U.S. Department of Energy Clean Hydrogen Production Standard (CHPS) Guidance

Summary

This guidance document contains the U.S. Department of Energy's (DOE's) initial Clean Hydrogen Production Standard (CHPS), developed to meet the requirements of the Infrastructure Investment and Jobs Act of 2021, also known as the Bipartisan Infrastructure Law (BIL), Section 40315. This guidance will be reviewed and may be subject to revision within 5 years, based on stakeholder feedback and in consultation with the U.S. Environmental Protection Agency, as required by the BIL.[1] CHPS is defined specifically in accordance with BIL Section 40315.

Background

Hydrogen plays a critical role in a comprehensive energy portfolio for the United States, and the use of hydrogen resources promotes energy security and resilience as well as provides economic value and environmental benefits for diverse applications across multiple sectors in the economy.[2] The DOE is committed to creating and strengthening technologically and economically feasible production, processing, delivery, storage, and use of clean hydrogen from diverse fuel sources.

The BIL amended the Energy Policy Act of 2005 (EPAct 2005) to accelerate research, development, demonstration, and deployment of hydrogen from clean energy sources.[3] Section 40315 of the BIL states that "not later than 180 days after November 15, 2021, the Secretary, in consultation with the Administrator of the Environmental Protection Agency and after taking into account input from industry and other stakeholders, as determined by the Secretary, shall develop an initial standard for the carbon intensity of clean hydrogen production that shall apply to activities carried out under this subchapter."[4] Further, the statute directs that the Secretary shall determine not later than 5 years after the initial standard is published, whether the standard should be adjusted below the existing threshold and to carry out such adjustment if deemed appropriate.[5]

The statute requires that the standard developed shall—

- "support clean hydrogen production from each source described [42 U.S.C. § 16154(e)(2)]," (e.g., including but not limited to fossil fuels with carbon capture, utilization, and sequestration (CCUS); hydrogen-carrier fuels (including ethanol and methanol); renewable energy resources, including biomass; nuclear energy);
- "define the term 'clean hydrogen' to mean hydrogen produced with a carbon intensity equal to or less than 2 kilograms of carbon dioxide-equivalent produced at the site of production per kilogram of hydrogen produced; and"

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[1] 42 U.S.C. 16166(b)(2).
[2] 42 U.S.C. 16151 note (a), BIL Section 40311 (Findings; purpose.)
[3] 42 U.S.C. 16151 note (b), BIL Section 40311 (Findings; purpose.)
[4] 42 U.S.C. 16166(a).
[5] 42 U.S.C. 16166(b)(2).

- "take into consideration technological and economic feasibility."[6]

Thus, the statute requires DOE to set an initial CHPS accounting for Congress's definition of "clean hydrogen" noted above, while also ensuring support for hydrogen production from diverse low-carbon energy sources, and consideration of technological and economic feasibility.[7] Accordingly, under the statute, the definition of clean hydrogen is a component of the CHPS and is not defined as the sole component of the CHPS.

In this guidance document, DOE implements the provisions of Section 40315 by adopting a CHPS that: (1) incorporates the definition of "clean hydrogen" provided in statute, and (2) supports diverse feedstocks and allows for consideration of technological and economic feasibility of achieving overall emissions reductions by establishing a lifecycle greenhouse gas emissions target for clean hydrogen production using a well-to-gate system boundary.

In accordance with 42 U.S.C. 16166(a), DOE issued a draft guidance document, following consultation with EPA in September 2022, and provided an opportunity for stakeholder feedback.[8] Approximately 120 respondents provided comments.[9] Comments on the system boundary of analysis were broadly supportive of the proposed well-to-gate boundary. Some commenters suggested expanding the system boundary to include component manufacturing emissions, including indirect greenhouse gases (GHGs) in life cycle analysis, and/or including guidance on hydrogen production pathways not explicitly described in the CHPS, such as those that utilize CO_2. These comments are in alignment with best practices currently under development domestically and internationally.

