November 14, 2022

VIA E-mail: cleanh2standard@ee.doe.gov

U.S. Department of Energy
James V. Forrestal Building
1000 Independence Avenue Southwest
Washington, D.C. 20585

Re: Air Liquide Comments on DOE's Clean Hydrogen Production Standard (CHPS) Draft Guidance

Dear DOE Representatives,

Air Liquide appreciates the opportunity to provide these comments to the U.S. Department of Energy (DOE) in support of the Clean Hydrogen Production Standard (CHPS).

Air Liquide entered the US market more than 100 years ago. Today, Air Liquide in the US counts more than 20,000 employees in more than 1,300 locations, offering industrial gases and related services to customers in a range of industries, including oil and gas, chemicals, steel, construction, food and beverage, research and analysis, electronics and healthcare. Hydrogen has been, and continues to be a core growth area for our business in the US.

Attached is our detailed response to the draft CHPS, emphasizing three main points:

1. We are supportive of a **standardized approach to evaluating the carbon intensity of hydrogen production** and stress the importance of alignment between the CHPS methodology and implementation of DOE programs and the provisions of IIJA and IRA.
2. **It is essential to include environmental attributes** such as power purchase agreements, renewable energy credits, and equivalent renewable natural gas crediting in the evaluation of hydrogen production carbon intensity. The alternative, requiring colocation of feedstock development and hydrogen production would greatly limit the ability to minimize costs and carbon emissions.
3. Clarifying the "point of production" in the pathway evaluation is important to ensure that pathways are evaluated on an equivalent basis. For gaseous hydrogen we recommend adopting existing industrial purity specifications and for liquid hydrogen we recommend including the liquefier in the production process evaluations.

We encourage further discussion on all of these items and look forward to continued collaboration on these topics. With our expertise in domestic and global hydrogen markets, our technology offerings in the areas of hydrogen production, gas distribution, and carbon capture, and our history of establishing strong partnerships with the DOE and energy market stakeholders, we offer our assistance to the DOE in furthering this program. For more information and follow-up please contact me at david.edwards@airliquide.com (612)747-7636.

Sincerely,

Dave Edwards, Ph.D.
Director, Air Liquide Hydrogen Energy

U.S. Department of Energy

DOE's Clean Hydrogen Production Standard (CHPS) Draft Guidelines

Response Provided by: Air Liquide

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Air Liquide supports the Clean Hydrogen Production Standard in establishing initial targets for lifecycle greenhouse gas emission reductions and in the potential to align DOE, IIJA, and IRA emissions evaluation methodologies.

The CHPS proposal is to establish an initial target for lifecycle greenhouse gas emissions of 4.0 $kgCO_2e/kgH_2$. We recognize this as an important target and establishing the methodology for carbon intensity assessment equally critical to mitigate emissions across the hydrogen production value chain. An effective methodology needs to be based on reasonable process assumptions, with a flexible calculation tool, enabling efficient verification and validation for the hydrogen producers and regulators. We believe the CHPS provides the basis for such a methodology.

<u>It is critically important that the CHPS creates a standard that can accommodate a variety of hydrogen production processes</u> and energy sources including production from existing and developing electrochemical and thermochemical processes using renewables, biomass, nuclear, and traditional fossil fuels. Accommodating the widest variety of production methods is in the best interest of the US as it enables each region to maximize their potential feedstocks and energy resources while addressing the local concerns related to the environment, economy, and society.

By providing a lifecycle approach from which to meet the standard, DOE will allow a variety of production pathways the flexibility to meet the standard and will open the door to innovation and investment in clean energy technologies such as advanced biomass conversions, electrolyzer systems and carbon capture technologies. This flexibility is particularly important as new production pathways are being established and existing production pathways are evolving.

Building on the DOE's Hydrogen and Fuel Cell Technology Offices projects portfolio, both the Bipartisan Infrastructure Law's (BIL) and the IRA include statutory obligations to develop and deploy clean hydrogen. The BIL sets a series of requirements that a clean hydrogen standard (1) support clean hydrogen production from a variety of diverse pathways; (2) target 2.0 $kgCO_2e/kgH_2$ at the point of hydrogen production, and (3) take into account technological and economic feasibility. Similarly, the enactment of the Inflation Reduction Act, which among other things, created a Clean Hydrogen Production

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Credit, calls for significant reductions in carbon emissions from hydrogen production as a condition of eligibility.

