



# Leading the Charge: How a Fuel Cell Compares to a Lead-Acid Battery

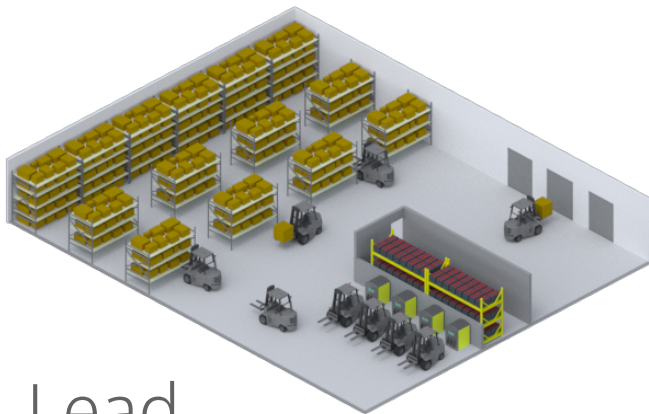


In recent years, the world has witnessed breakthroughs in technology and science that have improved our lives in various ways. When it comes to material handling operations, the same is true. Although a fuel cell has existed for years, Plug's imaginative team is continually looking at ways to improve its products based on customer feedback, including from leading retailers such as Walmart and Home Depot. Today, hydrogen is used safely in a number of industries, including food manufacturing, ammonia industry, steel manufacturing and oil refining.

For decades, lead-acid batteries may have seemed to be the only affordable power source for material handling facilities.

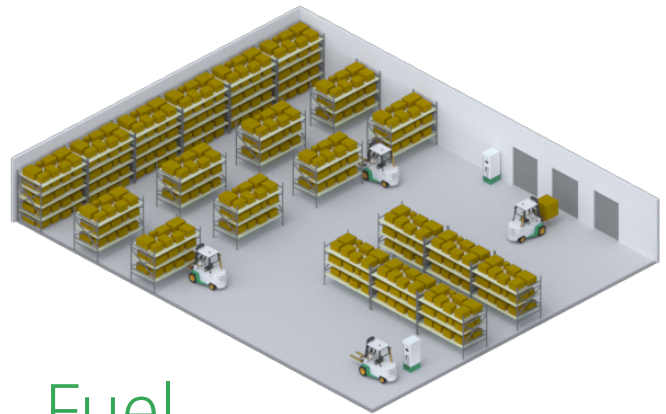
However, when it comes to fast-paced warehouses, a fuel cell has proven to be:

- More cost-effective
- More environmentally conscious
- More versatile



## Lead Batteries

HIGH electricity bills  
20 minute battery swaps  
Low warehouse optimization  
Decreased productivity



## Fuel Cells

ZERO emissions  
3 minute refueling  
Optimized warehouse space  
Increased productivity



# The Cost Comparison

Imagine saving up to \$300,000 per year in operations costs over 10 years for a medium-sized fleet. As your fleet size gets bigger, so will your annual savings. This is just one success story from Plug's customers. Customers reported saving money after transitioning to fuel cells in various ways.

The cost of hydrogen and its infrastructure is also declining as adoption grows among global corporations. Corporations are finding an immediate payback on their investments by establishing a hydrogen infrastructure in their warehouse facilities.

## **Increased Productivity:**

Fuel cell customers reported saving money through increased productivity. Productivity increased by up to 15% by transitioning from lead-acid batteries to fuel cells. In a facility running two or more shifts, operators may be required to swap or charge batteries several times, which can take up to 15 to 20 minutes per battery. Whereas hydrogen refueling takes less than three minutes, and can last through an entire shift.

What may be even more troubling for businesses is that lead-acid batteries reduce performance by up to 50% in cold or freezing environments, which can lead to inconsistent power levels, more battery change-outs and more batteries needing to be purchased. Lead-acid has various safety issues, including acid spills or battery flareups due to heat buildup.

However, hydrogen fuel cells are 100% safe and maintain 100% power 100% of the time. Plug's fuel cell customers with freezer facilities reported fuel cells maintain consistent performance even in temperatures as low as -22 degrees F.

Over the course of a year, the amount of time that could be saved on workforce productivity — and more importantly, workforce safety — is significant.

## **Increased Floor Space:**

Fuel cells have proven to require less floor space than batteries, which translates to more revenue for the business because valuable real estate is no longer occupied by massive battery rooms, and instead used for products or other revenue-generating items.

Additionally, greenfield sites eliminate the need to earmark funds for costly battery charging and changing infrastructure, including expensive copper wire, battery watering, maintenance equipment and space-consuming charging rooms. In fact, the use of fuel cells can reduce a customer's capital investment by approximately \$1 million dollars before they even break ground.

