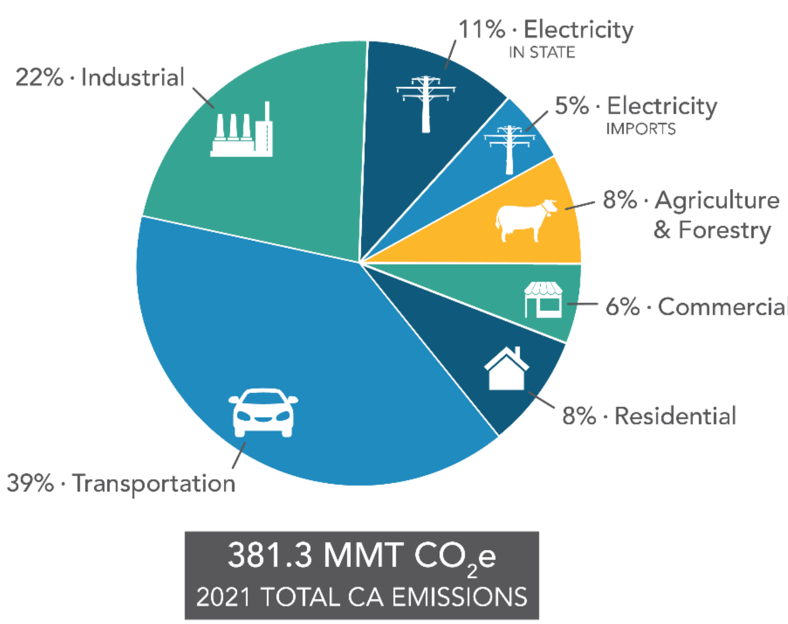
STATE CAPITOL
P.O. BOX 942849
SACRAMENTO, CA 94249-0115

California Legislature
STEVE BENNETT
ASSEMBLYMEMBER, THIRTY-EIGHTH DISTRICT

Select Committee on Building a Zero-Carbon Hydrogen Economy Informational Hearing

Hydrogen Promises and Protections

California has set ambitious climate goals to achieve a 40% reduction of Greenhouse Gas (GHG) emissions below 1990 levels by 2030. In 2022, California went further by setting a goal of achieving carbon neutrality by 2045, and a goal to ensure that emissions resulting from human activities are reduced 85% below 1990 levels. For the energy sector specifically, California has established a goal of powering our electricity grid with 60% renewables by 2030, 90% renewable and zero-carbon electricity by the end of 2035, 95% renewable and zero-carbon electricity by the end of 2040, and 100% renewable and zero-carbon electricity by the end of 2045. Meeting these climate goals will require sustained effort and focus, in addition to monumental shifts in our



economy. As can be seen on the California Air Resources Board (CARB) GHG Emissions Inventory website the three largest contributors to the state's emission are the transportation sector, the industrial sector, and the electricity sector. Increasing the amount of electricity generated by renewables – such as, wind, solar, and geothermal – will be important in both reducing our emissions in the electricity sector, as well as in other sectors as they shift towards electrification. However, as California makes progress towards its emissions goals policymakers will be faced with a growing challenge on how to decarbonize sectors that cannot be, or are not easily, electrified. Hydrogen provides a potential solution for hard to decarbonize as a replacement for fossil fuels, and as a potential long-term energy storage solution.

What is Hydrogen?

Hydrogen is the lightest element known and in a standard condition is an odorless, colorless, non-toxic gas (H_2). Hydrogen is the most abundant element in the universe. On Earth, sources of naturally occurring H_2 have been identified, however it is found most abundantly in the form of water (H_2O). Production methods vary, but hydrogen is most commonly produced via separation from water, fossil fuels, or biomass. As an energy carrier it has a high energy content by weight, but has the lowest energy content by volume (four times less than gasoline). Given this fact, the amount of physical space needed to store hydrogen is much higher than existing fossil fuels.

Hydrogen - Zero Emissions?

The carbon intensity, environmental impact, and energy efficiency of hydrogen depends on how it is produced and used, as well as what it displaces. Hydrogen can be produced from a number of feedstocks, including fossil fuels, biomass, and water electrolysis with electricity. Hydrogen can be used electrochemically, such as in a fuel cell, or by combustion, such as burning a turbine or internal combustion engine. Hydrogen, when consumed in a fuel cell, only produces water as a byproduct. Hydrogen, when used in a combustion engine however, produces low levels of oxides of nitrogen.

According to the International Renewable Energy Agency, as of December of 2021, almost 47% of the global hydrogen production is from natural gas, 27% from coal, 22% from oil (as a by-product) and only around 4% comes from splitting water via electrolysis.

Within the United States natural gas is the primary source of hydrogen produced (95%). The global GHG emissions of natural gas derived hydrogen surpasses the carbon emissions of Indonesia and the United Kingdom, combined – making hydrogen today a carbon-intense fuel.

