Section 45V Clean Hydrogen Production Tax Credits

COMMENTS ON PROPOSED TREASURY GUIDELINES

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NOTICE

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I. Background and Summary

On December 26, 2023, the U.S. Department of Treasury (Treasury) released the proposed rules related to the tax credit for production of clean hydrogen under Section 45V of the Internal Revenue Code (Section 45V rules).[1] The Section 45V rules establish three criteria (Energy Attribute Credit Criteria or EAC Criteria) applicable to electricity from a particular source for purposes of calculating the lifecycle greenhouse gas (GHG) emissions under the Greenhouse gases, Regulated Emissions, and Energy use in Technologies (GREET) Model.

These comments have been prepared on behalf and at the request of the Los Angeles Department of Water and Power (LADWP), in support of their efforts to achieve decarbonization by 2035, which will rely upon hydrogen as a resource.

The amount of lifecycle GHG emissions determine the amount of tax credit available, if any, for the production of hydrogen under Section 45V. The three EAC Criteria are:

- **Incrementality**: Electricity must be sourced from renewable resources that began commercial operation within three years of the hydrogen facility being placed into service.[2] Uprates to the renewable energy generators can count as a new source of clean energy.[3] The Section 45V rule requests comments about counting incremental energy from existing resources (*i.e.*, nuclear and hydropower power facilities), avoided retirements, and avoided curtailed energy from existing renewable resources.[4] Treasury has asked commenters to provide input on the appropriateness of a 5% cut-off for

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1 Federal Register, "Section 45V Credit for Production of Clean Hydrogen; Section 48(a)(15) Election to Treat Clean Hydrogen Production Facilities as Energy Property," December 26, 2023, https://www.federalregister.gov/documents/2023/12/26/2023-28359/section-45v-credit-for-production-of-clean-hydrogen-section-48a15-election-to-treat-clean-hydrogen

2 Prop. Reg. 1.45V-4(d)(3)(i)(A)

3 Prop. Reg. 1.45V-4(d)(3)(i)(B)

4 88 FR 89230-89233

curtailment and other approaches to situations when the incrementality criteria can be waived.[5,6]

- **Deliverability**: Electricity must be sourced from generators in the same region as the hydrogen producer.[7] The applicable regions are as defined in the U.S. Department of Energy's (DOE's) 2023 National Transmission Needs Study.[8] Specifically, the preamble of the proposed regulations states that DOE mapped the regions in the study to the Balancing Authorities Areas (BAAs) in the 45VH2-GREET model user manual (GREET User Manual).[9] The GREET User Manual provides a list of applicable balancing authorities by region, which differs from the map in the DOE National Transmissions Needs Study.

- **Temporal Matching**: Electricity used to produce hydrogen must be matched on an annual basis until December 31, 2027.[10] Thereafter, the energy consumed by the hydrogen producer must be matched on an hourly basis with production.[11] The annual matching period is considered a transition period to allow the electric power industry to develop time-specific EACs sufficient to track the three criteria of 45V on an hourly basis.

In this white paper, we provide comments on each of the EAC Criteria proposed by the Treasury and in some instances propose alternative approaches for each criteria where we believe they will be helpful in achieving the goal of reducing GHG emissions from hydrogen production. In general, our proposed alternatives are meant to help align the Section 45V Rule with real-world operation of the power system, with specific focus on power system operations in the Western Electricity Coordinating Council (WECC). We summarize our comments and recommendations as follows:

- **Incrementality:** The proposed 5% limit on claiming avoided curtailed renewable energy will not fully capture locational differences in system curtailments. We propose a

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5 *Ibid*.

6 We interpret the suggested approach to curtailment to provide all renewable facilities that ability to allocate 5% of the facility's production as meeting the incrementality criteria.

7 Prop. Reg. 1.45V-4(d)(3)(iii)

8 Prop. Reg. 1.45V-4(2)(d)(vi). See also U.S. Department of Energy, "National Transmission Needs Study," October 30, 2023, https://www.energy.gov/gdo/national-transmission-needs-study

9 Prop. Reg. 1.45V-4(b)

10 Prop. Reg. 1.45V-4(d)(3)(ii)(A) and 1.45V-4(d)(3)(ii)(B)

11 *Ibid*.

methodology that relies on the Locational Marginal Price (LMP) at the location of the hydrogen production load to identify hours when there is excess renewable energy on the system (a Per Se Curtailment Rule). In hours when the LMP is less than or equal to zero, the electrolyzer would be allowed to claim consumption in that hour as incremental renewable energy, even if produced by existing resources, as long as a Renewable Energy Credit (REC) is procured and retired.

- **Deliverability:** Our comments will explain existing power sourcing arrangements in the WECC, and how they do not conform to Section 45V rule on deliverability. The Section 45V rule will likely render current plans to develop new renewable resources unable to serve hydrogen production load for some utilities in the WECC. We propose an alternative mechanism that will ensure renewable generation is deliverable to hydrogen production load and utilizes functionally appropriate and well-established regions that align with regional wholesale markets in the WECC. This would include the Western Energy Imbalance Market (WEIM) and the Western Energy Imbalance Service (WEIS). This is similar to the treatment allowed in most of the Eastern Interconnection under Treasury's proposed deliverability regions. We further propose that incremental renewable resources not located in the same regional wholesale market as the electrolyzer can meet the deliverability requirement by securing firm transmission rights from the renewable source location to a delivery point within a BAA in the same regional wholesale market as the electrolyzer. The deliverability region requirement could be supplemented by an hourly emissions impact test (discussed in further detail below) to ensure that electrolyzer owners are incentivized to locate renewable resources where they will have a commensurate emissions impact relative to the emissions caused by the hydrogen production load.

- **Temporal Matching:** We comment on the potential cost of the proposed hourly matching requirement and propose an alternative approach based on annual matching. When coupled with the proposed deliverability requirements and the hourly emissions impact test, this ensures that hydrogen production load reduces overall system emissions, without imposing the same costs as hourly matching.

In the remainder of this whitepaper, we discuss our comments and recommendations in detail. In Section II, we discuss the incrementality criteria. Then, in Section III, we discuss the deliverability criteria. Next, in Section IV we discuss temporal matching. Finally, we provide a brief summary of our conclusions.

