November 14, 2022

Hydrogen Program
U.S. Department of Energy
1000 Independence Ave SW
Washington, DC 20585

RE: Feedback to the draft guidance for the Clean Hydrogen Production Standard (CHPS) developed to meet the requirements of the Bipartisan Infrastructure Law (BIL), Section 40315.

The Natural Resources Defense Council welcomes the opportunity to provide feedback to DOE's draft guidance on the CHPS. NRDC is an international nonprofit environmental organization with more than 3 million members and online activists. Since 1970, our lawyers, policy analysts, scientists, and other environmental specialists have worked to protect the world's natural resources, public health, and the environment. NRDC has offices in New York City, Washington, D.C., Los Angeles, San Francisco, Chicago, Bozeman, MT, Beijing, and New Delhi. We also have seconded staff with the U.N. High Level Climate Champions team leading their global green hydrogen strategy. We co-authored the U.N. global hydrogen principles and the hydrogen chapter of the 2022 Breakthrough Agenda report.[1]

We believe that with rigorous climate and community safeguards, hydrogen derived from 100%-- or near 100%-- renewable electricity and water (or "green" hydrogen to employ the shorthand) can play a key role in supporting U.S. climate goals when targeted at the hardest to electrify applications where alternative clean solutions may not exist. Applications include heavy industry (notably, steel) marine shipping and aviation. We do not support the deployment of fossil fuel-derived hydrogen or more broadly, hydrogen's deployment in applications where more efficient solutions—such as direct electrification—are available.

The CHPS will have strong bearing on the arc of the nascent clean hydrogen market and its impact will likely extend beyond its direct statutory intent as informing DOE's H2Hubs Program and Clean Hydrogen Research and Development Program. In fact, we are aware of several states that are already moving to adopt DOE's proposed standard in forthcoming state legislation, such that setting a climate aligned and rigorous CHPS is an imperative. Further, we strongly encourage DOE to consider the CHPS as an initial step towards developing a production standard applicable to all federal hydrogen investments, and possibly paving the way for a future regulatory standard (within the purview of the EPA) as the industry grows. The CHPS therefore constitutes a valuable opportunity to set ambitious goal posts and develop rigorous processes around emissions accounting, as well as data collection and verification. An ambitious CHPS

[1] UN High Level Climate Champions, UN Climate Champions launch 'guiding principles' for climate-aligned hydrogen, https://climatechampions.unfccc.int/un-climate-champions-launch-guiding-principles-for-climate-aligned-hydrogen/ ; International Energy Agency, International Renewable Energy Agency, UN Climate Change High Level Champions, The Breakthrough Agenda Report, 2022, https://iea.blob.core.windows.net/assets/49ae4839-90a9-4d88-92bc-371e2b24546a/THEBREAKTHROUGHAGENDAREPORT2022.pdf

that also embeds rigorous emissions verification and accounting mechanisms would also go a long way in building confidence in clean hydrogen as an effective climate solution; this is a valuable advantage considering the current high degree of skepticism and concerns around hydrogen.

On a general note, we strongly endorse and applaud DOE's adoption of the well-to-gate framework for lifecycle emissions, as a robust starting point. As we have previously communicated to DOE, this should be the minimum admissible boundary for hydrogen to be considered as a potential climate solution. We also agree with DOE's interpretation of the statutory text, namely that 1) this boundary is necessary to meet all three requirements set out in BIL and that the CHPS shall meet, and 2) the onsite definition for clean hydrogen is but one component of the CHPS and its intent as outlined in BIL.[2] We strongly recommend that DOE retain this initial boundary, and as we note below, position the proposed CHPS for the near-term expansion of the boundary to ensure clean hydrogen's climate integrity and align with and/or lead emerging global momentum.

