December 3, 2022

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RE: Notice 2022-58 Request for Comments on Credits for Clean Hydrogen and Clean Fuel Production

Submitted via www.regulations.gov;

Thank you for the opportunity to provide comments. We focus our responses to questions within .01 Credit for Production of Clean Hydrogen. We answered questions to which we have expertise, have outsize importance, and need more timely guidance. These comments are intended to complement those comments in response to Notice 2022-49 submitted November 4, 2022 by RMI (Comment ID: IRS-2022-0023-1881). A copy of these comments is attached as "Exhibit A."

RMI is a global non-profit that focuses on deep decarbonization of the world's most-polluting sectors and leads sustainability programs across five geographies: the U.S., India, China, the Global South, and cities. RMI engages with global businesses and policymakers on research and strategy to scale low-carbon hydrogen technologies. RMI hosts the Green Hydrogen Catapult, and has published research on hourly emissions accounting.

Overview

The § 45V credit will only effectively incentivize deployment and scaling of clean hydrogen if the emissions assessments for hydrogen production pathways are rigorous and enforceable.

Two major production pathways require significant guidance:

1. **Grid-connected electrolysis**, the basis of green hydrogen production, requires an accounting system that ensures effective reductions of GHG emissions on the grid.
2. **Methane-based hydrogen production**, the basis of blue hydrogen production, requires accurate accounting for upstream methane leakages and verifiable carbon capture reporting.

Analysis shows that in a worst-case scenario a weak framework for grid-connected electrolyzer emissions accounting could increase emissions by half a gigaton of CO2e over the lifetime of the credit while costing taxpayers billions of dollars.[1]

These comments include descriptions of two systems that could verify clean electricity inputs for grid-connected electrolyzers, but recognize there may be other preferable systems or hybrid frameworks that achieve the statutory requirements and Congressional intent.

RMI suggests that the Treasury and the IRS work with the Department of Energy, relevant agencies, and academics to explore and develop verification pathways.

Please reach out to John Coequyt (jcoequyt@rmi.org), Nathan Iyer (niyer@rmi.org), or Alex Piper (apiper@rmi.org) with any questions.

[1] This figure is based on preliminary analysis assuming electrolysis displaces SMR production and a conservative estimate based on DOE's projections of roughly 5 million metric tonnes (MMT) H2 production per year for ten years of the credit. One kg H2 production requires roughly 50 kWh electricity and according to the EPA eGRID2020 data, average grid intensity is roughly .3726 CO2e/kWh. Should weak accounting schemes allow grid-connected electrolyzers to qualify for the highest tiers of the credit, 5 MMT of hydrogen production receiving the PTC for 10 years could lead to roughly 1.02 gigatons of CO2e emissions. Under the assumption that this displaces SMR, the emissions would net out to roughly 0.42 gigatons CO2e.

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.01 Credit for Production of Clean Hydrogen.

(1) Clean Hydrogen.

Section 45V provides a definition of the term "qualified clean hydrogen." What, if any, guidance is needed to clarify the definition of qualified clean hydrogen?

(a) Section 45V defines "lifecycle greenhouse gas emissions" to "only include emissions through the point of production (well-to-gate)."2 Which specific steps and emissions should be included within the well-to-gate system boundary for clean hydrogen production from various resources?

The well-to-gate definition includes direct emissions (Scope 1) and indirect emissions (Scope 2) required to produce hydrogen. This should include the energy input source and input leakage rates, process emissions during production, and conversion related emissions for compression and transformation. Embodied carbon emissions should not be included. This comment will discuss the well-to-gate boundary for two major pathways: electrolytic hydrogen, and methane-based hydrogen production with carbon capture.

Electrolytic Hydrogen

For electrolytic hydrogen, there is one major step that must be considered: the direct carbon intensity of the input electricity used to produce hydrogen (e.g. current flowing through electrolyzer stack and balance of plant). Auxiliary electricity loads are out of scope of this lifecycle definition (e.g. facility operations including lighting and monitoring).

For behind-the-meter resources, the emissions associated to electricity refers to the emissions intensity to generate each kWh of electricity. The Treasury Department and the IRS should use the default settings of the GREET model, which excludes the emissions associated with the construction of or materials associated with electrolyzers, transmission, and powerplants. This is aligned with previous uses of the GREET model to calculate lifecycle emissions as part of the Renewable Fuel Standard:

"The EPA's assessment of fuel production does not include activities that are clearly unrelated to the fuel lifecycle (e.g., offset projects) or ***emissions associated with physical and organizational infrastructure*** *(e.g., facility construction, employees commuting to the facility)."*[3]

Congress defined "lifecycle greenhouse gas emissions" in the IRA as:

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[2] The well-to-gate system boundary for hydrogen production includes emissions associated with feedstock growth, gathering, and/or extraction; feedstock delivery to a hydrogen production facility; conversion of feedstock to hydrogen at a production facility; generation of electricity consumed by a hydrogen production facility (including feedstock extraction for electricity generation, feedstock delivery, and the electricity generation process itself); and sequestration of carbon dioxide generated by a hydrogen production facility.

[3] https://www.epa.gov/renewable-fuel-standard-program/lifecycle-analysis-greenhouse-gas-emissions-under-renewable-fuel

> the aggregate quantity of GHG emissions (including direct emissions and significant indirect emissions such as significant emissions from land use changes), as determined by the Administrator, related to the full fuel lifecycle, including all stages of fuel and feedstock production and distribution, from feedstock generation or extraction through the distribution and delivery and use of the finished fuel to the ultimate consumer, where the mass values for all greenhouse gasses are adjusted to account for their relative global warming potential. *26 U.S.C. § 45V (c)(1)(A) (adopting the definition set forth in 42 U.S.C. § 7545(o)(1)(H)).*

The statute further defined the term to only include the well-to-gate GHG emissions of hydrogen projects as determined under the most recent "'GREET model' developed by Argonne National Laboratory, **or a successor model (as determined by the Secretary)**." *26 U.S.C. § 45V(c)(1)(B) (emphasis added).*

The Treasury Department is directed to issue regulations or other guidance to carry out the purposes of section 45V, including for determining the lifecycle greenhouse gas emissions of hydrogen projects, by August 16, 2023. *Id*. at § 45V(f).

Renewable energy credits and power purchase agreements do not, on their own, demonstrate low-emissions electricity that could then qualify hydrogen producers using grid electricity. Hydrogen produced with grid electricity on average has an emissions intensity of over 20 kg CO2e per kilogram of hydrogen, over five times the qualifying threshold.[4] Any book-and-claim system that is used to claim lower lifecycle emissions must affirmatively prove that the emissions impact of the new electrolyzer load on the grid is being mitigated. Recent modeling demonstrates that additionality, regionality, and granular temporal matching (with associated measurements) are all required to eliminate the emissions impact of the new load.[5] Temporal matching can refer to either long-run locational marginal emissions accounting, or MWh matching. Please find further details on this issue in our answer to (1)(e) within these comments.

Methane-based pathways

Many pathways to produce hydrogen start with methane feedstocks. Typically, there are three main considerations:

1. Where is the methane from? Geologic source, from biological sources (biomass residues), or waste streams (landfills, dairy farms).
2. What is the methane leakage upstream of hydrogen production?
3. What is the level of carbon capture as the methane is converted into hydrogen, and what happens to that carbon?

Methane sourcing:

- **Waste methane**: The GREET model could provide negative values for certain sources of methane, like dairy farms, which capture waste methane. However, use in hydrogen

[4] Ricks, Wilson, Xu, Qingyu, & Jenkins, Jesse D. (2022). Minimizing emissions from grid-based hydrogen production in the United States. Zenodo. https://doi.org/10.5281/zenodo.7349406
[5] Ibid.

should not be considered “additional” and thus should be given a value of 0 net emissions, rather than significant negative net emissions.

- **Regulated waste methane**: Other sources of methane must be captured as part of regulatory requirements (e.g. landfill methane), and thus do not receive a negative value if used for hydrogen production.
- **Biogenic methane:** Methane produced via gasification of biomass. The emissions intensity should be based on the indirect land use of the crops, the emissions associated with the gasification process, and additional process emissions (e.g. methane leakage).
- **Fossilized methane:** Methane extracted from geological sources. Emissions associated with leakage and use are positive unless the carbon is also sequestered geologically.

Upstream leakage:

Methane pathways must include upstream methane leakage, including leakage from production, transportation, storage, and process emissions. The Department of Energy (DOE) finds that hydrogen produced using methane with a 95% carbon capture rate and 1% upstream leakage only just qualifies for the 45V credit.[6] In many instances, true leakage rates are much higher. Given methane’s significant global warming potential, accurate measurement of leakage is critical for 45V implementation.

Companies that do not have commodity specific data will initially use national leakage data when procuring input methane, which is currently available in GREET. Recent studies demonstrate conclusively that the Environmental Protection Agency (EPA) emissions inventory is vastly undercounting true methane leakage rates because the agency is relying on self-reporting and “literature” leakage rates, rather than true measurement. For example, independent satellite and fly-over methods have found true leakage rates up to 3.5x higher than the U.S. rates in the Permian basin[7,]. As a result, the Treasury Department and the IRS should be prepared to update the average leakage rates if the EPA updates the methane inventory in response to new data. Furthermore, basin-specific data will be available and should be used as part of GREET where possible.

Due to the likely significant upwards adjustments of leakage rates to handle methodology errors in the current inventory, GREET should be updated yearly for average rates. The IRA allocates $1.55 billion to EPA for methane monitoring and mitigation, and EPA’s supplemental proposal for Oil and Gas New Source Performance Standards/Emissions Guidelines requires leak monitoring at every well site, allows advanced detection methods, and establishes a super emitter response program via remote sensing.[8]

Hydrogen producers will likely want to certify their methane is cleaner than the national or basin average to qualify for higher tiers of the tax credit. The Treasury Department and the IRS should allow a pathway for producers to affirmatively prove clean feedstocks via a verified certification pathway.

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[6] https://www.hydrogen.energy.gov/pdfs/clean-hydrogen-production-standard.pdf

[7] https://www.science.org/doi/10.1126/sciadv.aaz5120, https://www.pnas.org/doi/10.1073/pnas.2202338119

[8] https://www.epa.gov/system/files/documents/2022-11/OIl%20and%20Gas%20Supplemental.%20Overview%20Fact%20Sheet.pdf, https://www.regulations.gov/docket/EPA-HQ-OAR-2022-0875

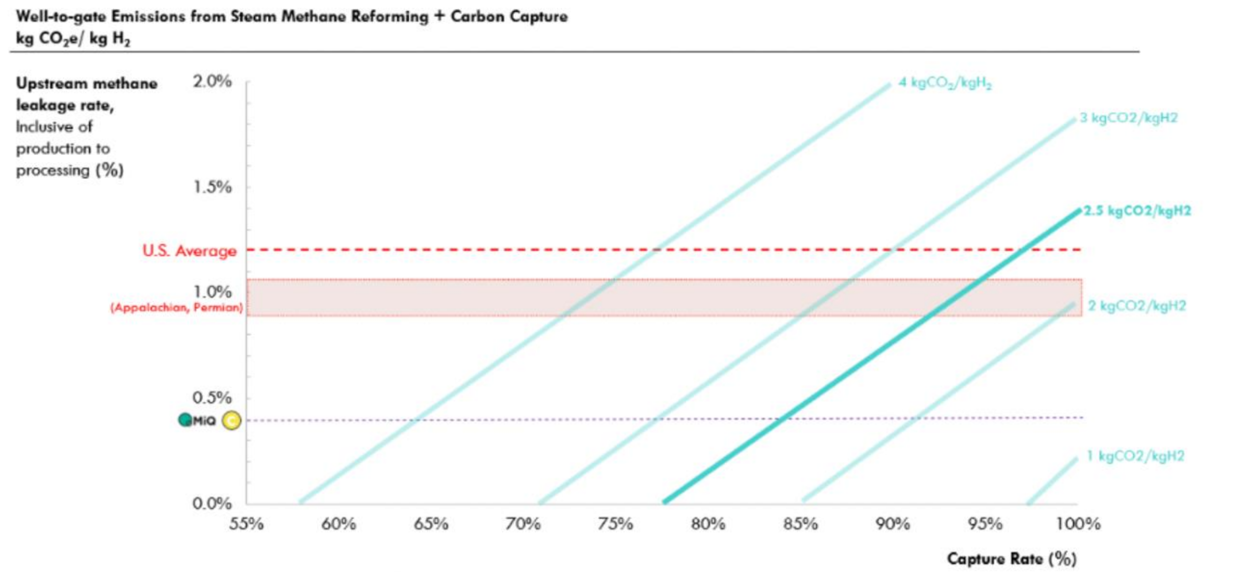

Exhibit 1: Clean hydrogen emissions intensity of steam methane reforming (SMR) with various methane leakage and capture rates on a 100-year methane lifetime including production, the gathering and boosting, and processing segments of the supply chain. The MiQ Certification, a tiered scheme that differentiates natural gas based on its methane emissions at the asset level,is shown in comparison to the average leakage rates for the United States. Sourcing gas with MiQ rating of C or better (<0.4%) is achievable in several US sub-basins.[1]

Certifying Low Leakage Methane:

Methane that is not specifically certified should use the "basin average" leakage rates to calculate upstream emissions. Additional systems to certify methane rates lower than average must be certified by the Treasury Department and the IRS and implemented by verified third-party applications which should be audited.

