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Three False Climate Solutions

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April 28, 2025

Context

- Two coal-fired power plants (Comanche Units 2 and 3) scheduled to be retired by 2031 due to state clean-energy legislation.
- Colorado Public Utilities Commission (PUC) established a proceeding to look at alternatives to Comanche but case has grown dramatically.
- Company (PSCo) now claiming loads will grow dramatically in coming years due mainly to electric vehicle charging and new internet server + artificial intelligence loads.
- Pueblo City and County have been pushing either an SMR or a gas-fired turbine with carbon capture as alternatives. They need property taxes and jobs to replace those associated with retiring coal units. The utility (Xcel subsidiary – PSCo) has agreed to pay payments in lieu of property taxes for 10 years after units retired.

Context Continued

- Pueblo is not in PSCo’s service territory. They don’t pay rates to the company so expensive investments don’t hurt their constituents. They would be paid for by PSCo ratepayers in Denver metropolitan area.
- The area around Pueblo (111 miles south of Denver) has excellent solar potential and already has a fair amount of solar capacity and some battery storage.
- The PUC’s current policy requires PSCo to give new solar resources being bid into its resource acquisition process a credit. PSCo wants to reverse this policy to a penalty because there’s too much solar within 37 miles of Pueblo. PSCo also wants the PUC to apply a very high connection charge to such resources. According to an unrealistic study by PSCo, adding another 1 gigawatt of solar within this area would create reliability issues when clouds come over the mountains.

Context Continued

- The company also wants a $100 million fund to look at new technologies like geothermal, carbon capture, nuclear, hydrogen, longer-term storage.
- We're concerned that the company wants to begin investing in new gas+carbon capture and nuclear and will use this fund to get its foot inside the door.
- PSCo has just increased its rate increase by $500 million to reserve manufacturing slots for new gas turbines due to heavy supply chain competition issues.
- PSCo says a new nuclear unit probably won't be online until 2035 but the industry has been heavily lobbying the state and, especially, Pueblo city and county.
- This is just Phase 1 of a two-phase case. After this phase, the company will develop its preferred plan – which we assume will include more gas in the short-term and nuclear in the longer-term, say after 2035. That will be in Phase 2.

What I've Tried to Do So Far

- Filed Testimony on:
  - On the uncertainties and risks of SMRs or large reactors, gas+carbon capture, and burning hydrogen in turbines to produce electricity.
    - Cost, schedules and technology uncertainties.
    - How much more expensive the cost of power from an SMR will be compared to power from renewables with or without storage.
    - What happens if you go down the road of new reactors and the currently-projected load increases that PSCo now forecasts don't materialize or the new loads as much as the company now forecasts.
  - Proposed a renewable energy park with renewables, battery storage, thermal storage and flexible demands as an alternative.

