Institute for Energy Economics and Financial Analysis

CCS and Blue Hydrogen

Unproven Technology and Financial Risk

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July 3, 2024

Risks Faced by Investors in Blue Hydrogen Projects

Significant uncertainty related to:

1. Governmental subsidies for which the project will qualify – that is, how "clean" will the blue H2 be, how large will the subsidies be, and how long will they exist?

2. How much of the CO_2 created during blue H2 production will be captured

3. How low upstream methane emission rates actually will be

4. Whether there will be a market for blue H2 produced by the project at a price that makes it financially viable

Risks Faced by Investors in Blue Hydrogen Projects

Significant uncertainty related to:

5. How much it's going to cost to produce blue H2, especially the cost of CO_2 capture and the risk of natural gas price volatility
6. Whether public opposition will prevent the siting of H2 and CO_2 pipelines
7. Whether the project will operate as planned after billions have been invested
8. Whether the carbon capture portion of the project will be out of service for a significant amount of time

Key Terms

- **Blue Hydrogen (blue H2)** is made from methane with CO_2 capture at H2 production facility
- **Methane,** main constituent of natural gas, is a very potent greenhouse gas
  - → Over a 20-year period, it is 83 times more powerful than CO_2
  - → Over a 100-year period, it is approximately 30 times more powerful than CO_2
- **Hydrogen** is an indirect greenhouse gas – it impacts global warming by extending the lifetime of methane in the atmosphere and increasing its concentration
- **Steam Methane Reforming (SMR)** is the predominant technology used today to produce H2 from methane
- **Autothermal Reforming (ATR)** is a newer technology that produces a single highly concentrated stream of CO_2 proponents say it should be easier to capture

Key Terms

- **Carbon Intensity (CI)** Measures how much CO_2e is emitted into the atmosphere for each kilogram of H2 that is produced
- **CO_2e** includes methane emissions into the atmosphere as well as CO_2
- The U.S. standard defines **clean hydrogen** as having a carbon intensity of **$\leq$4.0 kilograms (kg) CO_2e emitted / kg H2 produced.** The U.S. has no standard for what constitutes "low-carbon" or "low emissions" hydrogen; those are merely terms used to hype H_2
- **Carbon capture rate** is the percentage of the CO_2 that is captured during blue H_2 production compared to total CO_2 created

U.S. Federal Funding: CO_2 Management Is Essential for Accessing Tax Credits

45V Tax Credit

- 45V is based on kilograms of hydrogen produced and how "clean" the hydrogen is
- Only issued under 45V for hydrogen that has a carbon intensity under 4.0 kg CO_2e / kg H2, i.e., the clean standard
- Largest subsidy is $3/kg of clean H2

45Q Tax Credit

- 45Q targets carbon capture
- $85 per tonne CO_2 captured and permanently stored and $65 for CO_2 used for enhanced oil recovery (EOR) or other purposes
- Cannot be combined with 45V
- Will be tens of billions of dollars in subsidies to hydrogen producers

