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Chairman Manchin, Ranking Member Barrasso, and Members of the Committee, on behalf of Air Liquide's more than 23,000 employees in the United States, thank you for the opportunity to testify today on Clean Hydrogen. My name is Mike Graff, and I am the Chairman and CEO of American Air Liquide Holdings, Incorporated. Air Liquide entered the hydrogen market over 60 years ago and since then we have focused on hydrogen as a key molecule for investment, research and technology development. As a pioneer in the hydrogen market, we are also a proud member of the Fuel Cell and Hydrogen Energy Association, a leading voice on hydrogen issues in the United States. Air Liquide is also a founding member of the global Hydrogen Council.

It's estimated that hydrogen, over the next 30 years, could grow to account for up to 20 percent of the world's total energy demand. This would reduce annual CO2 emissions by roughly 6 gigatons compared to today's levels, and contribute roughly 20 percent of the abatement required to limit global warming to two degrees Celsius, according to a McKinsey & Company study. For the United States, hydrogen is a cornerstone of the energy transition, and an important component in enabling us to reach a low-carbon, and eventually carbon neutral society, with the potential to decarbonize applications in the industrial, energy and mobility sectors, among others, all while providing high paying jobs for American workers.

At Air Liquide we know the value of hydrogen firsthand, having played a leading role in hydrogen production, liquefaction, storage, and delivery for half a century. Hydrogen is crucial to achieving carbon neutrality by 2050. With more than $1 billion invested in hydrogen activities in the U.S., and more than $5 billion worldwide, at Air Liquide, we are not just talking about the potential of hydrogen, we are investing in its future. In fact, we have committed to an additional investment of nearly $10 billion in low-carbon hydrogen by 2035 as part of a plan to more than triple sales of hydrogen and help substantially curb emissions that will also support our own goal of achieving carbon neutrality by 2050.

The clean energy transition is a once in a lifetime opportunity—reimagining our energy future and doing so in a way that drives economic development and job creation in a sustainable manner. It will take the concerted efforts of both government and industry to reconsider every aspect of our energy landscape, and I'm very pleased to speak to you today about the important role that hydrogen can play in these efforts to achieve our collective net zero ambitions.

As I often say, hydrogen alone will not drive this clean energy transition, but the energy transition will not happen without hydrogen.

Today, I will focus on three key questions regarding hydrogen:

- How can the United States lead in hydrogen production?
- In what sectors can hydrogen make the greatest impact?
- What is needed to catalyze hydrogen's role in the energy transition?

How can the United States lead in hydrogen production?

The United States is blessed with abundant and diverse resources capable of producing clean energy. Hydrogen production is able to leverage the unique resources of different geographic regions. The most common production method is steam methane reformation which produces hydrogen from a high temperature catalytic reaction between steam and a hydrocarbon, most commonly natural gas. Air Liquide operates multiple facilities throughout the United States using this process. Another common method is known as electrolysis. Using this process we are able to use electricity to split water into its components of H2 (hydrogen) and O (oxygen) and capture the hydrogen and oxygen. Air Liquide currently operates such a facility in Becancour, Canada, which utilizes the world's largest Proton Exchange Membrane (PEM) electrolyzer currently in operation to produce low-carbon and renewable hydrogen at industrial scale.

Using steam methane reformers (SMRs) the United States can take advantage of its abundant natural gas reserves to produce hydrogen. This same SMR can be retrofitted with carbon capture equipment to dramatically reduce its carbon footprint. Air Liquide has developed a suite of carbon capture solutions called CryoCap™, which features our proprietary technology that can reduce CO2 emissions by 90 percent at an SMR. The utilization of carbon capture technologies can further the deployment of clean-hydrogen producing SMRs in areas with abundant natural gas while also dramatically reducing carbon emissions at existing facilities throughout the country.

