



Hydrogen Future

The U.S. Department of Energy’s (DOE) Office of Fossil Energy (FE) has focused on developing and advancing technologies that will enable and expand a domestic hydrogen (H₂) economy over the past three decades.

H₂ is the simplest and most abundant element in the universe and occurs naturally on earth in compound form. Carbon-neutral or even carbon-negative H₂ can be produced from fossil fuels, biomass, and waste plastics. H₂ unites the Nation’s natural gas, coal, nuclear, and renewable energy resources and H₂ produced from fossil fuels can play an important role in the transition to clean, low-carbon energy systems (Figure 1).

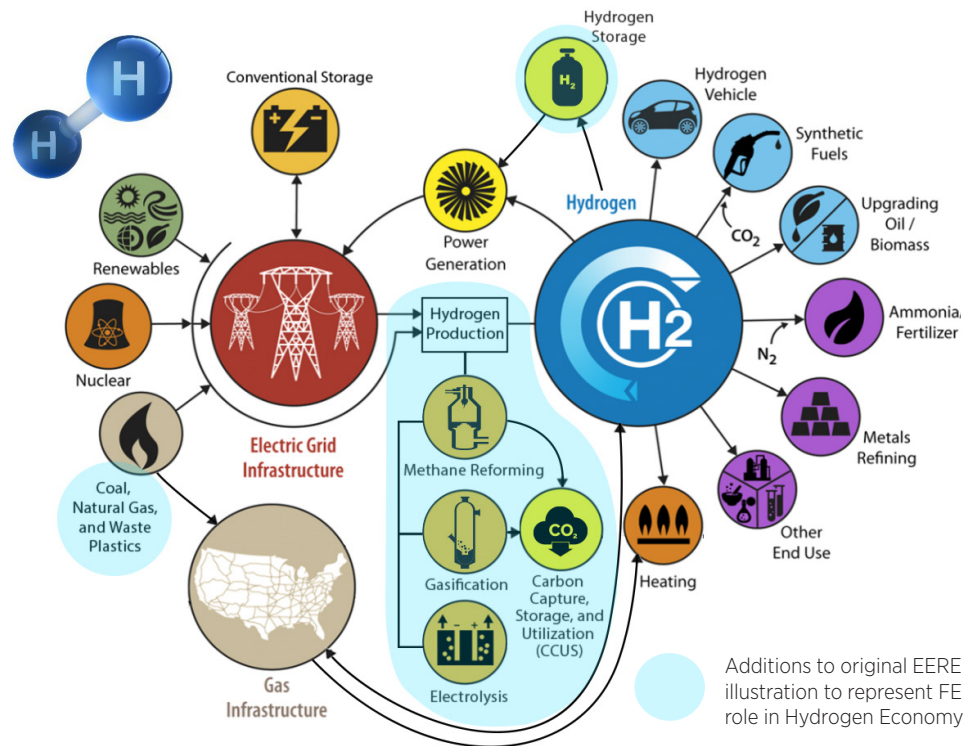


Figure 1. Integration of Fossil Energy into the Hydrogen Economy

Transition to a Hydrogen Economy

DOE is well positioned to accelerate a transition to an H₂ economy, and FE is committed to advancing technology solutions that utilize the Nation’s vast fossil energy resources.

FE’s research and development (R&D) programs can be divided into four major focus areas:

1. Carbon-Neutral Hydrogen Production using Gasification and Reforming Technologies;
2. Large-Scale Hydrogen Transport Infrastructure;
3. Large-Scale Onsite and Geological Hydrogen Storage; and
4. Hydrogen Use for Electricity Generation, Fuels, and Manufacturing.

Hydrogen Infrastructure

The vision of a decarbonized world where all energy sources produce H₂ as a common fuel, energy storage medium, and chemical processing component runs directly through infrastructure development. A broad-based H₂ market requires production

and distribution of large quantities of low-cost H₂ in a [complex infrastructure](#) that can provide the necessary quantities to end users.

Hydrogen Production and Costs

Currently, the United States produces more than 10 million metric tons (MMT) of hydrogen annually, with 95 percent produced from natural gas via steam methane reforming (SMR), 4 percent by coal gasification, and 1 percent by the electrolysis of water. Global H₂ production is approximately 70 MMT, with 76 percent from SMR, 22 percent from coal gasification, and 2 percent from electrolysis.

Through the use of [carbon capture, storage, and utilization \(CCUS\)](#) technologies demonstrated by FE, fossil fuels are the lowest cost source of carbon-neutral hydrogen and are negative (below-zero carbon) when

co-firing biomass. H₂ production from fossil resources is readily scalable using existing technologies. At present, H₂ generation from gasification and reforming are the only ways to generate the necessary quantities at reasonable costs. Figure 2 provides an overview of hydrogen uses and national benefits and shows the relationship of FE’s R&D program elements to support a hydrogen economy in the United States.

