EDF
ENVIRONMENTAL
DEFENSE FUND®
Finding the ways that work

December 3, 2022

Office of Associate Chief Counsel
(Passthroughs and Special Industries)
Treasury Department
Submitted electronically via the Federal eRuelmaking Portal

RE: United States Treasury Department's Request for Comments on Credits for Clean Hydrogen and Clean Fuel Production. Notice 2022-58

Environmental Defense Fund (EDF) appreciates the opportunity to provide comments on Treasury's implementation of the Clean Hydrogen and Clean Fuel Production credits (§ 45V and § 45Z) of the Inflation Reduction Act (IRA). Representing over 3 million members and supporters, EDF has been actively pursuing solutions to global climate change for over 30 years.

We would be glad to clarify or elaborate on any of the points made in the comments below. If there are any questions, Treasury staff can feel free to contact Dr. Pedro Piris-Cabezas (ppiris@edf.org), Senior Director, Global Transportation & Lead Senior Economist (45Z) and Akin Olumoroti (aolumoroti@edf.org), Senior Policy Analyst, Federal Climate Innovation (45V).

.01 Credit for Production of Clean Hydrogen (§ 45V)

The IRA provides generous funding for clean hydrogen production, which stands to play a significant role in the evolution of the hydrogen economy. Clean hydrogen offers the potential to solve pressing energy challenges for 'hard-to-abate' sectors such as industrial production and global transport, which have a few readily available alternatives to fossil fuels and feedstocks. However, it will be important to ensure that hydrogen is truly clean in terms of GHG intensity, as well as ensure that production is not overly incentivized relative to industry needs.

Our comments here echo many of the same themes submitted in an earlier set of comments on 11/4, with some elaboration. In particular, we call on Treasury to work with DOE to ensure that GHG intensity assessments are rigorous and account for both accurate upstream methane emissions and downstream hydrogen and CO2 emissions. We also offer feedback on proper verification of GHG emissions, accounting measures for on-grid renewable electricity, and the importance of avoiding windfall profits for producers.

1. **Clean Hydrogen. Section 45V (IRA) 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)."[1] Which specific steps and emissions should be included within the well-to-gate system boundary for clean hydrogen production from various resources?**

Considering the far-reaching implications of the 45V credits, it is critical that Treasury implements a rigorous lifecycle emissions accounting framework with a wide system boundary. As the Treasury notes in its "well-to-gate" definition, this should include upstream processes (e.g., electricity generation; feedstock extraction or production, treatment and delivery; fugitive emissions), hydrogen production itself (e.g., fuel combustion, fugitive emissions, and process emissions), and downstream processes associated with CO_2 transport and sequestration. It should also include management of other fugitive emissions like hydrogen throughout the value chain.

Upstream Scope 2 Emissions
The inclusion of upstream Scope 2 emissions in the draft clean hydrogen production standard from energy consumption is extremely important. Overlooking these emissions would incentivize hydrogen resources that pose serious climate risks – including steam methane reformers that source gas linked to high methane leakage, as well as electrolyzers powered by fossil fuel-based electricity generation. For example, an electrolyzer powered by the average U.S. electricity grid mix would register a carbon intensity as high as 20 $kgCO_2e/kgH2$ -- nearly double the carbon intensity of today's incumbent and unmitigated gas-based hydrogen production pathway.

It is important that these estimates are as accurate as possible, particularly given the range of methane leakage rates associated with different regional energy sources and the extent to which this can affect overall lifecycle emissions. (See response to 1b for more information.)

Downstream CO2 Emissions
In addition, the lifecycle assessment should include downstream emissions from carbon sequestration. It is the hydrogen producer's responsibility to demonstrate secure sequestration of carbon dioxide emissions (where applicable), as CO_2 is a direct byproduct of fossil fuel based hydrogen production. DOE has recognized this point and included carbon sequestration in its proposed Clean Hydrogen Production Standard; Treasury should be explicit that it is following suit.

Hydrogen Emissions
In addition to carbon dioxide and methane emissions, lifecycle assessments must also account for hydrogen emissions, in both production and downstream processes. Hydrogen is a short-lived, indirect GHG that causes warming by increasing the concentration of other GHGs in the atmosphere. It is also a small and slippery molecule that can easily escape from all parts of the value chain. Recent studies found hydrogen's warming

---

[1] 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.

power is over 30 times larger than CO_2 pound for pound over the 20 years after it is emitted, and about 10 times larger over 100 years – values that are 2-6 times higher than previously thought.[2] EDF research shows that if the hydrogen emission rate is high across the value chain, it can severely undermine the intended benefits of clean hydrogen.[3]

Calculations suggest that this emissions source may have a material effect on GHG intensity when both direct and indirect warming are considered. For illustration, we estimate that for a blue hydrogen facility with a 90% capture rate and 2.3% methane leakage rate, limiting hydrogen emissions to 1% would yield a GHG intensity of 3.2 $kgCO_2e$ /kgH2. However, under a high hydrogen emissions scenario of 10%, GHG intensity would rise to 4.5 $kgCO_2e$/kgH2 - falling below the 45V standard.[4]

Currently, estimates of hydrogen leakage rates range considerably, due to a lack of empirical data on leakage from specific infrastructure such as electrolyzers, pipelines, and storage.[5] Studies on hydrogen leakage often rely on natural gas supply chain leakage as a proxy, and there is a high degree of uncertainty in existing methane emission estimates. Moreover, the patterns of hydrogen leakage can be different from that of methane, with fluid dynamics theory suggesting that hydrogen can leak 1.3 to 3 times faster than methane, and experimental studies suggest different leak rates for different leak regimes.

