National Wildlife Federation Fact Sheet: Hydrogen as a Clean Energy Option

Hydrogen is the most abundant element in the universe, and in its gaseous form, H_2, is the smallest, lightest molecule. It is colorless, odorless, tasteless, non-toxic, and highly combustible. Given these properties, it has long been used as a source of light, heat, and transportation.

Today, hydrogen is used in many industrial applications such as ammonia and fertilizer production and oil and chemical refining. Yet its ability to store and produce energy without harmful byproducts has made it a prime focus for future use in electricity generation, transportation, and other hard-to-decarbonize sectors. Scaling up such uses will come with important challenges, risks, and considerations that must be accounted for to ensure they become truly clean, responsible energy alternatives.

Hydrogen Production

Most natural hydrogen does not exist in pure form, but rather, bound in molecules with other atoms. Therefore, hydrogen must be pulled out of these other compounds in order to be used. This process is known as hydrogen production and can be done in various ways.

The most common production method today is to break apart the methane molecules in natural gas through a process called steam methane reforming (SMR). Along with hydrogen, the byproduct of the process is CO_2. These emissions from the production stage, combined with the greenhouse gas (GHG) emissions from the production, transport, and use of natural gas makes this process highly GHG-intensive. Adding carbon capture and sequestration (CCS) to the process can minimize production emissions but does not eliminate the upstream emissions.

A cleaner alternative is to produce the hydrogen by running zero-carbon electricity through water to separate the hydrogen from the oxygen—a process called hydrolysis. This results in clean hydrogen production without large GHG emissions.

These production pathways are often referred to by a color-code shorthand. Production from fossil sources results in “gray hydrogen”; fossil with CCS is “blue”; hydrolysis powered by renewable energy is “green”; and powered by nuclear power is “pink”.

Hydrogen Fuel Cells and Other Potential Uses

The most immediate potential for hydrogen as a climate solution is replacing existing gray production with green, thus eliminating all of the related GHG emissions. Beyond that, there are numerous applications in which the energy stored in hydrogen molecules can be put to work to replace dirtier sources.

Hydrogen fuel cells reverse the hydrolysis process by combining hydrogen and oxygen to produce water, electricity, and small amounts of heat. This system is scalable to power small items such as personal computers, or larger things such as electric vehicles. At an even bigger scale, fuel cells could store energy to feed the electricity grid when wind or solar production is low, or serve as back-up generators for buildings, or power homes and other structures not connected to the grid.

Finally, hydrogen can be burned in traditional power plants to produce electricity. Some utilities have begun mixing gray hydrogen with natural gas with the goal of eventually switching fully to green hydrogen.

Recent Policies Have Invested in Hydrogen's Development

Due to its potential to help drive down industrial and power sector emissions, Congress included significant federal support for hydrogen in 2021's Infrastructure, Investment, and Jobs Act (IIJA) and 2022's Inflation Reduction Act (IRA). The IIJA created a definition for "clean hydrogen" as that produced with a carbon intensity not greater than 2 kg of CO_2-equivalent at the site of production for every kg of hydrogen produced. This would exclude gray hydrogen and inefficient blue hydrogen from qualifying as "clean."

The law then authorized $8 billion for at least 4 clean hydrogen hubs – regional locations where clean hydrogen production could be paired with end uses to help develop the technology and demonstrate its usefulness. These hubs are to be chosen according to diverse feedstocks and production methods, variety of end uses, employment potential, and geographic diversity with at least two located in regions with the greatest natural gas resources. It also authorized a $1 billion Clean Hydrogen Electrolysis Program to foster research, development, and commercialization of improved production methods. Next, it authorized $500 million for clean hydrogen manufacturing and recycling to spur the domestic supply chain. Finally, it requires the development of a National Clean Hydrogen Strategy and Roadmap to guide federal support for the industry.

All of this research and development would be for naught if clean hydrogen production was not economical. So, the IRA created a production tax credit to defray the cost. The threshold to qualify for the credit is 4 kg CO_2-equivalent on a lifecycle basis, with a tiered system to give added benefit for cleaner production and a maximum value of $3 per kg of H_2. Hydrogen production could also benefit from various other clean manufacturing incentives in the bill, and fuel cell vehicles also qualify for clean vehicle incentives.

Considerations for the Future

With federal support firmly in place and industrial demand on the rise, the future of clean hydrogen appears bright, though not without its challenges. On a practical level, advances will be needed in areas such as compact and safe hydrogen storage, efficient and increased production of catalysts and reactants, transport technologies and infrastructure, and monitoring and minimizing leakage.

This last part is particularly important because H_2 is, itself, a secondary GHG whose atmospheric impact at scale is not well known.[1] Because the molecule is so small, it can easily leak into the atmosphere at all stages of production, transport, and storage, and the technology to accurately monitor this leakage does not currently exist. This gap must be overcome to ensure the new industry does not inadvertently work against climate progress.

FOR MORE INFORMATION: Contact David DeGennaro at degennarod@nwf.org

[1] Ocko, Ilissa B. and Steven P. Hamburg. "Climate consequences of hydrogen emissions." Atmos. Chem. Phys., 22, 9349–9368, 2022. https://doi.org/10.5194/acp-22-9349-2022