II. Incrementality

Renewable generation that would have otherwise been curtailed meets the "incrementality" criteria of eligibility as this energy is incremental to electricity that would be consumed by existing demand. Treasury recognizes this and, in their proposed clean hydrogen tax rule, requests comments on allowing electrolyzers to claim avoided curtailment of renewable energy from existing renewable resources (those placed into service more than three years prior to the in-service date of the electrolyzer) as additional or incremental.[12] Treasury has suggested that such energy (claimed as incremental from avoided curtailment of existing renewables) be limited to 5% of generation from existing renewable resources, based on a nation-wide analysis of negative wholesale prices in recent years and forecasted long-run marginal emissions rates.[13]

A singular, nation-wide, static metric, does not capture the significant locational and temporal differences in curtailment patterns across the country and disregards how these are expected to change over time, given higher renewable penetration. We propose that Treasury use transparent market signals that are inherently poised to reflect locational and hourly variations in grid operation and curtailment patterns.

A. Non-Positive LMP Screen to Identify Avoided Curtailed Energy

It would be consistent with current and expected future grid operations for Treasury to allow electrolyzers to claim different amounts of avoided curtailed renewable energy as incremental clean energy based on their location. For example, the southwestern U.S., including southern California, Arizona, Nevada, and Utah, has abundant solar resources and experiences significant solar curtailments during daylight hours. This is especially true during spring months when electrical demand is low and hydro resources produce excess power due to snowmelt and

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[12] Treasury seeks these comments in connection with Proposed Regulation 1.45V-4(d)(3)(i)(A) on the following items: (1) whether a higher limit, such as 10%, would be appropriate; (2) how a 5% allowance should be tracked, allocated, and administered and how feasible it is for EAC tracking systems to incorporate data on such an allowance; (3) whether the 5% should apply to all existing minimal-emitting electricity generators in all locations or a subset; (4) whether such allowance should be assessed at the individual plant level or across an operator's fleet within the same deliverability region; and (5) any other administrability considerations. See 88 FR 89232.

[13] 88 FR 89231-89232.

associated water runoff.[14] This pattern is expected to expand in coming years as more renewable resources come onto the system, and will likely affect a larger geographic area during more months of the year, and more hours of the day (see Figure 3 below). Even within Treasury's proposed deliverability regions, renewable curtailments will vary significantly in the same region and at different times. It would align with the reality of the power system for Treasury to account for the temporal nature of curtailments. In certain seasons and at certain times of day, an electrolyzer located in the southwestern U.S. may be able to utilize avoided curtailed renewable energy for 100% of its consumption.

We propose an approach that is location-specific and time-matched (hourly or sub-hourly), based on transparent market signals, and demonstrates that curtailed renewable energy was available for consumption by an electrolyzer. In particular, we propose using the LMP at the location of the electrolyzer to determine if curtailed renewable energy is available in that time interval for consumption by the electrolyzer. Specifically, any time the LMP is equal to or less than $0/MWh, curtailed energy is available for consumption in that time interval and that location (a **Per Se Curtailment Condition**).

LMPs are transparent and publicly available market signals that provide information on the cost of the marginal generation resource at a specified location on the gird. Meaning, that the LMP indicates the cost of the generation resource available at that location and time to serve an incremental amount of load. LMPs are determined through a market-clearing engine implemented by the local market administrator and are based on offers to sell energy made by generation facilities in the market. All the Regional Transmission Organization (RTO)- and Independent System Operator (ISO)-administered markets in the country, including energy imbalance markets, such as the WEIM and WEIS, publish LMPs, [15] making LMPs available for almost all locations on the grid in the continental U.S.[16]

We propose that all consumption by an electrolyzer in any time period during a Per Se Curtailment Condition be attributed to incremental non-emitting energy, therefore the retired

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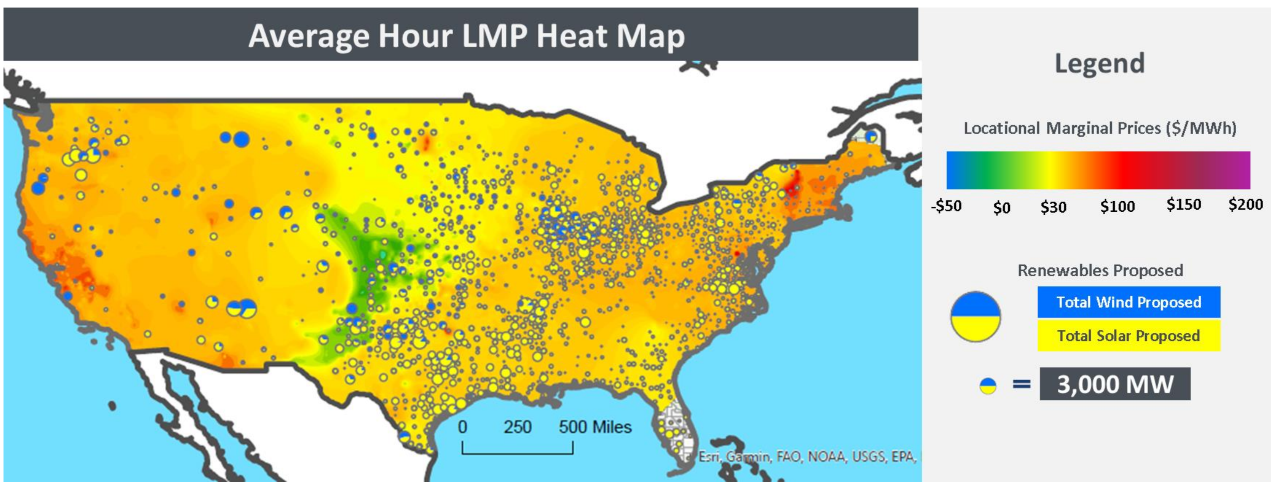
14 U.S. Energy Information Administration (EIA), "Solar and wind power curtailments are rising in California," accessed February 8, 2024.

15 The California ISO (CAISO), the Electric Reliability Council of Texas (ERCOT), the New York ISO (NYISO), the Midcontinent ISO (MISO), New England ISO (ISO-NE), the PJM Interconnection (PJM), the Southwest Power Pool (SPP), the Western Energy Imbalance Market (WEIM), and the Western Energy Imbalance Service (WEIS).

16 In regions where LMPs are not available, there are proxies that Treasury can use to implement a similar rule. For example, BAAs report system lambdas to FERC, which indicate the cost of the marginal generation resource in their BAA. However, system lambdas do not provide the same locational information as LMPs.