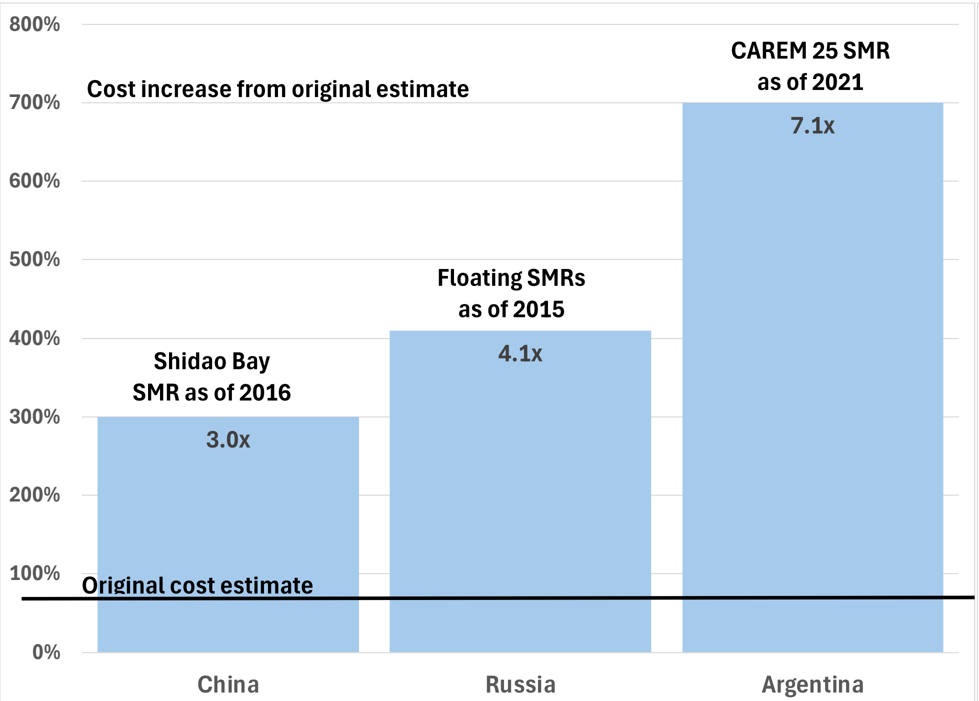
What We Need

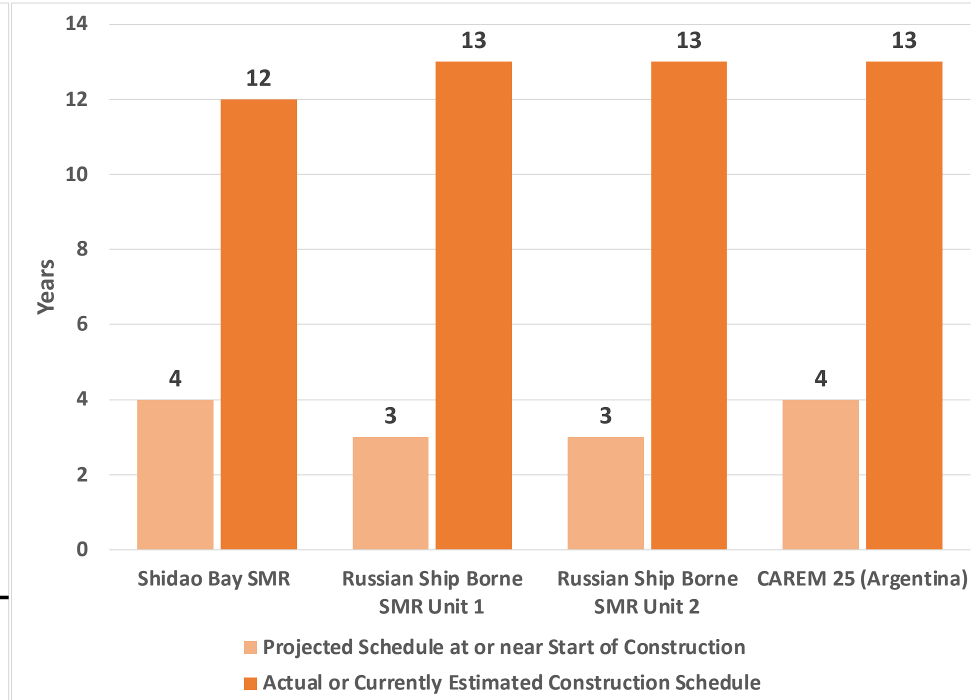
- Public comments:
  - More information on the uncertainties and risks of SMRs or large reactors
    - Cost, schedule, reasons why the PUC shouldn't expect the new SMR technologies won't work – especially that of X-Energy
    - The potential for large rate increases associated with investments in SMRs and/or large reactors – more Vogtles.
    - The benefits of storage and flexible loads
    - The risk of expensive stranded costs if new reactors and currently projected load increases don't materialize or at least not as much as now forecasted.
  - Anything you've got on the uncertainties of Gas+ carbon capture and/or burning hydrogen in a turbine to produce electricity

Nuclear – SMRs and Large Reactors

No SMR Designs Currently Being Marketed in U.S. Have Been Built, Are Under Construction or Has Been Licensed

SMRs Built in Other Countries Have Experienced Significant Cost Substantial Schedule Overruns





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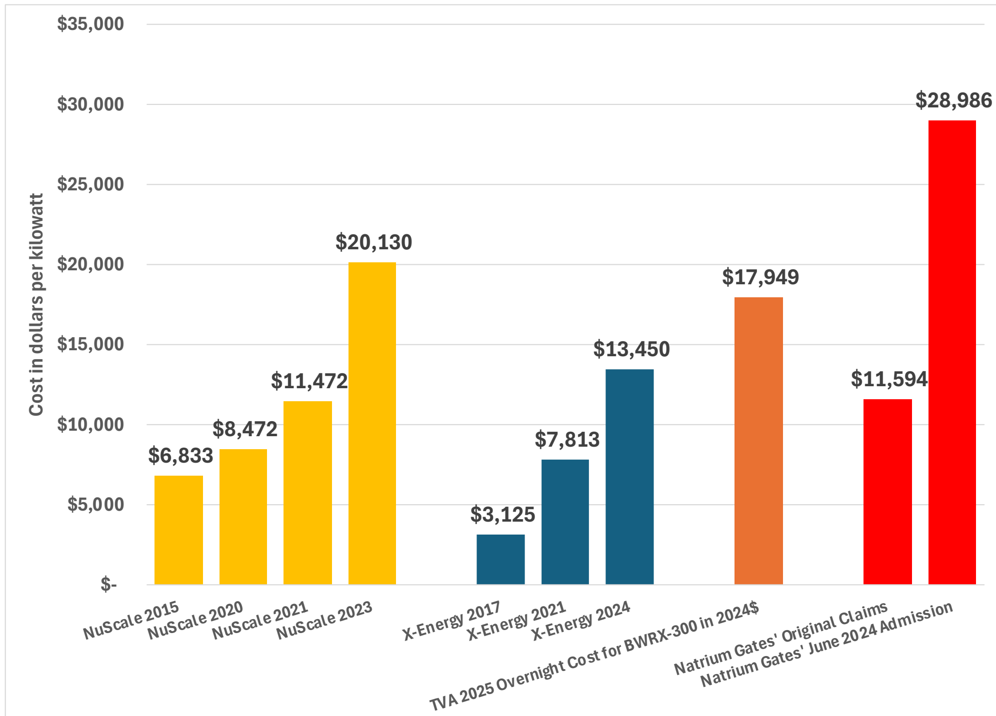
We Don't Know What SMRs Actually Will Cost - Estimated Costs for SMRs in U.S. Already Have Gone Up Dramatically

Estimated cost of NuScale's proposed UAMPS SMR, on a dollar per kW basis, increased by 138% between 2020 and 2023.

Estimated cost of X-Energy SMR increased by 72% between 2021 and 2024.

Costs of building SMRs should be expected to continue to go up significantly in the years before any will be online.



We Don’t Know When SMRs Will Be Ready – Estimated Schedules Already Have Been Pushed Back by Years

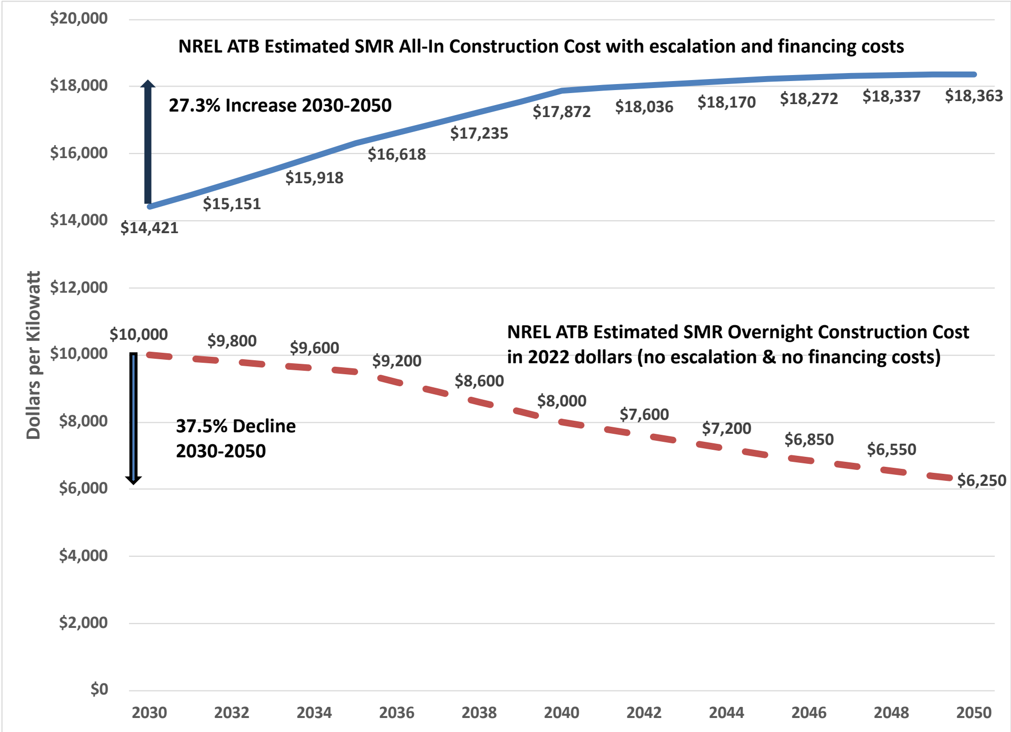
- NuScale originally told NRC that an SMR could be producing electricity by 2015-2016. But this was repeatedly pushed back – when the NuScale’s first proposed SMR was cancelled in 2023, its commercial operation date had slipped to 2029-2030.

