

A photograph of a wind turbine against a blue sky with light clouds. The turbine is white and stands on a tall tower. Other turbines are visible in the distance.

# HYDROGEN POLICY OVERVIEW

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Manager,  
Electricity Program

*October 2024*

ENERGY  
INNOVATION   
POLICY & TECHNOLOGY LLC



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# Agenda

- Context
- Hype
- Production
- Use
- Recap



## Context: Hydrogen Policy's Narrow Path

“

Hydrogen will be important for achieving our climate goals, but it can do so if and only if it is truly zero-carbon and directed to appropriate applications. Straying from this narrow path can reverse, delay, or raise the costs of emissions reductions.

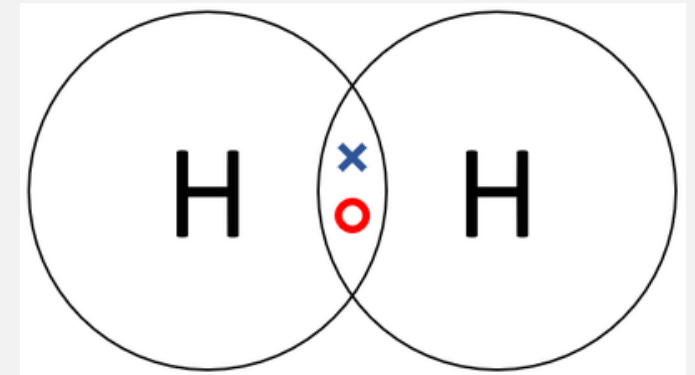
”

# Context: What is Hydrogen?

- Hydrogen ( $H_2$ ) is:
  - A gaseous molecule
  - that *can* be produced without greenhouse gas emissions and
  - that *can* be used in place of fossil fuels
- Hydrogen can help decarbonize things that are difficult or impossible to electrify
- But, it also risks doing more harm than good



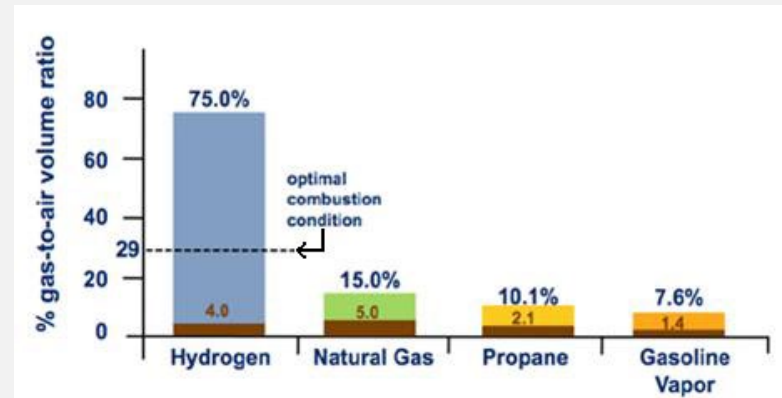
[https://en.wikiversity.org/wiki/The\\_periodic\\_table/Hydrogen](https://en.wikiversity.org/wiki/The_periodic_table/Hydrogen)



<https://keystagewiki.com/index.php/Hydrogen>

# Context: Comparison with Methane Gas

- **Safety:** hydrogen is colorless, odorless, leakage-prone, and highly flammable
- **Health:** hydrogen emits more harmful nitrogen oxides (NOx) than methane when burned in air
- **Climate:** hydrogen leaks have a strong climate-warming impact
- **Operational:** hydrogen's faster flame speed makes its combustion more difficult to control
- **Efficiency:** hydrogen has  $\sim 1/3^{\text{rd}}$  the energy content per unit volume and requires far lower temperatures to liquefy for transport/storage

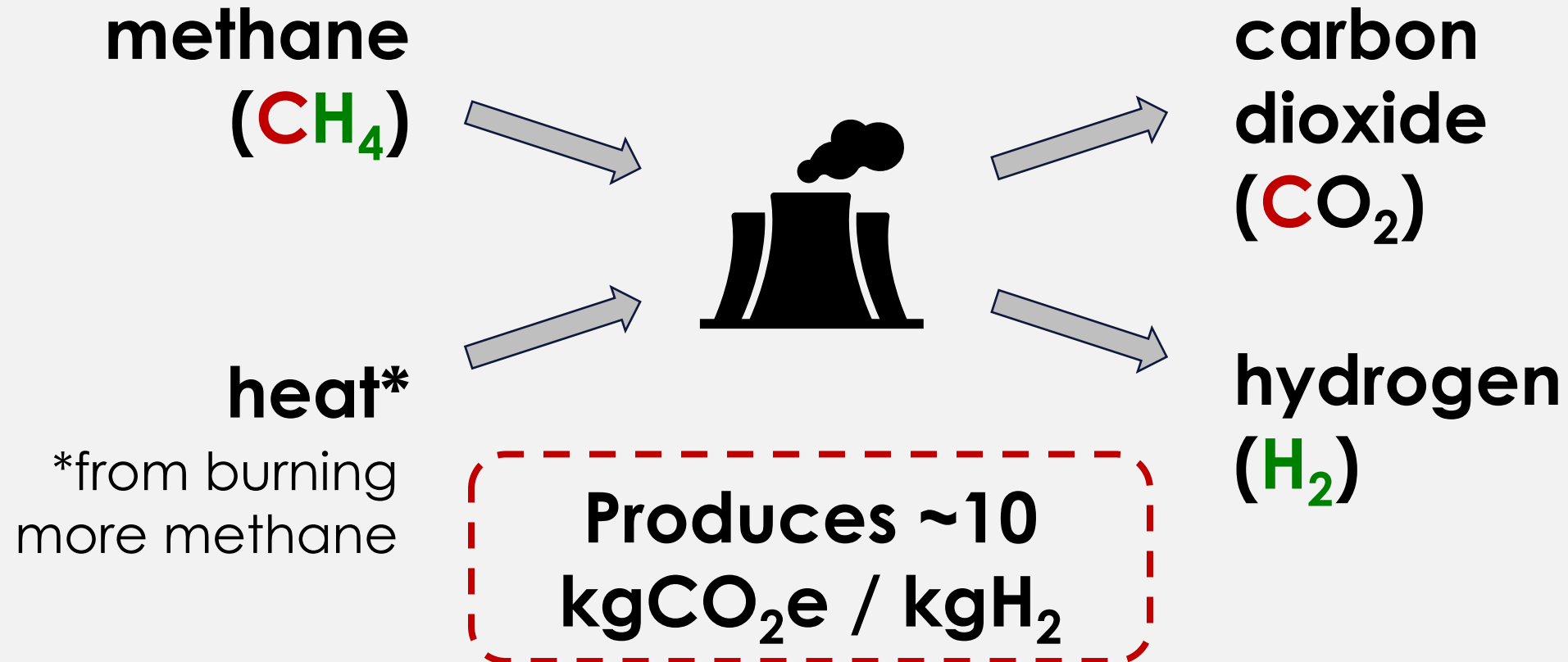


<https://h2tools.org/bestpractices/hydrogen-compared-other-fuels>



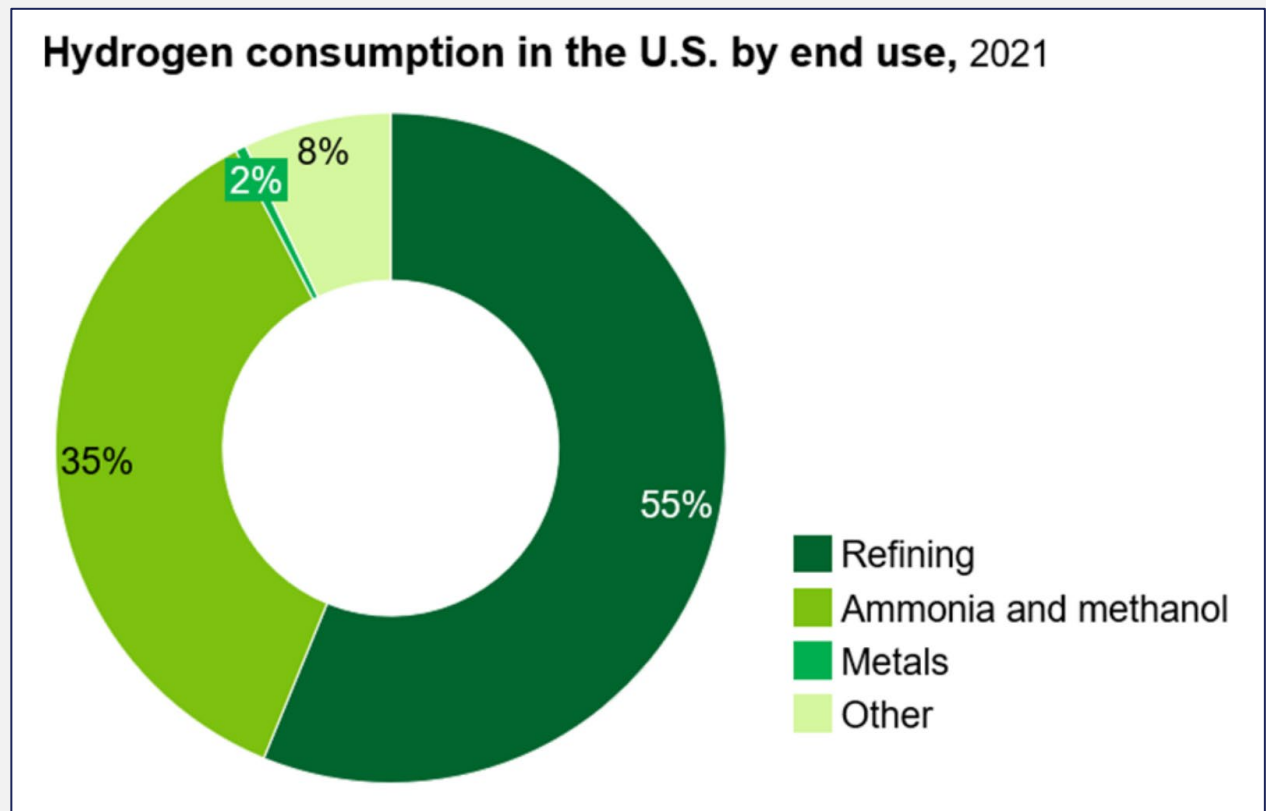
<https://h2tools.org/bestpractices/hydrogen-flames>