REC in that time period is excused from the incrementality requirement. The electrolyzer should not be required to procure and retire RECs from new renewable resources[17] for consumption in any period where the LMP is less than or equal to $0/MWh. In effect, the proposed incrementality criteria in the Section 45V rules would be waived for all energy consumed by the electrolyzer when the LMP is less than or equal to $0/MWh. For example, picture an electrolyzer that consumes 100 GWh of electricity in hours when its load node LMP was less than or equal to $0/MWh, out of a total consumption of 1,000 GWh of electricity in that year. That electrolyzer would have to procure and retire 1,000 GWh worth of total RECs in that year, but only 900 GWh would have to be from resources that meet the incrementality requirement. The remaining 100 GWh worth of RECs could be from *any* resource meeting the deliverability, and the temporal matching requirement, including existing renewables, as this energy would correspond to avoided curtailments.

FIGURE 1: ANNUAL AVERAGE LMP HEAT MAP



Source: The Brattle Group, data sourced from Hitachi Energy, Velocity Suite; Price Node coordinates come from S&P Global; Renewables proposed data comes from analysis of ISO interconnection queues and Lawrence Berkeley National Laboratory. Southeast and Florida represent the prices at power hubs.

LMPs are equal to the marginal cost of energy available at their location, based on the bids of sellers of power in the market.[18] In time periods when the LMP is less than or equal to $0/MWh, consumption of electricity is being compensated at that location, indicating that there is an excess of supply on the grid at that location.[19] Conditions of excess supply is what

[17] That is, renewable resources with in-service dates within three years of the in-service date of the electrolyzer.

[18] CAISO Tariff, Appendix C Locational Marginal Price. See https://www.caiso.com/Documents/AppendixC-LocationalMarginalPrice-asof-Feb1-2023.pdf.

[19] Seel et. al. ,Plentiful electricity turns wholesale prices negative, Advances in Applied Energy,2021; M Bajwa, J Cavicchi, Growing evidence of increased frequency of negative electricity prices in U.S. wholesale electricity markets, IAEE Energy Forum, 2017

leads to the curtailment of renewable energy. Stated differently, an LMP less than or equal to $0/MWh indicates that the cost of the generation resource available to serve an incremental increase in load at that location is $0/MWh or less and that incremental load would be paid to take energy off the grid at that time and location. These conditions indicate that the grid is inundated with excess renewable energy at this location and time and support the idea that incremental consumption, such as an electrolyzer, on the system at that location and time is being served by energy that would otherwise be curtailed.

It appears Treasury agrees with the assessment that negative wholesale prices indicate that incremental load would not increase emissions. Treasury states "curtailment is most likely to occur in the face of negative wholesale electricity prices if the marginal grid emissions rate is minimal or zero… [t]hese are times during which increased load is unlikely to increase significantly induced grid emissions."[20] However, Treasury does not propose a requirement based on this finding. The simplest approach would be to utilize the information provided by wholesale market prices, as pointed out by Treasury, and allow electrolyzers to claim the production of any renewable resources as incremental in hours when LMPs at the electrolyzer's location are less than or equal to zero.

B. Analysis of Non-Positive Prices in the WECC

LMPs are reported for different time intervals, for five-minute intervals up to hourly intervals, for all locations in the wholesale markets across the U.S. Therefore, they are able to capture both the temporal and the locational variability in curtailments (i.e., when LMPs are less than or equal to zero) in most regions of the U.S. In Figure 2 below, we analyzed the pattern of negative LMPs at the Intermountain Power Plant (IPP) node in 2023, on a monthly and hourly basis. The results demonstrate that curtailments are considerably higher during daylight hours and concentrated during the spring months, given the high levels of hydro generation and relatively low load during this period in the WECC.

[20] 88 FR 89232

FIGURE 2: FREQUENCY OF NEGATIVE LMPS AT INTERMOUNTAIN BY HOUR OF DAY AND MONTH

Year	Month	% of Hours with LMP <= 0																								# of Hours Curtailed	% of Hours
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		
2023	Jan	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0	0%
	Feb	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	4%	4%	7%	7%	7%	7%	0%	0%	0%	0%	0%	0%	0%	0%	10	1%
	Mar	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	10%	13%	19%	32%	23%	19%	23%	6%	0%	0%	0%	0%	0%	0%	46	6%
	Apr	0%	0%	0%	0%	0%	0%	0%	0%	3%	13%	20%	23%	33%	33%	30%	30%	27%	7%	0%	0%	0%	0%	0%	0%	66	9%
	May	0%	0%	0%	0%	0%	0%	3%	26%	39%	48%	55%	48%	48%	42%	48%	48%	45%	23%	0%	0%	0%	0%	0%	0%	147	20%
	Jun	0%	0%	0%	0%	0%	0%	0%	7%	23%	20%	23%	17%	23%	23%	20%	10%	7%	3%	0%	0%	0%	0%	0%	0%	53	7%
	Jul	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0	0%
	Aug	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0	0%
	Sep	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	7%	7%	3%	3%	7%	3%	0%	0%	0%	0%	0%	0%	0%	0%	10	1%
	Oct	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	6%	6%	10%	10%	6%	0%	0%	0%	0%	0%	0%	0%	0%	0%	12	2%
	Nov	0%	0%	0%	0%	0%	0%	0%	0%	3%	3%	3%	7%	7%	10%	7%	0%	0%	0%	0%	0%	0%	0%	0%	0%	12	2%
	Dec	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0	0%
Annual Average		0%	0%	0%	0%	0%	0%	0%	3%	6%	8%	11%	10%	13%	13%	12%	10%	8%	3%	0%	0%	0%	0%	0%	0%	356	4.1%

Sources and Notes: California ISO OASIS database: Real-Time 5 Minute LMPs averaged to the hourly level for the INTGS_3_UAMGNODE price node.

Figure 2 indicates that in 2023, during daylight hours and especially in spring months, electricity is often available at a non-positive price. In May of last year, approximately 20% of all hours had average 5-minute LMPs that were less than or equal to $0/MWh, and between 40% and 50% of these hours occurred between 8 am and 5 pm.