We will focus our comments on some of the key pieces of the CHPS that we deem to be highly consequential to ensuring that the clean hydrogen industry develops in a manner that supports decarbonization goals and does not instead jeopardize climate progress and U.S. ability to achieve its 2030 and 2050 climate goals. We respond to the following questions (sequenced by theme):

1- 4a). We argue that DOE has scope to – and should-- strengthen the proposed 4 kgCO2e/kgH2 threshold;
2- 1b), 1c). We argue that GREET may be a reliable tool if updated or supplemented to provide rigorous guidance for carbon intensity accounting of grid-connected electrolyzers, include hydrogen as a GHG and offer options to use shorter GWP timeframes for methane and hydrogen;
3- 2a). We argue that the IPHE boundary is a good starting point, but DOE should position the CHPS to expand the boundary in the near-term to include downstream hydrogen activities;
4- 3c). We reiterate the content set out in our joint comments with RMI that we submitted to the U.S. Treasury in the context of the implementation of 45V clean hydrogen production tax credits in the Inflation Reduction Act – with support and in collaboration from a range of organizations-- articulating the importance and key components of a rigorous emissions accounting system for grid-connected electrolyzers;

We look forward and stand ready to work with DOE on the design and implementation of the CHPS.

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[2] The statute requires that "the standard developed shall—" • "support clean hydrogen production from each source described in section 16154(e)(2) of this title" (e.g., including but not limited to fossil fuels with carbon capture, utilization, and sequestration (CCUS); hydrogen-carrier fuels (including ethanol and methanol); renewable energy resources, including biomass; nuclear energy); • "define the term "clean hydrogen" as provided in section 16166(b)(1)(B) to mean hydrogen produced with a carbon intensity equal to or less than 2 kilograms of carbon

4) Additional Information

a) Please provide any other information that DOE should consider related to this BIL provision if not already covered above.

We will comment on the proposed threshold of 4 kgCO2e/kgH2 on a well-to-gate basis. Contingent on DOE's clarification of the types of projects that would meet the proposed standard, **DOE has scope to strengthen this threshold to no more than 2.5 to 3 kgCO2e/kgH2,** leveraging this valuable opportunity to lift market ambition, bolster hydrogen's effectiveness as a climate solution, and both align with and lead emerging global standards.

- **DOE should clarify the sort of projects that it expects can meet the 4 kgCO2/kgH2 proposed threshold**

We were surprised by DOE's estimate that *"a steam methane reformer with ~95% carbon capture and sequestration (CCS) could achieve ~4.0 kgCO2e/kgH2 lifecycle emissions by using electricity that represents the average U.S. grid mix and ensuring that upstream methane emissions do not exceed 1%"*. Based on our calculations, the well-to-gate emissions of such a high-performing facility should not exceed 2.5 to 3 kgCO2e/kgH2. We estimate that the 4 kgCO2e/kgH2 proposed threshold would allow for projects that are:

- Equipped with 95% carbon capture but with methane leakage that hovers around 3%, a dangerous level which has already been recorded in the Permian Basin; or
- Linked to a low methane leakage rate of 1% but equipped with a low-performing carbon capture rate of approximately 70%

Those are only two examples and do not exhaust the universe of possible project components, but they indicate that the 4 kgCO2e/kgH2 may not represent the high level of technological and operational ambition that DOE seems to posit.

Therefore, to make an accurate assessment of the adequacy of the proposed 4 kgCO2e/kgH2 threshold, we ask that DOE further clarify the types of projects that it estimates can meet the standard, and how it reached that conclusion. Absent further DOE clarification, we will assume that that our estimates are accurate, and our comments below should be read with this in mind. We look forward to further discussions with DOE on this critical issue.