- The initial Xe-100 reactor was first planned to be online by 2027, but this too has been delayed with what is now being called “substantial completion” scheduled for September 2033 – with no mention as to when the reactor will be in commercial service.

Nuclear Supporters Mislead When They Claim that the Costs of Building New Reactors Will Go Down Over Time

SMR supporters focus on estimated ‘overnight costs’ which exclude escalation and financing costs.

When ‘All-In’ costs are included, it is clear that nuclear construction costs will continue to go up, not down.



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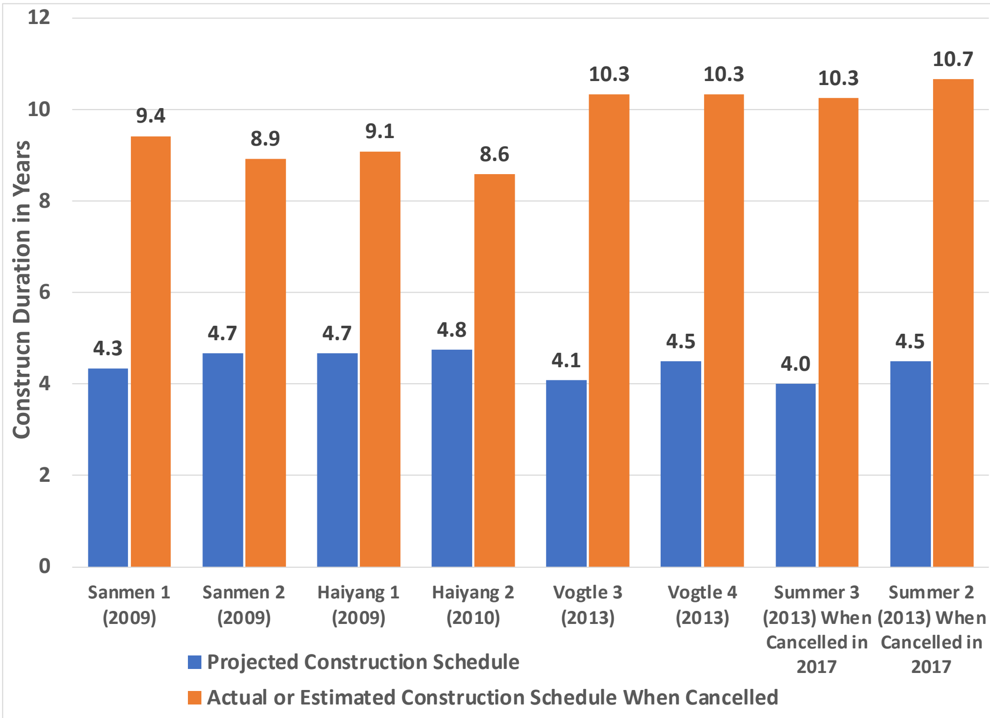
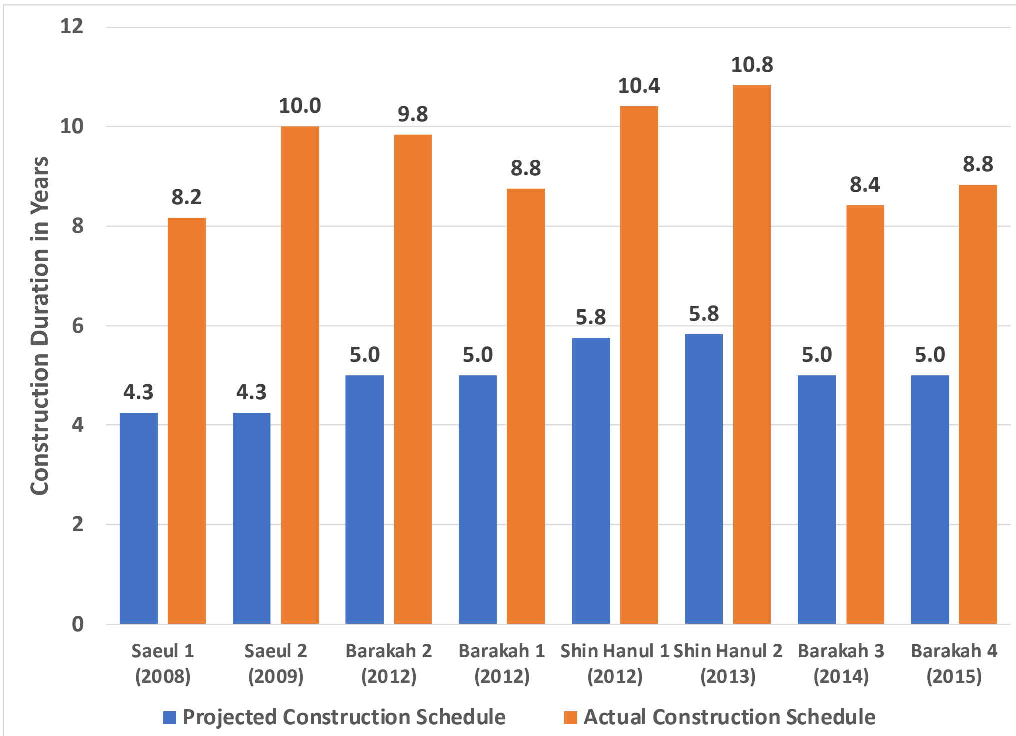
There is No Evidence that SMRs Actually Will Achieve a Positive Learning Curve

- Nuclear supporters claim that construction costs will go down as more SMRs and large reactors with same design are built.
- But there's no actual evidence to support this claim – except, perhaps, for savings from building multiple units on same site.
  - ❖ e.g., studies showing increases in French nuclear reactor construction costs over time.
- Difficult to compare costs of reactors in different countries - different labor and commodity prices, currency conversion rates, government subsidies and accounting practices.
- Instead, I have looked at reactor construction times for any evidence.

