Institute for Energy Economics and Financial Analysis

Blue Hydrogen:
Not Clean, Not Low-Carbon, Not a Solution

Making Hydrogen From Natural Gas Makes No Sense

David Schlissel

Anika Juhn

Key Takeaways

Blue hydrogen is produced from fossil fuels

U.S. standard defines **clean hydrogen** as having a carbon intensity of **≤4.0 kilogram of (kg) CO_2e emitted / kg H_2 produced**

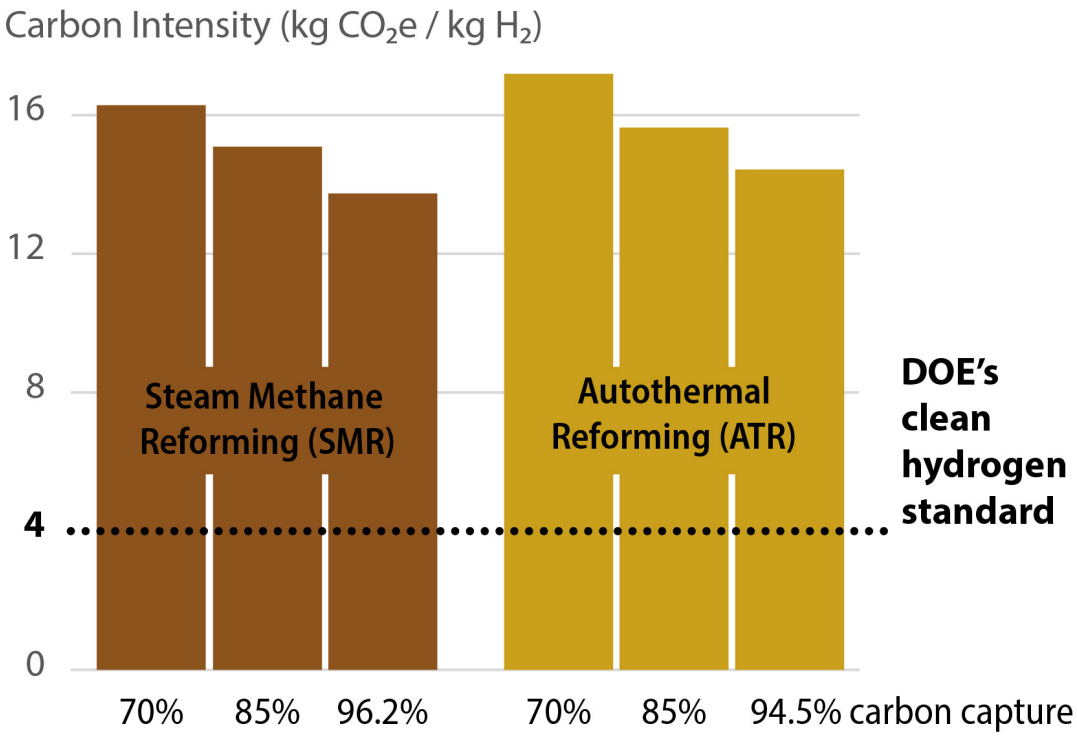
Meeting or beating this standard depends on a very favorable **set of assumptions:**

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**

Key Takeaways

With more **realistic assumptions**, carbon intensity of blue hydrogen will be **three to four times** higher than the clean standard

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

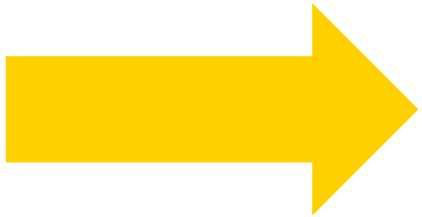


Why Have We Looked at This Question?

- 2021 Bipartisan Infrastructure Law (BIL) includes **billions in funding to establish hydrogen hubs** around the U.S.
- Money from the BIL will fund
  - Blue H_2 projects (from **fossil fuels**)
  - Green H_2 (from renewables)
  - Pink H_2 (from nuclear)
- Inflation Reduction Act (2022) includes **tens of billions in production tax credits** (PTC) for clean hydrogen and carbon capture & storage (CCS).

Evidence Blue Hydrogen Proponents Use to Prove it Will Be Clean and Low-carbon

- **Not much**
- Proponents repeat the words “hydrogen,” “clean” and/or “low-carbon” as often as possible, despite lack of evidence
- March, 2023 in DOE’s “Pathways to Commercial Liftoff: Clean Hydrogen”



Used word “clean” 494 times & “clean hydrogen” 376 times in 111 pages

How Have We Investigated These Claims?

- Studied the reasonableness of default assumptions built into **DOE's GREET model**
- Found many **not realistic**
- Reviewed scientific literature and real-world experience and **determined more realistic values** for key parameters
- **Modeled over 100 scenarios** in GREET to examine when blue hydrogen might be clean
- Used available data to add **estimates of downstream emissions**

Hydrogen Production Pathways Included in This Analysis

Steam Methane Reforming (SMR)

- Mixes natural gas (whose largest component is methane), air and high temperature steam to produce hydrogen
- Has two streams of CO_2; one high-concentration from H_2 production and one lower from fuel combustion

Autothermal Reforming (ATR)

- Mixes natural gas, pure oxygen and steam to produce hydrogen
- Has one, highly concentrated stream of CO_2

What Key Default Assumptions in DOE's GREET Model Are Unrealistic?