However, development of appropriate sensor technologies is currently underway which would enable such measurement. See 4b for more information.

EDF believes that LCAs should be expanded to include additional downstream Scope 3 emissions that would have a material effect on climate outcomes – including not only production emissions, but also those associated with liquefaction, compression, storage, transport, delivery, and distribution. The IPHE framework of life cycle emissions suggests that one criterion by which system boundaries should be judged is the materiality of the emissions and whether they are projected to decline in the future (i.e., this is the rationale for

---

[2] Ocko, Ilissa and Hamburg, Steve (2022). “Climate consequences of hydrogen leakage.” Atmospheric Chemistry and Physics. Vol. 22, Issue 14. https://acp.copernicus.org/articles/22/9349/2022/; and Warwick et al., (2022). “Atmospheric Implications of Increased Hydrogen Use”. Department for Business, Energy & Industrial Strategy. https://www.gov.uk/government/publications/atmospheric-implications-of-increased-hydrogen-use

[3] Ocko, Ilissa and Hamburg, Steve (2022). “Climate consequences of hydrogen leakage.” Atmospheric Chemistry and Physics. Vol. 22, Issue 14. https://acp.copernicus.org/articles/22/9349/2022/

[4] Assumes a SMR baseline of 10 kg CO2 / kg H2

[5] Hydrogen emissions associated with production include both unintended leakage and intentional purging/venting (which can be controlled by incorporating technology that recombines purged and vented hydrogen back into the production process). Overall, estimates of emissions associated with electrolytic hydrogen production currently range from 0.1% to 9.2%. Blue hydrogen production is estimated to have less than 1.5% hydrogen emissions, since waste gas is likely to be flared or used for process heat. Hydrogen also has the potential to leak from various delivery segments of the value chain, including compression, liquefaction, storage, and transportation via pipelines or trucks. Overall, current estimates of leakage rates for the full hydrogen value chain, including production, processing, storage and delivery, range up to 20%.

Estimates include Cooper et al., (2022). “Hydrogen emissions from the hydrogen value chain-emissions profile and impact to global warming”. Science of the Total Environment. Vol. 830. https://linkinghub.elsevier.com/retrieve/pii/S004896972201717X; Frazer-Nash Consultancy (2022). “Fugitive Hydrogen Emissions in a Future Hydrogen Economy”. https://www.gov.uk/government/publications/fugitive-hydrogen-emissions-in-a-future-hydrogen-economy; Arrigoni, A. and Bravo Diaz, L. (2022). “Hydrogen emissions from a hydrogen economy and their potential global warming impact”. Publications Office of the European Union, Luxembourg. doi:10.2760/065589, JRC130362; and Schultz et al., (2003). “Air Pollution and Climate-Forcing Impacts of a Global Hydrogen Economy”. Science, Vol. 302. https://www.science.org/doi/10.1126/science.1089527 not including emissions from construction of capital goods or business travel).[6] Under this same criterion, downstream hydrogen emissions should be considered because they are material and are not projected to decline in the absence of targeted mitigation measures.

Thus, the Treasury should note in its advisory to project developers the importance of hydrogen emissions and an intent to empirically account for hydrogen emissions in LCAs once it becomes technically feasible to do so. This includes working with DOE to ensure that the necessary reporting and verification structures and calculation tools (like GREET) are capable of incorporating hydrogen emission rates and warming potential. In the meantime, Treasury should work with the DOE to adopt reasonable interim hydrogen emissions rate estimates for different production processes and life cycle phases that can be incorporated into project developers' LCAs.

GWP Time Horizons

The global warming potential (GWP) metric allows comparisons of different pollutants against the warming potency of carbon dioxide over a specified time interval. GWP100 is the most commonly utilized metric. While GWP100 is a ratio of a pollutant's warming potency relative to carbon dioxide over 100 years, it hides the near-term potency of short-lived gases like methane and hydrogen. For example, methane's 100-year global warming potential is 27-30 times that of carbon dioxide, while its 20-year global warming potential is 80-83 times higher.[7] Hydrogen's GWP for a 20-year time horizon similarly yields a potency that is 3 times its 100-year impact, which is much higher than commonly thought and critical to account for the next couple of decades to curb emissions.

Extreme climate events such as hurricanes and heatwaves have shown to increase in probability based on a warming rate, rather than a global warming level.[8] The path dependency of such record-shattering climate events is evidence that near-term warming is as much a concern as long-term warming over the course of the century. With high emissions, extreme events that are nearly impossible in the absence of warming become more likely in the coming decades. Given that the impacts of climate change are already perceptible across societies and ecosystems on every continent and in every ocean, we must minimize near-term warming as much as possible to limit further damage.[9] It is important to standardize the use of additional metrics, such as GWP20, that convey the near-term impacts of hydrogen use alongside GWP100.

---

[6] IPHE, pg. 25, https://www.iphe.net/_files/ugd/45185a_ef588ba32fc54e0eb57b0b7444cfa5f9.pdf

[7] Forster, P., T. Storelvmo, K. Armour, W. Collins, J.-L. Dufresne, D. Frame, D.J. Lunt, T. Mauritsen, M.D. Palmer, M. Watanabe, M. Wild, and H. Zhang, 2021. The Earth's Energy Budget, Climate Feedbacks, and Climate Sensitivity. In *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 923–1054, doi: 10.1017/9781009157896.009

[8] Fischer, E.M., Sippel, S. & Knutti, R, 2021. Increasing probability of record-shattering climate extremes. *Nat. Clim. Chang.* **11**, 689–695. https://doi.org/10.1038/s41558-021-01092-9

[9] Sun, Tianyi, *et al.*, 2021. Path to net zero is critical to climate outcome. *Scientific Reports* 11, https://www.nature.com/articles/s41598-021-01639-y; and Ocko, Ilissa *et al.* Unmask temporal trade-offs in climate policy debates. *Science* **356**, 492–493 (2017), https://www.science.org/doi/10.1126/science.aaj2350.

