Additionality

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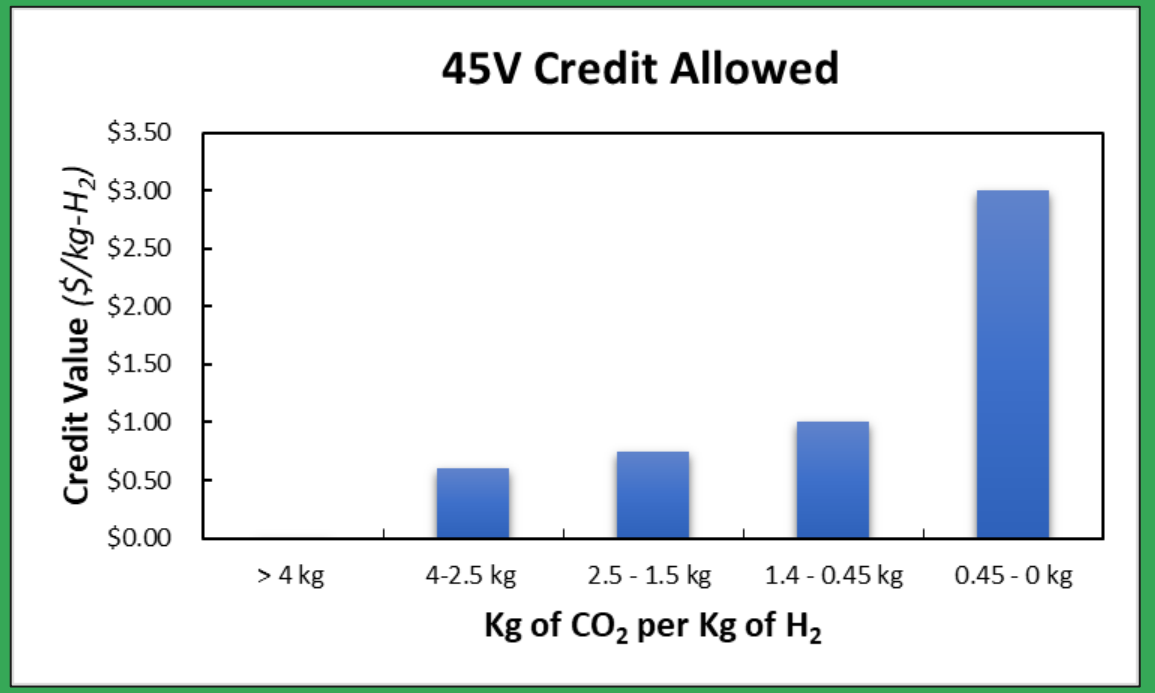
Clean Energy Tax Provisions in the Inflation Reduction Act

The federal government recently passed legislation which has over two dozen tax provisions that will accelerate the deployment of clean energy, clean buildings, and clean manufacturing. **A key piece of it (referred to as 45V) is designed to accelerate the buildout of the green hydrogen economy.**

45V has defined tax credits that can received based upon the associated emissions of the hydrogen that is produced. The cleaner the hydrogen, the greater the tax credit (see graph).



- There is significant debate over whether additional requirements should be enacted by the Treasury Dept when the PTC goes live
- The concept of the "three pillars", initially proposed by Princeton.
  - Additionality
  - Hourly Matching
  - Deliverability/Geographic Deployment

I.R.C. § 45V(c)(1)
Lifecycle Greenhouse Gas Emissions

I.R.C. § 45V(c)(1)(A)
In General — Subject to subparagraph (B), the term "lifecycle greenhouse gas emissions" has the same meaning given such term under subparagraph (H) of section 211(o)(1) of the Clean Air Act (*42 U.S.C. 7545(o)(1)*), as in effect on the date of enactment of this section.

I.R.C. § 45V(c)(1)(B)
GREET Model — The term "lifecycle greenhouse gas emissions" shall only include emissions through the point of production (well-to-gate), as determined under the most recent Greenhouse gases, Regulated Emissions, and Energy use in Transportation model (commonly referred to as the "GREET model") developed by Argonne National Laboratory, or a successor model (as determined by the Secretary).

Additionality, Time Matching, and Regionality are not included in the legislative language, any legislative intent or colloquies associated with 45V PTC

Three Pillar's Rationale for Additionality?

The rationale behind this concept is that grid will react to a new ELX project load demand by increasing generation. If there are not regulations set, then hydrogen producers ***could*** functionally consume clean power that could otherwise be used to decarbonize sectors like transportation and buildings while carbon-intensive power backfills the pre-existing demand in those sectors.

The numbers typically used are:

Electrolysis (50 kWh/kg-H_2) ***using 100% gas-fired energy*** (~0.4 kWh) would produce H_2 at an embodied emissions rate of ~20 kg-CO_2/kg-H_2.

Current SMR derived H_2 has an embodied emissions rate of 9.4 kg-CO_2/kg-H_2.

If electrolytic hydrogen producers cannot guarantee they are using **new**, **clean power** then they ***could*** be requiring the grid to produce power from fossil sources or be producing hydrogen with high embodied emissions rates.