We found **four key assumptions** by the DOE that lead the GREET model to underestimate the carbon intensity of blue hydrogen, often by significant amounts

1

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

= significant **understatement of warming impact** in the short term

2

Very low upstream **methane emissions rate of 1%**

= far **lower than recent scientific analyses** as well as satellite and air surveys of basins

3

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

= overly optimistic **carbon capture rates not proven** over long term at commercial scale

4

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

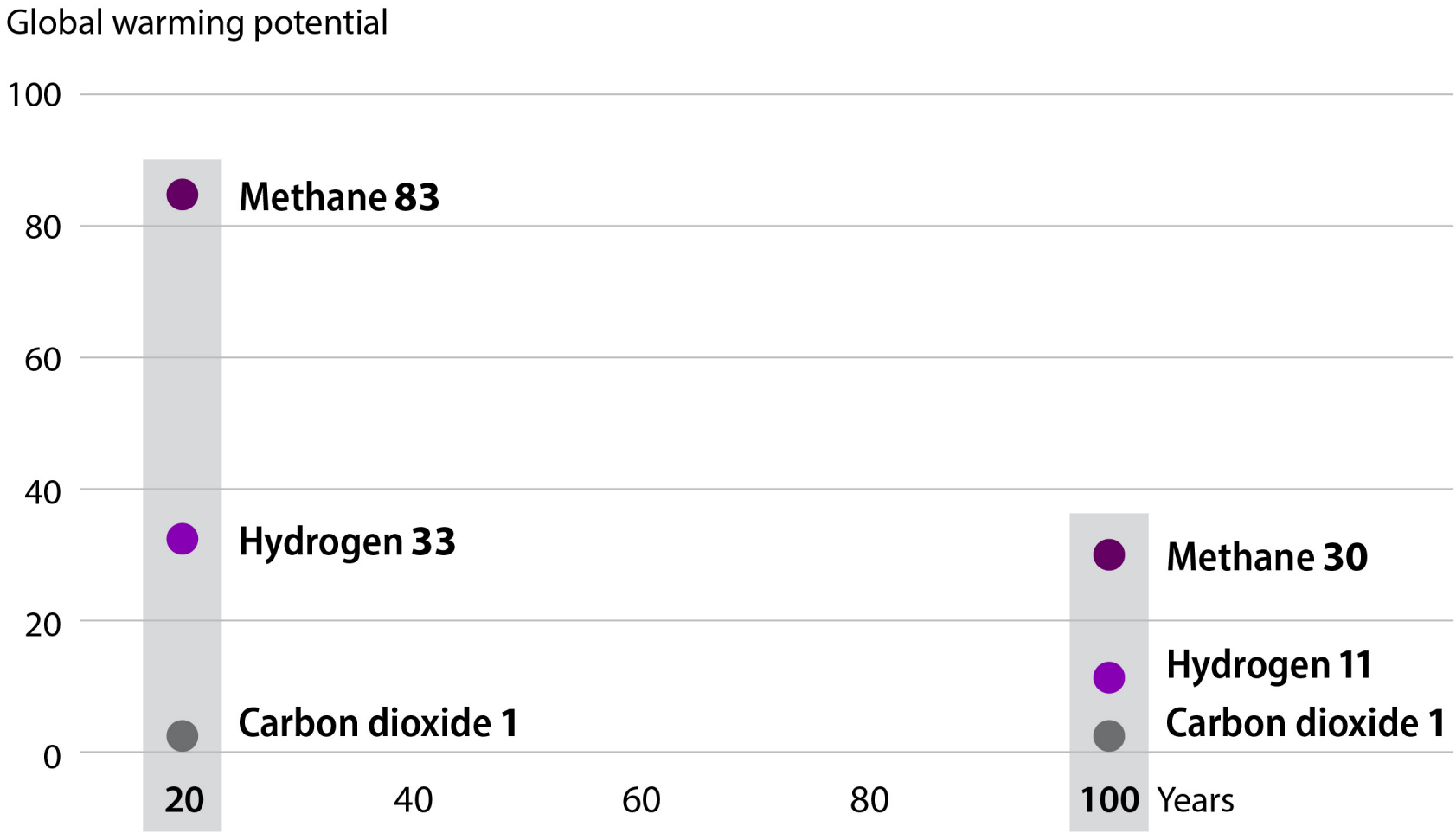
= omits significant **H_2 leakage** potential and energy required to **transport H_2**

Assumption #1

100-year global warming potential (GWP) for methane and no GWP for hydrogen

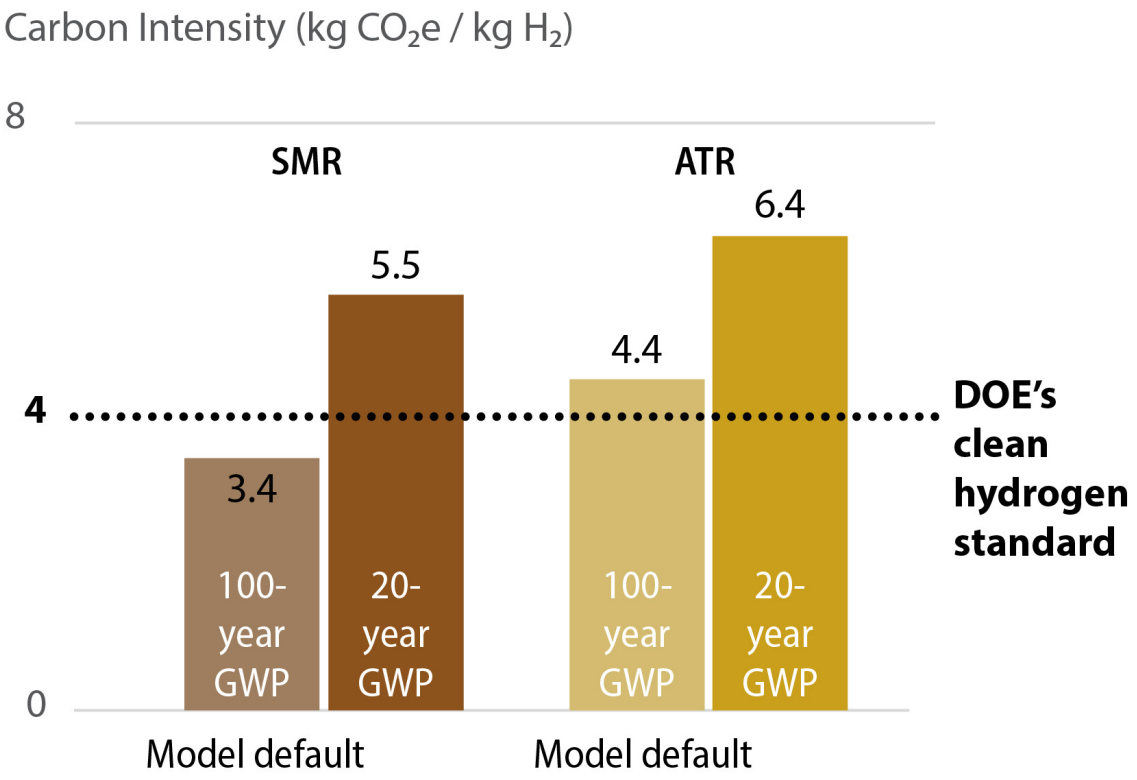
Why Do 20-year GWPs Matter?