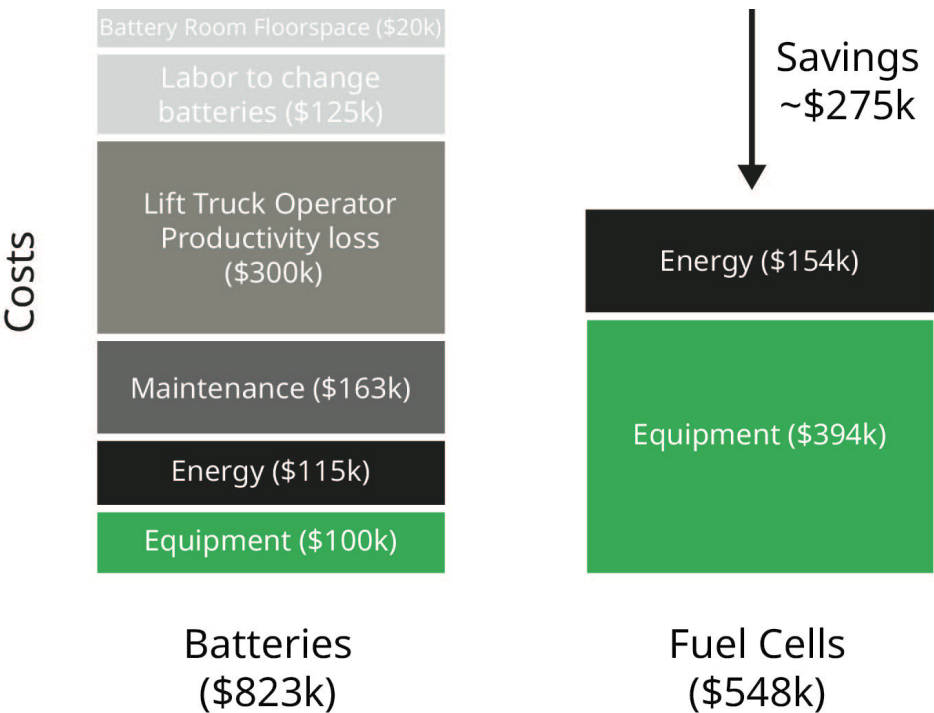
## **Decreased Electricity Bill:**

Lead-acid batteries represent 25% to 30% of a distribution center's entire electricity usage during regular hours, and about 50% of charges during peak demand. By leveraging direct connections to low-cost renewable energy generation, centrally generated green hydrogen can access some of the lowest cost energy on the grid today.

**Diving into the Numbers: A 10-Year Cost Comparison**

In the first scenario, we compare the cost of ownership per year over 10 years with a fleet of 50 forklifts. The scenario compares conventional lead batteries with Plug’s fuel cells. Here’s the breakdown of total cost of ownership.

Conventional Charging vs. Fuel Cells: Annual Cost of Ownership



In this scenario, fuel cells provide significant annual cost savings (34.17%) over conventional battery charging. The pertinent components include equipment productivity, floor space recovery, electricity and labor savings. There are additional savings beyond what you see here in the form of a 26% federal tax credit on the first year of expenditure for businesses that convert to fuel cells. This tax credit applies to both scenarios presented here.

Conventional Charging vs. Fuel Cells: Unproductive labor cost savings

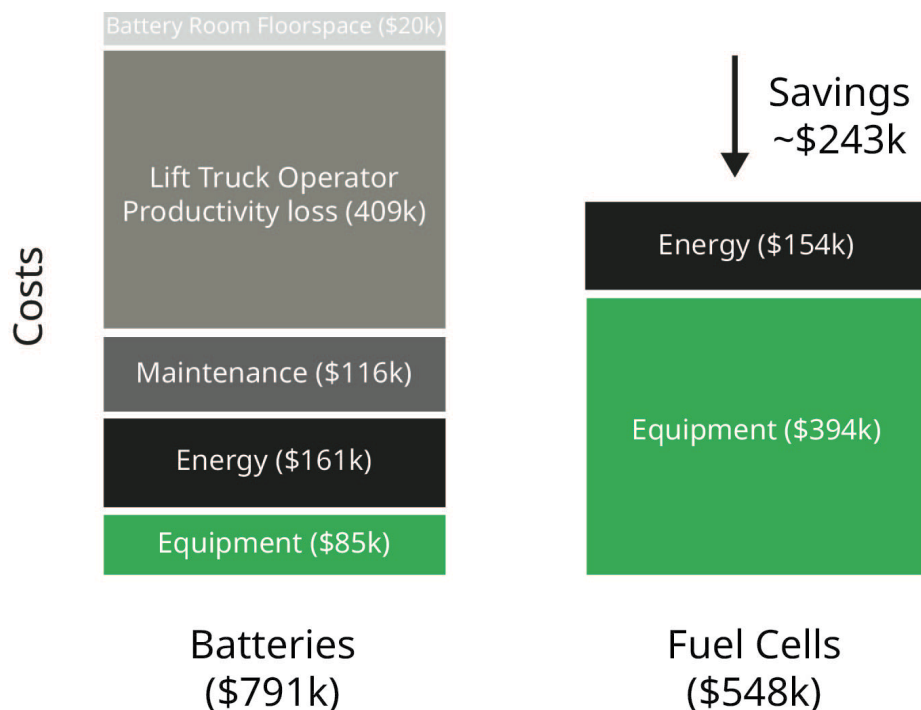
We see that nearly five full-time employees may be reallocated to revenue-generating productivity if businesses switch to fuel cells, which is equivalent to nearly \$300,000 in unproductive labor savings per year — a win for the customer using forklift fuel cells.

