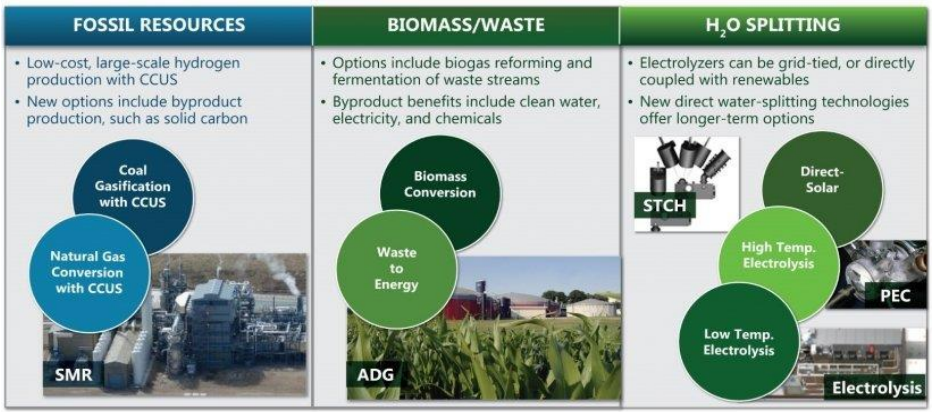
Hydrogen's Role in the Low-Carbon Economy

Hydrogen will play a key role in the transition to a clean energy economy across many sectors. Hydrogen does not release greenhouse gas emissions during combustion and can generate electricity, fuel vehicles, and provide heat for homes, businesses, and industry.

Hydrogen can be produced in several ways. The most common method is through steam-methane reforming (SMR), which uses high-temperature steam to heat methane from natural gas, producing hydrogen and carbon dioxide. More than 90% of hydrogen produced today is through SMR.[1] If an SMR plant is paired with carbon capture technology, CO_2 from the process can be captured and sequestered underground or reused as a feedstock. Alternatively, hydrogen can be produced via electrolysis, which uses an electrical current to split water molecules into oxygen and hydrogen. If the electricity used for electrolysis is produced from renewable sources, then green hydrogen is produced with no CO_2 emitted during the production process. Hydrogen produced from the reformation of biomass/waste, including renewable natural gas (RNG), can be considered carbon neutral. Hydrogen produced with fossil fuels can also be considered carbon neutral when paired with carbon capture, utilization, and storage (CCUS) technology.



Source: DOE, "Hydrogen Production Pathways"

Hydrogen has the highest energy content by weight of any fuel, 3X that of gasoline[2]

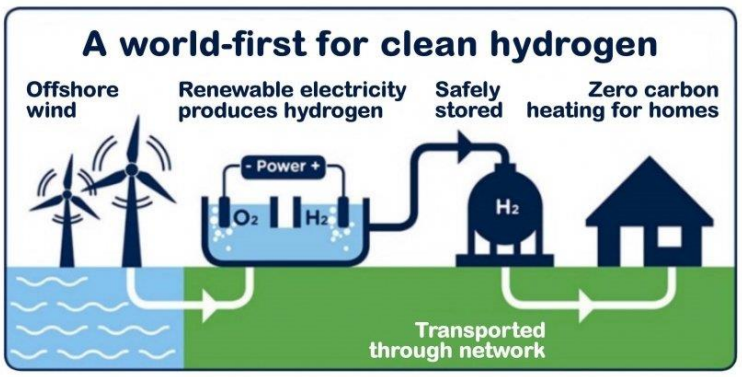
Blending Hydrogen with Natural Gas

Hydrogen produced through clean pathways, such as blue or green hydrogen, can be injected into existing natural gas pipelines to lower the carbon content of the fuel. Natural gas pipelines and combustion equipment can incorporate hydrogen in blends up to 30%, depending on equipment design and application.[3] Utilities are also blending hydrogen into their natural gas infrastructure to reduce greenhouse gas emissions, with some utilities blending up to 15% hydrogen into their existing pipeline infrastructure.[4] Certain combined heat and power (CHP) manufacturers have adapted their natural gas engines to run purely on hydrogen.[5] Reciprocating engines and gas turbines that run on 100% hydrogen are under development by all major CHP manufacturers, with systems expected to be available by 2030.

[1] Florence School of Regulation, *Hydrogen in the Energy Transition*, 2020
[2] EIA, *Hydrogen Explained*
[3] U.S. DOE, *HyBlend: Opportunities for Hydrogen Blending in Natural Gas Pipelines*, 2021
[4] Hawaii Gas, *Decarbonization and Energy Innovation*
[5] 2G Energy, *Hydrogen for CHP Systems*

Hydrogen Production from Excess Renewables

One of the main issues facing the renewable energy industry as technologies begin to scale is curtailment, i.e., "the reduction of renewable energy delivered due to oversupply or lack of system flexibility." [6] Instead of being curtailed, excess renewable energy can be used to power electrolyzers and produce hydrogen. Existing natural gas infrastructure can be used to provide long-duration storage of hydrogen, complementing shorter-duration battery storage systems. This could improve the economics of green hydrogen, as this stored hydrogen could improve utilization of renewable assets by providing electricity during periods of peak demand.



Source: DOE, "How Wind Energy Can Help Hydrogen Contribute to a Zero-Carbon Future"

Hydrogen's Applications

Hydrogen can be blended with natural gas, using existing infrastructure, to reduce emissions from residential, commercial, and industrial facilities. In the power sector, hydrogen can be used to provide backup power when renewable energy production is limited or used as long-duration storage. In the transportation sector, hydrogen can be used to power fuel cell electric vehicles (FCEV), which are more efficient than traditional internal combustion engine vehicles and produce zero tailpipe emissions.[7] In the industrial sector, hydrogen produced via electrolysis offers a promising pathway to decarbonization, especially for industries that require high-temperature steam through combustion processes.

Hydrogen can help meet 14% of U.S. final energy demand by 2050[8]

Hydrogen Programs and Policies

The U.S. Department of Energy (DOE) has dedicated programs and initiatives focused on making clean hydrogen more abundant, affordable, and reliable. DOE's Hydrogen Shot initiative is focused on reducing the cost of clean hydrogen by 80% by 2030.[9] This effort is complemented by DOE's Hydrogen Program Plan, which is a "cross-office strategic effort to accelerate research, development, and deployment of hydrogen and related technologies in the United States."[10] DOE is offering grants to support the development of 4 regional hydrogen hubs focused on improving the production, processing, and transportation of clean hydrogen across the U.S. The Canadian government has developed a plan to increase investment and deployment of hydrogen in order to reach their mid-century emission targets.[11] These initiatives will help to accelerate cost reductions for green hydrogen to the point that this fuel source will become competitive with fossil-fuel derived hydrogen.

[6] NREL, *The Curtailment Paradox in a High Solar Future*, 2021
[7] U.S. DOE, *Fuel Cell Electric Vehicles*
[8] Fuel Cell and Hydrogen Energy Association, *Roadmap to a U.S. Hydrogen Economy*
[9] U.S. DOE, *Hydrogen Shot*
[10] U.S. DOE, *Hydrogen Program Plan*, 2020
[11] Natural Resources Canada, *Hydrogen Strategy for Canada*, 2020