- **DOE can and should strengthen the proposed CHPS**

Aligning with the IRA floor for eligibility fails to leverage the opportunity that the CHPS presents to set a higher bar

While aligning to some degree with the IRA 45V clean hydrogen tax credits is sensible to harmonize policy and regulatory signals for developers, DOE should not align the CHPS with the bare minimum eligibility threshold for the tax credits. The 45V credits and CHPS are meant to serve different purposes; the main objective of the former is to drive scale, while the main objective of the latter is/should be to use limited appropriated funds to demonstrate feasibility and support projects that are the most appropriate beneficiaries of taxpayers dollars. Striving for strict alignment between the two instruments is therefore misguided. Alignment can be better achieved differently – by adopting the same initial lifecycle emissions boundary in determining the carbon intensity of the hydrogen and, importantly, the same emissions accounting and verification frameworks (we further comment on the latter theme in question 3c below). Further, developers will likely gravitate towards the 4 kgCO2e/kgH2 threshold (or lower) anyway to tap into the generous tax incentives. DOE should therefore design the CHPS such that its grantmaking targets projects that perform better than the bare minimum that the market will likely meet. By DOE's own admission "other policies and market forces may incentivize deployments that are cleaner than the targets established in the CHPS". The CHPS should not lag the market; it should demonstrate and drive ambition.

BIL statutory language can be interpreted as lifting the ambition of the CHPS

As DOE notes, BIL statutory language directs DOE to select H2Hubs that "demonstrably aid the achievement" of the CHPS and establish "a series of technology cost goals oriented toward achieving the CHPS." under the Clean Hydrogen Research and Development Program. Those directives can be interpreted as setting out the CHPS as an ambitious goal post, as opposed to the floor that the market will likely gravitate towards and exceed. The CHPS will guide DOE's research, development, and demonstration investments, and should therefore be based on high technological ambition and aim to demonstrate the feasibility of such ambition.

The CHPS offers an opportunity to set a world-leading standard

DOE notes that hydrogen projects that outperform the CHPS may be incentivized by policies being established in other countries, citing a series of more ambitious global standards including the European Taxonomy which classifies clean hydrogen as achieving lifecycle emissions of less than 3.0 kgCO2e/kgH2, the European Renewable Energy Directive which defines a lifecycle target of approximately 3.4 kgCO2e/kgH2, and the United Kingdom which set a standard of 2.4 kgCO2e/kgH2 (it bears noting that the 3.4 kgCO2e/kgH2 set out in the European RED includes emissions linked to hydrogen delivery, such that the emissions linked to hydrogen production are effectively capped at less than 3.4 kgCO2e/kgH2). As the country now offering the most generous hydrogen subsidies in the world (including the H2Hubs and IRA tax credits), the U.S. should not be trailing global production standards. Instead, the CHPS is an opportunity and imperative for DOE to develop world-leading standards, or at a minimum, align with global ambition. Furthermore, considering the prospects of international hydrogen trade, striving for alignment on a clean hydrogen definition/ambition will be key to facilitate trade.

In sum, the CHPS offers a critical opportunity for DOE and the U.S. to set a world-leading benchmark and accelerate the actualization of clean hydrogen's highest climate value proposition. We therefore recommend that at a minimum, DOE align with European benchmarks and define the CHPS as not exceeding 2.5-3 $kgCO_2/kgH_2$, subject to further tightening in no more than 5 years as statutorily stipulated. While this does not strictly line up with the IRA threshold limits (which is a misguided approach, as we argue above), it is still in harmony with IRA as it would adopt the same initial well-to-gate boundary – and the same emissions accounting framework as we argue in Q. 3c below) and therefore harmonize policy signals to developers.

1) Data and Values for Carbon Intensity

b) Lifecycle analysis to develop the targets in this draft CHPS were developed using GREET. GREET contains default estimates of carbon intensity for parameters that are not likely to vary widely by deployments in the same region of the country (e.g., carbon intensity of regional grids, net emissions for biomass growth and production, avoided emissions from the use of waste-stream materials). In your experience, how accurate are these estimates, what are other reasonable values for these estimates and what is your justification, and/or what are the uncertainty ranges associated with these estimates?