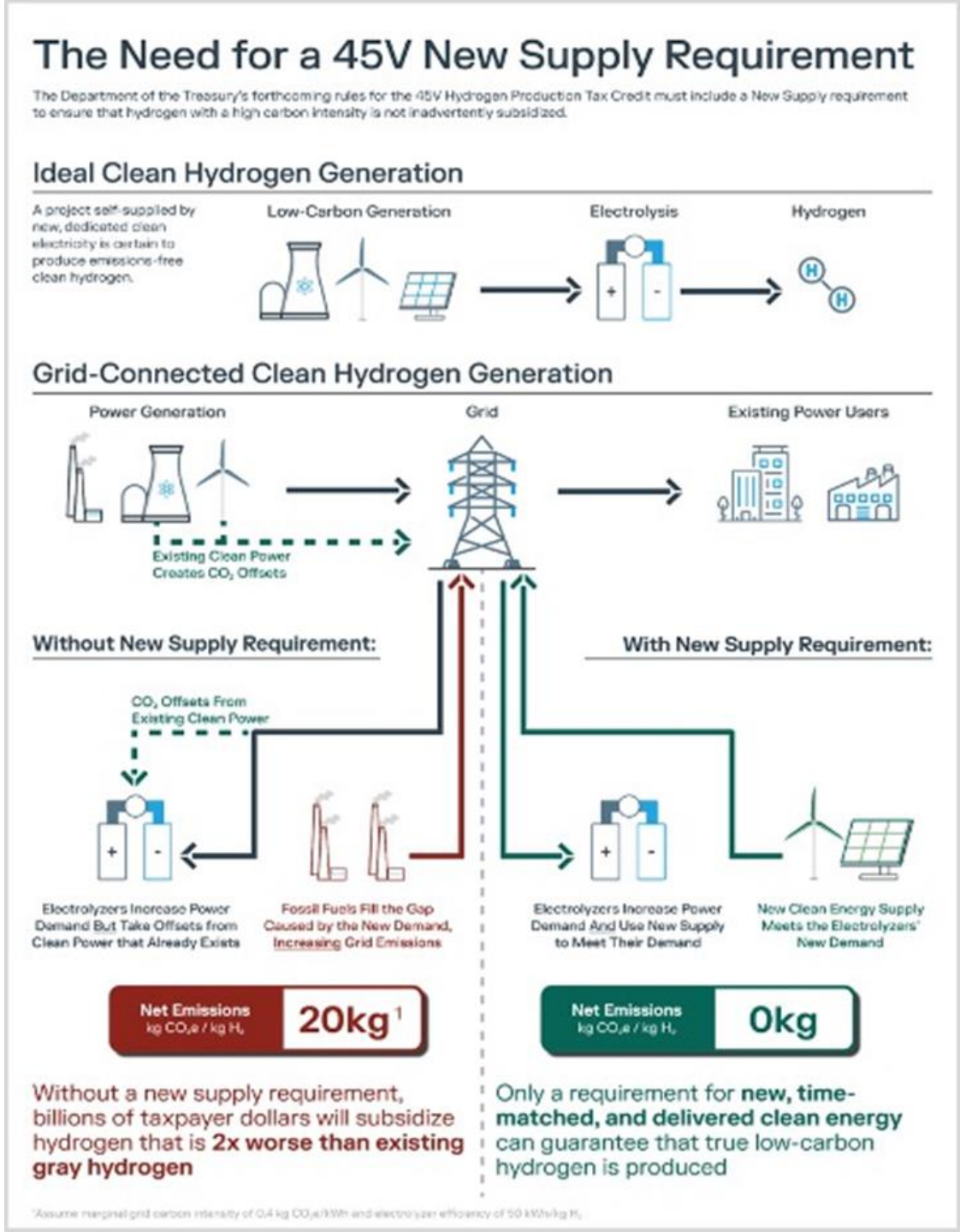
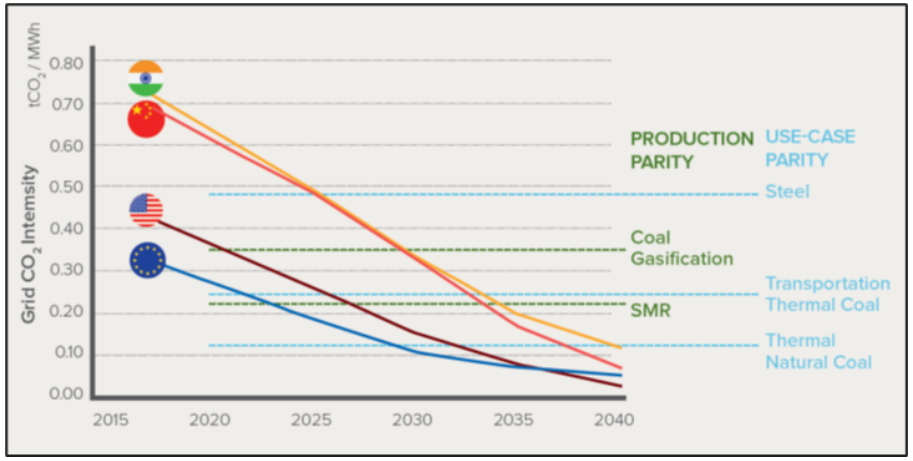


Image courtesy Jesse Jenkins

Counterpoints of Additionality - Summary

1. **Additionality would not seem to dramatically change the existing power systems emissions**
   - The Princeton analysis did not seem to consider existing policies such as cap-and-trade programs. It shows that in some regions IRA tax credits were already strong enough to support construction of sufficient new-build renewables to power both hydrogen demand and consumer demand.
   - Modeling by utilities indicates that additionality is only marginally impactful at best, far outweighed by EPA regulations and IRA renewable incentives
2. **The three pillars analysis does not consider the Administrations broader climate strategy**
   - This includes the adoption in the near future of new EPA regulations further restricting emissions from natural gas and coal-fired power plants.
   - The CO_2 intensity of power generation has been changing rapidly in the last decade, a trend that is projected to accelerate.
3. **By requiring hydrogen producers to met additionality requirements, the burden of decarbonizing the grid is effectively being put upon the hydrogen producers not the grid utilities**
4. **One-to-one mandatory matching in this manner has never been asked of any industry, even the power utilities. It would be enormously complex to realize.**



Projected US power CO_2 intensity in sustainable development scenarios. Graph courtesy of RMI (Hydrogens Decarbonization Impact for Industry)

In short, the Princeton paper which initially proposed the three pillars (including additionality) made some serious oversimplifications of the situation.