The methodology proposed in CHPS can provide the basis for a single, flexible, consistent methodology for these programs to evaluate and report process emissions. A single, consistent methodology is important as it enables efficiency in the evaluation and deployment of projects and technologies across the wide spectrum of production methods, regions, and hydrogen use sectors.

DOE recognizes the importance of this synergy and has proposed an initial standard under the BIL that "aligns with Section 13204 of the Inflation Reduction Act." We support the DOE in creating a standard that aligns with both programs and encourages DOE to ensure that this alignment is maintained in subsequent versions of a standard.

It is essential to include renewable energy credits in the evaluation of hydrogen production carbon emissions.

An important element in the development of a hydrogen ecosystem will be the appropriate use of feedstocks and energy required for production while optimizing the distribution networks to reduce costs and improve reliability of supply. Optimizing feedstock supply with distribution requires decoupling the locations where feedstocks are developed from where the hydrogen is produced. This can be done most effectively and efficiently by enabling the use of renewable energy credits for electrical power and natural gas supply in the production process and in the evaluation of process emissions.

DOE is seeking feedback on whether "renewable energy credits, power purchase agreements, environmental attributes associated with renewable natural gas, or other market structures be allowable in characterizing the carbon intensity of electricity emissions for hydrogen production." Allowing these market-based mechanisms to align energy sources with low, zero or even negative carbon emissions with hydrogen production infrastructure is critical to the efficient and accelerated development of hydrogen production infrastructure. These goals are shared by the current Presidential Administration and Congress. Furthermore, as called for in the BIL and IRA, it is Congress' intent that DOE allow for such market-based mechanisms.

Air Liquide supports the applicability of these market-based mechanisms to demonstrate the emissions for all types of energy supplies that may be used for hydrogen production. Hydrogen production has the flexibility to utilize electricity, natural gas, biogas, renewable natural gas, certified low-methane intensity natural gas, etc. as production feedstocks. While the DOE describes these market-based mechanisms as being used to characterize the carbon intensity of "electricity emissions" we must recognize that these market-based mechanisms can be used for all types of energy supplies, not just electricity. Limiting the use of these market-based mechanisms to electricity would inappropriately favor one production pathway over another and would stifle investment in a broad range of production pathways. It would be inconsistent with the BIL, which requires DOE to develop a CHPS that supports clean hydrogen production from a variety of sources. There is no justification for DOE to limit the use of the market-based mechanisms to hydrogen production pathways that use electricity.

Air Liquide encourages DOE to allow for the use of a wide variety of these market-based mechanisms, including, but not limited to, renewable energy credits, power purchase agreements, book-and-claim of environmental attributes, the ability to treat energy commodities on an accounting basis, renewable thermal credits, renewable identification numbers, and biogas credits. Providing the broadest interpretation of renewable energy credits, and enabling them to be managed through the existing market programs provides the most robust solutions to the market while optimizing energy resources across regions and reducing overall production costs.

Allowing for market-based mechanisms is aligned with the Biden Administration's clean energy goals and the goals of both the IRA and the BIL the largest ever federal investments in clean energy. IRA provides tax credits for clean energy technologies based on their emissions reductions through a "tech neutral" framework. Preventing the use of market-based mechanisms of low, zero and negative-emission energy sources is contrary to the goals of the Administration and Congress.

The alternative to enabling renewable energy credits would be co-location of renewables with hydrogen production facilities. This contradicts the intent of the two bills in that it biases solutions to regions or technologies that are advantaged by location and energy resource types. It is inefficient and costly to require that energy sources be co-located with hydrogen production for the reduced emissions to be considered in the lifecycle analysis. The location of hydrogen production often is driven by hydrogen demand as well as other siting, permitting, and operating considerations. An appropriate location for hydrogen production is not always aligned with the availability of low emission energy sources. Additionally, some energy sources, such as biogas and renewable natural gas, have locations driven by the existing biogas sources (i.e. landfills, farms, wastewater treatment plants, etc), and physically moving these operations to co-locate with the hydrogen production facility is not feasible. Instead, allowing the use of market-based mechanisms that allow the hydrogen production to contract for the environmental benefits overcomes these logistical constraints and inefficiencies. Limiting the use of market-based mechanisms would stifle the growth of the nascent hydrogen economy, particularly in geographic areas that have insufficient access to clean energy sources and would limit federal incentives for hydrogen production to parts of the country with an abundance of clean energy.

