# Enabling Clean Hydrogen

*UN Energy 24/7 Compact*

*Apr, 2023*

Killian Daly - Executive Director, EnergyTag

# Introduction

- EnergyTag is non-profit helping define and promoting 24/7.
- Years experience in Hydrogen Industry. Worked on hourly matched electrolyser project design.
- EnergyTag has supported Co-signed letter in US and EU supporting robust rules for clean hydrogen production.

# Clean Hydrogen Needs 3-Pillar Clean Electricity


## Principles of 24/7 Carbon-Free Energy

24/7 Carbon-Free Energy means that every kilowatt-hour of electricity consumption is met with carbon-free electricity sources at every hour of every day, everywhere. It is based on the following principles:

- **Time-matched procurement:** matching hourly electricity consumption with carbon-free electricity generation. Hourly matching helps connect clean energy purchasing to underlying electricity consumption.
- **Local procurement:** purchasing clean energy on the local/regional electricity grids where electricity consumption occurs. This is the only way to drive the electricity-related emissions that a consumer is directly responsible for to zero.
- **Technology-inclusive:** recognizing the need to create zero-carbon electricity systems as quickly as possible. All Carbon-Free Energy technologies can play a role in creating this future.
- **Enabling new generation:** focusing on delivering additional Carbon-Free Energy to drive the rapid decarbonization of electricity systems.
- **Maximizing system impact:** addressing the dirtiest hours of electricity consumption where the most fossil fuel is used in generation.

Source: UN 24/7 Compact

# EU Hydrogen Will be 3-Pillar Hydrogen

EUROPEAN
COMMISSION

Brussels, 10.2.2023
C(2023) 1087 final

**COMMISSION DELEGATED REGULATION (EU) …/...**

**of 10.2.2023**

**supplementing Directive (EU) 2018/2001 of the European Parliament and of the Council by establishing a Union methodology setting out detailed rules for the production of renewable liquid and gaseous transport fuels of non-biological origin**

Source : European Commission

- ➔ All Renewable Hydrogen produced in **and imported to EU** will be 3-pillar from 2030.
- ➔ Transition to hourly could have been shorter. But EU tracking legislation needs updating. **US has no such block.**
- ➔ **Deviations** from three pillars **in US would be have more serious emissions consequences** as 1) no carbon price 2) dirtier grids and 3) much larger subsidy.
- ➔ Hydrogen Europe stated "These strict rules **can be met**" upon release of EU rules.
- ➔ Projects announcements have increased since announcement of the rules.

# Growing Consensus that 24/7 is Truly Clean

## Governments

## Energy Experts

IEA

Technische Universität Berlin

PRINCETON UNIVERSITY

EUI FLORENCE SCHOOL OF REGULATION

## System Operators

entsoe

alliander

## EU/US NGO for Green H2

Bellona
Clean Air Task Force
Client Earth
Climate Action Network
Deutsche Umwelthilfe
Environmental Defense Fund
Global Witness
International Council on Clean Transportation
Natural Resource Defence Council
Transport & Environment
Union of Concerned Scientists.

## UN Compact

24/7 CARBON FREE ENERGY

SUSTAINABLE ENERGY FOR ALL

United Nations

UN ENERGY

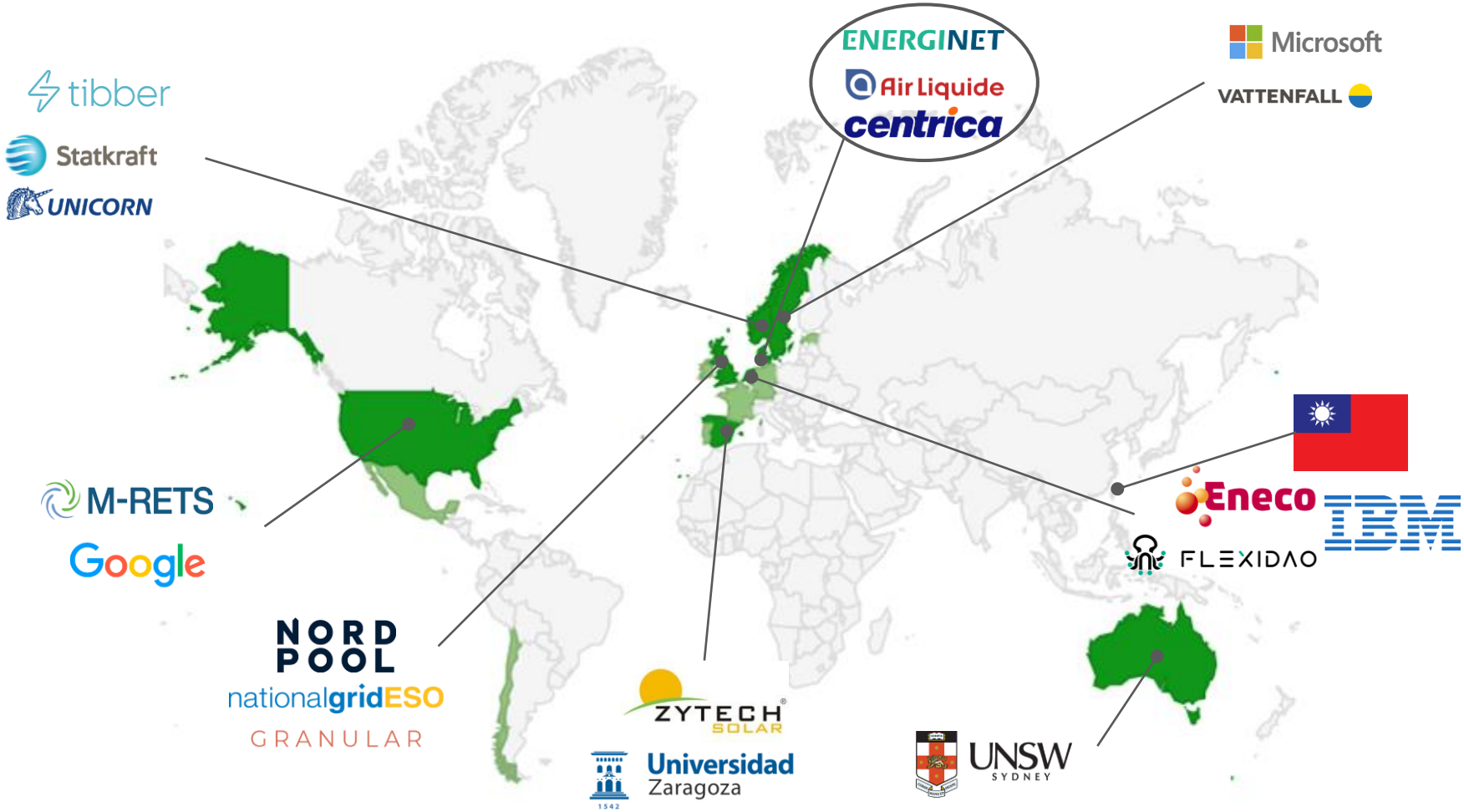
HIGH-LEVEL DIALOGUE ON ENERGY

118 Signatories

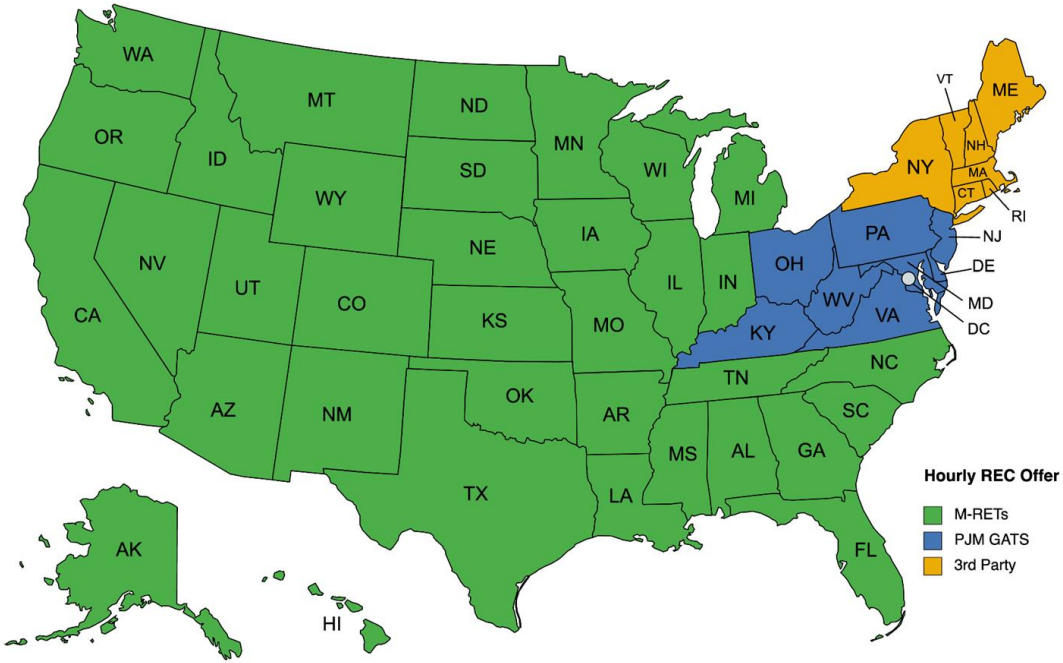
# Hourly Matching Feasibility

- From experience - 3-pillar electrolysers are possible in industry.
  - Air Liquide's "Elygator"
  - AES - Air Products
- Electrolysers should be flexible to take advantage of clean cheap power.
  - PEMs can ramp in seconds (see peer reviewed data and research)
- Hydrogen supply can be firm with hourly matching
  - Source high capacity factor clean power to match 70-100%+ of time.
  - Store hydrogen (or electricity)
  - Rely on existing production capacity.