Incorporating 20-year time horizons into LCAs is straightforward: Use GWP factors 80 (83 if fossil origin) for methane, and 33 for hydrogen. Treasury should work with DOE and the Argonne National Laboratory to better integrate this capability in GREET and require hydrogen producers calculate and report an alternative LCA using GWP20, in addition to the standard GWP100.[10]

Evaluation Cycle

We recommend that hydrogen LCAs be conducted on a yearly basis. Treasury should not only require an initial LCA to determine alignment with the CHPS, but it should specify that this evaluation must take place every year and anytime there is a material change in the hydrogen production process to remain compliant.

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?

Although the Inflation Reduction Act specifies GREET as the standard tool for emissions accounting for hydrogen production, there are still significant gaps in emissions accounting methodology for green hydrogen production. In particular, the GREET model does not currently incorporate hydrogen emissions, is primarily focused on transportation as an end use, and provides insufficient granularity regarding methane emissions. As Treasury and DOE more clearly establish the parameters of the clean hydrogen standard and the necessary reporting processes, they should ensure that the model is properly updated in order to comprehensively account for and assess emissions in a manner that fits the current standard and its future evolution.

Hydrogen Emissions & Temporal Dynamics in GREET

To have a thorough accounting for clean hydrogen production emissions as the hydrogen economy develops, GREET will need to begin incorporating hydrogen as a greenhouse gas and add shorter timeframes for global warming potentials of short-lived pollutants like hydrogen and methane. Within GREET, the default global warming potentials of these greenhouse gases are presented as 100-year values, which underestimates the damage done by short-lived greenhouse gases. GREET should include an advisory about using GWP20 values as well to estimate the climate impacts of methane. Moreover, hydrogen, which is a powerful indirect greenhouse gas that triggers warming effects in the atmosphere for a decade after it is emitted, should also be included as an emissions source within GREET.[11]

End Uses in GREET

Currently, GREET is primarily a transportation focused model. It can comprehensively evaluate energy and emissions impacts of advanced and new fuels and the fuel cycle from well to wheel. However, hydrogen will have other end uses beyond transportation, and the

---

[10] GREET currently includes a GWP20 option, but it's not a default option and is difficult to incorporate into LCAs.

[11] Incorporating 20-year time horizons into LCAs can easily be done, utilizing GWP factors 80 (83 if fossil origin) for methane, and 33 for hydrogen.

current model is not well-suited to conduct full lifecycle analysis for non-transportation applications (apart from steel production). GREET should be updated to ensure its accuracy in non-transportation applications, as well as any temporal implications.

Methane Emissions Estimates in GREET
It is important that upstream methane emissions rates are as accurate as possible, particularly given the range of methane leakage rates associated with different regional energy sources and the extent to which this can affect overall lifecycle emissions. Based on Table 1 of Argonne's Hydrogen Life-Cycle Analysis in Support of Clean Hydrogen Production,[12] GREET currently applies a nominal upstream methane leakage of 1% (or 2% for high) in the bottom-up/top-down hybrid approach (which is based on updating the EPA's GHGI using Alvarez et al.[13] and Rutherford et al.[14] studies). However, Alvarez et al. finds a national average leak rate of 2.3%. Additionally, other recent empirical studies have indicated much larger values for certain wet-gas production basins.[15] The upstream methane leak rate is a major contributor to overall lifecycle emissions in hydrogen production pathways utilizing natural gas as a feedstock.

Therefore, Treasury should consider pathways toward incorporating basin-specific methane estimates, including working with DOE to update current GREET estimates based on the best available data from published academic studies or verified third party measurement platforms utilizing established methodologies.

e. (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?

EDF supports NRDC and RMI's comments on the importance of developing a rigorous renewable electricity accounting framework for grid-connected electrolyzers that ensures system-wide GHG emissions.

As noted in the comments, annual accounting systems that allow unbundled EACs should be a non-starter because of their carbon emissions impacts. As a rule, the more granular the time period (i.e., hourly matching), the more assurance regulators and policymakers will have that hydrogen producers are effectively offsetting induced emissions from their grid-connected power electrolyzers with clean energy resources 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. Annual

---

[12] Argonne National Laboratory, *Hydrogen Life-Cycle Analysis in Support of Clean Hydrogen Production,* https://greet.es.anl.gov/publication-hydrogenreport2022

[13] Alvarez et al., Assessment of Methane Emissions from the U.S. Oil and Gas Supply Chain, 361 Science 186 (2018), https://science.sciencemag.org/content/361/6398/186.

[14] Rutherford et al., Closing the Methane Gap in US Oil and Natural Gas Production Emissions Inventories, 12 Nature Comms. 4715 (2021), https://www.nature.com/articles/s41467-021-25017-4#citeas.