Hydrogen Export Opportunities

FE previously worked in H₂ handling and can leverage its efforts on liquefied natural gas. This experience will help DOE identify the safety and terminal requirements that are necessary to export U.S. H₂ to countries that are shifting to a H₂ economy. In those markets, H₂ can be used for electricity, manufacturing, transportation, and residential purposes.

Emerging Markets for Hydrogen

As we get closer to a decarbonized world, H₂ presents long-term potential in many sectors beyond existing industrial applications. If the cost of H₂ production and utilization can be made significantly lower compared to the cost of other fossil fuels, it could be used to run transportation, buildings, and power sectors. Some of the emerging uses of H₂ include electric grid management, energy storage and fuel cell vehicles, as well as blending H₂ into existing natural gas pipelines and decarbonizing industrial processes, such as steel production, cement production, and other chemical engineering applications.

All these uses would eventually create major increases in H₂ demand, and they would potentially require foreign markets to be opened for H₂ exported from the United States.

DOE Research and Development

At DOE, the offices of Fossil Energy, Energy Efficiency and Renewable Energy, and Nuclear Energy, are collaborating on research areas and technologies for H₂ production, transport, delivery, and storage, along with power production via fuel cells, electrolysis, and turbines.

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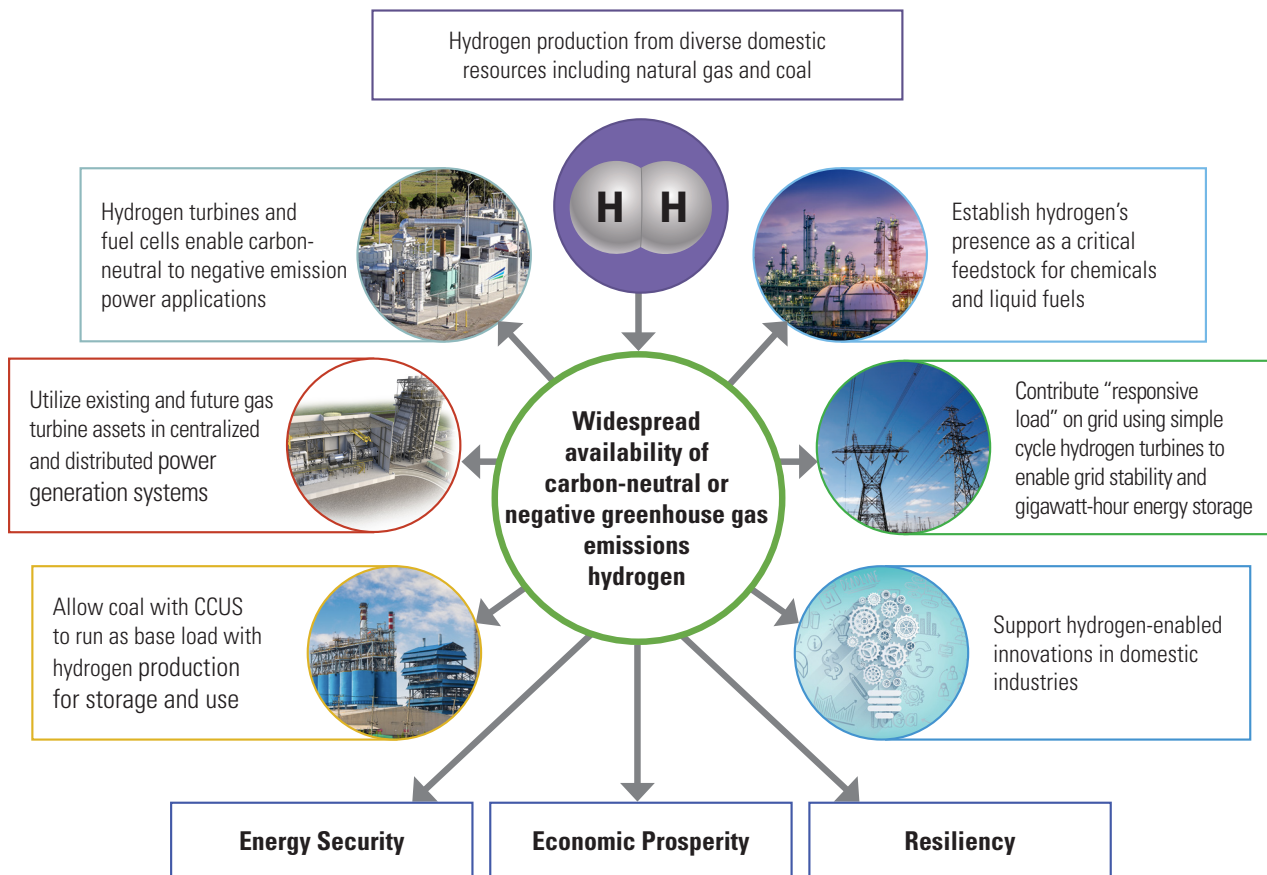


Figure 2. Relationship of FE Program Elements to Comprehensive Hydrogen Strategy