That same SMR technology can produce renewable hydrogen when using renewable natural gas (RNG) as a feedstock. RNG is methane that is captured from landfills, wastewater treatment facilities, and dairy digesters and purified. This is how Air Liquide will produce renewable hydrogen for the mobility markets in our new facility in North Las Vegas. Air Liquide is a leading producer of membrane technology widely used today to produce RNG. We recently announced the construction of two new RNG production facilities that will be built here in the U.S., one in Rockford, Illinois, and another in Delavan, Wisconsin. The Rockford facility will be Air Liquide's largest biomethane production unit with a biomethane capacity of 380 GWh per year. When hydrogen produced using RNG is combined with carbon capture technologies such as Cryocap™, in some instances this process can produce net-negative CO2 hydrogen.

Similarly, the electricity used in an electrolyzer can be tailored to the resources of a given region. In Becancour, Canada, we are able to take advantage of an abundant supply of hydropower and supply the northeast United States with low-carbon, renewable hydrogen. Air Liquide has already produced over 1,000 tons of hydrogen which has been seamlessly supplied to both the mobility and industrial markets, including in the New York Power Authority's power demonstration project aimed at decarbonizing the power grid. Elsewhere this same process can use wind, solar, nuclear or a variety of other power sources to create low-carbon, renewable hydrogen.

In many of these instances, hydrogen can address intermittency issues of other renewable power sources by creating hydrogen from low-carbon power when grid supply outpaces demand, and storing it for later use. In fact, Air Liquide operates the world's largest hydrogen storage facility in Beaumont, Texas. This facility currently ensures an adequate supply of hydrogen for fuel and chemical customers in the Gulf Coast, but the same technology could be used to increase grid

resiliency and provide low-carbon hydrogen to a plethora of different end uses. The storage cavern holds 4.5 billion cubic feet of hydrogen. This is the equivalent of more than 350 GWh in energy, enough power to backup a nuclear plant for one to two weeks. At a smaller scale, fuel cells have already proven a reliable back-up power replacement for stationary diesel generators, offering significant reductions in emissions and noise pollution.

Perhaps most importantly, hydrogen can ensure that the United States remains a leader in the energy economy of the future. When we talk about hydrogen's ability to create jobs, we're really talking about its power to transform communities by providing opportunities for the existing workforce to transform to clean energy jobs, and training a new generation of workers for careers in producing a source of clean energy that provides great pay and benefits.

According to the "Road Map to a U.S. Hydrogen Economy" produced by the Fuel Cell and Hydrogen Energy Association, by 2030, the hydrogen economy in the U.S. alone could generate an estimated $140 billion per year in revenue and support 700,000 total jobs across the hydrogen value chain. In the U.S., hydrogen is projected to be even more robust by 2050 accounting for at least $750 billion in revenue and 3.4 million jobs. Air Liquide is excited to help lead this emerging economy, and we are not just talking about the potential of hydrogen, we are investing in its future.

Air Liquide will soon be opening a $200 million investment utilizing a steam methane reformer which, with biogas feedstocks, will provide low-carbon and renewable hydrogen to the mobility market. And as stated before, Air Liquide has committed to an additional investment of nearly $10 billion in low-carbon hydrogen by 2035. It is my sincere hope that as much of this investment as possible will be invested right here in the United States. These investments will be critical to helping Air Liquide reach its climate commitments of decreasing its CO2 emissions in absolute value by 33 percent by 2035, and achieving carbon neutrality by 2050.

In what sectors can hydrogen make the greatest impact?

Just as there are multiple ways to produce hydrogen, this energy vector can be used in many different ways to contribute to a low-carbon economy. Existing users of hydrogen, such as petrochemical and fertilizer producers, chemical manufacturers, and steel production can decarbonize by converting existing assets to use hydrogen produced using low-carbon production methods.

Perhaps the most exciting potential for hydrogen is in the transportation sector. Today, this sector emits more than 20 percent of all CO2 emissions globally[1] which means that the decarbonization of this market is essential to reaching the net-zero ambitions that we are discussing here today.

We have seen significant adoption of hydrogen in the transportation sector already, so I think when people hear "hydrogen energy" and the "energy transition," what most readily comes to mind is hydrogen mobility. At Air Liquide, we believe strongly in hydrogen as a transformative transportation fuel of the future.

