INTELLIGENCE UPDATE

Emerging tech: low-carbon hydrogen

Peter Judge
10 Sep 2025

EMERGING TECHNOLOGY SERIES

This report is one of a series on emerging and potentially disruptive technologies that may be deployed in digital infrastructure. Here, Uptime Intelligence considers the use of low-carbon hydrogen, particularly green hydrogen, for on-site standby or primary power.

EMERGING TECHNOLOGY: LOW-CARBON HYDROGEN	
Key innovation	Hydrogen created by electrolysis using renewable electricity is a potential zero- or low-carbon energy source for data centers.
Potential impact *(1 is low, 5 is high)*	**1** Low efficiency and high cost mean that the hydrogen economy will develop slowly.
State of maturity	Early adopter/specialist deployment, mostly with government support.
Main drivers to deployment	Green hydrogen provides a low-carbon energy source that helps operators meet net-zero targets.
	Green hydrogen has support from many governments because it can make effective use of curtailed wind and solar electricity.
	Hydrogen can be consumed using existing equipment, including fuel cells and gas turbines.
Main barriers to deployment	Low round-trip efficiency and high capital investment requirements make green hydrogen expensive.
	Supplies of hydrogen are limited.
	Delivery networks are very localized.
Possible date range for wide deployment	2050
Some key innovators/ companies involved	Electrolyzers: Plug Power, Bloom Energy, Siemens.
	Fuel Cells: Plug Power, Bloom Energy, Ballard Power Systems.
	Generators: Solar Turbines, GE Vernova.
	Operators with present or future access to green hydrogen: ECL, NorthC.
Some key companies or type of companies most affected (positively or negatively)	Hydrogen suppliers: Air Products, Linde.
	On-site power infrastructure: Vertiv, Schneider Electric, Eaton.

UPTIME INSTITUTE 2025

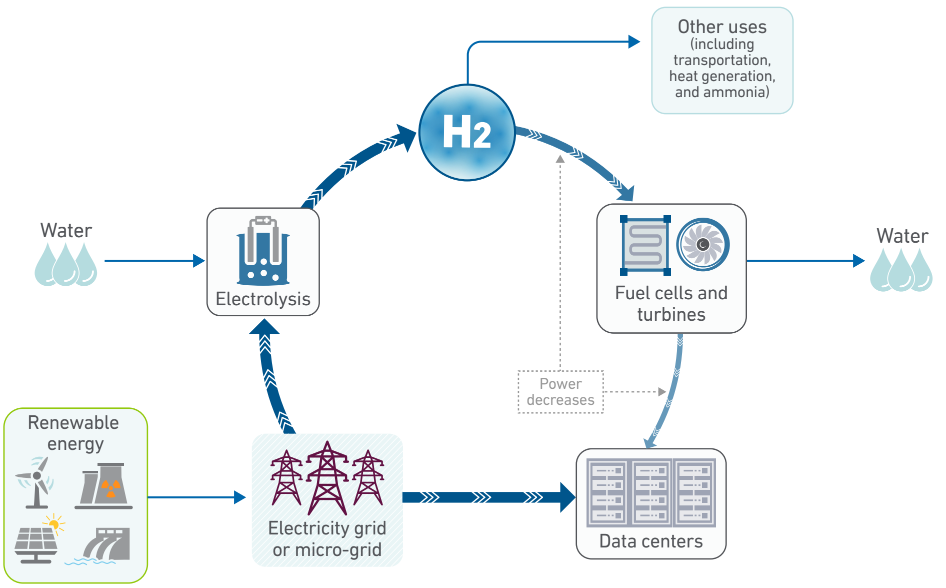
Context

Data center operators need carbon-free options for on-site standby generators and reliable, dispatchable electricity generation to power their facilities. Hydrogen could help address these challenges. It also enables operators managing renewable energy resources through power purchase agreements to capture both energy and economic value from curtailed electricity generation.

Currently, the most readily available on-site power options are fossil fuel-based: diesel for standby and natural gas for primary power. In comparison, hydrogen represents a low-carbon energy source, particularly when it is produced by electrolysis using renewable electricity. It can be piped, stored and consumed in ways similar to fossil fuels.

Government strategies support a hydrogen economy in which green hydrogen displaces fossil fuels in some applications such as electricity and heat generation (see **Figure 1**). However, reliable, economical and widespread supplies of low-carbon hydrogen are not expected until 2040 to 2050 at the earliest.

Figure 1 Data centers' place in the hydrogen economy



UPTIME INSTITUTE 2025

The technology

Hydrogen is burned in gas turbines to produce energy or it is consumed in fuel cells to provide electricity (see **Table 1**). It has a significantly higher gravimetric power density than diesel, gasoline or lithium-ion batteries. However, its much lower volumetric energy density poses challenges for its use, transport and storage.

Table 1 Data centers can consume hydrogen in three ways

	Proton exchange membrane (PEM) fuel cells	**Solid oxide fuel cells (SOFC)**	**Turbines/engines**
Fuel	Hydrogen	Hydrogen or natural gas	Hydrogen or natural gas
Efficiency	40% to 50%	60%	20% to 35%
Temperature	<120°C (248°F)	500°C to 1,000°C (932°F to 1,832°F)	1,250°C (2,282°F)
Application	Standby	Primary	Primary or standby

UPTIME INSTITUTE 2025

Data center operators can improve efficiency and the economics by implementing combined cooling, heat and power (CCHP) systems, which harness the heat generated in the fuel cell or generators.

While pure hydrogen is rarely found in nature, it is primarily manufactured from fossil fuels:

- Steam reformation of methane produces gray hydrogen (about 76% of global supply).
- Coal gasification produces black or brown hydrogen (about 23%).

