New York State Hydrogen Assessment

Summary | April 2025

NEW YORK STATE | NYSERDA New York State Energy Research and Development Authority
50 YEARS 1975-2025

NYSERDA's Promise to New Yorkers:

NYSERDA provides resources, expertise, and objective information so New Yorkers can make confident, informed energy decisions.

Our Vision:

New York is a global climate leader building a healthier future with thriving communities; homes and businesses powered by clean energy; and economic opportunities accessible to all New Yorkers.

Our Mission:

Advance clean energy innovation and investments to combat climate change, improving the health, resiliency, and prosperity of New Yorkers and delivering benefits equitably to all.

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Summary

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Abstract

New York State (NYS) recognizes hydrogen as a potential solution for decarbonizing its hard-to-electrify sectors, supporting the ambitious legislative goals outlined in the Climate Leadership and Community Protection Act (Climate Act). To evaluate hydrogen's feasibility, costs, and deployment opportunities across New York State's energy landscape, the New York State Energy and Research Development Authority (NYSERDA) collaborated with leading research institutions to conduct a comprehensive assessment, with a focus on hydrogen produced with electrolysis and water, using renewable and nuclear energy.

Hydrogen demand could reach 1.1 million metric tons (MT) annually by 2050, accounting for 11.4% of the State's total energy market. However, the high levelized cost of hydrogen presents a major barrier to widespread adoption. Among cost components, hydrogen production from renewable electricity represents the most significant part, contributing more than half of total hydrogen costs, outpacing storage and distribution expenses. The findings highlighted cost barriers across all examined sectors, including high-temperature industrial applications and fuel-cell electric vehicles (FCEVs). The technoeconomic landscape suggests addressing these challenges requires targeted innovation in electrolyzer efficiency, pipeline infrastructure, geologic storage solutions, and hydrogen-compatible end-use technologies.

This assessment provides a detailed framework for hydrogen development in New York State, identifying critical research priorities and deployment pathways that could position hydrogen as a complementary solution to electrification in achieving the State's ambitious climate objectives.

Keywords

hydrogen, decarbonization, electrolyzers, hard-to-electrify, industrial process heat, district heating, on-road transportation, nonroad applications

Summary

As the U.S. energy landscape undergoes a historic transformation, New York State is committed to putting forward policies and programs that send a strong signal that public-private partnerships can catalyze economic growth and advance the State's energy transition.

New York State (NYS) has led in climate action. The NYS Climate Leadership and Community Protection Act (Climate Act) established some of the nation's most aggressive climate goals, including an 85% reduction in greenhouse gas (GHG) emissions from 1990 levels by 2050. This commitment has accelerated the growth of renewable energy and widespread electrification while ensuring innovation and technology are advancing along with manufacturing competitiveness and supply chain security. However, hard-to-electrify sectors—such as high-temperature industrial processes and heavy-duty transportation—require alternative decarbonization solutions, such as clean hydrogen to help the State transition toward a zero-emission economy. meet the State's climate objectives.

Built on years of research and modeling, the New York State Energy Research and Development Authority (NYSERDA) Hydrogen Assessment evaluates hydrogen's potential to decarbonize key sectors. Beyond sector-specific research, this study explores the infrastructure investments and research support needed to scale hydrogen production, storage, and distribution. It examines cost projections, supply chain constraints, and technology advancements that influence economic feasibility and can accelerate hydrogen deployment. This report focuses on hydrogen produced with electrolysis and water, using renewable energy and nuclear.

By integrating sector-specific insights with a comprehensive view of hydrogen's role in the State's energy transition, the 2025 Hydrogen Assessment serves as a guide for policymakers, industry stakeholders, and innovators. It provides key findings that inform the next steps for building a robust hydrogen economy aligned with New York State's ambitious climate goals. This Executive Summary highlights the study's key findings.

S.1 Projected Hydrogen Demand

Through a comprehensive literature review, the study projected potential hydrogen demand in New York State's hard-to-electrify sectors. It presents three demand scenarios—Low-, Mid-, and

High-demand—modeled for 2030, 2040, and 2050. These scenarios outline a range of potential market growth and technological development across sectors.

As shown in Table S-1, under the Mid scenario, hydrogen market demand is expressed as the percentage of energy derived from hydrogen relative to the total energy consumption in that sector.