The well-to-gate system boundary used to establish the emissions target in the CHPS also aligns with Section 13204 of the 2022 Inflation Reduction Act (IRA), which creates a new 10-year production tax credit (the 45V Credit) for "qualified clean hydrogen"; many commenters also supported this alignment. In the 45V Credit, "qualified clean hydrogen" is defined as hydrogen produced "through a process that results in a lifecycle greenhouse gas emissions rate of not greater than 4 kilograms of CO_2e per kilogram of hydrogen."[10]

DOE's Clean Hydrogen Production Standard

Based on the BIL's statutory factors and stakeholder feedback, the CHPS establishes a target for well-to-gate lifecycle greenhouse gas emissions of $\leq$4.0 $kgCO_2e/kgH_2$. The establishment of a well-to-gate target aligns with statutory requirements to consider not only emissions at the site of production but also technological and economic feasibility and to support clean hydrogen production from diverse energy sources. This approach received wide support from respondents to the draft CHPS. A target of $\leq$4.0 $kgCO_2e/kgH_2$ will encourage low-carbon hydrogen

6 42 U.S.C. 16166(b)(1).
7 *Id.*
8 https://www.hydrogen.energy.gov/pdfs/clean-hydrogen-production-standard.pdf.
9 www.hydrogen.energy.gov.
10 The monetary value of tax credits available under 26 U.S.C. § 45V depends on the well-to-gate lifecycle emissions of a deployment. The provision has four tiers of credits, with each tier corresponding to a range of lifecycle GHG emissions, and lower emitting tiers corresponding to higher value credits.

production from diverse feedstocks and using state-of-the-art technologies that are expected to be deployable at scale today. This target is also consistent with the IRA's definition of "qualified clean hydrogen." This target is likely achievable by facilities that achieve ≤2 $kgCO_2e/kgH_2$ at the site of production, which potentially have additional emissions from upstream and/or downstream processes.

Fossil fuel systems that employ high rates of carbon capture or other thermal conversion processes such as pyrolysis, electrolysis systems that primarily use clean energy (e.g., renewables, nuclear), and certain biomass-based systems (e.g., gasification, reforming of renewable natural gas) are all generally expected to be capable of achieving ≤4.0 $kgCO_2e/kgH_2$ on a well-to-gate basis using technologies that are commercially deployable today as well as achieving ≤2 $kgCO_2e/kgH_2$ at the site of production. For example, a steam methane reformer with ~95% carbon capture and sequestration (CCS) could achieve ~4.0 $kgCO_2e/kgH_2$ well-to-gate emissions by using electricity that represents the average U.S. grid mix and ensuring that upstream methane emissions from the natural gas supply chain do not exceed 1%. Electrolysis systems that source about 15% of their electricity from the grid and the remainder from clean energy sources could also achieve ~4.0 $kgCO_2e/kgH_2$ well-to-gate emissions. Both of these systems, and other pathways for hydrogen production (e.g., biomass gasification or reforming of renewable natural gas) could also achieve emissions lower than 4.0 $kgCO_2e/kgH_2$ through optimized design choices, including, for example, use of clean electricity and low-carbon forms of biomass.[11] Over the coming decade, hydrogen production technologies that achieve the well-to-gate target are also expected to become economically competitive through a combination of research, development, demonstration, and deployment to ultimately achieve economies of scale and private sector market lift-off.

It is important to note that the well-to-gate target included in the CHPS represents an initial step toward accounting for the full emissions impact of hydrogen production. The well-to-gate system boundary does not include other potentially impactful emissions sources, such as those associated with component manufacturing or those associated with downstream hydrogen distribution. DOE is funding analysis to evaluate the magnitude of these emission sources and future versions of the CHPS may incorporate additional targets to address those emissions.

System Boundary for Well-to-gate Target

As shown in Figure 1 below, the emission sources that are accounted for in the well-to-gate target in this guidance include upstream processes (e.g., electricity generation, fugitive emissions), as well as downstream processes associated with ensuring that CO_2 produced is safely and durably sequestered.[12] Stakeholders have flexibility regarding how the well-to-gate target could be achieved. For example, systems that do not release GHGs at the site of

[11] Emissions analysis conducted using GREET model, available online at: https://greet.es.anl.gov/greet.models.

[12] In situations where the CO_2 is utilized, the emissions of hydrogen production depend on the manner in which the CO_2 is utilized and the processes its use displaces. Where CO_2 utilization is conducted, the CO_2 may be treated as a co-product of hydrogen production, and the emissions attributed to the hydrogen may be adjusted accordingly. Future versions of CHPS may provide guidance on accounting for CO_2 as a co-product, in alignment with other international best practices for CO_2 utilization that are currently under development.

production or that achieve aggressive rates of carbon capture would have more flexibility for the design of upstream and downstream steps, while systems that use electricity with a lower carbon intensity or mitigate fugitive emissions would have more flexibility at the site of production. The well-to-gate system boundary accounts for these tradeoffs by including all key emissions sources associated with feedstock extraction or production, generation of electricity, feedstock delivery, hydrogen production, potential releases during CO_2 transport, and carbon capture and sequestration of GHGs generated by the production process. Examples of key emission sources within these steps are depicted in Figure 1 below.

