# Green Hydrogen & Renewable Energy


FSU Undergraduate Research Opportunity Program — Center for Undergraduate Research & Academic Engagement

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## Background

Energy is vastly important to modern society. Currently, most of the global energy consumption comes from fossil fuels. To meet net-zero emissions and combat pollution, society needs to move towards renewable energy sources, such as green hydrogen produced by electrolysis.

If it were that easy, the world would have already made the switch, but there are a few barriers that need to be overcome. Specifically, a significant research gap exists in how to effectively manage intermittent renewable energy sources to ensure a steady supply and meet demand. There is a need for large-scale energy storage to maintain a steady electric supply.

The purpose of this research is to analyze the integration of green hydrogen into the energy industry as an energy carrier for electricity production, transportation, and industrial use, and, more importantly, as a large-scale, versatile energy storage system to reduce carbon emissions. By analyzing current developments and applications, this research aims to synthesize how sustainable energy system pathways are being developed.

## Findings

***Why Green Hydrogen?***

**The Problem:** Most current hydrogen is "Gray" (fossil fuel-based) and emits significant $Co_2$.

**The Solution:** Green hydrogen is produced by electrolyzers using electricity produced by wind and solar energy to split water.

**100% Clean:** The only fuel that is zero-emission from start to finish.

**High Power:** Carries 2–3x more energy than gasoline by weight.

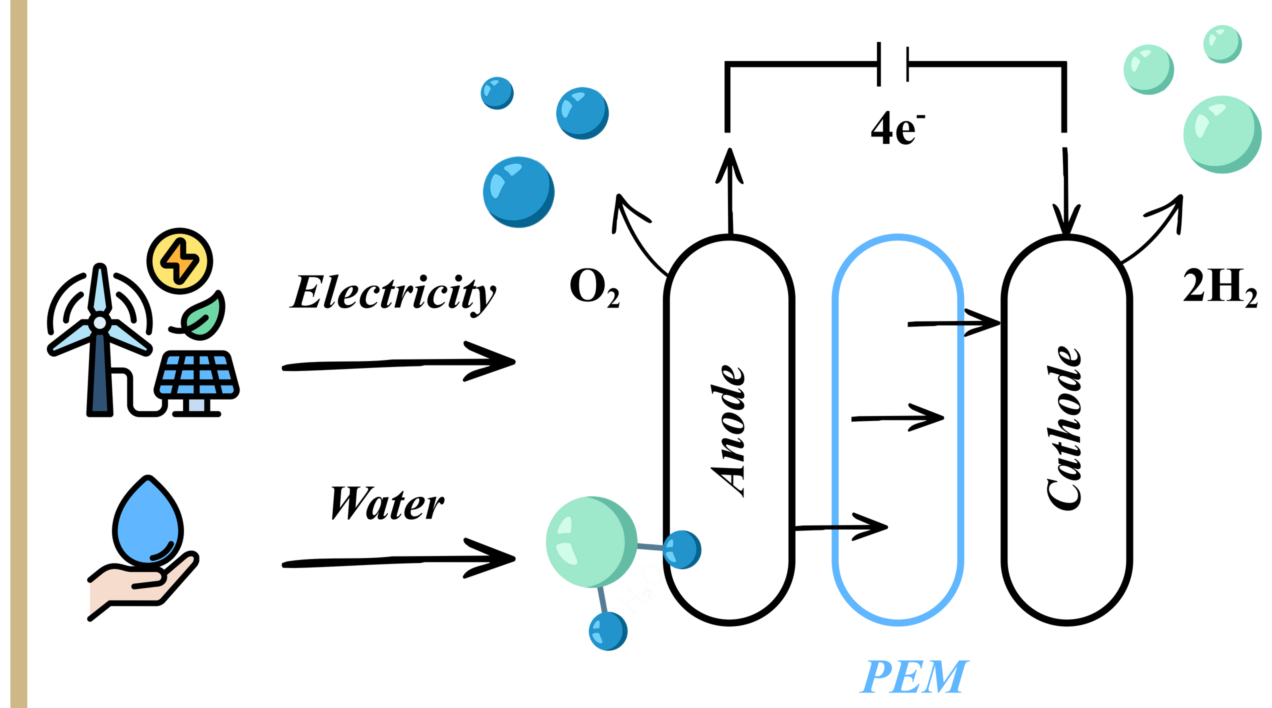
***The Storage Challenge***

**Size:** Hydrogen takes up a massive amount of space; it requires compression or liquefaction at -253°C.

**Innovation:** Testing metal hydrides that act like a "sponge" to soak up hydrogen.

**Safety:** Allows hydrogen to be stored safely as a solid.

**Proton Exchange Membrane (PEM) electrolysis**




**Anode Reaction:** $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$

**Cathode Reaction:** $4H^+ + 4e^- \rightarrow 2H_2$

***The Cost Gap***

**Current Price:** Green (~$4.85/kg) vs. Gray ($1.20–$2.40/kg).

**2030 Outlook:** Expected to drop below $2.00/kg as renewable costs fall.

***Beyond Cars: Applications***

**Aerospace:** Lightweight and high energy; perfect for airplanes and space travel.

**Efficiency**: Fuel cells are nearly 2x more efficient than internal combustion engines.

**Industry:** Essential for eco-friendly fertilizers (ammonia) and fuels (methanol).

## Methodology

This study uses qualitative research to evaluate the technical and economic use of green hydrogen in modern sustainable energy systems. This research functions as a literature review rather than an experiment, utilizing a qualitative framework to analyze existing data. The research investigated current implementation strategies for green hydrogen.

This involved a review of academic articles published between 2024 and 2026, selected for their focus on technical barriers and industrial applications. These findings were then compared against current industry uses, such as the Duke Energy plant in DeBary, Florida, and Toyota's hydrogen fuel cell developments.

By analyzing academic literature, this study identified current challenges of hydrogen storage and explored the role of green hydrogen as a sustainable energy solution.

## Discussion

***Duke Energy Debary Green Hydrogen Plant***

- Storage System is the first "end to end" green hydrogen facility in the U.S. that can produce, store, and burn 100% green hydrogen.
- Uses an on-site 74.5-megawatt solar farm to power electrolyzers that split water into hydrogen and oxygen.
- The hydrogen is compressed and stored in reinforced containers acting as a "backup battery" for the sun's energy.
- When energy demand is high, the stored hydrogen is sent to a modified 7E gas turbine (upgraded with GE Vernova technology) to generate carbon-free electricity.

***Toyota Mirai Fuel Cells in Vechicles***

- World's first mass produced hydrogen fuel cell vehicle which uses a PEM fuel cell.
- The fuel cell creates electricity through a chemical reaction between hydrogen (from the tank) and oxygen (from the air).
- The only byproduct of this reaction is pure water vapor, which exits the tailpipe.
- FCEVs like the Mirai offer a range of over 400 miles and can be refilled in under 5 minutes, similar to a traditional gas car.

## GE Vernova 7E gas turbine

83 megawatt (MW) 7E gas turbine will have the ability to operate on natural gas, liquid fuel, 100% hydrogen, or a blend of natural gas and hydrogen

## References