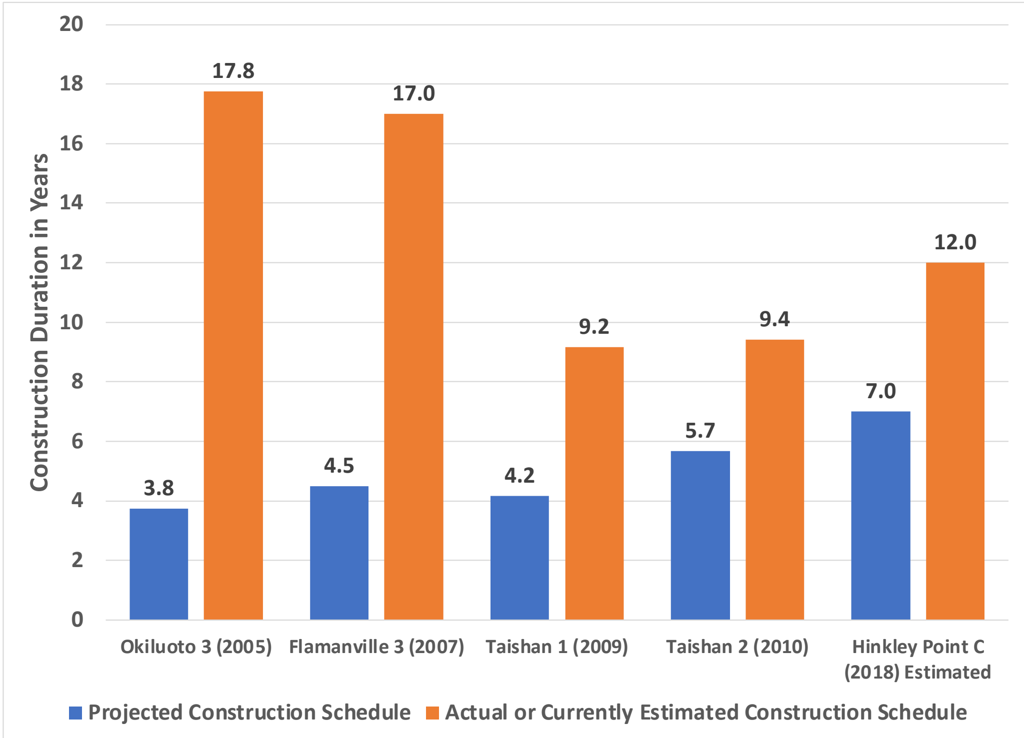
There is No Evidence that Nuclear Has Achieved a Positive Learning Curve – AP1000 Construction Times



There is No Evidence that Nuclear Has Achieved a Positive Learning Curve – AP1400 Construction Times



There is No Evidence that Nuclear Has Achieved a Positive Learning Curve – EPR Construction Times



Key Evidence From These Charts

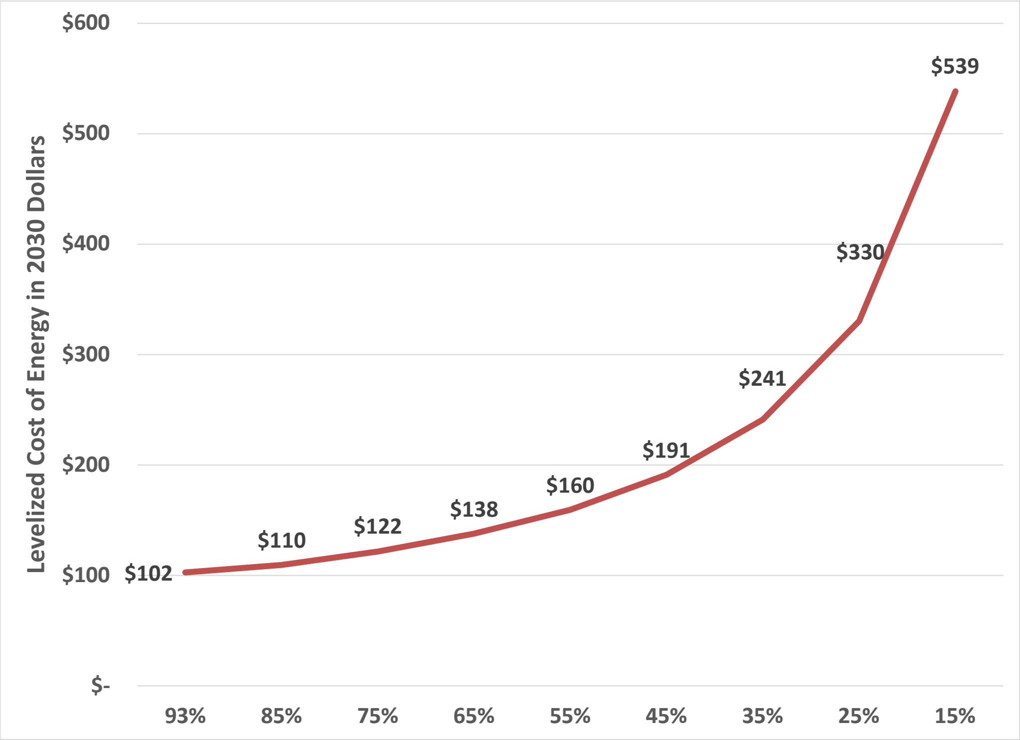
1. Almost all of these reactors with new designs were initially projected to take between 4 and 5.5 years to build, but all experienced significant schedule overruns.
2. None show evidence of a positive learning curve – even the four AP1400 units built at the same site.
3. If there were a positive learning curve, Vogtle 3 and 4 should have been completed in less time to build than the four Chinese AP1000s but clearly weren't.

SMRs Are Not Good Tools for Addressing Climate Change – Average Cost per MWh goes up as Capacity Factors Decline

An SMR cannot achieve both a high capacity factor and cycle between lower and higher power levels depending on the availability of intermittent wind and solar resources.