The use of these market-based mechanisms is well-established in many energy applications outside of hydrogen. According to a 2015 report from the Center for Resource Solutions, 36 states "recognize that RECs can be used to track and transact renewable electricity on the grid" and 35 states "recognize the supremacy of RECs to demonstrate compliance of regulated entities with state laws requiring provision of renewable electricity to grid customers, such as Renewable Portfolio Standards (RPSs), or participation in voluntary state programs for provision of renewable electricity to grid customers." Further, FERC "has also recognized that 'environmental attributes' can be traded separately and are not necessarily bound to or conveyed with the 'energy or capacity.'"

In adopting market-based mechanisms a validation process, calculated on an annual basis without geographic limitations, would be most beneficial. This streamlined system would make it easier for both industry and government to ensure compliance with the proposed standard by requiring one determination of compliance, rather than requiring near-continuous monitoring of activity across the industry. This annual true-up would also ease the administrative burden on hydrogen producers and ensure their investments are directed towards industrial operations rather than hiring staff for the sole mission of ensuring real-time compliance. Placing geographic requirements on these market-based mechanisms would impede the growth of the clean hydrogen industry in areas that do not have readily abundant clean energy supplies. If a hydrogen production facility has purchased RECs, or participated in a power purchase agreement, or participated in the purchase of environmental attributes associated with the production of renewable natural gas to facilitate the expansion of clean energy, it should be rewarded even if that clean energy development is in another part of the country, as it is still accomplishing the core mission of the legislation.

Air Liquide believes the "well to gate" boundaries of CHPS is appropriate provided the point of hydrogen production is clarified to ensure that pathways are evaluated on an equivalent basis. For gaseous hydrogen we recommend adopting existing industrial purity specifications and for liquid hydrogen we recommend including the liquefier in the production process evaluations.

In an effort to encourage the production of low carbon hydrogen with availability to all use sectors, it is appropriate to establish the lifecycle boundary as a "well-to-gate" emissions analysis. As proposed, this analysis should include upstream emissions associated with feedstock development through the point of hydrogen production, including the downstream emissions associated with the transport and sequestration of CO_2.

Figure 1 of the CHPS document shows the proposed emissions sources for the lifecycle evaluation. We believe this represents a comprehensive list of emissions sources within the boundary and provides maximum flexibility with regard to diverse emission sources and production processes with the exception that we believe liquefaction should be included in the production process when used. Given the diverse methods of hydrogen production in development, DOE should be flexible in its ability to reevaluate the lifecycle system boundaries to represent the new technologies and processes as they are developed.

Air Liquide strongly believes that the system boundary for the lifecycle assessment should be better clarified in order to ensure that all process assessments are done on an equivalent basis. Per the CHPS "Lifecycle target corresponds to a system boundary that terminates at the point at which hydrogen is delivered for end use" and then clarifies that this corresponds to a product of 1 kilogram of hydrogen at 99% purity and 3 megapascals (MPa) pressure with a method to correct for other pressure conditions. These statements appear to be contradictory in two ways:

1. Hydrogen at 99% purity in most cases, is not ready for "delivery to end use". This does not represent conditions of a market grade of hydrogen. Instead, we recommend using the existing CGA grade (QVL B General Industrial Applications or "industrial grade") with 99.95% purity as the specification. Using an established, market validated grade of hydrogen provides a method of validation and standardization that ensures that all production lifecycle processes are held to the same production standard.
2. Hydrogen liquefaction is an important component of the production process and represents a condition of being ready for "delivery to end use". Omitting the liquefaction process from liquid hydrogen production removes from consideration the additional energy required for this process and fails to recognize the liquid state as the final product. In order to best meet the goals of the BIL and IRA programs, it is important that the entire energy used in production is captured in the "well to gate" process.

The GREET "fuel-cycle" model is the best representation of "well-to-gate" emissions analysis for hydrogen that is familiar and trusted by stakeholders. In setting the lifecycle emissions boundary for CHPS, it would not be appropriate for DOE to utilize the "vehicle cycle" model, which incorporates the lifecycle emissions of automobiles, from raw materials mining to vehicle disposal. (Given the manner that hydrogen is produced, the "vehicle cycle" model would not provide the most accurate understanding of the lifecycle emissions for hydrogen.) For the purposes of establishing the CHPS, DOE should provide further clarity to stakeholders that use of the GREET "fuel cycle" model is the most appropriate for analyzing lifecycle emissions.

Air Liquide Responses to selected sections of the CHPS Draft Guidelines seeking stakeholder feedback.