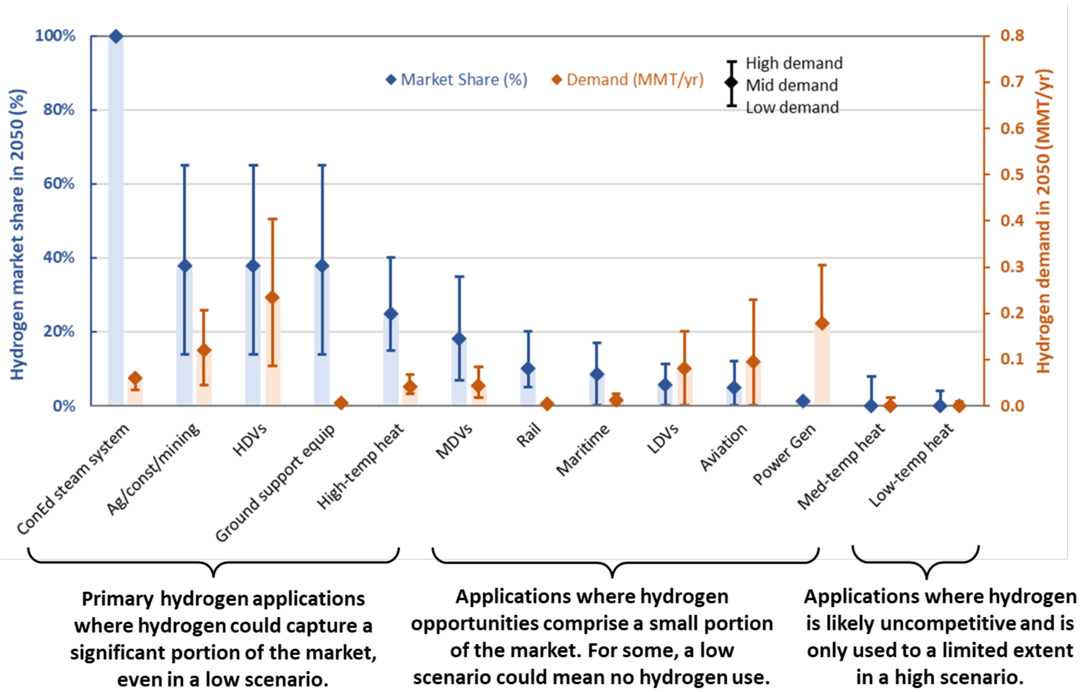
Table S-1. Projected Hydrogen Market Share in 2050 (Mid Scenario)

Sectors	Hydrogen Market Share[a]
District Heating	100%
Industrial Process	25%
Power Generation	1.3%
LDVs	6%
MDVs	18%
HDVs	38%
Other transportation (e.g., Aviation, Maritime, Rail, Ground Support Equipment)	2%–22%

[a] Market share is expressed as a percentage of the total energy consumption in each sector.

While market shares vary, hydrogen demand is expected to grow through 2050 across all Low-, Mid-, and High-demand scenarios.

Figure S-1. Projected Hydrogen Demand in 2050



In addition, the study considered seasonal and geographical demand across all three scenarios, reflecting the following results:

- **Seasonal demand:** By 2040, hydrogen demand peaks in winter months, driven by district heating needs and increased statewide electrification.
- **Geographical demand:** Hydrogen adoption concentrates around the New York Metropolitan area, a major hub for industrial, transportation, and heating needs.

These findings highlight that while hydrogen is a powerful decarbonization tool, seasonal and geographical factors must guide infrastructure investment.