# Millions of MWh of hourly tracking globally, today



# Hourly RECs Already Available Across the U.S




- Between **M-RETs and PJM** hourly RECs already available across most of the US.
- EnergyTag Standard can **help harmonise** hourly tracking as needed.

# *The U.S. "Clean" Hydrogen Battle*

*April 2023*

**Rachel Fakhry**

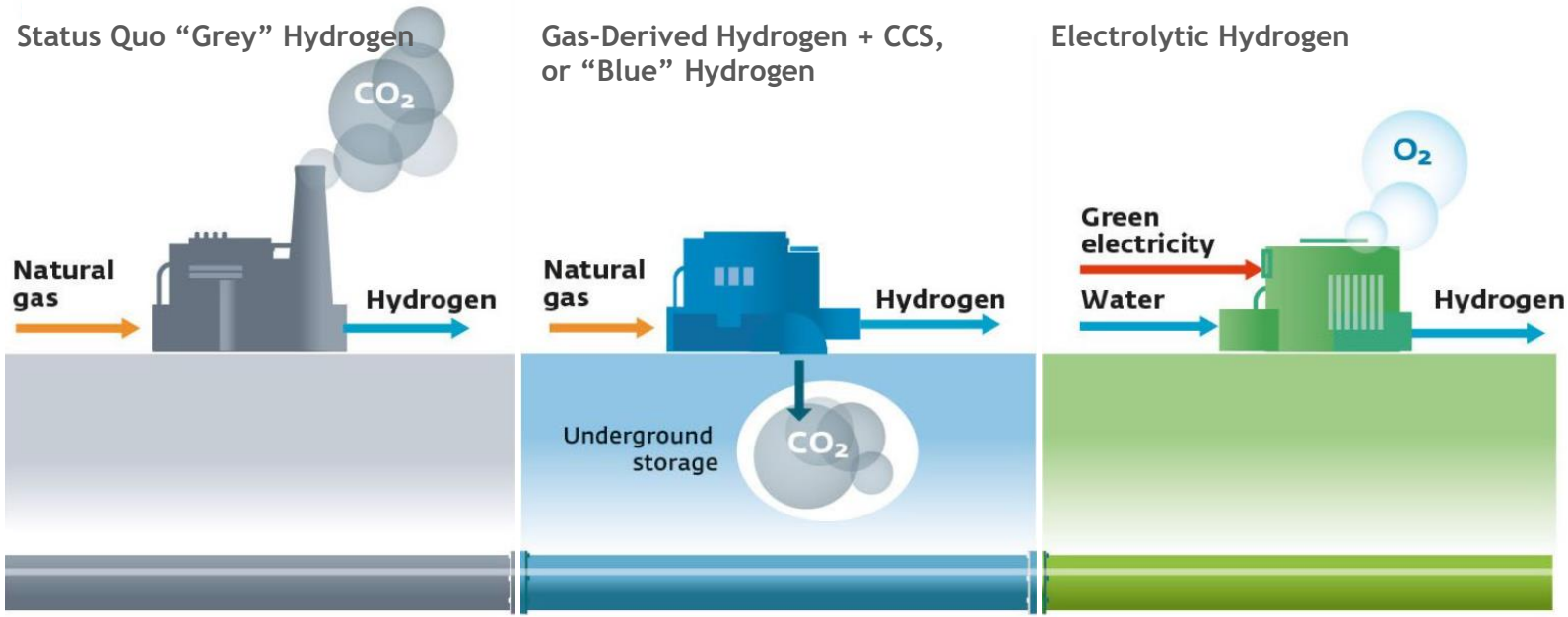
**Director of Emerging Technologies**

## Key Points

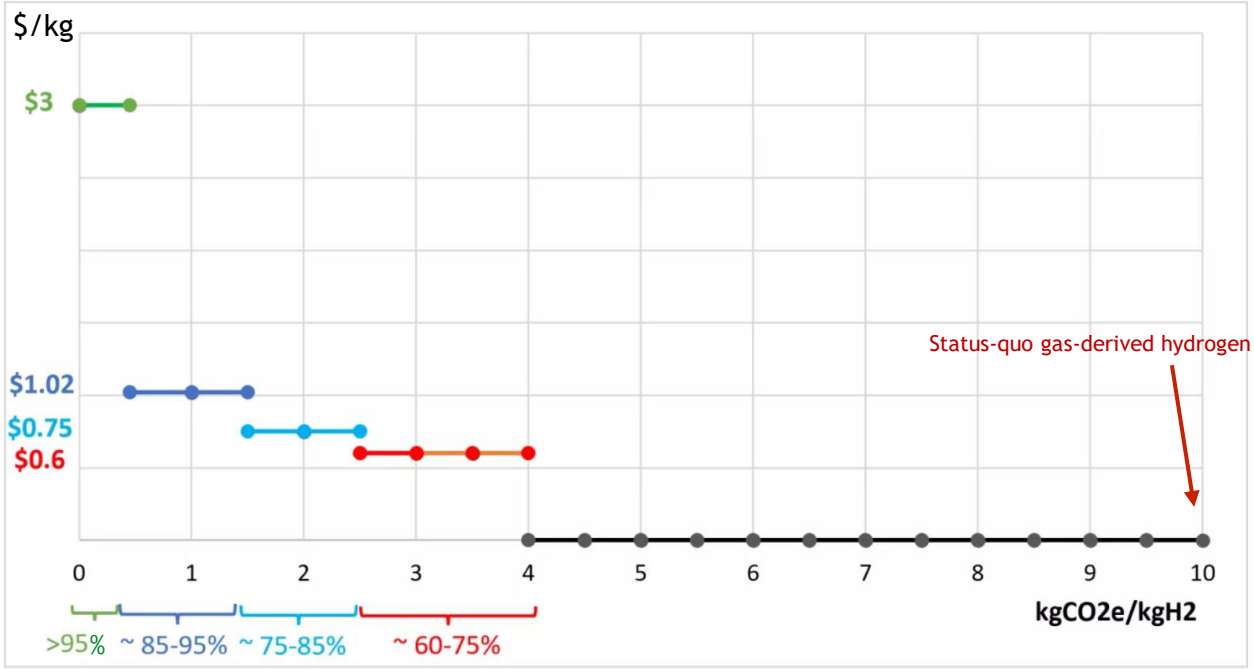
- High stakes: billions of $$ and potential hundreds of millions of tons of carbon missions
- It all hinges on the Biden administration
- Rigorous guardrails are necessary in the form of the three pillars – new supply, hourly matching, deliverability
- Fierce fight

# CONTEXT SETTING

# Hydrogen production sources



# What is the 45V clean hydrogen tax credit?




*Production tax credit in $ per kilogram of hydrogen produced ($/kg) relative to the carbon intensity of the produced hydrogen in kilograms of carbon dioxide equivalent per kilogram of hydrogen (kgCO2e/kgH2).*

## 45V is a substantial and long-lived subsidy

- More than $100B over its lifetime
- AES/Air Products project in Texas: $3 Billions in subsidies *(Energy Innovation estimate)*
- Very long lived (~2045)

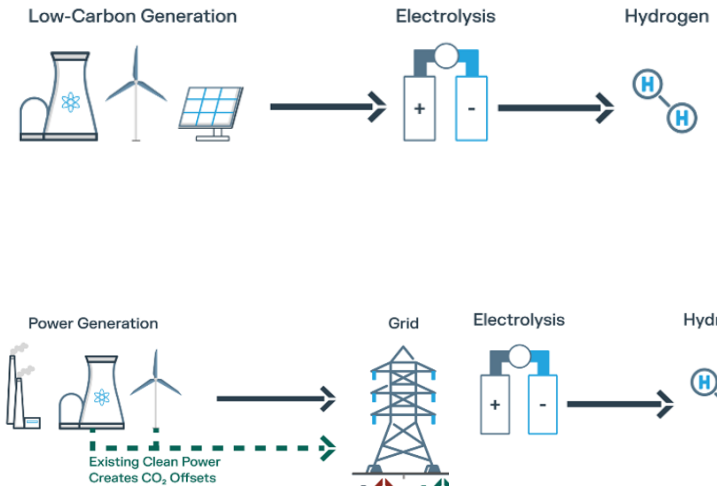
## The implications of 45V hinge on Treasury, DOE, EPA and the White House

- Subsidy tied to the lifecycle GHGs of hydrogen production
- Treasury directed to issue guidance for calculating the lifecycle GHGs of hydrogen projects, within one year of the IRA's enactment
- Department of Energy (DOE), Environmental Protection Agency (EPA), and the White House are closely engaged