Unlike carbon dioxide, methane and hydrogen have a more significant impact on warming in the first few decades after they are emitted



Impact of Changing GWP From 100-year to 20-year

When the significant short-term warming effects of methane are considered, blue hydrogen does not meet the clean standard

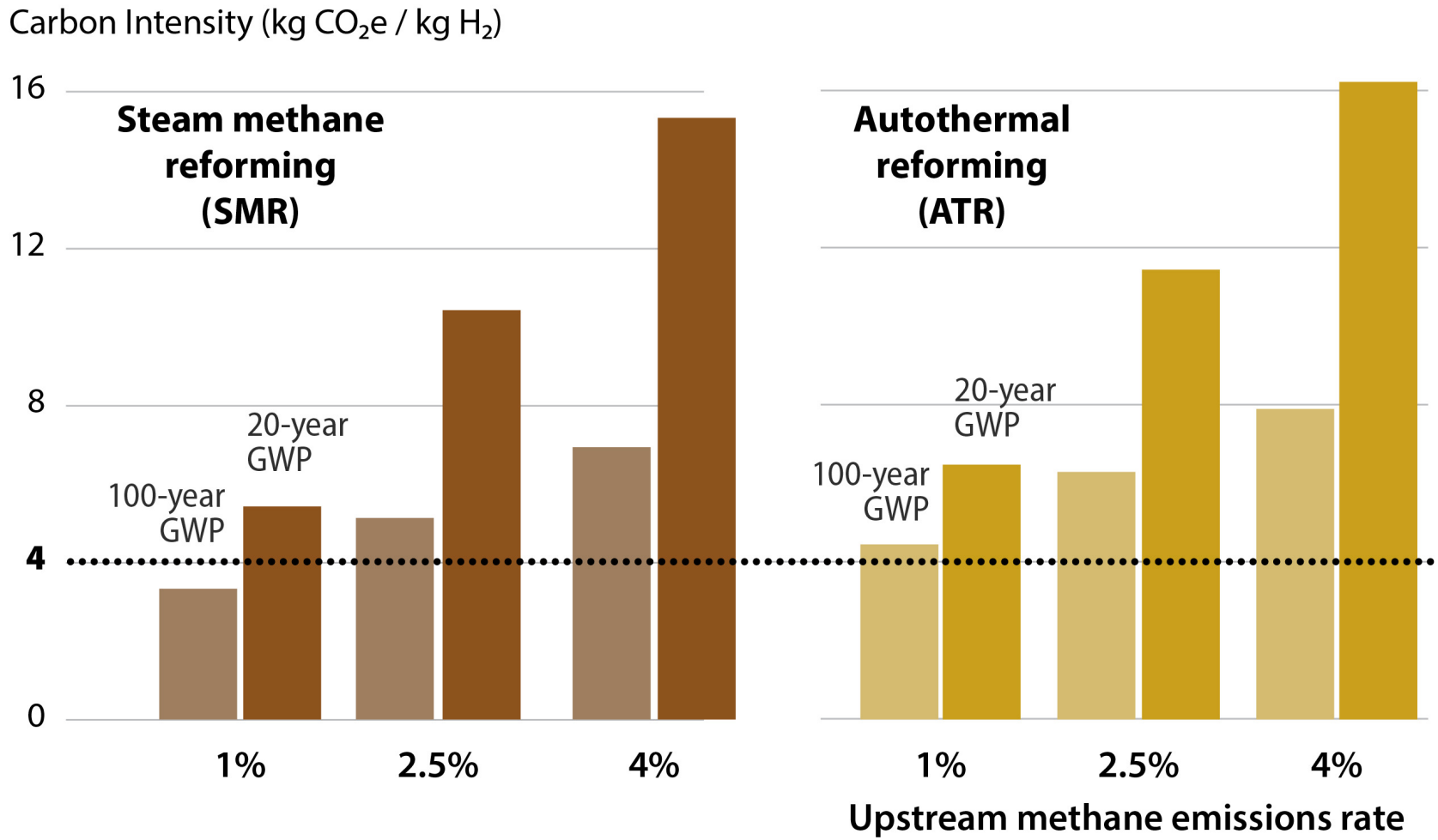


Assumption #2

Upstream methane emissions rate of 1%

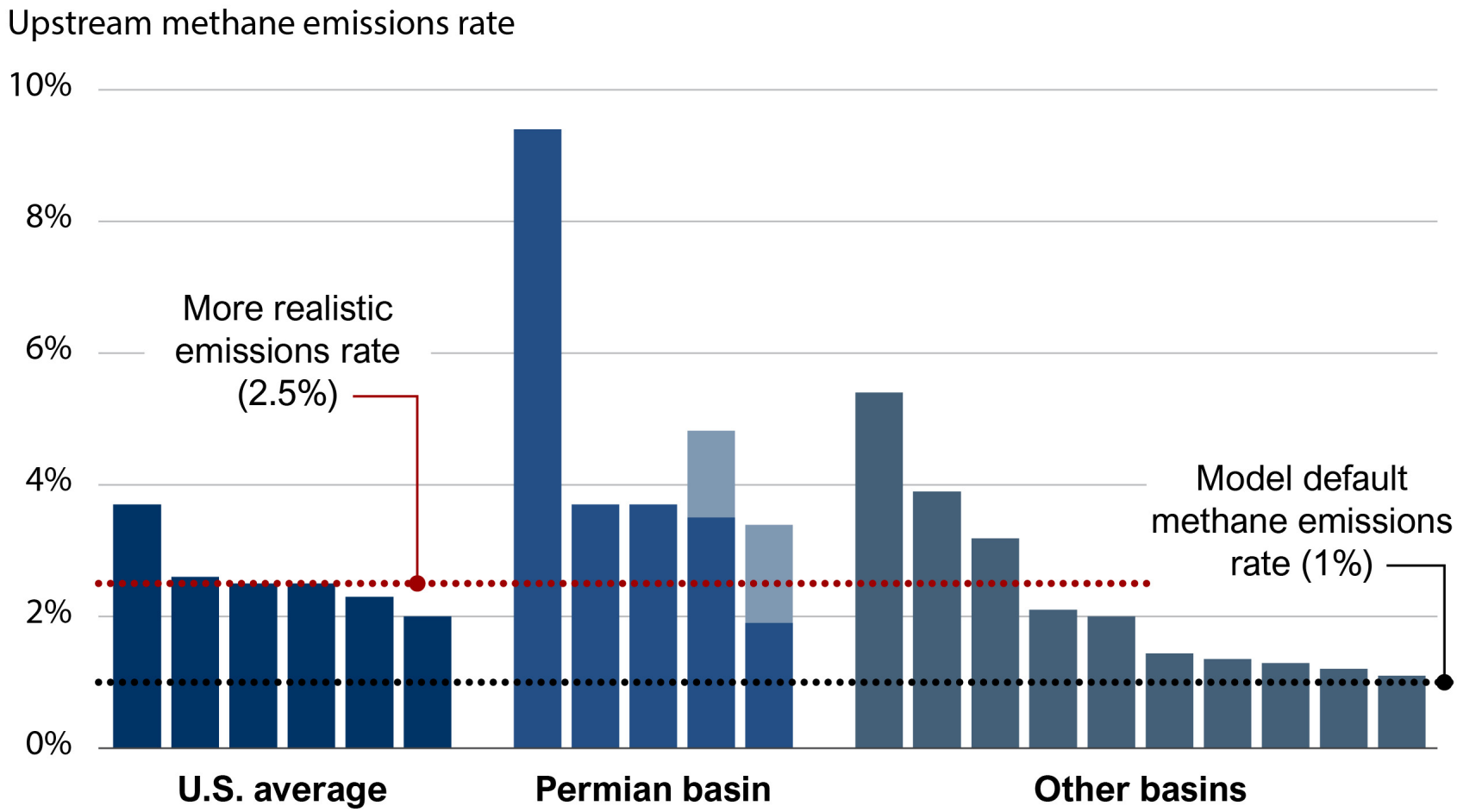
Why Do Upstream Methane Emissions Matter?