RMI recommends, at a minimum, core emissions sources be accounted for as specified under MiQ certification standards relating to fugitive emissions and incomplete combustion sources for natural gas.[9] MiQ provides an independent methane emissions certification standard, and already certifies 4% of the global gas market, and is quickly growing, offering a scalable and standardized certification solution for methane[10].

Increasing direct measurement (including modeling, metering, enhanced emissions factors) of these sources should follow methodologies already established in best practice guidelines such as MGP or OGMP2.0 for natural gas, including a minimum annual inspection of sources.[11,12] At the minimum, the intermediate level of methodological complexity should be used when analyzing key emissions categories (i.e., Tier 2 IPCC) to incorporate regional and production factors.[13, 14, 15] This means emissions are to be reported by detailed source type utilizing generic emissions factors, equivalent to Level 3 of the OGMP2.0 framework[16].

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9 https://miq.org/
10 https://miq.org/the-methane-mission/
11 https://methaneguidingprinciples.org/
12 https://www.ccacoalition.org/en/resources/oil-and-gas-methane-partnership-ogmp-20-framework
13 https://miq.org/
14 https://methaneguidingprinciples.org/
15 https://www.ccacoalition.org/en/resources/oil-and-gas-methane-partnership-ogmp-20-framework
16 http://ogmpartnership.com/sites/default/files/files/OGMP_20_Reporting_Framework.pdf

How to calculate landfill gas:

The landfill gas (LFG) to hydrogen pathway has one of the lowest well-to-gate carbon intensities after wind and solar in the GREET model.[17] When considering just on-site GHG emissions, the LFG-H2 pathway is considered net-carbon-negative. This is due largely to: 1) the treatment of LFG-related CO2 emissions as biogenic and therefore zero-emission, and 2) the GHG emissions credits that are taken for the avoided methane emissions when compared to "business as usual" landfill practices.

Existing regulations under the Clean Air Act require landfills of a certain size to install a gas capture system and control their LFG via flaring, combustion for energy generation, or treatment for sale or beneficial use. Of the over 1,100 municipal landfills that report to EPA's Greenhouse Gas Reporting Program (GHGRP), roughly 90 percent of emissions come from landfills that have gas capture systems in place.[18] Landfills that generate sufficient gas to support hydrogen production would likely already be required to capture and control LFG under the Clean Air Act, meaning the avoided emissions of the LFG-H2 pathway vs. BAU would be minimal (relating to potential reductions in methane emissions when LFG is used for SMR rather than flared).

During collection and processing, the LFG to hydrogen pathway carries similar risk of methane emissions as a BAU landfill. Notably, a variety of site-specific factors (including landfill cover material, working face area, gas capture system design, and precipitation) impact landfill gas collection rates, oxidation, and in turn methane emissions from landfills.[19] In calculating carbon intensity, it is critical the GREET model leverage site-specific landfill data (such as under EPA's Waste Reduction, or WARM, model) to fully account for the upstream emissions from uncontrolled methane at landfills.

Recent aerial surveys show methane leakage rates at landfills can be significant. For example, the California Methane Survey flew AVIRIS-NG, mounted on an aircraft, over 270 landfills and 166 organic waste facilities repeatedly during 2016-18 to quantify their contribution to the state methane budget. The survey found methane "super-emitter" activity in every surveyed sector including waste, where a few point sources had an outsized impact on overall emissions (e.g., 10% of sources represented nearly 60% of emissions). Specifically, 30 landfills and 2 composting facilities were the largest methane point source emitters in the state (43% of total emissions in the study), exhibiting persistent, potentially anomalous activity.[20]

We recommend DOE revise the LFG-H2 pathway to fully account for uncontrolled methane at landfills and potential fugitive emissions. First, we recommend DOE require hydrogen projects that use landfill gas as a feedstock to certify their methane emissions throughout LFG collection, processing, and transmission– supported by emissions monitoring technologies and LDAR (leak

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[17] https://www.energy.gov/sites/default/files/2022-06/hfto-june-h2iqhour-2022-argonne.pdf

[18] NPRM at 37008

[19] Lee U, Han J, Wang M. Evaluation of landfill gas emissions from municipal solid waste landfills for the life-cycle analysis of waste-to-energy pathways. Journal of Cleaner Production. 2017;166:335-342. ; Barlaz et al. (2009) Controls on Landfill Gas Collection Efficiency: Instantaneous and Lifetime Performance, J. Air & Waste Manage. Assoc. 59:1399.

[20] Riley M. Duren et al. Final report for California Energy Commission: Energy Research and Development Division (2020, July). *Final Project Report: The California Methane Survey*. https://www.energy.ca.gov/sites/default/files/2021-05/CEC-500-2020-047.pdf; Riley M Duren et al. (2019). *California's methane super-emitters*. Nature, 575: 180–184. https://doi.org/10.1038/s41586-019-1720-3

detection and repair) practices at the landfill. DOE should also require landfills used in clean hydrogen projects to comply with a set of best management practices that can improve collection efficiency (e.g., optimizing well density, minimizing the active work face, using biocover materials, and installing emissions monitoring technology). Absent these changes, classifying landfill gas as a clean feedstock creates perverse incentives for landfill operators who by prioritizing methane generation for hydrogen production over emissions reduction could create potentially worse outcomes than under business-as-usual practices.

Carbon storage verification:

Permanent geological sequestration should be required to account for CO2 emissions associated with hydrogen production. In some cases, CO2 is pumped into a well to produce more oil in a process known as enhanced oil recovery (EOR). CO2 that is used for EOR should not be given full "credit" for the purposes of the LCA and should reflect the *net* sequestration. In addition, any uses of CO2 (e.g. for synthetic fuels) do not eliminate the carbon from the atmosphere, they simply add one additional step. Thus, permanent sequestration is the only way to ensure the waste CO2 is not ending up in the atmosphere due to hydrogen production.

Surface and subsurface monitoring for leakage and validating storage capacity is further advanced than carbon capture monitoring. The IPCC has set forth extensive monitoring protocols as well as a framework for identifying environmental risks of underground geologic storage of carbon.[3] The US EPA has released a similar framework as well.[4] These systems, in combination with the auditing process created for the implementation of the 45Q carbon capture credit, can be used to create metrics to evaluate long-term carbon storage and credibility of climate benefit (complementing the DOE's Enhance the Safety and Security of CO2 Storage funding), in part to limit potentially elongating fossil fuel production through enhanced oil recovery.[5]

(b)(i) How should lifecycle greenhouse gas emissions be allocated to co-products from the clean hydrogen production process? For example, a clean hydrogen producer may valorize steam, electricity, elemental carbon, or oxygen produced alongside clean hydrogen.

For the purposes of this credit, the downstream co-products are not relevant to the emissions associated with clean hydrogen production. The "well-to-gate" lifecycle boundary ends at hydrogen production. Any considerations of co-products as "offsetting" the emissions intensity of hydrogen production should be excluded as out of scope for the hydrogen production tax credit.

(ii) How should emissions be allocated to the co-products (for example, system expansion, energy-based approach, mass-based approach)?

[No answer]

(iii) What considerations support the recommended approaches to these issues?

[No answer]

(c)(i) How should lifecycle greenhouse gas emissions be allocated to clean hydrogen that is a by-product of industrial processes, such as in chlor-alkali production or petrochemical cracking?

We recommend that byproduct hydrogen production must reflect a weighted intensity of the production inputs; while this hydrogen is produced as a by-product and not as a core product, the relative emissions footprint should still be recognized to not create an inconsistency in the broader assessment of GHG emissions.

(ii) How is byproduct hydrogen from these processes typically handled (for example, venting, flaring, burning onsite for heat and power)?

[No answer]

(d) If a facility is producing qualified clean hydrogen during part of the taxable year, and also produces hydrogen that is not qualified clean hydrogen during other parts of the taxable year (for example, due to an emissions rate of greater than 4 kilograms of CO2-e per kilogram of hydrogen), should the facility be eligible to claim the § 45V credit only for the qualified clean hydrogen it produces, or should it be restricted from claiming the § 45V credit entirely for that taxable year?

Hydrogen-producing facilities should be judged by the average emissions intensity of all hydrogen produced over a certain period. Cherry-picking hours of clean production while ignoring hours of dirty production incentivizes projects that increase overall emissions.

Congressional intent evidenced by the Senate colloquy directs the Treasury Department and the Treasury Department and the IRS to implement the 45V tax credit in a way that reduces "effective greenhouse gas emissions." The credit is also designed to support deployment of hydrogen production, so the Treasury Department and the IRS should consider flexible options that provide some certainty to private developers and investors without endangering the key emissions reductions target.

If developers are allowed to cherry pick, "opt out" hours will likely be carbon-intensive enough to cancel out any emissions benefits from the qualifying clean hydrogen production at other hours of the day. The cost-effectiveness of running an electrolyzer at the highest possible capacity factor combined with the value of the 45V PTC can incentivize cherry-picking by industry. However, the climate impacts of cherry-picking will undermine the intent of the tax credit. Allowing this kind of crediting flexibility would lead to emissions increases, significant taxpayer dollars spent on poorly designed projects, and potential public backlash.

For example, a system that runs on solar during the day (50%) and natural gas during the night (50%) would have an overall emissions intensity of over 10 kg CO2e per kg H2, which is 20 times higher than the top credit threshold. In a system that allows a facility to claim the 45V credit for the hydrogen it produces despite also producing hydrogen that does not qualify, that same facility would receive the top credit 50% of the time, translating on average to $1.50 per kg of hydrogen. If all hydrogen production is considered, this facility would receive no credit.

Aggregation, or averaging of hourly hydrogen production, will be necessary to qualify electrolyzers that fluctuate in emissions intensity. Aggregation or averaging of emissions intensity to qualify for 45V requires:

- Establishing a timeframe (daily, weekly, monthly, annually)
- Measuring the hourly emissions intensity of hydrogen production (subject to frameworks established and discussed later in this RFI) during this timeframe
- Averaging the emissions for each hour over the chosen timeframe to get a final emissions intensity

The averaged value would be used to determine which 45V PTC tier all the hydrogen produced during this time qualifies. Importantly, this averaged value would need to apply to all hydrogen produced from the same facility during the time period. Producers should not be allowed to allocate "dirty electricity" to some electrolyzer stacks and qualify for full credit for production from other stacks through accounting gimmicks.

Below, we describe two hydrogen production pathways which require sub-annual aggregation of granular data. Additional comments can also be found in our response to (1)(e).

<u>Aggregation for grid-connected electrolysis:</u>

- The timescale chosen to aggregate emissions can range from yearly to daily for a facility and will influence ramping strategy and risk management by developers. Aggregating this data over a longer time period in theory provides more flexibility for developers to miss hours due to unfavorable weather conditions, faulty forecasting, and natural disasters. However, a large disruption could cause a project to move to the next credit tier for an entire year which could bankrupt a project and subject it to substantial risk. Shorter-term aggregation (weekly/monthly) increases the chance of short-term "misses" (e.g. electrolyzer ramping or generation issues) but reduces the impact of those misses (translates to reduced credit values over a shorter period).
- During hours in which sufficient clean generation is unavailable ("missed hours"), the emissions intensity should be calculated using **average grid emissions (hourly where available)**. No hydrogen production from the facility can be ignored when aggregating emissions – we suggest including a high penalty (including credit ineligibility) for facilities that do not track and report all associated hydrogen production.
- We suggest the Treasury Department and the IRS allow monthly or yearly aggregation of hourly electricity measurements to allow developers to choose their level of risk tolerance, forecasting ability, and electrolyzer ramping.