# COMPLEXITY AND RISKS

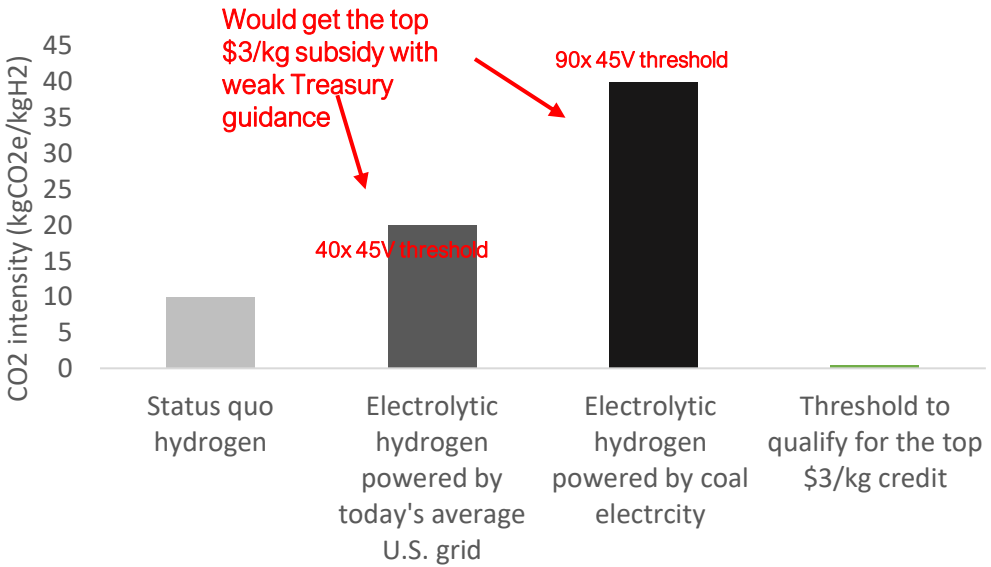
# Hydrogen projects range in complexity; projects relying on “offsets” need rigorous rules

- Calculating lifecycle GHG emissions can be quite tricky
- The complexity varies from project configuration to another
  - EASY: “Behind the meter”, not drawing power from the grid
  - MORE COMPLICATED: Grid-connected, drawing grid power, buying credits/offsets
- Need some parameters/rules around the sort of “offsets” allowed to be used



## High risks of 45V *increasing* emissions if Treasury guidelines are weak

- Electrolysis is an electricity hungry process (more than 25% of electricity is lost in the process)
- Even small shares of fossil fueled electricity powering electrolysis would result in significant emissions




More than 100 million tonnes of emissions increases in this decade; equivalent to the power sector emissions of North Carolina

## The three pillars: why do we need them?

- Three pillars = parameters around the credits/offsets

- **Only parameters/system** that ensures effective offsetting of grid emissions and that hydrogen projects are either directly or indirectly powered by clean electricity
    - Inarguable:
    - Princeton University; Energy Innovation, Rhodium Group, MIT Energy Initiative

## The three pillars are legally necessary to meet IRA requirements

- IRA defines a hydrogen project's lifecycle emissions by referencing the Clean Air Act (implements the federal Renewable Fuel Standard)
- The analogy to 45V is clear:
  - Effectively requires Treasury to **account for the *systemwide* emissions of hydrogen production, i.e., induced grid emissions**
  - For example, if a hydrogen project drives increased fossil fuels on the grid, Treasury *must account for those emissions.*
- It is near impossible for a hydrogen project to meet the IRA emissions thresholds without adopting the three pillars

→ The pillars legally necessary to meet IRA requirements.

# THE FIGHT

BUSINESS

# How a tax break meant to curb climate change could make it worse

Green hydrogen is branded a zero-carbon superfuel. But at the behest of big energy firms, new subsidies could go to a product with a much different climate profile.

By Evan Halper

March 3, 2023 at 6:00 a.m. EST

# The great 'green hydrogen' battle

Tens of billions in federal tax credits could build a vital low-carbon hydrogen industry — or increase carbon emissions. We tackle the complexities in a series.

28 March 2023


MAR 29 • 1HR 31M

## We're about to give billions of dollars to clean hydrogen. How should we define it?

A conversation with Rachel Fakhry of NRDC.

BUSINESS

# The Fight to Define Green Hydrogen, With Billions of Dollars at Stake

NextEra and BP argue for looser rules on tax credits for hydrogen production

*By Amrith Ramkumar and Katherine Blunt*

Feb. 12, 2023 5:30 am ET

# The fight to define 'green hydrogen' could determine America's emissions future

The Treasury Department's definition will affect billions of dollars in federal subsidies for the nascent industry.

# Landscape of stakeholders

## Pro- 3 pillars

- All environmental groups
- Community, local and environmental justice groups
- Hydrogen developers and OEMs (e.g., Intersect Power, Electric Hydrogen)
- Renewable energy developers (e.g., EDP Renewables)
- Academics and research groups (e.g., Princeton University, Energy Innovation)
- Large customers (e.g., Google)
- Registries and hourly matching organizations (e.g., M-RETS, EnergyTag)

## Anti- one or more of the 3 pillars

- Hydrogen developers (e.g., Plug Power)
- Utilities (e.g., NextEra)
- Renewable energy organizations (e.g., American Council for Renewable Energy, *though not unanimous across members*)
- Consulting firms (e.g., Wood McKenzie, E3)

## Opposition to one or more of the pillars: Why?

- Anti-additionality:
  - Companies/utilities looking to use existing clean energy assets (e.g., existing nuclear plants) to produce hydrogen, regardless of the emissions impact of diverting this existing clean energy from the grid

- Anti-hourly matching:
  - Companies/utilities:
    - Looking to maximize subsidies and shareholder value by running an electrolyzer quasi 24/7; and/or
    - With a business model/in a region where hourly matching may not pencil out at today's electrolyzer costs (e.g., in an exclusively solar region)

# THANK YOU!

# Smart 45V Guidance Design to Cut Emissions and Grow Clean Hydrogen

**Dan Esposito**
Senior Policy Analyst

*April 2023*

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- Non-partisan climate policy think tank working with policymakers regardless of political affiliation.
- We provide objective research based on scientific assessments to identify **the most effective economywide emissions reduction policies.**
- We prioritize policies in the largest emitting nations and sectors, focusing on policies that accelerate technology-neutral zero-carbon solutions at the speed and scale necessary to fight climate change.
- We work towards a climate safe future where people and the planet thrive with economic, security, and equity benefits.
- Our technology-neutral policy recommendations are grounded in data, driven by our open-source and peer-reviewed Energy Policy Simulator model and our book *Designing Climate Solutions*.
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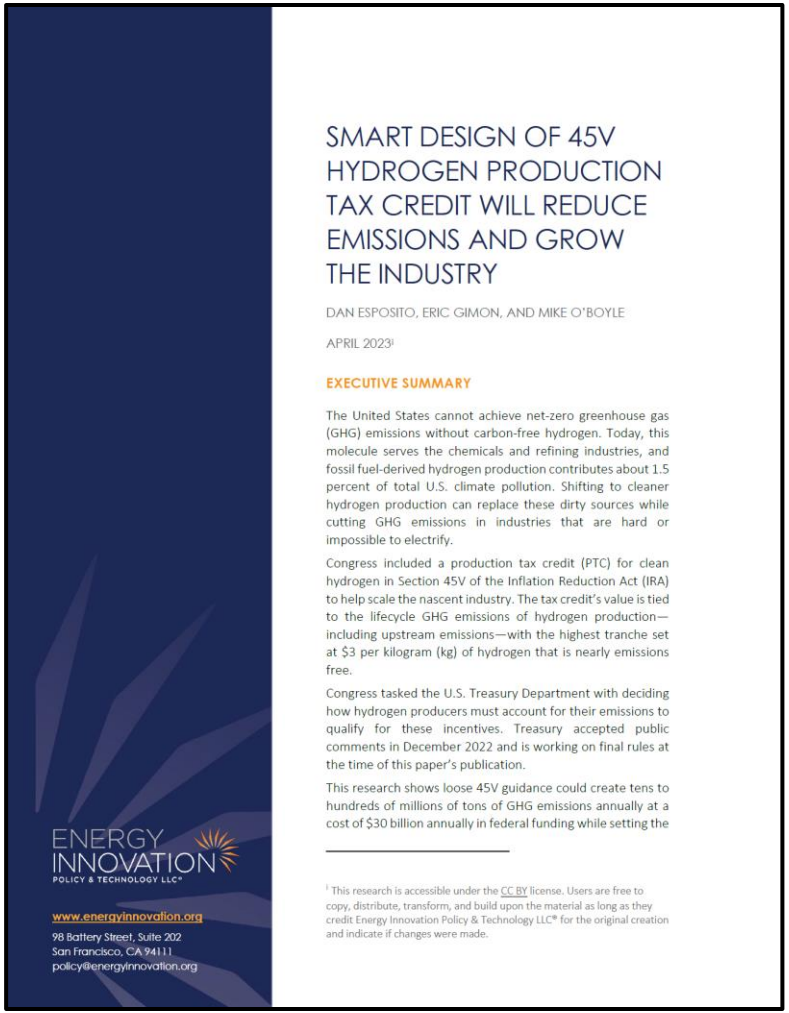
- *Web: https://energyinnovation.org | Newsletters: https://energyinnovation.org/newsletters/*

Key Takeaways

Smart 45V guidance is:

- **Essential**
  - GHG emissions impact
  - Long-term clean H2 impact
- **Implementable**
- **Financially viable**



# SMART DESIGN OF 45V HYDROGEN PRODUCTION TAX CREDIT WILL REDUCE EMISSIONS AND GROW THE INDUSTRY

DAN ESPOSITO, ERIC GIMON, AND MIKE O'BOYLE

APRIL 2023[1]

## EXECUTIVE SUMMARY

The United States cannot achieve net-zero greenhouse gas (GHG) emissions without carbon-free hydrogen. Today, this molecule serves the chemicals and refining industries, and fossil fuel-derived hydrogen production contributes about 1.5 percent of total U.S. climate pollution. Shifting to cleaner hydrogen production can replace these dirty sources while cutting GHG emissions in industries that are hard or impossible to electrify.