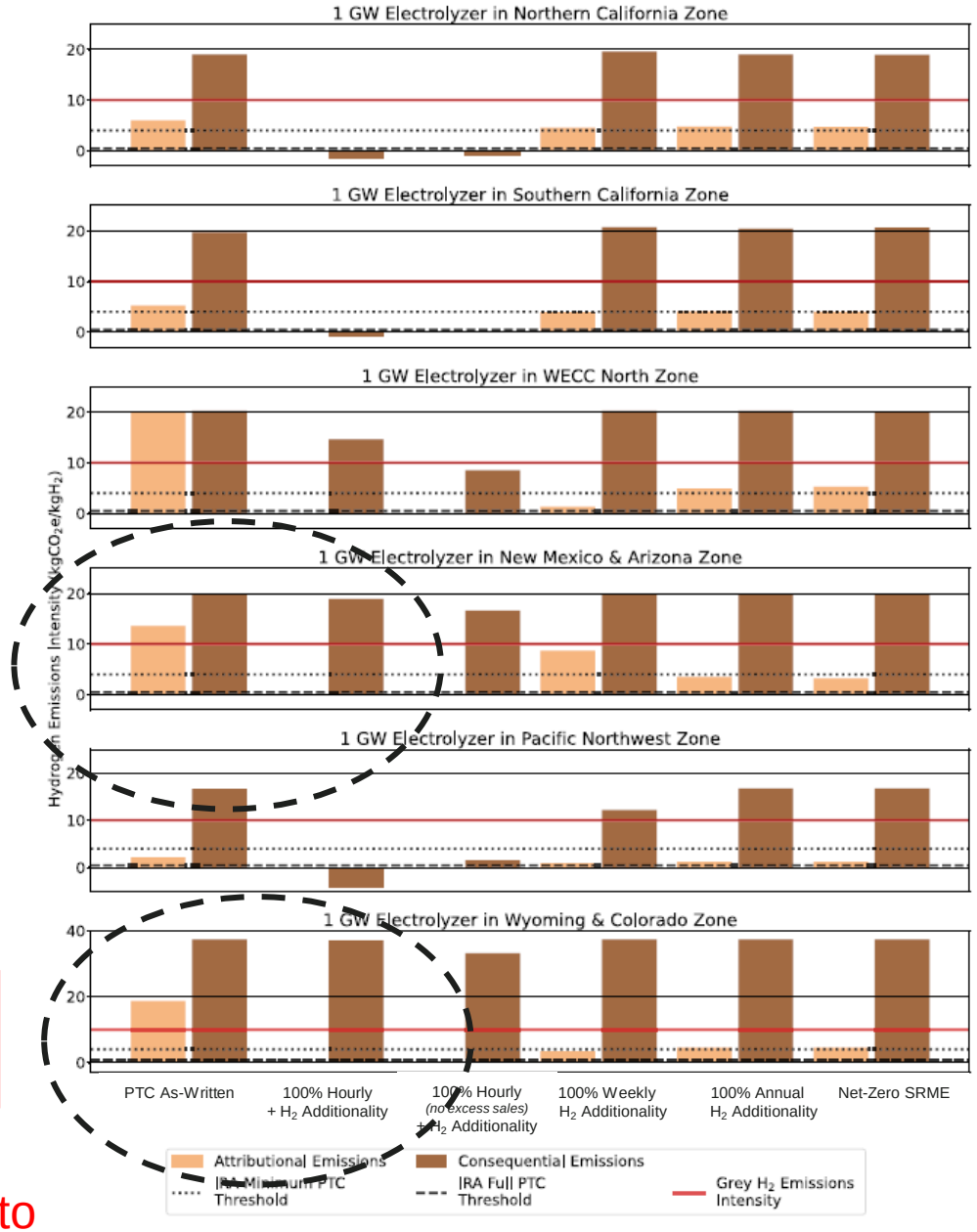
Renewables are Highly Incentivized

If you try to apply a simplistic additionality approach, the result is that hydrogen production will be attracted to regions where the cost of additionality compliance is lowest. This is basic economics.

Under this premise, hydrogen production would be incentivized to locate themselves in regions like New Mexico, Arizona, Wyoming, and Colorado which have significant renewable resources (regions also with high marginal emissions rates that will be slower to come down). Hydrogen products would not be as incentivized to site themselves in other regions which have no "excess" renewable generation (but do have lower marginal emissions rates). The analysis performed by Ricks et al. at Princeton showed that **the imposition of the additionality requirement in the carbon-intensive regions provides no emissions benefit.**

Their analysis (at right) shows that with or without additionality and hourly matching, **there was the same consequential emissions rates in those regions.**

This implies that the same amount of new wind and solar generation is coming online with or without the additionality requirement because the IRA incentives are already sufficient to support the investment. The Princeton analysis showed as much.



Graphs from Ricks et al. "Minimizing emissions from grid-based hydrogen production in the United States".

IRA already effectively includes enough incentives to support the buildout of the hydrogen economy.