S.2 Infrastructure Costs and Opportunities

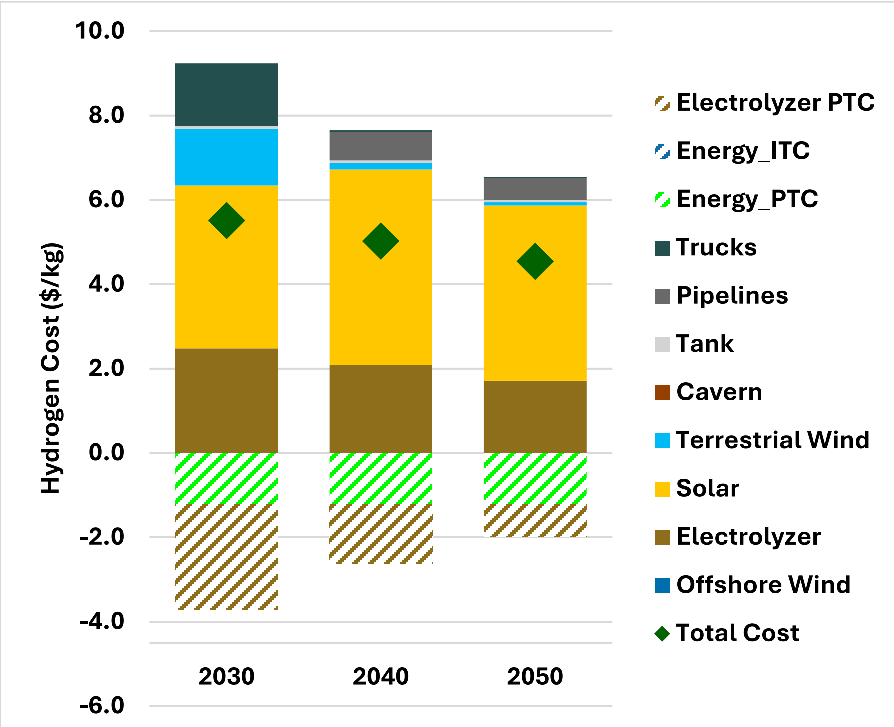
Using technoeconomic optimization modeling, the study examined renewable electricity production, storage, and transmission infrastructure needed to meet projected hydrogen demand at the lowest possible cost. The model incorporated real-world constraints, such as renewable resource availability, technology cost trajectories, hydrogen imports, and geologic storage resources.

In the base case, which reflects current market projections, the study found that by 2050, the levelized cost of hydrogen (net of all incentives) would reach $4.50 per kilogram (kg).

Through 2050, the cost of renewable electricity will remain the primary driver of hydrogen production costs, accounting for more than half of total expenses. Electrolyzer costs also play a significant role in overall hydrogen pricing. Projected advancements in electrolyzer technology are expected to reduce the levelized cost of hydrogen by 22%—equivalent to a $1.75 per kilogram (/kg) decrease—between 2030 and 2050. Additionally, as hydrogen demand grows, the transition from truck-based transport to pipelines in 2040 could lower transportation costs by 64%, or $0.95/kg.

Figure S-2. Projected Hydrogen Costs in 2030, 2040, and 2050 Under Base Case

Key modeling parameters for the base case in the following chart can be found in section 3.2.



S.3 Pathways to Deploy Hydrogen Technology in Hard-to-Electrify Applications

To determine strategic deployment pathways, the study analyzed cost barriers preventing adoption of hydrogen technologies over fossil fuel applications. A total cost of ownership (TCO) analysis assessed costs for the following end uses:

- Light-duty vehicles (LDVs) requiring long-range and fast refueling
- Medium-duty vehicles (MDVs) and heavy-duty vehicles (HDVs)
- District heating
- High-temperature industry

Hydrogen use in power generation will be considered in future NYSERDA studies.

Even with existing incentives, such as the Inflation Reduction Act (IRA) tax credits and State incentives for zero-emissions vehicles, hydrogen technologies face significant cost barriers compared to fossil-fuel-based technologies. Table S-2 summarizes the additional lifetime costs of hydrogen adoption in key sectors.

Table S-2. Summary of Additional Total Cost of Ownership to Adopt Hydrogen Technology Compared to Existing Fossil Fuel Technologies

Use Case	TCO Gap Unit	Lifetime Cost Barrier to Adopt Hydrogen Technology	Key Cost Challenges and Uncertainties
LDVs	$/vehicle	$14,608	• Cost of delivered hydrogen and refueling stations • Availability of incentives
MDVs	$/vehicle	$84,553	
HDVs	$/vehicle	$512,595	
District Heating	$/MMBtu	$51	• Cost of delivered hydrogen • Delivery and storage costs
High-Temperature Industry	$/MMBtu	$38	

S.4 Innovation Focus Areas

The study assessed technological challenges across the hydrogen value chain, including:

- Renewable-energy-based hydrogen production
- Storage and transmission solutions
- Hydrogen adoption in hard-to-electrify sectors

Before identifying the research and development (R&D) needs, the study provides an overview of current technologies and the barriers preventing large-scale commercial adoption. Table S-3 summarizes the key areas.