Congress included a production tax credit (PTC) for clean hydrogen in Section 45V of the Inflation Reduction Act (IRA) to help scale the nascent industry. The tax credit's value is tied to the lifecycle GHG emissions of hydrogen production—including upstream emissions—with the highest tranche set at $3 per kilogram (kg) of hydrogen that is nearly emissions free.

Congress tasked the U.S. Treasury Department with deciding how hydrogen producers must account for their emissions to qualify for these incentives. Treasury accepted public comments in December 2022 and is working on final rules at the time of this paper's publication.

This research shows loose 45V guidance could create tens to hundreds of millions of tons of GHG emissions annually at a cost of $30 billion annually in federal funding while setting the

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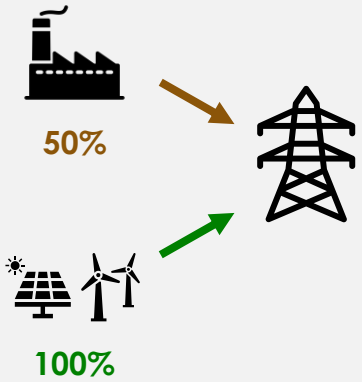
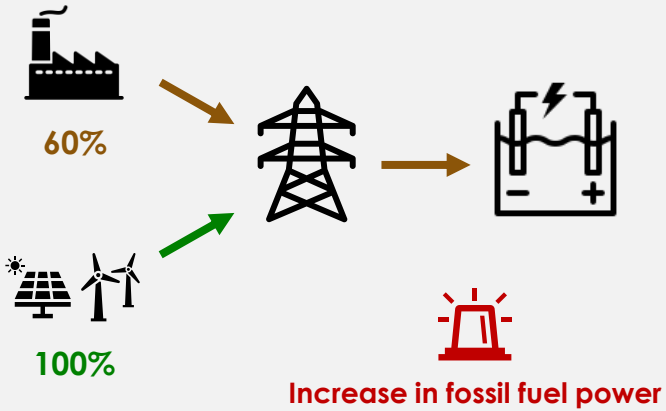
# Electrolyzers' Impact on the Power Grid

