November 4, 2022

**To:** Hydrogen and Fuel Cell Technologies Office, Department of Energy

**Subject:** Clean Hydrogen Production Standard Draft Guidance

The Institute for Policy Integrity (Policy Integrity) at New York University School of Law and WattTime respectfully submit the following comments to the Department of Energy (DOE) regarding the draft guidance on the Clean Hydrogen Production Standard (CHPS). Policy Integrity is a non-partisan think tank dedicated to improving the quality of government decisionmaking through advocacy and scholarship in the fields of administrative law, economics, and public policy.[1] WattTime is a non-profit entity that aims to provide research, education, and assistance on the environmental benefits of electricity use timing, and advocates for a data-driven approach to solving environmental problems.

As DOE explained in the draft guidance, the Infrastructure Investment and Jobs Act (IIJA) requires DOE to establish the CHPS.[2] Then the Secretary of Energy must establish a program to support the development of at least four regional clean hydrogen hubs that demonstrably aid the achievement of the CHPS.[3] The Secretary shall also conduct activities to advance and support the establishment of a series of technology-cost goals oriented toward achieving the CHPS.[4] In the draft guidance, DOE proposed a CHPS of 4.0 kg $CO_2e$/kg $H_2$ from well to gate, which DOE arrived at in part by using the Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies Model (GREET) to analyze the target's feasibility.

**These comments focus on two methodological points that DOE should consider when calculating the carbon intensity of hydrogen production.** The proper resolution of these questions is critical for the implementation of the CHPS and the selection of the clean hydrogen hubs. DOE's decisions on these points may also be critical for the upcoming Department of Treasury rulemaking(s) for clean-hydrogen production tax credits, as DOE's final guidance may influence how the Department of Treasury resolves the same methodological issues in the implementation of the Inflation Reduction Act.[5]

**First, to ensure accurate accounting of the emissions that result from producing hydrogen with grid electricity, DOE's final guidance should endorse the use of marginal emissions**

[1] These comments do not purport to represent the views, if any, of New York University School of Law.
[2] 42 U.S.C. § 16166(a).
[3] *Id.* § 16161a(b)(1).
[4] *Id.* § 16154(e)(1).
[5] *See* 26 U.S.C. § 45V.

**rates with appropriate spatial and temporal granularity.** While the default emissions assumptions of GREET may be reasonable for selecting the CHPS, assessing the performance of a given facility requires different data. Marginal emissions rates with appropriate granularity reflect the true emissions consequences of using grid electricity to produce hydrogen. Additionally, a marginal-emissions approach would promote the efficient allocation of resources by incentivizing clean hydrogen production when and where renewable generation would otherwise be curtailed. **An annual-average approach to estimating emissions, as used in GREET, could significantly miscalculate emissions from some hydrogen production, potentially undermining the goals of the CHPS by leading to the selection of deployments that do not demonstrably aid achievement of the target.**

**Second, DOE's final guidance should state that renewable energy credits (RECs), power purchase agreements (PPAs), and other market structures may be used to characterize the carbon intensity of hydrogen production only when those instruments represent true avoided emissions.** Thus, DOE should specify that these instruments may be used to reduce the carbon intensity of hydrogen production (1) only when there is additionality and (2) by an amount that is calculated by using a marginal-emissions approach.

## I. Assessment of Whether a Deployment Demonstrably Aids Achievement of the CHPS

*Question 3a: How should the GHG emissions of hydrogen commercial-scale deployments be verified in practice? What data and/or analysis tools should be used to assess whether a deployment demonstrably aids achievement of the CHPS?*

**Response: DOE should endorse the use of a temporally and spatially granular marginal-emissions approach for assessing whether a deployment demonstrably aids achievement of the CHPS, rather than the current default assumptions in GREET, which use an annual-average approach to estimating emissions.**

DOE's final guidance should make clear that emissions from the use of grid electricity should be calculated based on a temporally and spatially granular marginal-emissions approach, rather than the annual average-emissions approach. **Accordingly, the final guidance should state that GREET, which uses an annual-average approach, should not be used to assess whether a deployment demonstrably aids the achievement of the CHPS unless and until any GREET successor model is updated to adhere to a marginal-emissions approach.** A marginal-emissions methodology is superior to the current GREET methodology for two main reasons. First, a marginal-emissions approach provides a more accurate estimate of the true emissions impact of additional hydrogen production using grid electricity. Second, using marginal emissions rates better incentivizes hydrogen production when and where renewable energy production would otherwise be curtailed.