[15] *See, e.g.*, Lin et al., *Declining methane emissions and steady, high leakage rates observed over multiple years in a western US oil/gas production basin*, 11 Sci. Reports 22291 (2021) ,https://www.nature.com/articles/s41598-021-01721-5 (finding a steady leak rate of 6-8% over six years in the Uinta Basin); Chen et al., *Quantifying Regional Methane Emissions in the New Mexico Permian Basin with a Comprehensive Aerial Survey*, Environ. Sci. Technol. 2022, 56, 7, 4317–4323 (2022), https://doi.org/10.1021/acs.est.1c06458 (finding a 9% leak rate in the New Mexico Permian).

matching requirements alone does not reduce emissions and results in hydrogen sources with very high emissions.[16] Hourly matching requirement is also receiving support from leading organizations like M-RETs, EnergyTag and Singularity, who are confident that a nationwide system could be designed, implemented and enforceable in time for clean hydrogen project development, and in line with statutory requirements.[17] Engagement with these stakeholders should be part of the Treasury's evaluation process.

See response to 4b for more details.

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 that the taxpayer produces.**
    b. **What criteria should be considered by the Secretary in making a determination regarding the provisional emissions rate?**

The Secretary should consult with DOE and Argonne National Laboratory to verify the provisional emissions rate and have the relevant production process included in the GREET model. These provisional rates should also be made public and open to stakeholder feedback.

4. **Recordkeeping and Reporting**

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

Guidance on Hydrogen Monitoring and Mitigation
45V states that "Not later than 1 year after the date of enactment of this section, the Secretary shall issue regulations or other guidance to carry out the purposes of this section, including regulations or other guidance for determining lifecycle GHG emissions." As part of this process, Treasury should include guidance on the importance of monitoring and mitigating hydrogen and methane leakage. DOE has already noted the importance of addressing leakage, stating in its National Clean Hydrogen Strategy and Roadmap, "It will be important to develop measurement and monitoring solutions and to factor in hydrogen leakage risks into decisions to build out hydrogen transport infrastructure." While DOE has indicated intent to address hydrogen leakage risks in its hydrogen hub investments,[18] Treasury must

---

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

[17] EnergyTag and Granular Energy Certificates, Accelerating the Transition to 24/7 clean power - https://www.energytag.org/wp-content/uploads/2021/05/EnergyTag-and-granular-energy-certificates.pdf

[18] DOE states in its Regional Clean Hydrogen Hubs FOA, "It will be imperative for H2Hubs to mitigate any hydrogen losses from an economical, safety, and environmental impact perspective. 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 H2Hubs." DOE also notes, "DOE is actively developing sensor technologies to detect and quantify hydrogen leaks at a part per billion level. As these sensors come become commercially available in the coming years, DOE may require H2Hubs to install both indoor and outdoor sensors to ensure monitoring, data collection, and risk mitigation related to hydrogen losses." https://oced-exchange.energy.gov/Default.aspx#FoaId4dbbd966-7524-4830-b883-450933661811

take similar steps as well, given that 45V stands to drive wide scale hydrogen deployment across the country.

This includes requiring producers to include empirical hydrogen emissions in their LCAs, once determined to be technically feasible (and in the meantime, working with DOE to develop suitable estimates). Treasury should also require companies to develop and submit a plan for monitoring and mitigating hydrogen and methane leakage. These plans should describe steps taken by the facility to detect and reduce leakage and should be consistent with all safety and other regulations or guidance in effect. These plans should be developed and reported to Treasury within 12 months of receiving the credit; failure to comply would result in recapture of the credit.

Technologies and Solutions for Mitigating Hydrogen Emissions
Empirical data collection is needed to understand site level hydrogen emissions at commercial facilities. EDF has learned, through decades of work on methane emissions measurement and quantification, that component level emission factors can lead to severe underestimation of real-world emissions.[19] Facility level data collection and emission quantification requires high frequency (seconds) and high sensitivity (low ppb level) sensing technologies and well demonstrated dispersion models. While emission factors can be a useful tool to estimate total supply chain emissions, they should be verified with empirical data.

The types of sensors required to monitor hydrogen leakage at sufficient precision and frequencies are still in the early demonstration stage. However, they are likely to become commercially available on a similar timeframe as major hydrogen deployment.
While the requisite sensor technologies are being developed, the industry should make plans to implement (and budget) for hydrogen measurement, reporting and verification systems, as well as leakage and repairs.

In the meantime, the industry should explore several common-sense best practices that may reduce hydrogen leakage, including but not limited to:

- Minimizing boil-off and otherwise eliminating venting of hydrogen gas, applying oxidation for vented gas when possible
- Proper treatment of hydrogen losses during electrolysis, such as recombination of hydrogen with oxygen
- Stronger insulation of pipes and storage vessels, as well as proper materials (e.g., plastic lining)
- Minimizing transport and delivery / co-locating facilities
- Minimizing points of pressurization and depressurization
- Regular facility inspections

Methane Monitoring
On the methane front, a broad range of advanced monitoring technologies are already commercially available and can be utilized by operators to detect, pinpoint and quantify

---

[19] Alvarez, Ramon, et al. (2018). "Assessment of Methane Emissions from the U.S. Oil and Gas Supply Chain." https://www.science.org/doi/10.1126/science.aar7204

fugitive emissions. [20] Widespread adoption and deployment of these technologies – even in the absence of regulatory requirements – demonstrates their cost-effectiveness and the opportunity to incorporate these methods into a regulatory scheme. These advancements should be integrated into the framework of a regulatory scheme, and hydrogen producers should be required to detail their use in a methane mitigation plan.

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

EDF supports NRDC and RMI's comments on the importance of developing a rigorous renewable electricity accounting framework for grid-connected electrolyzers that ensures system-wide GHG emissions. We present key highlights below.