Emissions related to the production and transportation of methane result in releases of greenhouse gases more than 80 times as potent as CO_2 in terms of warming potential



What Do Recent Scientific Studies Say About Methane Emission Rates?

Based on a survey of the current scientific literature, U.S. average upstream methane emissions rates are much higher than 1%



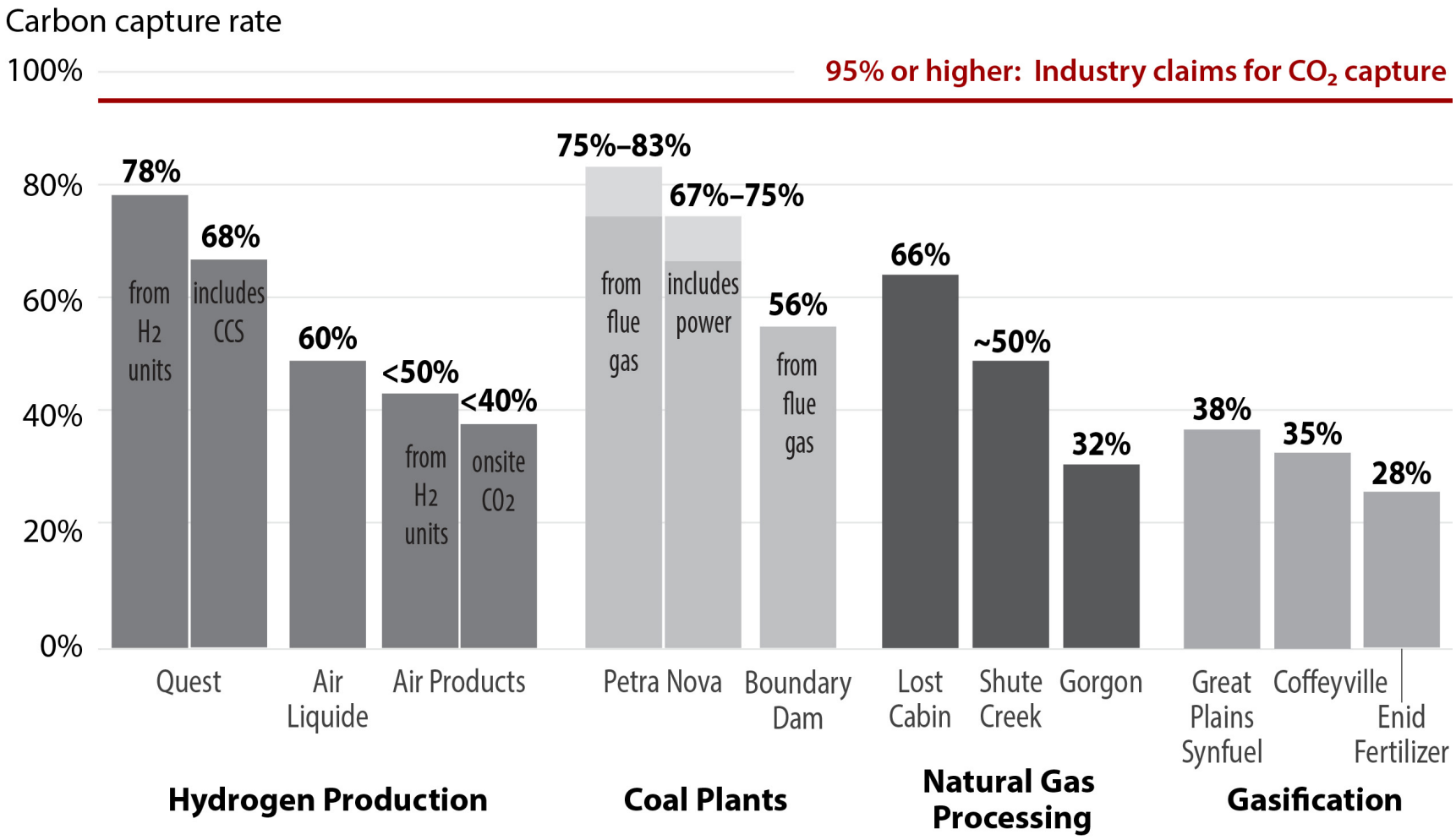
Assumption #3

Very high carbon capture rates

What CO_2 Capture Rates Does the DOE Assume?