## A. **Compared to the current GREET methodology, a marginal-emissions approach that is temporally and spatially granular would provide a more accurate estimate of the true emissions impact of using grid electricity to produce hydrogen.**

A new electrolyzer creates additional electricity demand. The emissions related to this additional demand depend on the emissions intensities of the additional generating resources that are used to meet this demand. Marginal emissions rates show exactly this: the increase in emissions when electricity demand increases by an incremental amount at a given time and location.

**Average Estimates Misrepresent the Actual Emissions Impact of Additional Load.** A simple example demonstrates the necessity of a marginal-emissions approach for emissions accounting. Imagine that a new electrolyzer were located in the Pacific Northwest, where hydroelectric generation is abundant. If the emissions intensity of the hydrogen produced by that electrolyzer were calculated by looking at the average carbon intensity of the grid, the emissions intensity would be relatively low. But the real effect of the new load from the electrolyzer would be significantly different: Because there is not enough hydropower to meet the full regional demand for electricity, adding load in the Pacific Northwest from an electrolyzer would require more electricity generation from some other resource to meet total demand, likely a coal or natural gas plant. That plant would be the marginal plant in the region, and its emissions intensity would dictate the true emissions intensity of the electrolyzer. Thus, despite a low average emissions intensity of the regional grid, the actual carbon intensity of the hydrogen would be high because the additional generation needed for the electrolysis would come from fossil-fuel resources. GREET estimates electricity-use emissions by looking at the average grid mix, not the emissions of the marginal plant.[6] As the GREET documentation acknowledges, "the bulk average cannot be used within a marginal analysis, which seeks to identify the electrical facility on the margin that would be used if a new electrical load were added to the grid."[7]

**Temporal Resolution Must Be Sufficiently Granular to Be Meaningful.** Although any averaging approach would obscure the variability in emissions from electricity use, GREET's particular approach to averaging would lead to especially inaccurate estimates of carbon emissions because the model uses *annual* averages of the grid's carbon intensity.[8] Indeed, the GREET documentation recognizes that the timing of electricity use determines actual emissions and that the model "may not fully capture some time-of-use features" for flexible loads such as an electrolyzer that can intentionally time when it produces hydrogen.[9]

Hourly or sub-hourly marginal emissions rates change as frequently as the grid dispatch changes. Figures 1 and 2 show sample periods of marginal emissions for California Independent System Operator (CAISO) and Southwest Power Pool (SPP), and each figure depicts how the marginal emissions often oscillate between zero and either approximately 800 lbs $CO_2$/MWh in CAISO or

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[6] J. KELLY ET AL., ARGONNE NAT'L LAB'Y, UPDATING ELECTRIC GRID EMISSIONS FACTORS 1 (2016).
[7] *Id.*
[8] *See id.*
[9] *Id.*

1,400 lbs $CO_2$/MWh in SPP.[10] These variations indicate how dramatic the misestimation could be if an annual-average approach were used instead of an hourly or sub-hourly marginal-emissions approach. **For that reason, DOE's final guidance should endorse using temporally granular marginal emissions rates.**

