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2021 IEPR Comments

Thank you for the opportunity to comment. Please find our comment attached.

Additional submitted attachment is included below.

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January 28th, 2022

California Energy Commission (CEC) Docket 21-IEPR-01
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Draft 2021 Integrated Energy Policy Report (IEPR) Volume III Decarbonizing the State's Gas System

Air Products, the only United States (U.S.)-based global industrial gas company, has been in operation for over 80 years and has operations in more than 50 countries around the globe. The company's core industrial gases business provides atmospheric and process gases and related equipment to manufacturing markets, including refining and petrochemical, metals, electronics, food and beverage and healthcare (including oxygen for COVID response). Approximately 20,000 employees globally work to make Air Products the world's safest and best performing industrial gases company, providing sustainable offerings and excellent service to our customers.

Worldwide, Air Products is the largest hydrogen producer with over 8,000 metric tons per day of production capacity and safely operates over 1,800 miles of industrial gas pipelines – including the world's largest hydrogen pipeline network system located in the U.S. Gulf Coast. Within California, the company safely operates nine hydrogen production facilities, 35 miles of hydrogen pipeline and currently supplies a network of light-duty and heavy-duty transit bus hydrogen fueling stations, facilitating the transition to carbon-free transportation and zero emission vehicles, in line with California's goals. In fact, Air Products has supplied a majority of the hydrogen used in the California mobility market to date.

Air Products has a strong history of application development for various industries including energy, power, chemicals, glass, metals, iron and steel. With that application experience, Air Products has proprietary designs for hydrogen blending and storage equipment and has applied its unsurpassed safety record in the safe production, storage, handling and distribution of hydrogen and other gases to its development of application equipment. Air Products has exceptional in-house combustion expertise with state-of-the-art combustion laboratories and strong computational simulation capabilities with which Air Products has developed burner technology for multiple industries. AP has collaborated in the past and continues to work with several government agencies, research institutes (DOE, NASA, EPRI etc.) and major industry partners.

We see an important role for hydrogen as a low carbon energy source to meet the state's decarbonization goals. We appreciate the opportunity to comment on this particular volume of the 2021 IEPR report.

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Long-Term Gas Planning Process

Air Products strongly supports the concept of a comprehensive long-term gas planning process for the state of California like what has been done traditionally for electricity. It is important that this process be transparent with substantive opportunities for stakeholder interaction. California's decarbonization goals are ambitious and stakeholders that can develop low-carbon hydrogen solutions from production to end-use should be encouraged to participate and provide important input.

Hydrogen Coupled with Carbon Capture & Sequestration (CCS) has an Important Role to Play

Each method of hydrogen production has a distinct role to play in various geographies – depending on the availability of natural resources including renewable power, land, and sequestration pore space – but all methods can fundamentally provide a significant reduction in greenhouse gas emissions. Regardless of the hydrogen "color", expanding the role of hydrogen as an energy source can have an immediate impact on reducing greenhouse gas emissions when compared to other fuel sources. Implementation of policy supporting a rapid transition to hydrogen use and performance-based policies on a sectoral basis are the most effective ways of decarbonizing hard-to-abate sectors and quickly developing the quantities of hydrogen production required to displace higher carbon intensity fuels both in the industrial and transportation sectors. California is blessed with both renewable energy and sequestration resources.

Producing hydrogen with CCS should play a very important role in attaining the carbon reduction goals of the state. The International Energy Agency, in their *Net Zero by 2050 Roadmap*[1], amplifies the role of CCS, including CCS coupled with hydrogen as one of the seven key pillars to achieving net zero emissions. In fact, it suggests the need for a global 150-fold increase in hydrogen coupled with CCS by 2030 and a 450-fold increase by 2050. While the carbon intensity of conventionally produced hydrogen is already lower than petroleum-based fuels when used in transportation, it can be significantly further reduced with CCS. Negative carbon emissions can be achieved by coupling CCS with hydrogen produced by biomass or biogas – including using gasification.

Hydrogen production utilizing CCS also allows for the build-out of the substantial increase in renewable power supply and the transmission capacity to deliver it where it is needed. The ability to

[1] Net Zero by 2050 - A Roadmap for the Global Energy Sector (windows.net)

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simultaneously decarbonize the current power sector, increase power demand for further electrification, and add the incremental renewable generation capacity to support hydrogen production via electrolysis will constrain achieving all three objectives. In contrast, hydrogen production with CCS supply can satisfy the near-term requirements while hydrogen demand and renewable energy supply can grow in parallel. Deployment of hydrogen produced using CCS concurrently with the development of renewable hydrogen opportunities will accelerate carbon reductions in multiple sectors sooner than if either technology were exclusively favored.