Blue Hydrogen Is Not Clean or Low Carbon

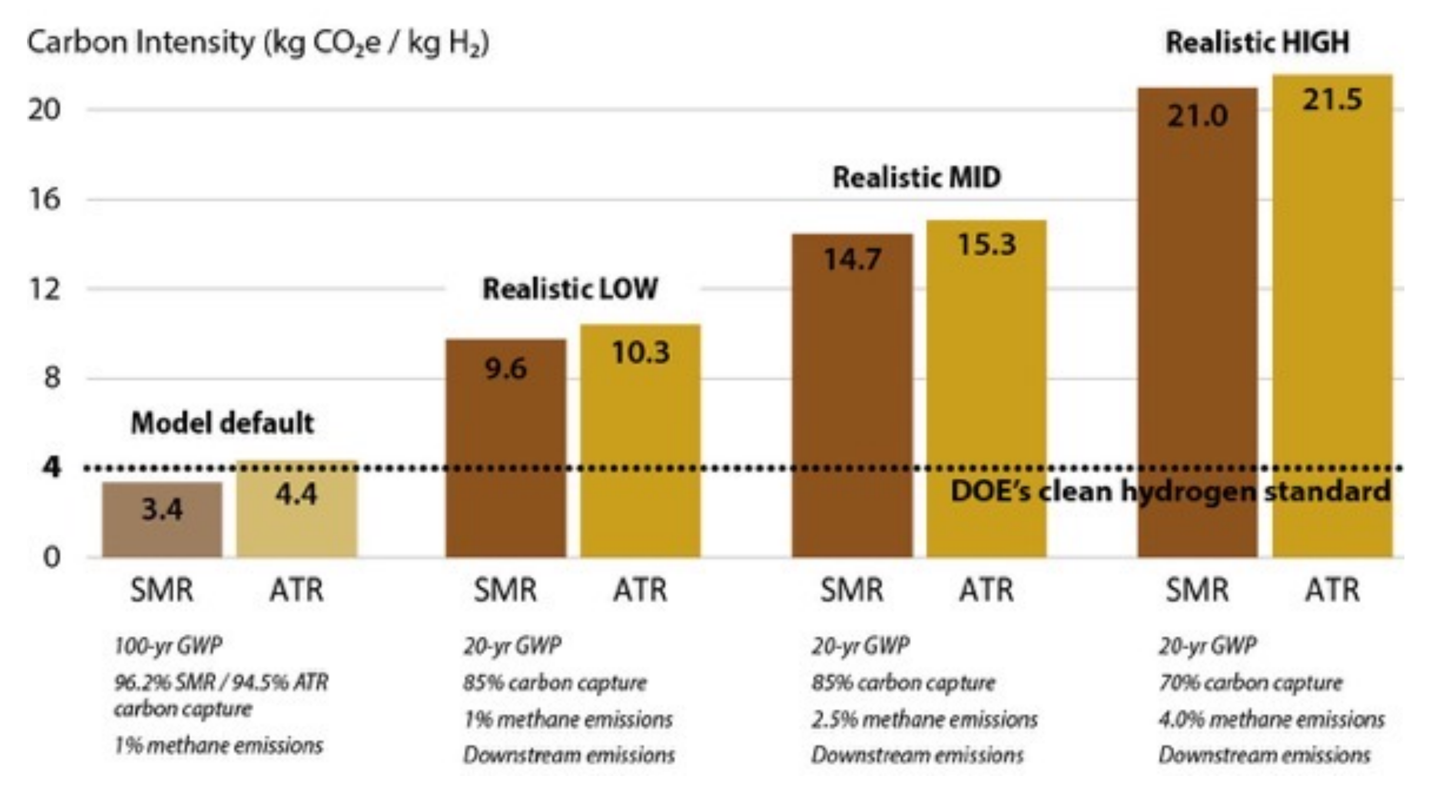
How Is Carbon Intensity Determined in the U.S.?

- U.S. Department of Energy has developed a model named GREET to calculate the carbon intensity for a variety of hydrogen production pathways.
- The model includes (1) upstream emissions that are related to extracting the fuel and the feedstock used in the production of H2 and (2) the emissions at the production facility.
- However, contrary to current science and real-world experience:
    - GREET uses the lower 100-year global warming potential (GWP) for methane, rather than its higher 20-year GWP. This is contrary to the reality that climate crisis is here today, not 100 years off in the future.
    - Very high carbon capture rates and very low upstream methane emissions rates also are built into the model.
    - the carbon intensity calculation in GREET does not include any global warming potential for H2 or any emissions downstream of the production facility.
- These assumptions mean GREET substantially understates carbon intensity of blue H2

What If the Assumptions Are Different?

We assumed more realistic parameters for four key inputs and estimate **far higher carbon intensity** for blue hydrogen:

1. Range of carbon capture rates
2. Higher upstream methane emissions rates
3. 20-year global warming potential (GWP) time horizon
4. Limited downstream emissions



Unproven Carbon Capture Technology Is Key to Blue Hydrogen's Financial Viability

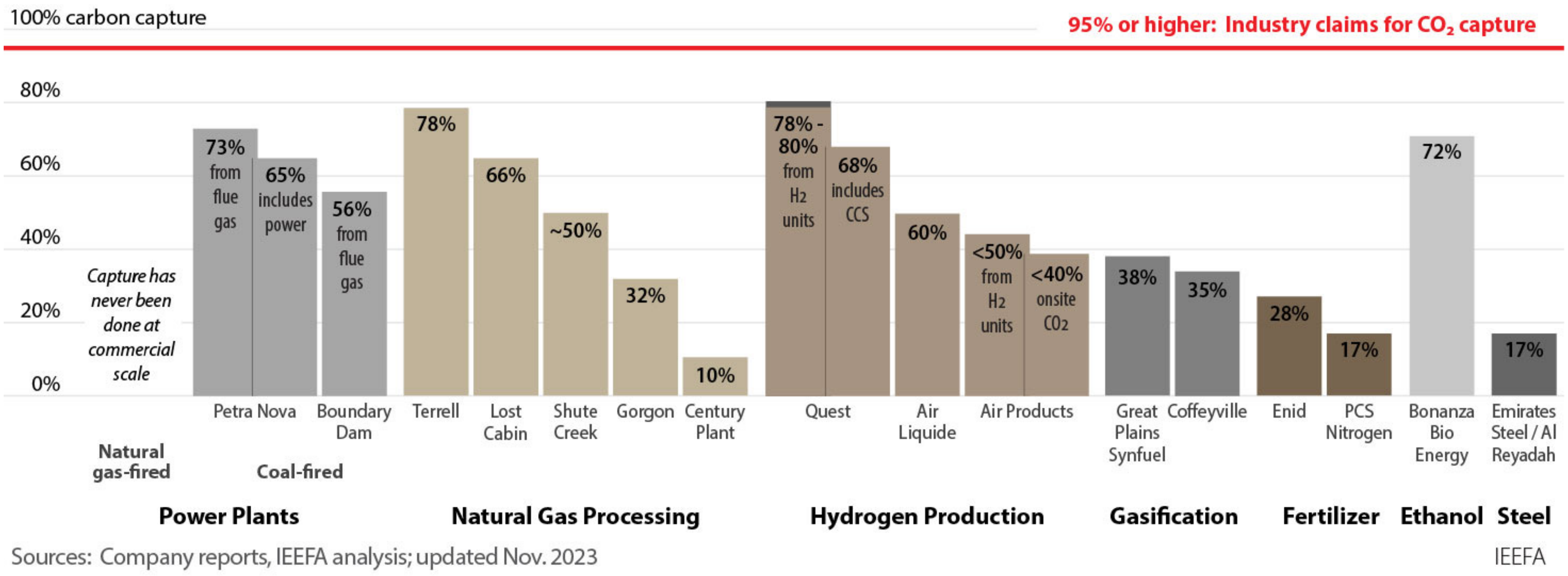
Why High CO_2 Capture Rates Are Important