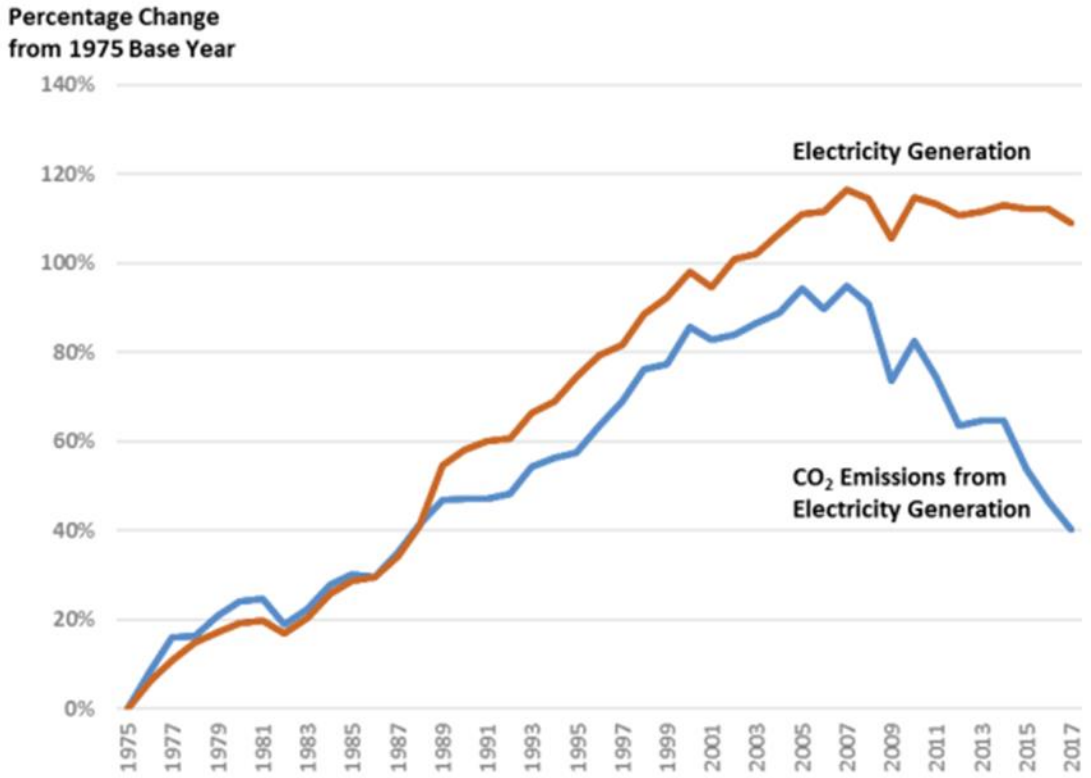
Limitations of Additionality

- **It would be very challenging to identify resources that would not otherwise have been present without the demand for hydrogen.**
  - This was a key challenges for the Koyoto Protocol. *(M. Axel "Interpreting the Additionality of CDM Projects: Changes in Additionality Definitions … over Time" 2009)*

"This definition could be extended to encompass even *new, non-mandated* resources that would have been build with or without having being procured for hydrogen production specifically… However, **this broader definition of additionality is likely difficult if not impossible to enforce**, as it requires counterfactual knowledge of which resources would have been developed had the hydrogen producer *not* made certain procurement choices.

- Princeton Paper (Ricks et al. 2023)

- **The argument for additionality assumes that current and future carbon policies are completely ineffective at reducing the degree of grid associated emissions**
  (both by reducing plant emissions, retiring existing assets, and deploying new renewables).
  The Princeton researchers admitted as much, stating:



Graph showing US electricity generation CO_2 emissions over the past 50 years (Data courtesy of U.S. Energy Information Administration. Image courtesy of CRS)

The Three Pillars is based upon at a static point in time and fails to incorporate the industry trends that are emerging. The U.S. electric grid is clearly beginning to clean and reduce the associated emissions by asset retirement, new renewable generation, and cleaner operations at existing sites.

A policy mechanism that explicitly prioritizes system-wide emissions reductions, such as a carbon pricing or cap-and-trade program, could help encourage climate-positive outcomes alongside electrolysis deployment by financially disincentivizing electricity consumption in hours when fossil plants are on the margin and directing hydrogen production toward end uses with the greatest overall decarbonization potential. **A cap-and-trade program in particular would likely mitigate the need for further hydrogen-specific regulations by ensuring that system-wide emissions cannot increase as a result of electrolysis operation.**

-Princeton Paper (Ricks et al. 2023)

Limitations of Additionality

- **EPA will be preparing and finalizing its regulations on carbon emissions from new and existing generators in the near future.**
  - Regulations will require existing generators to reduce their emission rates by substantial amounts and place limitations on emissions for new installations.
  - In addition, there will continue to be assets which will be retired.
  - The overall effect of this policy will be to lower the emissions rate of the existing fossil assets and thereby lower the grid mix emissions.
  - Combined with expected renewable growth from incentives in the IRA, **these changes will act to dramatically lower the marginal emission rate of grid electricity across the entire country**.

	Emissions Reductions from 2005 Level			
Imposed Policies	**2025**	**2030**	**2035**	**2040**
111 b CCUS	-49%	-69%	-76%	-91%
111 b CCUS with H_2 Additionality	-46%	-68%	-74%	-91%
111 b/d CCUS with H_2 Additionality	-48%	-77%	-84%	-96%
111 b CCUS - EPA Clean Air Act Natural Gas Regulations 111 d CCUS - EPA Clean Air Act Coal Regulations				

Annual CO_2 Emissions Reductions

	Millions Short Tons			
Imposed Policies	**2025**	**2030**	**2035**	**2040**
111 b CCUS	-21	99	217	497
111 b CCUS with H_2 Additionality	-97	70	172	499
111 b/d CCUS with H_2 Additionality	-43	313	425	614
111 b CCUS - EPA Clean Air Act Natural Gas Regulations 111 d CCUS - EPA Clean Air Act Coal Regulations				

Tables constructed using data from Constellation Modeling ("American manufacturers need equal access to clean hydrogen to decarbonize their operations)