If updated or supplemented, GREET can serve as a reliable tool for emissions accounting. However, given that it was built to mainly serve and inform transportation-related technological pathways, it is not fit for purpose and will require diligent and timely updates/supplementation to beef up its rigor in estimating carbon intensities of hydrogen production. The following revisions will be key:

- *Accounting of the carbon intensity of electricity powering grid-connected electrolyzers*

In its current form, GREET does not offer a solid set of guidelines and accounting options for grid-connected electrolyzer projects, as it does not capture the complexity and dynamics of compliance instruments like clean energy attributed credits (EACs) that electrolyzers will likely rely on to demonstrate compliance with the CHPS (or the carbon intensity limits embedded in the IRA 45V tax credits). As we discuss in greater detail in Question 3c below, this is a highly consequential issue given the extent to which electricity emissions can dictate total hydrogen production emissions, and the high risk that emissions shoot up if electrolyzers are powered by even modest shares of fossil electricity. In its current form, GREET does not allow for the sort of rigorous accounting that is necessary to ensure the climate integrity of grid-connected electrolyzers that employ a book-and-claim system (by way of EACs). DOE should therefore update or supplement GREET to enable various renewable energy procurement schemes and electricity emissions offsetting frameworks to be accurately captured. The expectation that GREET will likely be adopted as the main tool in the implementation of the 45V clean hydrogen tax credits underscores the urgency of implementing those revisions. We look forward to working with DOE on this high-stakes issue.

- *Including hydrogen as an indirect GHG and using shorter timeframes for GWP*

We echo comments by the Environmental Defense Fund (EDF) to this proposed CHPS that GREET should be revised to begin including hydrogen as a GHG (or an emitting source) and to enable the option to select shorter timeframes for global warming potentials of short-lived pollutants like hydrogen and methane. Those revisions are critical to bolstering the integrity and effectiveness of GREET as the main tool for the accounting of the carbon intensity of hydrogen sources.

c) Are any key emission sources missing from Figure 1? If so, what are those sources? What are the carbon intensities for those sources? Please provide any available data, uncertainty estimates, and how data/measurements were taken or calculated.

We echo and reference comments by EDF to this proposed CHPS that "hydrogen emissions should be explicitly included within LCAs once emissions rates are able to be empirically assessed and/or reasonably estimated". Considering the marked impact of leakage on clean hydrogen's climate value, it is critical that DOE expressly positions the LCA to include hydrogen leakage across the value chain, including in the production step as well as downstream activities, as soon as such those emissions can be reasonably and feasibly estimated.

2) Methodology

a) The IPHE HPTF Working Paper (https://www.iphe.net/iphe-working-paper-methodology-doc-oct-2021) identifies various generally accepted ISO frameworks for LCA (14067, 14040, 14044, 14064, and 14064) and recommends inclusion of Scope 1, Scope 2 and partial Scope 3 emissions for GHG accounting of lifecycle emissions. What are the benefits and drawbacks to using these recommended frameworks in support of the CHPS? What other frameworks or accounting methods may prove useful?

The current IPHE lifecycle emissions boundary is a good starting point. But DOE should position the CHPS to expand the boundary in the near-term to include downstream hydrogen activities.

Leaning in on existing global frameworks in support of the CHPS is sensible, notably to harmonize policy and investment signals for developers across jurisdictions. In fact, a call for such global harmonization featured in the key recommendations outlined in the recently published Breakthrough Agenda report (hydrogen chapter) by the International Energy Agency, International Renewable Energy Agency and UN Climate Change High Level Champions. However, DOE should avoid strict adherence to those frameworks and instead leverage its strong national and international standing to push ambition forward where there is scope to do so. For example, the lifecycle boundaries currently defined by IPHE in the HPTF Working Paper are a good start but-- as IPHE (which DOE of course co-chairs) notes-- those can and are planned to be expanded in the near term to encompass downstream emissions linked to hydrogen infrastructure, transport and delivery. There is further strong global momentum pulling in this direction, manifested in the following initiatives (those are not comprehensive):

1- The global Breakthrough Agenda report which expressly calls for the expansion by no later than mid-decade of a globally harmonized emissions accounting methodology to downstream hydrogen activities;[3]
2- The voluntary global green hydrogen standard being developed by the Swiss-based Green Hydrogen Organisation (with North American company HyStor recently committing to ensuring its projects meet the standard): while the first phase of the standard was limited to capping green hydrogen production emissions, work is now gearing up to develop emissions for the storage, conversion and delivery of green hydrogen and its derivatives