We were disappointed to see reference to the flawed Howarth/Jacobson Study "How Green is Blue Hydrogen" coupled with CEC dismissing the role of hydrogen coupled with CCS. We believe the report has significant flaws with respect to its scope and incorrect assumptions which led to inaccurate conclusions. Air Products has developed, and is developing, advanced blue hydrogen projects. Air Products' blue hydrogen projects represent a material improvement in emissions by applying prevailing policy and globally accepted scientific principles and life-cycle analysis methods. Our analysis of our projects show that blue hydrogen has a carbon footprint 80-92% lower than the estimates in the flawed report.

Amongst other factors, the report assumes an unreasonably high methane leakage rate of 3.5% during natural gas production, distribution and storage. According to the National Energy Technology Laboratory, the average U.S. rate of 1.24% is more representative (95% confidence level range of 0.84-1.76%). And these leak rates are likely to be further reduced as additional methane regulations are implemented. The report also assumes a non-standard 20-year Global Warming Potential (GWP) for methane of 86 when the 100-year factor is 34, thereby inaccurately increasing carbon dioxide (CO_2) emissions related to methane by a factor of 2.5. (Global Warming Potentials are a measure of the heat absorbed by the atmosphere over a given time-period due to emissions of a gas.). As an example, the Air Resources Board's greenhouse gas inventory utilizes 100-yr GWPs consistent with the Intergovernmental Panel on Climate Change 4th assessment report. Lastly, the report only evaluated one production technology equipped with limited carbon capture. There are multiple ways to make blue hydrogen and the selection of technologies, energy sources and carbon capture rates, significantly impact the potential emission reductions and hydrogen carbon intensities.

Additionally, respected organizations also published analyses of life-cycle emissions for blue hydrogen projects and draw very different conclusions from the referenced report.

- A study by Pembina Institute (a non-profit think-tank that advocates for strong, effective policies to support Canada's clean energy transition) released the same day, cited a carbon

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footprint for blue hydrogen that was two to 10 times less than the flawed report results.
  - (1.9 to 8 kg CO_2/kg H2 for Pembina vs. Howarth at 16.2-18.4 kg CO_2e/kg H2)
- CCSA, a trade association with extensive experience in carbon capture, responded to the study, noting that the flawed research overestimates the carbon footprint of blue hydrogen by a factor of 10 based on up-to-date assessments and engineered solutions.

Overall, the report extrapolates from a flawed worst-case scenario to broad generalizations against blue hydrogen without justification and therefore is baseless in its findings.

It's important to note that CCS can contribute to overall greenhouse gas reductions AND air pollution reductions. CCS has been clearly demonstrated and supported by globally respected scientific research over many years. Indeed, California's Lawrence Livermore National Lab has been a strong proponent of CCS and demonstrates that support at workshops based on their report *Getting to Neutral*.[2] Strategies to capture CCS will also deliver additional criteria air pollutant reductions, which may vary based on technology and application, but are directionally consistent and deserve further analysis. We ask that CEC provide a more balanced discussion of hydrogen production utilizing CCS in the IEPR.

Utilization of the Natural Gas System for Hydrogen

Safety, reliability, and affordability are key aspects of delivering energy to residential, commercial, and industrial consumers. While Air Products is not opposed to hydrogen blending into natural gas as a method of decarbonization, we believe that there are a number of considerations that need to be taken into account before proceeding with this concept to assure that safety, reliability and affordability of the delivered energy is maintained. There is a brief acknowledgment of some issues related to transmission on page 68 of document, but we want to reinforce and augment the issues referenced. Some of these considerations are being studied currently, but more work is needed.

Hydrogen Pipeline Integrity and Safety

Modern gas pipeline systems are optimized to transport natural gas. To adapt to transporting a hydrogen blend, the distribution system needs a thorough systematic, component by component review to ensure safe operation. Research in this area needs to ensure the sustained durability of the pipeline system at proposed hydrogen blend levels.

[2] https://www-gs.llnl.gov/content/assets/docs/energy/Getting_to_Neutral.pdf

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Hydrogen is known to cause embrittlement or cracking in the welds of transmission pipelines depending on pipe metallurgy and operating conditions. Hydrogen gas reduces the fracture toughness, crack propagation resistance and ductility, and increases the fatigue crack growth rates for pipeline steels and their welds. Research already commissioned by the CEC needs to carefully examine this failure mechanism and recommend materials and inspection protocol to safeguard the public against this risk.