Table S-3. Hydrogen Technology: Current Status, Challenges, and Needs

Category	Current State of the Art	Technical Challenges	Needs
Production	• AEL is the most mature electrolyzer technology in commercial operation, widely used globally and in NYS • PEM electrolyzers, although commercially available, are less common than AEL • SOEC electrolyzers are in the pilot stage	• PEM relies on high-cost rare earth materials but efficiently handles dynamic loads • AEL and SOEC have durability challenges and are difficult to integrate with variable renewables	• Scaling up manufacturing and developing new materials to improve durability • Advancing electrolyzer designs for better performance and cost reduction • Demonstrating hydrogen production integrated with renewables

Table S-3. (continued)

Category	Current State of the Art	Technical Challenges	Needs
Pipelines	• Hydrogen blending up to 20% demonstrated in existing natural gas networks (UK) • 1,600 miles of hydrogen-specific pipelines in the U.S., primarily for oil refining	• Steel embrittlement, leakage, low volumetric energy density of hydrogen	• Evaluating and piloting natural gas pipeline conversion for hydrogen in NYS • Developing new hydrogen compressor designs
Underground Storage	• Commercial-scale hydrogen storage in salt caverns, primarily for the chemical and refining industries (U.S. and UK) • Pilot projects integrating salt cavern storage with power generation and electrolysis	• NYS's bedded salt deposits differ from the salt domes typically used for hydrogen storage • Potential use of depleted oil and gas reservoirs for hydrogen storage	• Studying NYS geology for salt cavern storage suitability • Piloting geological hydrogen storage in salt caverns and depleted oil and gas reservoir
Emerging Storage Technologies	• Commercial ammonia production, storage, and distribution system • Metal hydride storage solutions at the pilot stage	• High cost and significant energy requirements for converting hydrogen from chemical and material-based storage	• Evaluating the safety, cost, and footprint of alternative hydrogen storage technologies • Improving ammonia reactors and crackers to reduce energy input and enhance flexibility • Enhancing hydrogen storage and extraction efficiency in metal hydrides
Building Applications	• Hydrogen heating through blended gas in pilot projects (UK) • Hydrogen fuel cells for combined heat and power in pilot projects (Japan)	• Compatibility of hydrogen with existing heating technologies • Availability of 100% hydrogen-based heating for district steam systems	• Identifying district steam systems suitable for hydrogen • Evaluating retrofitting vs. replacing heating systems for hydrogen use • Demonstrating 100% hydrogen in district steam systems
Industrial Process Heat	• Hydrogen used for high-temperature steel manufacturing in pilot projects (U.S. and Sweden)	• Compatibility with existing heating processes • Managing 100% hydrogen combustion for industrial heat	• Analyzing retrofits vs. new equipment for 100% hydrogen combustion • Studying hydrogen combustion behavior • Developing new hydrogen combustion-based heat technologies • Demonstrating 100% hydrogen for industrial heat

Table S-3. (continued)

Category	Current State of the Art	Technical Challenges	Needs
Power Generation	• Test gas turbines operating with up to 40% hydrogen (not commercially deployed) • Diffusion-type turbines reportedly capable of 100% hydrogen combusting • Commercial lean-premixed combustion (low NOx) in turbines supporting up to 50% hydrogen by volume • Studies of hydrogen's effect on the grid • PEM fuel cells commercially available for backup power	• Managing 100% hydrogen combustion with low NOx emissions • Hydrogen's impact on balance-of-plant applications • Adapting fuel cells for peaking power applications	• Conducting cost-benefit analysis of combustion vs. fuel cells for power • Demonstrating 100% hydrogen lean-premixed turbines and natural gas turbine retrofits • Developing NOx control strategies for hydrogen and ammonia combustion • Conducting RD&D on fuel cells for peaking power • Analyzing tradeoffs between electrical grid and hydrogen transmission capacity expansion • Piloting geological hydrogen storage with infrastructure for firm capacity generation • Conducting RD&D on multifuel microgrids and trigeneration systems (electricity, heat, and hydrogen)
Nonroad and Limited On-Road Applications	• Limited commercial deployment of FCEVs (light-, medium-, and heavy-duty) and refueling stations • Hydrogen-powered port and airport equipment in pilot projects (U.S. and China) • Commercial hydrogen-powered material-handling equipment • Hydrogen-powered trains in pilot projects (U.S. and Europe)	• Lack of widespread hydrogen refueling infrastructure • Refueling technology for medium- and heavy-duty FCEVs • Onboard hydrogen storage systems and fuel cell durability	• Demonstrating medium- and heavy-duty hydrogen refueling stations • Conducting RD&D on high-pressure, high-flow hydrogen refueling technology • Reducing fuel cell material costs by minimizing rare earth component usage
Aviation and Maritime Applications	• Hydrogen-powered aircraft and maritime vessels in pilot stage, limited to small size and short distance	• Need for high-energy-density, carbon-neutral fuels	• Planning studies on synfuels and biofuels for energy-intensive applications • Conducting RD&D for hydrogen-powered aircraft and marine vessels • Conducting RD&D for synfuel production

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