# Context: Fossil-Based Hydrogen Production



# Context: Today's Hydrogen End-Uses

- The U.S. produces 10 million metric tons (MMT) of hydrogen annually
- This is responsible for ~1.5% of all U.S. climate pollution
- The vast majority is used to refine oil or make chemicals (e.g., inputs to fertilizer) – processes that need H<sub>2</sub> as a feedstock

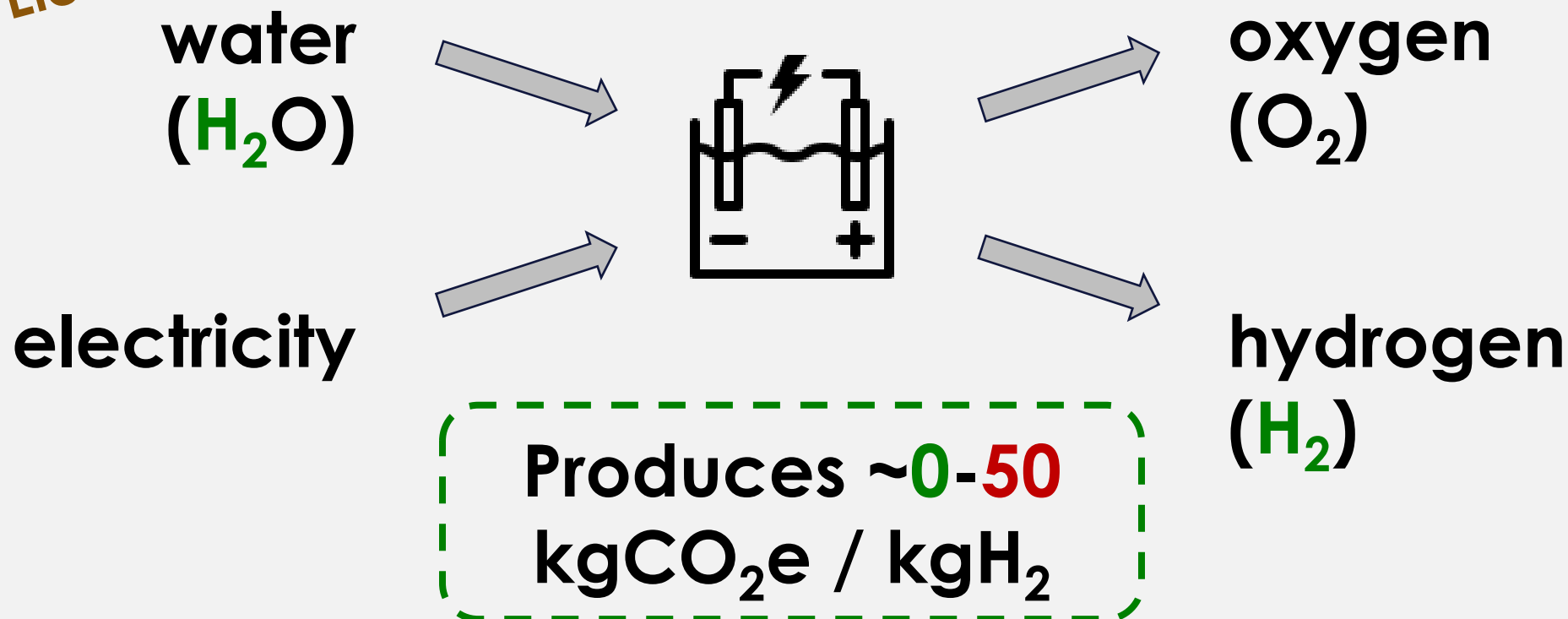


<https://www.hydrogen.energy.gov/pdfs/us-national-clean-hydrogen-strategy-roadmap.pdf>



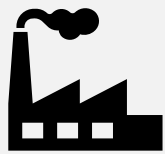
# Context: Carbon-Free Hydrogen Production

*Example: Electrolysis*



# Context: Potential Future Hydrogen End-Uses

## Chemical Feedstock



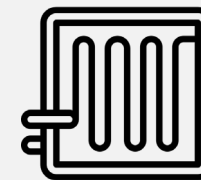
- Used to make or alter other compounds
- Generally no substitute – cannot be electrified

## Combustion



- Burned to produce heat
- Inefficient process
- Can emit harmful air pollution (NO<sub>x</sub>)

## Fuel Cell



- Used to generate electricity
- Very efficient and clean process but often beat by electrification

