How Competitive Is Hydrogen Today, and What Investments Are Needed to Make It a Mainstream Energy Source?

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Introduction

- Hydrogen has been researched for decades as a clean energy source. Still, significant investments worldwide are being made in hydrogen to address climate change, achieve Net-Zero emissions targets, and move toward sustainable energy systems.
- Green hydrogen is hydrogen produced through the electrolysis of water, using electricity from renewable resources like wind and solar energy.
- High production, storage, and transportation costs are limiting the widespread adoption of hydrogen. Current research often overlooks economic feasibility by focusing solely on its environmental benefits.
- My research examines the financial viability of hydrogen by comparing its costs to traditional energy sources and identifying key barriers to adoption.
- Understanding the financial challenges will help shape policies and investments in technology advancements necessary for hydrogen to play a significant role in global sustainability energy systems.

Methods/Materials

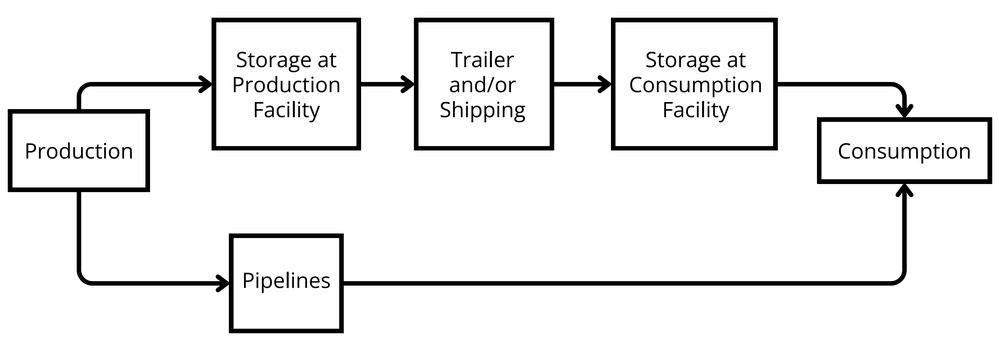
- My research analyzed and summarized a range of sources, including published literature and government reports, with a focus on the U.S. Department of Energy's Hydrogen Shot plan, which represents a major investment in U.S. hydrogen technology.
- A key source was the meta-analysis by Sharma et al. (2023), which was chosen because of its extensive reach. It analyzed 610 peer-reviewed journal articles from the past 50 years to provide insight into the hydrogen economy.
- The study focused on production, storage, and transportation costs, necessary infrastructure investments, and the economic competitiveness of hydrogen compared with other energy sources.
- By examining trends from various published sources, the analysis highlights key economic challenges and policy gaps that must be addressed for hydrogen fuel to achieve widespread adoption.

Findings

- If the cost of green hydrogen can be drastically reduced, it could serve as a sustainable fuel source due to its zero emissions.
- The U.S. government aims to lower the cost of clean hydrogen to $1.00 per kilogram by 2031 through the Hydrogen Shot initiative and has devoted billions of dollars to achieve this goal.
- The Department of Energy estimates that hydrogen currently costs around $5.00/kg. Reducing this to the target of $1.00/kg would make hydrogen more competitive with other energy sources and increase its market viability.
- The technology for generating green hydrogen, such as electrolyzers, is expensive; reducing these costs could enhance hydrogen's competitiveness in transportation and industry sectors.
- Producing hydrogen requires more electricity than it can generate, making it less efficient for continuous power generation.
- Currently, electricity used to make hydrogen costs more than the electricity hydrogen can generate, making it an inefficient choice for constant power generation.
- Transporting hydrogen using trucks powered by fossil fuels raises its cost per kilogram and reduces its overall sustainability.
- Due to these factors, hydrogen is not yet a practical substitute for widespread energy use but may be viable in sectors where direct electrification is not feasible, such as aviation and large-scale transportation.

Fuel Type	Estimated price per respective unit	Estimated converted price/kg
Green Hydrogen	$5.00/kg	$5.00/kg
Natural Gas	$3.73/MMBtu	$0.20-0.50/kg
Crude Oil	$70.56/barrel	$1.25/kg
Kerosene	$3.78/gal	$0.60/kg
Gasoline	$3.25/gal	$1.16/kg

It should be noted that converting to price/kg is still not an accurate comparison, as each fuel source has different energy densities; for instance, a kg of gasoline has more usable energy than a kg of natural gas. Additionally, some fuel sources, such as natural gas, are currently priced unusually low, but this is likely to change in the future.



A simplified view of the storage requirements found within the hydrogen supply chain (Burke, et al., 6).

Discussion

- My research analyzed various aspects of hydrogen, including production, storage, and transportation costs, to provide an overview of its benefits and drawbacks.
- Hydrogen has significant sustainability potential, but achieving economic viability requires major investment in the energy sector's overall infrastructure.
- Current hydrogen costs remain too high to compete with conventional energy sources, but the U.S. is on track to reach the targeted $1.00/kg by 2031.
- High-pressure storage appears most effective for short-term use, while liquefaction is better suited for long-term storage despite its high energy demands.
- A broad hydrogen distribution network enhances a country's energy security by reducing dependence on fossil fuels, mitigating risks associated with supply disruptions.
- Strengthening the global hydrogen network requires international collaboration to accelerate development and deployment.
- Future research should examine global energy demand trends to determine whether cost-competitive hydrogen systems could handle rising energy needs or if additional infrastructure investments would be required.

Future Policies

- Currently, electricity transmission in the U.S. is at capacity, meaning hydrogen must be transported using new and innovative methods.
- One proposal is retrofitting the existing natural gas pipeline network for hydrogen transport. While costly, this investment could establish a long-term sustainable energy infrastructure for future generations.
- Hydrogen-powered vehicles have been in development for years, but widespread adoption requires investment in fueling infrastructure and incentives for consumers and manufacturers.
- Strengthening regulatory frameworks and increasing government-sponsored hydrogen projects are essential. This includes eliminating fossil fuel subsidies and pricing externalities.
- According to Sharma et al. (2023), transitioning to clean energy will require up to $1.6 trillion in investments from both public and private sectors in developed countries.
- Identifying the most efficient and cost-effective method of producing hydrogen from renewable energy while minimizing energy loss remains a key challenge.

References

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