Grid-connected electrolyzers will need to rely on mechanisms like energy attributes certificates (EACs) and power purchase agreements (PPAs) to offset their emissions. However, not all clean EACs are made equal – and any such book-and-claim system must reduce effective, system-wide greenhouse gas emissions while at the same time ensure that only EACs and PPAs that are consistent with bidding zones and restrictions are eligible (i.e., see details on additionality, regionality, and granular temporal accounting below).

We recommend Treasury work with DOE to implement a two-step approach committing to effective accounting pillars for grid-connected electrolyzers. In the near term, Treasury and DOE should use the GREET model to assess hydrogen projects' carbon intensity – using either the grid average for a grid-connected electrolyzer, or a site-specific number for on-site projects. In the medium term, Treasury and DOE should create a technical working group (including EPA and EIA) to establish a robust electricity emissions accounting framework.

Such a framework should, at minimum, meet the following requirements:
- It should have sufficient rigor and stringency to avoid emissions increases on the grid and deliver on the requirement to reduce effective GHG emissions;
- It should be implementable by relevant agencies of government, including Treasury; and
- It should have a measure of certainty and practicality for industry so as not to hinder the economics and market lift-off of grid-connected electrolytic hydrogen.

Given these requirements, the following three key principles are critical for ensuring a truly low emitting regime of green hydrogen production:
- **Additionality**: 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, which could substantially increase net emissions.
- **Regionality**: An emission accounting framework should incorporate relevant spatial variability in power system dynamics and grid congestion and impose operational

---

[20] Highwood Emission Management, Technical Report: Leak detection methods for natural gas gathering, transmission, and distribution pipelines (2022), https://highwoodemissions.com/wp-content/uploads/2022/04/Highwood_Pipeline_Leak_Detection_2022.pdf

guardrails to ensure clean energy resources powering electrolyzer loads are located in a region that allows for reasonable electricity delivery.

- **Granular Temporal Accounting**: The more granular the time period (i.e., hourly matching), the more assurance regulators and policymakers will have that hydrogen producers are effectively offsetting induced emissions from their grid-connected power electrolyzers with clean energy resources 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.

The framework should also encourage the use of surplus renewable electricity to fully exploit the synergies from the decarbonization of the power sector. The transition to renewables-based power generation system the United States is embarked on means that pairing surplus renewable electricity with the production of e-fuels could generate valuable ancillary benefits through grid-balancing services. Indeed, once large wind or solar capacity is in place power production becomes intermittent, and the ability to manage the load becomes a critical feature for balancing the grid. These benefits can significantly reduce the electricity cost for green hydrogen production through power purchase agreements with interruptible demand provisions, accelerating its uptake while addressing the risk of displacement emissions.

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?

A robust emissions verification system is central to the proper classification of hydrogen produced and the allocation of proper incentive levels. Moreover, establishing a strong verification system stands to yield other benefits, such as certainty that what buyers are procuring is truly clean hydrogen.

Verification of Hydrogen Production Emissions
To verify emissions from hydrogen production, Treasury should work with DOE to require hydrogen emissions monitoring, reporting and verification across the value chain. While this is already feasible and should be required for certain segments of the value chain (e.g., methane leakage from oil and gas production), other segments may require the use of models and other estimation tools (e.g., hydrogen leakage).

To help assess whether a deployment aids in achievement of the CHPS, Treasury can look to existing emissions and activity data in EPA's Greenhouse Gas Reporting Program (GHGRP).[21] While there are known issues of under-reporting for certain sectors within the GHGRP,[22] it provides a foundation for generating emission estimates based on reported data that Treasury could work with EPA and DOE to improve for use in this context. Greenhouse

---

[21] Greenhouse Gas Reporting Program (GHGRP) - https://www.epa.gov/ghgreporting

[22] Rutherford et al., Closing the Methane Gap in US Oil and Natural Gas Production Emissions Inventories, 12 Nature Comms. 4715 (2021), https://www.nature.com/articles/s41467-021-25017-4#citeas.

gas emissions from a wide variety of sectors report emissions to this program and can be used to help estimate actual emissions from hydrogen deployments.[23]

GHGRP data, however, is not fully comprehensive—not all facilities are required to report, not all sectors are covered, and emissions of hydrogen are not currently reported. And, in many cases, reported data is not based on actual monitoring and measurement. We therefore recommend that Treasury use this data when it is available and accurate but supplement it with additional information (e.g., hydrogen production flow chart, list of raw materials for hydrogen production and their associated GHG emissions, energy metering system diagram, etc.) whenever necessary. And while emission estimates reported to the GHGRP are useful in the near-term, Treasury should ultimately ensure CHPS is achieved in practice through verification procedures, including periodic monitoring and measurement of actual emissions.

Oil and gas facilities that would likely supply natural gas to future commercial-scale deployments of blue hydrogen already report their methane emissions data to the EPA through subpart W of the GHGRP. These reporting protocols, which are currently under revision and must be further updated in accordance with a Congressional directive in the IRA,[24] provide data that can be used in assessing upstream emissions of blue hydrogen deployments. Treasury should also consider requiring more rigorous monitoring and reporting of upstream methane emissions for facilities supplying natural gas used to make blue hydrogen.

In addition to reporting on upstream methane emissions, the GHGRP requires hydrogen production facilities to report CO_2, methane, and N_2O emissions. Reporting facilities include "process units that produce hydrogen by reforming, gasification, oxidation, reaction, or other transformations of feedstocks."[25] We encourage Treasury to work with EPA and DOE in evaluating these reporting requirements and consider whether additional revisions to hydrogen production facility reporting standards are necessary for accuracy and to encompass emerging forms of production.