<u>Aggregation for methane emissions:</u>

- For projects that wish to prove cleaner methane sources, granular emissions tracking is also required. Upstream producers must provide regular data to differentiate its commodity leakage from the basin or national average. While data is typically available on a monthly or yearly basis, depending on how often the upstream fields are measured, hydrogen facilities hoping to differentiate their methane must have repeated granular measured data to ensure the methane procured is cleaner than the basin average.

- Given overall methane will fluctuate, the Treasury Department and the IRS should average out the measured values for projects that wish to demonstrate lower methane averaged over a year when calculating credit value. However, the risk of cherry-picking measurement data is high – thus self-reporting will not be an effective way to validate leakage rates and has led to significant undercounting in the EPA inventory.
- If a sub-yearly aggregation timeframe is allowed, the same facility could get different credit levels for different months. This policy's implementation depends on how often measurement occurs and how comprehensive it is.

(e) How should qualified clean hydrogen production processes be required to verify the delivery of energy inputs that would be required to meet the estimated lifecycle greenhouse gas emissions rate as determined using the GREET model or other tools if used to supplement GREET?

This answer was developed in coordination with other environmental NGOs including Natural Resources Defense Council (NRDC), Environmental Defense Fund (EDF), Clean Air Task Force (CATF), and Union of Concerned Scientists (UCS).

The Treasury Department and the IRS will be responsible for establishing the standards required to differentiate the lifecycle GHG emissions of electricity or methane inputs from national/local averages typically used within the GREET model. The Treasury Department and the IRS should quickly establish a robust system that can identify lower, or zero carbon feedstocks and those new values should be verified by the Treasury Department and the IRS and inputted into GREET to calculate lifecycle emissions.

The Treasury Department and the IRS should rely on existing certification and tracking mechanisms for pathways that align with GREET model feedstock measurement. The Treasury Department and the IRS should then develop a framework for grid-connected electrolyzer facilities seeking 45V qualification. This framework could then integrate with GREET to establish qualification for these facilities. More on our recommendations to establish this specific framework are below:

Statutory Authority of the Treasury Department and the IRS

Congress defined "lifecycle greenhouse gas emissions" in the IRA as:

> the aggregate quantity of GHG emissions (including direct emissions and significant indirect emissions such as significant emissions from land use changes), as determined by the Administrator, related to the full fuel lifecycle, including all stages of fuel and

> feedstock production and distribution, from feedstock generation or extraction through the distribution and delivery and use of the finished fuel to the ultimate consumer, where the mass values for all greenhouse gasses are adjusted to account for their relative global warming potential. *26 U.S.C. § 45V (c)(1)(A) (adopting the definition set forth in 42 U.S.C. § 7545(o)(1)(H)).*

The statute further defined the term to only include the well-to-gate GHG emissions of hydrogen projects as determined under the most recent "'GREET model' developed by Argonne National Laboratory, **or a successor model (as determined by the Secretary)**." *26 U.S.C. § 45V(c)(1)(B) (emphasis added).*

The Treasury Department and the IRS is directed to issue regulations or other guidance to carry out the purposes of section 45V, including for determining the lifecycle greenhouse gas emissions of hydrogen projects, by August 16, 2023. *Id*. at § 45V(f).

Congressional Intent

Determining well-to-gate GHG emissions requires multiple frameworks to evaluate the various hydrogen project pathways. Emissions accounting is relatively simple for electrolyzer projects primarily and directly powered by a clean energy facility. However, it is complex for other types of projects, such as electrolyzers connected to the bulk power grid that primarily consume grid power. Congressional guidance offers important direction for how the Treasury Department and the IRS should consider those grid-connected projects. Legislative history clarifies that grid-connected electrolyzers that use grid power and procure clean energy attributes certificates (EACs) to offset their consumption are meant to be *eligible* for the PTC at the highest tiers.[21]

> Mr. CARPER: It is …my understanding of the intent of section 13204, is that in determining ''lifecycle greenhouse gas emissions'' for this section, the Secretary shall recognize and incorporate indirect book accounting factors, also known as a book and claim system, that reduce effective greenhouse gas emissions, which includes, but is not limited to, renewable energy credits, renewable thermal credits, renewable identification numbers, or biogas credits. Is that the chairman's understanding as well? Mr. WYDEN. Yes. Mr. CARPER. Thank you, Mr. Chairman. Additionally, I would like to clarify that the intent of section 13701 allows the Secretary to consider indirect book and claim factors that reduce effective greenhouse gas emissions to help determine whether the greenhouse gas rate of a qualified fuel cell property, which does not include facilities that produce electricity through combustion or gasification, is ''not greater than zero.'' Is that the chairman's understanding? Mr. WYDEN. Yes

[21] We use energy attribute certificates (EACs) as an umbrella term that encompasses a range of potential grid electricity offsetting mechanisms, including Renewable Energy Credits (RECs), Clean Energy Credits, Zero Emission Credits (ZECs), and others.

168 Cong. Rec. S4165 (Aug. 6, 2022).[22]

However, not all clean EACs are made equal: any such book-and-claim system must "reduce **effective** greenhouse gas emissions." There are two major takeaways from this key requirement:

- "Reduce" assumes active changes to the grid to eliminate emissions. The producer cannot simply use accounting sleights of hand. The phrase suggests a producer must take an active role driving GHG reductions to offset emissions linked to grid-connected projects.
- "Effective greenhouse gas emission" refers to the system-wide impact of the project. Many accounting systems can "attribute" clean power to a project, but in practice increase system-wide emissions by increasing fossil fuel generation (we further discuss this dynamic in our policy recommendations). The statute and legislative history do not support weak or ineffective accounting systems that ignore the system-wide emissions impact of a new hydrogen project. The goal of this policy, as outlined above, is to reduce U.S. GHG emissions and incentivize clean hydrogen projects.

Congressional language allowing the Secretary to implement a "successor model" if needed, and issue regulations or other guidance to carry out the *purposes of section 45V* gives the Treasury Department and the IRS clear authority and the tools to implement the 45V tax credits in a manner that adheres to the statute and Congressional intent.

Policy recommendations consistent with statutory authority and Congressional intent

Our policy recommendations encourage the Treasury Department and the IRS to adopt a two-step approach. The first step relies on the already-established GREET model, and the second step relies on a "successor model" and the issuance of new guidelines for determining the lifecycle GHG emissions of hydrogen projects, particularly grid-connected electrolyzer projects. As we discuss below, ensuring that a system **"reduces effective greenhouse gas emissions,"** per Congressional intent, is complex and requires design and adoption of a rigorous, well-designed accounting framework. This rigorous framework may include certain flexibilities to make sure it works effectively. A "successor model" and/or new guidelines for determining lifecycle GHG reductions should be developed through deliberative engagement with experts and stakeholders and put in place to provide the necessary framework for grid-connected electrolyzers to qualify for 45V. Our recommendations outline the pillars and key elements of a system that "reduces effective greenhouse gas emissions."

We sum up our recommendations to the Treasury Department and the IRS as follows:

1. **Implement a two-step approach, committing to effective accounting pillars for grid-connected electrolyzers in any preliminary guidance:** The varying degrees of

[22] https://www.govinfo.gov/content/pkg/CREC-2022-08-06/pdf/CREC-2022-08-06-pt1-PgS4165-3.pdf, pages 1-2.

complexity that characterize hydrogen production pathways require a phased approach (described below), with the Treasury Department and the IRS committing to a rigorous emissions accounting system for grid-connected electrolyzers that leverages additionality, regionality, and hourly accounting for emissions impacts - critical components to an effective accounting system.

   a. **In preliminary guidance:** The Treasury Department and the IRS should accredit hydrogen projects that meet the 45V carbon intensity thresholds using the GREET model. Electrolyzers powered off-grid by zero carbon power should qualify. Initially, emissions linked to electrolyzers' consumption of grid electricity should also be calculated using the GREET model. The Treasury Department and the IRS should also use this initial guidance opportunity to commit to rigorous principles of accounting to ensure grid-connected electrolyzer production is clean. This will provide certainty to developers and support the Treasury Department and the IRS process of establishing guidance along the statutorily required timeline.
   b. **In future guidance**: With comprehensive support from the Department of Energy (DOE), Environmental Protection Agency (EPA), and Energy Information Administration (EIA), the Treasury Department and the IRS should build on initial qualifying principles (to promote certainty for investors) and explore how they can optimally implement a rigorous emissions accounting system for grid-connected electrolyzers. They should track the development of new tracking mechanisms that could enable a more robust accounting scheme, such as timestamped EACs.

2. **Consider and assess two leading potential frameworks** we propose could ensure effective qualification of low emitting hydrogen projects and low grid emissions: 1) hourly-matched EACs with additionality and deliverability requirements, which is emerging as a leading framework for ensuring consistent carbon-free electricity, and 2) locational-marginal emissions matching, an early concept worthy of further investigation. We recommend the Treasury Department and the IRS work with the DOE and EPA to evaluate those two potential accounting systems and develop a method that is practical to implement, provides certainty for producers, and rigorously enforces the legislated requirements.

Considering the far-reaching implications of the 45V credits, it is critical that the Treasury Department and the IRS implement a rigorous emissions accounting framework that ensures the emissions integrity of grid-connected electrolyzers. The generous 45V tax incentives significantly reduce cost impacts on grid-connected electrolyzers and bolster market lift-off. We encourage the Treasury Department and the IRS to work closely with DOE to utilize the GREET model where appropriate and develop the appropriate and rigorous framework needed for grid-connected electrolyzers. By offering the largest subsidies for clean hydrogen in the world, the IRA creates the imperative and opportunity for the U.S. to adopt a world-leading framework that, if replicated, can put the global hydrogen market on a sound course.

Emissions Accounting for Grid-Connected Projects is Complex and Requires Development of a Rigorous Framework

Emissions accounting is relatively simple for a range of projects, including electrolyzers that are directly powered by co-located, "behind-the-meter" renewable energy resources and are not connected to the electricity grid. The GREET model is generally a suitable tool for those projects. In contrast, emissions accounting is more complex for grid-connected electrolyzers that are mostly or wholly powered by the electricity grid and rely on mechanisms like EACs and power purchase agreements to offset their emissions.

The GREET model should be adapted to incorporate data with hourly granularity, so it can be used from the offset to evaluate market-based accounting models and ensure "effective" GHG emissions reductions. The grid is a complex, dynamic system. To verify effective GHG emissions reductions, system-level modeling and granular grid emissions data are required. To date, the vast majority of existing market-based approaches (such as renewable energy credits) were designed to drive renewable generation, but do not verify system-wide emissions impacts. It will be especially important to consider systemic impacts when adding significant new load for electrolytic hydrogen. Ultimately, a framework with expanded capabilities will be needed to establish a robust system for monitoring grid-connected projects, which could then be integrated with GREET. Implementing a successor model or a GREET-integrated emissions accounting framework will require rigor and careful consideration of various scenarios and their implications.

There is high risk that a weak accounting framework will fail to "reduce effective greenhouse gas emissions" of grid-connected electrolyzers. Conservative estimates show that a weak system could increase net emissions by nearly 500 million tonnes of CO2e[23]. We define a failing framework as one that either inaccurately estimates the carbon intensity of grid-connected electrolyzers or attributes a carbon intensity that does not reflect the reality of their induced emissions on the grid.

The risks are twofold:

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[23] This figure is based on preliminary analysis assuming electrolysis displaces SMR production and a conservative estimate based on DOE's projections of roughly 5 million metric tonnes (MMT) H2 production per year for ten years of the credit. One kg H2 production requires roughly 50 kWh electricity and according to the EPA eGRID2020 data, average grid intensity is roughly .3726 CO2e/kWh. Should weak accounting schemes allow grid-connected electrolyzers to qualify for the highest tiers of the credit, 5 MMT of hydrogen production receiving the PTC for 10 years could lead to roughly 1.02 gigatons of CO2e emissions. Under the assumption that this displaces SMR, the emissions would net out to roughly 0.42 gigatons CO2e.

1. **Emissions increases on the grid:** Assuming DOE's recently proposed target for clean hydrogen production by 2030, 45V uptake could conservatively pay out more than $120 billion over the next 20 years.[24] Grid connection could be the easiest way for producers to seek qualification. Absent a robust system requiring them to effectively and demonstrably offset their grid power consumption, grid-connected electrolyzers can be up to *twice* as emissions intensive as hydrogen produced from natural gas. This is in direct conflict with statute Congressional intent. DOE's assessment finds projects that use any more than 15% grid power will not qualify for the tax credit at all due to the carbon intensity of the grid.[25] Weak accounting systems will keep dirty generators online and slow grid decarbonization, risking U.S. decarbonization efforts and driving emissions up as a result of increased hydrogen production. A rigorous accounting system that supports power sector and industrial decarbonization in this decade is essential to achieve the goals of a 50-52% emissions reduction by 2030, a carbon-free electricity system by 2035, and a net-zero GHG economy by 2050.[26]

2. **Undermined confidence in hydrogen and the IRA as a climate solution:** High-profile accounting failures in which taxpayer money is used to subsidize facilities that lead to significant increases in grid emissions could risk the reputation of clean hydrogen, undermine the overall clean energy tax credit package, and call into question the United States' climate leadership. The damage incurred by a weak emissions accounting system, which could lead to elimination or reform of the 45V tax credit, would do more to stymie the clean hydrogen industry than establishing a rigorous system in the first place.