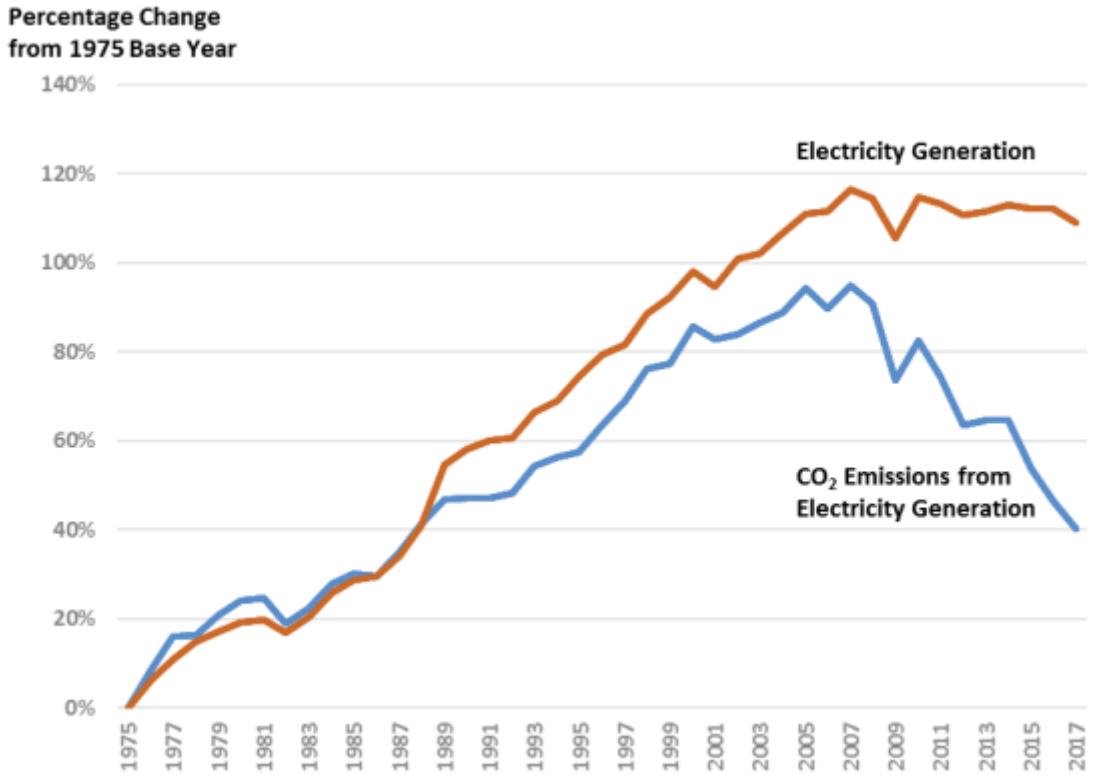
Given the scope of the power generation industry, any additionality requirement would have a marginal (at best) impact upon the grid emissions rate. **The Constellation assessment (above) shows that without additionality, the net emissions associated with electrolytic hydrogen production will have little to no impact upon the grid emissions rates.** (Not positive as suggested by the advocates of additionality)

Counterpoints of Additionality

- **A one-to-one matching would be a higher threshold than any business or industry running right now in the system**.
- The power industry is being pushed in this direction, but it has been over a 20+ year process.
- The additionally rule would be requiring this while in a market that is already severely supply chain constrained.
- Is the same being asked of any other new industry/facility/or manufacturing plant?

Asking for this level of restriction, at this point in time, is creating an economic barrier that is so extreme (in order to deliver) that projects will simply not survive.

The intent of the PTC was not to overly regulate the production of hydrogen, it was to incentivize and accelerate it.



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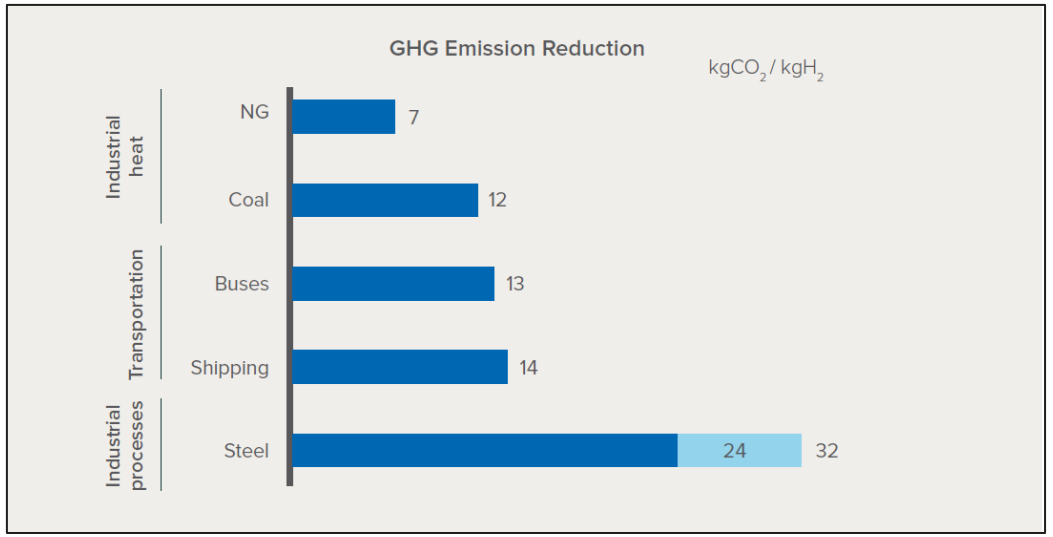
Major Federal Regulations for Power Generation

1970 – Clean Air Act
2005 – Clean Air Interstate Rule
2011 – Mercury and Air Toxics Standards
2011 – Cross-State Air Pollution Act
2015 – Clean Power Plan (repealed)
2019 – Affordable Clean Energy Rule
2023 – New EPA Clean Air Act Draft Regulations Released

Hydrogen Can Make An Impact Now!