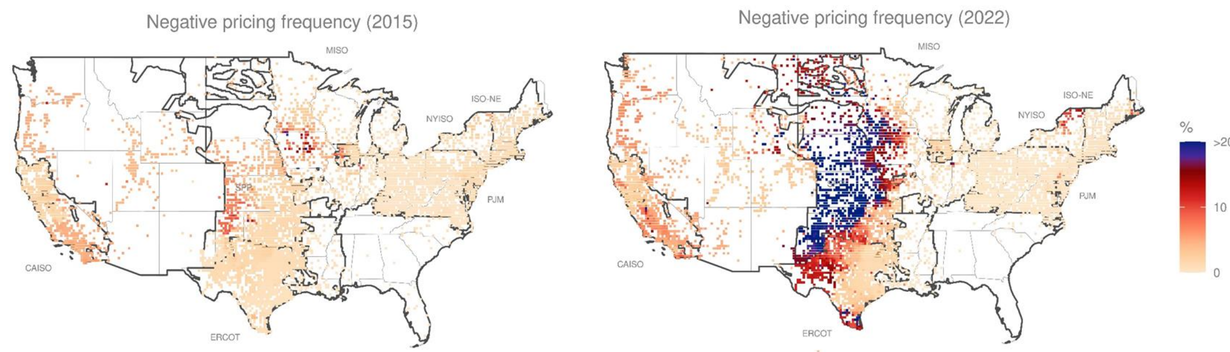
An analysis by Lawrence Berkeley National Laboratory (LBNL),[21] cited by Treasury in their guidance,[22] analyzed the frequency of negative pricing across over 50,000 nodes in the U.S. from 2012 to 2022. The analysis found that the frequency of negative prices has increased across the country due to the growth of renewable energy and the frequency varies widely as well (see Figure 3 below). The Southwest Power Pool (SPP) experiences higher frequency of negative prices in over 20% of hours, as compared to the Northeast and Mid-Atlantic regions that experience relatively low levels of negative prices. This analysis highlights the importance of taking into account the changing nature of the grid with the penetration of a higher amount of renewables.

Figure 3 shows data from the LBNL on the frequency of negative LMPs across the country in 2015 and 2022, illustrating the increasing trend in negative prices due to the growth of renewable energy. In 2015, few locations in the country saw negative LMPs greater than 10% of the time. Just seven years later, in 2022, a large region of the country from western Texas to North Dakota saw negative prices 20% of the time or more, and several locations in southern California saw negative prices approximately 10% of the time. As more renewable resources come online in future years, we expect this trend to continue and for negative prices to occur more frequently over a larger geographic region.

[21] Berkeley Lab, Electricity Markets & Policy, The Renewables and Wholesale Electricity Prices (ReWEP) Tool.

[22] 88 FR 89232

FIGURE 3: FREQUENCY OF NEGATIVE LMPS IN 2015 AND 2022 ACROSS RTOS



Source: Berkeley Lab, Electricity Markets & Policy, The Renewables and Wholesale Electricity Prices (ReWEP) Tool

A Per Se Curtailment Rule is uniquely aligned with electrolysis based hydrogen production, which has the operational capability to take advantage of negative price conditions, by purchasing electric energy under such conditions to run the electrolyzer and making hydrogen available for consumption, including electrical generation, during periods of high pricing.

The Advanced Clean Energy Storage (ACES) Facility, which is scheduled for commercial operation in 2024, is a prime example of the feasibility of such arbitrage. A Per Se Curtailment Rule based on LMP pricing at IPP would directly align the operational incentives of the ACES Facility with the intent and purpose of Section 45V.

III. Deliverability

The requirements to demonstrate the deliverability of renewable energy to hydrogen production load need to align with the real-world operation of the power system, including wholesale power markets that pool transmission assets and rights to deliver economic energy across the market footprint. Deliverability requirements should also provide the correct incentives to locate new renewable resources on the grid in locations where they will have an impact on reducing carbon emissions. We find that the Section 45V Rule fails on both objectives. To address this, Treasury should realign the regions in the WECC and clarify the role of firm transmission rights in establishing deliverability. We discuss an approach that would provide correct incentives for locating new renewable resources in Section III on Temporal Matching.

A. Aligning Deliverability with Grid Operation

The deliverability regions proposed by Treasury do not align with how the power system operates, how resources are procured and delivered, or with the operation of wholesale power markets. This is particularly true in the WECC region.

The deliverability regions identified by Treasury were adopted from the National Transmission Needs Study conducted by DOE.[23,24] There are several issues Treasury should clarify or amend with respect to the DOE Transmission Study regions as applied to Section 45V:

- Treasury should confirm that the proposed deliverability regions in the Section 45V rules align with BAA regions, including pseudo-tied generation resources that are physically interconnected in one BAA but are deemed to be produced in a different BAA, which provides Balancing Authority (BA) services and exercises BA jurisdiction over the resource. As discussed later, it would be appropriate for Treasury to consider delivery regions that align with wholesale market boundaries, but at a minimum, delivery regions should not split BAAs between multiple regions.
- The DOE Transmission Study regions do not align with how resource procurement and delivery occur in the WECC. The majority of utilities and customers in the WECC are not members of large, multi-state RTOs as is the case in the eastern U.S. In an RTO region, all transmission owners (TOs) participate in a joint transmission tariff. Therefore, a generation resource interconnected to any TO in the RTO only needs to secure transmission service once, under the RTO's tariff, to deliver to load interconnected anywhere in the same RTO. In the WECC, it is common practice for utilities to sign Power Purchase Agreements (PPAs) or directly own generation resources that are interconnected to other utilities' transmission systems and in other BAAs. Utilities will secure long-term firm transmission rights on a neighboring utility's transmission system to ensure that remotely located generation resources are deliverable to their load. For example,
  - The Los Angeles Department of Water and Power (LADWP) contracts and owns generation resources that are interconnected across multiple BAAs in California, Utah, and Arizona.[25]
  - The Tri-State Generation & Transmission Cooperative (Tri-State) owns generation resources physically interconnected to the Public Service Company of Colorado (PSCO)

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23 Prop. Reg. 1.45V-4(d)(2)(vi)

24 U.S. Department of Energy, "National Transmission Needs Study," October 30, 2023,

25 Los Angeles Department of Water & Power, "Power System," 2023.

BAA, the Western Power Area Administration (WAPA) Colorado-Missouri (WACM) BAA, and the Public Service Company of New Mexico (PNM) BAA. Tri-State uses these resources, spread over three BAAs in the WECC, to serve their load across multiple DOE Transmission Study regions (the proposed Mountain, Southwest, and Plains 45V regions).[26]