A Two-Step Approach is Necessary for the Treasury Department and the IRS to Develop a Robust Framework for Grid-Connected Projects

We recommend that the Treasury Department and the IRS adopt the following two-tiered implementation system commensurate with the varying degrees of complexity:

- In preliminary guidance, we recommend the Treasury use the GREET model, as delineated in statute, to qualify projects. Near-term usage of the GREET model means projects primarily relying on behind-the-meter clean electricity to power their electrolyzers will qualify for the PTC. And grid-connected projects that can input granular data into the GREET model proving they rely on renewable grid electricity to power their electrolyzers could also qualify, if compliant with restrictions. The Treasury Department and the IRS should also express support for a framework that includes

[24] https://www.hydrogen.energy.gov/pdfs/clean-hydrogen-strategy-roadmap.pdf. This number is a rough estimate meant to illustrate the magnitude of the incentives and underscore the importance of ensuring that they are subsidizing truly "clean" hydrogen.
[25] https://www.energy.gov/eere/fuelcells/articles/clean-hydrogen-production-standard
[26] https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/22/fact-sheet-president-biden-sets-2030-greenhouse-gas-pollution-reduction-target-aimed-at-creating-good-paying-union-jobs-and-securing-u-s-leadership-on-clean-energy-technologies/

rigorous emissions accounting principles outlined in these comments and commit to refining and implementing said framework as quickly as possible.

- In preparation for final guidance, the Treasury Department and the IRS should collaborate with DOE, EPA, and other relevant agencies to evaluate concepts, feasibility, and frameworks for emissions accounting of hydrogen projects that seek to be primarily grid connected. We believe that this process can be completed to meet statutory deadlines and that engaging in a deliberate and transparent process to get those rules right is of vital importance.

At no point should the Treasury Department and the IRS allow grid-connected hydrogen producers to use unbundled renewable energy credits or other ineffective emission attribution mechanisms to qualify for the PTC. Hydrogen projects have significant upstream and downstream partners and will be the cornerstone to entire industrial communities. By starting with effective requirements, the Treasury Department and the IRS can avoid the impossible choice of undermining projects that are designed around weak initial guidance. The lock-in effect of these rules will be significant, with tens of billions of dollars on the line.

Based on recent analysis, we recommend three design pillars that are each necessary, but not individually sufficient, for any rigorous emissions accounting framework for grid-connected electrolyzers. We also provide two potential emissions accounting frameworks that internalize the pillars and can robustly deliver "effective" emissions reductions.

Criteria and Design Pillars

Practical Criteria

An emissions accounting framework for grid-connected electrolyzers should meet, at a minimum, the following criteria:

- Sufficient rigor and stringency to avoid emissions increases on the grid and deliver on the requirement to reduce effective GHG emissions;
- Implementable by the Treasury Department and the IRS with supporting agencies, including DOE;
- Certainty and practicality for industry so as not to hinder the economics and market lift-off of grid-connected electrolytic hydrogen.

Guided by those criteria, we outline design pillars that should be embedded in any robust framework, as well as two potential frameworks for consideration. Based on analyses and engagement with a range of stakeholders, including clean energy nonprofits, hydrogen developers, academics, and peer environmental groups, it is our assessment that both frameworks have the potential to adequately satisfy the three criteria and internalize the design pillars. We call on the Treasury Department and the IRS, in conjunction with supporting agencies, to further assess the emissions impacts, cost, and operational implications of each framework and any others identified.

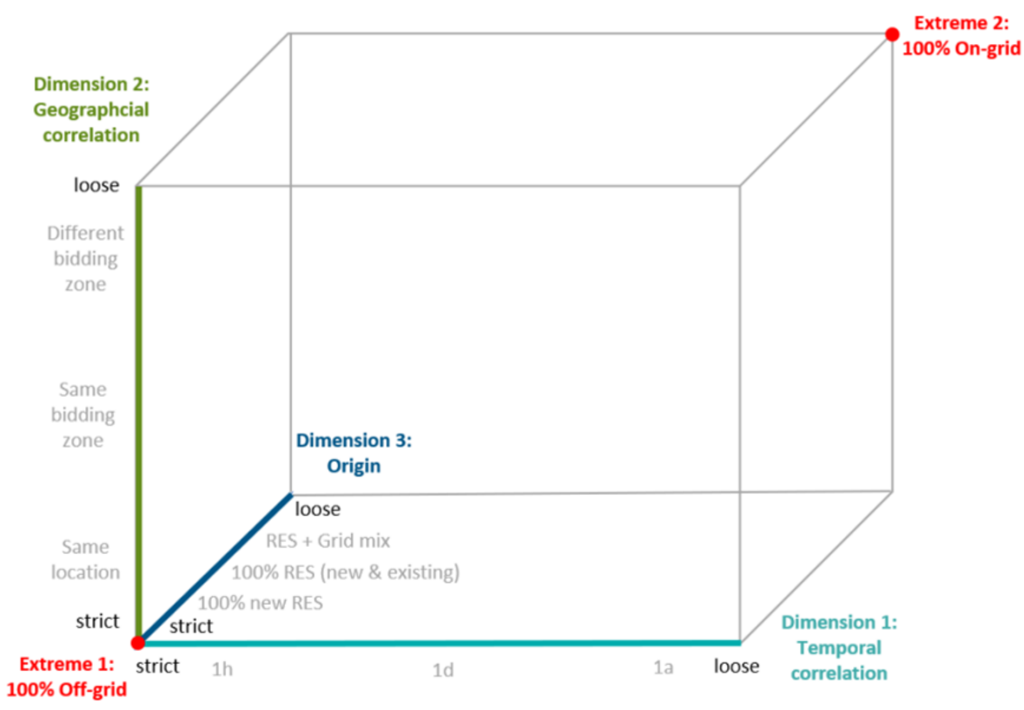
Design Pillars

We identify three key pillars as fundamental to any emissions accounting scheme that rigorously accounts for the emissions of grid-connected electrolyzers:

1. Additionality
2. Regionality
3. Granular temporal accounting

These pillars represent variables which can be adjusted to change the stringency of the framework. Using the visualization below, we think that a strict origin, granular temporal correlation (equivalent to strict in the figure below), and moderately strict geographical correlation are critical to ensuring low emitting grid-connected hydrogen production as required by law.[27]

Figure 1. Regulatory dimensions



1. Strict additionality

[27] https://cadmus.eui.eu/bitstream/handle/1814/74850/RSC_WP_2022_44.pdf?sequence=1&isAllowed=y, page 10.

Additionality is a key requirement to ensure developers are offsetting the direct emissions generated as a result of adding load from grid-connected electrolyzers. To offset emissions linked to new grid power consumption, electrolyzers should contract *new* clean generation to match this load. If electrolyzer loads are not paired with additional clean generation, the grid will respond by ramping fossil generators to serve the new load. The effective GHG impact of fossil generators should make the facility in question ineligible for the 45V tax credit. Existing renewable generators are already meeting loads on the grid, such that attributing this preexisting clean energy to electrolyzers would merely shuffle its attribution and divert clean electricity from current loads, delaying the decarbonization of sectors including buildings and transportation.

New load from hydrogen producers without new, clean electricity generation will also send a market signal to ramp up more generators on the margin, which are often natural gas generators, to meet additional demand. A recent study by Princeton University estimates that absent additionality requirements, grid-connected hydrogen projects could have an emissions rate that is up to *5 times* the threshold that would make a project eligible for even the lowest tax credit.[28] Our estimates corroborate this finding: we estimate that absent additionality requirements, grid-connected electrolyzers could result in **half a gigaton** of carbon emissions over the lifetime of the credit if hydrogen producers deploy unbundled EACs to offset their emissions. Additionality is a necessary, but not sufficient, feature for any accounting standard that evaluates the system-wide emissions impacts of grid-connected electrolyzers and seeks to "reduce effective greenhouse gas emissions." Additional necessary criteria are outlined in the sections below.

Mechanisms to demonstrate additionality require further assessment. The Treasury Department and the IRS and DOE should evaluate a range of options and implement a rigorous framework. Given the critical importance of additionality, the process of defining it and outlining the proper demonstration mechanisms should embed a high degree of transparency and stakeholder engagement. Options for consideration include but are not limited to: requirements for electrolyzers to sign power purchase agreements with *new* clean energy projects that come online within a set timeframe, financial tests that quantify the incremental impact of the hydrogen project on the clean energy project's economics (demonstrating that the project would not be financeable otherwise), proof clean generation would have otherwise been curtailed or at-risk of closure but for the new demand from electrolyzers, and other mechanisms.

The generous federal incentives on the table (IRA tax credits and DOE hub grants) can significantly reduce cost impacts linked to additionality requirements. In fact, the Princeton and European University Institute studies estimate a system that requires additionality and further embeds other strict criteria would impose only modest costs on electrolyzer projects. There are also a number of choices the Treasury Department and the IRS could make to increase the flexibility of the standard for a diversity of projects. The Treasury Department and the IRS and

[28] Ricks, Wilson, Xu, Qingyu, & Jenkins, Jesse D. (2022). Minimizing emissions from grid-based hydrogen production in the United States. Zenodo. https://doi.org/10.5281/zenodo.7349406

DOE should further evaluate unique instances of clean power procurement that could meet an additionality definition:

- hydrogen projects contracting with re-powered renewable energy projects
- a well-designed and time-bound grace period for project development and interconnection
- curtailed or unused clean electricity, assuming that a robust framework is in place to verify that the clean power would indeed have otherwise been curtailed or not produced absent demand from the hydrogen project, and the clean power is subject to deliverability criteria, discussed in the following section, ensuring, there are no grid constraints and transmission congestion preventing the clean power from "serving" the hydrogen project
- Clean electricity generators that would otherwise retire but for the hydrogen project's electricity demand keeping the generator online (subject to rigorous and transparent demonstration criteria)

2. Regionality

Regionality establishes a geographic boundary within which both the clean energy project that the electrolyzer is relying on for EACs and the electrolyzer must be located. The boundary can range from "anywhere" (i.e., no restrictions), to the same grid, to the same RTO, to the same interconnection node. More flexibility increases the risks of increased emissions due to transmission constraints[29], while also providing access to areas with the best clean energy potential. In some regions, tighter geographic boundaries can lead to greater emissions reductions. Transmission constraints can prevent procured renewable projects from delivering electricity into the region/grid where the electrolyzer is located; this could result in those procured renewable projects either displacing other renewable energy and/or displacing fossil resources resulting in emissions abatement that may not be proportionate to the electrolyzers' direct emissions impact. A lack of deliverability would undermine the connection between the emissions induced by the electrolyzer and the emissions abatement delivered by the procured clean energy projects.

It is critical that any emissions accounting framework considers grid congestion/constraints, and impose operational guardrails to ensure clean energy resources powering electrolyzer loads are located in a place that allows for an appropriate degree of electricity deliverability.

3. Granular Temporal Accounting

Temporal accounting refers to the degree of alignment between the times when the electrolyzer is consuming grid power for operation and times when procured clean energy projects are

[29] Wilson Ricks, Qingyu Xu and Jesse D. Jenkins, "Enabling grid-based hydrogen production with low embodied emissions in the United States"

generating. Temporal accounting can be hourly (i.e. the electrolyzer only operates within the same hours the renewable project generates), daily, monthly, quarterly, annually, or unrestricted (i.e., unbundled renewable energy credits and stored credits). More granular time periods provide more assurance that hydrogen producers are effectively offsetting induced emissions from their grid-powered electrolyzers with clean energy operating in real time. As solar and wind generation increases on the grid, the daily variation of grid emissions increases, thus hourly measurements promote more accurate emissions accounting.