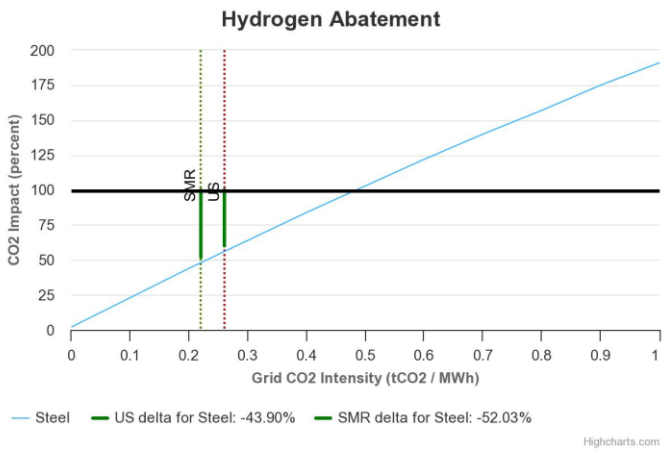
- **Looking at emissions only through the lens of production only is a gross oversimplification of a highly complex system.**
- **Hydrogen can substantially reduce emissions for other high polluting industries and mobility applications right now.** That is what the writers of the PTC realized and why they wrote the legislation in the manner they did.



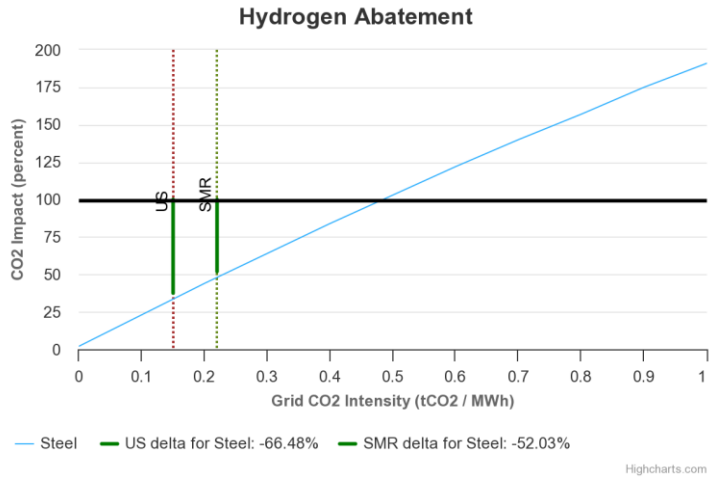
Graph showing the GHG emission reduction by deploying a kg of H2 in various applications. (Image and graphs (below) courtesy of the Rocky Mountain Institute "Hydrogen's Decarbonization Impact for Industry").

Even though the decarbonization of industries such as HD mobility, shipping, and steel are only just beginning, **it is critical that the H_2 supply infrastructure be developed to support them as they begin their energy transition.**

As the grid gets cleaner, the net positive benefit of electrolytic hydrogen will only increase (as shown).