- WAPA Upper Great Plains West (WAUW BAA) has hydro resources in Montana[27] (the proposed Mountain 45V region) that it uses to serve load[28] in the SPP BAA (the proposed Plains 45V region).[29]
- WAPA Colorado River Storage Project (CRSP) is in the WACM BAA, which is in the Mountain DOE region, but has federal statutory customers in the PNM and El Paso Electric (EPE) BAAs, which are in the Southwest DOE region.[30]
- Palo Verde nuclear power plant is located in the Southwest region but Southern California Edison Co. (SCE), LADWP, and several California Municipalities have an ownership stake in the facility.[31]
- The Hoover Dam, owned by the U.S. Bureau of Reclamation, is located in the WAPA Lower Colorado BAA (WALC), meaning that it is located in the proposed Southwest 45V region. However, there are long-term supply agreements in place to sell power from the Hoover Dam to public utilities, cooperatives, municipalities, irrigation districts, and tribes in Arizona, California, and Nevada. These utilities span two of the proposed 45V regions (California and Southwest).[32]
- Several utilities in the Pacific Northwest own or contract for generation resources that are physically interconnected on the Bonneville Power Administration (BPA) or the NorthWestern Energy (NWMT) BAAs, and secure firm rights on the BPA and NWMT transmission systems to deliver that power to their BAAs.
  - For example, the Colstrip power plant, located in the Northwestern Energy (NWMT) BAA (placing it in the proposed Mountain 45V region) was historically co-owned by

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26 Tri-State has 55 MW of solar contracted and 200 MW currently under construction in New Mexico. Tri-State Generation and Transmission Association, Inc., "Annual Progress Report 2020 Electric Resource Plan," Dec. 1, 2021; Unit Power Purchase Contracts Dataset from HitachEnergy.

27 WAPA, "About UGP," 2024.

28 WAPA, "UGP Customers," 2024.

29 WAPA, "SPP Membership," 2024.

30 WAPA, "CRSP Customers," 2023.

31 EIA, "Nuclear Reactor Ownership," September 2023.

32 WAPA, "Power Projects," Oct. 27, 2023.

Portland General Electric (PGE), Puget Sound Energy (PSE), Avista, PacifiCorp, and Northwestern Energy. These owners had long-term transmission rights to deliver power from the plant to their respective BAAs, some of which are located in the proposed Northwest 45V region (PGE, PSE, Avista). Two of the Colstrip units have retired in recent years, and several of the owners have sold their shares as they move to exit thermal generation and decarbonize their resource mix. However, some of the previous owners of Colstrip have retained their transmission rights to Montana and are using those rights to develop clean energy resources near the Colstrip.[33] These new clean energy resources will be in the NWMT BAA, and therefore the proposed Mountain 45V region, which would exclude them from being deliverable for an electrolyzer developed by one of the Northwest entities with transmission rights to Colstrip.

  - PGE plans to procure 311 MW of the Clearwater Wind Project in Eastern Montana. PGE will own 208 MW of the plant and plans to procure 103 MW through PPAs. The final phase of construction will be complete in June 2024.[34]
  - PSE also signed a 20-year PPA for 350 MW of the Clearwater Wind Project, and plans to develop Beaver Creek wind farm in Stillwater County, MT, a 248 MW plant planned to come online in 2025.[35]

- PacifiCorp is developing the Gateway West transmission projects to transport wind energy in Wyoming, which lies in the PacifiCorp East BAA and the proposed Mountain 45V region, to the PacifiCorp West BAA that is in the proposed Northwest 45V region. Under the current proposal for deliverability, a potential electrolyzer in PacifiCorp West will be unable to take advantage of this wind energy from this new transmission project[36]

Figure 4 illustrates some of these examples.

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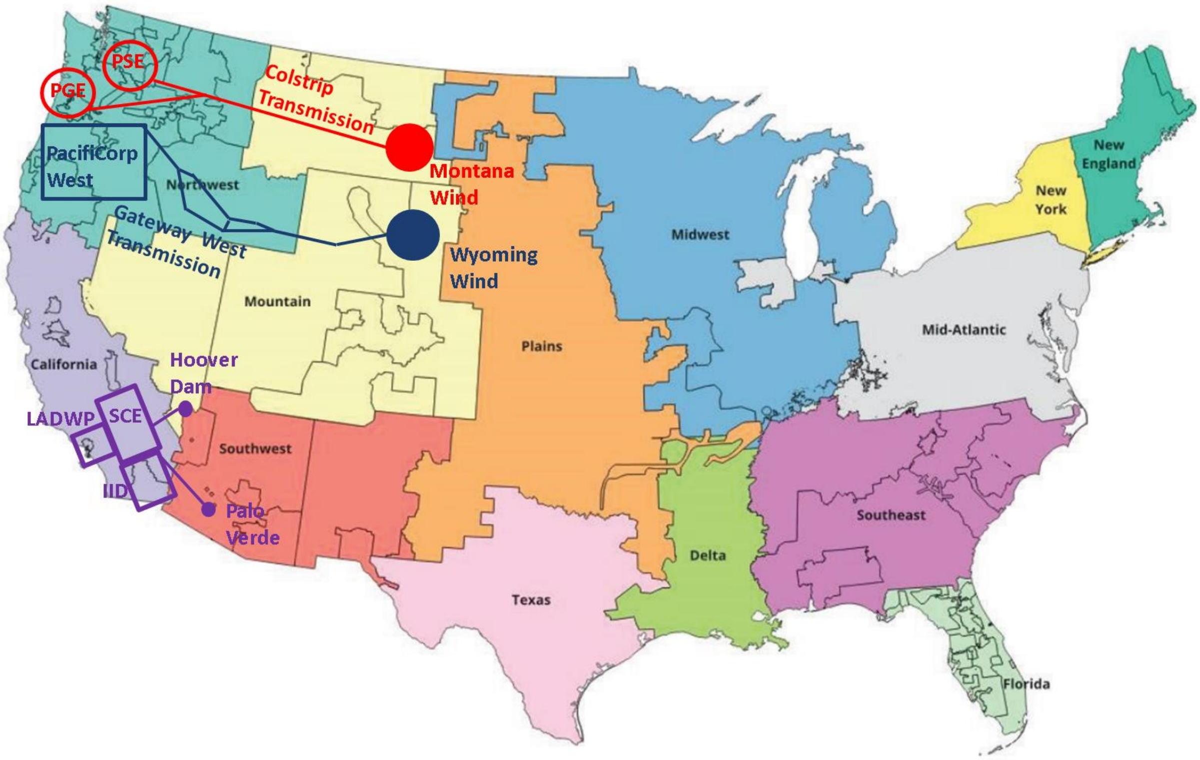
[33] Portland General Electric, "Clean Energy Plan and Integrated Resource Plan 2023," June30th, 2023; PSE, "PSE in Montana: Power Purchase Agreements,"2022.

[34] Ibid.; Capital IQ Clearwater Wind Power Plant Profile.

[35] PSE, "Puget Sound Energy announces clean energy wind project," 2023.

