Air Company Comments to DOE Clean Hydrogen Standard Guidance

Submitted via email to Cleanh2standard@ee.doe.gov

Ms. Karen Dandridge
Office of Hydrogen, Fuel Cells and Infrastructure Technologies
DOE Office of Energy Efficiency and Renewable Energy

Re: U.S. Department of Energy Clean Hydrogen Production Standard (CHPS) Draft Guidance

Air Company appreciates the opportunity to respond to the U.S. Department of Energy Clean Hydrogen Production Standard (CHPS) Draft Guidance consultation. Air Company is the world's leading carbon dioxide (CO_2) utilization company, creating consumer and industrial products from CO_2. Using carbon-free electricity to power our process, our systems convert captured CO_2 into valuable products such as sustainable aviation fuel (SAF), ethanol, and methanol — with oxygen and water as the only byproducts. AIR COMPANY's technology demonstrates that CO_2 conversion offers a significant opportunity to create valuable products that can displace legacy fuels, while reducing net CO_2 emissions. Hydrogen produced via electrolysis is a critical step of our process, and we offer our comments in this letter with the focus on "green" hydrogen production.

We commend the U.S. DOE for working to establish an initial target for lifecycle GHG emissions with the goal of encouraging clean hydrogen production in the United States. Our hydrogen production process relies significantly on clean electricity for the electrolyzation of water in order to produce and use the clean hydrogen, together with biogenic CO_2, as an input in our proprietary hydrogenator/carbon dioxide conversion system to produce valuable products. We agree with the proposed system boundary for the lifecycle target under CHPS and believe it is appropriate to use the GREET model through the point of hydrogen production, which aligns with the legislative language under section 45V of the Inflation Reduction Act. Furthermore, we agree that for "green" hydrogen production process that does not emit CO_2 as a bi-product, the boundary should end with generation of green hydrogen.

About Air Company

In September 2022, Air Company announced the launch of our sustainable aviation fuel produced via a cutting-edge power-to-liquids (PtL) process, which achieves the greatest CO_2 emissions reduction in comparison to currently approved SAF manufacturing pathways. The importance of this innovative climate technology is underscored by commitments from global aviation partners to purchase over one billion gallons of AIRMADE™ SAF, including JetBlue, Virgin Atlantic, and Boom Supersonic. We are proud to have established a partnership with the United States Air Force, with whom we completed a first-of-its-kind unmanned flight using Air Company's 100% unblended, drop-in CO_2-derived SAF.

Since 2017, we have been developing advanced catalytic hydrogenation reactor technology for CO_2 conversion with the goal to achieve world-scale production of decarbonized commodity chemicals and fuels. Our thermochemical catalytic conversion process is inspired by and mimics photosynthesis — but operates at a much higher rate to convert waste CO_2 coupled with hydrogen to derive sustainable chemicals (e.g., ethanol) and transportation fuels (e.g., SAF). Using green hydrogen derived from water electrolysis, our system releases only water (which is recycled) and oxygen as a byproduct. Our entire product slate has a net-negative or net-neutral carbon emission footprint. While many other related processes often rely on multiple upstream unit operations and reactors in order to target the same products, Air Company's process is a single-step thermochemical conversion process that utilizes a novel family of proprietary heterogeneous catalysts. Air Company's catalyst composition and process technology have already been granted 2 patents with over 10 pending patent applications.

In 2021, we deployed our CO2 hydrogenation technology at a pilot scale, and we are working to advance our solution to achieve commercial scale. In short, our production process includes the following key steps:

- Procurement and Utilization of Captured Industrial CO_2: The CO_2 used in our production is captured and sourced from industrial plants.
- Electrolysis (hydrogen production): The green hydrogen used in our process is supplied through on-site water electrolysis using renewable energy. Our electrolyzer splits water (H_2O) into hydrogen (H_2) and oxygen (O_2). The oxygen gas produced in this process can be released into the atmosphere or sold as a byproduct, and the hydrogen gas is fed into our Carbon Conversion Reactor (with the captured CO_2).
- Hydrogenation (carbon conversion): Our patented and proprietary Carbon Conversion Reactor (CCR) system is a packed-bed flow system where captured CO_2 is hydrogenated with green hydrogen (H_2) and converted to sustainable, renewable chemicals and fuels. The CO_2 and H_2 are fed through reactor tubes packed with our patented catalyst.
- Distillation/Fractionation: Our distillation process separates the components of the two-phase reactor liquid effluent comprised of normal paraffins and alcohols, namely ethanol, methanol, and water, which all have different boiling points. The normal paraffins are further separated to fuel range hydrocarbons using traditional downstream fractionation methods.
- Further Refinement & Product Blending: As an additional downstream hydrocarbon process option, alcohols can be further upgraded, refined and blended into sustainable aviation fuel (SAF), similar to that of conventional Jet A fossil fuel.