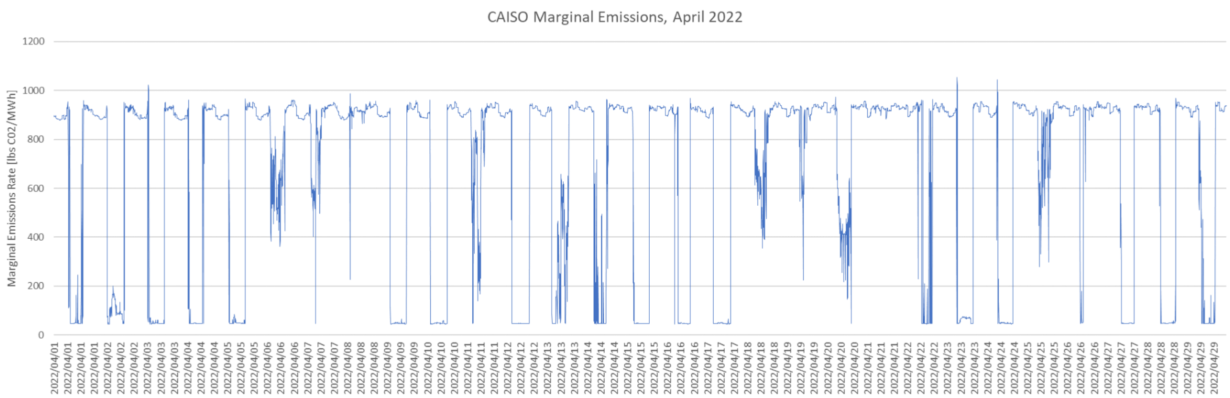


Figure 1: variability in CAISO marginal emissions

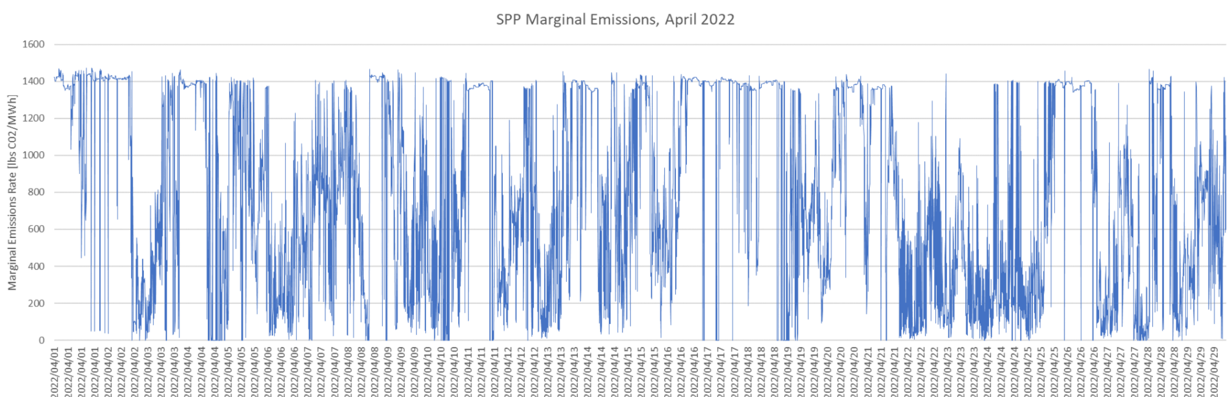


Figure 2: variability in SPP marginal emissions

Additionally, GREET's annual-average emissions rates reflect the grid mix from 2017,[11] even though the 2016 GREET update states that emissions data should be updated annually.[12] Using GREET to assess whether a deployment demonstrably aids the achievement of the CHPS would mean using data that does not fully reflect the rapidly evolving mix of generation resources. In contrast, many of the currently available marginal emissions rates use real-time data. **The age of the GREET data is a further reason why employing GREET's annual averages would lead to inaccurate estimates of carbon intensity of hydrogen production.**

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[10] Each figure reflects marginal emissions rates as modeled by WattTime. *See Methodology: How Does WattTime Calculate Marginal Emissions?*, WATTTIME, https://perma.cc/NTD8-F88L; WATTTIME, MARGINAL EMISSIONS MODELING: WATTTIME'S APPROACH TO MODELING AND VALIDATION (2022), https://perma.cc/6DMQ-NX7P.

[11] LONGWEN OU & HAO CAI, ARGONNE NAT'L LAB'Y, UPDATE OF EMISSION FACTORS OF GREENHOUSE GASES AND CRITERIA AIR POLLUTANTS, AND GENERATION EFFICIENCIES OF THE U.S. ELECTRICITY GENERATION SECTOR 2 (2020).