- SMR will capture **96.2%** of the CO_2
- ATR will capture **94.5%** of the CO_2
- But there is **no actual commercial operating experience** to support such high capture rates

Real-world Carbon Capture Experience Is Far Below DOE's Current Assumptions

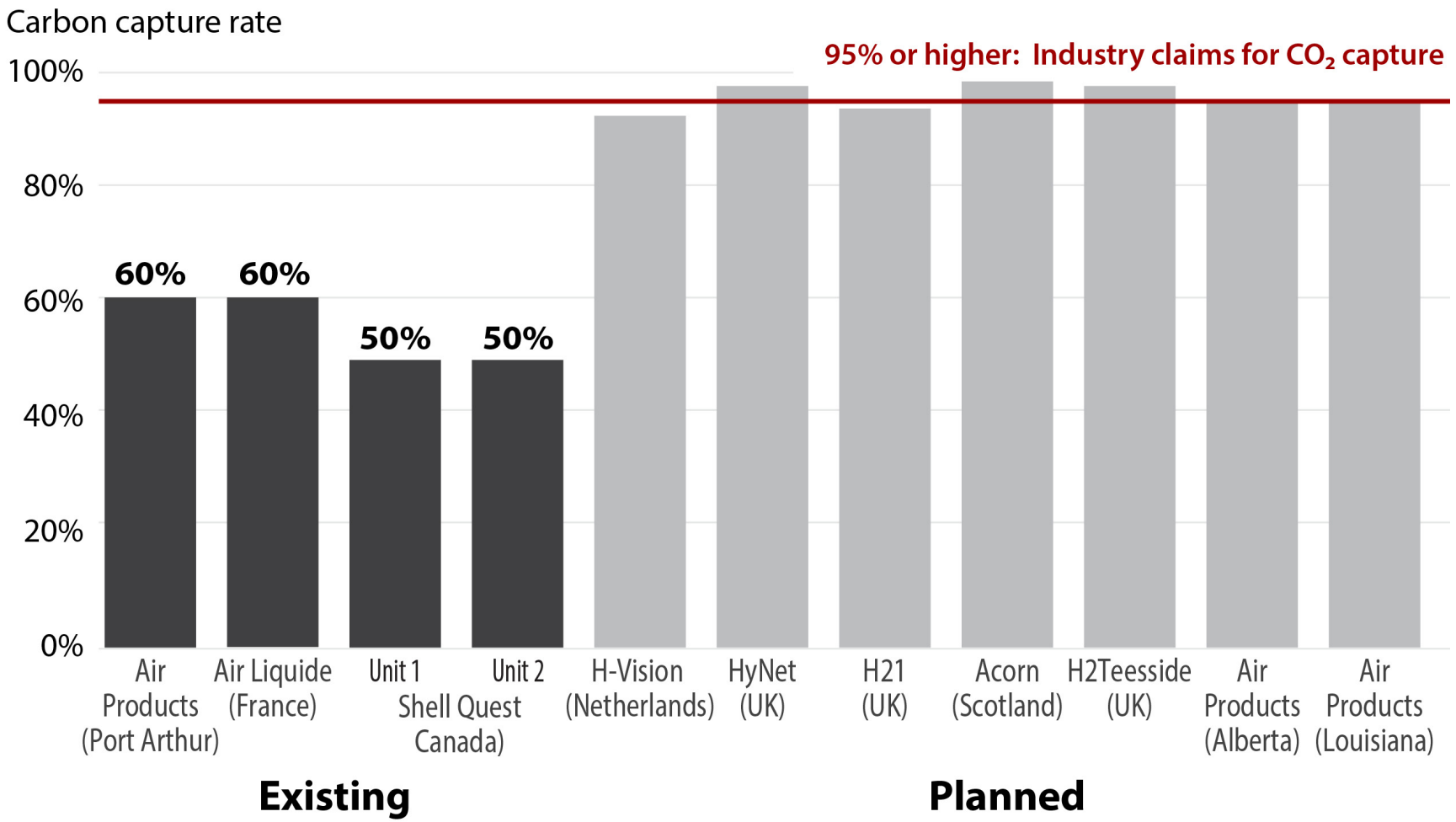


On What Evidence Does the DOE Base Its Assumed High CO_2 Capture Rates?

- **Claims by the developers** of proposed hydrogen production facilities that have not yet been built or operated, or are even under construction. Some of these projects have not yet even been funded.

