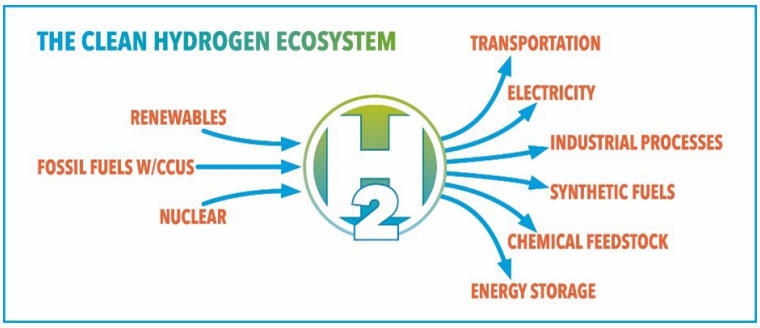
HYDROGEN USE POTENTIAL

Many industries are identifying the use of clean hydrogen in their strategies to reduce their greenhouse gas footprint, and as a result, there are a wide range of applications where the use of clean hydrogen is either growing or has the potential for significant future demand. These diverse applications highlight the scale of the technical potential for clean hydrogen to decarbonize our economy. This potential is being recognized worldwide, with investments by government and industry ramping up in many countries.



Clean hydrogen can be used in a number of applications. It can be used to generate electricity or as form of storage for back up generation. It can be used as a fuel to heat buildings or used in certain industrial applications, as a transportation fuel in any mode of transport that uses a fuel cell, and it can be used as a chemical feedstock to produce other products or fuels.

Transportation

Hydrogen and fuel cells will be an important part of decarbonizing the transportation sector. Specifically, hydrogen fuels can be used to reduce emissions for hard-to-abate modes of transportation such as long-haul, heavy-duty trucks. Hydrogen fuel provides an important alternative to electric vehicles when longer driving ranges, carrying heavy loads, or faster refueling times are involved. Hydrogen is already being used in more than 8,800 passenger and commercial vehicles, with a growing infrastructure of approximately 45 hydrogen fueling stations in the U.S.

Hydrogen can also be used in marine applications. The use of hydrogen in various marine vessels and at ports for drayage trucks, shore power (electricity for ships while docked), and cargo equipment can reduce both carbon dioxide and other emissions, which are typically located in communities with higher rates of air emissions.

Other opportunities for hydrogen include rail, particularly where lines for electrified trains is either impossible or too costly, as well as certain aviation applications where the weight, range, and fueling times of hydrogen systems offer advantages over alternate options like batteries.

In order to utilize hydrogen in this sector, issues related to fuel cell cost and durability, and hydrogen storage, delivery, and dispensing must be addressed. Additional challenges include storage infrastructure for the vehicle and establishing adequate supply chains to ensure that this fuel source is reliable.

Chemical and Industrial Processes

Several industrial and manufacturing processes typically require large volumes of hydrogen, including oil refining and ammonia production. Replacing that hydrogen with clean hydrogen will significantly reduce the greenhouse gas footprint from those processes.

Steelmaking is receiving increasing attention as a source of demand for hydrogen. Steel is the most commonly used metal product worldwide, and the conventional method to produce it involves using coal in blast furnaces to reduce iron ore to iron. Between 7% and 9% of global greenhouse gas emissions are due to steel manufacturing, and by using hydrogen as the primary reducing agent, those emissions can be dramatically reduced. A number of demonstrations of the use of hydrogen in steelmaking are currently underway, including operational facilities in Austria and Sweden.

Clean hydrogen can also be used to produce synthetic fuels production. Given that this is done via a reaction using captured carbon dioxide with clean hydrogen using biologic or catalytic processes, the idea of co-locating hydrogen production facilities with CCS facilities is being considered. Co-locating can help reduce costs and create better market opportunities.

Other industrial applications that can use clean hydrogen include manufacturing and industrial food processes.

Information and graphics courtesy of the U.S. Department of Energy's 2020 Hydrogen Program Plan unless otherwise noted.

It is important to note that application-specific hydrogen requirements can strongly affect commercial viability. For instance, in steel production, while blast-furnace processes are the current industry standard, the promising alternatives using high concentrations of hydrogen in the reducing agent, such as DRI (direct reduction of iron), rely on sufficiently low-cost hydrogen for cost-competitiveness. Across different industrial end uses, the hydrogen cost contribution will depend on process-specific requirements for hydrogen purity, pressure, and other factors that affect production, delivery, and storage costs. Commercial viability will require continued cost reductions in all these areas.

Power Generating Applications

Hydrogen can be used in a broad range of stationary power-generation applications—including large scale power generation, distributed power, combined heat and power (CHP), and backup power. As noted, hydrogen can provide power through electrochemical conversion using fuel cells or through combustion of hydrogen using turbines in simple- or combined-cycle generation, as well as in engines.

The advantages of power generation using hydrogen combustion include: fuel flexibility, through the ability to burn hydrogen and blends of fossil fuels; fuel security through integration with hydrogen storage; the ability to meet large demands for electricity; and the flexibility to follow loads from variable generation.

Progress has been made in the modification of commercially available combustion turbines to accommodate high hydrogen blends (up to 100% H2), but continued RD&D is needed for qualification in utility-scale power generation. Additional RD&D is also needed to assess the compatibility of hydrogen blends with equipment designed for using natural gas (e.g., building equipment and appliances), and to develop separation technologies that can recover high-purity hydrogen from blends for use in applications where pure hydrogen has a higher value.

Conversion and End-Use Needs and Challenges:

- Lower-cost, more-durable, and more-reliable fuel cells that are available in a wide range of sizes and can be mass-produced
- Turbines that can operate on high concentrations of hydrogen or pure hydrogen
- Development and demonstration of large-scale hybrid systems
- Systems integration, testing, and validation to identify and address the challenges unique to each application
- Demonstration of end-use applications, including steel manufacturing, ammonia production, and techniques for producing synthetic fuels from hydrogen and carbon dioxide
- Demonstration of grid-integration to validate hydrogen energy storage and grid services