Hydrogen Policy Landscape

European Union

In July of 2021 the European Union (EU) officially adopted the European Climate Law, setting a goal to become climate-neutral by 2050 and setting a goal to reduce net GHG emissions 55% below 1990 by 2030. Among the many strategies the EU is employing in order to meet their climate goals is an increase in the production of hydrogen. As of 2022, hydrogen only accounted for about 2% of the EUs energy mix. The overall emissions attributed to hydrogen in Europe, 96% of which is produced from fossil fuels, ranges between 70 and 100 million tonnes of CO2 annually.

Following the adoption of the Climate Law, European Commission undertook efforts to establish a policy framework and a set of guardrails to minimize unintended consequences from hydrogen production. Hydrogen is an energy carrier and not a direct source of energy itself. As such, the Commission noted electrolytic hydrogen production will require large amounts of new renewable generation, potentially up to 500TWh by 2030, or otherwise risk increasing demand for fossil-based power generation. Hydrogen production driving new and increasing fossil fuel power development seemed counter to the EU's decabronization goal. In order to protect against such negative policy outcomes the EU established a set of rules to govern the production of electrolytic hydrogen: additionality, geographic deliverability, and temporal matching – collectively known as the "three pillars." More specifically, the Commission adopted:

- Additionality rules: Producers have to ensure that electricity used to create hydrogen is supplied by renewable resources.
  - This requirement can be met by either locating the necessary amount of renewables at the same location as the hydrogen production facility, or by entering a contract with an operator producing renewable electricity.
  - This rule enters effect on January 1, 2028 As a measure of flexibility hydrogen facilities that are operating prior to January 1, 2028 have until January 1, 2038 to comply with the rule.
  - The Commission also exempts regions that can prove that 90% of their energy was produced via renewable generation, so long as hydrogen production does not exceed the proportion of renewable energy produced in their area.
- Geographic deliverability: Producers must show that the additional renewables are located in the area the hydrogen is produced.
  - This can be met by showing that the renewable energy is supplied within the same area as the electrolyzer, or an interconnected area that meets specific criteria.
  - EU nation states may impose additional criteria on producers.
- Temporal matching: Producers must show that the generation of renewable electricity coincides with hydrogen production.
  - Until December 31, 2029 producers may match their hydrogen production with their use of renewable electricity on a monthly basis (monthly matching).
  - Beginning January 1, 2030 hydrogen must be produced within a one-hour period as the renewable electricity (hourly matching).
  - A member nation may implement the hourly matching requirement beginning on July 1, 2027.
  - The temporal matching requirement can also be considered met if the price of electricity is below as certain threshold.

Collectively the pillars are meant to avoid a greater reliance on fossil fuels due to increased hydrogen production. Additionality's primary goal in the EU is seen as necessary to ensure that hydrogen grows with renewables, instead of simply increasing energy demand resulting in an increased reliance on fossil fuels. Hourly matching is similarly seen by the Commission as avoiding reliance on fossil fuels by requiring that producers prove that the energy used to produce hydrogen is supplied by renewables, instead of being supplied by fossil fuels that are supplying electricity while the hydrogen is being produced. Geographic deliverability is meant, in the EU, to ensure that the energy claimed by the hydrogen producer is properly accounted for and being supplied in the same region that the hydrogen is being produced. These pillars are seen as working in conjunction together to eliminate unintended consequences.

United States

Currently, the US is estimated to produce 10 million metric tons (MMT) of hydrogen, resulting in about 100 MMT of GHG emissions, per year. The hydrogen produced in the US is primarily used in refining (55%) or chemical processes (35%). On November 15, 2021 President Biden signed into law the Infrastructure Investment and Jobs Act, which included $8 billion to the Department of Energy (DOE) to establish hydrogen research and pilots across the country, known as the Regional Clean Hydrogen Hubs Program (H2Hubs). This investment in hydrogen is part of a long-term strategy to spur the growth of clean hydrogen and economic development.

In addition to the $8 billion dollars that the federal government has committed for H2Hubs, under the Inflation Reduction Act the Treasury Department was tasked with developing a federal tax credit to incentivize the production of clean hydrogen, otherwise known as the 45V tax credit (45V). The tax credit is structured to provide up to a $3 tax credit per kilogram of hydrogen produced, with higher credits granted to lower-carbon-intensive hydrogen. In December of 2023 the Treasury Department released its draft proposal, which included a version of the three pillars:

- Additionality: Requires the hydrogen producer to use renewable electricity that is in operation no more 36 months prior to the production of the hydrogen.
  - Generation resulting from a generator's newly added capacity ("uprates") are also considered new sources of clean power.
- Geographic Deliverability: Requires hydrogen producers to show that the renewable energy produced comes from the same region where the hydrogen is produced.
- Hourly Matching: Beginning in 2028 hydrogen producers would be required to match the production of their hydrogen an hourly basis.

In providing context for 45V, the DOE released a white paper that provides discussion on why the three pillars are necessary. In short, the DOE commented that all three pillars are necessary because without all three pillars, "there is a strong likelihood that the hydrogen production would in many cases significantly increase induced grid emissions." This occurs because as hydrogen production is added to the grid it results in additional grid load that must be met by dispatchable resources, primarily natural gas (this is true in California as well), in addition to efficiency losses inherit to producing hydrogen.