[12] KELLY, *supra* note 6, at 1.

**Spatial Resolution Should Reflect Grid-Management Realities.** Marginal emissions rates vary not only with time but also with geography. GREET divides the United States into large regions with different average carbon intensities, and these regions generally do not align with grid-operation boundaries.[13] In practice, for any given change in load, a balancing authority (of which there are 66) manages the grid by turning on or off the power plants within its area to meet the changes in load.[14] These decisions happen on the balancing-authority level, or on a smaller spatial scale because of operational constraints (most notably, limitations in transmission). As a result, when an electrolyzer draws electricity from the grid to produce hydrogen, the carbon intensity will depend on where that electrolyzer is located. Figure 3 depicts the spatial variation in marginal emissions rates at a representative moment in time, as modeled by WattTime.[15] **Given this variability, DOE should endorse the use of marginal emissions rates that align with the footprints of balancing authorities, or with even smaller areas when available, to better reflect the actual emissions caused by generating hydrogen with electricity.**

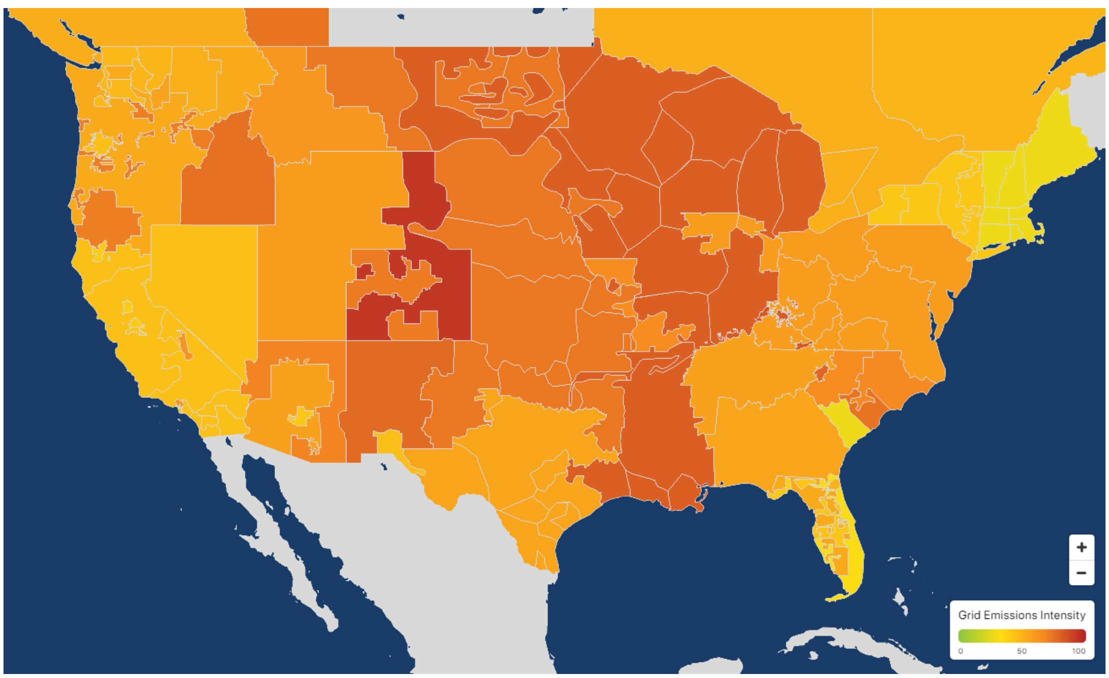


Figure 3: spatial variability in marginal emissions rates

**B. <u>Using marginal emissions rates would better incentivize hydrogen production when and where there is more renewable energy curtailment.</u>**

When clean resources are being curtailed, the marginal emissions rate is zero for that region because any additional demand would be met by clean resources that would have otherwise been curtailed. Many regions of the US grid have an oversupply of renewable generation during

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[13] *See id.* at 2–3.
[14] *See U.S. Electric System Is Made Up of Interconnections and Balancing Authorities*, U.S. ENERGY INFO. ADMIN. (July 20, 2016), https://perma.cc/5XWJ-WT8X.
[15] *See supra* note 10; *see also Grid Emissions Intensity by Electric Grid*, WATTTIME, https://www.watttime.org/explorer/#3.89/43.6/-111.64 (last visited Oct. 25, 2022).

certain periods. But the periods when consuming electricity causes no emissions are intermittent and determined by the specific generating resources in a region.

