



The Adoption of Hydrogen Fuel Cell-Powered Lift Trucks

Maturing technology makes financial
and operational sense



Abstract

What if your materials handling operation could achieve higher operational productivity, eliminate cumbersome battery charging infrastructure and deliver consistently high performance? Well, it's possible with lift trucks powered by hydrogen fuel cells, and today's materials handling industry is the perfect fit for this innovative power solution.

Large, successful organizations are integrating fuel cell technology into their lift truck fleets and benefiting from the lower operational costs, reduced emissions and improved reliability. Now, major lift truck brands are bringing fuel cell technology in-house, with ultimate plans to offer hydrogen lift truck solutions with factory warranty coverage and supporting infrastructure.

This white paper examines the adoption of hydrogen fuel cell-powered lift trucks, the availability of hydrogen and the benefits and best-suited applications for this impressive technology



Yale® truck with Nuvera® Hydrogen Fuel Cell



It Starts with the Basics

A fuel cell is an energy conversion device used to capture and use the power of hydrogen. It produces electricity from hydrogen and oxygen, with water vapor and heat as the only byproducts. Since these byproducts don't produce any emissions or pollutants, hydrogen fuel cells serve as an ideal choice for warehouse, manufacturing, retail and food applications.

A steady, cost-effective supply of hydrogen is critical to the success of any hydrogen-dependent operation and is an important requirement for any decision maker considering the implementation of hydrogen fuel cell-powered lift trucks. To maintain hydrogen access, operations can rely on two different methods:

Hydrogen Shipments

One solution is to depend on regular hydrogen shipments from a chemical production plant. However, this method leaves operations vulnerable in the event of a missed shipment and requires users to manage fuel deliveries. Additionally, the emissions from transporting hydrogen to the point-of-use can offset the positive environmental impact.

On-Site Hydrogen Systems

A more cost-effective, risk-averse and lower-emission alternative is on-site hydrogen generation. Using a facility's natural gas and municipal water connection, on-site hydrogen systems can offer complete compression, storage and dispensing solutions to refuel lift trucks powered by hydrogen fuel cells. Scalable on-site generation systems can produce anywhere from 25 to 150 kilograms of hydrogen per day, making it a cost-effective solution for both modestly sized and large fleets. In all cases, an analysis should be conducted to determine whether hydrogen shipments or on-site hydrogen generation makes the most sense.





Building the Business Case – The Major Benefits

With on-site hydrogen generation offering a viable fuel supply option, what can operations expect with a fleet of hydrogen fuel cell lift trucks? Four major benefits drive the case for adoption.

Increased uptime

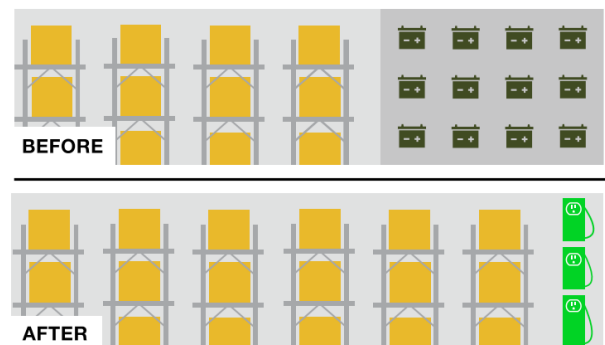
Currently, most electric lift trucks use lead acid batteries. Once the battery charge expires, the battery must be removed and taken to a charging room, and a freshly charged battery must be installed. This equates to **20 minutes of lost productivity** every four to eight hours. Hydrogen fuel cells can be rapidly refueled in just **three minutes**, similar to an internal combustion powered lift truck. In multi-shift operations with two or more battery replacements per day, the quick refueling of hydrogen fuel cells saves time and increases operator efficiency. Furthermore, since lift truck operators can refuel hydrogen themselves, operations can keep business moving and make more efficient use of labor resources.

Natural Gas Prices at Historic Lows

Natural gas prices are at historic lows, and its use for a variety of applications in several industries is becoming more widespread. This is great news for hydrogen fuel cell users, as hydrogen is produced from natural gas and its increased availability enables more customers to generate their own hydrogen.

Small footprint

On-site hydrogen generation and fueling equipment consists of a compact hydrogen generator and auxiliary equipment located outside of the building, eliminating the significant indoor space required for battery charging and storage rooms. This enables more efficient use of existing space, while growing throughput capacity and productivity. This is especially beneficial for operations located close to urban centers with higher real-estate costs, enabling them to avoid large capital expenditures, such as investing in a larger facility.



Constant power

Hydrogen fuel cells deliver constant voltage until fuel tanks are depleted. This means that in normal operating conditions, fuel cell-powered lift trucks experience no performance degradation during the shift, running at full speed and reducing wear on truck motor controllers. Compared to battery-powered lift trucks that suffer performance degradation over the last half of the battery charge, hydrogen fuel cells offer sustained performance and improved component longevity.



Lower emissions, lighter impact

With only water vapor and heat as byproducts, hydrogen fuel cells produce zero harmful emissions. On average, companies that generate hydrogen on-site can expect a **33 percent average reduction** in greenhouse gas emissions compared to lead acid battery systems charged from the electrical grid – a critical reduction for companies that prioritize green initiatives and strive to reduce their carbon footprint.

The disposal of batteries affords further financial and environmental advantages for hydrogen fuel cell-powered systems. Lead acid batteries typically **require replacement every three to four years**, accumulating replacement costs and burdening operations with the disposal of depleted units. However, fuel cells only need replacement every ten years, resulting in a lower lifecycle cost, reduced disruption to operations and minimal environmental impact.

Operations Best Suited for Adoption

A variety of factors make an application well suited for hydrogen fuel cell lift trucks. Some of the best opportunities include:

- Multi-shift operations that want to reduce battery replacement downtime and increase efficiency
- Growing operations that need additional indoor space to increase capacity
- Operations that want to reduce their carbon footprint
- Confined settings in which air quality is an important consideration to protect employee health

33%

**REDUCTION IN
GREENHOUSE
GAS EMISSIONS
COMPARED TO
LEAD-ACID**

ZERO

**HARMFUL EMISSIONS:
WATER VAPOR AND
HEAT BYPRODUCT**





Making Operational, Environmental and Business Sense

In general, deploying hydrogen fuel cells can offer a cleaner, safer workplace and significant productivity and financial advantages over other electric lift truck options. Fuel cell-powered

lift trucks offer a realistic, long-term solution that addresses the challenges facing material handling operations to reduce total cost of operation and increase efficiency. Combine these favorable conditions with consistent access to fuel with on-site hydrogen generation solutions, and further adoption of hydrogen fuel cell-powered lift trucks makes sound financial and environmental sense.

Adapt to Evolving Trends

Lift trucks powered by hydrogen fuel cells are an effective materials handling solution to address evolving industry trends in distribution and fulfillment, with several developments paving the way for greater commercial adoption.