In the case of additionality the correlation is fairly straightforward if there is a large additional load on the grid and that energy is not matched with a corresponding renewable resource, emissions will increase as more easily dispatchable resources (fossil fuels) are used to generate the necessary electricity. However, even in the case of a hydrogen producer entering a contract with a low-GHG resource, or renewable resource, there is still the risk of increasing emissions. If the low-GHG resource would have already been supplying existing load and is simply redirected to serve hydrogen specifically (also known as resource shuffling), then more energy would be needed to make-up for the lost low-GHG resource, which could be deemed to be unintentional resource shuffling. These types of scenarios could potentially increase the need for fossil fuels on the grid (as dispatchable resources), or delay the retirement of existing facilities, such as natural gas plants in California. Potentially, these scenarios could also increase reliability challenges that have prompted the State to invest billions of dollars into supply- and demand-side resources through the Electric Supply Strategic Reliability Reserve Program.

In real world applications this is further complicated by whether energy is located, or able to be delivered, near a hydrogen production facility, and at what time the energy is used. For example, if a producer adds new renewable resources, but those renewables resources are outside of the state. In that case the direct emissions would be dependent on the electricity supplied in the production facilities geographic area and the area where the renewable resources are located would also have to make up for the lost energy, likely relying on dispatchable resources.

Similarly, if a producer is able to buy renewable resources, but produce hydrogen at a different time, the DOE notes a risk of increased emissions. If a hydrogen plant buys solar credits, which are generated during the day, but operates their hydrogen facility during hours of the day when solar is not the primary resource on the grid. In that case the real world emissions could exceed the credited savings. There also exists the risk that without precise, hourly matching, that production of renewables will be to account for energy on paper, but not used in fact to supply the hydrogen production facility. Furthermore, there is a risk that an incentive is created to purchase the cheapest renewable (potentially solar) without giving consideration to the best-fit resource for that demand due to the energy draw of hydrogen throughout all hours of production, resulting in a grid that is more dependent on one type of resource and less diversified.

It is important to remember that decarbonization is the underlying goal in all of these efforts to incentivize hydrogen production. Encouraging ways of producing hydrogen that result in emissions greater than what fossil resources contribute, just to grow the market, would be counter to this underlying goal.

California

According to the 2023 Integrated Energy Policy Report by the California Energy Commission, California currently produces an estimated 1.06 MMT of hydrogen per year, resulting in 10.57

MMT of CO_2 emissions out of the state's 381.3 MMT of total CO_2 emissios. Put differently, hydrogen accounts for about 2.8% of the state's total emissions and is primarily produced at refineries. California is also a leader in light-duty fuel cell vehicle adoption and fuel demand with 12,993 registered hydrogen vehicles on the road in California. Additionally, the state has awarded $256 million dollars to fund hydrogen fueling stations, and is home to 51 of the nation's 52 publicly accessible hydrogen fueling stations. Leveraging these existing investments industry, labor organizations, and the administration partnered together as a single public-private entity known as ARCHES to put forward a successful application for the H2Hubs program. The ARCHES application was selected as a potential recipient of $1.2 billion for a clean hydrogen hub, pending negotiations with the DOE. ARCHES has set a goal of being the cleanest hub in the nation and produce non-fossil derived hydrogen.

As California moves forward hydrogen holds the potential to help decarbonize hard to electrify sectors. However, it will also require additional planning, as noted in the 2023 Integrated Energy Policy Report. For example, electrolytic hydrogen could potentially require 54.8 GW (35.8 GW for electricity generation and 18.4 GW for transportation fuels) of additional renewables in order to produce the hydrogen required to displace diesel and fossil fuels, according to the 2023 Integrated Energy Policy Report. Policymakers will have to balance the climate benefits of a new, clean hydrogen supply chain against its costs, from a reliability and economics perspective. Policymakers will also have to grapple with decarbonizing the existing hydrogen supply chain as well.

Things to Consider

- Does the increase demand for energy by hydrogen create a risk of increased energy costs?
- To what extent is hourly matching needed to send the proper market/pricing signals that encourages the production of renewable resources year around 24/7?
- Who will pay the costs of adding new renewables to the grid and building out the associated infrastructure to serve hydrogen production facilities?
- What are the emissions of electrolytic hydrogen today, using the state's current grid energy mix?
- How do we ensure that increased production of hydrogen does not lead to increased emissions?
- How much will the 45V hydrogen production tax credit influence the production of hydrogen?
- What are the potential emissions savings of hydrogen compared to fuels like gasoline or diesel?
- What are the potential emissions savings of hydrogen compared to other firm electricity sources like natural gas, hydroelectric, and geothermal generation?
- Do California's existing policies prevent unintended consequences, or is hydrogen unique enough that a different policy framework is necessary?
- How does California ensure that resources built using public funds in the near-term will be consistent with California's long-term economy-wide decarbonization requirements?