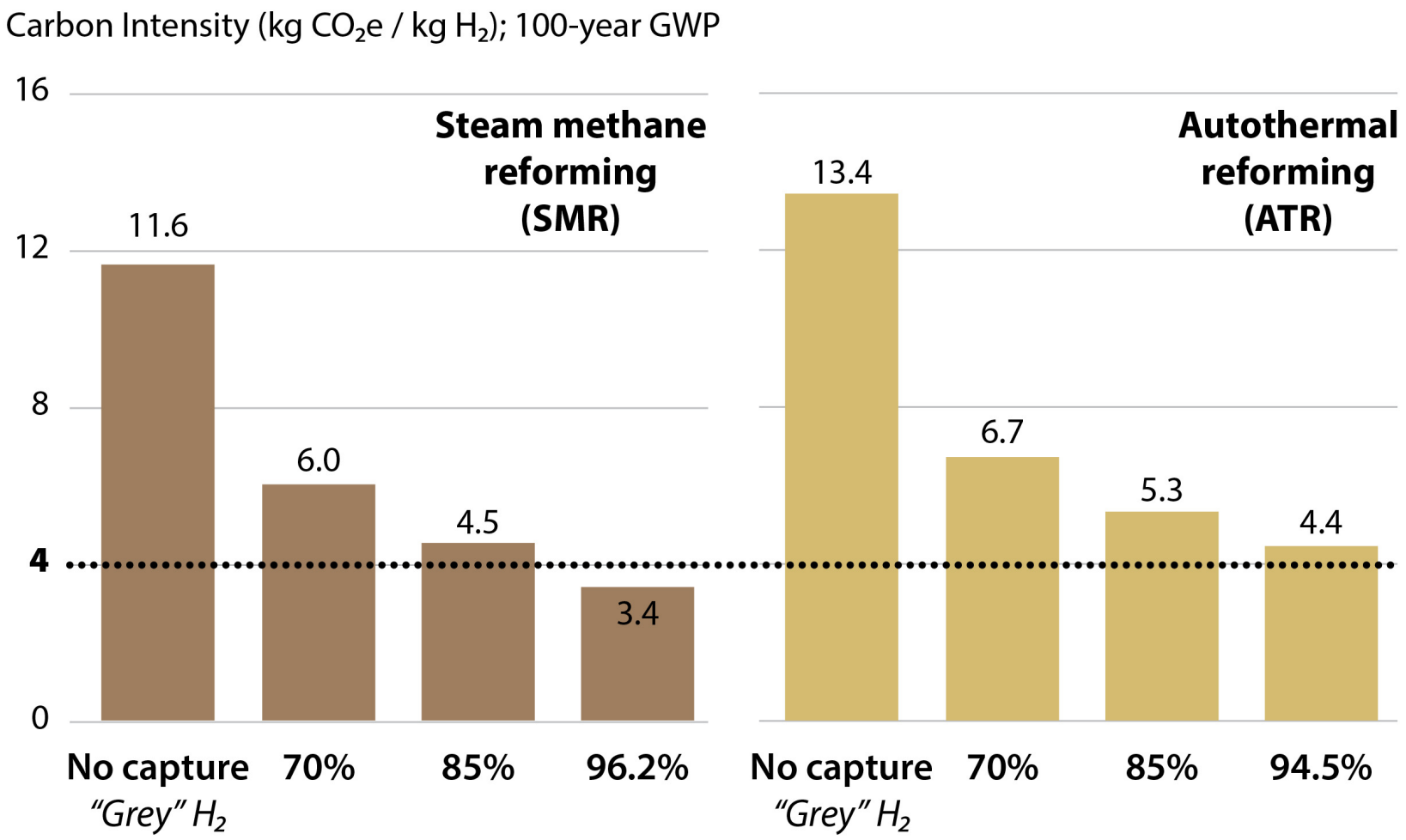
- Results of **small-scale testing** (e.g., 1% or 5%) of new and enhanced capture technologies.

What Is the Basis for DOE's Assumed High CO_2 Capture Rates?



Why Is the Carbon Capture Rate Important?

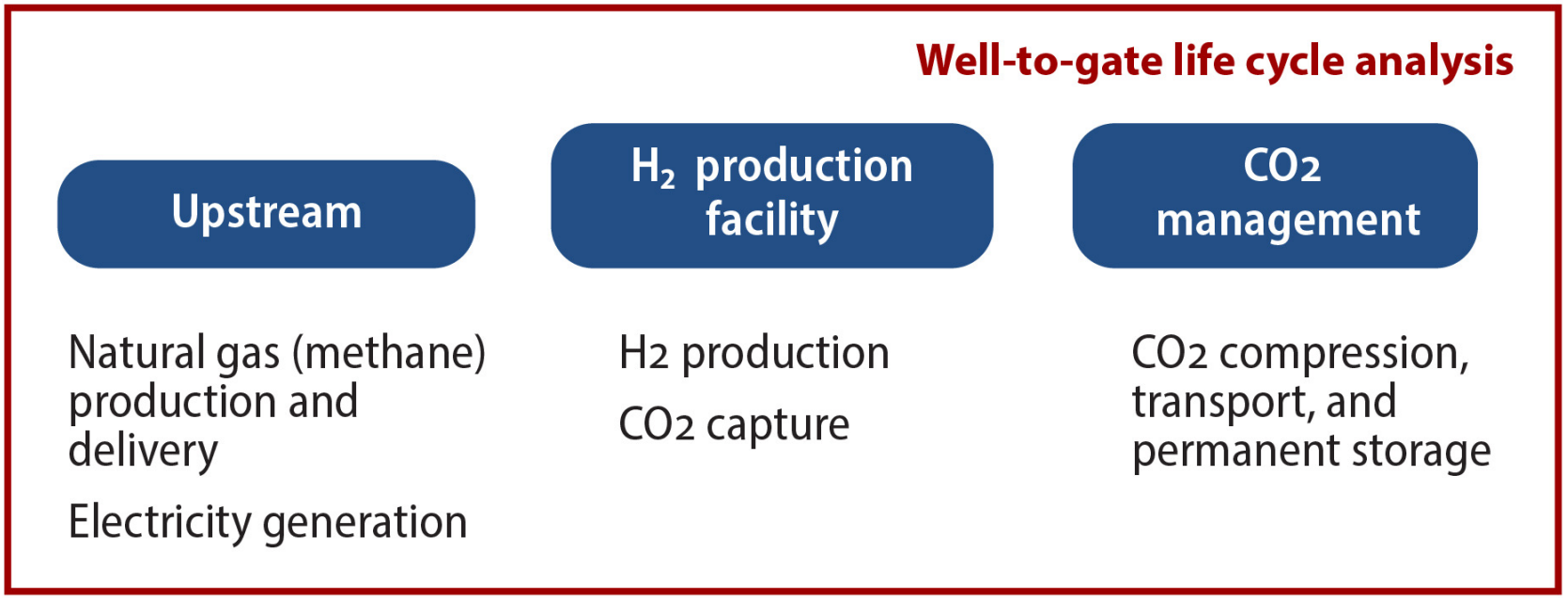
Carbon capture can't make blue hydrogen clean. Assuming very high capture rates relative to industry performance, blue hydrogen still exceeds the "clean hydrogen" standard.



Assumption #4

Downstream emissions should be excluded

A True Life Cycle Analysis?



- Well-to-gate mandate from IRA and DOE
- Downstream emissions other than CO_2-related are excluded
- Potent global warming impact of hydrogen is not included

Hydrogen Is an Important Global Warming Gas

- Hydrogen is an indirect greenhouse gas with a **20-year GWP 33 times stronger than CO_2**
- Hydrogen is a very small molecule that **can easily escape** from pipelines and related equipment
- There currently is **no technology that can find all the very small leaks** through which hydrogen can escape
- It is **not known how much hydrogen is currently leaking** and current published estimates range from less than 1% up to 10% across the hydrogen value chain

Downstream Emissions Are Not Reflected in Blue Hydrogen's Carbon Intensity

- There is **no GWP for hydrogen** in the current version of GREET, neither a 20-year nor a 100-year GWP
- Congress has mandated that the calculation of carbon intensity should **not include downstream emissions**, such as hydrogen leaks or emissions related to the compression and transport of hydrogen
- But that doesn't mean we can or should ignore these emissions

Results

What Assumptions Have We Made in This Study?