Annual accounting schemes allow for looser correlation between electrolyzer load and clean energy generation and could permit electrolyzers driving significant increases in grid emissions to pass off as clean. The climate risk occurs when electrolyzers operate during times of high marginal grid emissions (e.g., at night when gas plants are running and renewable generation is low) and supplement their electricity consumption with annual EACs generated by clean energy facilities with low marginal emissions abatement (e.g., a new solar project in California that displaces other renewables during the day and insufficiently displaces marginal gas plants). Annual accounting systems and systems that allow unbundled EACs are a non-starter due to their carbon emissions impacts.

This dynamic is illustrated in the Princeton study, which finds additionality coupled with only annual matching when hydrogen producers are allowed to deploy unbundled EACs is ineffective at reducing electrolyzer emissions and results in hydrogen sources with very high emissions qualifying for the 45V credit. This finding is corroborated by a recent study by the European University Institute which sees increased gas generation and associated net system emissions in the case of annual EAC matching schemes. These impacts directly contradict statute and Congressional intent.

Importantly, a system can utilize hourly accounting without requiring hourly matching. An emissions score can be calculated for every hour that a producer is seeking 45V credit and used to create an average emissions rate over a broader time period. We distinguish this as hourly emissions accounting with granular emissions matching. This is examined further in the section on aggregation.

Hourly accounting with a granular matching system is feasible for the Treasury Department and the IRS to implement and industry to comply with. These mechanisms are receiving increased support from a growing range of stakeholders. For example, leading organizations developing hourly EAC markets, like M-RETs, EnergyTag, and Singularity, are confident that a nationwide system could be implemented and enforceable in time for clean hydrogen project development and in line with statutory requirements. Engagement with these stakeholders should be part of the Treasury Department and the IRS evaluation process.

Aggregation and Calculating Credit Values

We encourage the Treasury Department and the IRS to consider aggregated temporal compliance for grid-connected electrolysis. Providing aggregation pathways for compliance will ease the administrative burden of enforcement and will provide greater certainty to investors and project developers.

Aggregation or averaging of emissions intensity to qualify for 45V requires the Treasury Department and the IRS to:

- Establish a timeframe (daily, weekly, monthly, annually)
- Measure the granular emissions intensity of hydrogen production (subject to frameworks established and discussed later in this RFI) during set timeframe
- Average the granular emissions over the chosen timeframe to get a final emissions intensity and qualification for a specific 45V tier.

Aggregating over a longer time period may provide more flexibility for developers to miss hours due to unfavorable weather conditions, faulty forecasting, or natural disasters. However, a large disruption could cause a project to move to the next credit tier for an entire year which could bankrupt a project and subject it to substantial risk. It also risks allowing a facility to intentionally run on cheap, dirty energy resources for a significant period if the facility is undershooting their 45V carbon emissions threshold for the year. Shorter-term aggregation (daily/weekly/monthly) increases the chance of short-term "misses" (e.g. electrolyzer ramping or generation issues) but reduces the impact of those misses (translates to reduced credit values over a shorter period).

During hours in which sufficient clean generation is unavailable ("missed hours"), the emissions intensity should be calculated using **average grid emissions. However, a more accurate way to calculate this would be to use short-run marginal grid emissions where available**. No hydrogen production from the facility can be ignored when aggregating emissions – we suggest including a high penalty (including credit ineligibility) for facilities that do not track and report all associated hydrogen production.

The averaged value would be used to determine what tier of the 45V PTC all the hydrogen produced during this time qualifies for. Importantly, this averaged value would need to apply to all hydrogen produced from the same facility during the time period. Producers should not be allowed to allocate "dirty electricity" to some electrolyzer stacks and qualify for full credit for production from other stacks through accounting gimmicks.

The Treasury Department and the IRS may also consider allowing hydrogen producers that prove they are programming their electrolyzers to ramp up and down in accordance with the day ahead electricity generation forecast. Each producer should be able to anticipate with a high degree of confidence what hours in the day their procured clean energy will be able to produce electricity. If producers align their hydrogen production with these hours, this could be a way for Treasury to accredit clean hydrogen producers more easily.

Transmission and distribution line losses

The EIA estimates that roughly 5% of electricity is lost due to transmission and distribution line losses.[30] Hydrogen production is so power intensive that this level of electricity loss could lead to roughly one additional kg of carbon emissions for every kilogram of hydrogen produced, depending on the carbon intensity of its connected grid.[31]

A hydrogen producer contracting new clean energy to match their load could overbuild clean generation at a rate equal to the latest EIA line loss data to overcome this challenge.

Two Potential Systems to Reduce Effective Emissions

Two model systems for consideration would effectively promote emissions reduction by deploying the above pillars while satisfying the three criteria relating to emissions accounting rigor, implementable by agencies, and reasonableness for industry. The following table provides an overview of both, followed by a description of the key elements for each.

Overview of key features of the 24/7 Carbon Free Electricity (CFE) and Marginal Emissions Accounting frameworks (compared with an Annual Accounting Framework that allows for unbundled EACs, without Additionality)

The table below compares core features of three different accounting schemes, two that could maximize emissions reduction through more stringent restrictions and one that could hinder effective emissions accounting because of its relative leniency. Schemes include:

1. **Hourly matching of carbon free electricity**, a leading approach for ensuring that grid electricity is offset through timely procurement of clean energy sources.
2. **Hourly marginal emissions accounting**, which directly measures and offsets emissions from grid electricity.
3. **Annual accounting without additionality**, which allows unbundled EACs produced at any time to offset the use of fossil-intensive grid electricity on an annual basis without requirements that any of the matched clean power be new. As discussed above, this represents a weaker framework that risks subsidizing highly emitting hydrogen sources and is at odds with statute and Congressional intent; we add it here for comparison purposes.

A rigorous accounting scheme should incorporate our design pillars; the Treasury Department and the IRS, with support from DOE and other agencies, may adjust the stringencies of the

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[30]https://www.eia.gov/tools/faqs/faq.php?id=105&t=3#:~:text=The%20U.S.%20Energy%20Information%20Administration,States%20in%202017%20through%202021.

[31] Rough analysis shows that at a rate of 50 kwh/kg H2, with an average grid emissions intensity of 0.85 lbs/kwh, and a line loss of about 5%, every kilogram of hydrogen produced using grid power could result in roughly an additional kilogram of carbon emitted for electricity that never actually gets delivered.

criteria below as needed to accomplish this.

	24/7 Carbon Free Electricity (CFE)	Hourly Marginal Emissions Accounting	Annual matching without additionality (For Comparison)
Additionality	Requires additionality.	Requires additionality.	No additionality requirements.
Regionality	Narrow regional boundaries that requires direct electricity delivery. The tighter the regional boundaries, the greater the emissions reductions and deep grid decarbonization. However, tighter regionality can also increase costs.	Does not require regionality. Relaxed regional restrictions can create efficiency, allowing clean energy to be built in the dirtiest grids, while hydrogen projects are built within cleaner grids. Narrower regional boundaries can support deliverability of new clean energy.	No regionality requirements.
Temporal Matching	Hourly matching.	Flexibility in the granularity of these measurements. Hourly measurement of both induced CO_2 from electrolyzer operation and avoided CO_2 from CFE generation is reasonable and should be considered.	Annual matching.
Variable Measured	Hourly grid electricity consumption is measured and offset.	Hourly marginal emissions induced by grid electricity consumption are measured and offset.	Average grid electricity consumption is measured and offset.
Impact	Good: Deep decarbonization in tighter geographical areas. Investment in emerging clean technologies and solutions are incentivized. Largely ensures clean hydrogen production.	Good: Carbon emissions are fully offset. Hydrogen projects are encouraged to be built in areas with robust clean energy and curtailed renewables. New clean energy is built in dirtiest grids to offset marginal emissions most efficiently.	Bad: EACs are transferred to hydrogen projects from already existing clean resources, diverting clean energy away from other grid uses. Fossil fuel generation often steps in to meet overall load and emissions increase.

24/7 Carbon Free Electricity (CFE)

The 24/7 CFE approach requires that electrolyzer load be matched with *additional* clean electricity supply on an *hourly* basis throughout the year, with tight regionality requirements. This system would embed all three pillars outlined above – strict additionality, granular temporal matching, and tight regionality.

An hourly matching system would also be commensurate with emerging policy and market dynamics, which bolster its practicality. On December 8, 2021, President Biden signed Executive Order 14057 on Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability which sets out the goal of powering federal facilities with 100% carbon-free electricity by 2030, including 50% on a 24/7 basis.[32] In addition, corporate procurement preferences are gravitating towards hourly matching mechanisms with some of the largest corporations and energy users like Google and Microsoft committing to 24/7 carbon free energy.[33] The 45V tax credits and those policy and market developments could therefore be mutually reinforcing and accelerate the wide scale adoption of 24/7 CFE systems.

A 24/7 CFE approach may add some costs and complexity to hydrogen projects. Should a hydrogen producer seek to operate for long hours, they would need to ensure that they procure sufficient clean power to offset their total load at every hour. Such a system would require diverse clean energy resources, including hybrid renewable portfolios (e.g., solar + wind + storage) and possibly, some technologies that are not fully commercialized (e.g., enhanced geothermal). This could make some projects less economically efficient than a pure emissions-based approach like marginal emissions accounting (which we discuss below). However, new studies are concluding that the added costs linked to a 24/7 system can be modest. The Princeton study estimates that 100% hourly REC matching requirements would add between $0 and $1/kgH$_2$ to the levelized cost of hydrogen. In addition, a recent joint letter to the European Commission penned by a coalition of environmental organizations, think tanks and industry amplifies this point, citing recent findings that an hourly matching system would result in minor cost impacts and a range of benefits.[34]

A 24/7 CFE approach would also encourage investments in emerging clean energy technologies and solutions that will be required for full grid decarbonization, such as enhanced geothermal, battery storage, and other clean firm technologies. Further, hourly load matching would encourage flexible electrolyzer operations, fluctuating in lockstep with the generation profile of the procured carbon-free electricity as discussed in the temporal matching section above. This flexibility to ramp up operations when renewables are abundant and ramp down otherwise is projected to be a valuable asset for a future grid with very high shares of renewable penetration, bolstering reliability and reducing system-wide costs.[35]

Marginal emissions accounting

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32 https://www.federalregister.gov/documents/2021/12/13/2021-27114/catalyzing-clean-energy-industries-and-jobs-through-federal-sustainability

33 Google's 24/7 carbon-free energy goal set to achieve by 2030; Microsoft 100/100/0 goal to run 100% of the time on energy with 0 emissions by 2030.; Eurelectric gathers EU suppliers and buyers in its 24/7 Hub to drive demand.

34 https://bellona.org/news/renewable-energy/2022-10-bellona-signs-letter-forthe-european-commission-to-decide-on-rfnbo-delegated-act-to-enable-informed-debate-and-vote-in-the-european-parliament-and-council; https://cadmus.eui.eu/bitstream/handle/1814/74850/RSC_WP_2022_44.pdf?sequence=1&isAllowed=y

35 https://www.utilitydive.com/news/how-utilities-harness-green-hydrogen-productions-flexibility/626096/

Unlike 24/7 CFE which focuses on offsetting project *loads* with clean electricity as a proxy for emissions, marginal emissions accounting focuses on directly offsetting *emissions*. This approach calculates the emissions intensity of the grid where electrolyzer demand occurs (using the marginal grid emissions rate) and requires procurement of clean energy at a location and time that reduces emissions by an equal amount (also using the marginal emissions rate at that location).[36]

Marginal emissions accounting systems do not require a strict regional requirement in the same way as 24/7 CFE, because the emissions themselves are being measured and offset. 24/7 CFE uses clean electricity as an emissions proxy, making deliverability an important component of this system. Marginal emissions accounting can be more efficient by allowing developers to invest in clean projects where it offsets their induced emissions at the lowest price.

There are outstanding questions with this approach. Data availability and methods for calculating marginal emissions rates are currently limited and require approximations. Different methods would need to be evaluated for accuracy and consistency, though there are systems already in place and being developed that could serve as a starting point, including the EPA's AVoided Emissions and geneRation Tool (AVERT).[37] This challenge may be alleviated by the directive included in the Infrastructure Investment and Jobs Act requiring the EIA to collect and publish estimated marginal emissions rates for different balancing authorities and nodes.[38] However, this process is in early stages.

Marginal emissions accounting can introduce uncertainty for hydrogen project developers and financiers concerning the emissions intensity of a hydrogen project as the carbon intensity of the grid changes, and with it both the marginal emissions impact of the hydrogen producer and the procured clean energy change. For example, if a hydrogen producer enters into a power purchase agreement with a solar facility on a dirty grid such that it avoids significant emissions in the near-term, the producer will need some type of certainty that they can count on those (or comparable) avoided emissions for a specific amount of time. As the grid changes, the offsetting clean energy project will lose emissions value, developers will be required to build a new clean energy project or risk losing eligibility for the tax credit.