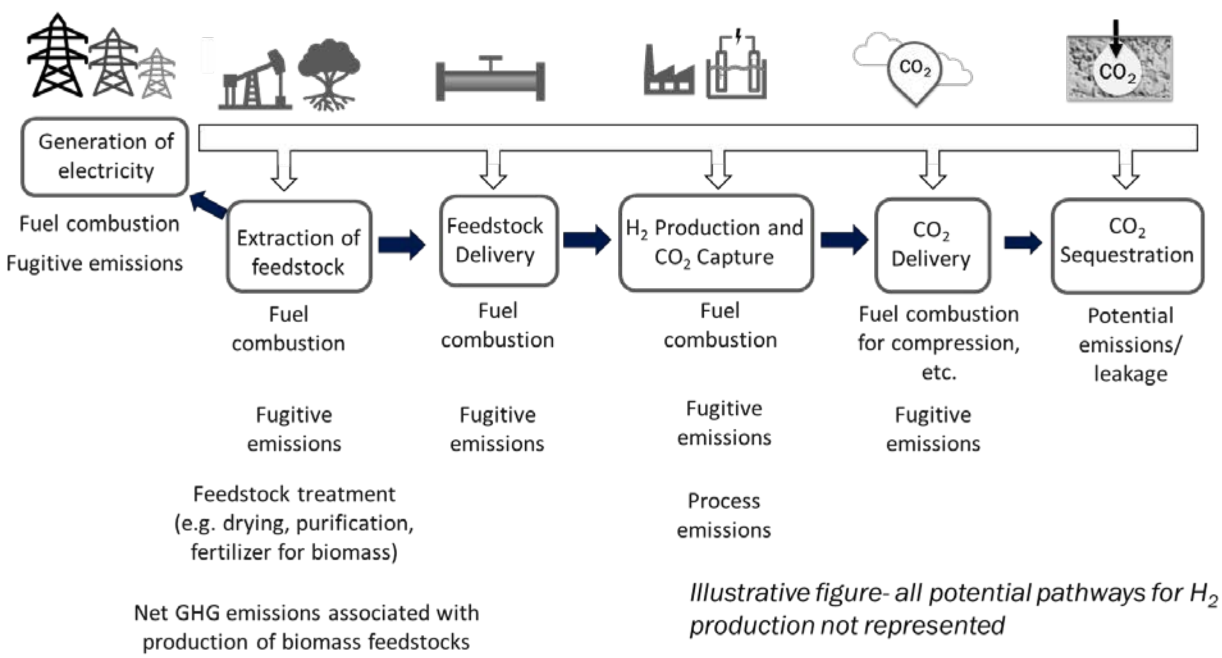

Figure 1: A well-to-gate system boundary enables consistent and comprehensive evaluation of diverse hydrogen production systems. Examples of key emission sources within each step typically considered in the boundary are shown above.[13]

[13] In the CHPS, the well-to-gate target corresponds to a system boundary that terminates at the point of hydrogen production, before it is delivered for end use. This system boundary includes CCS even if sequestration is not at the site of production, but does not include other post-hydrogen production steps such as potential liquefaction, compression, dispensing into vehicles, etc., consistent with the intent of a hydrogen production standard. To enable consistent comparisons across different hydrogen production technologies, the target corresponds to a functional unit of 1 kilogram of hydrogen at 99% purity and 3 megapascals (MPa) pressure. If a hydrogen production system achieves a higher pressure than this threshold, lifecycle analysis using GREET will adjust its emissions intensity accordingly. This adjustment is currently done by estimating the emissions that would have been generated by compression from 3 MPa to the pressure actually achieved and deducting these emissions from those generated by hydrogen production (effectively crediting the hydrogen production system for achieving a higher pressure that is likely to offset further compression requirements downstream).