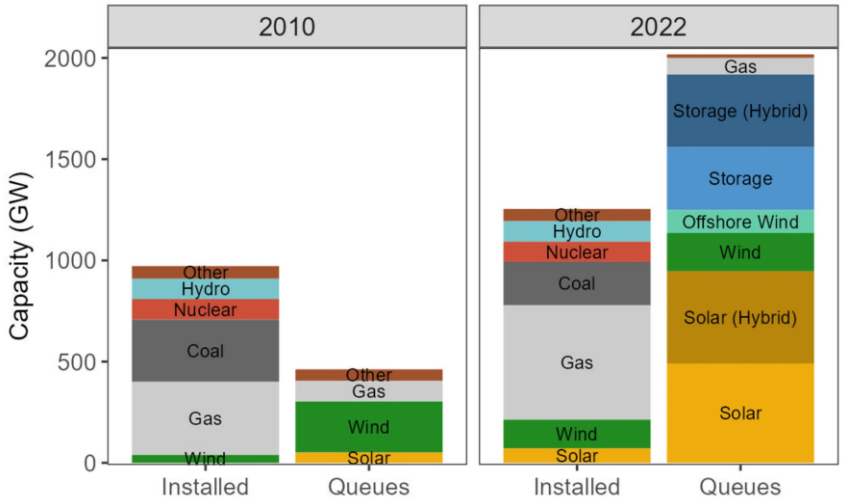
2025 US Grid Mix



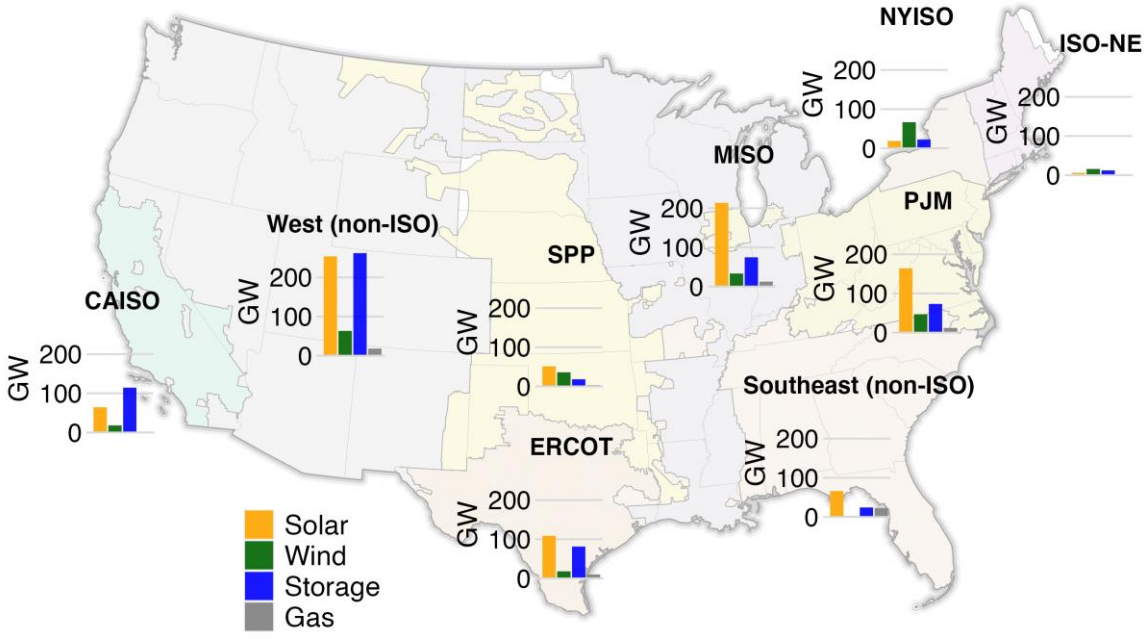
2030 US Grid Mix

Interconnection Challenges

- The U.S. electric grid interconnection back log is staggering.
- At present, the U.S. has an installed capacity of 1,250 gigawatts.
- As of April 2023, there are **2,020 gigawatts of capacity in the interconnection queue** lines around the country.
- 1,350 gigawatts of that are mostly clean generation. The rest, 670 gigawatts, are for storage projects.
- On average, it takes a new power generation project **35 months to go from the interconnection request being filed to an interconnection agreement** being reached.
- Of all grid operators, the highest completion % reached was in ERCOT with **~31%.**
- The greatest reason for this low completion percentage is due to the **rise in interconnection costs.**
- Historically, costs were around $100/kWh. This has risen to several hundred dollars for solar/wind, with spikes even higher in some regions. **This is something the Princeton review measurably underestimated are will only get worse**.
- This historically high interconnection demand is overwhelming an already taxed system. There are ~38,000 MW of renewable projects in PJM which ultimately were approved but will not longer be built.

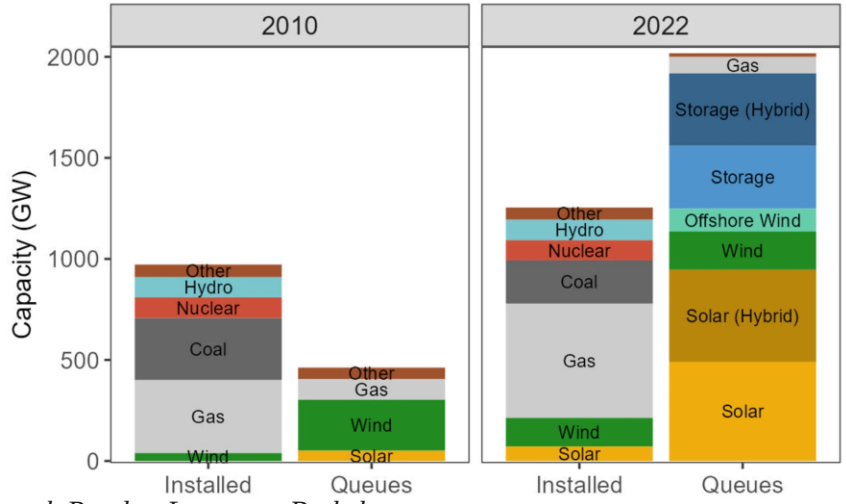


Images courtesy of Joseph Rand at Lawrence Berkeley National Laboratory



Interconnection Challenges

- The time to project completion vary significantly from region to region. At present, a **project put into the PJM queue today may not be constructed by 2030**.
- There are also challenges with completing a renewable project and hydrogen production project (each hundreds of millions of dollars) concurrently.
- The timing of these two projects would have to be perfect in order to avoid a stranded asset in one or the other. This would be a significant area of concern for a bank looking to finance.
- In addition, there are enormous complications with citing and interconnecting projects of this size. In many cases the grid will need to be upgraded to support it (an entirely new, and expensive, project).



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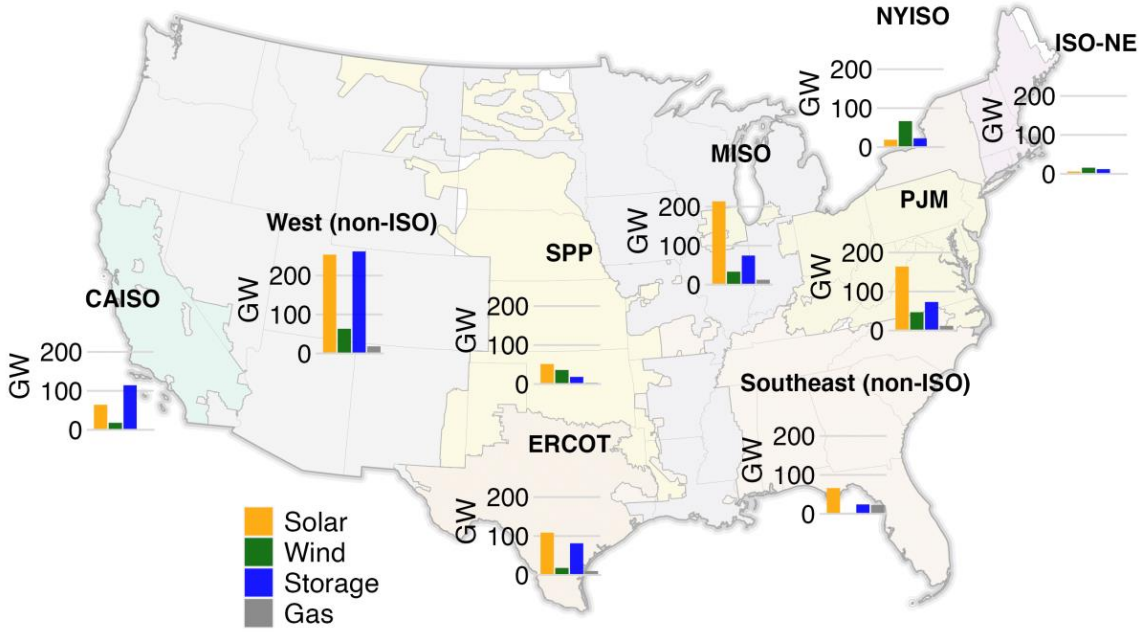
An additionality requirement would serve to set the hydrogen economy back, at minimum 5 to 10 years, simply from an interconnection perspective.



