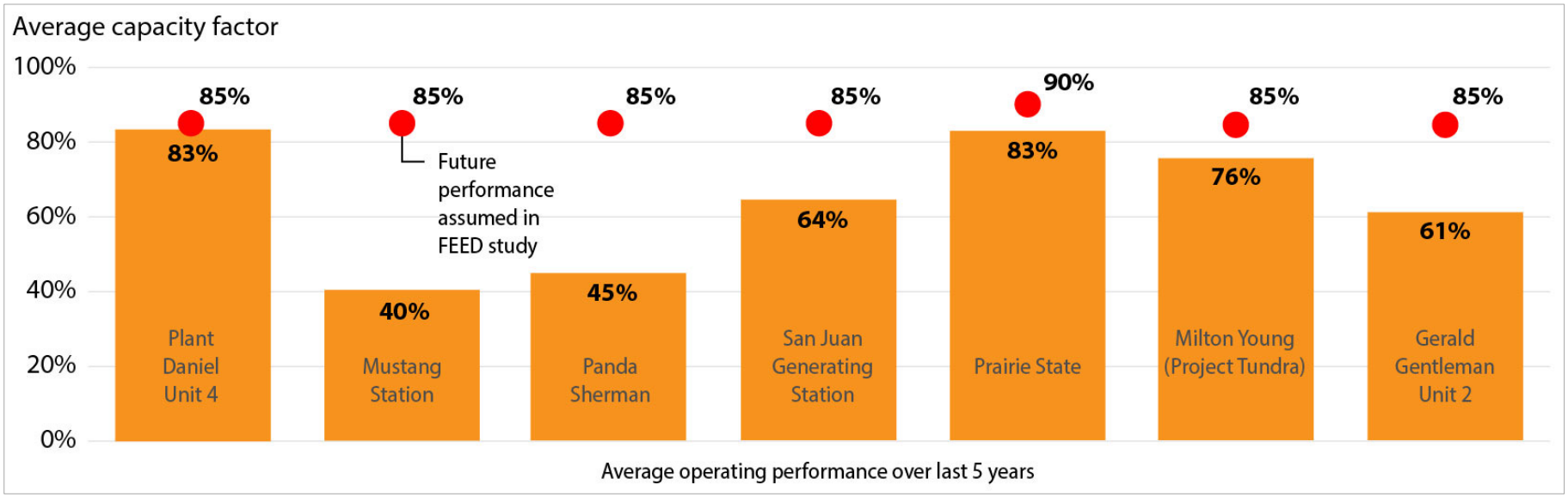
Cost Risks For Investors

1. Very high and likely volatile CO_2 capture costs.

2. Natural gas price volatility.

3. In many cases, the power and industrial plants will have to operate much better in the future in order to produce more CO_2 that can be captured.

Another Risk: Owners Will Often Want to Run Plants More in the Future to Produce More CO_2 and Higher Profits



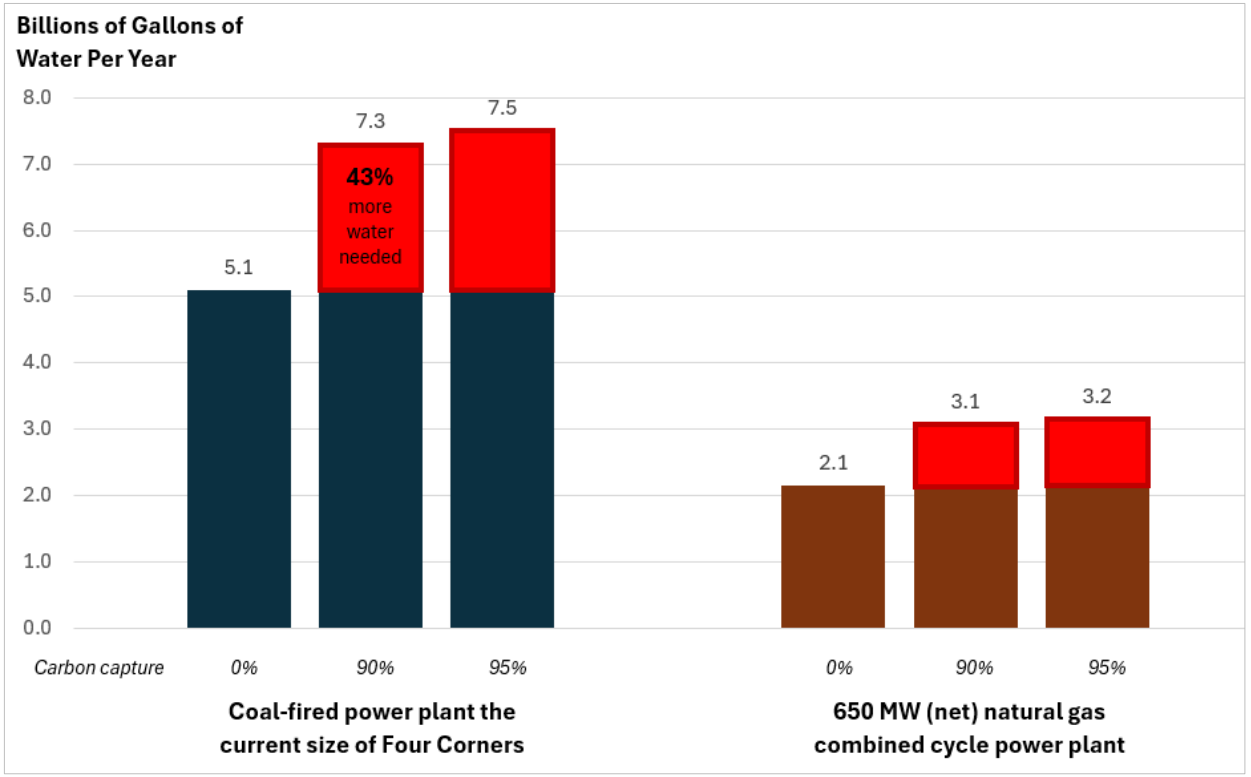
***Capacity Factor**: A measure of how much power the plant actually produces versus how much it would have produced if it had operated at 100% power for all of the hours of the time period being looked at – month, year, or series of years.*