Emissions analysis using a well-to-gate system boundary has been demonstrated by DOE and its National Laboratories in previous work[14] and is aligned with international best practices. Use of this system boundary will enable the nascent domestic industry to better integrate with global hydrogen markets. More than 20 countries have been coordinating since 2019 to harmonize emissions analysis methodologies and boundary conditions for hydrogen pathways through the International Partnership for Hydrogen and Fuel Cells in the Economy's (IPHE's) Hydrogen Production Analysis Task Force (H2PA TF), which is co-led by the U.S.[15] The H2PA TF's initial work product focused on developing mutually agreed upon emissions analysis methods for hydrogen production and was published in a draft working paper recommending using a comprehensive system boundary including emissions upstream and downstream of the point of production.[16]

Implementation

The CHPS serves to guide the DOE's hydrogen programs in EPAct 2005, as amended.[17] These include, for example, the Regional Clean Hydrogen Hubs Program and the Clean Hydrogen Research and Development Program. As set forth below, the BIL provisions governing Regional Clean Hydrogen Hubs (Hubs) provide that DOE can select projects that do *not* meet the CHPS so long as DOE selects projects that "demonstrably aid the achievement" of the CHPS by mitigating emissions as much as possible across the supply chain (e.g., through aggressive carbon capture onsite, measures to mitigate fugitive methane emissions, or use of clean electricity).[18] Additionally, the Clean Hydrogen Research and Development Program directs DOE to establish "a series of technology cost goals oriented toward achieving the CHPS."[19] Thus, these programs are expressly designed to reduce the carbon intensity of hydrogen production from diverse feedstocks over time. Accordingly, projects selected under those programs may not necessarily be required to meet the CHPS so long as they "demonstrably aid" the achievement of the CHPS.

DOE thus encourages applicants for funding to reduce emissions across the supply chain as aggressively as technologically and economically feasible. Previous DOE analyses of the emissions of hydrogen production from various feedstock have identified examples of parameters that could be optimized in real-world deployments to achieve these metrics.[20,21] For

[14] Elgowainy, A., "GREET Model for Life Cycle Analysis of Greenhouse Gas Emissions". Argonne National Laboratory. 2021 October 28. https://www.energy.gov/sites/default/files/2021-11/h2iq-hour-10282021.pdf

[15] For more information, please see https://www.iphe.net.

[16] IPHE 2021, Methodology for Determining the Greenhouse Gas Emissions Associated With the Production of Hydrogen, A Working Paper Prepared by the IPHE Hydrogen Production Analysis Task Force, Available online: https://www.iphe.net/iphe-working-paper-methodology-doc-oct-2021.

[17] 42 U.S.C. 16166(a).

[18] 42 U.S.C. 16161(a)(b)(1).

[19] 42 U.S.C. 16154(e)(1).

[20] Lewis, E., et al. Comparison of Commercial, State-of-the-Art, Fossil-Based Hydrogen Production Technologies. DOE/NETL-2022/3241. Pittsburgh, PA. National Energy Technology Laboratory. https://www.netl.doe.gov/energy-analysis/details?id=ed4825aa-8f04-4df7-abef-60e564f636c9.

[21] Elgowainy, A. "GREET Model for Hydrogen Life Cycle GHG Emissions". 2022 June 15. Argonne National Laboratory. https://www.energy.gov/sites/default/files/2022-06/hfto-june-h2iqhour-2022-argonne.pdf.

example, DOE may give preference to projects that mitigate upstream fugitive emissions, use a cleaner electricity generation mix, employ high rates of carbon capture and sequestration, or blend fossil fuels with renewable natural gas or low-carbon biomass. When applying to DOE solicitations, applicants should review requirements and merit review criteria within those solicitations for corresponding guidance on DOE's expectations of successful proposals.

When evaluating well-to-gate emissions, DOE recommends that stakeholders use a life cycle emissions tool to characterize well-to-gate emissions such as Argonne National Laboratory's Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies (GREET) model. Emissions accounting methods within GREET are largely aligned with the International Standards Organization (ISO) 14044 standard and best practices published by the IPHE.

Additionally, as noted above, the CHPS in the current guidance will be reviewed and may be subject to revision within 5 years, as required by the BIL. This revision could account for emissions sources not currently included in the well-to-gate system boundary, such as emissions associated with infrastructure build out, component manufacturing, and leakage of indirect greenhouse gases. Data from demonstration and deployment projects, including the Hubs, will also inform those future revisions. It is also important to note that other policies and market forces may incentivize deployments that are cleaner than the targets established in the CHPS.[22]

[22] For example, deployment of technologies that can achieve even lower lifecycle emissions may be incentivized by policies being established in other countries. The European Taxonomy classifies clean hydrogen as that which achieves lifecycle emissions of <3.0 $kgCO_2e/kgH_2$ and the European Renewable Energy Directive sets a lifecycle target of approximately 3.4 $kgCO_2e/kgH_2$. As another example, the United Kingdom set a standard of 2.4 $kgCO_2e/kgH_2$. To support achievement of such targets, technologies that can achieve less than 4.0 $kgCO_2e/kgH_2$ may advance over the coming years, which may further enable their deployment domestically.