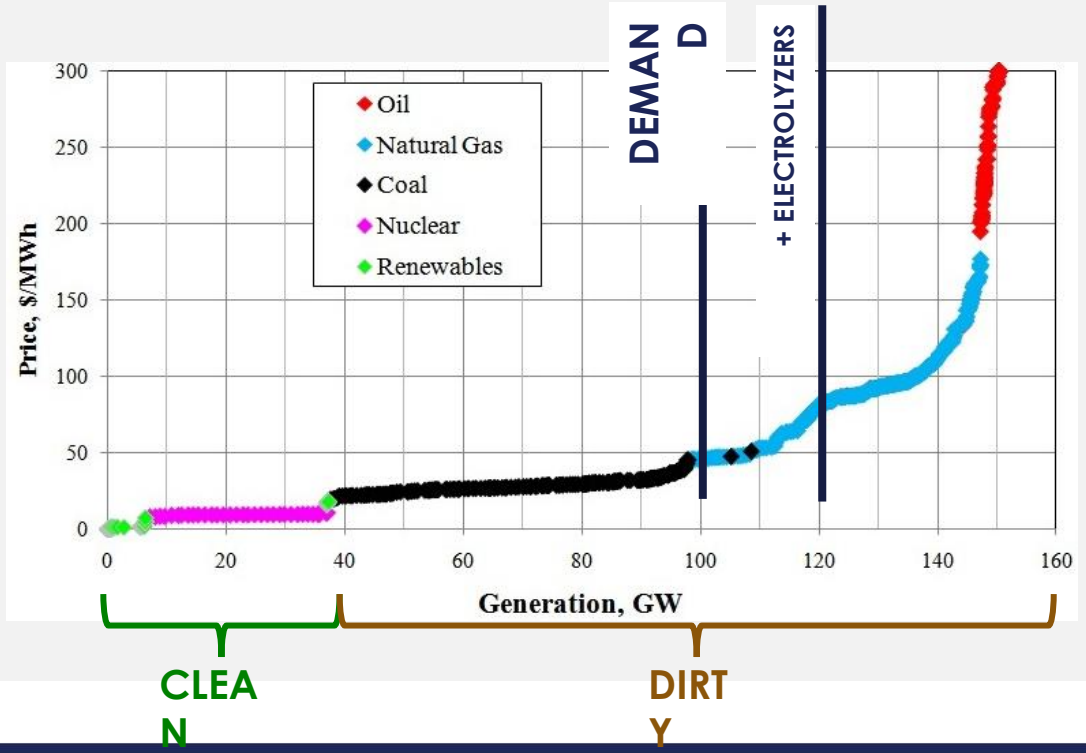
**No Electrolyzer**



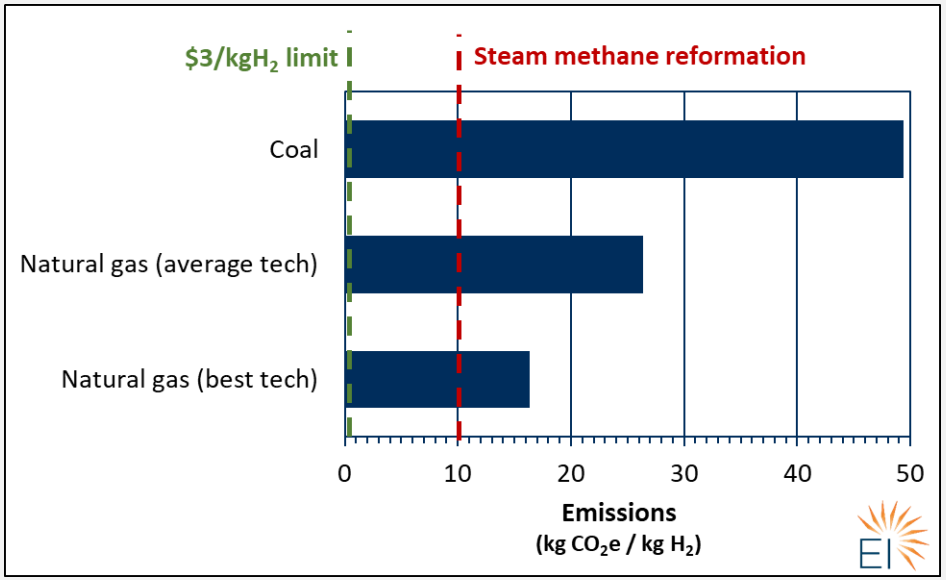

**Dirty Electrolysis**

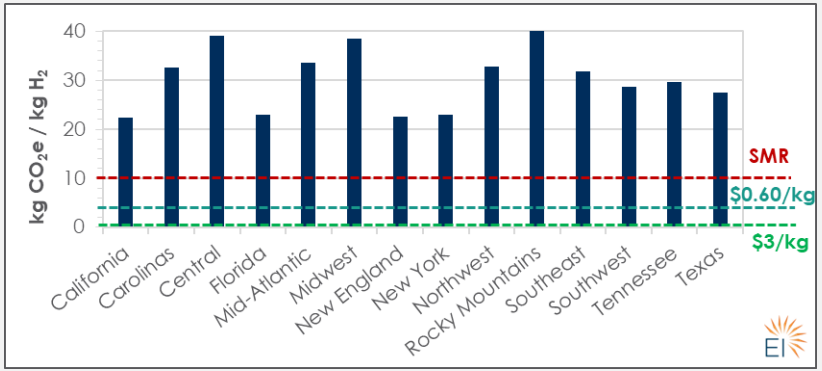


# Electrolyzers' Impact on the Power Grid (2)

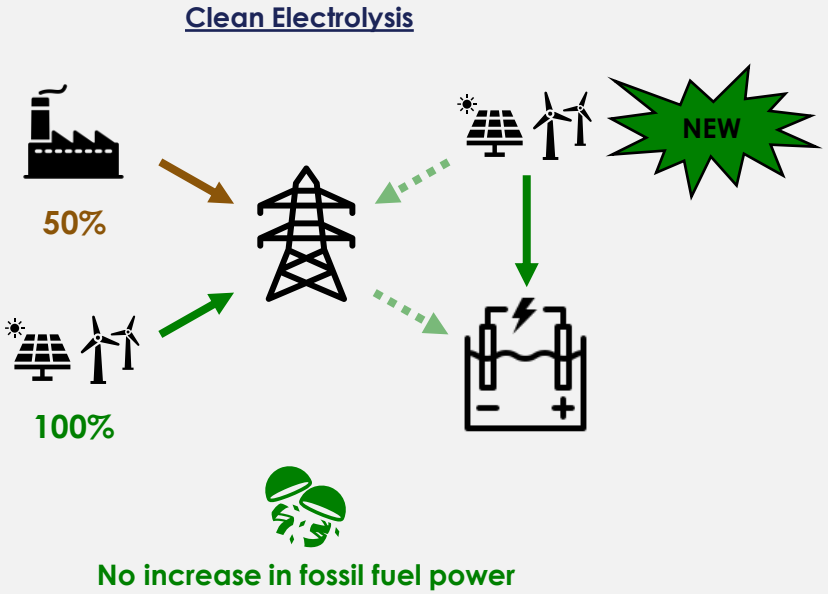


# Electrolysis Emissions (No Additionality)



## The Solution

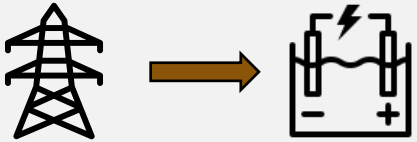


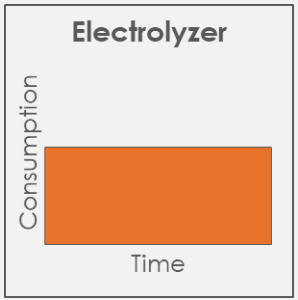

NEW

DELIVERABLE

TIME-MATCHED

Loose 45V Guidance → Inflexible Systems



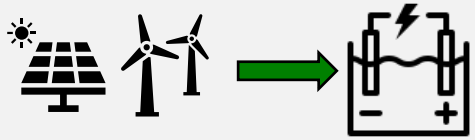


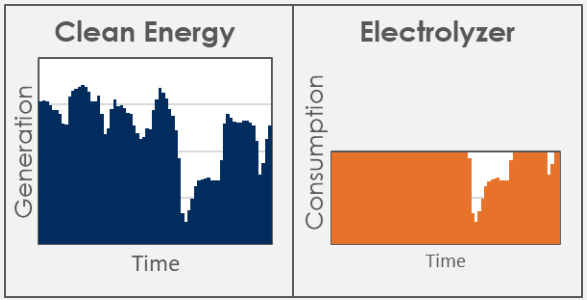

**24/7** Run around the clock

 Maximize gov't subsidies

 No need for $H_2$ storage

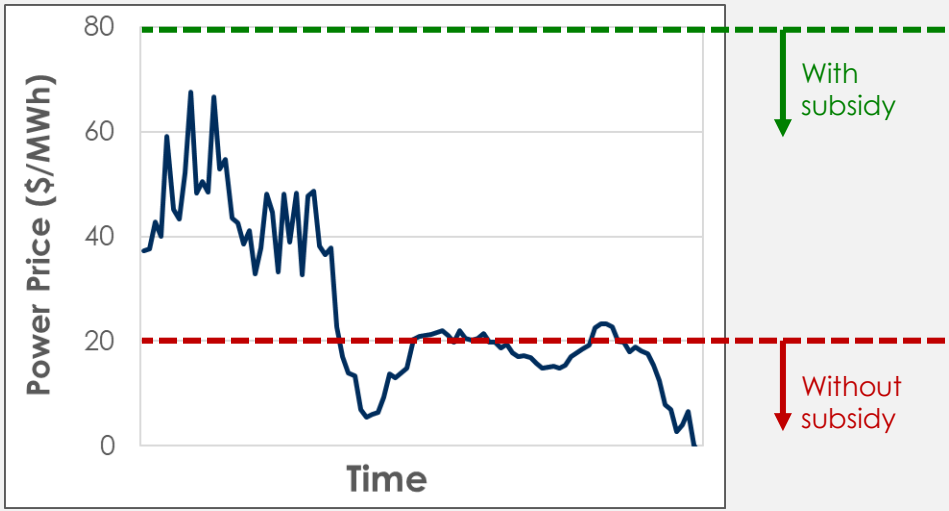
Stringent 45V Guidance → Flexible Systems