As in any cutting-edge process, production and associated supply chain costs of our renewables-powered industrial products are higher than fossil fuel-based incumbents. The variety of tax credits authorized by the IRA will play a significant role in commercializing these products faster, displacing fossil fuel-based products sooner, and accelerating the reduction of U.S. GHG emissions in line with the 1.5-degree global ambition. Therefore, our answers below aim to support DOE's efforts to develop the CHPS standard. We welcome continued engagement on these topics and thank the U.S. DOE for this opportunity to provide input.

Sincerely,

Natalia Sharova
Climate Policy Manager

Questions and Answers

1) Data and Values for Carbon Intensity

b) Lifecycle analysis to develop the targets in this draft CHPS were developed using GREET. GREET contains default estimates of carbon intensity for parameters that are not likely to vary widely by deployments in the same region of the country (e.g., carbon intensity of regional grids, net emissions for biomass growth and production, avoided emissions from the use of waste-stream materials). In your experience, how accurate are these estimates, what are other reasonable values for these estimates and what is your justification, and/or what are the uncertainty ranges associated with these estimates?

We recommend that the CHPS periodically reviews and updates the GREET model to ensure that the data represents the latest available information in respect to the carbon intensity of regional grids as the number of renewable energy generators on the grid continues to grow across the country, and the average carbon intensity in regions is expected to continue to improve. It may be appropriate to update such carbon intensity data on an annual basis in order to maintain up to date data for private markets to accurately model and invest.

2) Methodology

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?

In the production of green hydrogen via electrolysis, a significant oxygen co-product stream emerges especially for large-scale manufacturing scenarios. This oxygen stream is a valuable co-product that should be considered in the LCA analysis. Because oxygen and hydrogen are tied stoichiometry and due to oxygen's positive impact on environment, it appears that an energy-based approach would suffice in this case where the first law of thermodynamics and entropy balances are verified.

3) Implementation

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

The U.S. DOE (or other appropriate agencies) might consider requiring a submission of a third-party verified or third-party conducted LCA assessment to demonstrate how clean hydrogen produced at a specific facility compares to the legacy hydrogen production with fossil fuels (without carbon capture).

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 considerations) if they are allowed for use?

We support the use of power purchase agreements (including virtual and physical PPAs), transparent renewable energy credits (including “unbundled” RECs), and other contractual pathways to procure renewable energy. We believe this flexibility is critical, particularly for production of hydrogen via electrolysis (“green” hydrogen) as it would offer more options to producers in terms of their facilities’ location, help avoid project delays, and help mitigate potentially high costs associated with some electricity procurement pathways. In addition, the ability to contract by way of PPA enables and incentivizes renewable generation and associated network infrastructure investment furthering emissions reductions. Similarly, we support the use of behind-the-meter power supply arrangements in the case of self-supplying electricity for hydrogen production, plus also grid stabilization (i.e., demand response) as grid infrastructure and corresponding market regulations are revised and updated to cater for hydrogen production project needs.

For Air Company, co-locating with CO_2-producing facilities such as ethanol plants is critical because efficient CO_2 transportation infrastructure is lacking in most regions across the United States and can become prohibitively expensive. Additionally, co-locating with renewable energy generation can be extremely cost prohibitive given access to CO_2 feedstocks is site-specific (whilst direct air capture technologies scale) plus further network investment that is often required as part of connecting new generation to the grid in regional areas of the United States. As such, there are cost-related limitations to where our facilities can be located whilst being commercially viable. Procuring clean electricity is a critical step of our production process, and finding locations where both are feasible and cost-effective remains to be challenging. Stringent and narrow requirements for electricity procurement pathways will further limit suitable locations for our facilities, which can be damaging as we are working to scale our cutting-edge technology. We encourage further discussion and insight in relation to being able to potentially provide demand response and grid efficiencies as we look to develop in locations across United States.