There is always debate about battery electric vehicles versus hydrogen fuel cell electric vehicles, but the truth is that these technologies should be deployed in ways that complement each other, because ultimately, each has an important role to play if we're going to decarbonize the transportation sector. When used as a fuel in a hydrogen fuel cell vehicle, hydrogen does not generate any pollution at its point of use: zero greenhouse gases, zero conventional pollutants and zero noise. Today, hydrogen and hydrogen fuel cells are already used to power all manner of transport solutions like forklifts and material handling equipment, and are especially well suited to fleet vehicles and heavy-duty transportation. Hydrogen fuel cell electric vehicles are ideal for decarbonizing heavy-duty applications that require heavy payloads, such as trucks and buses, because the storage of hydrogen requires less space and weight than a battery array. Because hydrogen vehicles are comparable to traditional vehicles in range and refueling times, they allow fleet vehicles to go farther and have less refueling/downtime than battery electric vehicles. Similarly, fuel cells allow for customers to choose a light duty option with a fueling experience similar to what they have with gasoline while simultaneously addressing the issues related to charging access, range, vehicle size, and cold weather operation.

Heavy-duty vehicles play a complementary role to light-duty vehicles in the development of fuel cells and hydrogen supply. While there are many more light-duty vehicles on the road, heavy-duty vehicles drive larger fuel consumption per vehicle. Between them, they can develop a sustainable vehicle and fuel market, enabling scale and bringing down the cost of hydrogen through investments in manufacturing, production, and supply to the broad transportation market.

Additionally, heavy-duty markets can be established by focusing on fleet or transportation centers that enable a large number of vehicles with a relatively small number of refueling stations in a "return to base" operation. As infrastructure and vehicle adoption grows, long-haul trucking and regional station networks will follow.

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[1] https://hydrogencouncil.com/wp-content/uploads/2017/11/Hydrogen-scaling-up-Hydrogen-Council.pdf, page 30

An important aspect of the proliferation of fuel cell vehicles are the benefits brought to communities that may experience environmental justice impacts. These communities often are more disproportionately impacted by conventional pollutants from energy-related emissions as a result of their proximity to industrial sectors, energy production, or highways or other transportation corridors. The conversion of public transportation and heavy-duty vehicles to hydrogen eliminates tailpipe emissions, including conventional pollutants and greenhouse gas emissions, and noise, and reduces the impact on these communities. By having a refueling process comparable to traditional gasoline fueling stations, zero-emission hydrogen fuel cell electric vehicles expand access to zero emission vehicles for those that do not have access to personal garages with charging capabilities or adequate public charging stations.

Of course, the expansion of fuel cell vehicles means that a reliable hydrogen fuel supply will be necessary, and Air Liquide's investment in Nevada that I mentioned earlier will do just that. At full capacity, our liquid hydrogen plant in Nevada will provide enough fuel to keep more than 40,000 hydrogen fuel cell electric vehicles on the road, significantly improving the supply to this critical market.

Additionally, Air Liquide is at the forefront of hydrogen storage and liquefaction technologies, and we are developing the next generation of gaseous, liquid, and even solid state storage. We recently announced a joint development agreement with Faurecia, a global leader in automotive technology, to design and produce on-board liquid hydrogen storage systems for heavy-duty vehicles that can double the amount of hydrogen stored compared to gaseous hydrogen, meaning a vehicle can operate for twice as long on a single fueling. Heavy-duty trucks operating on liquid hydrogen have twice the autonomy of those operating on gaseous hydrogen, and benefit from a short refueling time and optimized payload.

What is needed to catalyze hydrogen's role in the energy transition?

This brings us quite naturally to our final question: What is needed to catalyze hydrogen's role in the energy transition?

The private sector is ready to lead, but government policies will play an important role in hydrogen's market growth and penetration. Public-private partnerships are critical to success because a policy portfolio that drives private investment can result in a self-sustaining market and ensure rapid adoption at scale.

We have a vision for the future role of hydrogen and we have the proven technologies needed to demonstrate at-scale deployment. The last element we need to ensure a successful energy transition is a policy framework that will encourage and enable the transition and drive investment at scale.