In order to be profitable, SMRs must run as much as possible and produce, and sell, as much energy as Possible.

Therefore, SMRs will compete with, not complement, renewables.



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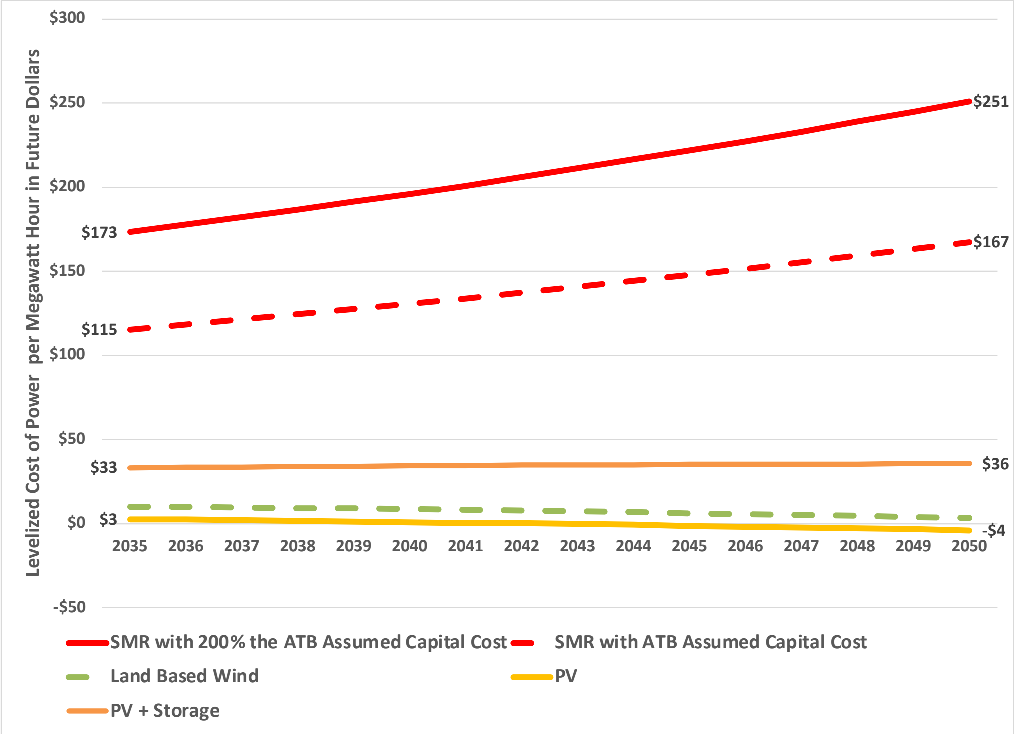
Even With 50% Nuclear ITC in IRA, Power from SMRs Will Be More Expensive Than Power From Renewables + Storage

But SMR power costs could be higher, perhaps much higher, than shown here.

- Higher construction and/or O&M costs.
- Some (many?) projects might only be eligible for 30% or 40% ITC - not 50%.
- Longer construction times &/or higher financing rates - mean higher total financing costs.
- Higher annual escalation – I used 2.5% annual same as NREL ATB. Actual nuclear production plant costs have escalated at much higher average annual rates.
- Higher commodity prices &/or wages.



Carbon Capture and Storage (CCS)

What Is Carbon Capture and Sequestration (CCS) and Why Is It Now Such a Big Issue?

CCS is touted as key part of reducing emissions of CO_2 from fossil-fired power plants, hydrogen production facilities, and certain large industries that that would otherwise be emitted into the atmosphere.

All, or very nearly all, of the CO_2 produced by any of these facilities will have to be captured and promoters claim CCS technology is proven.

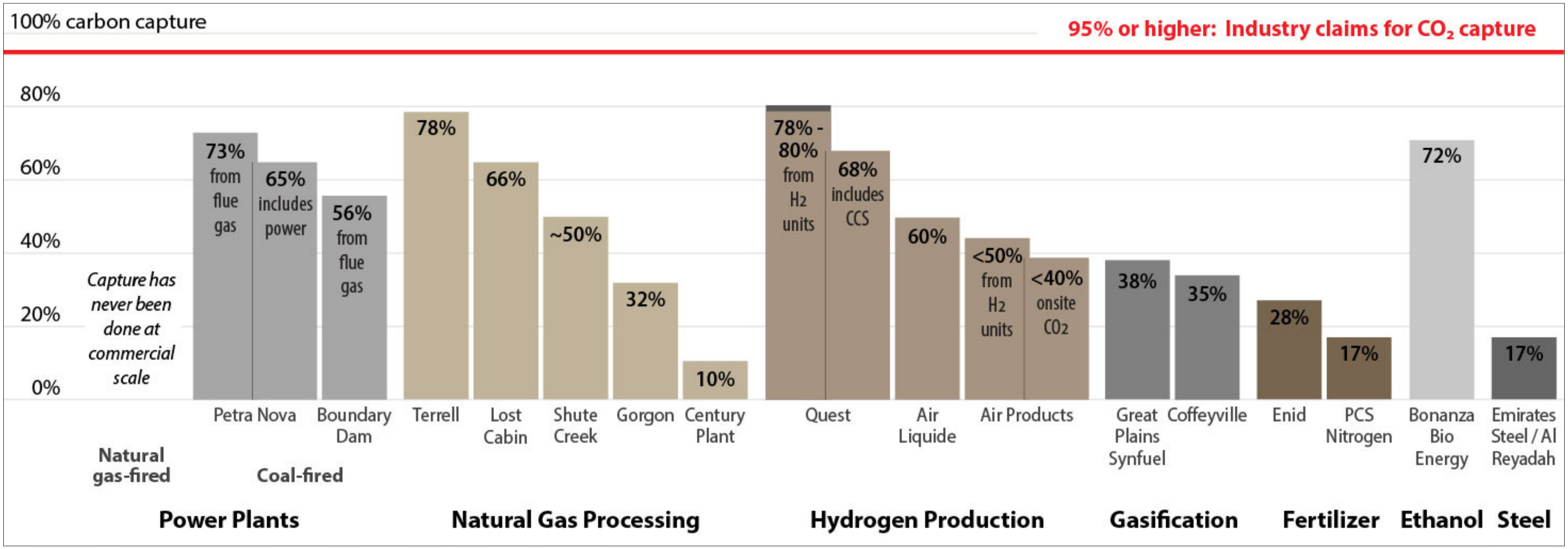
Key questions:

1. Can CCS reliably capture >90% of the CO_2 from a plant, and do so reliably and consistently?
2. Will CCS be financially viable without massive, permanent government subsidies?
3. Can we be certain CO_2 stored "permanently" underground actually will stay there?
4. Are there cheaper, more reliable, and faster options for decarbonizing the economy?
5. What are the health and other impacts for the community and the environment?