DOE should therefore quickly pivot to expanding the emissions boundary to encompass downstream activities, in lockstep with global momentum and stepping into a leadership role where the latter stalls. For now, DOE should expressly note that future iterations of the CHPS (in no later than 5 years, per statutory language) will reflect an expanded emissions boundary encompassing those activities (in addition to hydrogen leakage emissions as noted in 1b) and 1c) above once emission rates are able to be feasibly assessed and/or estimated). This would also be consistent with the H2Hubs FOA, whereby DOE rightly sets the expectation that *"Delivery and storage infrastructure should be designed to minimize releases, leaks, and fugitive emissions. Any emissions or criteria pollutants associated with transport, delivery, and distribution will factor into the LCA of the H2Hub."*

3) Implementation

c) Should renewable energy credits, power purchase agreements, or other market structures be allowable in characterizing the intensity of electricity emissions for hydrogen production? Should any requirements be placed on these instruments if they are allowed to be accounted for as a source of clean electricity (e.g. restrictions on time of generation, time of use, or regional considerations)? What are the pros and cons of allowing different schemes? How should these instruments be structured (e.g. time of generation, time of use, or regional considerations) if they are allowed for use?

The framework that DOE will implement to characterize the emissions intensity of grid-connected electrolytic hydrogen is highly consequential and will make or break hydrogen's value

[3] International Energy Agency, International Renewable Energy Agency, UN Climate Change High Level Champions, The Breakthrough Agenda Report, 2022, https://iea.blob.core.windows.net/assets/49ae4839-90a9-4d88-92bc-371e2b24546a/THEBREAKTHROUGHAGENDAREPORT2022.pdf (page 61)

as a climate solution. Although this guidance is specific to the implementation of the CHPS and DOE hydrogen deployment funding, it is generally expected that whatever framework DOE adopts should equally apply to the manner in which 45V clean hydrogen tax credits are implemented (as Treasury will likely ---and should-- strongly lean in on DOE to define guidance for the implementation of the credits). The reason is threefold: 1) there is no valid argument for DOE to recommend a guidance that it deems rigorous for grid-connected electrolyzers in the context of IRA implementation and go on to adopt a different approach in implementing the CHPS; 2) the harmonization of the two structures is important to avoid sending bifurcated market and investment signals to developers and creating market confusion with different hydrogen projects subject to different operating requirements (e.g., electrolyzer projects in H2Hubs supported by DOE funds vs. electrolyzers elsewhere abiding by IRA guidelines); and 3) H2Hubs are meant to achieve commercial scale and long-run operations without DOE support or oversight, such that selecting H2Hubs that are committed to a rigorous emissions accounting framework and make commensurate investments will be critical. Given this ultimate – and sensible—harmonization of emissions accounting frameworks between CHPS and IRA implementation, the framework that DOE will implement for the CHPS will likely become the law of the land and define the long-run course of the nascent hydrogen market. In short, it is vital for DOE to get it right.

The risks of an insufficiently rigorous emissions accounting framework are twofold:

1. Subsidizing highly emitting electrolytic hydrogen sources powered by fossil plants -- which can be up to *twice* as emitting as today's "grey" hydrogen-- that induce net increases in system-wide emissions. DOE's own assessment finds that the margin of relying on average grid power is narrow (no more than 15%) before electrolytic hydrogen starts rapidly exceeding acceptable emissions thresholds, underscoring the importance of rigorous accounting systems. Net increases in grid emissions also risk stymying U.S. decarbonization efforts considering that the rapid decarbonization of the power sector in this decade is the mainstay of achieving both the U.S. 2030 NDC and net-zero GHGs by 2050. 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.
2. Undermining confidence in electrolytic hydrogen as a climate solution and in consequence, stalling market growth on account of societal opposition.

