ACADIA CENTER EXPLAINS

Hydrogen and the Clean Energy Future

Summary and Recommendations - Fall 2023

WHAT IS HYDROGEN AND WHY WOULD IT BE USED FOR ENERGY?

Hydrogen, a colorless, odorless, and flammable gas, has drawn attention as a potential clean energy source for various applications. It can be combusted to produce heat or used in a fuel cell to produce electricity. Alternatively, it can be used as an input to create hydrocarbon fuels like synthetic natural gas. Like electricity, hydrogen acts as an "energy carrier," allowing energy to be transported from one place to another.

WHAT IS HYDROGEN'S CURRENT ROLE IN OUR ECONOMY?

Today, hydrogen is used in industrial processes like oil refining and fertilizer production. In recent years, there has been an expanded focus on the potential for using hydrogen to help decarbonize other sectors of the economy, including power generation, transportation, and the natural gas distribution system.

GREEN HYDROGEN, BLUE HYDROGEN, GRAY HYDROGEN – WHAT'S THE DIFFERENCE?

Hydrogen doesn't emit greenhouse gases (GHGs), whether combusted or used in a fuel cell to generate electricity. However, the GHG emissions resulting from hydrogen production vary widely. Hydrogen can be produced using either fossil fuels or electricity.

There are three types of hydrogen depending on how it is made. Hydrogen produced using renewable electricity and water in a process known as electrolysis is called '**green hydrogen**.' While this is the least carbon-intensive means of producing hydrogen, the process is currently inefficient and expensive. Green hydrogen does not produce greenhouse gas emissions (GHG) but creates significant nitrogen oxide (NOx) when combusted, impacting air quality. Green hydrogen holds promise for decarbonizing specific sectors, but it cannot be considered a silver bullet solution for climate change. Presently, 95% of hydrogen in the U.S. is '**gray hydrogen**,' produced using a GHG-intensive process known as steam methane reforming (SMR) of natural gas. **Blue hydrogen** captures and stores CO2 during SMR, yet still produces higher GHG emissions than directly burning natural gas.

Hydrogen is used predominantly in oil refineries, agribusiness, and chemical and industrial processes, with gray hydrogen being the primary form used. Green hydrogen can have high-value applications, such as replacing gray hydrogen in specific industries, decarbonizing difficult-to-electrify processes like steel manufacturing and long-haul transportation, and serving as storage for excess renewable electricity.

GRAY HYDROGEN

Methane in natural gas is used to produce hydrogen in a process that releases significant amounts of CO_2

Powered by fossil fuels and electricity

BLUE HYDROGEN

Similar production to gray hydrogen but releases less CO_2 by capturing and storing it.

Powered by fossil fuels and electricity

GREEN HYDROGEN

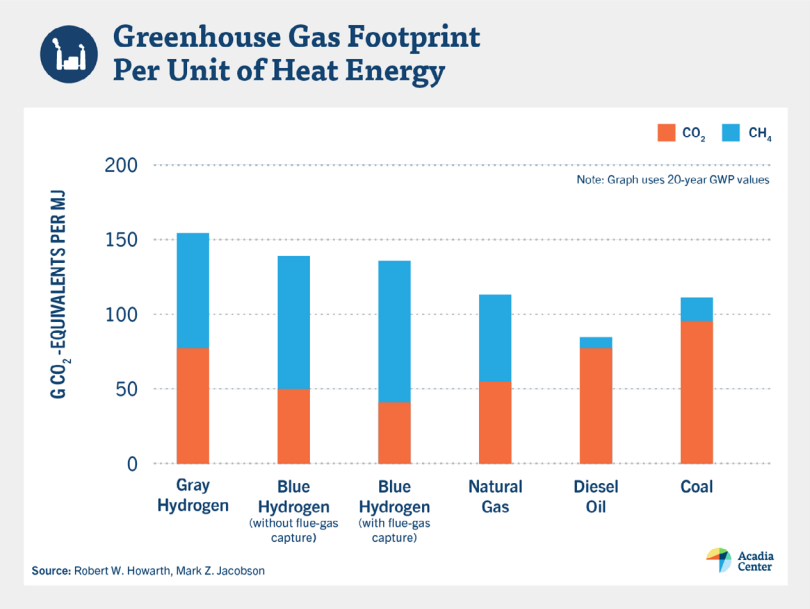
Uses electrolysis to separate hydrogen from oxygen in water without creating CO_2

No fossil fuels are used

DOES HYDROGEN MAKE SENSE AS A REPLACEMENT FOR NATURAL GAS?

Blending hydrogen into the natural gas distribution system poses challenges based on its physical characteristics. Hydrogen can degrade pipes and is prone to leaking, thus not compatible with the existing gas distribution system. Although hydrogen doesn't release GHG emissions when combusted, emerging evidence has highlighted the potential climate damage from direct hydrogen leaks into the atmosphere. Particularly if used in homes and businesses, hydrogen could pose a significant safety threat due to its leak-prone and highly combustible nature.

Using valuable renewable electricity to produce green hydrogen in the gas distribution system comes with a massive opportunity cost—we need renewable electricity to decarbonize the electric grid, electrify heating for homes and



This figure demonstrates the high level of GHG emissions associated with the production of gray and blue hydrogen relative to fossil fuels including natural gas, diesel oil, and coal.

businesses, and electrify transportation. Blending hydrogen into the gas distribution system is highly inefficient and a poor use of renewable electricity. Even as renewable electricity generation expands over the coming years, it is difficult to envision a scenario where large amounts of "excess" renewable electricity will be available for hydrogen production. This hard reality puts a damper on proposals to decarbonize the gas distribution system using hydrogen.

WHAT ARE THE ALTERNATIVES TO HYDROGEN AND WHY SHOULD WE USE THEM?

It is going to depend on the sector. Using renewable energy and directly electrifying significant sectors, including building heating and passenger vehicle transportation, is much more efficient than turning to hydrogen. However, there are sectors of the economy that are currently difficult to electrify. These include shipping, aviation, specific industrial end uses, and chemical production. We will almost certainly need some amount of green hydrogen to decarbonize these sectors. Still, the primary alternative for most parts of the economy is direct electrification using technologies like heat pumps and electric vehicles. Direct electrification is the superior alternative for cars and home heating from all angles: cost, efficiency, safety, and practicality.

HOW DOES ACADIA CENTER ADDRESS THESE CONCERNS?

Acadia Center is actively engaged in discussions around hydrogen in regional and state forums and membership in entities such as the Connecticut Clean Energy Task Force Hydrogen Uses Working Group. Acadia Center is leveraging its technical expertise related to hydrogen and analytical capabilities to assess assumptions and claims made for the expanded use of hydrogen. We apply thorough independent quantitative analysis, develop detailed public comments, present them to state agencies and educate partners. Acadia Center is actively involved in state-level "Future of Gas" proceedings that are considered potential pathways for reducing emissions associated with the natural gas distribution system. Throughout these processes, Acadia Center provides technical analysis and research to demonstrate the limitations of hydrogen in the gas distribution system and the benefits of electrification paired with energy efficiency.

A SOLUTION – WITH CAVEATS

Hydrogen shows promise as a clean energy solution if it is strategically deployed for specific high-value applications. Its potential lies in decarbonizing challenging sectors and as a storage medium for renewable electricity. While not a one-size-fits-all solution, hydrogen can contribute to reducing greenhouse gas emissions and building a more sustainable energy future.

For more information, visit our website: https://acadiacenter.org/work/transition-to-clean-energy-sources/

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