Treasury should also analyze upstream GHG emissions from electricity used to produce hydrogen. This may require working with EPA to require reporting of electricity consumption data. EDF recently recommended that EPA require reporting of data on energy consumption by facilities that are already subject to reporting requirements under the GHGRP, as well as by facilities that meet certain thresholds for overall energy consumption and/or energy-use capacity (depending on the type of facility).[26] In collecting this data, we

---

[23] We note that for certain sectors, only larger facilities are required to report (those emitting >25,000 CO2e). Therefore, GHGRP data may not capture all emissions, and in these cases, DOE should use other available tools to supplement and ensure accuracy.

[24] *See* 42 U.S.C. § 7436(h) (directing EPA to "revise the requirements of subpart W . . . to ensure the reporting under such subpart, and calculation of [the methane waste charge], . . . accurately reflect the total methane emissions and waste emissions from the applicable facilities" by August 2024).

[25] 40 C.F.R. Part 98, Subpart P- Hydrogen Production, https://www.ecfr.gov/current/title-40/part-98/subpart-P

[26] *See* EDF Comments on Revisions and Confidentiality Determinations for Data Elements Under the Greenhouse Gas Reporting Rule, 87 Fed. Reg. 36,920, at 80, https://blogs.edf.org/energyexchange/files/2022/10/EDF-GHGRP-Comments-10.6.2022-Final.pdf; *see also id.* at 9-14 (explaining how such reporting could apply to electrolysis facilities).

recommend distinguishing between purchases of electricity and other forms of energy, and for electricity specifically, gathering data on a wider range of attributes.

In addition, reported GHG emissions data should be publicly available through a web-based data repository to maintain easy accessibility and transparency, so that organizations are able to track progress over time and identify opportunities to further reduce pollution.

Verification of Upstream Methane Rates
We recommend two pathways for ensuring developers use accurate upstream methane emissions data in determining rates specific to their deployment. First, developers could use methane emissions data reported by oil and gas companies to subpart W of the GHGRP. The IRA recently directed EPA to update these methods to ensure reporting is based on empirical data to improve the accuracy of both the basin averages and individual company data. Second, gas used for hydrogen production could be subject to independent monitoring, reporting, and verification (MRV) requirements. To credibly ensure gas is produced with low methane emissions, comprehensive direct measurement and independent verification and transparency around intensity calculations are needed. We have provided more details about these two approaches in comments submitted to the EPA and DOE.[27]

Transparency
It is critical that LCA estimates submitted to the Treasury be made publicly available, particularly for projects receiving public support and funding. The hydrogen economy is in its infancy, and these early tax incentives are intended to facilitate quick learning, provide opportunities to test concepts and refine processes before the hydrogen economy fully takes off. Making the LCAs and other relevant documentation submitted to the Treasury by those seeking to claim tax credits public will allow for the necessary public engagement in the process and facilitate crucial learning.

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

Denial of Double Benefit with 45Q
EDF unequivocally supports the current prohibition of double benefit between 45V and 45Q. Combining both tax credits would greatly over-incentivize the production of hydrogen from fossil fuel sources.

Duration
The 45V clean hydrogen production tax credit provides a high degree of policy support for hydrogen projects that meet particular GHG intensity thresholds, offering up to $3/kg for the cleanest forms of hydrogen. These credits apply to facilities with construction beginning before January 1, 2033 and are provided for 10 years.

While some amount of tax credit may be appropriate to facilitate the development of a clean hydrogen industry and reduce costs, the combined level and duration of this subsidy risks over-incentivizing clean hydrogen production. Costs of renewable electrolytic hydrogen were

---

[27] *See* EDF Comments on Revisions and Confidentiality Determinations for Data Elements Under the Greenhouse Gas Reporting Rule, 87 Fed. Reg. 36,920, at 80, https://blogs.edf.org/energyexchange/files/2022/10/EDF-GHGRP-Comments-10.6.2022-Final.pdf; see. Pgs. 17-22

already projected to fall below $3/kg by 2030, even before this PTC came into effect, due in part to declining electricity costs.[28]

The Treasury should carefully monitor the markets and report to Congress with recommendations if changes are necessary. For instance, Treasury could request that Congress consider implementing a phase-down period to better align with projected cost declines. For example, credits could begin phasing down in 2028, reaching $0 by 2033. At a minimum, Treasury should ensure that the credit does not result in windfall profits (i.e., that a facility's claimed credit levels do not exceed production costs) – including by requiring facilities to report per unit production costs on an annual basis.

.02 Comments on Credits for Clean Fuel Production (§ 45Z)

The comments below offer a number of recommendations for the Treasury to consider in its efforts to maximize the tax credits' benefits in mitigating greenhouse gas (GHG) emissions in a sustainable manner. These comments focus on the applications to sustainable aviation fuels, with a focus on ensuring reductions in the aviation sector's climate impacts.

While EDF's comments would a priori be relevant for the full spectrum of fuels, we would like to emphasize the importance of alternative fuels for aviation, as these become particularly relevant for the aviation sector and the Administration's Sustainable Aviation Fuels (SAF) Grand Challenge. Over the past decade, EDF has been highly engaged in climate policy at the International Civil Aviation Organization (ICAO), leading and participating in expert working groups developing ICAO's Sustainability Framework for SAF – an effort that builds heavily on United States programs as well as other programs from other parts of the world. In parallel, EDF has also been highly engaged in efforts at the United States Congress with regards all SAF tax credits included in the Inflation Reduction Act of 2022.