2) Methodology

b) Use of some biogenic resources in hydrogen production, including waste products that would otherwise have been disposed of (e.g., municipal solid waste, animal waste), may under certain circumstances be calculated as having net zero or negative CO2 emissions, especially given scenarios wherein biogenic waste stream-derived materials and/or processes would have likely resulted in large GHG emissions if not used for hydrogen production. What frameworks, analytic tools, or data sources can be used to quantify emissions and sequestration associated with these resources in a way that is consistent with the lifecycle definition in the IRA?

The use of such biogenic feedstocks for hydrogen production provides an extremely important pathway for zero and net-negative hydrogen production. Additionally, because these feedstocks are direct replacements for fossil natural gas, they can immediately be used in existing facilities enabling a rapid transition to low-carbon hydrogen at scale. In the California transportation markets, for example, the inclusion of such feedstocks into the hydrogen pathways of the Low Carbon Fuel Standard (LCFS) has enabled a near immediate market transition to zero carbon hydrogen fuels, albeit at a modest initial scale.

Because of the efficiency of hydrogen fuel cells, we have found that production of hydrogen from these biogenic resources is the best use of such feedstocks from an emissions perspective in the transportation sector. As such, biogenic resources allow for rapid transitions, low emissions, and large scale conversions of existing facilities to renewable hydrogen production, exceeding every other known technology in theory and now in practice.

In the evaluation of emissions from such biogenic processes, it is important to consider the net impacts. If not captured and processed as biogas, these methane rich emissions can have a many times GHG impact than if it is converted to hydrogen. As such, <u>it is important that the lifecycle assessments enable these avoided methane emissions to be included in the assessment.</u>

A typical biogas plant, located at a waste-water treatment facility, municipal solid waste facility, agricultural digester or other site uses the raw biogas feedstock, purifies the gas to natural gas pipeline spec for network injection, and rejects remaining off gases (mostly CO_2 and N_2). As such, every molecule of methane that is injected into the natural gas netwerk is replacing a molecule of methane that would have been released to the atmosphere. Such atmospheric methane has a lifetime GHG potential of about 30X that of CO_2.

<u>We recommend that the lifecycle assessment allow for avoided methane emissions at the biogas processing facility with a one-for-one avoided emissions credit.</u> Ie, allow every quantity of methane gas injected into the network to credit the displacement of a similar quantity of methane into the atmosphere.

c) How should GHG emissions be allocated to co-products from the hydrogen production process? For example, if a hydrogen producer valorizes steam, electricity, elemental carbon, or oxygen co-produced alongside hydrogen, how should emissions be allocated to the co-products (e.g., system expansion, energy-based approach, mass-based approach), and what is the basis for your recommendation?

d) How should GHG emissions be allocated to hydrogen that is a by-product, such as in chlor-alkali production, petrochemical cracking, or other industrial processes? How is byproduct hydrogen from these processes typically handled (e.g., venting, flaring, burning onsite for heat and power)?

Co-production of hydrogen with other valuable off streams and the allocation of emissions in by-product hydrogen can be treated very similarly. In each case, an accounting of all feeds, offtakes, and products can determine the overall carbon intensity of the process. The challenge becomes how to appropriately distribute the carbon emissions across the product streams. <u>Air Liquide recommends that the carbon</u>

emissions be divided on primarily an energy basis and secondarily on an economic value basis.

Dividing emissions on an energy basis: When the primary value of off streams and co-products is in terms of energy, the intrinsic energy value of the stream can be used to allocate the emissions. Electricity, steam, carbon monoxide, fuels, and other co-products can be accounted for on this energy basis and provides an equitable, measurable, market valued approach to distribute the emissions.

Dividing emissions on an economic basis: when energy is not the primary value of the off streams, the economic value of streams can be used as a secondary criteria. Produced water, product CO2, solid carbon, oxygen and other co-products can be evaluated for their market value and the emissions allocated accordingly. As with the energy basis, this provides an equitable, measurable, market valued approach to distribute the emissions in line with the energy basis methodology.

Other bases for distribution of emissions include a mass or molar basis that do not provide good mechanisms as they do not associate the emissions with the value of the streams and, as such, do not provide a market driven incentive for emission reductions as would be seen with either the energy or economic bases described above.

3) Implementation

c) 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 consideration) if they are allowed for?

This was described in detail above. It is our position that such credits must be allowed broadly in order to ensure the best use of resources in the development of the hydrogen energy ecosystems.