RESEARCH ADDENDUM

Examination of Proposed Exemptions to Incrementality Requirements for Section 45V

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Princeton University | February 22, 2024

This supplementary material builds on analysis and methods described in "Minimizing emissions from grid-based hydrogen production in the United States," published in *Environmental Research Letters* (https://doi.org/10.1088/1748-9326/acacb5), and has not itself been subject to formal peer review. See the full paper for further context.

Context

In a Notice of Proposed Rulemaking (NOPR) released on December 26, 2023, the US Treasury proposed requiring that all electrolysis-based hydrogen production receiving the Section 45V Clean Hydrogen Production Tax Credit procure energy attribute certificates meeting requirements for incrementality, temporal matching, and deliverability. In discussing the proposed incrementality requirement, the NOPR requested input on several possible ways in which this requirement could be relaxed in a final rulemaking while maintaining the Inflation Reduction Act's strict emission thresholds for 45V qualification. One proposal involved exempting 5-10% of the hourly output of all existing clean generators from incrementality requirements in order to account for potential avoided retirements of existing facilities and use of power that would otherwise have been curtailed. Another proposal involved entirely exempting States with power sector carbon cap policies from incrementality requirements. In this research addendum we provide supplementary power sector modeling examining the emission impacts of both of these proposals.

Impact of a 5-10% Incrementality Exemption for Existing Clean Generators

Figure 1 shows the aggregate carbon impact of exempting 5% and 10% of the output of existing clean generators in California from incrementality requirements under scenarios with 1 GW and 5 GW of local installed electrolysis capacity. These policies induce additional carbon emissions from hydrogen production in direct proportion to the amount of existing capacity exempted from incrementality requirements. **We observe a consequential emissions intensity of roughly 20 kgCO2e/kgH2 for any hydrogen produced by electrolyzers taking advantage of this incrementality exemption, an indirect emissions impact far exceeding the legal lifecycle emissions requirements for 45V qualification.** In other words, any partial exemption of existing clean generators from incrementality requirements is effectively equivalent to waving all 45V emissions requirements for a certain amount of hydrogen production, an allowance that Treasury has no statutory authority to grant.

Impact of a Complete Incrementality Exemption for States with Binding Carbon Cap Policies

Figure 2 shows the impact of a binding regional carbon cap policy on the emissions intensity of electrolytic hydrogen production in the Pacific Northwest. The first two columns show hydrogen carbon intensities with and without an incrementality requirement, while the third shows the carbon intensity in a scenario with no incrementality requirement where emissions from the Pacific Northwest model zone are capped at the level observed in a case without any local hydrogen production. **While this binding emissions cap prevents *local* increases in carbon emissions in the Pacific Northwest zone, it does not avoid significant *system-wide* carbon emissions resulting from hydrogen production exempted from incrementality requirements**. The emissions 'leakage' observed in this case primarily results from increased consumption of locally-generated hydropower in the Pacific Northwest, reducing exports to other regions that in turn backfill the lost supply with a mix of clean and dirty resources. **While some cap-and-trade policies incorporate border adjustment mechanisms in an effort to mitigate leakage from imports of carbon-intensive power, there is a significant body of research demonstrating that the mechanisms used in US state policies**

today are ineffective at accomplishing this goal.[1,2] Furthermore, no existing policies account for leakage from reduced exports, i.e. the primary mechanism of leakage observed in our results. It is possible that future state or regional cap-and-trade policies could be designed to minimize carbon leakage from both imports and exports. However, further analysis would be required to validate such novel mechanisms as sufficiently robust.