2. **Establishment of Emissions Rate for SAF. Section 45Z(b)(1)(B)(iii) provides that the lifecycle greenhouse gas emissions of sustainable aviation fuel shall be determined in accordance with the Carbon Offsetting and Reduction Scheme for International Aviation or "any similar methodology which satisfies the criteria under § 211(o)(1)(H) of the Clean Air Act (42 U.S.C. 7545(o)(1)(H)), as in effect on the date of enactment of this section." What methodologies should the Treasury Department and IRS consider for the lifecycle greenhouse gas emissions of sustainable aviation fuel for the purposes of § 45Z(b)(1)(B)(iii)(II)?**

It is crucial for the successful decarbonization of aviation that a robust methodology is applied to avoid unintended consequences on ecosystems and communities and undermining emissions reduction targets. Relying on first-generation, food-based biofuels to rapidly develop the U.S. SAF markets would be misguided, counterproductive, and would create an expensive and risky distraction from long-term aviation decarbonization. Without proper safeguards, those fuels could undermine President Biden's goal of reducing U.S. GHG

---

[28] Bloomberg New Energy Finance, 2020. Hydrogen Economy Outlook. https://data.bloomberglp.com/professional/sites/24/BNEF-Hydrogen-Economy-Outlook-Key-Messages-30-Mar-2020.pdf

emissions by 50% in 2030, trigger substantial land-use impacts and food price inflation, and disadvantage U.S. industry in new markets for low-carbon aircraft and hydrogen-based fuels.

Furthermore, increased use of food-based biofuels will increase greenhouse gas emissions, and diverting crops to jet fuel production could also exacerbate food price shocks for consumers. Food prices have already increased significantly lately, and increasing the share of food-to-fuel production would continue to worsen this problem.

Finally, promoting crop-based biofuels risks disadvantaging U.S. industry in new international markets for low-carbon aircraft and fuels. The U.S. should support technologies that will have the widest international acceptance and largest foreign markets, rather than push niche fuels that are unlikely to gain worldwide support.

The technologies used to produce first-generation food-based biofuels simply do not provide a technological steppingstone to the advanced biofuels necessary to drive deeper decarbonization.

While the combination of the language in 45Z and ICAO's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) SAF framework include the critical guardrails to prevent the deployment of unsustainable aviation fuels, significant guidance is necessary to ensure proper implementation and interpretation. Such guidance should:

- **Ensure that food and feed feedstocks that cause or contribute indirectly to the loss of natural habitats, including forests, grassland, or wetlands, are not eligible for financial support.**
    - Feedstocks with a significant induced land-use change (ILUC) risk should not be entitled to tax credits unless measures are adopted to reduce that risk. The ICAO CORSIA SAF framework already has operational methodologies to recognize land management practices that reduce the risk of ILUC. Only land-based feedstocks that comply with them should be entitled to the tax credit.
    - The 50% reduction threshold in lifecycle GHG emissions was intended to prevent pathways that pose a high risk for ecosystems and vulnerable communities from qualifying. Therefore, any attempt to reduce lifecycle emissions by means of, e.g., avoided emissions, carbon capture and storage or removal credits to compensate for ILUC GHG emissions and meet the 50% reduction threshold is at odds with the need to prevent negative impacts on ecosystems and vulnerable communities and the Treasury should not allow it.
    - Perennial energy crops with default negative ILUC values (net carbon sequestration) rely on the assumption that such feedstocks have been grown on marginal land to reduce the risk of ILUC. Fuel producers would need to demonstrate compliance with that assumption using ICAO CORSIA methodology for demonstrating low land use change risk. Then, for estimating the carbon sequestration, fuel producers would need to follow the direct land use change methodology in ICAO document "CORSIA Methodology for Calculating Actual Life Cycle Emissions Values". No soil organic carbon sequestration (SOC) and biomass sequestration should be recognized until a robust methodology has been developed and approved.

  - Similarly, perennial energy crops such as sugarcane with default positive ILUC values (net carbon release) should not use SOC and biomass sequestration to compensate ILUC emissions from, e.g., indirect forest and pastureland conversion. Therefore, the estimated SOC and biomass sequestration credit needs to be subtracted from the default ILUC values applicable to such perennial energy crops in accordance to the breakdown of the ILUC value estimates available in ICAO supporting document "CORSIA Eligible Fuels – Life Cycle Assessment Methodology". Then, as it is the case for the perennial energy crops with default negative ILUC values, for estimating the carbon sequestration, fuel producers would need to follow the direct land use change methodology. No soil organic carbon sequestration (SOC) and biomass sequestration should be recognized until a robust methodology has been developed and approved.

- **Ensure that feedstocks that are entitled to claim zero ILUC values such as used cooking oil and tallow do not contribute indirectly to the loss of ecosystems, food insecurity, malnutrition and hunger.** The ICAO CORSIA SAF framework assumes that these feedstocks have zero ILUC emissions. Therefore, to claim zero ILUC values, SAF producers would need demonstrate that their feedstocks are entitled to claim zero ILUC values through certification. For example, in a mixture of edible tallow and inedible tallow traditionally used for energy purposes, only the latter should be entitled to tax credits. The ICAO CORSIA methodology is subject to interpretation on this matter. The Treasury should provide clear guidance to prevent unintended consequences on ecosystems and people.