Natural gas is used in homes for cooking and heating. Hydrogen has a wider flammability range and lower minimum ignition energy compared to natural gas. These facts coupled with the higher propensity to leak (due to molecule size) could create more dangerous conditions in residential applications where such leaks may go undetected. Odorants, like mercaptan, are used so homeowners can detect natural gas, but are not yet approved for hydrogen. Moreover, hydrogen burns almost invisibly creating unique risks to the public that do not need to be addressed for natural gas. There needs to be more research done in this area to determine the best public safeguards for these characteristics of hydrogen gas.

System Capacity and Reliability

Hydrogen blends can impact the accuracy of existing gas meters, which, in turn, would impact the billing process for gas supplies. Hydrogen has a lower energy density than natural gas and at higher blend levels, gas meters will show a higher volume of use for the same energy supply.

Because of the lower heating value of natural gas, more volume of hydrogen is needed for the same energy requirements. In some cases, this will limit the peak flow in high demand scenarios. These bottlenecks and potential mitigation need to be identified as part of this research project.

Impacts on Industrial End Users

While research to ensure public safety is of the utmost importance, we suggest that the CEC also prioritize research on the impacts to industrial users. Some areas for further research to both quantify and mitigate impacts include:

- Hydrogen blends used in equipment like gas turbines will alter the combustion characteristics (due to different combustion air requirements index and a low ignition

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energy) and can lead to higher local flame temperatures in burners. This can increase Nitrogen Oxides (NOx) emissions in existing equipment without retrofit which will exacerbate federal air quality attainment issues in some regions of California (like Southern California). The costs of these retrofits to mitigate NOx emissions must also be included any cost-effectiveness analysis as discussed below.

- Higher localized flame temperatures in combustion equipment must also be studied for its impact on equipment lifespan.

- Hydrogen's lower energy density requires more volume of hydrogen to generate the same amount of energy as natural gas. This fact could cause existing industrial equipment to become rate limited. This could be a significant impact on industrial users and production that needs to be evaluated and quantified.

- Because heat transfer mechanisms from hydrogen flames are different when compared to natural gas flames, a change in burners may be necessary to provide the heat profile needed by the industrial application.

Costs & Cost-Effectiveness

The lower heat content of hydrogen relative to natural gas will require more volume of gas used to maintain the same heating requirements. The impact of this additional volume of gas and its associated costs needs to be quantified for the benefit of ratepayers. This is in addition to the need to quantify the costs of all the system and end user impacts discussed above.

The CO_2 reduction benefit from the combustion of these blends needs to be quantified, along with the system upgrade costs, to determine the cost per metric ton of CO_2 reduction. By doing so, you can assess the cost-effectiveness of this use of hydrogen which can be compared to other potential uses with associated CO_2 reductions. It is important this approach be cost-effective considering the potential impacts to ratepayers.

To the extent that natural gas-hydrogen blends are being contemplated for energy storage, research needs to be done to compare the round-trip efficiency of the blend to other storage options (like battery or pumped storage) and to quantify any incremental costs associated with the lower efficiency.

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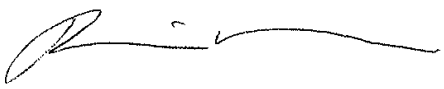
Role of the Private Sector

While we understand that this section of the IEPR is looking at the role of the natural gas system more broadly in a decarbonized future, the inclusion of hydrogen without mention of the role of the private sector market is concerning and risks sending the wrong signal to market participants. To date, the private sector has played the predominant role in hydrogen production, transmission, and distribution to facilitate various end uses in the industrial and transportation sectors. This has happened efficiently without direct regulation or a utility model and should be encouraged. We see private market development for hydrogen continuing with the growth of hydrogen hubs in response to increased demand for decarbonization with the help of the government incentives offered via the infrastructure bill recently passed in Congress. Currently, private (unregulated) natural gas providers and industrial consumers can enter contractual arrangements for natural gas supply utilizing the regulated transmission system. Achieving deep decarbonization quickly will require multiple supply demand models and private systems with hydrogen supply arrangements between private entities and should be encouraged We request that the CEC involve private hydrogen producers in established work groups and regulatory processes to the extent that hydrogen's role is being contemplated for the legacy natural gas system.

Air Products appreciates the opportunity to provide feedback for this research solicitation. Please feel free to contact me by phone (916-860-9378) or email hellermt@airproducts.com.

Respectfully,



Miles Heller
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