In the next scenario, we looked at the cost of ownership per year over 10 years for powering a fleet of 50 forklifts with fast-charging lead batteries compared to Plug’s fuel cells. Here’s a breakdown of how fuel cells compare:

The fast-charge scenario shows that annual savings are 31.36%. The most impactful issues continue to be equipment productivity gains through consistent voltage, floor space recovery, electricity and unproductive labor savings. Additionally, both charging equipment and extra material handling equipment that are needed with fast-charging are not needed in the fuel cell scenario. Although these numbers are conservative, there is a dramatically increased chance of incurring higher rates for peak demand utility, which you avoid when choosing fuel cells.

## Fast Charging vs. Fuel Cells: Unproductive labor cost savings

By adopting hydrogen fuel cells instead of fast-charging, 6.5 full-time employees may be reallocated to revenue-generating activities, which is equivalent to \$409,000 in unproductive labor savings per year – just one of many benefits of fuel cells.



## The Environmental Comparison

### Green Hydrogen Source:

When companies adopt hydrogen fuel cells, replacing the lead-acid batteries they formerly used in material handling equipment, they eliminate the costs associated with handling and storing toxic materials, while reducing greenhouse gas emissions by up to 80%.

In addition, Plug is building an infrastructure of green hydrogen production plants to service its material handling customers and beyond. Customers can expect Plug to produce 500 tons of liquid green hydrogen per day by 2025 and 1,000 tons per day by 2028.

### Zero Emissions During Operation:

Hydrogen fuel cells are a clean and green source of energy because the byproducts are simply heat and water, making them superior to lead-acid batteries, which rely solely on the grid to be powered. Fuel cell reaction is an electrochemical conversion and not combustion, therefore the only emission is water.

### Safe Recycling:

Hydrogen fuel cells can also be safely recycled with Plug offering complete end-to-life services. Plug employs a structured approach to recycling. From monitoring products reaching end-of-life to implementing a four-pronged approach to baselining carbon intensity of the fuel cell products, Plug focuses on circularity.



## Plug's Path to 100% Sustainability

With the realization that corporations need to reduce their carbon footprint in order to maintain a healthy planet, there's been a growing adoption of hydrogen. When it comes to decarbonization, customers turn to Plug to provide a full ecosystem of products. State and federal governments, realizing the need for renewable energy, have increasingly offered companies incentives to upgrade their operations, while the cost of commercial electricity has skyrocketed to record prices.

Plug's convenient availability of hydrogen and the entire ecosystem of solutions allow our customers to meet their sustainability goals, while promoting environmentally friendly business practices to the public.

## The Versatility Comparison

Aside from the cost and environmental comparison, business owners and leaders should consider the number of pitfalls associated with lead-acid batteries, including the challenges operators and other employees must face when working with batteries.

Businesses that work with lead-acid batteries have learned the many challenges in maintaining its lackluster performance and that working with them requires more training compared to fuel cells. In addition, workers must also deal with acid spills, proper ventilation in charging rooms and other challenges related to handling lead-acid batteries.

Whereas Plug offers a comprehensive list of services that support businesses every step of the way. In addition, fuel cells don't use hazardous materials, which eliminates the risk of dangerous spills. Fuel cells also don't need any unique ventilation or change-outs, reducing over risks.

## Hear From the Customers

After more than a decade of development and refinement, hydrogen fuel cells have proven viable for the commercial market, as evidenced by the more than 52,000 material handling vehicles powered by Plug at more than 165 operations sites. These sites have more than 907 million hours of operation. Many of these companies are repeat customers that have either expanded their current fleet or deployed additional sites elsewhere. Furthermore, Plug includes infrastructure, service and de-commissioning costs.