Map of the U.S. showing the interconnection backlogs for the various regions.

Facility Operation Limitations

Operational profiles for hourly-matched electrolysis systems are shown … and illustrate how electrolyzers occasionally reduce consumption during periods of clean electricity scarcity to avoid drawing power from the grid mix.
- Princeton paper (Ricks et al. 2023)

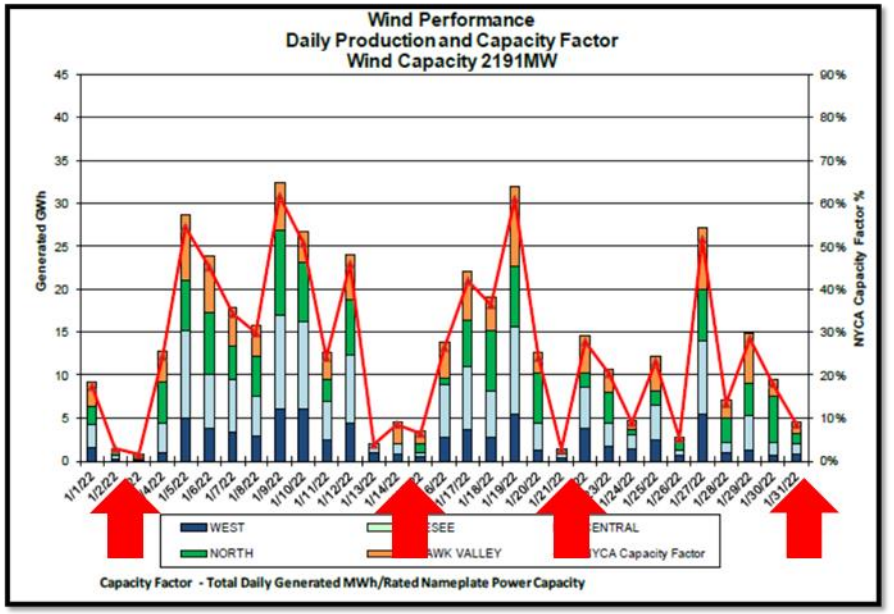
The proponents of the Three Pillars regulations are failing to grasp **the challenges and implications of attempting to turn down a hydrogen generation facility and the frequency in which it would be required to occur under their three pillars**.

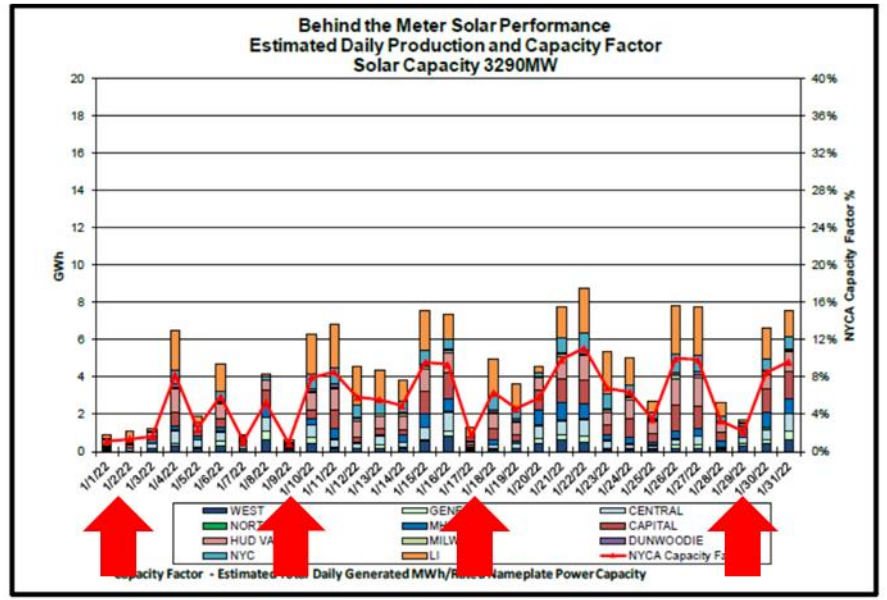
In January 2022, NYS saw the installed solar and wind perform below 25% capacity for multiple days at a time (see right).

A critical component of any large-scale hydrogen production facility will be the off-take agreements that make it economically viable. At this scale, any off-take partner will not be able to endure a multi-day event of reduced supply.

The only solution under the three pillars regulations would be to build expensive large-scale storage and overproduce hydrogen during times of excess OR installed significant quantities of batteries to power the facility through low renewable availability. (Batteries themselves which would require green electrons to charge.)

This will drive up the cost and complexity of a project.





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1. **Additionality would not seem to dramatically change the existing power systems emissions.**

2. **The three pillars analysis does not consider the Administrations broader climate strategy.**

3. **Hydrogen can make an impact right now and its scale up needs to being in order to support decarbonization of challenging industries.**

4. **One-to-one mandatory matching in this manner has never been asked of any industry, even the power utilities. It would be enormously complex to realize.**

The intent of Congress was not to overly regulate the production of green hydrogen, it was to incentivize and accelerate its deployment.

Green Hydrogen at Work™