Capturing CO_2 from a Natural Gas-Fired Unit is Unproven Technology and Will be More Difficult Than From a Coal Plant

- Because the concentration of CO_2 in the flue gases from a gas-fired generator are much lower that their concentration in the flue gases from a coal-fired plant, it will be more difficult, more energy-intensive and more expensive to capture than the CO_2
- Only one commercial-sized gas-burning power plant captured CO_2 and that was only from a 40 MW slipstream which represented a mere 7% of the plant's flue gases.
- The captured CO2 did not have to be stored or transported any meaningful distance – in was used right next to the power plant.
- And CO_2 capture at the plant ended two decades ago.

There's No Evidence that Existing Commercial-Scale CCS Projects Have Captured Close to 95% of Their CO_2



Sources: Company reports, IEEFA analysis: Blue Hydrogen: Not clean, not low carbon, not a solution.

There is Only Very Limited Experience with Carbon Capture

CCS has been around for decades, but there are **only about 30 active carbon capture projects in the world**. Numerous projects had been cancelled or have failed.

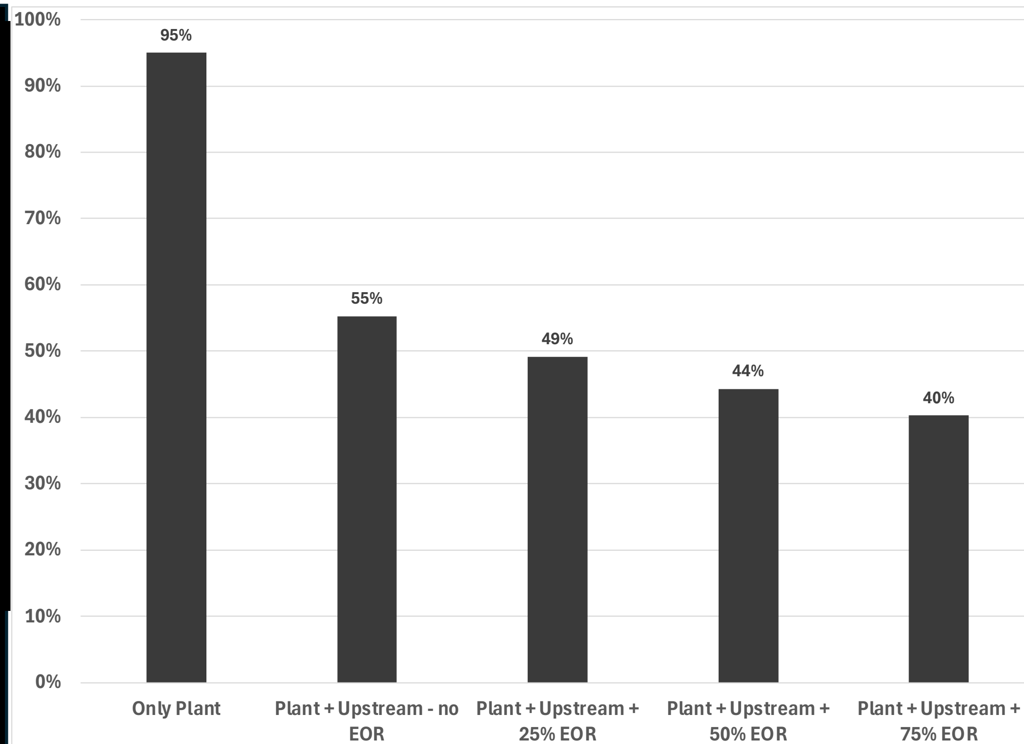
- Coal-fired power plants: There are **only two** in the world capturing any of their CO_2.
- Gas-fired power plants: **No CO_2 is being captured** at an operating commercial-size gas-fired generator.
- Steel plants: **CO_2 has been captured at one plant** in the UAE.
- Concrete plants: **No plant** has captured any CO_2.
- Hydrogen plants: **None of the 3 plants** that produce hydrogen from natural gas has captured more than 68% of the total CO_2 it has created.

It Is Important to Look at the Life Cycle Emissions of Fossil-Fired Power Plants

It is important to consider the entire life cycle of a proposed hydrogen production facility or a power plant project with carbon capture. This includes upstream and, if there are any, downstream CO_2 equivalent emissions.

Mistake to focus just the capture rate at the proposed facility.

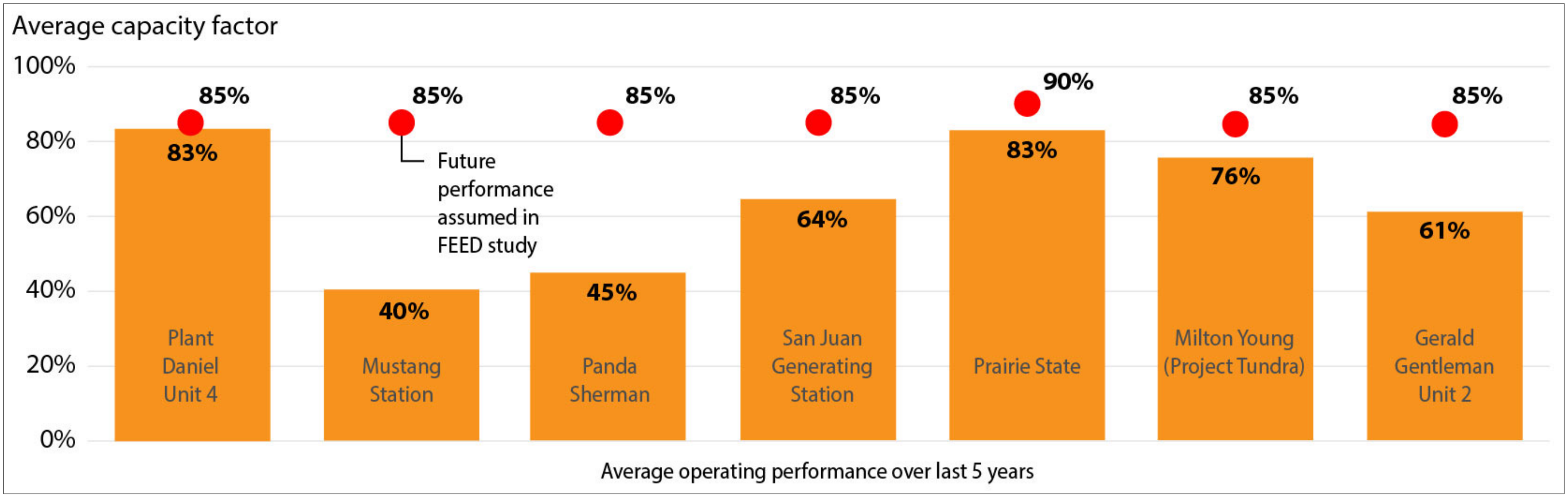
In this chart, "upstream" refers to methane emissions between the well and the power plant.