[36] PacifiCorp, Energy Gateway, accessed February 9, 2024

FIGURE 4: EXAMPLES OF RESOURCE PROCUREMENTS CROSSING 45V REGION BOUNDARIES



Source: Original 45V Regions map sourced from U.S. Department of Energy, [Guidelines to Determine Well-to-Gate Greenhouse Gas (GHG) Emissions of Hydrogen Production Pathways using 45VH2-GREET 2023](), December 2023; annotated to include approximate locations of resources and transmission projects

In all these examples, the proposed DOE Transmission Study regions would split apart the utilities from their owned or contracted generation resources (See Figure 4). Therefore, regardless of the final deliverability regions determined by Treasury, it would be consistent with power system operations to allow resources to be claimed as deliverable across regional boundaries. Treasury has requested comments on how to verify that power outside of one region is actually deliverable to an electrolyzer in another region.[37] This can be accomplished by requiring the claiming entity to demonstrate that they have secured firm transmission rights to deliver the remote generation to their BAA, and to provide an electronic record of the transmission scheduled on an hourly basis to deliver the power into their region (commonly referred to as a NERC Tag or E-Tag).

The examples demonstrate how the use of long-term firm transmission rights to deliver power from remotely located resources has been common practice in the WECC for decades, and will continue to be an important driver of decarbonisation efforts as the region seeks to integrate a

[37] 88 FR 89233

geographically and technologically diverse supply of clean energy. In fact, the sale of long-term firm transmission rights has recently enabled the development of regional transmission infrastructure in the WECC to deliver clean energy to load, in the absence of an RTO-style regional transmission planning process.[38] In addition, delivery of power using firm transmission rights is easily verified, using an E-Tag. Therefore, excluding incremental renewable resources from being counted as deliverable across 45V regions, if backed up by firm transmission rights and an E-Tag, would bias electrolyzers located in the WECC and potentially undo existing resource plans aimed at decarbonizing the power system in the region.

A further bias against electrolyzers in the WECC, compared to the eastern U.S., is created by the proposed 45V regions due to the misalignment of western regions with existing regional wholesale markets. The DOE Transmission Study regions in the eastern U.S. align closely with wholesale markets. ERCOT, NYISO, ISO-NE, PJM, and SPP closely align with individual regions in the DOE Transmission Study, while MISO is split into MISO-North (approximately the Midwest region) and MISO-South (the Delta region). The DOE did not apply similar treatment of wholesale power markets in the WECC. The CAISO market loosely aligns with the California region, with the inclusion of the LADWP BAA, the BANC BAA, and other smaller BAAs located in California. However, the Western EIM (WEIM) and Western EIS (WEIS) are not reflected in the DOE Transmission Study regions. Ignoring the WEIM and WEIS in developing the deliverability regions is inconsistent with how these markets improve the deliverability of power across their footprints.

The members of the WEIM and WEIS pool their transmission assets and contracted transmission rights to allow the market to deliver power across the footprint without having to procure or pay for separate transmission service. Furthermore, the WEIM and the WEIS, administered by CAISO and SPP respectively, conduct a Security Constrained Economic Dispatch (SCED) to determine the lowest cost dispatch of resources in the market to serve load, subject to deliverability constraints on the transmission grid.

In this way, the WEIM and WEIS solve for deliverability of power collectively across their entire footprints in a single, centralized market-clearing process. Establishing deliverability regions in the WECC that align (or closely align) with the WEIM and WEIS footprints would be consistent with Treasury's treatment of wholesale markets in the eastern U.S.

[38] Merchant transmission projects that rely on the sale of long-term firm transmission rights and are currently under advanced development in the WECC, include SunZia, SWIP-North, TransWest Express, Cross-Tie, and Southline.

In the next section, we discuss the need to align incentives for locating new renewable resources on the grid at locations where they will have a commensurate impact on reducing carbon emissions as hydrogen production load. We explain why the three criteria work in concert to achieve Treasury's overall objective of ensuring that hydrogen production load does not increase emissions in the power sector, and why it is not sufficient to only require that new generation resources be located in the same geographic regions as the hydrogen production load.

IV. Temporal Matching

Recent studies evaluating temporal matching requirements indicate hourly matching achieves the largest emissions reduction compared to other temporal matching options (e.g., annual matching) over the long-term and attracts investment in the necessary resources to achieve long-term deep decarbonisation.[39] However, the same studies also indicate that the cost of hourly matching is considerably higher than other temporal matching options.[40] In addition, the data and instruments needed to implement hourly matching are not immediately available and will likely not be available to implement hourly matching by 2028 as Treasury proposes.

We propose an alternative approach that combines some elements of both annual and hourly matching. Our proposed approach would achieve emissions reductions at a lower cost than pure hourly matching and can be implemented with less effort than hourly matching, which would require the development of time-matched EACs. In the future, as the grid becomes increasingly decarbonized and the tracking of hourly energy attributes matures, hourly matching may be necessary to achieve full decarbonization.

A. Background on Hourly Matching

One of the primary goals of the Section 45V Rule is to incentivize the production of clean hydrogen without diverting renewable energy from other uses. If energy were diverted, fossil generation would likely have to increase to meet demand, resulting in an overall increase in

39 Ricks et al., "Minimizing emissions from grid-based hydrogen production in the United States," Environmental Research Letters. Jan 6, 2023; Zeyen et al., "Hourly versus annually matched renewable supply for electrolytic hydrogen," Zenodo, Dec. 19, 2022.

40 Zeyen et al., "Hourly versus annually matched renewable supply for electrolytic hydrogen," Zenodo, Dec. 19, 2022; BCG, "Green Hydrogen: An assessment of near-term power matching requirements," Apr, 2023.

emissions. Hourly matching (in concert with the other criteria) avoids this by requiring hydrogen producers to consume carbon-free electricity that is produced in the same hour that it is consumed.

Proponents of hourly matching argue that emissions are (usually[41]) lower with this strategy than with annual matching, largely due to higher volumes of renewable build.[42] Though it is not possible to fully disentangle the factors producing superior GHG performance of hourly matching, a common element driving this result seems to be the propensity of hourly matching to require the hydrogen electrolyzers to procure *more total renewable* supply than the electricity they consume (i.e., to overbuild renewables relative to their total demand). If the excess renewable supply can be sold into the power grid, it can displace fossil supply; in scenarios where excess renewable purchase and sales are large enough, it can more than offset the renewable-competition effect and induce net negative emissions in the long run.