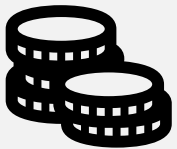
# Hydrogen Hype: Driving Forces



Utility Proposals



Federal Investments



State Proposals



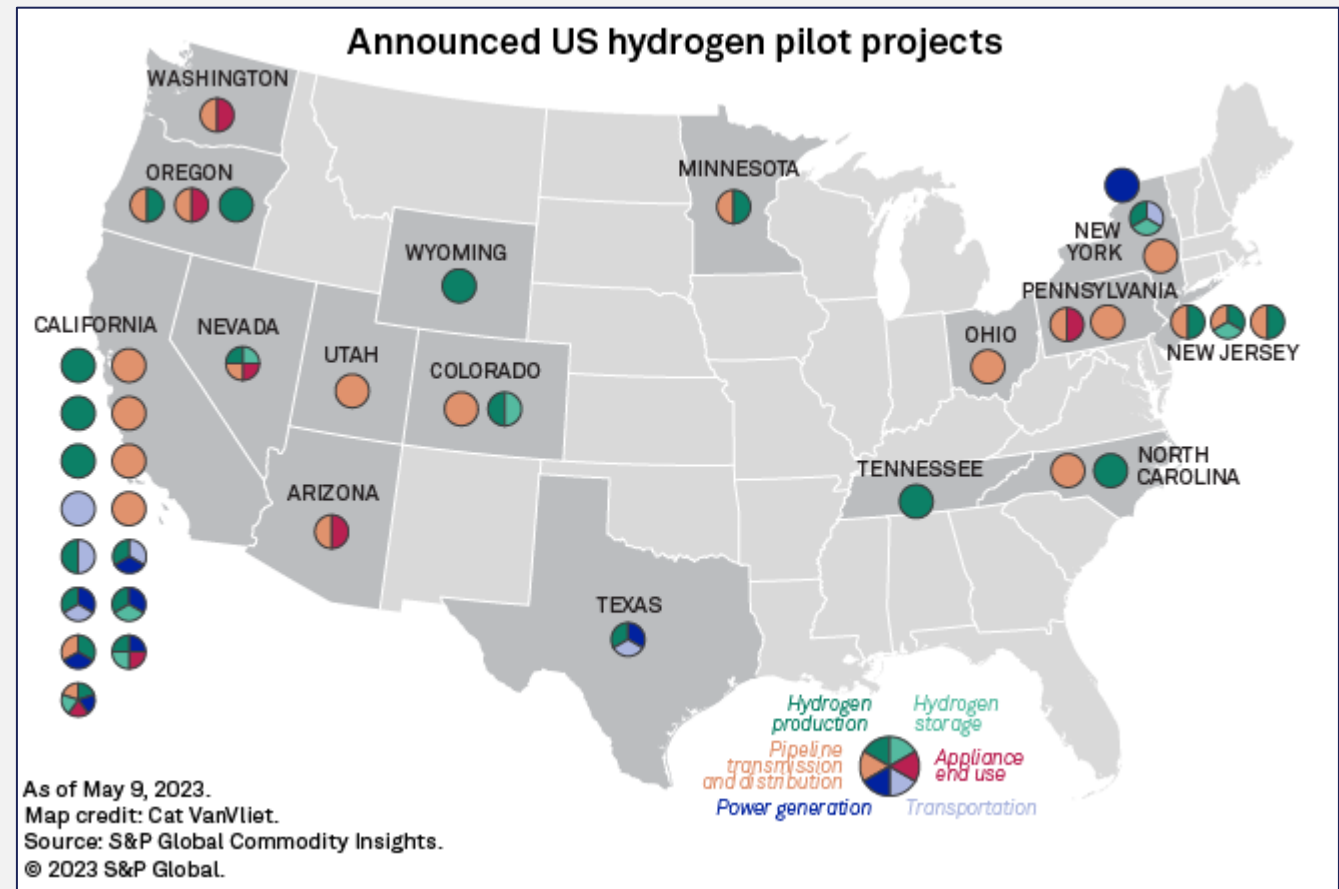
European Action



Power Plant Regulations

# Hydrogen Hype: Utility Proposals

- Utilities are feeling the squeeze from calls to electrify buildings and move away from gas-fired power generation
- Many proposals focus on blending H<sub>2</sub> into existing natural gas infrastructure or co-firing H<sub>2</sub> in existing and new power plants

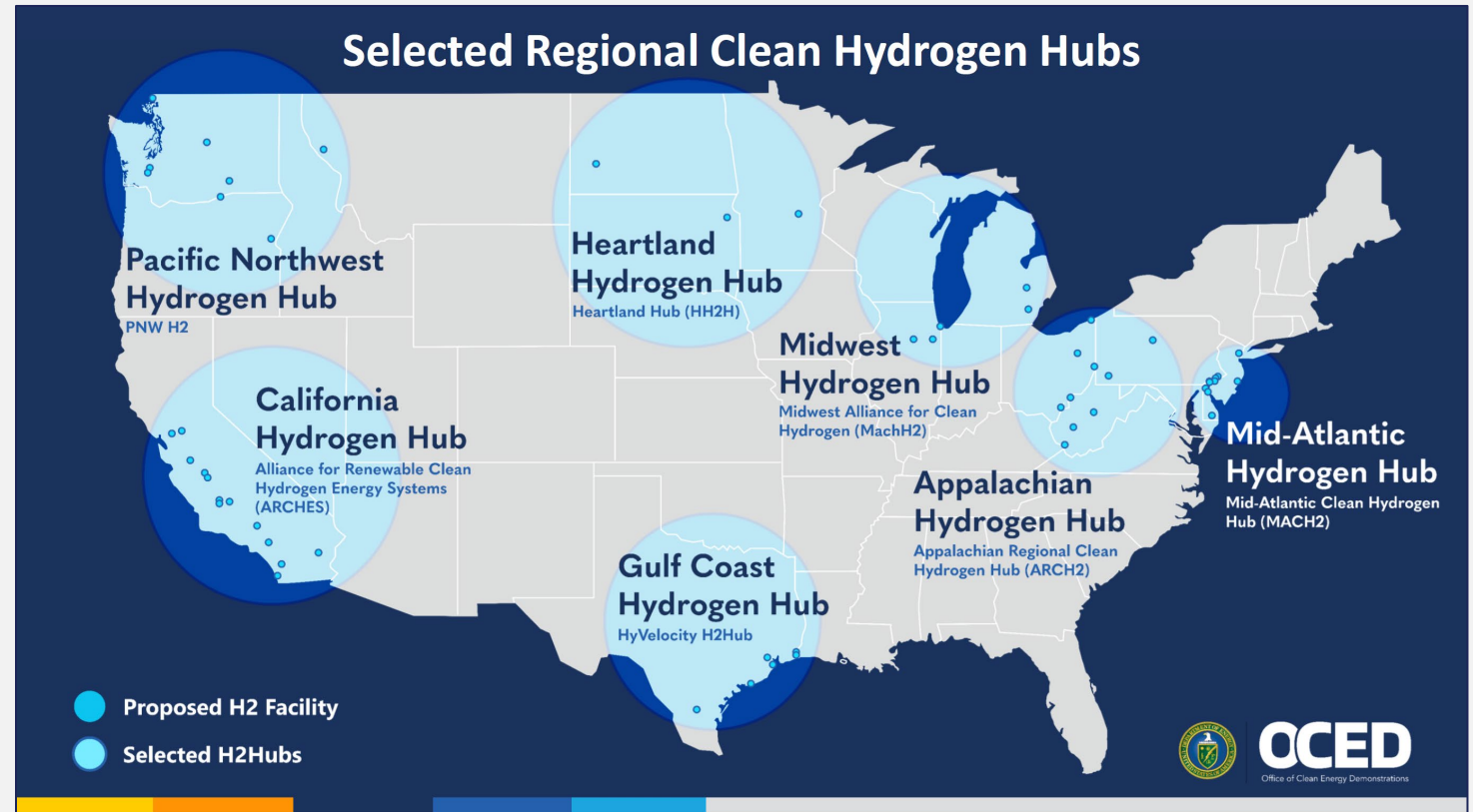


[https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/cpil-2719760-article\\_news\\_title-textbox-gas-utilities-increasingly-focus-on-pipeline-blending-in-hydrogen-pilot-pro-75656565](https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/cpil-2719760-article_news_title-textbox-gas-utilities-increasingly-focus-on-pipeline-blending-in-hydrogen-pilot-pro-75656565)

# Hydrogen Hype: Federal Investments (IIJA)

## Infrastructure Investment & Jobs Act of 2021 (IIJA)

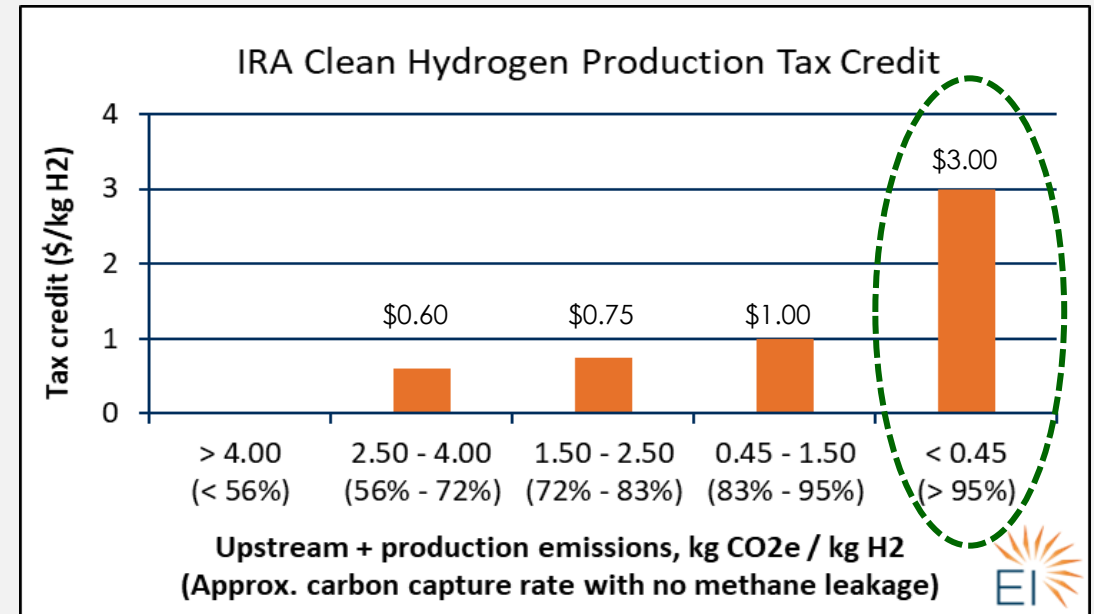
- \$7 billion for 7 hydrogen hubs
- Must test different production methods and end uses
- Many phases to play out over ~8-12 years