Federal & State Subsidies for Carbon Capture Provide Incentives for Production of More CO_2, Not Less

- Under 45Q plants are **incentivized to become CO_2 factories**, "farming for CO_2 subsidies"
- The **more CO_2 captured = the more $$ to owners** from U.S. taxpayers
- **No requirements** that project captures all, or nearly all, of CO_2 it produces
- The amount of CO_2 captured depends on two factors:
  - How much CO_2 is produced
  - How much of that CO_2 is captured and either stored underground or used
  - Consequently, fossil plant owners will want (1) to run their plants more (2) to produce as much CO_2 as they can (3) in order to capture more CO2 and (4) receive more credits from federal & state gov'ts

With 45Q Subsidies Fossil Plant Owners Will Want to Run Their Power Plants More



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.*

Average CO2 Capture Costs Will Be Higher if Capital Costs Go Up Further and/or Capture Rates Are Lower

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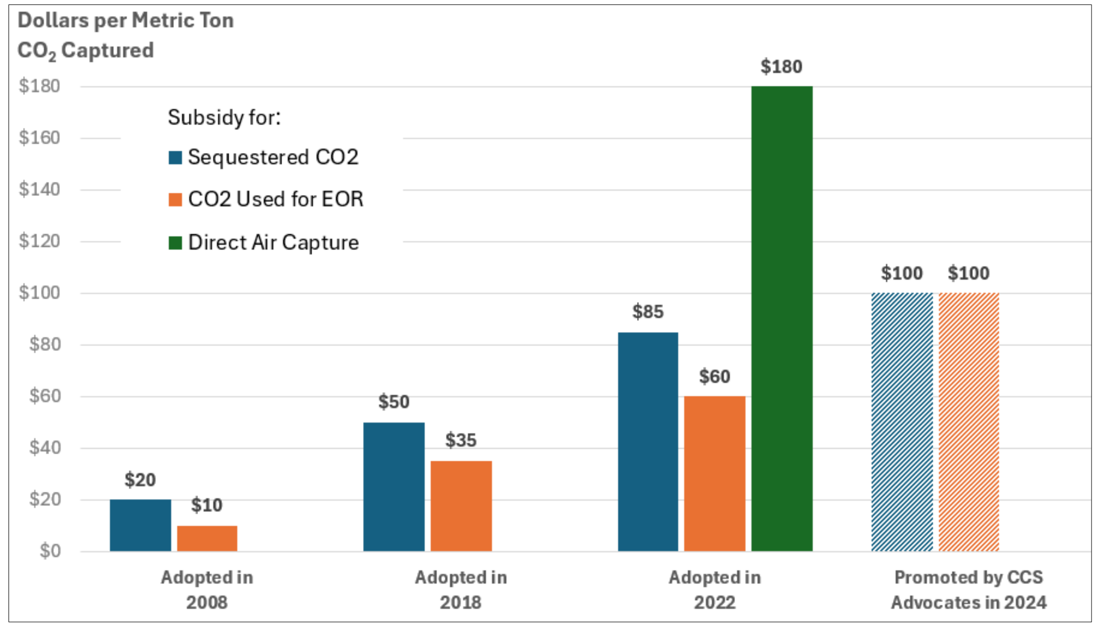
Federal 45Q CCS Tax Subsidies Are Going Up, A Lot

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.



Burning Hydrogen in a Turbine to Generate Electricity

Burning 'Green' Hydrogen, Produced Using the Electricity from Renewables, In a Turbine Is Very Inefficient

- Producing enough 'green' hydrogen to generate 1 MWh of electricity when burned in a very efficient turbine would require 3.86 MWh of electricity from renewable resources – for a roundtrip efficiency of just 26%
- Producing enough green hydrogen to generate 1 MWh of electricity when burned in a very efficient combined cycle plant would require 2.68 MWh of electricity from renewables – for a roundtrip efficiency of 37%.
- It would be far better and much more efficient to use the electricity produced by renewables to directly displace fossil fuels.
- Using the electricity produced by renewables should only be used to produce the hydrogen needed for essential uses that cannot be done better through electrification.

Burning Hydrogen to Produce Electricity May Seem Like a Good Idea, But Its Not

- Hydrogen (H2) has the benefit that when burned in a turbine it produces water not CO_2.
- Sounds good, but its not.
- When H2's entire life cycle is considered, it is clear that burning H2 is not an effective tool for decarbonization.
- This is true whether you're looking at burning either 'green' H2, produced from water using electricity from renewable resources, or 'blue' H2, produced from the methane in natural gas. This also would be true if the electricity from a nuclear power plant were used to produce H2 from water.