Considering the far-reaching implications, it is imperative for DOE to implement a rigorous emissions accounting framework that ensures the climate integrity of grid-connected electrolyzers. And by offering the largest subsidies for clean hydrogen in the world, IRA poses both an imperative and opportunity for DOE to adopt a world-leading framework that, if replicated, can put the global hydrogen market on a sound climate course.

We put forth key elements of our the NRDC-RMI joint comments to the Treasury concerning 45V tax credits implementation and drafted with support and collaboration from a host of leading organizations. DOE should adopt the same pillars and a similar framework in its implementation of the CHPS.

Criteria and Design Pillars

Practical Criteria

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

1. Sufficient rigor and stringency to avoid emissions increases on the grid and deliver on the requirement to reduce effective GHG emissions;
2. Implementability by DOE;
3. 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. It is our assessment that both frameworks have the potential to adequately satisfy the three criteria and internalize the design pillars, based on our own analyses and meaningful consultation with a range of stakeholders including clean energy companies, hydrogen developers, academics, and peer environmental groups. We strongly recommend that DOE further assess the emissions impacts, cost, and operational implications in a highly transparent process with meaningful socialization and engagement with a wide range of stakeholders including academics, grid operators, industry, and environmental groups.

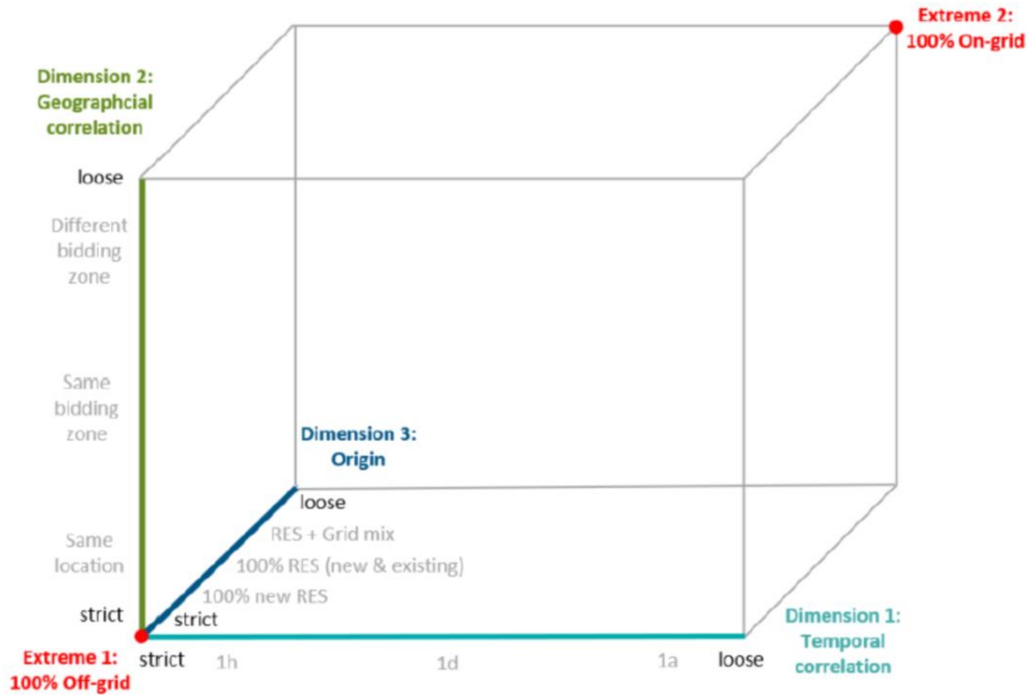
Design Pillars

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

Those pillars are based on three variables for which the stringency can be adjusted. Using the visualization below, we think that a strict origin, accurate temporal assessment of emissions impact, and moderately strict geographical correlation are critical to ensuring truly low emitting grid-connected hydrogen production.[4]

Figure 1. Regulatory dimensions



1. **Strict additionality is fundamental; a system without additionality is a non-starter**