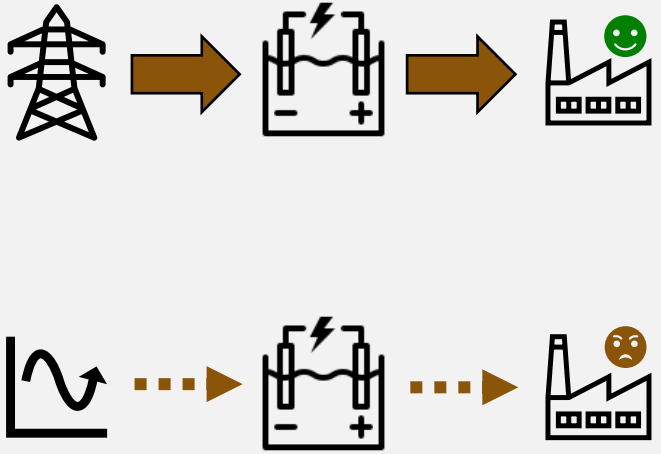





- Ramp up and down
- Fewer gov't subsidies
- $H_2$ storage to firm output

## Inflexible Systems – Problem



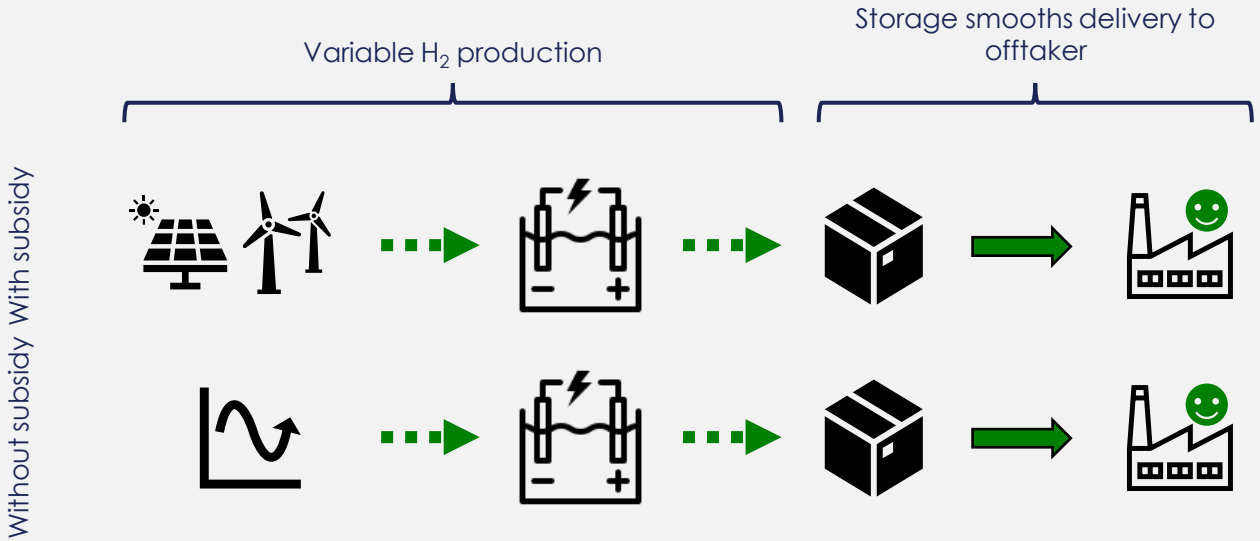



Inflexible Systems – Consequences

**Option 1:**
Stranded Assets
Lost Jobs
Derailed Industry

**Option 2:**
Subsidy Extension
More GHGs
Delayed Problem

# Flexible Systems – Sustainable Growth



# Flexible Systems – Grid Benefits

Very low or negative power prices

=

Excess renewables

=

Electrolyzer online

Higher power prices

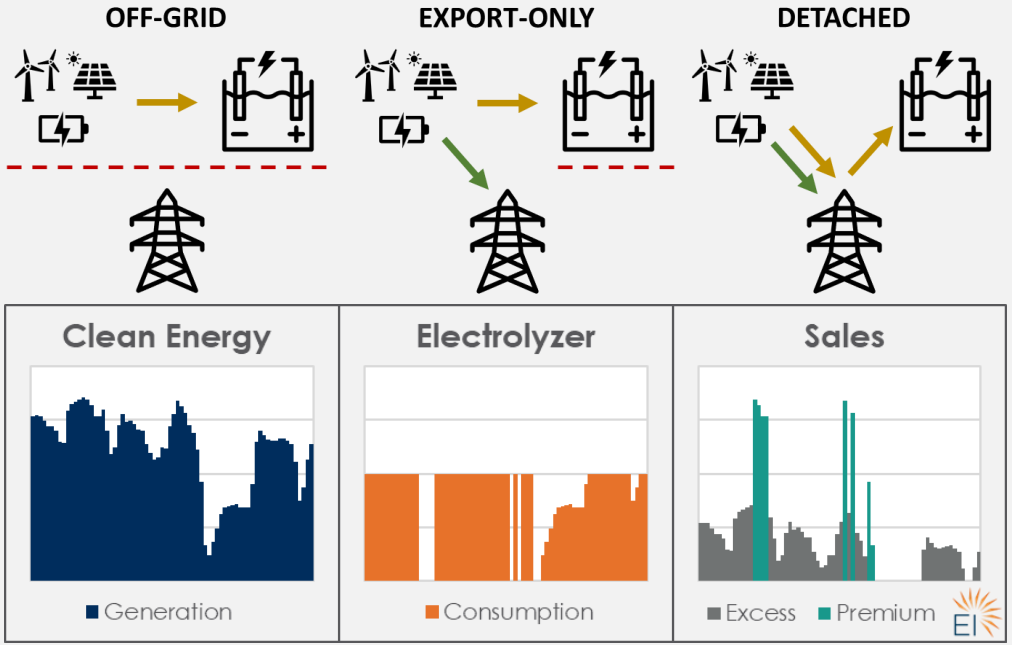
=

Fossil power online

=

Electrolyzer offline

## Project Configurations

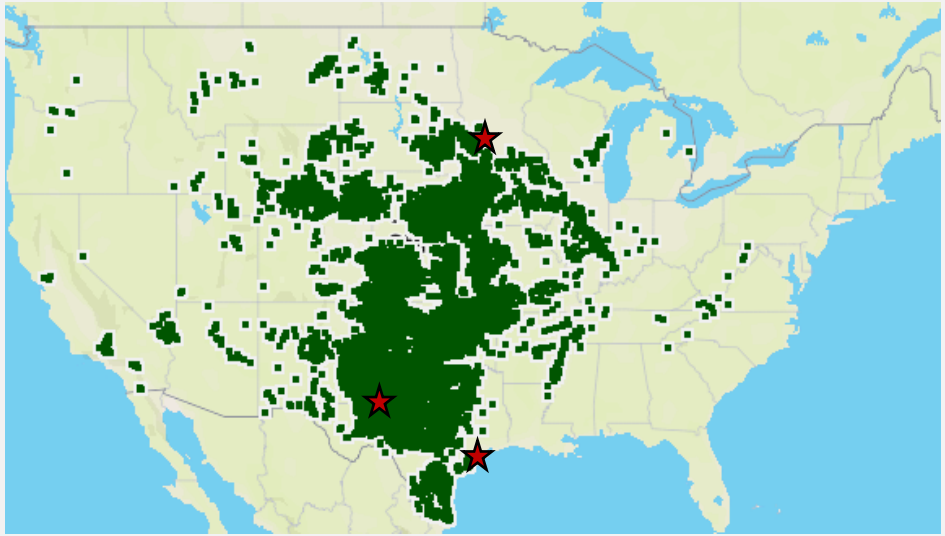


## Results

- Export-only projects can easily sell hydrogen at $1/kg and make a profit IF located in places with decent wind resources.
- Key assumptions:
  - CapEx = $1,400/kW-year
  - O&M = $90/kW-year
  - Finance + Tax Shield = $90/kW-year
  - Restricted revenue from excess power sales to the grid to keep focus on value of electrolysis.
  - Chose a low power price year to be conservative.

| Metric | West Texas | Near Houston | Southwest Minnesota |
|---|---|---|---|
| Electrolyzer capacity (MW) | 1 | 1 | 1 |
| Electrolyzer capacity factor (%) | 88.1 | 81.8 | 87.0 |
| Solar capacity (MW) | 3.0 | 3.5 | 2.0 |
| Solar capacity factor (%) | 25.9 | 20.8 | 21.2 |
| Solar levelized cost ($/MWh) | 16.20 | 19.32 | 27.47 |
| Wind capacity (MW) | 2.0 | 2.8 | 4.0 |
| Wind capacity factor (%) | 43.6 | 34.5 | 45.2 |
| Wind levelized cost ($/MWh) | 19.20 | 23.93 | 16.39 |
| Share of power sold to grid (%) | 47 | 52 | 61 |
| Revenue from hydrogen sales and 45V (%) | 79 | 72 | 76 |
| Revenue from excess power sales to grid (%) | 16 | 22 | 24 |
| Revenue from premium power sales to grid (%) | 5 | 6 | 0 |
| Profits ($/kW-yr) | **143** | **85** | **61** |

# Financial Viability of Compliant Projects Today



# Thank you

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Read more! **Google "Energy Innovation 45V"**

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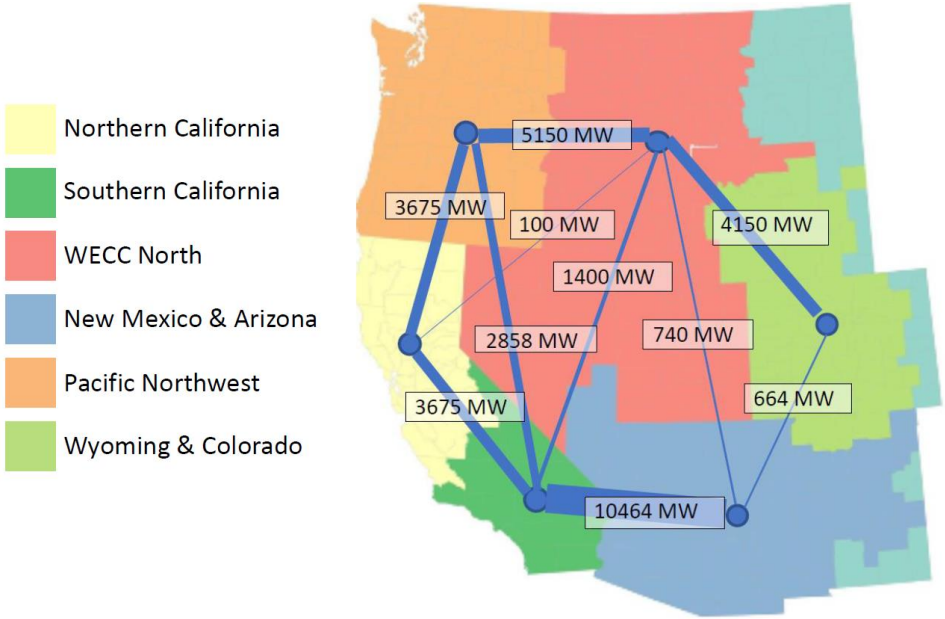
# Modeling Evidence: Why the Three Pillars?

- Used **GenX** to investigate the impact of grid-based hydrogen production on **system-wide emissions** under multiple possible PTC implementations
- Used a six-zone model of the US Western interconnection as an example system, with a planning year of 2030
- Added a large electrolysis load to each zone
- Assessed the emissions impacts of this additional load under various clean energy procurement requirements