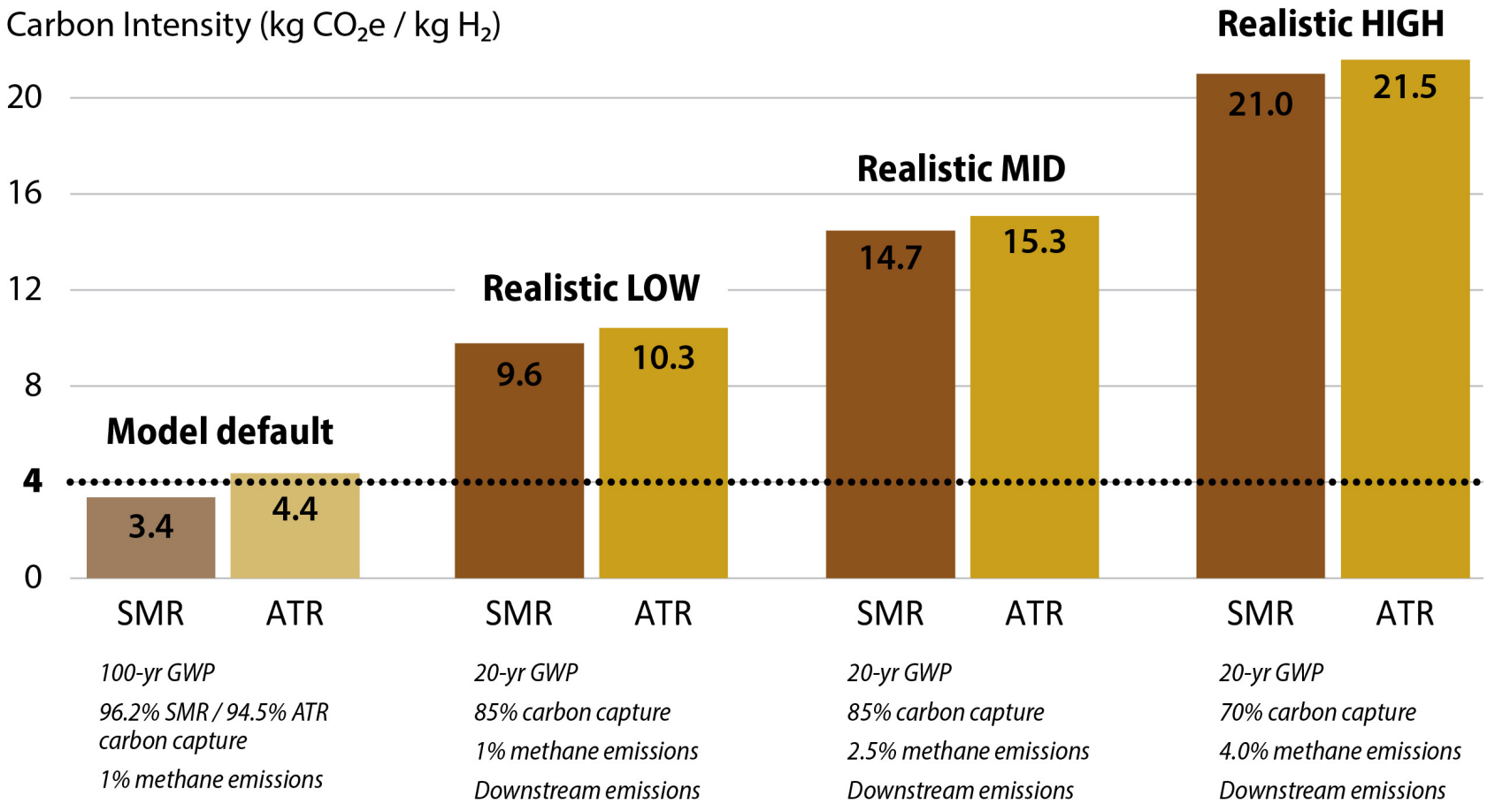
Our calculations of blue hydrogen carbon intensity results are based on the following:

1. Both 20-year and 100-year **GWPs**
2. Selected **methane emission rates** from 1% up to 4%
3. **Carbon capture rates** of 70%, 85% and the GREET defaults
4. Scenarios with and without **downstream** hydrogen emissions and transmission