# Hydrogen Hype: Federal Investments (IRA)

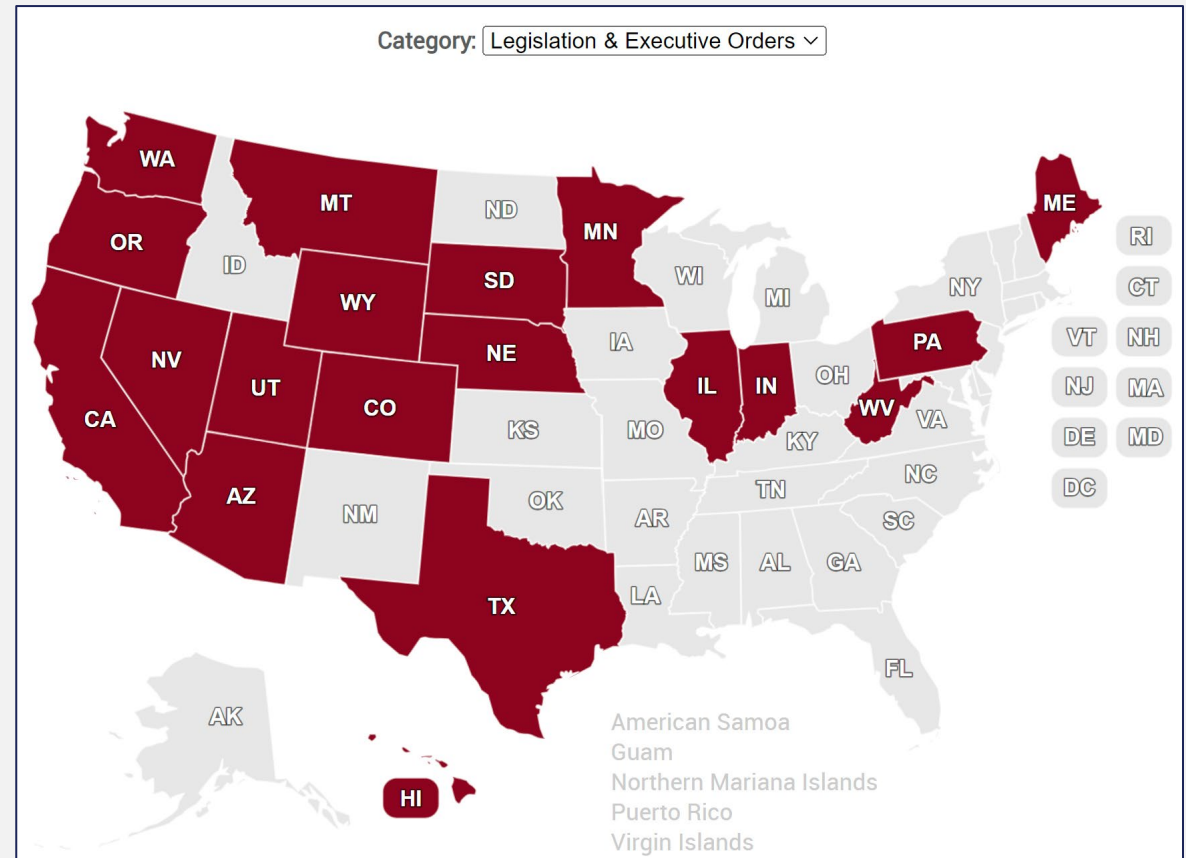
## Inflation Reduction Act of 2022 (IRA)

- “45V” tax credit values are based on lifecycle production emissions – account for methane leakage
- Value is up to \$3/kg H<sub>2</sub> (3x current price of dirty hydrogen)
- U.S. Treasury published draft rules in Dec. 2023 (aligning with EU) but has not yet issued final rules



# Hydrogen Hype: State Proposals

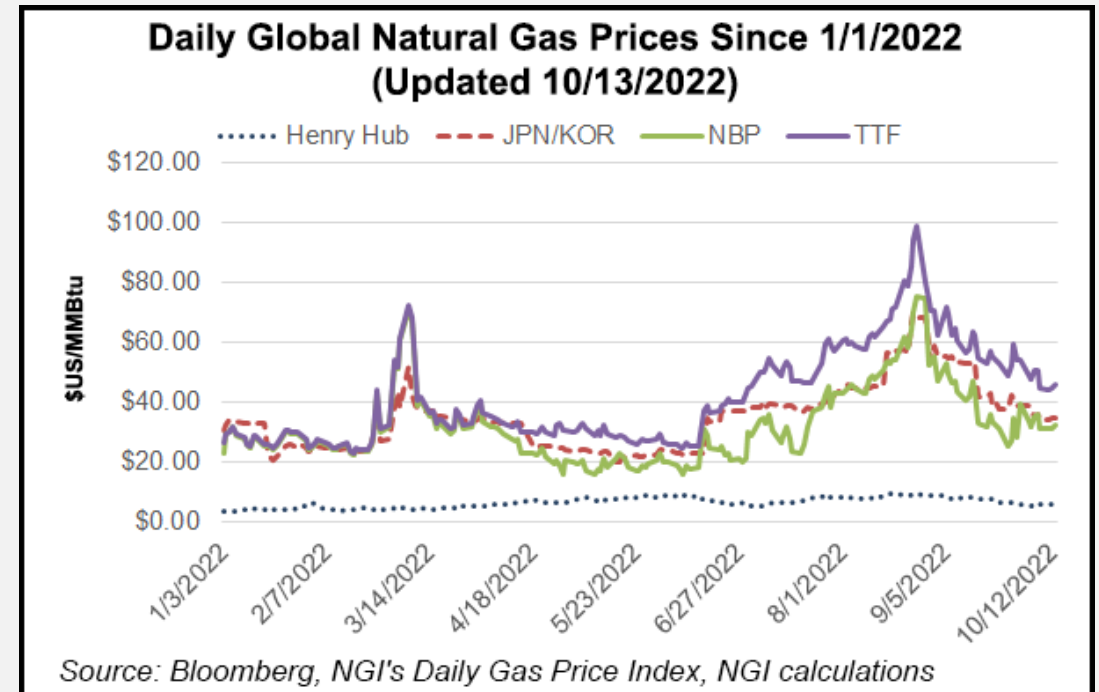
- Given huge influx of federal money and investor interest, states don't want to miss out on new jobs, industries
- Almost every state has some H<sub>2</sub> involvement (roadmaps, working groups, etc.) – map shows states with legislation and executive orders



<https://www.naseo.org/hydrogen-map> - as of April 3, 2024

# Hydrogen Hype: European Action

- Russia's invasion of Ukraine amplified EU concerns about its reliance on Russian natural gas and increased urgency to diversify to other energy sources
- Liquid natural gas imports are very expensive
- EU sees hydrogen as part of a strategy to reduce natural gas dependence altogether



Henry Hub = US index  
NBP = UK index  
TTF = EU index

<https://www.naturalgasintel.com/as-europe-prepares-for-winter-natural-gas-market-fears-worst-may-be-yet-to-come/>



# Hydrogen Hype: Power Plant Regulations

- New U.S. Environmental Protection Agency rules regulate GHGs from new natural gas and existing coal power plants
- Proposed rules included an explicit hydrogen co-firing compliance pathway
- Final rules benchmark to carbon capture technology instead, though hydrogen is allowed

## Proposed H<sub>2</sub> Option (**Scrapped in Final Rule**)

**2032:** 30% by volume H<sub>2</sub> co-firing

\* All new baseload units

\* All new intermediate load units

\* Large existing baseload units

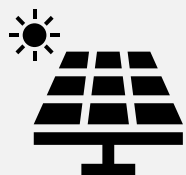
**2038:** 96% by volume H<sub>2</sub> co-firing