Electrolysis of water using low-carbon electricity produces green hydrogen, which provides around 0.1% of today's supply.

Companies such as Shell and Equinor also offer blue hydrogen — a version of gray hydrogen with emissions reduced by carbon capture. Blue hydrogen is currently more prevalent than green hydrogen at around 1% of the market, but its manufacture still depends on fossil fuels.

Implementations

The petrochemical industry produces about 70 million metric tons of gray hydrogen annually, primarily for use in oil refining and the manufacture of ammonia for fertilizers.

Hydrogen has a limited supply chain. In petrochemical hubs such as the US Gulf Coast, pipelines deliver gray hydrogen to local refineries and ammonia plants.

Outside these areas, hydrogen is typically transported by trucks using refrigerated tube trailers. These are impractical for on-site power, as each carries only around 500 kg of hydrogen — enough to power a 2 MW data center for roughly one hour.

Proposed hydrogen hubs — mostly at existing petrochemical sites such as Houston in the US and Eemshaven in the Netherlands — could expand the pipeline network. However, developments are progressing slowly, and hydrogen supplies will remain localized for the foreseeable future.

For data centers, green hydrogen (or any form of hydrogen) remains a niche option for on-site power. Uptime Institute is aware of one operator using hydrogen for primary power and another using it for backup power.

Primary power

ECL plans to open the first 50 MW phase of its TerraSite-TX1 campus near Houston in 2025. The site has a redundant supply of gray hydrogen from three pipelines. ECL intends to adopt blue hydrogen and, eventually, green hydrogen if and when these become available from the same pipelines.

Standby power

NorthC uses green hydrogen for standby power at two facilities in the Netherlands, with the plan to use it for primary power when a piped supply is available.

- In Groningen, a 3.5 MW data center uses proton exchange membrane (PEM) fuel cells and an on-site hydrogen supply to cover a four-hour utility power outage, supplemented by diesel for longer events.
- In Eindhoven, a 4.5 MW data center uses Innio Jenbacher gas engines with enough on-site hydrogen for four hours of operation. For longer outages, the engines switch to a piped natural gas supply.

Other operators, including Microsoft and Equinix, have tested hydrogen as an option for backup power but have not yet adopted it.

Economics

While gray hydrogen costs $2 or less per kilogram, green hydrogen currently ranges from $8 in the US to $12 in Europe.

Prices are expected to come down, but this depends on:

- The development of cheaper electrolyzers with higher energy-conversion efficiency.
- Increased supplies of low-cost (preferably curtailed) low-carbon or carbon-free electricity.
- An established storage and distribution system, forming part of a hydrogen economy.

Analysis by Vertiv suggests the total cost of ownership (TCO) of hydrogen-powered PEM fuel cells could match that of diesel generators if the price of green hydrogen falls to around $4 per kg. However, Vertiv believes that prices need to drop further — to about $2 per kg — before operators will switch in significant numbers.

Stimulus programs launched by the EU and the Biden-era US administration aimed to reduce the price of green hydrogen to $1 per kg by 2030, but this goal will not be achieved, according to the International Energy Agency (IEA). Bloomberg New Energy Finance (BloombergNEF) predicts that only China and India will achieve prices below $2 per kg for green hydrogen by 2050.

BloombergNEF and the IEA note that governments announced inadequate grants and subsidies, then failed to fully deliver them. In addition, electrolyzer costs have not fallen as fast as hoped, and low-carbon electricity generation is currently insufficient to support a strong green hydrogen market.

(These reports predate the Trump administration's reduction of green hydrogen plans in the US.)

Commercial activity

The IEA's 2024 report puts global hydrogen demand at around 97 million metric tons in 2023, of which only 1 million metric tons was low-carbon (both green and blue) hydrogen.

In 2023, low-carbon hydrogen projects received $3.5 billion in investment — about 80% for green hydrogen (electrolysis) and 20% for blue hydrogen (carbon capture).

China and Europe are leading in green hydrogen (with roughly half of global electrolysis investment in China and one-third in Europe), while North America is leading in blue hydrogen.

Despite this investment, the increase in hydrogen supply will not be sufficient to meet government targets or power data centers by 2030. The IEA predicts the production of 4 million tonnes of low-emissions hydrogen annually in 2030, while BloombergNEF believes 15 million metric tons is possible, split evenly between green and blue hydrogen.

Drivers and barriers

Drivers of green hydrogen usage include:

- The need for low-carbon alternatives to diesel generators and on-site natural gas generation.
- The opportunity to capture and use excess wind and solar generation that would otherwise be curtailed.

Barriers include:

- The price of green hydrogen is expected to remain higher than comparable energy sources for decades.
- Availability is extremely limited. There are virtually no pipelines, and road delivery is impractical for large-volume uses such as data centers.

The Uptime Intelligence View

> Green hydrogen is expected to play a role in future energy plans — as a transportable fuel for electricity and heat generation, and as a means to exploit wind and solar output that would otherwise be curtailed. However, that role is distant and uncertain, due to cost issues.
>
> For data centers, the use of green hydrogen to generate electricity — either for standby power or primary power — will remain uneconomic and impractical for decades to come.
>
> In the meantime, operators should consider alternative low-carbon energy sources for standby and primary power.

Other related reports published by Uptime Institute include:

Hydrogen in data centers: an introduction
Hydrogen fuel cells: a niche option for standby power
Low-carbon hydrogen: not yet viable as primary power source

ABOUT THE AUTHOR

Peter Judge

Peter is a Senior Research Analyst at Uptime Intelligence. His expertise includes sustainability, energy efficiency, power and cooling in data centers. He has been a technology journalist for 30 years and has specialized in data centers for the past 10 years.
pjudge@uptimeinstitute.com