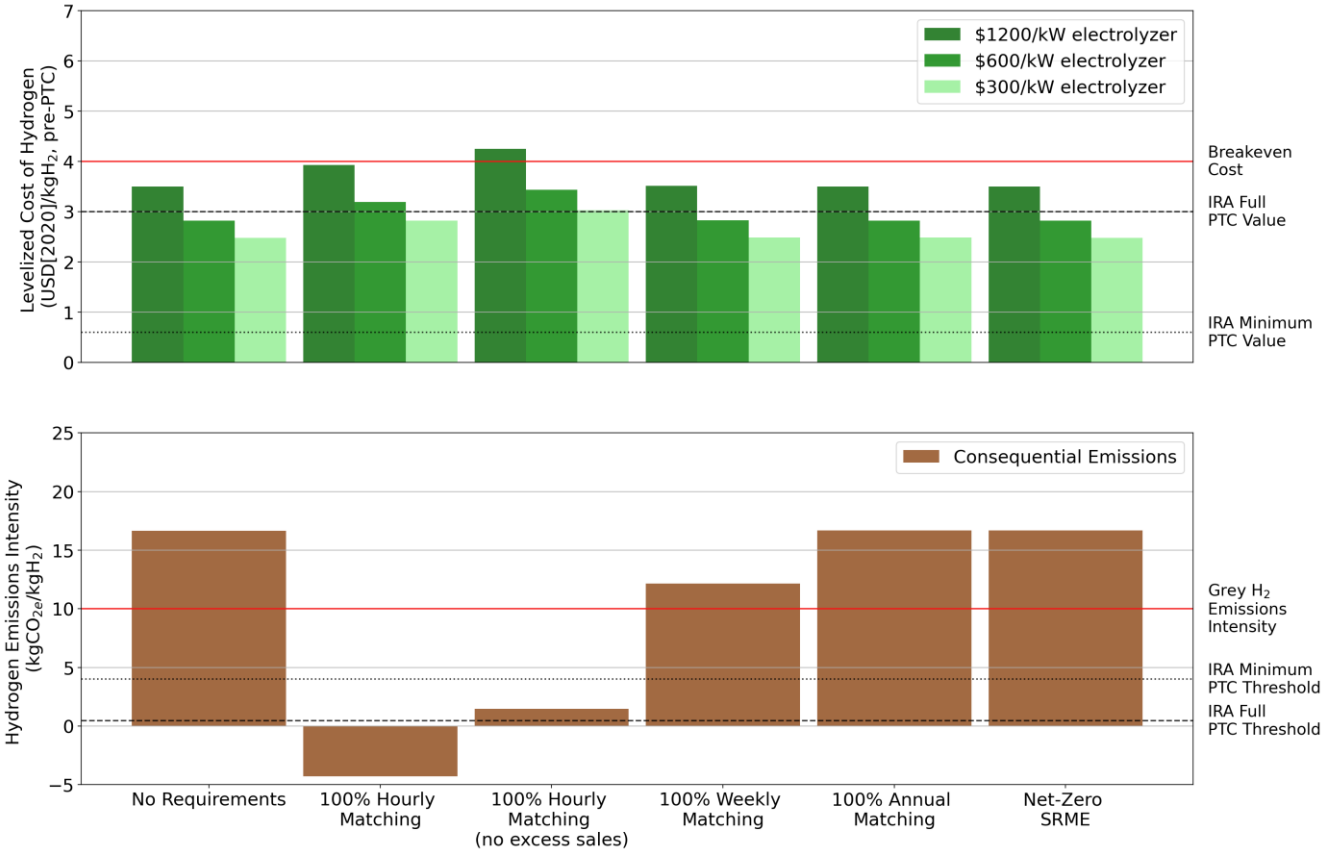



GenX system topology

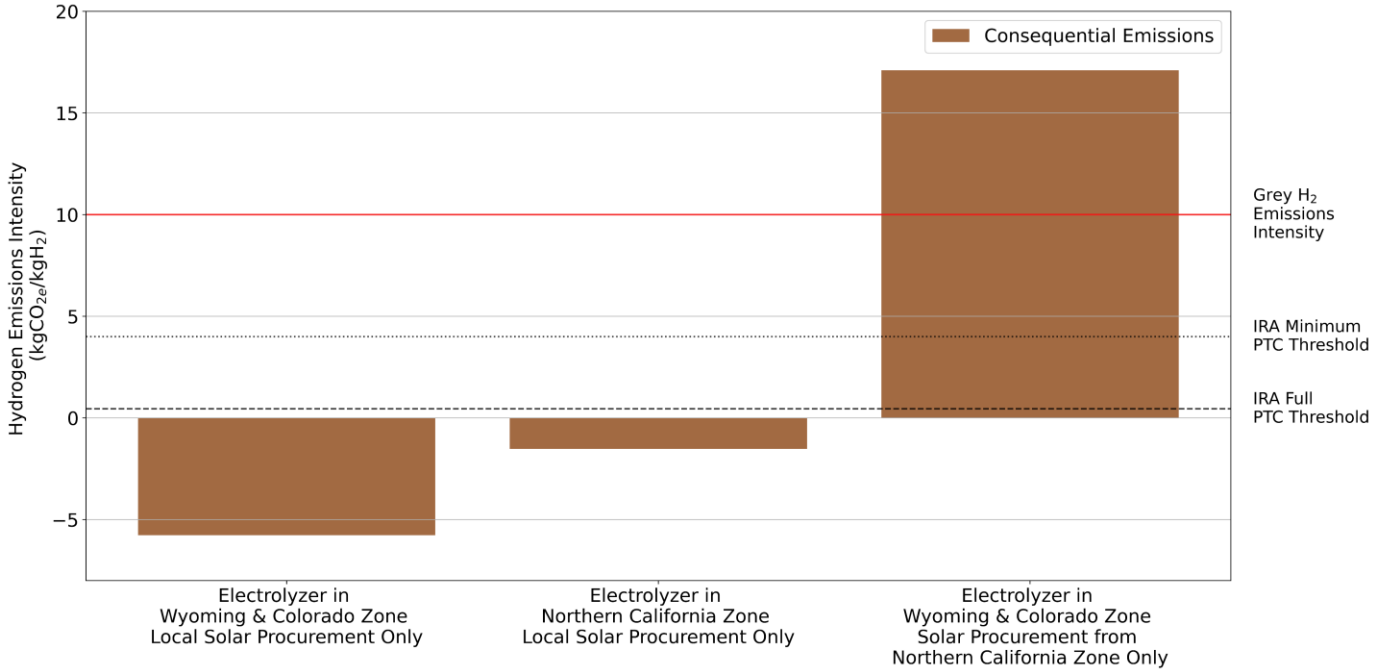
- Annual matching leads to emissions outcomes no better than making no clean energy procurements at all

- Hourly matching was the only strategy that successfully enabled $H_2$ production without adverse emissions impacts

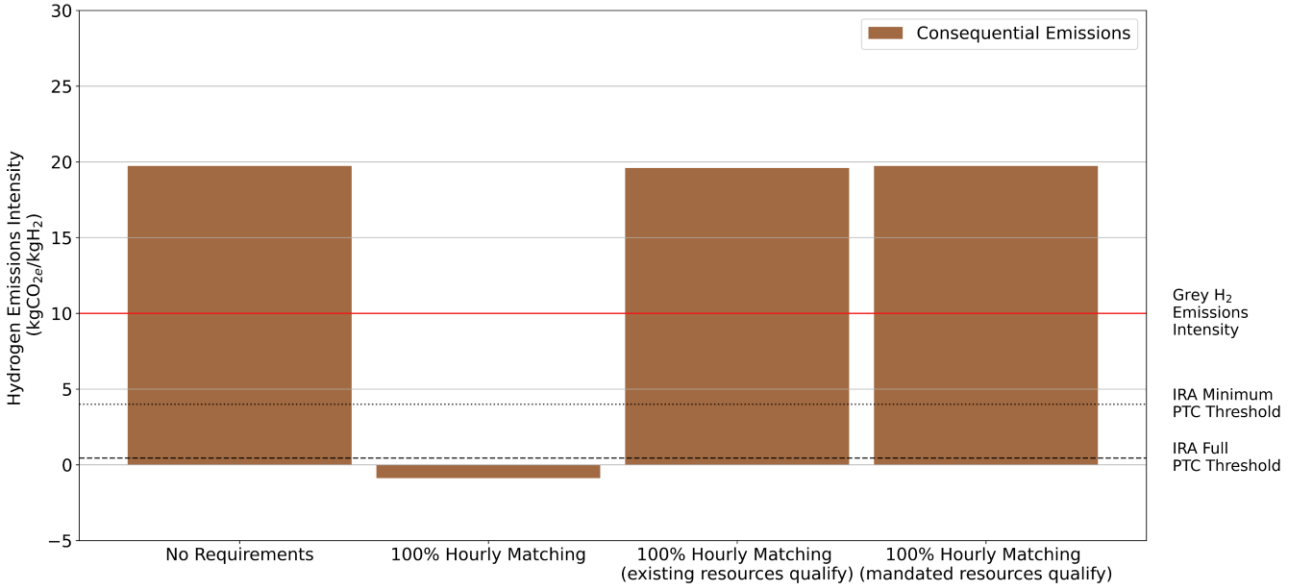
- Incremental cost is fairly low



- When procurement of transmission-constrained resources is allowed, much of the benefit of hourly matching is eliminated
- Congestion prevents ‘matching’ clean resources from actually delivering power, forcing reliance on fossil



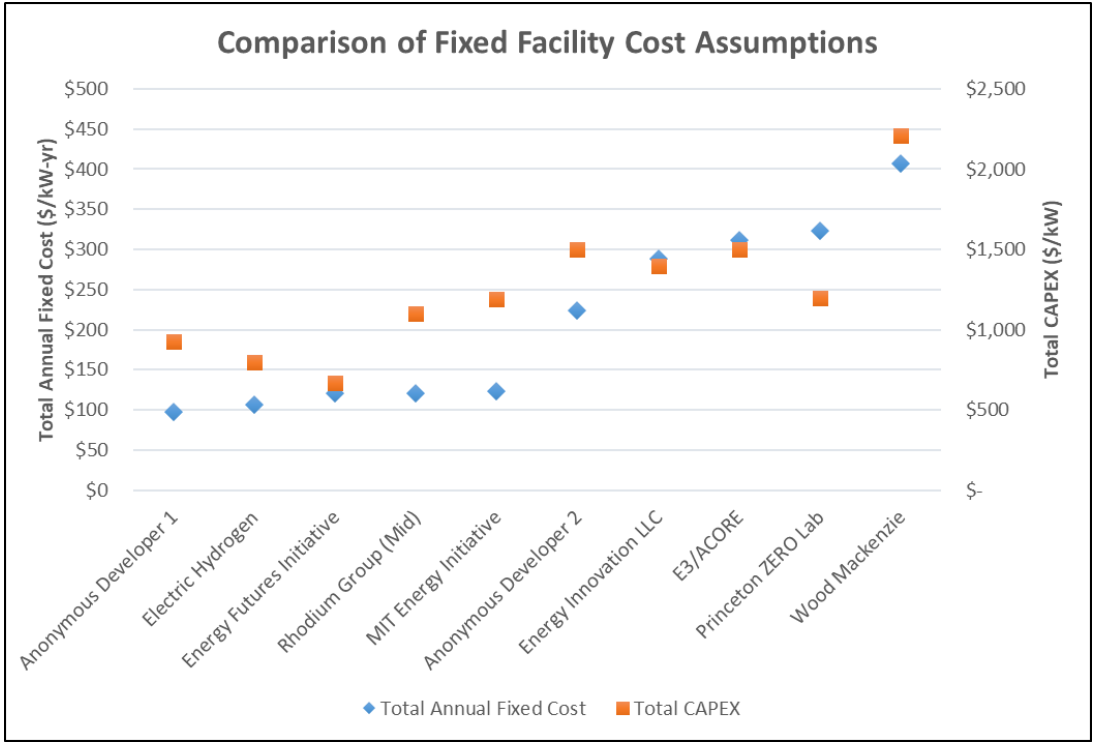
- Procurements should have a causal relationship with new resource deployments
- Allowing procurement of existing resources (or those mandated for deployment under state policy) completely undermines an hourly matching policy
- Still, enforcing ‘true’ additionality depends on knowing counterfactual outcomes and is likely impossible



- A number of studies have investigated the cost of complying with the Three Pillars

- Most find that even with the Three Pillars requirements, subsidized $H_2$ production in the US will be competitive from day one.