\* All new baseload units

\* Large existing baseload units

# Production: Clean Electrolysis Challenge

## Essential Principles for Ensuring Truly Clean Electrolytic Hydrogen:



**Incrementality** – use *new* sources of clean electricity

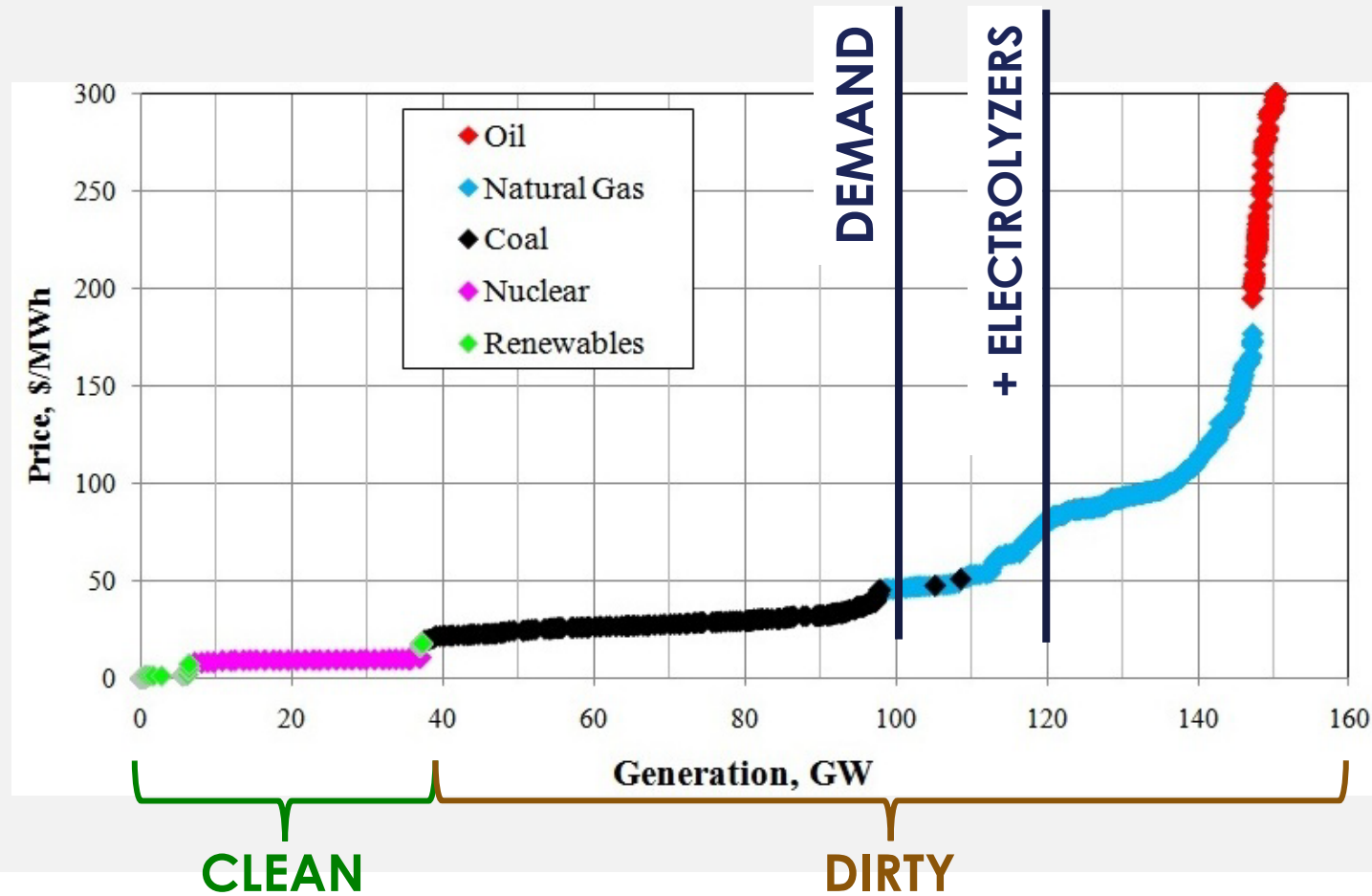


**Deliverability** – use *local, deliverable* sources of clean electricity

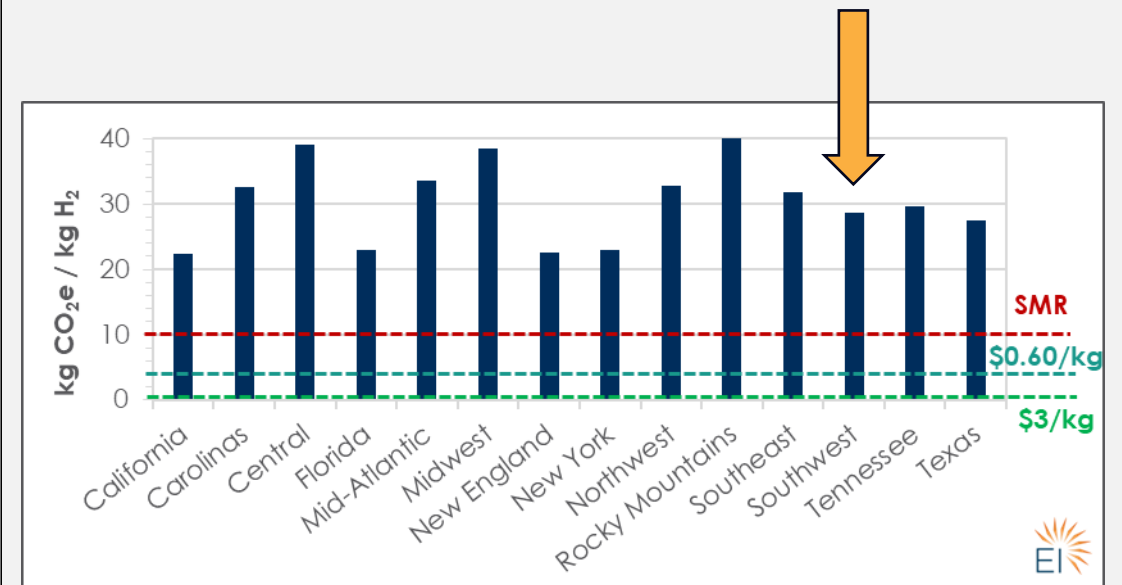
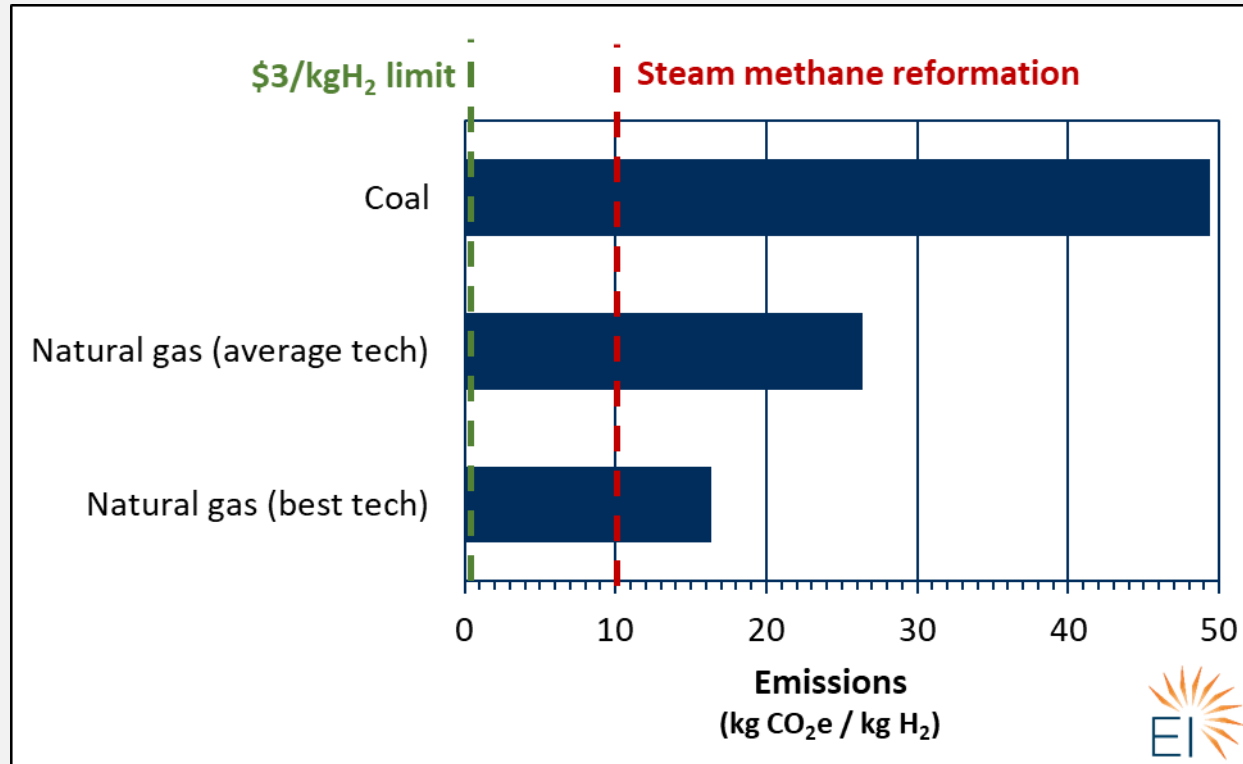


**Hourly time-matching** – ensure electrolyzer runs at same time of clean electricity generation

# Production: Illustrative Dispatch Curve



# Production: Emissions Impact of Forgoing Pillars



# Production: Consumer Impact of Forgoing Pillars

- Weak 45V rules would drive an increase in electricity prices, local air pollution, and reliability risks
- By contrast, the three pillars could improve these three outcomes
  - Electrolyzers would help bring more renewables online
  - Electrolyzers would act as flexible demand

## Evidence of Electricity Bill Impact

- **Texas A&M:** 1 GW crypto load = 2% increase wholesale ERCOT electric prices
- **NBER:** Upstate NY households paid extra \$204 million annually due to increased crypto loads
- **Princeton:** 45V without three pillars would increase power prices by 8% in California, 10% in Colorado compared to with three pillars