If DOE were to measure the carbon intensity of grid electricity based on temporally and spatially granular marginal emissions rates, electrolyzers would be incentivized to locate in regions that experience curtailment and to produce during periods of curtailment. That outcome would reduce total costs to society by aligning hydrogen production with available clean electricity that would have otherwise gone to waste.

Figure 4 illustrates the growing magnitude of curtailment and thus the potential to intentionally pair electrolysis with excess clean generation under a marginal-emissions approach.

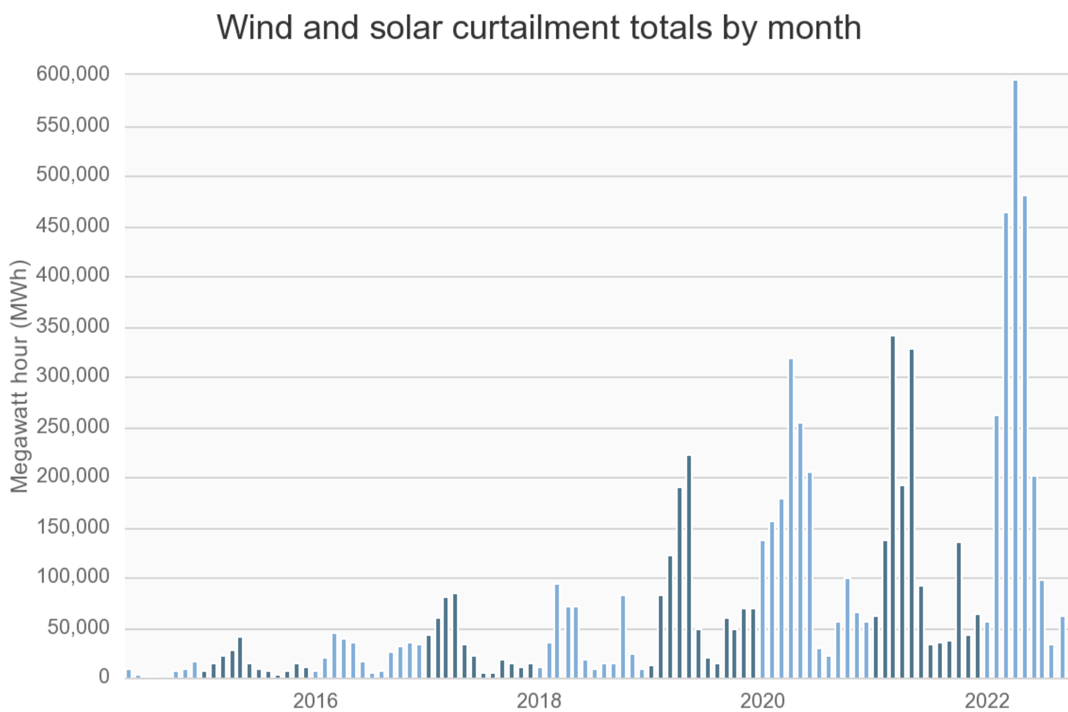


Figure 4: CAISO Curtailment[16]

**C. <u>A marginal-emissions approach would be administrable.</u>**

A marginal-emissions approach would be administrable because marginal emissions rates are available from a variety of sources. PJM Interconnection publishes granular marginal-emissions rates through its data platform,[17] and other balancing authorities are also beginning to provide similar data.[18] Granular and real-time marginal estimates are also available from other research