Comparing the 24/7 and Marginal Emissions Accounting Frameworks

The following table compares the two frameworks based on cost efficiency, ability to implement, and effectiveness at incentivizing useful technologies and solutions. These frameworks illustrate

[36] This approach is described in greater detail here: https://www.watttime.org/news/insight-brief-accounting-for-impact/
[37] https://www.epa.gov/avert
[38] https://www.watttime.org/app/uploads/2022/05/WattTime-HowWattTimeGaugesAndIteratesOnMOERAlgorithmQuality-vFinal-202205.pdf

how different regimes can ensure that hydrogen qualifying for the 45V tax credit effectively reduces carbon emissions. Additionality, temporal matching, and regionality restrictions should be calibrated to enhance system efficiencies while enabling broader clean hydrogen deployment.

	24/7 Carbon Free Electricity (CFE)	Marginal Emissions Accounting
Cost-efficient emissions reductions	More expensive in some locations with lesser access to carbon free sources	More cost-efficient in the short-term, costs may increase over time
Producer incentives aligned with system-wide emissions reductions	Supports project-specific and grid decarbonization	Supports system-wide decarbonization, could increase emissions locally
Tracking and data required	Hourly clean energy generation data	Hourly marginal grid emissions rates
Certainty for projects developers and industry	Requires forecasting and flexible loads. Provides fairly robust certainty for developers.	Marginal emissions impacts and reductions will change over project lifetime, leading to less certainty for developers.
Provides near-term incentives for technologies and solutions that will be useful in long-term grid decarbonization	Yes	Yes, but only if buyers plan ahead for performance and avoided emissions impacts of procured CFE over the long term

Conclusion

The proposed framework must reduce effective GHG emissions to comply with the language and intent of the legislation.

Commit to the three design pillars. Additionality, deliverability, and granular temporality should be included as part of any book-and-claim system used to qualify clean hydrogen production for the 45V tax credit. Systems that do not require some degree of additionality, or systems that allow annual matching with unbundled EACs should not be considered.

The Treasury Department and the IRS should adopt a two-step approach:

> **Immediate guidance**: Evaluate emissions of grid-connected hydrogen electrolyzers using the GREET model, while allowing zero carbon behind the meter resources to count as "zero carbon".

August 2023 guidance: work with DOE and EPA to develop and enforce a robust system incorporating the pillars for grid-connected electrolyzers hoping to qualify for the 45V.

This approach can provide near-term direction while allowing time to grapple with the complexity of a grid-connected accounting system. A well-considered approach will be critical to deliver on Congressional intent and prevent high emitting projects from qualifying for this generous tax credit, creating a climate and reputational disaster.

A large and growing coalition of energy experts, hydrogen developers, granular EAC market developers, and environmental nonprofits have been collaborating on these ideas and could serve as an initial task force the Treasury Department and the IRS leans on to further develop a rigorous and practical emissions accounting framework.

(i) How might clean hydrogen production facilities verify the production of qualified clean hydrogen using other specific energy sources?

[No answer]

(ii) What granularity of time matching (that is, annual, hourly, or other) of energy inputs used in the qualified clean hydrogen production process should be required?

Refer to question (1)(e) for reference. Further details are provided below:

The following comment is focused primarily on grid-connected electrolysis:

Hourly accounting provides maximal accuracy and granularity to calculate the emissions impact of an electrolyzer. If a producer is contracting clean energy during the day (e.g. solar) and is dependent on fossil fuel generators to produce electricity during the night, the emissions of that electrolyzer system will be too high to achieve a tax credit. Less stringent time matching – i.e., daily, weekly, or quarterly – offers flexibility to new hydrogen producers as they ramp up operations but will not restrict emissions from new hydrogen production as effectively.

Proponents of less granular accounting (e.g., quarterly or yearly accounting) argue the fossil fuel consumption during the night is displaced by extra clean generation during the day. However, this is not the case. Peer reviewed research found that annual accounting can be wildly inaccurate, potentially over- or under-estimating the emissions associated with annual accounting by over 35%. This gap is likely to increase over time.[39] Over the next decade, most grids in the US will achieve renewables saturation, meaning that additional renewables will no longer displace fossil fuels at certain peak production hours. This will make it more difficult to guarantee a low emissions rate via offsets without hourly accounting.

The other major issue with greater than hourly accounting is that many clean resources experience a phenomenon known as "value deflation"[40], whereby the value of variable clean

[39] https://iopscience.iop.org/article/10.1088/1748-9326/ac6147
[40] https://thebreakthrough.org/articles/quantifying-solar-value-deflation

resources decreases as the overall grid penetration increases. For example, all solar resources are generating at maximum capacity at the same time, meaning that the middle of the day will eventually be saturated with solar power. Additional solar power will eventually contribute no emissions benefits unless there is a way to store this energy and release it at a better time.

Dumping renewable power into the bulk power grid initially may reduce fossil fuel generation, but over time will displace the need for another clean power generator. The long-term effect of uncorrelated loads is thus undermined by the dynamic nature of the grid because it is not considering the core daily generating pattern[41].

Capacity expansion modeling from the Princeton ZERO lab quantifies this phenomenon[42], demonstrates that annual matching with unbundled EACs is functionally equivalent to no restrictions at all in the state of California. Significant support[43] from companies, REC aggregators, and academics have driven the creation of hourly accounting frameworks[44].

The cost of hourly matching will be increasingly manageable given near-term projected cost declines for hydrogen production and the availability of cost-effective and diversified renewable energy. RMI modeling found that over the next two years, electrolyzers that match hourly can still produce hydrogen at competitive costs in key locations in the U.S.[45] Thus, the cost of hourly time matching is only challenging for single resource projects that do not have a strategy for fully covering electricity consumption with clean electricity, and thus explicitly depend on fossil fuels and accounting tricks.

See section 1(d) for a more robust discussion on how the Treasury Department and the IRS should aggregate emissions measurements to determine the overall credit.

2) Alignment with the Clean Hydrogen Production Standard.

On September 22, 2022, the Department of Energy (DOE) released draft guidance for a Clean Hydrogen Production Standard (CHPS) developed to meet the requirements of § 40315 of the Infrastructure Investment and Jobs Act (IIJA), Public Law 117-58, 135 Stat. 429 (November 15, 2021).4 The CHPS draft guidance establishes a target lifecycle greenhouse gas emissions rate for clean hydrogen of no greater than 4.0 kilograms CO2-e per kilogram of hydrogen, which is the same lifecycle greenhouse gas emissions limit required by the § 45V credit. For purposes of the § 45V credit, what should be the definition or specific boundaries of the well-to-gate analysis?

The CHPS comment period should not alter the **boundaries** of the well-to-gate analysis enumerated as part of the section 45V hydrogen production tax credit. The main sources of emissions beyond the point of production include the emissions associated with electricity generation, methane leakage, and indirect land-use impacts for biomass-based pathways.

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[41] https://rmi.org/insight/clean-power-by-the-hour/
[42] Ricks, Wilson, Xu, Qingyu, & Jenkins, Jesse D. (2022). Minimizing emissions from grid-based hydrogen production in the United States. Zenodo. https://doi.org/10.5281/zenodo.7349406
[43] https://docs.google.com/document/d/1GAz92nGucVPPWvx2xBt74jwn2B4Y8NlSeq6MfeopS6Y/edit
[44] https://www.energytag.org/wp-content/uploads/2021/05/EnergyTag-and-granular-energy-certificates.pdf
[45] https://rmi.org/insight/fueling-the-transition-accelerating-cost-competitive-green-hydrogen/

The primary **exclusions** in the system boundary are construction and embodied emissions of electrolyzers and associated powerplants and connective infrastructure.

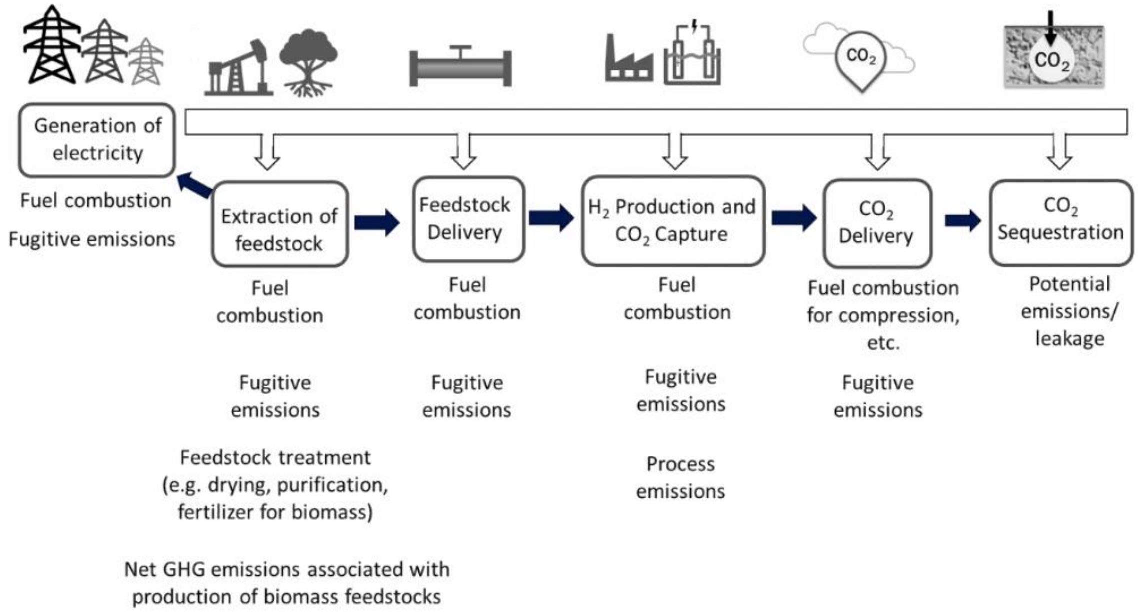

Figure 1: A lifecycle system boundary enables consistent and comprehensive evaluation of diverse hydrogen production systems. Examples of key emission sources within each step typically considered in the boundary are shown above.[11]

The above diagram is being used by DOE as a reference for measuring well-to-gate emissions. The only addition we recommend is leakage from landfills or biogenic facilities tapped for green hydrogen should also be considered for that source to qualify for 45V.

The CHPS process is an open-ended exercise to identify the total lifecycle emissions for hydrogen projects beyond the requirement of the IIJA. The IIJA text requires projects to produce hydrogen if the emissions intensity is less than 2 kg CO2e/ kg H2 at the point of production (source). This requirement could be read to exclude the upstream methane leakage and electricity generation emissions, which are critical parts of hydrogen production lifecycle emissions. However, the DOE via the CHPS comment process demonstrated that the agency would consider the broader lifecycle beyond what is required in the text.

The main value of the CHPS guidance is the process and certification for upstream leakage, electricity, and indirect emissions. In other words, DOE is reviewing methodologies to certify cleaner than average commodities for use in hydrogen production to demonstrate clean production. This output is directly relevant to the administration of the hydrogen PTC.

(3) Provisional Emissions Rate.

> *For hydrogen production processes for which a lifecycle greenhouse gas emissions rate has not been determined for purposes of § 45V, a taxpayer may file a petition with the Secretary for determination of the lifecycle greenhouse gas emissions rate of the hydrogen the taxpayer produces.*

(a) At what stage in the production process should a taxpayer be able to file such a petition for a provisional emissions rate?

The taxpayer should be able to file a petition before building the facility. For certification of feedstocks (e.g. electricity, methane, biomass), the Treasury Department and the IRS should have a formal system that avoid the need for extensive case-by-case determinations and should attempt to capture most production pathways in guidance. When edge cases do arise, the provisional process should begin before the project breaks ground to provide up-front regulatory certainty.

(b) What criteria should be considered by the Secretary in making a determination regarding the provisional emissions rate?

The secretary should be critical of "negative emissions" or offset calculations based on counterfactuals (e.g. this waste stream would have been released into the atmosphere, but now it is used for hydrogen, so this process is worth negative emissions).

The Secretary should also consider land use changes when evaluating the emissions rate of hydrogen produced with biomass feedstocks.

The Secretary should avoid creating provisional emissions rates for feedstocks that have already been characterized by the Treasury Department and the IRS standards. For example, methane and electricity from the grid will be two core inputs for hydrogen production, and their compliance pathways must be highly characterized by the Treasury Department and the IRS for this credit to be functional. Companies should, in almost all cases, be required to use the standards emissions calculations when calculating the associated emissions (e.g. average grid emissions or qualifying RECs with hourly matching, additionality, and deliverability).