# Production: Flexible Production Key (1)



## BTM Nuclear Example

**Electrolyzer:** gets \$80/MWh revenue  
(\$1/kg sale price + \$3/kg 45V credit)

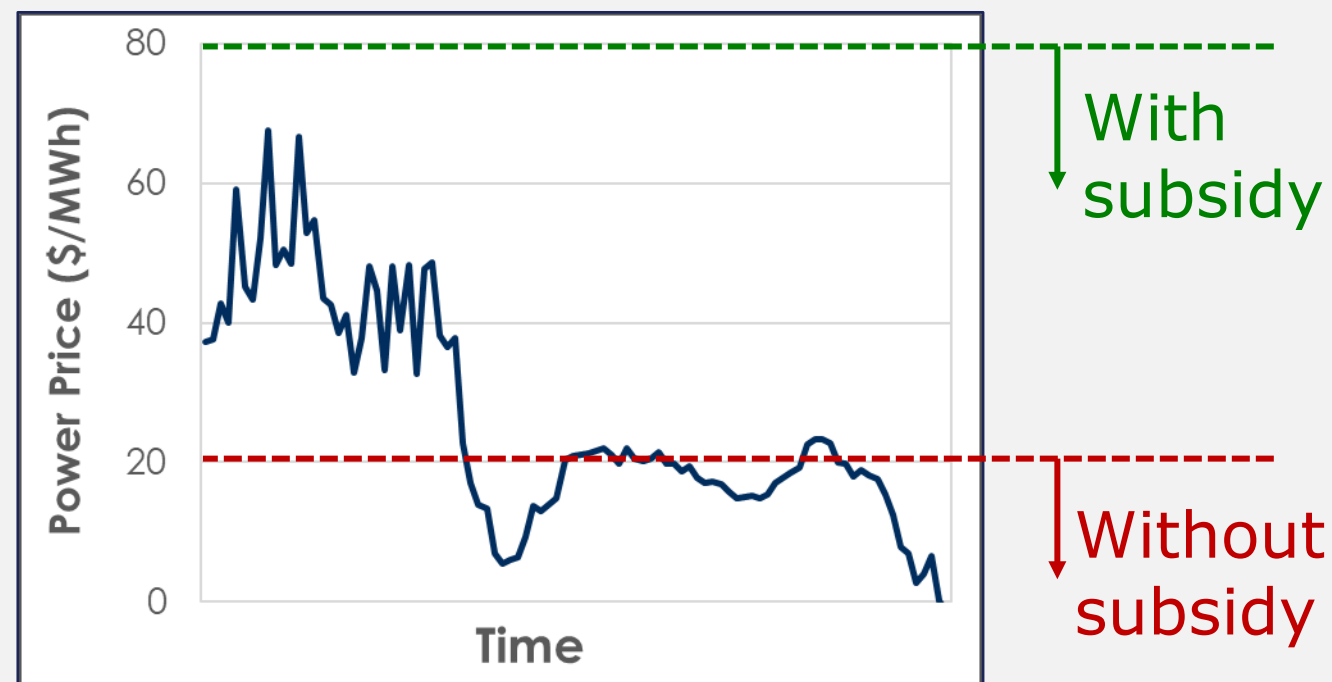
**Nuke:** needs \$45/MWh

**Profit during 45V:** \$35/MWh

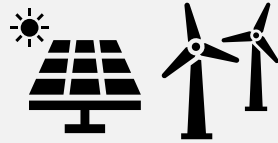
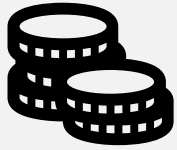
**Shortfall after 45V:** \$25/MWh

Marginal H<sub>2</sub> production cost  
of \$1/kg requires **<\$20/MWh**

## Grid-Connected Example



# Production: Flexible Production Key (2)

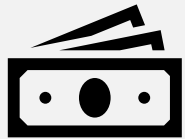


Very low or negative  
power prices

(competitively-priced H<sub>2</sub>)

Excess renewables

Electrolyzer online



Higher power prices

(couldn't sell H<sub>2</sub>)

Fossil power online

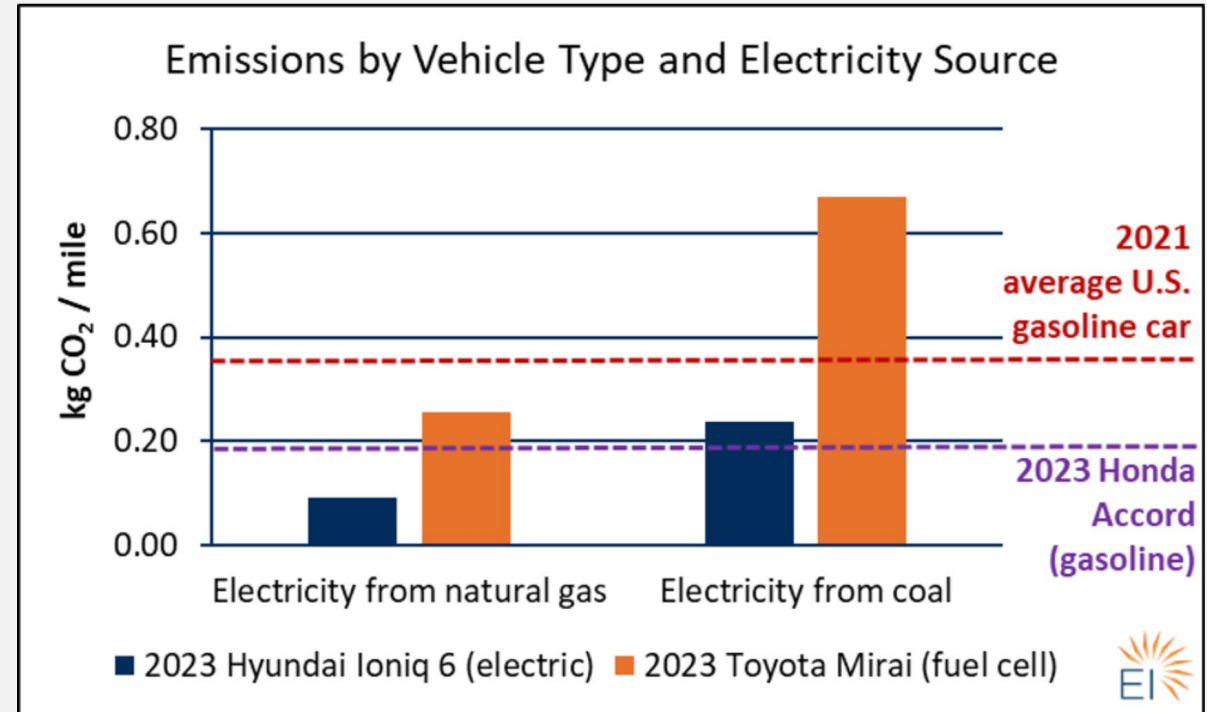
Electrolyzer offline

# Production: Double Standard Myth

**Myth:** electric vehicle incentives aren't tied to the three pillars, so it would be a double-standard to require them for hydrogen

**Reality:**

- A coal-powered electric vehicle has a similar emissions impact as a gasoline vehicle
- A coal-powered hydrogen vehicle would be more than 3x worse than a gasoline vehicle



<https://www.forbes.com/sites/energyinnovation/2023/12/17/hydrogen-isnt-electric-vehicles-treating-it-the-same-under-45v-tax-credit-would-be-a-mistake/?sh=6414e47351c6>



# Production: Industry Can Meet Three Pillars

Acciona & Nordex Green Hydrogen  
 Avantus  
 EDP Renewables  
 Electric Hydrogen  
 Fervo Energy  
 Firstlight Power  
 First Solar  
 GridStor  
 Leeward Renewable Energy  
 Nucor  
 Synergetic

<https://s3.documentcloud.org/documents/23854072/hourly-matching-industry-letter-final.pdf>



<https://www.airproducts.com/energy-transition/air-products-response-to-45v>

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<https://www.taxnotes.com/research/federal/other-documents/irs-tax-correspondence/group-urges-hourly-matching-implementation-for-hydrogen-credit/7h1c6>



<https://greenh2catapult.com/2023/11/06/joint-letter-on-45v-implementation/>

Hy Stor Energy LP  
 Air Products  
 ACCIONA & Nordex Green Hydrogen  
 CWP Global  
 Fervo Energy  
 Synergetic  
 Strata Clean Energy - P2X  
 Rondo Energy

<https://hystorenergy.com/wp-content/uploads/2024/03/45V-NPRM-Industry-Support-Letter-March-1-2024.pdf>

# Use: Competitive Prospects for Decarbonization

## TERRIBLE

Like using champagne to water a lawn, these uses waste an expensive product to provide a lower-quality service where far better alternatives exist

## POOR

Hydrogen may have viable niches; public support should identify and target these exceptions, but most proposed investments will likely fail

## UNCERTAIN

These uses have too much technological uncertainty on performance and cost; policy should pursue hydrogen's potential without fully committing to it

## GOOD

Hydrogen will likely serve a large part of the market, though biofuels and less-mature electric technologies will also play a role

## EXCELLENT

Other factors may influence the size of these markets, but the markets themselves will almost certainly be completely captured by hydrogen