Increased Water Demand with Carbon Capture — Coal and Gas-Fired Power Plants

Adding carbon capture to a power plant increases the amount of water required.

A coal-fired power plant capturing ≥90% of its CO_2 emissions would need ~43% more water.

Natural Gas Combined Cycle (NGCC) plants with ≥90% carbon capture would require almost 50% more water.



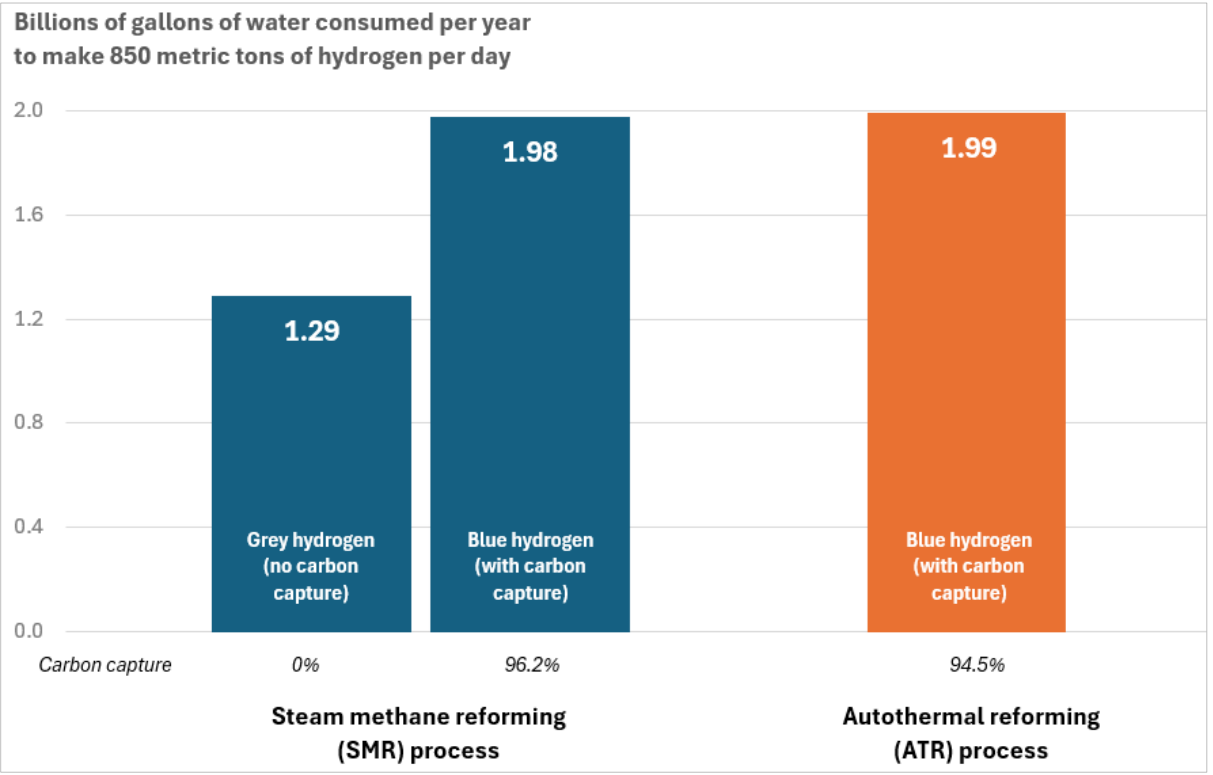
Source: Cost and Performance Baseline for Fossil Energy Plants – Volume 1: Revision 4A: Bituminous Coal and Natural Gas to Electricity, DOE/NETL 2023-4320, October 2022.

Water demand for hydrogen production is substantial.

Including carbon capture in a hydrogen production system increases the water demand by 35% compared to grey hydrogen.

A large blue hydrogen production facility with carbon capture (producing 850 metric tons of hydrogen from methane per day) would use nearly 2 billion gallons of water in a year.

Increased Water Demand with Carbon Capture — Production of Hydrogen from Methane



Source: *Comparison of Commercial State-of-the-Art, Fossil-Based Hydrogen Production Technologies*, NETL- DOE, April 2022.

IEEFA Reports on Hydrogen:
www.ieefa.org/topic/hydrogen

For More Information

Contact:
David Schlissel at dschlissel@IEEFA.org

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