Conversely, studies have found that this overbuilding leads to considerably higher costs under an hourly matching than under other clean energy procurement approaches, especially when applied individually on a specific customer-resource basis, rather than in aggregate. Relatedly, studies also find that it is more expensive (with \$0.4–\$1/kg being the “consensus range” of incremental costs across studies) to produce hydrogen with hourly matching than with annual matching, as shown in Figure 5. The drivers of the higher cost of production from hourly matching are associated with the mismatch between variable and patterned renewable profiles versus the flat production profile that would be preferred by electrolyzer developers to maximize their capacity factors (and reduce levelized electrolyzer cost). To match the renewable output with electrolyzer demand, studies model alternative options all of which impose some cost, including: (a) curtailing or selling excess renewables, (b) deploying batteries

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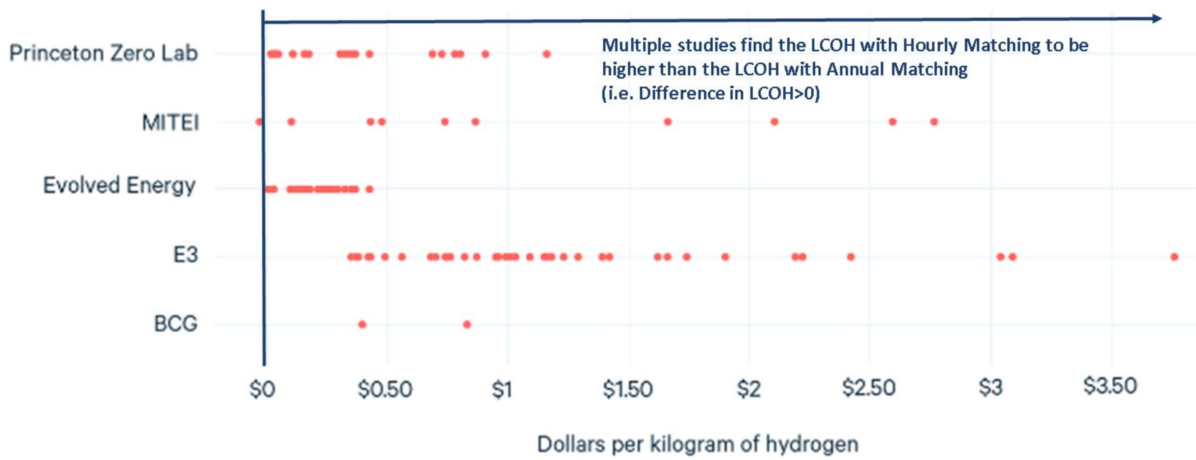
[41] Under certain specific conditions, hourly matching can produce more emissions than an annual matching approach. As an example of when this could occur, consider a scenario where wind is the renewable resource producing excess supply in the middle of the night relative to hydrogen production load. If the excess wind can be sold overnight in an annual matching strategy, it may displace emitting generation leaving the electrolyzer to charge from grid power during the daytime hours when there is excess solar that might otherwise get curtailed. In this circumstance, an hourly matching constraint would incentivize the electrolyzer owner to store the excess wind in a battery and discharged during the day when the system has excess solar generation (this is the opposite of how a battery would operate if seeking to reduce system-wide emissions). The likelihood hourly matching will misalign with overall GHG abatement will diminish as the system becomes increasingly decarbonized.

[42] Ricks et al., "Minimizing Grid-Based Hydrogen Production in the United States,” Jan. 6th, 2023; E3 and ACORE, “Analysis of Hourly & Annual GHG Emissions,” Apr. 2023.

to absorb and reshape renewable supply, and/or (c) building excess renewables relative to an annual energy matching volume.[43]

FIGURE 5: LEVELIZED COST OF HYDROGEN (LCOH) IN HOURLY MATCHING MINUS LEVELIZED COST OF HYDROGEN IN ANNUAL MATCHING ACROSS SCENARIOS



Source: Adapted from Resources for the Future

Given that the ultimate objective is to ensure that hydrogen production reduces more emissions than it causes, we propose an alternative approach that combines elements of annual and hourly matching and is less expensive, yet effective, at meeting the same goals for the near term rather than the overly restrictive requirement of hourly matching.

B. Annual Matching with Hourly Impact Test

We propose an alternative that combines elements of an annual and hourly matching requirement for grid connected hydrogen production facilities. We proposed that electrolyzers be subject to an annual matching requirement, coupled with an hourly emissions impact test using the Locational Marginal Emissions (LME) at the electrolyzer location and the renewable resource location (LME Netting). The annual matching requirement would force each electrolyzer to procure and retire RECs equal to its annual consumption.

43 Ricks et al., "Minimizing emissions from grid-based hydrogen production in the United States," Environmental Research Letters. Jan 6, 2023; Energy Innovation Policy & Technology LLC. 'Smart Design Of 45V Hydrogen Production Tax Credit Will Reduce Emissions And Grow The Industry," Apr. 2023; Wood Mackenzie, "Green hydrogen: what the Inflation Reduction Act means for production economics and carbon intensity," Mar. 2023.

The objective of the hourly emissions impact test is to provide the correct incentives to locate new renewable generation resources on the grid at locations where they will have a commensurate impact on reducing carbon emissions as hydrogen production load.

Renewable resources have the incentive to locate where there is the best wind or solar on the grid, which creates pockets of wind or solar production in certain regions. Incremental wind or solar added to an existing pocket of the same resources on the grid creates operational problems for the system, but also has a diminished emissions reduction impact. Development of the same type of renewable resources at the same location creates several problems:

- Increased congestion on the system, which will have financial implications for customers and require grid operators to dispatch higher-cost resources that are likely carbon emitting to alleviate congestion and serve load.
- Higher interconnection costs for future renewable resources that will likely require expensive transmission upgrades.
- Greater curtailment of renewable energy due to limited transmission capacity to deliver excess renewable generation to load that reduces the long-term value of renewables located in the area.

LME Netting would measure the relative emissions impact of hydrogen production load compared to the emissions abatement impact of the renewable generation claimed by that electrolyzer. LME Netting, paired with an annual matching requirement, would be an alternative to the proposed hourly matching criteria. The screen would compare the LME at the hydrogen production load location and at the renewable resources to determine the annual GHG impact of hydrogen production net the GHG emissions abatement impact of the renewable resource. At the end of the year, if the emissions impact of the electrolyzer are found to be greater than the emissions abatement of the generators, the electrolyzer will be required to procure and retire an additional amount of RECs to make up for the differential that would have to meet the deliverability, incrementality criteria, and be matched on an annual basis with the hydrogen production load.