Additionality is a key requirement to ensure that developers are offsetting the emissions of the new load from grid-connected electrolyzers. To offset emissions linked to new grid power consumption, electrolyzers must contract new clean generation to match this load. If electrolyzer loads are not paired with new clean generation, the grid will respond by ramping fossil generators to serve the new load. Existing renewable generators are already meeting loads on the grid, such that attributing this clean energy to electrolyzers would merely shuffle its attribution and contribute to no real emissions reductions on the grid, delaying the decarbonization of other sectors. A recent study by Princeton University (undergoing peer review) estimates that absent additionality requirements, grid-connected hydrogen projects could have an emissions rate that is up to 20 $kgCO_2e/kgH_2$.[5]

Mechanisms to demonstrate additionality require further assessment. DOE should evaluate a range of options and implement a rigorous framework. Considering the critical importance of

[4] https://cadmus.eui.eu/bitstream/handle/1814/74850/RSC_WP_2022_44.pdf?sequence=1&isAllowed=y
[5] Wilson Ricks, Qingyu Xu and Jesse D. Jenkins, "Enabling grid-based hydrogen production with low embodied emissions in the United States," Andlinger Center for Energy and the Environment, Princeton University, October 2022, https://zenodo.org/record/7183516#.Y1a6cXbMJPY

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 that 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 (H2Hubs grants and IRA tax credits) can significantly reduce cost impacts linked to additionality requirements. In fact, as we note below, the Princeton and European University Institute studies estimate that 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 DOE could make to increase the flexibility of the standard for a diversity of projects. Options include (and which DOE should further evaluate): allowing hydrogen projects to contract with repowered renewable energy projects (with the hydrogen project driving the repowering), providing a well-designed and time-bound grace period for project development and interconnection, and allowing curtailed clean power to qualify as additional (assuming that a robust framework is in place to verify that the clean power would indeed have otherwise been curtailed absent demand from the hydrogen project).

2. Regionality

Regionality establishes a geographical 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 constraints11, 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 simply displacing other renewable energy on their grid and/or displacing fossil resources resulting in emissions abatement that may not be proportionate to the electrolyzer's emissions. A lack of deliverability would therefore undermine the connection between the emissions linked to the electricity consumed by the electrolyzer and the emissions abatement delivered by the procured clean energy projects.

It is critical that any emissions accounting framework incorporate relevant spatial variability in power system dynamics and grid congestion/constraints, and impose operational guardrails to ensure clean energy resources powering electrolyzer loads are located in a region 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 generating. Temporal accounting can range from hourly (i.e. the electrolyzer only operates within the same hours the renewable project generates), to annual, to no restrictions (i.e., unbundled renewable energy credits and stored credits). The more granular the time period (i.e. hourly), the more assurance the government will have 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 sub-daily measurements are required for accurate emissions accounting.

In contrast, annual accounting schemes entail loose correlation between electrolyzer load and clean energy generation and allow electrolyzers that drive 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 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 EAC matching is ineffective at reducing electrolyzer emissions and results in hydrogen sources with very high emissions (up to 20 kgCO2/kgH2) qualifying for the 45V credit.[6] 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.[7] Hourly matching is emerging as a critical instrument, offering the necessary emissions accounting rigor.

For example, the Princeton study finds that requiring hydrogen producers to match their electricity consumption on an hourly basis with local clean generation can achieve the necessary low carbon intensities for hydrogen to be counted as a potential climate solution.

This mechanism is also receiving increased support from a growing range of stakeholders. 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 for 45V IRA tax credits. Engagement with these stakeholders should be a critical part of DOE's assessment process.

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[6] Wilson Ricks, Qingyu Xu and Jesse D. Jenkins, "Enabling grid-based hydrogen production with low embodied emissions in the United States" (page 8)

[7] Robert Schuman Centre for Advanced Studies
The Florence School of Regulation, Working Paper, Green hydrogen – How grey can it be?, 2022, https://cadmus.eui.eu/bitstream/handle/1814/74850/RSC_WP_2022_44.pdf?sequence=1&isAllowed=y

Two Potential Systems to Reduce Effective Emissions

We recommend two potential systems for consideration that internalize the above pillars and satisfy the three criteria relating to emissions accounting rigor, implementability by agencies, and reasonableness for industry. The following table provides an overview of both, followed by a description of the key elements of each.