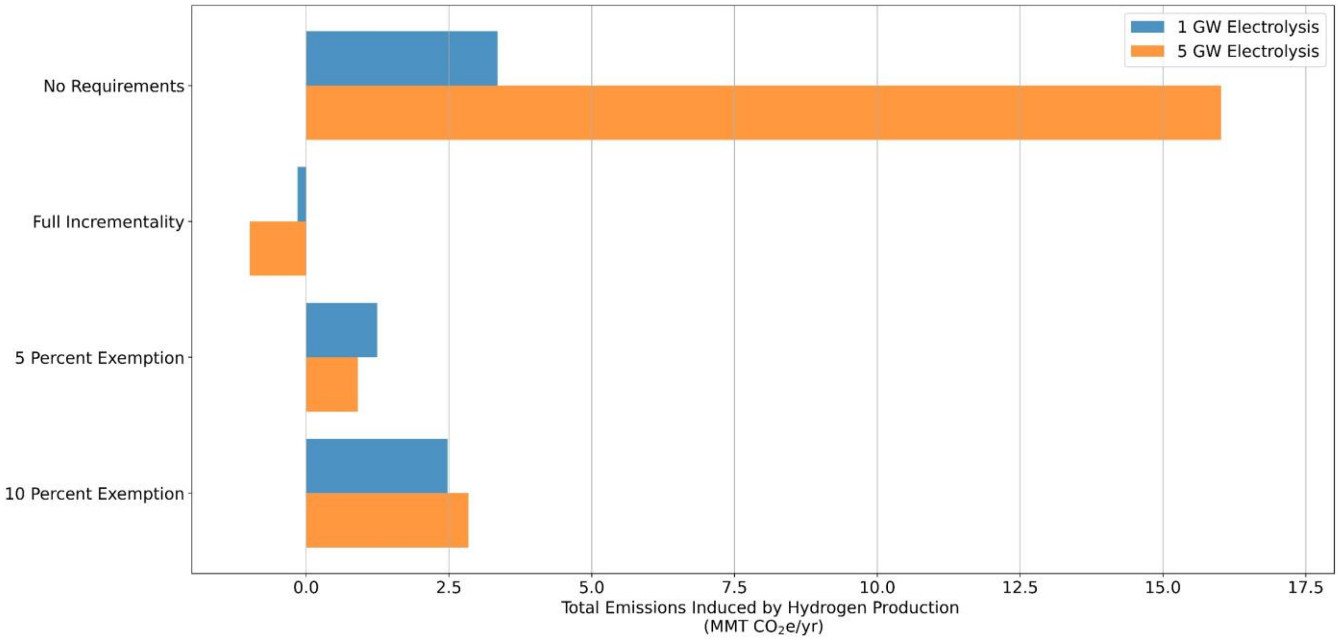

Figure 1: Total emissions induced by subsidized electrolytic hydrogen production in southern California under scenarios with no incrementality requirement, a full incrementality requirement, and 5% and 10% incrementality exemptions for existing carbon-free generators. Outcomes are shown for scenarios with 1 GW and 5 GW of local installed electrolysis capacity.

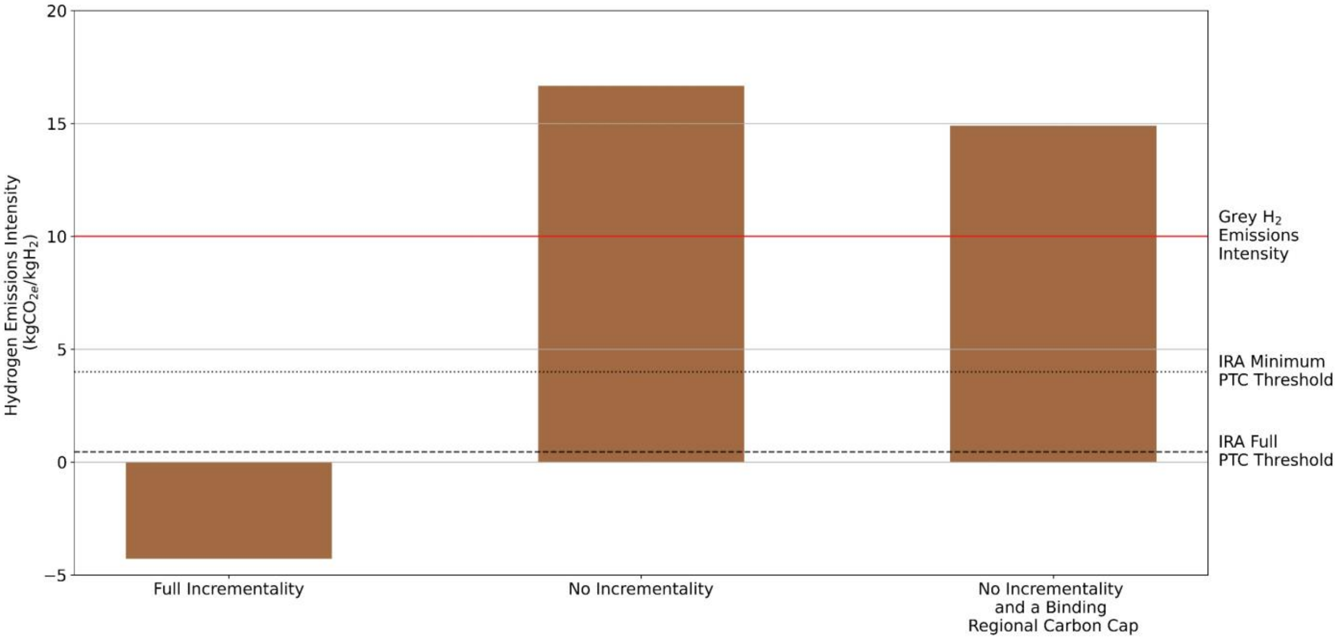

Figure 2: Emissions intensity of hydrogen production in the Pacific Northwest under scenarios with a full incrementality requirement, no incrementality requirement, and no incrementality requirement alongside a binding carbon cap for the local model region.

[1] Xu, Q. and Hobbs, B. F. "Economic efficiency of alternative border carbon adjustment schemes: A case study of California Carbon Pricing and the Western North American power market," *Energy Policy* Vol. 156, 2021.

[2] Bushnell, J., Chen, Y., and Zaragoza-Watkins, M. "Downstream regulation of CO2 emissions in California's electricity sector," *Energy Policy* Vol. 64, 2014.