Already we have seen significant strides forward in promoting hydrogen energy through public policy, notably with the clean energy provisions in the Infrastructure Investment and Jobs Act (IIJA). Thank you Chairman Manchin and members of the committee for your hard work to create these provisions which provide critical support for the necessary framework and infrastructure needed to galvanize a national hydrogen market. Funding for regional hydrogen hubs will support the localization of hydrogen production and distribution, which will benefit communities by creating and maintaining high-paying jobs, while establishing new hydrogen markets or growing existing ones. Additionally, thank you Senators Heinrich and Cassidy for your support of the Hydrogen Infrastructure Initiative. Introduced in cooperation with Senators Coons and Cornyn, this package of three bills encourages the adoption of hydrogen technologies in those sectors where hydrogen offers an efficient and effective path to decarbonization, including ports and industrial sectors

Last year, Air Liquide had the honor of hearing first-hand about hydrogen's importance to the Administration when we hosted the U.S. Secretary of Energy Jennifer Granholm at our hydrogen production facility in Texas. The Secretary expressed great enthusiasm for hydrogen's ability to decarbonize hard-to-abate sectors, meet the United States' goal of net-zero carbon emissions by 2050, and to provide not just jobs, but *careers* in a clean industry.

For its part, the U.S. is taking a whole of government approach – and hydrogen is poised to play a key role across economic, industrial, and energy sectors, all with environmental benefits.

Programs like the Department of Energy's Energy Earth Shots Initiative and the Hydrogen Shot's aim to facilitate the deployment and reduce the cost of clean hydrogen are great examples of how government and industry can work together to achieve economies of scale, a critical factor in advancing hydrogen's role in the energy transition. Additionally, the rapid implementation of the Infrastructure Investment and Jobs Act will catalyze the growth of clean energy technologies like hydrogen.

For instance, the DOE Hydrogen Hubs will provide an opportunity to accelerate the hydrogen markets across the U.S. Air Liquide is an active partner in several early stage hub discussions. Among these, we are exploring hubs in the Gulf Coast to decarbonize our existing assets; hubs in California to expand the hydrogen transportation sector into heavy-duty vehicles; and hubs in the

Northeast to help decarbonize industry and enable better grid resiliency. And, we continue to consider other opportunities in other geographic areas. By producing hydrogen locally we invest in our communities and reduce the environmental footprint related to distribution. Additionally and importantly, the DOE Hydrogen Hubs will catalyze clean energy ecosystems.

Of course, renewable feedstocks and low-carbon production methods will further advance our ability to achieve net-zero objectives as they directly address the carbon intensity of hydrogen. Policies that reward investments in low-carbon hydrogen production are vital, such as the Clean Hydrogen Production Act, which Senator Carper announced during a visit to Air Liquide's own advanced innovation center in the Senator's home state of Delaware and which the Senate Finance Committee passed as part of a larger package. This important tax credit is included in Build Back Better and will incentivize the production of clean hydrogen and help catalyze the production and use of hydrogen across all sectors. It will also supercharge the industry's ability to develop key hydrogen technologies, help create high paying jobs, and lower the CO2 emissions across many sectors.

Flexibility is imperative, but a policy portfolio that rewards outcomes, allows for market growth, and results in open market dynamics that drive innovation, investments, and sustainable growth, is a good place to start.

Finally, we encourage that the government consider all options for hydrogen production. At Air Liquide, we believe that the focus should be on the outcome of using low-carbon hydrogen rather than the production method. By focusing on the environmental outcome of being "low-carbon" we can address the carbon intensity of the hydrogen and enable producers the flexibility of relying on the energy resources abundant in that region to provide a robust supply of low-cost hydrogen while minimizing the environmental impacts. This will play a key role in helping the United States reach the goal of net zero emissions by 2050.

To me, the inspiring challenge of achieving net-zero ambitions is finding the ways to leverage the current momentum with the right combination of technologies, policies, and portfolio decisions. I think the good news is that we have a very strong solution in hydrogen energy.

At Air Liquide, we believe that hydrogen will transform the future but as for any major change, we know that the transition to a clean energy economy won't happen overnight. But with the commitment to the environment from companies like Air Liquide, and all those here today, I am confident that with hydrogen energy, we will transition to a clean and sustainable future.

Chairman Manchin, Ranking Member Barrasso, and Members of the Committee, thank you for your time today. I look forward to answering your questions.