# Use: Quantitative Metrics

## BUILDINGS



Prospects

**TERRIBLE**

**GHG Abatement**  
(using zero-carbon H<sub>2</sub>)

**6-8**  
kgCO<sub>2</sub>e/kgH<sub>2</sub>

**H<sub>2</sub> Demand Potential**  
(if replacing all fossil fuels)

**78**  
MMT H<sub>2</sub>

**H<sub>2</sub> Breakeven Price**  
(vs. incumbent fossil fuel)

**0.4-0.5**  
\$/kgH<sub>2</sub>

**Hydrogen has at best a negligible role to play in decarbonizing buildings.**

**CONTEXT:** U.S. gas utilities have announced at least 22 proposals to blend hydrogen with natural gas in their pipelines, aiming to deliver lower-carbon fuels to homes and businesses for space heating, hot water, cooking, and clothes drying.<sup>21</sup> Concepts for net-zero gas delivery vary from switching to a “clean fuels” portfolio—consisting of hydrogen, renewable natural gas

# Use: End-Use Fact Sheets

- Top-line findings
- Context
- Scope
- Infrastructure needs
- Social impacts
- Competing technologies
- Takeaway
- Further reading (with featured story)



**Download report  
and fact sheets**

# Hydrogen's competitive prospects for decarbonization by end-use sector

EXCELLENT

GOOD

UNCERTAIN

POOR

TERRIBLE



Refining



Primary Steel



Seasonal Electricity Storage



Heavy-Duty Vehicles



Day-to-Day Power Generation



Ammonia



Aviation (Long-Haul)



Aviation (Short-Haul)



Industrial Process Heat



Light-Duty Vehicles



Marine Shipping (Long-Haul)



Marine Shipping (Short-Haul)



Buildings



Petrochemicals

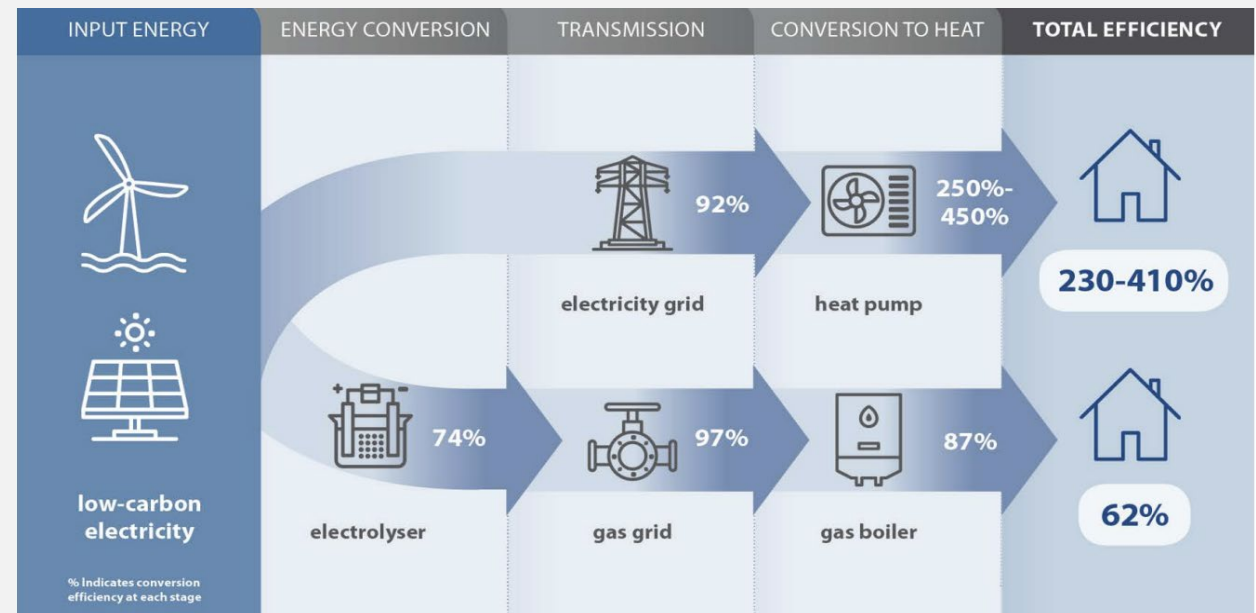
Download report  
and fact sheets

# Use: Example of “Buildings” End-Use

Problems of H<sub>2</sub> in buildings:

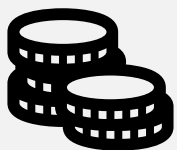
- Requires far more energy
- Appliances and most pipes can only handle up to ~5-20% hydrogen by volume
- Climate Band-Aid: 20% H<sub>2</sub> by volume = 7% GHG reduction
- Moving beyond 20% H<sub>2</sub> = costly logistical nightmare

## Heat Pumps vs. Hydrogen



<https://www.theccc.org.uk/publication/hydrogen-in-a-low-carbon-economy/>

## Use: Qualitative Takeaways



Hydrogen's low-value uses are all when used for energy, while its high-value uses are all when used as a feedstock



Hydrogen's low-value uses are much more dependent on the development of sprawling hydrogen pipelines and end-use equipment than its high-value uses

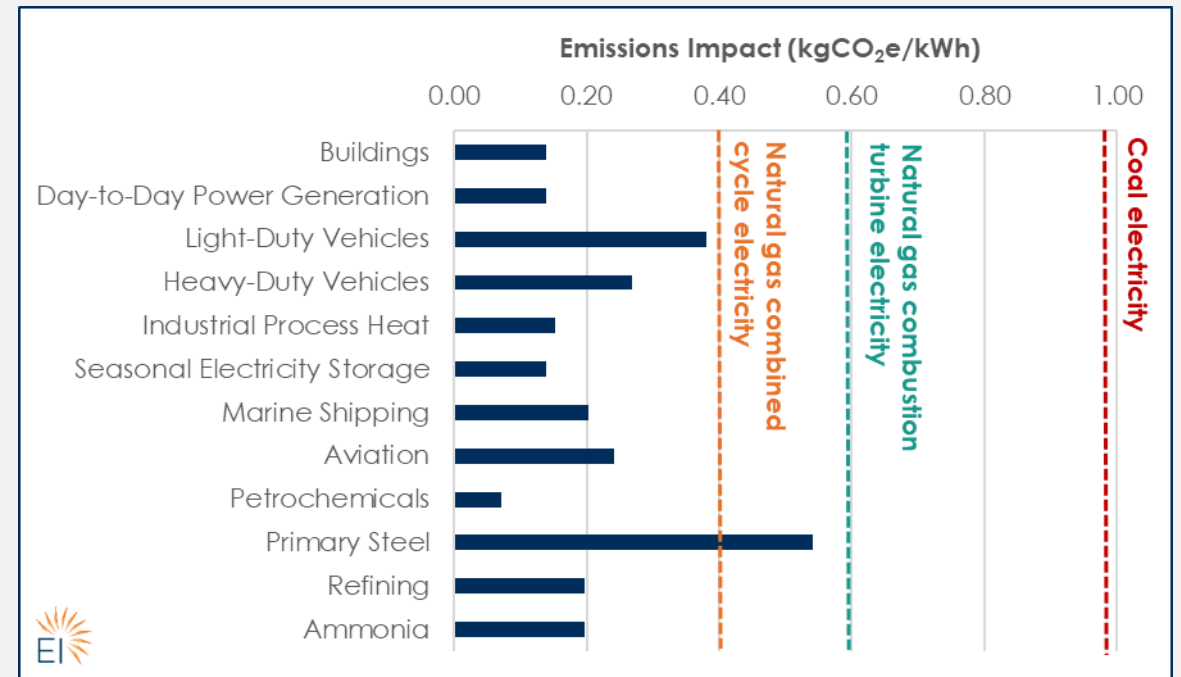
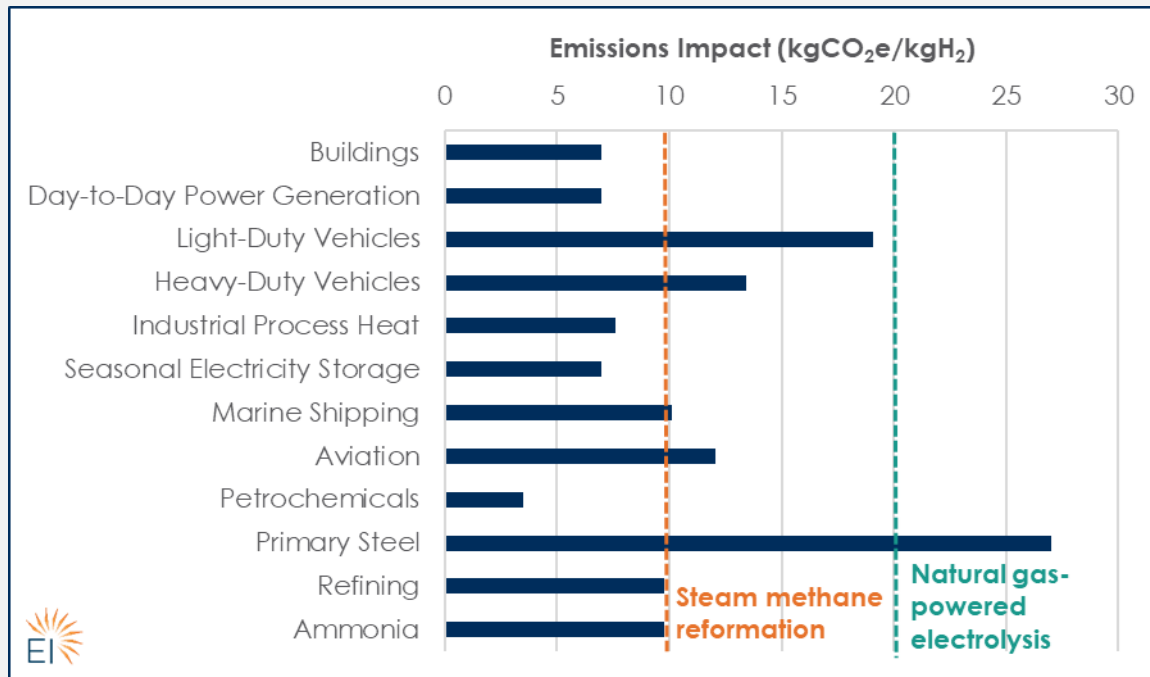