1. Without a very high capture rate, projects cannot achieve a carbon intensity of $\leq$4.0 kilograms (kg) CO_2e emitted / kg H2 produced – **so, no 45V subsidies**

2. A higher capture rate means more tonnes of CO_2 are captured and more 45Q credits are received by the project. This means more revenue for the project and investors

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.



Originally appeared in IEEFA report Blue Hydrogen: Not clean, not low carbon, not a solution.

Key Findings From the Real World: CO_2 Capture Data

1. Owners of CO_2 capture facilities generally don't make capture rates & costs of capture public – so data available for only ~1/2 of existing capture facilities
2. Only three commercial-scale H2 production facilities now have CO_2 capture. All use SMR technology.
3. None has achieved even an 80% CO_2 capture rate.
4. Some new facilities may use ATR, but others may continue to use SMR.
5. ATR has never been used at the scale of larger projects now being proposed – poses risk of scaling up the technology.
6. Also, no CO_2 has been captured at commercial-scale H2 production facility with ATR technology.
6. Uncertain if plants with ATR actually will achieve $\geq$94.5% CO_2 capture rates.
7. Big gamble for investors.

Capture Data Highlights Reality Vs. Hype

How then does the government decide that blue H2 facilities will achieve CO_2 capture rates $\geq$94.5%?

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

2. The results of very small-scale testing of new and evolving capture technologies – on the order of 1%-5% of the CO_2 emissions from commercial-scale projects. Scaling up is a risk.