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[16] *Managing Oversupply*, CAISO, https://perma.cc/LG6T-U2SK (select "all" from the menu under "view").
[17] *Five Minute Marginal Emission Rates*, PJM Interconnection, https://dataminer2.pjm.com/feed/fivemin_marginal_emissions/definition (last visited Oct. 25, 2022).
[18] Karen Palmer et al., RESOURCES FOR THE FUTURE, OPTIONS FOR EIA TO PUBLISH $CO_2$ EMISSIONS RATES FOR ELECTRICITY 21–22 (2022), https://perma.cc/6VAA-JEQX; *Dispatch Fuel Mix*, ISO New England, https://www.iso-ne.com/isoexpress/web/reports/operations/-/tree/gen-fuel-mix (last visited Oct. 25, 2022) (marginal fuel; see "marginal flag string"); *Fuel on Margin*, SPP, https://marketplace.spp.org/pages/fuel-on-margin (last visited Oct. 25,

and academic sources like WattTime, as evidenced by Figures 1, 2, and 3.[19] The Energy Information Administration is also in the process of releasing real-time or near-real-time marginal emissions data.[20]

## II. Characterization of Emissions Intensity Using RECs and Other Market Structures

*Question 3c: 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?*

**Response: When calculating the carbon intensity of hydrogen in light of RECs, PPAs, and other market structures, DOE should accurately account for the net emissions associated with hydrogen production in light of those instruments.**

If electrolyzers seek to use RECs, PPAs, or other market structures to characterize the carbon intensity of hydrogen produced with grid electricity, DOE should rely on rigorous carbon accounting principles to ensure accurate estimates of the hydrogen's true carbon intensity in light of those instruments. First, these instruments must satisfy the principle of additionality by representing the production of energy that would not have otherwise happened. Second, the avoided-emissions value of any instrument should reflect the true quantity of displaced carbon emissions that is attributable to the energy represented by the instrument, which will depend on the timing and location of the clean generation.

**Renewable Generation Should Be Additional.** If an electrolyzer purchases a REC to effectively offset the carbon intensity of the electricity that was used to produce hydrogen, the electrolyzer must show that the clean production associated with the REC is additional to the grid, not simply electricity that was always going to be generated and used by some other consumer.[21] Without this requirement, the use of a REC could merely reshuffle the allocation of electricity on paper and fail to genuinely offset any emissions resulting from the hydrogen

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2022) (real-time marginal fuel); *Real-Time Fuel on the Margin*, Midcontinent Independent System Operator, https://www.misoenergy.org/markets-and-operations/real-time--market-data/market-reports/#nt=%2FMarketReportType%3AReal-Time%2FMarketReportName%3AReal-Time%20Fuel%20on%20the%20Margin%20(xls)&t=10&p=0&s=MarketReportPublished&sd=desc (last visited Oct. 25, 2022) (real-time marginal fuel).

[19] Palmer, *supra* note 18, at 22–25; Kyle Siler-Evans, Inês Lima Azevedo & M. Granger Morgan, *Marginal Emissions Factors for the U.S. Electricity System*, 46 ENV'T SCI. & TECH. 4742 (2012).

[20] *See* 42 U.S.C. § 18772(a)(2)(B) (requiring the Energy Information Administration to establish an online database that includes, where available, the estimated marginal greenhouse gas emissions per megawatt hour of electricity generated); Palmer, *supra* note 18.

[21] *See* Michael Gillenwater, *Redefining RECs—Part 1: Untangling attributes and offsets*, 36 ENERGY POL'Y, 2109, 2112-2113 (2008).

production.[22] Because the electrolyzer is actually adding load to the grid, which may be met with fossil-fuel resources, allowing RECs to offset electric load on a 1:1 basis regardless of additionality might lead to misclassifying high-emission hydrogen production as demonstrably aiding achievement of the CHPS. The same additionality principles apply to PPAs. If a clean generation resource has already been built, then its power was always going to be sold to some consumer. A PPA for this energy would represent the mere reallocation of energy on paper without doing anything to offset the electrolyzer's new load.