Not worst-case scenarios

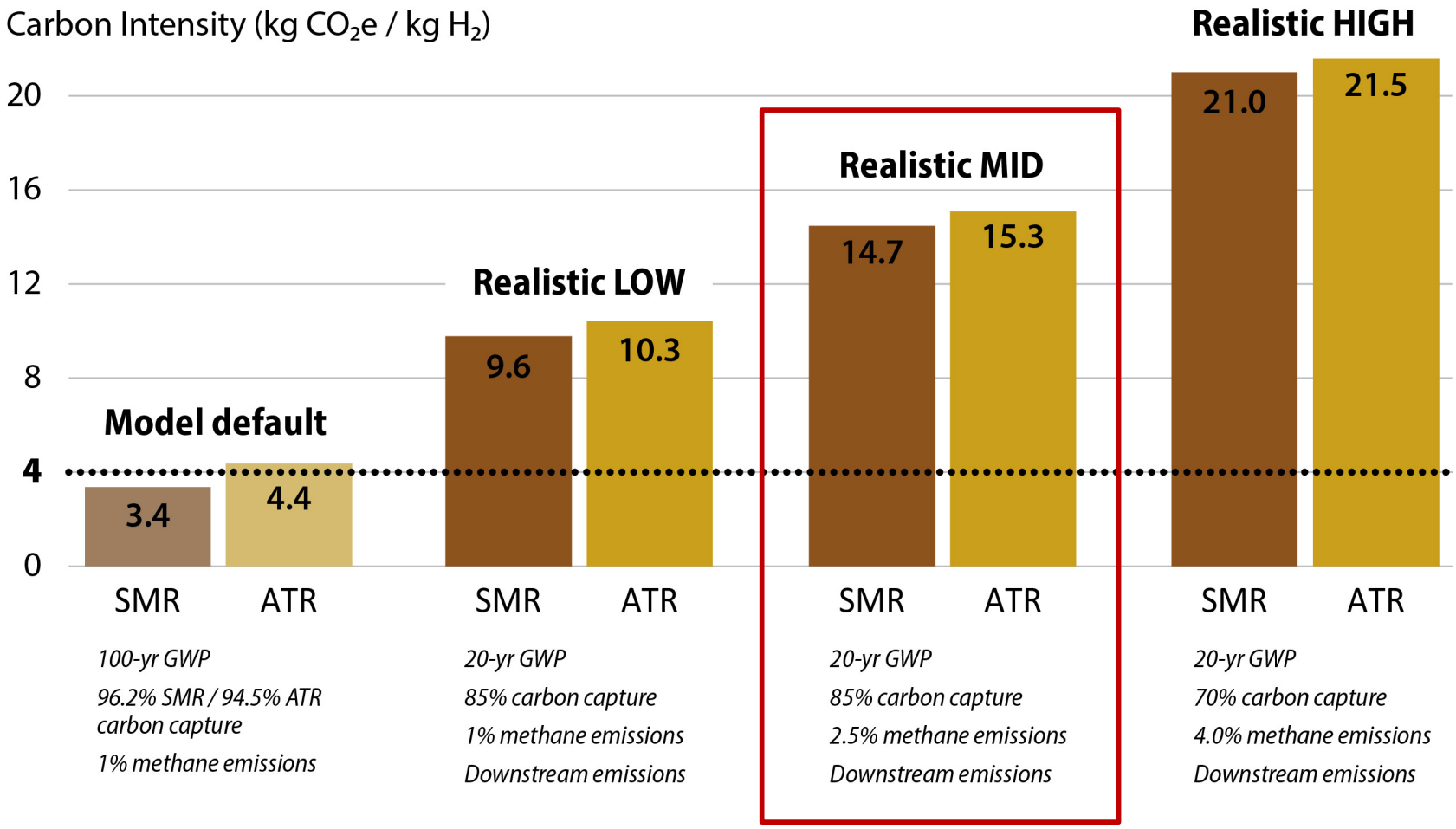
How Dirty Could Blue Hydrogen Be?

Realistic assumptions indicate the carbon intensity would be triple that of the "clean hydrogen" standard or even greater



How Dirty Could Blue Hydrogen Be?

Realistic assumptions indicate the carbon intensity would be triple that of the "clean hydrogen" standard or even greater; the mid-range realistic scenario is highlighted



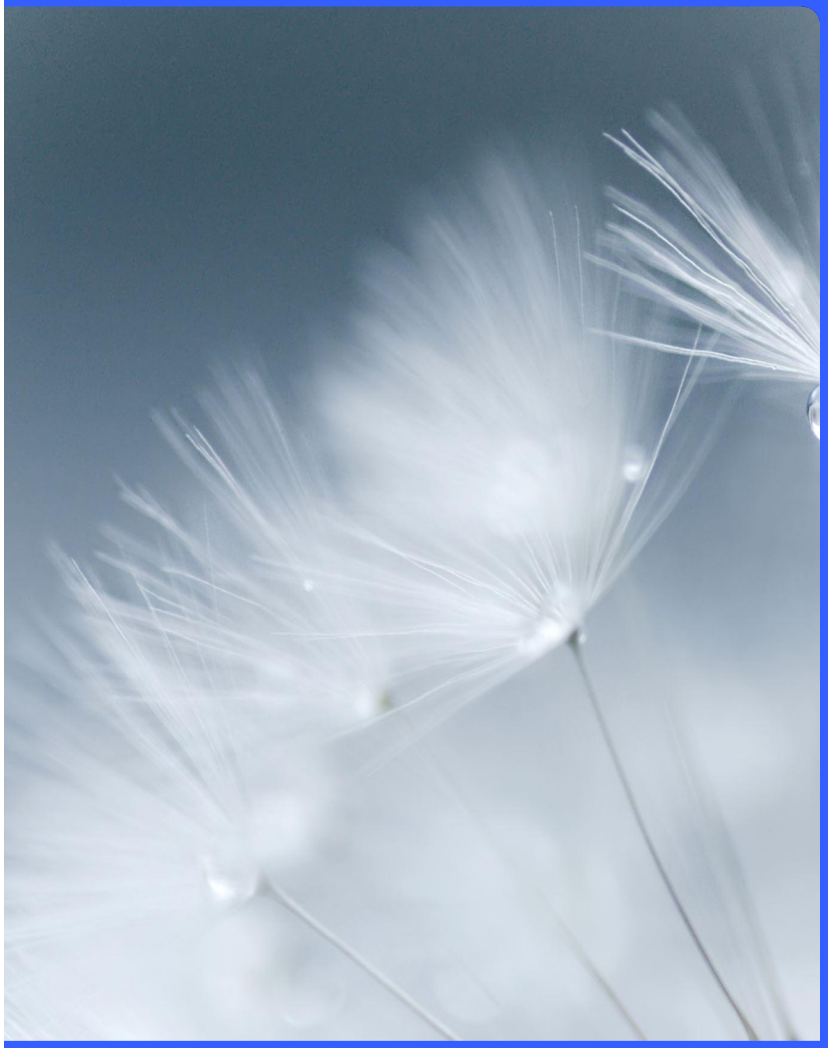
Conclusions

1. Contrary to the claims of blue hydrogen proponents, the fuel is not clean or low-carbon and it never will be.

2. Unless you accept all of the unrealistic default assumptions built into the DOE GREET model, producing blue hydrogen from natural gas is shown to have carbon intensities potentially as high as 5 times the DOE's clean standard.

3. There is significant risk that the support and funding of blue hydrogen projects will make global warming worse because projects built in the coming years will continue to produce high carbon intensity blue hydrogen for decades.

4. Neither the U.S. federal government nor state governments should fund dirty blue hydrogen production projects.



Questions?

Contact

David Schlissel, dschlissel@ieefa.org

Anika Juhn, ajuhn@ieefa.org

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