The following examples provide a snapshot of some of the leading businesses that are experiencing the attractive benefits and savings that using fuel cells provide over battery technologies:

**Amazon** made a bold promise: To be net carbon zero by 2040. To reach that goal, the technology company is relying on Plug's technology to power its distribution centers around the world. Amazon is using more than 15,000 fuel cells to power 70 sites with plans to add additional sites in 2022.

**Walmart** is committed to its partnership with Plug, using hydrogen and fuel cells in its distribution centers across the U.S. and Canada, including many in refrigerated and freezer distribution centers with temperatures as low as -29°C, as one of the ways it reduces costs. With new Walmart distribution centers already operating with Plug's turnkey power, fuel and service bundle, the Fortune 500 leader has avoided costs associated with installing, maintaining and operating traditional lead-acid battery systems. Furthermore, with potential greenhouse gas emissions reductions of up to 80%, compared to batteries charged from the grid, fuel cells are helping the company become a more sustainable operation. As of January 2022, there are 10,000 fuel cells operating at 41 hydrogen fuel sites across Walmart distribution centers, with more planned for the year.

**Colruyt Group**, a leading supermarket corporation, was the first logistics center in Europe operating solely on fuel cell-powered material handling vehicles, signing up in 2015 to use 200 fuel cell units in its Halle, Belgium facility. Colruyt Group's sustainability initiatives involve optimizing its own operations and collaborating with others in its supply chain to minimize its impact on the environment. Adoption of the fuel cell solution enhances this initiative – Colruyt Group increases efficiency of its workers in a safer environment by removing lead-acid batteries from the workplace. Fuel cells are powered by clean hydrogen fuel, generating only heat and water as byproducts.

**Wegmans** is a longtime user — and believer — of hydrogen fuel cells. This leading supermarket chain upgraded its technology in 2010 when it began using Plug's fuel cell to power its fleet of more than 300 pallet jacks and forklifts. Wegmans reported seeing improved productivity, lower labor costs and higher employee satisfaction when it made the transition. The company also adopted fuel cell technology for its new warehouse to be opened in 2023.

**Stellantis**, a multinational automotive manufacturing corporation, chose Plug's fuel cells to power operations in its multi-million square foot facilities in Detroit. As a leading automotive manufacturer in the U.S., the company relies on 800 fleet of tuggers and counter-balanced trucks to operate nonstop in the main assembly line to keep up with the demand. Stellantis has successfully used 16 dispensers that power the forklifts up to three shifts around-the-clock in the most demanding environment.

Fuel cells can be customized under Plug's product offerings. Fuel cells can be deployed by the hundreds for large operations or as few as 25 for small companies. For smaller material handling businesses, the cost of deploying hydrogen fuel cells is feasible through the work Plug has done with its partners and smaller customers to develop a downsized fueling infrastructure scaled to economically meet the needs of these smaller businesses. Additionally, customers with modest-sized fleets have committed to investing in and adopting Plug's sustainable solutions that allow enhanced operations and a clean competitive advantage in the market.

## Interested in Learning More?

**Webinar:** Elevate Your Warehouse Performance

**When:** Tuesday, August 16, 2022

**Description:** Learn about the benefits of green hydrogen fuel cells over leadacid batteries, and its impact on forklift fleet performance as it relates to productivity, costs, warehouse space and the environment. You'll also hear case studies by applications, fleet sizes and industries.



## Join the Hydrogen Movement

Fuel cells are powering our world, including material handling operations, in a smoother and a smarter way. The world's leading companies have made them an integral component in maintaining their global competitiveness. Since being introduced to the material handling sector, Plug's hydrogen fuel cells have proven themselves to be a more reliable product at a lower overall cost than batteries. The world is quickly moving in the direction of renewable, smart energy. Join us in this movement and let's power your operations with the energy of the future. Contact us to learn how Plug can help you move your business into the future.

## About Plug

Plug is building an end-to-end green hydrogen ecosystem, from production, storage and delivery to energy generation, to help its customers meet their business goals and decarbonize the economy. In creating the first commercially viable market for hydrogen fuel cell technology, the company has deployed more than 52,000 fuel cell systems and over 165 fueling stations, more than anyone else in the world, and is the largest buyer of liquid hydrogen. With plans to build and operate a green hydrogen highway across North America and Europe, Plug is building a state-of-the-art Gigafactory to produce electrolyzers and fuel cells and multiple green hydrogen production plants that will yield 500 tons of liquid green hydrogen daily by 2025. Plug will deliver its green hydrogen solutions directly to its customers and through joint venture partners into multiple environments, including material handling, e-mobility, power generation, and industrial applications. For more information, visit [www.plugpower.com](http://www.plugpower.com).