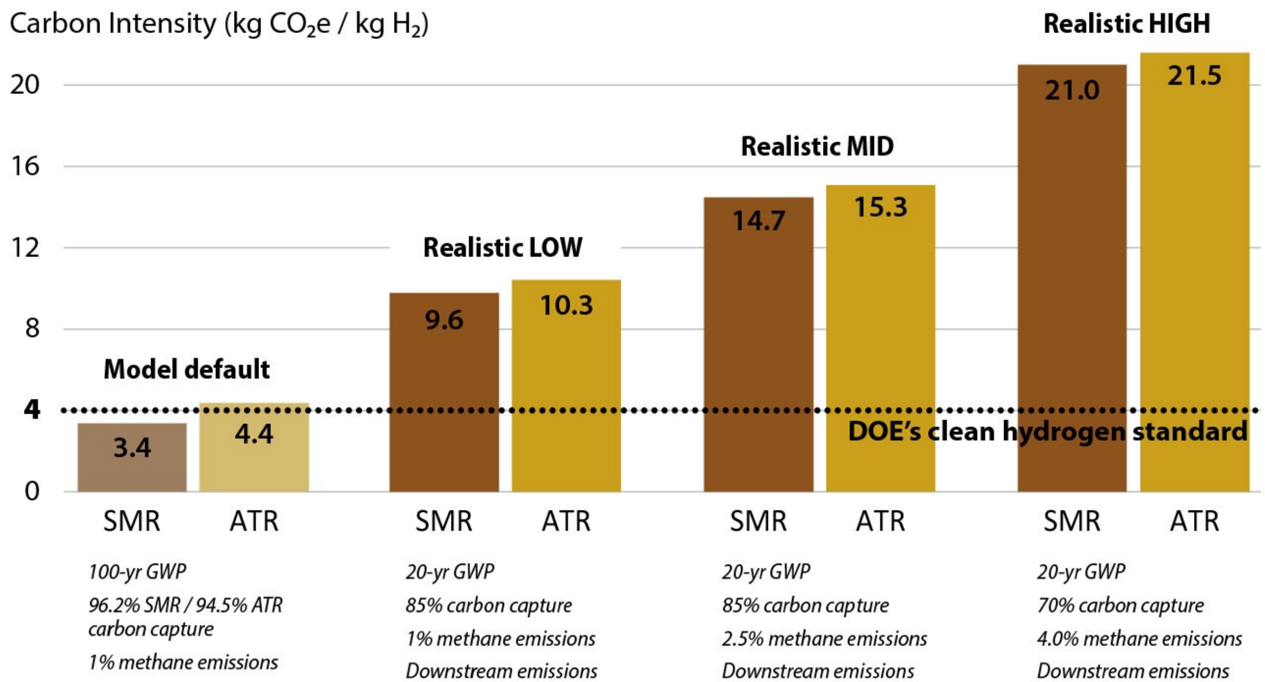
Producing Hydrogen from Natural Gas Is Not Clean, Not Low Carbon, Not a Solution to the Climate Crisis

The federal standard for clean hydrogen is that ≤4.0 kilograms of hydrogen are emitted into atmosphere for each kg of hydrogen produced.

The DOE has claimed that producing 'blue' hydrogen from the methane in natural gas is clean.

However, this is based on a number of unrealistic assumptions.

If more realistic and real-world assumptions are used instead, it becomes clear that blue hydrogen will not be clean.



There Are Significant Differences in the Physical and Chemical Properties of Hydrogen and Methane

- There are a number of physical and chemical differences between hydrogen and methane:
- Hydrogen is the smallest molecule, much smaller than methane.
  - ❖ This means hydrogen is much more likely
- Hydrogen has less than one-third the energy density of methane by volume.
  - ❖ This means that more than three times as much hydrogen as methane must be produced, transported and burned in a turbine to provide the same input energy for an equal amount of electricity.

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- There are a number of physical and chemical differences between hydrogen and methane:
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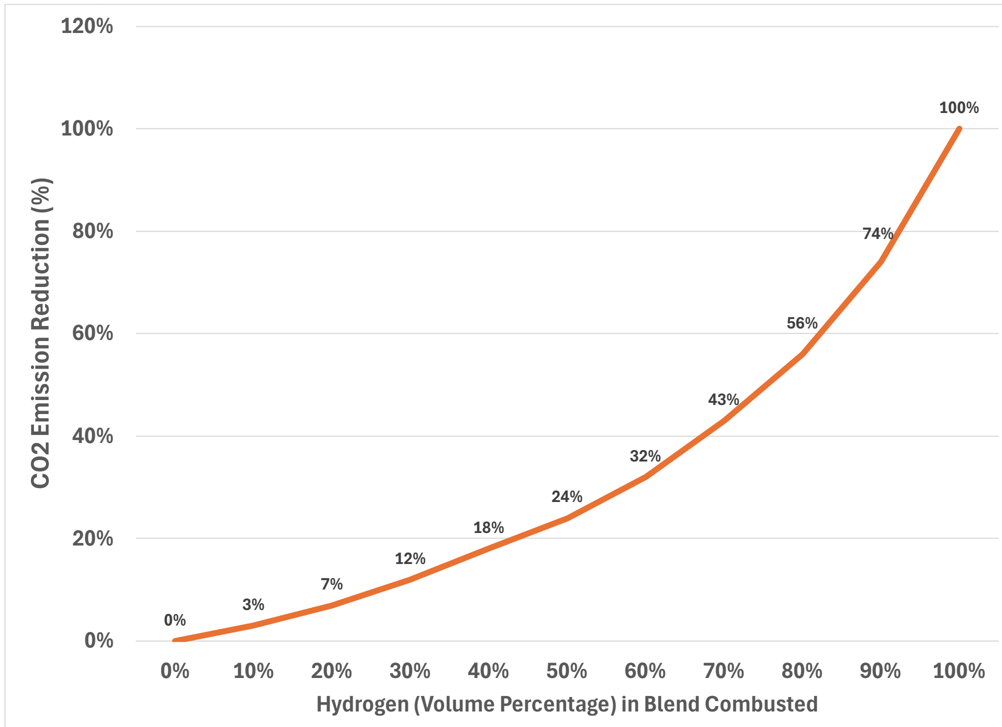
Burning 100% H2 or a Blend of Gas and H2 With a High % of H2 Needed to Achieve Significant Reductions in CO_2 Emissions

Burning a blend with 20% H2 reduces CO2 emissions by only 7%.

Burning a blend with 50% H2 reduces CO2 emissions by just 24%.



But Transporting Blends With Even Moderate Percentages of H2 May Not Be Possible in Existing Piping Network

- Materials in existing pipeline network not compatible with pure H2 or a blend with a high percentages of H2.
- Only a very small amount of existing network carries hydrogen – only about 1600-1800 miles, located mainly in Louisiana and Texas.
- Blending H2 with natural gas could cause accelerated cracking or pipe failures.
- A transition to 100% hydrogen, or even blends with high % of H2, likely won't be possible without significant retrofits and replacements.
- Likely to be time consuming and very expensive.
- Trucking the huge amounts of H2 that would be needed not feasible.