The U.S. electricity market consists of a patchwork of regulated and deregulated regions, which impacts options for electricity procurement. Some regions also might have a cleaner electricity mix, and more renewable projects already under construction or in the interconnection queues, which makes it easier for businesses in those regions to procure clean electricity in a timely manner. Other regions might have less clean electricity available, but they might be attractive to business for other reasons (e.g., access to other feedstocks, abundance of skilled labor and favorable local policy settings). Therefore, restricting pathways for energy procurement can deter businesses from considering certain regions, which can potentially impact those regions’ economic development, emissions reduction plans/climate targets and employment opportunities for local communities.

Another reason why CHPS should allow the use of a variety of clean electricity pathways at least during the initial 5 years is due to the significant interconnection bottlenecks across the country for renewable energy projects. The impact that interconnection delay of multiple years can have on a facility relying on clean electricity for its entire business cannot be understated. According to Lawrence Berkeley National Laboratory, renewable energy projects spent up to 3.7 years in queues before being built, which represents data across five regions.[1] According to the same source, only ~23% of projects that requested interconnection from 2000 - 2016 have reached commercial operations and 72% have withdrawn. A facility that is reliant on supply of clean electricity, such as any green hydrogen-producing facility, should not be required to undertake a risk of such a delay and should have other electricity procurement options available that would allow meeting the CHPS standard. Stringent and limiting electricity procurement requirements can be particularly damaging to pilot and demonstration facilities deploying pre-commercial technologies as it would add another significant risk to successful demonstration of a novel technology or its novel application. As such, this transfers through to investment/project finance uncertainty whereby delaying the decarbonization of hard-to-abate sectors such as aviation.

The proposed draft standard notes that “electrolysis systems that source about 15% of their electricity from the grid and the remainder from clean energy sources” could achieve the proposed CHPS target. We would like to caution against setting specific thresholds for how much energy can be procured from the grid as some regions have much cleaner electricity mixes (e.g., Washington State, North East of the United States) and facilities in such regions can potentially rely more on the grid for their power demand and meet the target. Green hydrogen producers will likely need to rely on a combination of pathways to procure clean electricity, and the CHPS lifecycle target should allow and accommodate a combination of electricity procurement pathways, including PPAs, RECs, electricity from the regional grid, and/or onsite generation when feasible (behind-the-meter).

Restricting the ways a hydrogen producer can procure renewable/carbon-free energy could impede the growth of the green hydrogen industry by increasing the costs of clean electricity procurement (and associated grid infrastructure needs) and potentially delaying projects and deterring project investment. Currently, the average cost of renewable electricity procured through PPAs is increasing in the U.S., interconnection delays are rampant, and limitations associated with on-site renewable generation are significant (e.g., land availability, high construction costs in the period of high inflation, limited availability and high cost of battery storage). These challenges can be particularly damaging to innovative, pre-commercial companies, their investors, employees, and local regional communities where opportunities to manufacture products exist. Therefore, we believe it is important to allow a variety of electricity procurement pathways that will offer flexibility to green hydrogen producers and thus help advance the growth of this nascent industry in the United States.

We anticipate that the IRA tax credits will support the growth of the green hydrogen industry, which in turn will increase the demand for carbon-free electricity. If the CHPS includes narrow requirements for electricity procurement, it will risk creating damaging bottlenecks for the industry and can deter new/small companies from entering the market. We recommend that the DOE reviews the clean electricity procurement requirements in five years after the initial standard is implemented, as directed by BIL, to consider narrowing the requirements if the electricity market conditions are improved (e.g., the transmission infrastructure and interconnection queues), more carbon-free sources are available on the grid, and project developers and green hydrogen producers have more cost-effective options to procure and/or install reliable clean electricity (e.g., including clean back up generation solutions such as battery storage).

---

[1] Queued Up: Characteristics of Power Plants Seeking Transmission Interconnection As Of The End Of 2021, Lawrence Berkeley National Laboratory (April 2022).