Hydrogen's low-value uses often increase the risk of social harms and inequitable outcomes, while its high-value uses generally do the opposite



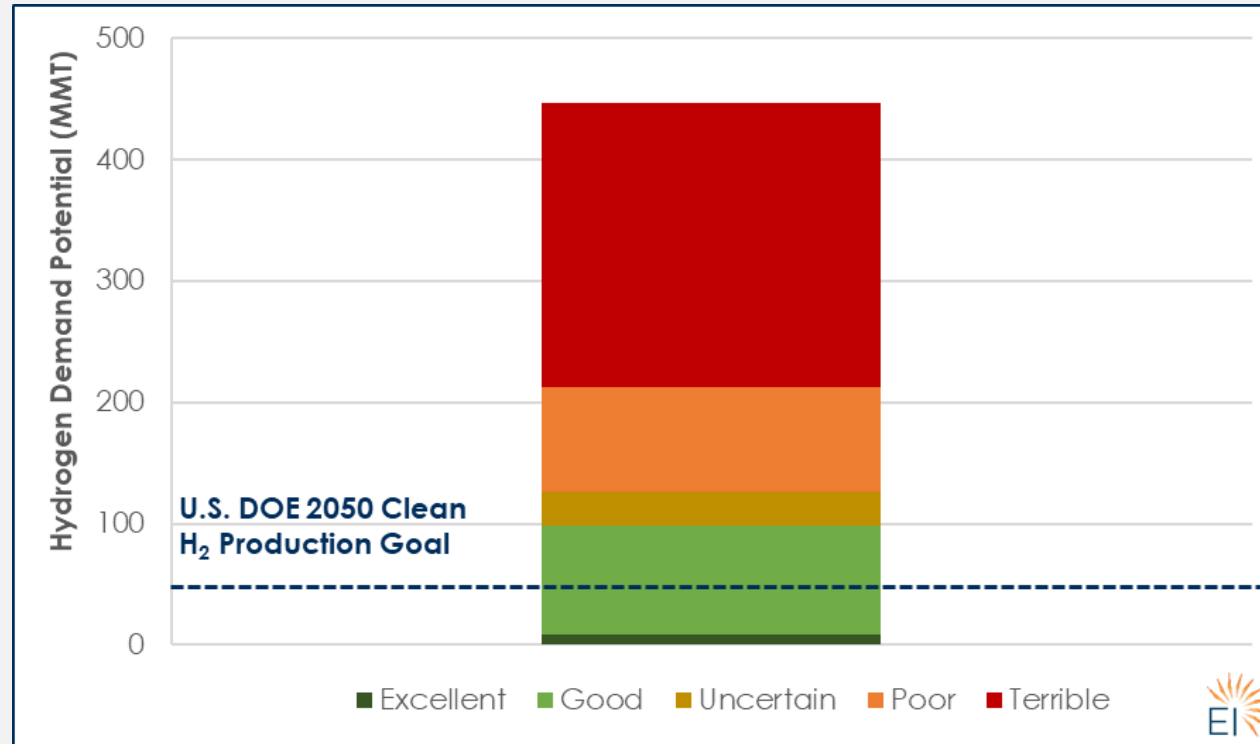
Hydrogen's uptake in high-value uses will require targeted demand-side policies—supply-side subsidies alone will not ensure this outcome (and may make better alternatives for low-value uses look worse)

# Use: Net Emissions Impact





# Use: Market Potential



# Use: Boosting H2's High-Value Uses



Advance market commitments (AMCs)



Contracts for difference (CfDs)



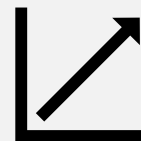
Reverse auctions



Subsidies for end-use equipment or utilization



Research and development (R&D) support for emerging technologies



Performance standards

## Use: Minimizing H2's Low-Value Uses



Focus midstream infrastructure on tight industrial clusters



Hedge bets on hydrogen infrastructure investments



Require a high burden of proof of value and community benefits agreements



Set rigorous health and safety standards

**ALSO: Critical to ensure Treasury finalizes strong guardrails for 45V**

# Recap: H2 Decisions Are Not Yet Final

Haug said once the seven hubs were chosen, they entered into negotiations with the federal government over terms and conditions, prompting DOE lawyers to go "line item by line item" through project proposals and contracts to safeguard taxpayer dollars, weighing what would happen in various scenarios.

"So all those mechanics have to get worked out in excruciating detail. The projects themselves, they're just concepts on a piece of paper. They have to go through the full [National Environmental Policy Act] process, the whole permitting process, which takes years, right?" Haug said. "That's kind of the state of maturity that we're at."

The three hubs that have reached final agreements are in a phase that will allow them to start working on the economics of hydrogen projects, as well as pre-engineering work, according to Haug. The hubs with agreements are the ARCHES hub of California; the ARCH<sub>2</sub> hub in Appalachia; and the Pacific Northwest Hydrogen Association (PNWH<sub>2</sub>), which spans Oregon, Washington and Montana.

Once the final agreements are reached, Haug said, it could take 18 months to two years for each hub to lay out its scope and general plans.

"So we are many years away from breaking ground unless it's something as simple as...a municipality wants to buy fuel cell buses, or you have trucking companies that want to convert from diesel to using fuel cell vehicles," Haug said. "You can buy the bus, but if there's nobody producing high clean hydrogen to fuel the bus, well, there's no point in buying the bus until I have that."

He added that communities near the hubs should expect to hear more from DOE after the guidance comes out.

"They'll start to hear a lot more, and we are eager to engage. I do sense that there is in some communities this frustration of why hasn't the DOE talked to us?" he said. "And it's because we've been locked away in these negotiations with lawyers and we're at such a beginning stage."

## Recap: Summary

- Hydrogen policy has a narrow path forward to deliver on its climate, consumer, and equity goals. Navigating this path requires:
  - Strong guardrails on hydrogen production to ensure it is truly clean;
  - Protections to limit hydrogen's uptake in (and risks from) its low-value uses; and
  - Targeted investments that boost hydrogen's uptake in its high-value uses.
- Treasury will likely finalize 45V rules after the election, and DOE is still in the very early stages of implementing the hydrogen hubs – very little H2 policy is locked in.
- There is still time (but also urgency) to influence policymakers to backtrack on harmful decisions and pass/implement smart hydrogen policy – we are available to give briefings, provide testimony, and support with custom research.

# Hydrogen Policy's Narrow Path Forward

**Careless  
subsidization of  
H2 production**

**Clean economy  
and strong H2  
industry via smart,  
targeted policy**

**Support for  
H2 where better  
alternatives exist**



**Underinvestment  
in H2's high-  
value uses**

# Recap: Energy Innovation Resources

## **Hydrogen Policy's Narrow Path**

Report: <https://energyinnovation.org/publication/hydrogen-policys-narrow-path-delusions-and-solutions/>

Fact sheets: <https://linkmix.co/25714416>

## **45V**

Research summary memo: <https://energyinnovation.org/publication/evidence-shows-three-pillars-remain-crucial-for-45v-hydrogen-tax-credit-to-protect-climate-consumers-industry/>

Bicameral letter of support: <https://www.whitehouse.senate.gov/wp-content/uploads/2024/09/Letter-to-Biden-Administration-re-45V-Hydrogen-Tax-Credit-09-11-2024.pdf>

## **Hydrogen in the power sector**

EI/SEPA Hydrogen Insight Brief: <https://sepapower.org/resource/hydrogen-insight-brief-series/>

Canary Media article: <https://www.canarymedia.com/articles/hydrogen/the-problem-with-making-green-hydrogen-to-fuel-power-plants>



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