The primary use of provisional rates is from novel feedstocks or processes, which should be relatively sparing. Public comment and review, or agency guidance will be critical to avoid creating loopholes.

(4) Recordkeeping and Reporting.

(a) What documentation or substantiation do taxpayers maintain or could they create to demonstrate the lifecycle greenhouse gas emissions rate resulting from a clean hydrogen production process?

EACs with the ability to reflect attributes including time of production, proof of additionality, and evidence of deliverability. The Treasury Department and the IRS should allow for third-party, independent tracking platforms to organize and compile this data. Transmission service rights or Network Integration Transmission Service rates should be considered to prove deliverability, depending on the region.

For proof of additionality, the associated project should have a direct contract that bundles the environmental attributes and the physical electricity, and the project associated with the EACs must be additional (e.g. contracted and built as part of the hydrogen load). In addition, clean attributes must not be used to fulfill regulatory requirements.

(b) What technologies or methodologies should be required for monitoring the lifecycle greenhouse gas emissions rate resulting from the clean hydrogen production process?

For more detail on electricity accounting, see our response for 1(e)

Methane accounting:

Natural gas supply to use (unless there is a direct connection between the two) is fungible. Therefore, it is typically proactive enough to utilize national averages for leakage rates. Producers do have a choice in how to credibly differentiate their product through purchasing certified gas. There are multiple systems for verifying this, including the MiQ standard, Equitable Origin EO100, and Project Canary TrustWell.[46,47,48]

(c) What technologies or accounting systems should be required for taxpayers to demonstrate sources of electricity supply?

Any accounting system requires additionality, deliverability, and granular MWh accounting. See question 1(e) for more detail.

To verify electricity emissions for electrolyzers, there are several potential systems that the DOE could adopt:

- **Behind-the-meter generation with a direct connection from clean resources:**
  - The LCA should not include the construction costs of the electricity generation facilities or associated transmission construction
- **Average grid emissions or residual grid mix**
  - Leverage data from the EIA – this data should be public on annual time-steps for each major grid region and trivial to calculate
  - More robust hourly data is available in some jurisdictions
- **Time-based Energy Attribute Certificates** – piloted by Google[49]
  - A critical improvement to the traditional REC markets in that it drives effective emissions reductions
  - As these markets develop, hub developers should be able to use these to demonstrate compliance with the required LCA and the associated hydrogen production tax credits.
  - Energy Tag and over 100+ global organizations have developed and implemented T-EACs with a full methodology available[50]

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46 https://miq.org/
47 https://www.equitableorigin.org/adopt-eo100/
48 https://www.projectcanary.com/private/trustwell-and-rsg-definitional-document/
49 https://cloud.google.com/blog/topics/sustainability/t-eacs-offer-new-approach-to-certifying-clean-energy
50 https://energytag.org/wp-content/uploads/2022/03/20220331-EnergyTag-GC-Use-Case-Guidelines-v1-FINAL.pdf

- An overview of existing hourly tracking projects worldwide demonstrates this system's readiness for deployment by the DOE for LCA compliance[51]
- After internal conversations with Ben Gerber, the M-RETs CEO, the M-RETs system can be scaled nationally in 12-18 months and has already piloted similar programs in the MISO region if the PTC requires it[52]

- **Locational Marginal Emissions** – piloted by REsurety, Brattle, and Microsoft
  - "The LME is a metric that measures the tons of carbon emissions displaced by 1 MWh of clean energy injected to the grid at a specific location and a specific point in time" - REsurety, Brattle whitepaper[53, 54]
  - The LME is an economical way to build renewable projects to displace the overall grid emissions to offset induced emissions by a new load
  - Modeling organizations like Watt-Time have developed a methodology to infer the marginal emissions despite the lack of full data available in many locations[55]

To verify additionality:

Additionality can be a challenge to verify, however there are several principles that are critical.

- Direct financial offtake agreement between the energy developer and the hydrogen developer
- Credits from existing renewable facilities (pre-IRA) should not count, as no additional clean generation is coming online to displace the emissions associated with the new load
- Projects are not additional if their environmental attributes are used to fulfill compliance with state policies (e.g. Renewable Portfolio Standards) or other voluntary credit markets

Additionality does increase project risk, requiring hydrogen producers to ensure the development of new clean resources to serve their load with partners. Interconnection queues can delay projects, but the inability to build new clean resources due to transmission congestion all but assures that the electricity is coming from existing fossil resources.

Edge cases and exceptions where additionality may not be required include:

- Purchase of clean power that otherwise would be curtailed, as long as there is no transmission congestion between the electrolyzer load and the power generator
- Large low-carbon loads that are not receiving priority economic dispatch (e.g. nuclear that is getting displaced from the generation stack)
- Repowering of retiring renewable facilities with unused capacity

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51 https://docs.google.com/spreadsheets/d/1zdwTHf2X_jxqeVJoDAPImRrhnHDiItAd9jNBGEsJv6g/edit#gid=1741548934

52 https://www.mrets.org/hourlydata/

53 https://www.businesswire.com/news/home/20210714005708/en/%C2%A0REsurety-launches-%E2%80%9CLocational-Marginal-Emissions%E2%80%9D-data-product-to-empower-customers-to-measure-and-maximize-how-much-carbon-they-cut-through-clean-energy-purchases

54 https://resurety.com/wp-content/uploads/2022/03/REsurety-Locational-Marginal-Emissions-A-Force-Multiplier-for-the-Carbon-Impact-of-Clean-Energy-Programs.pdf

55 https://www.watttime.org/marginal-emissions-methodology/

The DOE should look across the government to pull together the data for this effort. The Executive Order on Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability requires federal buildings to procure clean energy matching the hourly load.[56] The DOE should consider collaborating on this methodology and build a shared process and data structure.

In addition, the Infrastructure Investment and Jobs Act calls for the U.S. EIA to publish spatially and temporally granular electricity emissions rate data which can be used to calculate the emissions profile of electrolysis. The DOE should engage with the EIA to incorporate this more granular data where available.

(d) What procedures or standards should be required to verify the production (including lifecycle greenhouse gas emissions), sale and/or use of clean hydrogen for the § 45V credit, § 45 credit, and § 48 credit?

[No Answer]

(e) If a taxpayer serves as both the clean hydrogen producer and the clean hydrogen user, rather than selling to an intermediary third party, what verification process should be put in place (for example, amount of clean hydrogen utilized and guarantee of emissions or use of clean electricity) to demonstrate that the production of clean hydrogen meets the requirements for the § 45V credit?

The hydrogen production credit is large enough where, over the course of the credit lifetime the value of the credit exceeds the costs to produce clean hydrogen. As a result, companies could dispose of the hydrogen and still make profit. The Treasury Department and the IRS should ensure that the hydrogen is sold to a third party or used for a legitimate commercial activity to avoid credit farming.

The DOE has identified a variety of valuable use-cases for clean hydrogen via the national roadmap, which the Treasury Department and the IRS can use to distinguish productive use from credit farming. Taxpayers thus should disclose the use of the hydrogen to the Treasury Department and the IRS if the same company is using it. Any sale price for hydrogen below a certain level relative to the current hydrogen price should be flagged to ensure the offtaker is a legitimate entity and the hydrogen is not being wasted as part of fraudulent credit farming.

Hydrogen Waste and Fraud

One major source of potential fraud is generating hydrogen with electricity, and then generating electricity with hydrogen. While there are some legitimate use-cases for hydrogen in the electricity sector (e.g. long duration storage), use of hydrogen as shorter duration storage likely makes no sense from a climate perspective or a technology perspective without a massive credit subsidy. While the value of storage as an arbitrage mechanism (charge when power is cheap, release when power is expensive) is a potential source of funding, most facilities will have an

[56] https://www.federalregister.gov/documents/2021/12/13/2021-27114/catalyzing-clean-energy-industries-and-jobs-through-federal-sustainability

incentive to dump excess hydrogen in a very low value use case that approximates low value disposal of hydrogen to maximize their credits. Hydrogen production power production remains the highest risk for fraud – low sale prices/ self-dealing in this sector are key warning signs.

(f) Should indirect book accounting factors that reduce a taxpayer's effective greenhouse gas emissions (also known as a book and claim system), including, but not limited to, renewable energy credits, power purchase agreements, renewable thermal credits, or biogas credits be considered when calculating the § 45V credit?

Indirect book accounting factors should be allowed, but **additional requirements** are required to ensure effective GHG emissions are achieved. Attribution of clean credits alone is insufficient – real projects are required to be built to neutralize the GHG emissions associated otherwise associated with adding new loads to the grid.

Congressional intent clearly requires "effective" greenhouse gas emissions reductions for systems that use indirect book accounting factors (see 1(e) for more discussion). There are two ways to evaluate an accounting scheme – via attributional emissions and consequential emissions impacts.

Attributional emissions are the calculated emissions from a given scheme but provide no insights into the quality of the scheme. For example, an electrolyzer receiving low quality renewable energy credits (such as unbundled RECs) can claim to have zero emissions, when in reality the new load is driving up natural gas consumption when evaluating the system-wide impacts.

Consequential emissions evaluate the overall change in emissions in the grid system and can be considered the "effective" emissions impact of a new source of demand. The Treasury Department and the IRS should prioritize consequential emissions, rather than simply attributional emissions, to evaluate the effective GHG impact of hydrogen feedstocks. Attributing zero emissions to an ineffective scheme is worthless and unaligned with the legislative text. Our comments focus on systems that eliminate consequential impacts of new hydrogen loads on the grid.

To ensure "effective GHG emissions reductions," the book and claim system must be granular, rigorous, and implementable. Many emissions accounting schemes allow for procurement to claim the electricity is clean, but often the system wide GHG effect is negligible. While practicality for industry players is an important consideration, it is secondary to the strict emissions requirements in statute.

(g) If indirect book accounting factors that reduce a taxpayer's effective greenhouse gas emissions, such as zero-emission credits or power purchase agreements for clean energy, are considered in calculating the § 45V credit, what considerations (such as time, location, and vintage) should be included in determining the greenhouse gas emissions rate of these book accounting factors?

Granular (ideally, hourly) time measurements, deliverability, and additionality must all be included in determining the GHG rate of the book accounting factors used to qualify hydrogen production for the 45V PTC, as described by our comments to question (1)(e).

(5) Unrelated Parties.

(a) What certifications, professional licenses, or other qualifications, if any, should be required for an unrelated party to verify the production and sale or use of clean hydrogen for the § 45V credit, § 45 credit, and § 48 credit?

[No answer]

(b) What criteria or procedures, if any, should the Treasury Department and the IRS establish to avoid conflicts of interest and ensure the independence and rigor of verification by unrelated parties?

[No answer]

(c) What existing industry standards, if any, should the Treasury Department and the IRS consider for the verification of production and sale or use of clean hydrogen for the § 45V credit, § 45 credit, and § 48 credit?

For the 45V credit, industry standards for procurement of clean electricity must be carefully vetted. Many "clean energy accounting systems" account for clean electricity, but not the overall system wide GHG impacts. In addition, the hydrogen PTC requires a level of precision and granularity unmatched by most other systems: to achieve the top credit, over 97.5% of the input electricity must be zero carbon, with the other 2.5% from high efficiency natural gas generators. Use of hourly accounting is required to demonstrate emissions levels below this threshold.

There are several methodologies that can accurately capture system-wide emissions impacts; these systems require additionality and hourly accounting data. The Treasury Department and the IRS should open the door to multiple validated pathways, leaning on expertise from national labs and the DOE science office, along with a technical working group with leading experts from the NGO, academic, and industry world.

Black box methodologies can hide many assumptions that undermine the legitimacy of these systems, and thus any new emissions system should lean on agency experts to validate the system and avoid credit gaming.

(6) Coordinating Rules.

(a) Application of certain § 45 rules. **(i) Section 45V(d)(3) includes a reduction for the § 45V credit when tax-exempt bonds are used in the financing of the facility using rules similar to the rule under § 45(b)(3)). What, if any, additional guidance would be helpful in determining how to 9 calculate this reduction? (ii) Section 45V(d)(1) states that the rules for facilities owned by more than one taxpayer are similar to the rules of § 45(e)(3). How**

should production from a qualified facility with more than one person holding an ownership interest be allocated?