1. **Overview of key features of the 24/7 Carbon Free Electricity (CFE) and Marginal Emissions Accounting frameworks (compared with a weak Annual Accounting Framework Without Additionality)**

The table below compares the core features of three different accounting schemes:

- **Hourly matching of carbon free electricity** - a leading approach for ensuring that grid electricity is offset through timely procurement of clean energy sources.
- **Hourly marginal emissions accounting** - directly measures and offsets emissions from grid electricity.
- **Annual accounting without additionality** allows environmental attribute certificates 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, the third is a weak framework that risks subsidizing highly emitting hydrogen sources and should be a non-starter; we add it here for comparison purposes.

	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. The tighter the regional boundaries, the greater the emissions reductions and deep grid decarbonization. However, tighter	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	No regionality requirements.

	regionality can also increase costs.	within cleaner grids. Narrower regional boundaries can support deliverability of new clean energy.	
Temporal Matching	Hourly matching.	Flexibility in the granularity of these measurements. Hourly measurement of both induced CO2 from electrolyzer operation and avoided CO2 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 risks stepping in to meet overall load and emissions increase.

2. 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.[8] 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.[9] A DOE framework 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 a degree of 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, largely owing to the generous IRA tax subsidies for both clean hydrogen and renewable energy projects. 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.[10]

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. This flexibility to ramp up operations when renewables are

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[8] Executive Order, Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability, https://www.federalregister.gov/documents/2021/12/13/2021-27114/catalyzing-clean-energy-industries-and-jobs-through-federal-sustainability

[99] 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.

[10] Bellona signs letter for the European Commission to decide on RFNBO delegated act to enable informed debate and vote in the European Parliament and Council, 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;

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.[11]

3. Marginal Emissions Accounting

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).

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 slightly 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). This challenge may be alleviated by the directive included in the Infrastructure Investment and Jobs Act requiring the Energy Information Administration to collect and publish estimated marginal emissions rates for different balancing authorities and nodes. However, this process is in early stages and unclear when that data would be available at the scale needed for this system.

Additionally, 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 CHPS compliance.

Developers will need to model future marginal emissions rates and induced emissions offsets, which may inject additional risk and cost.

4. Comparing the 24/7 and Marginal Emissions Accounting Frameworks

[11] Eric Gimon, "How utilities can harness green hydrogen production's flexibility in balancing a high-renewables grid", June 2022, UtilityDive, https://www.utilitydive.com/news/how-utilities-harness-green-hydrogen-productions-flexibility/626096/

The following table compares the two frameworks based on cost efficiency, implementability, and effectiveness at incentivizing useful technologies and solutions.

	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 implementation of the CHPS, in particular as it relates to the accounting framework for grid-connected electrolyzers, will have strong bearing on the nascent clean hydrogen market. It is projected that the CHPS and its implementation mechanisms will be the de-facto national standard, with several states already moving to adopt and/or legislate the CHPS as a state standard. It is therefore imperative that DOE formulates a rigorous system from the outset to avoid derailing the U.S. bid to meet its 2030 and 2050 climate goals and undermine confidence in the nascent clean hydrogen market. Considering the complexity of the issue, we strongly recommend that DOE conduct in-depth assessments of various accounting frameworks, guided by and aiming to deliver on the intent of our design pillars. The process should be highly transparent and collaborative, with strong stakeholder engagement – including with academics, grid operators, industry and environmental organizations—and periodic touchpoints for feedback. DOE may wish to convene a task force to meaningfully engage on this effort.

We thank DOE for this opportunity for feedback and look forward to working with all relevant DOE offices on the design and implementation of the CHPS.

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