- **Ensure that SAF pathways involving large quantities of natural gas properly capture upstream methane emissions in the lifecycle emissions rates.** There are several SAF production pathways that involve large quantities of natural gas being used as process energy (see for instance the corn-based ethanol to jet pathway for which the energy from natural gas amounts to around 60% of total energy in the jet fuel) and/or as a feedstock for hydrogen production. While large quantities of natural gas use result in large lifecycle emissions, some SAF producers are envisioning using Carbon Capture and Storage (CCS) to address them and stay competitive. However, SAF with significant natural gas input are also subject to upstream emissions: methane leaks from venting, flaring and fugitive emissions from natural gas production. Upstream emission estimates derived from data reported in inventories and used for lifecycle analyses have traditionally led to significant underestimation of total emissions from the oil and gas sector, with the greatest divergence in the production segment.[29] A large body of peer-reviewed literature has documented this failure to fully capture methane emissions, primarily attributing the divergence to the failure to account for intermittent, large emission events. Over the last decade, research by EDF and others has quantified the significance of methane emissions caused by oil and gas production and the persistent underestimation of fugitive and abnormal process emissions.[30] Accounting for these emission events can

---

[29] See, e.g., Ramon A. Alvarez et al., Assessment of methane emissions from the U.S. oil and gas supply chain, 361 Sci. 186, 187 (July 13, 2018).; Rutherford et al., Closing the Methane Gap in US Oil and Natural Gas Production Emissions Inventories, 12 Nature Comms. 4715 (2021), https://www.nature.com/articles/s41467-021-25017-4#citeas.

[30] EDF, Methane Research Series: 16 Studies, https://www.edf.org/climate/methane-research-series-16-studies.

> increase methane emissions estimates by 60-70%.[31] The Treasury Department needs to make sure that the lifecycle values applying to SAF pathways involving large quantities of natural gas fully capture methane emissions accordingly.

Finally, it is also imperative for the Treasure Department to ensure that "any similar lifecycle methodology [to ICAO CORSIA]" for estimating compliance with the 50% reduction neither undermine nor fail to meet the level of protection CORSIA methodology guarantees.

4. **Special Rules. Section 45Z(f)(1) provides several requirements for a taxpayer to claim the §45Z credit, including for sustainable aviation fuel a certification from an unrelated party demonstrating compliance with the general requirements of the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) or in the case of any similar methodology, as defined in § 45Z(b)(1)(B)(iii)(II), requirements that are similar to CORSIA's requirements. With respect to this certification requirement for sustainable aviation fuel, what certification options and parties should be considered to support supply chain traceability and information transmission requirements?**

ICAO's SAF verification program represents the international best practice that guides any 45Z-related certification. It provides a full-fledged monitoring, reporting and verification system including a high level of assurance that should also guide certification beyond SAF. The ICAO's approach is the most comprehensive SAF Framework adopted to date as it ensures full supply-chain traceability and compliance with crucial sustainability criteria, as noted above. This is essential to safeguard against direct and indirect negative effects on ecosystems and communities that are not captured or are underestimated by the lifecycle assessment approach and to promote sustainable development in line with the United States' commitments under the Paris Agreement.

The criteria cover 12 themes that encompass the three pillars of sustainability: social, environmental, economic. Provisions pertain to emissions reductions, carbon hotspots, water, soil, air, conservation, waste and chemicals, human and labor rights, land use rights and land use, water use rights, local and social development, and food security. For each theme, a principle a set of criteria are outlined. The criteria capture the binding provisions. To be eligible under ICAO's CORSIA to generate emissions reduction credits for compliance purposes, SAF must meet all the sustainability criteria, available here.

The ICAO sustainability framework works as an umbrella standard that relies on ICAO-approved independent Sustainability Certification Schemes (SCS) for its implementation. These organizations define the sustainability certification requirements including the indicators and metrics to evaluate compliance with the criteria, set the requirements for certification bodies, auditors and accreditation bodies, and monitor the effectiveness of the assurance system. To become ICAO-approved SCS must undergo a thorough evaluation process and meet a comprehensive set of requirements in line with ICAO's eligibility framework and requirements for SCS, available here.

---

[31] Alvarez et al., *supra* note 1.

CORSIA's sustainability criteria for SAF take a robust and equitable approach, placing environmental and social safeguards on the production of SAF across its entire supply chain. It also provides a harmonized approach to ensure that air carriers using SAF across the world strive for these same values of climate ambition, environmental integrity, human rights, and social equity.

Adopting measures to verify that the negative environmental and social consequences of certain feedstocks are properly addressed would also ensure a level playing field across alternative fuel pathways. This is a sine-qua-non condition for ensuring resources are invested wisely and effectively and deliver on the imperative of the net-zero climate goal.

Guidance is necessary to ensure proper implementation and interpretation of the certification requirements. Such guidance should:

- **Ensure that any qualifying SAF meets – and is certified to comply with – ICAO's Sustainability Criteria for CORSIA SAF and other relevant traceability requirements**. The reference to "*any general requirements, supply chain traceability requirements, and information transmission requirements established under ICAO CORSIA*" in 45Z (f)(1) refers to requirements in ICAO Document "CORSIA Eligibility Framework and Requirements for Sustainability Certification Schemes". "[A]ny general requirements, supply chain traceability requirements, and information transmission requirements established under ICAO CORSIA" include all the requirements in Tables 2, 3 and 4 of that ICAO Document, including the CORSIA sustainability criteria specified in ICAO Document "CORSIA Sustainability Criteria for CORSIA Eligible Fuels". All these requirements are applicable to all economic operators along the SAF supply chain both in the U.S. and abroad to ensure supply chain traceability and sustainability. These requirements also encapsulate critical components of the lifecycle methodology that are not captured in the default lifecycle values. In the absence of these requirements, clean fuel producers could wrongly claim greater tax credits than they deserve – and, in some cases, become eligible without meeting the minimum requirements to access the tax credit.

Finally, the Treasure Department needs to ensure that "similar requirements [to ICAO CORSIA]" for certification neither undermine nor fail to meet the level of protection CORSIA methodology guarantees.