Cost Uncertainty

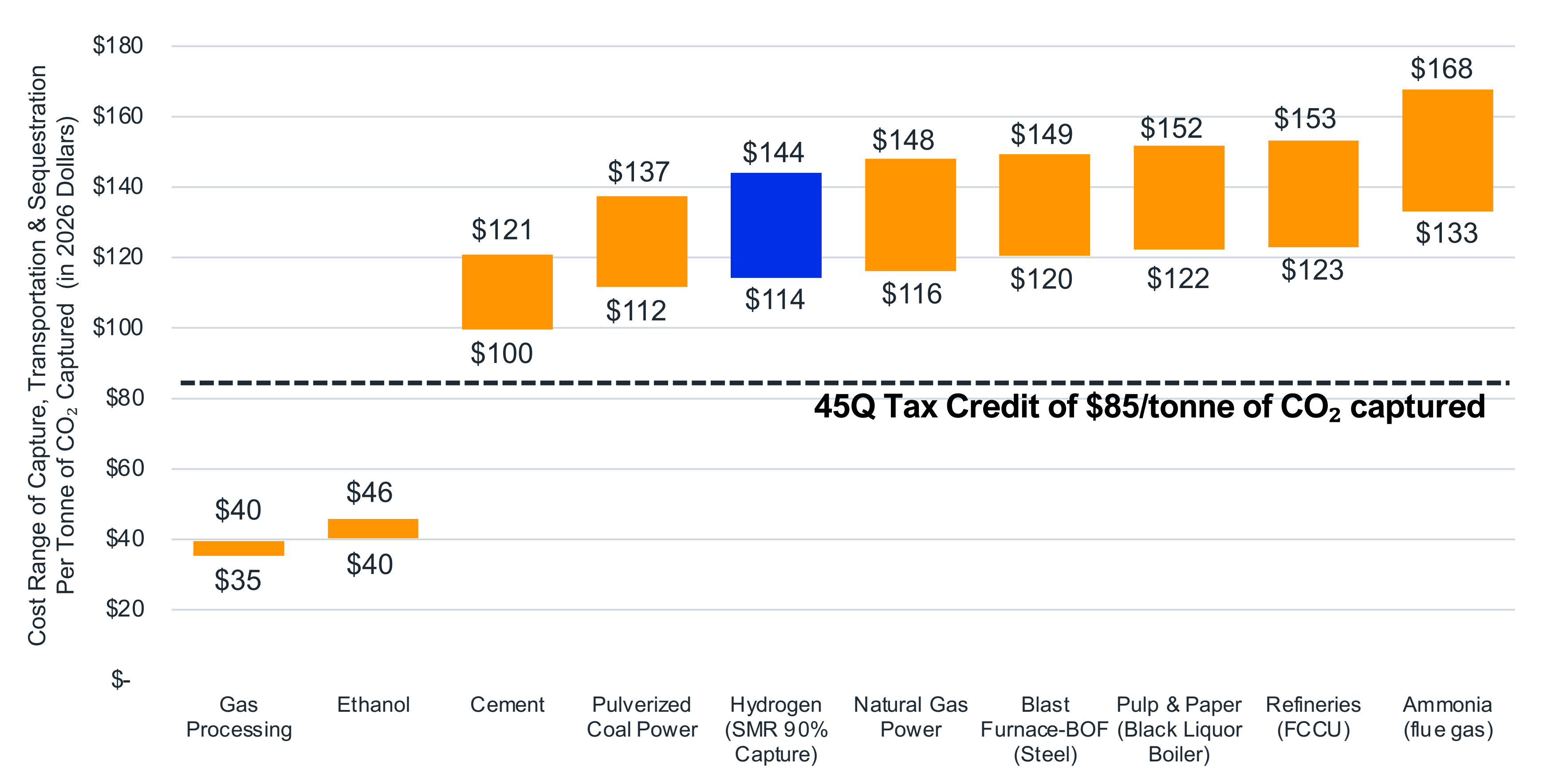
Cost Risks For Investors

1. Very high CO_2 capture costs
2. Natural gas price volatility

CO_2 Capture Costs Going Up, Not Down

- Four years ago, U.S. Department of Energy had a goal of reducing carbon capture costs by 50%, to perhaps as low as $30/tonne.
- But those days are long gone, as actual and projected capture costs both have gone up dramatically.
- In response to rising capture costs, the 45Q CCS tax subsidy has been increased from $50/tonne to $85/tonne for geologically stored CO_2 and from $35/tonne to $65/tonne for CO_2 used for enhanced oil recovery or other purposes.
- Still many say these increases are not nearly enough to make CCS financially viable.
- Exxon and others are already lobbying for an “initial” increase in the 45Q tax subsidy to $100/tonne for geologically stored CO_2 and an increase in the period during which projects would receive 45Q subsidies from the current 12 years to 30.
- But even that won’t be enough to cover the cost of carbon capture for many important industries.

Recently Estimated CO_2 Capture Costs



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 U.S.DOE

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

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.

Assuming Capture Costs Will Go Down Over Time Is A Big Gamble

- CCS proponents claim that because of “learning by doing,” capture costs will go down over time.
- But there is no evidence for this.
- Not like circumstances that led to steep declines in solar, wind and battery storage costs.
- More likely capture costs will be higher than currently projected.
  - Risk of upscaling capture technologies.
  - Capture costs based on how much CO_2 captured - if facilities capture less CO_2, average cost per tonne will be higher.
  - Potential for higher than projected escalation of prices for construction resources – design, labor and commodities such as steel, concrete, piping, etc.
  - ATR technology never used in large H2 production facilities on the scale of those being proposed.
  - ATR technology never used at commercial-scale with carbon capture.

Natural Gas Price Risks

- Natural gas is both a feedstock and a fuel for blue hydrogen.
- This makes blue hydrogen production prices very sensitive to natural gas prices.
- Natural gas prices have been volatile in the past.
- But now the increased exports of LNG have linked U.S. customers to the increased volatility of the global natural gas market and raised prices for them.

Market Risks

Major Uncertainty: Will There Be Enough Customers To Buy All the H_2?

- Government spending is focused on dramatically increasing the supply of hydrogen, not developing policies and incentives to create demand for that hydrogen.
- Electrification is a major, declining-cost competitor.
- The number of industrial sectors in which there are technically and economically feasible alternatives to clean hydrogen is growing – for example, transportation (vehicles, buses and trains) and heating.
- And the number of sectors where clean hydrogen will be essential is shrinking – See Michael Liebreich's Hydrogen Ladder.

For More Information

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