[No answer]

(b) Coordination with § 48. **(i) What factors should the Treasury Department and the IRS consider when providing guidance on the key definitions and procedures that will be used to administer the election to treat clean hydrogen production facilities as energy property for purposes of the § 48 credit? (ii) What factors should the Treasury Department and the IRS consider when providing guidance on whether a facility is "designed and reasonably expected to produce qualified clean hydrogen?"**

[No answer]

(c) Coordination with § 45Q. **Are there any circumstances in which a single facility with multiple unrelated process trains could qualify for both the § 45V credit and the § 45Q credit notwithstanding the prohibition in § 45V(d)(2) preventing any § 45V credit with respect to any qualified clean hydrogen produced at a facility that includes carbon capture equipment for which a § 45Q credit has been allowed to any taxpayer?**

Uses of hydrogen past the point of production is not within the scope within the same facility.

Using clean hydrogen to produce synthetic fuels with captured CO_2 from a separate system (e.g. Direct Air Capture) that receives 45Q is permissible, as the stacking provision only refers to CO_2 captured as a byproduct of clean hydrogen production. However, care must be taken to ensure that the carbon capture from blue hydrogen (steam methane reformation + carbon capture) is being permanently sequestered – mixing carbon sources could open the door for fraud.

If hydrogen is being created from a methane pathway, the process CO_2 is captured, and then a separate CO_2 stream is re-introduced for synthetic fuels, the process is ripe for abuse. This is an absurd, circular, and comically expensive way to make fuels, but due to credit stacking may be economically viable. The DOE should rely on strict accounting guidelines to require clearly separated pipelines and carbon sources. There may be attempts to mix carbon from many sources into the same infrastructure to confuse auditors and commit fraud.

(7) Please provide comments on any other topics related to § 45V credit that may require guidance

Through extensive stakeholder engagement, RMI has heard talking points that are not aligned with the data.

1. **"If the Treasury Department and the IRS requires a production pathway for electrolysis that is too temporally stringent (like hourly matching) only methane-based pathways will qualify."**

Hydrogen companies that make this point might have a soft cost problem or a lack of resources, but we have found that this does not apply across the hydrogen industry. There are multiple developers that are pursuing and finalizing large scale green hydrogen projects that would qualify and benefit from this credit. Electric Hydrogen has confirmed that they plan to develop a 100 MW full stake polymer electrolyte membrane (PEM) electrolyzer plant that can accommodate temporal matching requirements, and Air Liquide in Denmark has been successfully using hourly matching at a 1.5 MW electrolyzer since 2020.[57], [58] These green hydrogen projects will qualify under strict temporal matching requirements and will benefit from the full tax credit benefit. Furthermore, studies by The Florence School of Regulation and Princeton University both found that the benefits of hourly matching requirements outweigh the financial costs it adds to the production of hydrogen.[59],[60]

In addition, RMI modeling found that near-term cost decreases will allow for negative cost hydrogen in combination with the hydrogen PTC and the electricity tax credits[61].

2. **"A strict system won't provide enough certainty to industry to allow them to invest in new projects."**

Granular certificates (also called Time-based Energy Attribute Certificates or T-EACs), which are used to assure tight temporal matching, are already technically feasible at a large scale—1 TW of energy is currently being tracked hourly. That number is expected to grow to 10TW or more by next year, largely driven by global energy purchasers like Google, Microsoft, and the US government (which has committed to using half 24/7 carbon free energy by 2030) committing to using Granular Certificates (GCs) to achieve zero-carbon energy.[62]

This growth will be key to scaling up GC registries quickly. Leading organizations developing hourly GC markets like M-RETs, Energy Tag, and Singularity are confident that a national registry system can be implemented and enforced. M-RETS, which is currently the largest registry in the United States, estimates that this system can be fully scaled up across all 50 states in a year's time, before any hydrogen projects are ready for finalization.[63]

Energy Tag has published scheme standards for how to use GCs to match energy usage at an hourly scale as well as guidelines and use cases for organizations looking to use GCs.[64] These standards are accompanied by a series of demonstration projects around the world that are all tracking energy offsets at an hourly scale. The growing market for granular certificates and the standardization of a national enforceable system will provide certainty to hydrogen producers and developers operating under temporally stringent regulations.

3. **"Electrolyzer costs will not come down fast enough to allow for temporal matching."**

Given the increasing demand for hydrogen power, plants that produce electrolyzer units will scale up dramatically in the next few years. In the last two years, western electrolyzer producers

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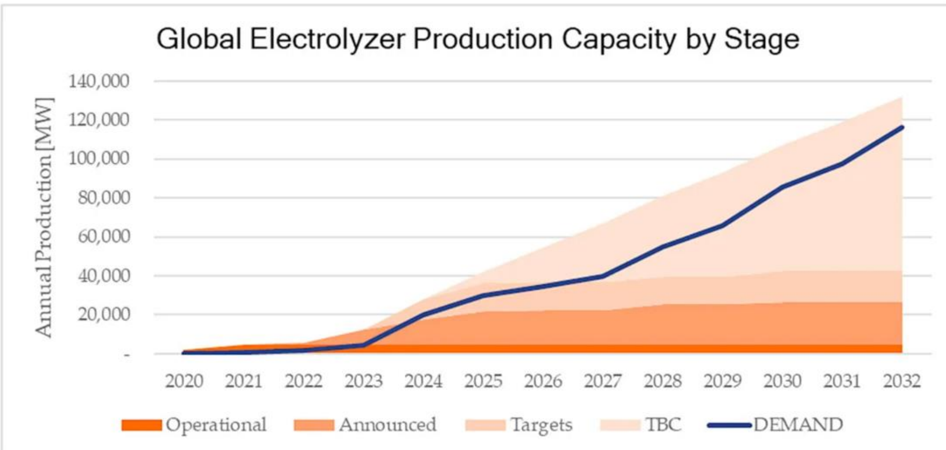
[57] https://eh2.com/
[58]https://docs.google.com/spreadsheets/d/1zdwTHf2X_jxqeVJoDAPImRrhnHDiItAd9jNBGEsJv6g/edit#gid=1741548934
[59] [3] https://cadmus.eui.eu/bitstream/handle/1814/74850/RSC_WP_2022_44.pdf?sequence=1&isAllowed=y
[60] https://zenodo.org/record/6229426
[61] https://rmi.org/insight/fueling-the-transition-accelerating-cost-competitive-green-hydrogen/
[62] [5] https://docs.google.com/document/d/1GAz92nGucVPPWvx2xBt74jwn2B4Y8NlSeq6MfeopS6Y/edit
[63] Ibid.
[64] https://energytag.org/publications/

alone announced plans to build electrolyzer gigafactories that will output 42 gigawatts of electrolyzers per year by 2030; and worldwide fourteen different producers plan to build electrolyzer gigafactories, with planned technologies encompassing PEM, anion exchange membrane (AEM), and solid oxide electrolyzer (SOE). This increasing production will create economies of scale for electrolyzer production and will push technological advances to electrolyzer production forward. Rethink Energy predicts that the learning rate for electrolyzers will be 14%, reducing capital costs for electrolyzers from $1,400 per kW to $340 by the year 2030.[65]



Source: Rethink Energy, "The Swelling Pipeline of Electrolyzer Gigafactories"

Furthermore, IRENA projects similarities between the costs for electrolyzers and the dropping cost of solar and wind in the early 00's as those technologies scaled up.[66] IRENA has identified strategies that can reduce the investment costs of electrolyzers by 40% in the near term and 80% in the long term, ranging from technology improvements to whole-of-system changes. These cost reductions are also aligned with DOE projected cost reductions[67] as the size and throughput of electrolyzer manufacturing increases.

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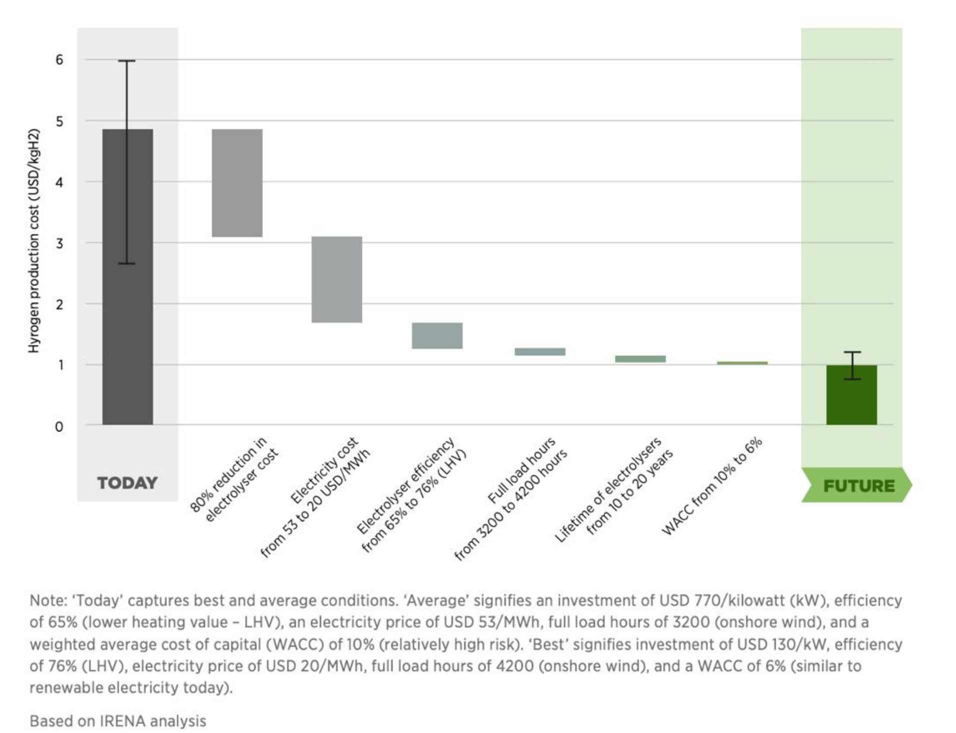
[65] https://energyindustryreview.com/metals-mining/complexul-energetic-oltenia-to-resume-lignite-mining-in-rosia-quarry/
[66] 9 https://irena.org/publications/2022/mar/world-energy-transitions-outlook-2022
[67] https://www.nrel.gov/docs/fy19osti/72740.pdf



Source: IRENA, "Green Hydrogen Cost Reduction: Scaling up Electrolysers to Meet the 1.5ºC Climate Goal"

4. **"Hourly EACs are not available for all geographies."**

Hourly EACs are a fast-growing resource in the power sector. Even so, until now there has not been a strong national incentive encouraging them to expand. The Treasury Department and the IRS 45V implementation recommendations will be a strong demand signal encouraging hourly EACs to be offered in all US geographies. We can expect that ISOs and utilities will start to provide this data--which is already being collected but is not yet used for EACs once that demand signal is triggered. If hourly EACs are not available in a certain geography now, it is likely that they will be soon.

Because the Treasury Department and the IRS will most likely aim for a tighter temporal scheme than yearly matching, all hydrogen projects should be prepared to adopt hourly matching as soon as it is available in their geography. If a project only plans to match on an annual scale and then hourly matching becomes available to it, it could potentially lose eligibility for the tax credit and therefore lose a significant amount of funding. M-RETs, which partnered with Google to launch its hourly EAC program in 2021, expects that its hourly GC trading system can be scaled up across the whole country in one year.[68] M-RETS runs the backend for WREGIS, another EAC platform for the Western grid. In addition, the regional transmission organization PJM offers hourly load data to support hourly matching.

5. **"Requiring bundled EACs shouldn't be a requirement to prove that hydrogen is clean."**

[68] https://docs.google.com/document/d/1GAz92nGucVPPWvx2xBt74jwn2B4Y8NlSeq6MfeopS6Y/edit

A system that allows unbundled clean energy credits to qualify hydrogen generators as clean risks gaming and emissions increases due to the lack of integrity and additionality requirements. If the Treasury Department and the IRS allow for unbundled credits, the PTC could allow projects that use natural gas as the marginal resource and claim credits that are not actually tied to additional clean power added to the grid. These projects could receive the maximum PTC payments while emitting 40 times more carbon than the credit's strictest requirements (20 kg CO_2e per kg H_2).

New clean generation is necessary to match new electrolytic loads, otherwise the effective greenhouse gas impact is worse than existing steam methane reforming (SMR) process for hydrogen creation. Unbundled EACs have been found to have almost no impact on increasing additional renewable energy but provide a cheap way for an organization to appear to promote renewable energy.[69] Allowing unbundled credits would directly contradict the language and the intent of the law and must be included as a requirement for certification of clean hydrogen.

Exhibit A

RMI Response to Notice 2022-49
https://www.regulations.gov/comment/IRS-2022-0023-1881

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[69] https://www.sciencedirect.com/science/article/pii/S1040619019303008