# Innovating Out of The Climate Crisis: Hydrogen

## Briefing Note

## Quick Facts

- The energy industry uses up to six different colors to describe the different types of hydrogen based on how it is produced. The two most popular options for clean energy are green and blue hydrogen. Blue hydrogen is produced from natural gas by using a Steam Methane Reformer (SMR) with carbon capture, utilization, and storage (CCUS). Green hydrogen uses electrolysis with renewable electricity.
- 96 percent of today's hydrogen production comes from fossil fuels for use in oil refining and the manufacturing of chemicals like ammonia and methanol.
- Some 40 percent of today's carbon emissions are from hard-to-abate sectors like steel and cement, and a recent study showed that clean hydrogen can help reduce carbon emissions of heavy industries like these.
- In the future, hydrogen may also be used in transportation and building heat and power, as well as for storing renewable energy.

## Technology & Innovation

- A Utah-based project, backed by more than $500 million in loan guarantees from the Department of Energy (DOE), is working to manufacture clean hydrogen generated from excess renewable energy and provide seasonal energy storage. The sheer scale of the project demonstrates several significant innovations. Its bank of electrolyzers—the devices that generate hydrogen from water—totals 220 megawatts, and it stores the hydrogen in two 4.5-million-barrel salt caverns. The project will help prevent more than 125,000 metric tons of CO2 emissions per year.
- New electrolyzer technologies enable the devices to switch on and off easily, making them better suited to pairing with variable sources of renewable energy like wind and solar. Linking these machines in large networks, and powering them with ever-cheaper renewable energy, could make green hydrogen cost-competitive by 2030.
- Methane splitting, a nascent technology for producing hydrogen, uses 3-5x less electricity than electrolysis and produces two saleable products: hydrogen for use in energy, and solid carbon, which can be used in rubber, tires, and plastics. A Nebraska-based startup using the technology is valued at more than $1 billion, and has attracted funding from major investors like BlackRock and NextEra Energy.
- Converting natural gas pipelines to accommodate hydrogen can save 50-80 percent on investment costs relative to building new pipelines, but it does pose some technical challenges, including the potential for hydrogen to physically damage steel pipes and for the tiny hydrogen atoms to escape. Using fiber reinforced polymer pipelines and mixing hydrogen with natural gas in the pipelines are just two solutions being researched today.


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# Challenges & Opportunities

- Russia's invasion of Ukraine, and its simultaneous interruptions in energy deliveries to Europe, have spurred interest in hydrogen in Europe. While hydrogen will not provide a solution to the immediate crisis, the uncertainty in fossil energy supply is driving investment in hydrogen production. In July 2022, the European Union announced a 15-country, 35-company partnership that will jointly invest $5.5 billion in developing hydrogen infrastructure, spurred in part by the conflict.
- Hard-to-abate sectors such as steel manufacturing, aviation, chemical production, and long-distance trucking are responsible for some 40 percent of global greenhouse gas emissions, and hydrogen may be able to help decarbonize them. Industry participants are optimistic that hydrogen can be a desirable alternative to the electrical grid for heavy duty vehicles in the relatively near term. Power generators and aviation, shipping, steel, and cement companies are also exploring the technology, but applications in these industries are seen to be further away from commercial use.
- Today, the United States produces 10 million metric tons of hydrogen per year. About 90 million metric tons are produced globally. Virtually all—some 96 percent—of this hydrogen is made from fossil fuels.
- By 2050, according to industry analysis, hydrogen could be meeting nearly 20 percent of total energy demand, generating $2.5 trillion in total annual revenue and supporting 30 million jobs.
- In areas where renewable or low-carbon energy is abundant, such as the Middle East, Australia, and parts of Europe, proposals for new plants are proliferating, but still far behind the potential need. If all the projects in the pipeline today are ultimately built, they will result in up to 24 MT of green and blue hydrogen production per year. But, just 4 percent of those projects are under construction or at a final investment decision, and meeting a 2050 target for global net zero emissions could require 4x as much production—some 100 MT annually.
- If even current hydrogen demand was met exclusively by green hydrogen, it would require some 3,600 TWh of renewable energy per year—more than the annual electricity generation of the European Union. Until the grid is deeply decarbonized, there is a high opportunity cost to using renewable energy for hydrogen production rather than electricity.
- If full lifecycle emissions are taken into account, including fugitive methane emissions during mining, transport, and hydrogen production, blue hydrogen can be more polluting than simply burning natural gas or diesel as fuel. Climate advocates point to this finding to argue that the industry should focus exclusively on green hydrogen, and that hydrogen use should be limited to just the hardest to decarbonize sectors.

# Policy & Regulatory Landscape

- In 2021, the U.S. Department of Energy launched the Hydrogen Shot—the first in a series of Energy Earthshots intended to boost innovation in sectors critical to the clean energy economy. The Hydrogen Shot aims to reduce the price of green hydrogen from $5 per kg today to $1 per kg in a decade—an 80 percent reduction. For comparison, gray hydrogen costs as little as $0.90 per kg today, while blue hydrogen can cost less than $1.50 per kg.
- The Bipartisan Infrastructure Law includes $9.5 billion in funding for new hydrogen projects, including $1 billion to reduce the cost of commercially produced green hydrogen and $500 million to support green hydrogen equipment manufacturing and recycling. The bulk of the funding—$8 billion—is dedicated to establishing as many as 10 hydrogen hubs around the country, which will develop and demonstrate new technologies for producing hydrogen from fossil fuels, nuclear, and clean energy, as well as new uses for the fuel in transportation, industry, and more.
- The Inflation Reduction Act extended an existing tax credit that offered up to $3 per kg of hydrogen produced. To claim the maximum credit, producers must limit the carbon intensity of their hydrogen generation processes to no more than 0.45 kg CO2 equivalent (C02e) per kg of hydrogen—a level only green hydrogen can reach. Blue hydrogen producers are not necessarily shut out, though; as long as carbon intensity is no higher than 2.5 kg CO2e, they can claim a partial credit. Gray hydrogen produces 8-12 kg CO2e. The subsidy is generous enough that some hydrogen can be cost-competitive with fossil fuels.

# National Security Considerations

- The U.S. military is testing a variety of hydrogen-powered vehicles, including an Army truck and a Navy drone. Hydrogen-powered devices offer a number of battlefield advantages, including a near-silent engine, lower thermal signatures that make them more difficult to detect with infrared cameras, and both longer ranges and higher power than existing battery-powered vehicles.
- The Army and the Navy are experimenting with man-portable devices that can generate hydrogen nearly anywhere, enabling deployed units to refuel vehicles, drones, and other tactical elements in the field.
- In June 2022, President Joe Biden invoked the Defense Production Act to spur production of critical clean energy technologies, including hydrogen electrolyzers and fuel cells. The determination will allow the government to invest in companies that can expand manufacturing and installation of these technologies.

This briefing note is part of ASP's *Innovating out of the Climate Crisis* programming which seeks to explore innovations in technology and policies in key clean energy areas. These innovations will help facilitate our collective ability to adapt to climate change, ultimately leading to a more resilient nation.

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