LME Netting aligns incentives to locate resources in areas where they will have the greatest emissions impact, and to locate hydrogen production resources in areas where there is abundant opportunity to develop new renewable resources. The proposed screen would provide a clear signal on the actual emissions impact of electrolyzer consumption relative to the emissions abatement created by new renewable resources. The LME test is likely to be less costly than the proposed hourly matching requirement, as it increases flexibility on REC purchases, lowering the cost of integrating hydrogen production onto the grid. This will help decarbonize other sectors of the economy that can use clean hydrogen as a substitute for fossil fuels, while ensuring that hydrogen production has a positive impact on emissions reduction in the power sector.

Treasury's proposed EAC Criteria approach of deliverability based on the DOE regions, hourly matching, and incrementality based on the in-service date of resources, can be enhanced with LME Netting to provide the correct incentives to locate new renewables on the grid at locations where they will have the largest emissions reduction impact. There is an implicit assumption in Treasury's proposal that hourly matching will solve this problem by forcing electrolyzers to over procure renewables. This is incorrect. While the hourly matching requirement will force electrolyzers to over procure, there is nothing preventing an electrolyzer from locating their resources in the most renewable-rich areas of the grid that are already over saturated with renewable generation, while getting full credit for 100% of the production of those resources. This will exacerbate the problem of crowding renewables onto the grid in the same locations, increasing interconnection costs for other new renewable resources (potentially crowding them out and preventing them from being built), increasing congestion on the grid, and increasing system curtailments without ensuring that the power consumption from the associated electrolyzer does not have a relatively high emissions impact in another location on the grid.

LMEs provide location and time specific emissions rates for electricity consumption on the grid. To date, only PJM has released locational emissions data for their market.[44] To apply this test nationwide would require other market operators to produce the same data. However, given that this data is already calculated by third-party providers, it should be easily provided by the market operators and is likely less burdensome to implement then the temporal matching regime proposed by Treasury. LMEs would allow electrolyzers to compare the hourly emissions impact of their consumption against the hourly emissions reduction from renewable generation. The LME measures the amount of carbon emissions displaced by injecting a unit of clean energy at the grid in every hour, at every node. This data are both locationally and temporally granular. The LME differential between the supply and demand locations is thus representative of the difference between the LME *avoided* by the supply and LME *caused* by the demand. If the electrolyzer's LMEs were lower than the LMEs of the renewables, the facility would receive a credit equal to the difference multiplied by its consumption in that hour.

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[44] Proprietary LME data is available through vendors such as ReSurety for most of the RTO/ISO markets in the U.S. See "ReSurety and WattTime to Make Marginal Emissions Data Widely Available to Support More Impactful Climate Action". REsurety.com, January 10, 2023. https://www.pjm.com/markets-and-operations/m/emissions

Alternatively, if the electrolyzer's LMEs were higher than the LMEs of the renewables, the facility would have a deficit for that hour. At the end of the year, the hourly credits and deficits are totalled, and if the facility has an aggregate deficit it would be required to buy additional RECs equal to that deficit.

LME Netting creates the right incentives for siting renewables in zones without congestion but also ensures that the hydrogen production load has a negative impact on overall system emissions.

V. Conclusion

The Section 45V Rule establishes a framework to determine the amount of tax credit available, if any, for the production of clean hydrogen. The proposed framework centers on three criteria—Incrementality, Deliverability, and Temporal Matching—designed to ensure that the tax credits are available only to hydrogen production with little or no greenhouse gas emissions and do not divert renewable energy from other uses. While we support the Treasury's objectives, we have identified several opportunities to improve the proposed rules to better align with real-world operation of the power system, particularly in the WECC. Specifically, we propose the following:

- **Incrementality:** We agree that avoided curtailments should count towards the incrementality requirement and propose that an electrolyzer be allowed to claim its energy consumption as avoided curtailment in all hours when the LMP at the location of the electrolyzer is less than or equal to zero, as long as a REC is procured and retired. The energy consumed during these hours would count towards the incrementality requirement, even if the power is sourced from existing resources, as it corresponds to excess energy.

- **Deliverability:** We propose an alternative geography for WECC that will ensure renewable generation is deliverable to hydrogen production load and utilizes functionally appropriate and well-established regions that align with regional wholesale markets in the WECC. This alternative geography is similar to the treatment allowed in most of the Eastern Interconnection under Treasury's proposed deliverability regions. We also propose that incremental renewable resources not located in the same regional wholesale market as the electrolyzer can meet the deliverability requirements by securing firm transmission rights and providing an E-Tag from the renewable resource to a delivery point in a BAA in the same regional market as the electrolyzer.

- **Temporal Matching:** Given the potential cost of the proposed hourly matching requirement, we propose that this condition be replaced with an annual matching requirement with LME Netting with an hourly emissions impact test to ensure that electrolyzer owners are incentivized to locate renewable resources where they will have a commensurate emissions impact relative to the emissions caused by the hydrogen production load. LME Netting would sum the annual difference between the hourly LME of the load and supply nodes and require the electrolyzer to procure RECs in an amount equivalent to the "excess" emissions at the load node.

These alternative approaches are consistent with the Section 45V Rule. However, these proposed alternatives better reflect the real-world operating conditions of the wholesale electric markets, particularly in the WECC.

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ABOUT BRATTLE

The Brattle Group is an economic consulting firm with 500 professionals across North America, Europe, and Asia-Pacific. Brattle has assisted market operators, utilities, regulators, and market participants in the US, Canada, and worldwide with insightful, rigorous analyses that help navigate a changing energy landscape. Our work informs wholesale market designs, planning processes, and investment decisions to meet reliability and environmental objectives cost-effectively.

We have contributed to the design of capacity markets and/or energy and ancillary services (E&AS) markets such as PJM, MISO, ERCOT, CAISO, NYISO, ISO-NE, and SPP in the US, and the AESO and IESO in Canada. Brattle has also evaluated regional transmission organization (RTO) formation/expansion benefits in the U.S. West and Southeast; developed a framework and tools for transmission benefit-cost analysis and applied them to many of the large transmission projects in the U.S.; and advised state agencies on their procurements and transmission plans for meeting clean energy objectives.

Brattle has deep expertise in the hydrogen industry, assisting clients in North America and Europe evaluate the economics of hydrogen production, transportation, and end-use applications. In addition, we have assisted clients evaluate proposed hydrogen infrastructure regulations and clean production tax credits.

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