Accordingly, DOE's final guidance should make clear that, before an electrolyzer can use market structures to characterize the carbon intensity of hydrogen, the electrolyzer should be required to demonstrate that the associated clean generation would not have been built but for the prospect that the clean generator could sell the RECs to or enter into a PPA with the electrolyzer.[23] Additionality is not necessarily satisfied by contracting with a clean generator that has yet to be built. In the context of RECs, if the associated generation would have happened irrespective of any REC sales, the RECs sold by that generator would not represent avoided emissions that could be claimed by an electrolyzer. Thus, no offset purchased under these circumstances should be recognized vis-à-vis the CHPS. In these comments, we do not take a stance on which of the multiple tests for assessing additionality is most appropriate for implementing the CHPS.[24]

**Offset Rules Should Attend to Marginal Emissions Rates**. Assuming additionality has been satisfied, there are further accounting principles that DOE should adopt in the final guidance to ensure that offsets purchased by electrolyzers are counted in accordance with the actual emissions reductions that they represent. As explained above, because marginal emissions rates vary by time and location, the emissions displaced by clean energy generation also vary widely depending on the generation mix at a given time and place.[25] The emissions reduction associated with a renewable generator for a given period is the product of (a) the amount of power generated and (b) the marginal emissions rate when and where the renewable generator was operating.[26]

If a clean generator sells RECs (or other offsets) based on energy produced when the marginal generator was coal or natural gas, those RECs would be associated with a high amount of avoided emissions because that same quantity of energy would have been supplied by fossil fuels if the clean generator had not been operating. Thus, an electrolyzer could purchase those RECs

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[22] *See* GOV'T ACCOUNTABILITY OFF., GAO-11-345, OPTIONS FOR ADDRESSING CHALLENGES TO CARBON OFFSET QUALITY 8 (2011), https://perma.cc/6FUU-ZEG6.

[23] *See id.* at 3 ("An offset is additional if it would not have occurred without the incentives provided by the offset program.").

[24] *See id.* at 18–21 (comparing different approaches for testing additionality).

[25] *See, e.g.,* Duncan S. Callaway, Meredith Fowlie & Gavin McCormick, *Location, Location, Location: The Variable Value of Renewable Energy and Demand-Side Efficiency Resources,* 5 J. ASS'N ENV'T & RES. ECONS. 39 (2018).

[26] WATTTIME, ACCOUNTING FOR IMPACT: REFOCUSING GHG PROTOCOL SCOPE 2 METHODOLOGY ON 'IMPACT ACCOUNTING' 8 (2022), https://perma.cc/9B6W-BJFQ; Aleksandr Rudkevich & Pablo A. Ruiz, *Locational Carbon Footprint of the Power Industry: Implications for Operations, Planning and Policy Making, in* HANDBOOK OF $CO_2$ IN POWER SYSTEMS 131 (Qipeng P. Zheng et al., eds. 2012).

and use them to lower the carbon intensity of hydrogen produced with grid electricity. In contrast, when a clean generator produces electricity when renewable resources are being curtailed, the clean generator is displacing no emissions, and an electrolyzer cannot claim any emissions offset based on a REC associated with that energy production. As discussed above, granular marginal estimates are available that would facilitate the calculation of the true avoided-emissions value of RECs based on time and geography. The same accounting principles would apply if an electrolyzer has a financial/virtual PPA involving the purchase of clean energy.[27]

For physical PPAs, assuming additionality has been met, clean power that is physically delivered and used by the electrolyzer within a single region at the time of hydrogen production would have an emissions intensity of zero.[28] But if a clean generator cannot itself source all the power contracted for under a physical PPA, the carbon intensity of the electricity procured from third parties would depend on the resources called upon to fill the deficit.[29] For additional energy purchased on the wholesale market, the carbon intensity would be that of the marginal plant for the region at the moment of generation.

Respectfully Submitted,

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[27] *See Financial PPA*, EPA (Feb. 25, 2022), https://perma.cc/67XS-ZQBL.
[28] *See Physical PPA*, EPA (Feb. 25, 2022), https://perma.cc/8YA3-F9GE.
[29] *See* AM. COUNCIL ON RENEWABLE ENERGY, *Renewable Energy PPA Guidebook for Corporate and Industrial Purchasers* 11-12 (2016), https://perma.cc/LJ3K-GZDY.