- Some studies disagree, and our recent LCOH intercomparison report explains why that is the case

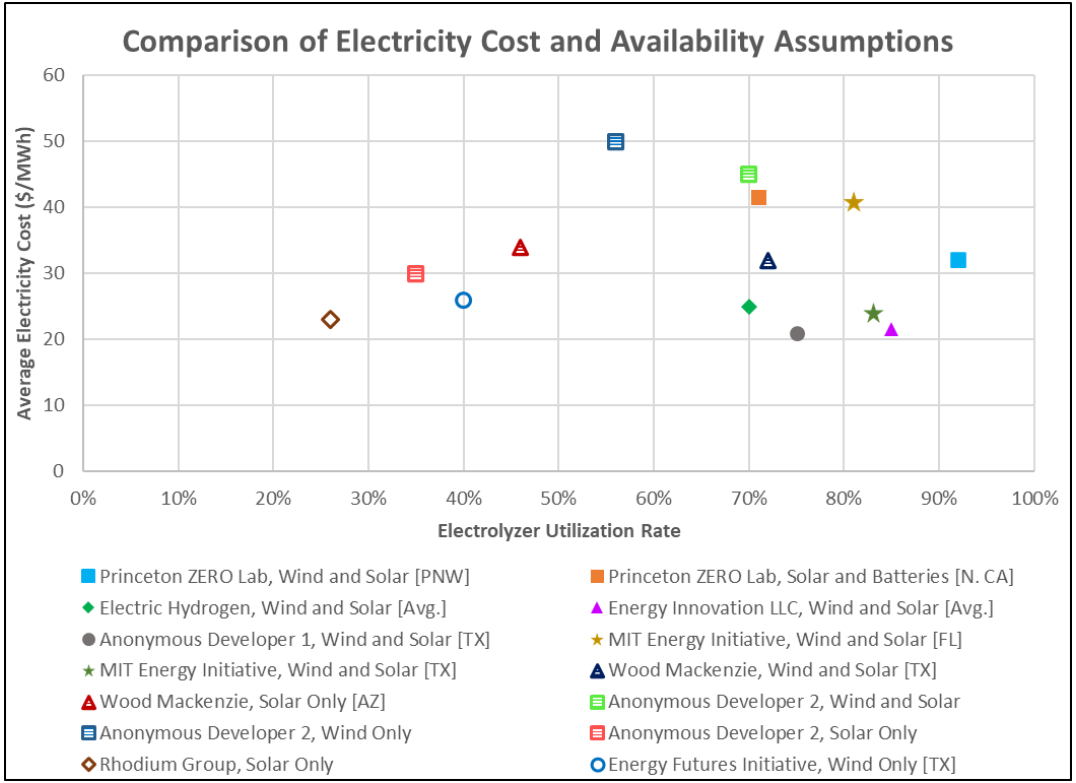



Most estimates of current electrolyzer facility costs fall between $700/kW and $1500/kW

- High fixed costs or low utilization rates lead to uncompetitive projects.

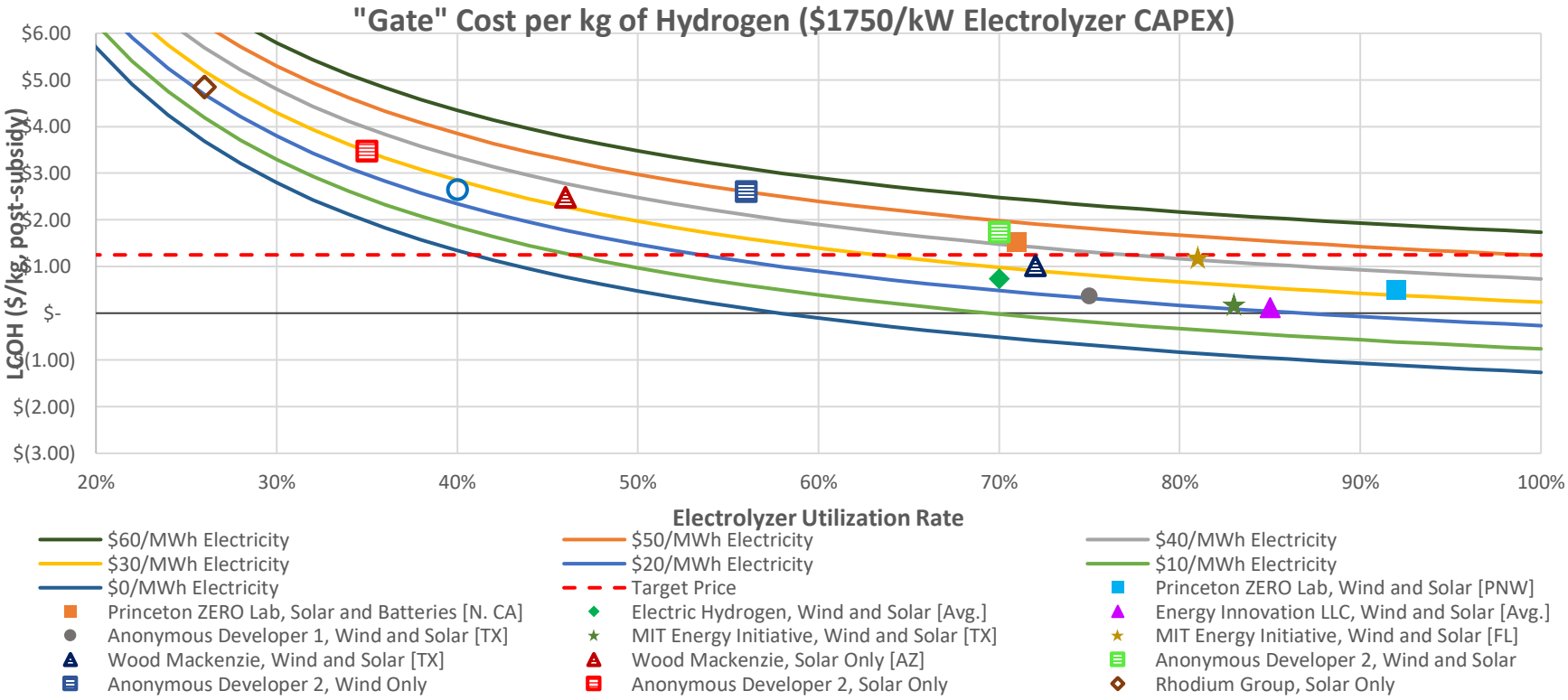
- Studies that optimize the sizing of both wind and solar power find that high utilization rates are achievable under the Three Pillars.

- Oversizing renewables and selling excess clean power is a winning strategy, leading to low cost premiums.

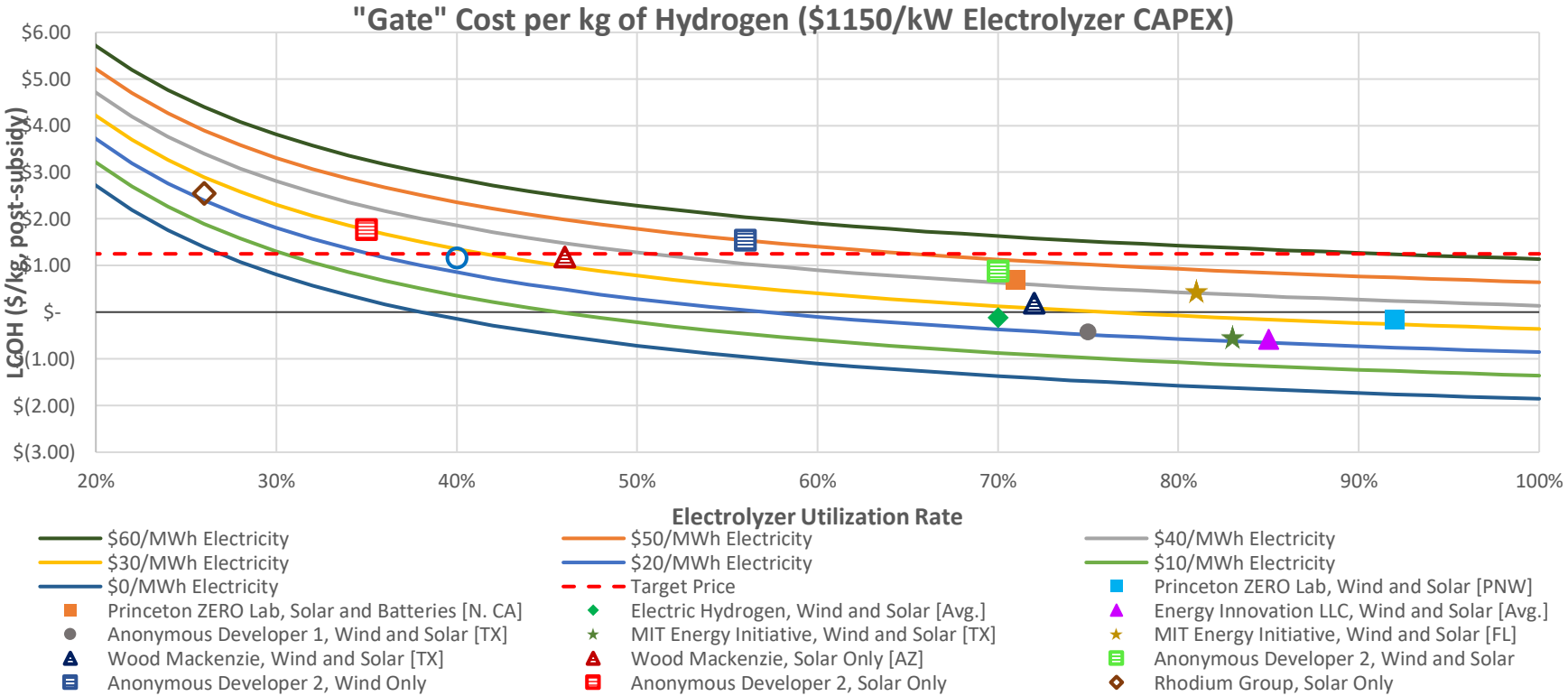



Optimizing the mix of clean electricity resources is key to a successful Three Pillars hydrogen project.

- Even at DOE's most conservative electrolyzer cost estimates, optimized clean energy portfolios lead to cost-competitive hydrogen production under the Three Pillars



- As costs fall, more and more projects will become competitive, and hydrogen prices will drop below $0/kg in the most ideal locations. Single-resource projects may remain uncompetitive.



- At DOE's 2030 cost projections, utilization rates become much less important. Clean hydrogen cost therefore becomes less location-dependent.