A SPECIAL SUPPLEMENT TO
MODERN MATERIALS HANDLING

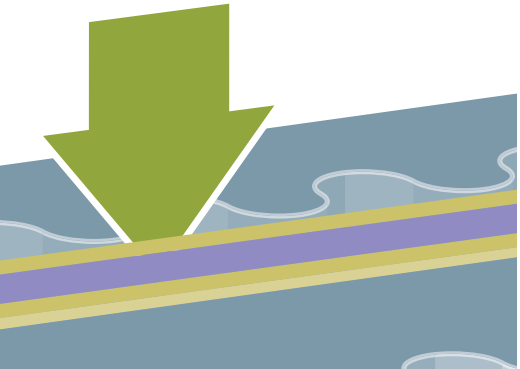
Fuel Cells: The science, study and promise of the newest player in materials handling

These alternative sources of energy on the lift truck scene may prove to be a viable alternative, after a little help.

By Josh Bond, Contributing Editor

Given volatile propane prices and the limitations of batteries, companies might feel as though they are forced to choose the lesser of two evils when powering their lift truck fleets. The emergence of fuel cell technology in the materials handling industry could offer a viable third option, but many questions remain unanswered. How reliable and durable is the hardware? How safe are hydrogen fuel cells? What are the up-front and long-term costs? To what extent are fuel cells greener than conventional energy sources?

In recent years, fuel cell manufacturers and their customers have seen enough promise to begin a series of small-scale lift truck trials, many of which have turned into larger trials or full-scale installations. But even as pioneers work to answer some of the questions above, the long-term data many buyers prefer simply hasn't yet been collected. Only time will tell how much of the lift truck market fuel cells will ultimately capture. Early indications suggest the technology could compete strongly in materials handling applications, offering reliable performance, a smaller carbon footprint as well as multifaceted savings.



Following the invention of fuel cells in 1838, they were referenced in the writings of Jules Verne, the father of science fiction. Laboratories spent the next century and a half working on the science, but viable commercial solutions remained a fiction. In a world where technological revolutions seem to come on a daily basis, impatient consumers and industry experts alike developed a dismissive attitude toward the technology.

"It's always been a joke that fuel cell technology has been 'the coming thing in the next few years' for 30 years," says Eric Jensen, director of research and development for new technologies at Crown Equipment.

Now that solutions have finally hit the market, Jensen suggests lift trucks could be the proving ground for more widespread adoption of the technology. "Materials handling is kind of hidden. It's not in the consumer limelight. You see advances in fuel cell technology for the automotive industry, and it ends up on the front page. But I believe materials handling is leading the way with fuel cells for the automotive industry," he says.

Fuel cells in the field

The space between lift trucks and freight trucks has already been bridged at sites like the new hydrogen fueling station at a Kimberly-Clark distribution center in Graniteville, S.C. Unveiled on Feb. 11 as the first of its kind, the station supports the entire lift truck fleet of the DC as well as county government vehicles and a Bridgestone/Firestone manufacturing facility across the street.

Bob Simon is director of process solutions for GENCO ATC, which partnered with Kimberly-Clark, Plug Power and Air Products to realize the hydrogen station project. The station was built with the help of $1.1 million in American Recovery and Reinvestment Act dollars designed to accelerate the commercialization of hydrogen fuel cells. According to Simon, the application submitted to the U.S. Department of Energy suggested over-the-road freight trucks that travel routinely between the same destinations might benefit from hydrogen fueling stations at each stop.

In the meantime, the technology will likely be dependent on similar federal grants to build momentum in the market. "The outlook is promising, but there are still some obstacles, namely cost," says Simon. "Without programs and incentives, it will be hard to overcome some of the reservations in the industry. Customers are willing to be leaders, but they don't want to be pioneers."

Frank Devlin, fuel cell segment manager for Raymond, agrees, noting that despite hydrogen's reputation as catastrophically combustible, tens of thousands of fuel cell refuelings have occurred with no reported incidents. As fuel cells continue to prove themselves, energy prices might also work to encourage customers to give it a chance.

"Energy is on everyone's minds these days, especially with the political unrest in the Middle East," says Devlin. "People are asking what's the best way to power anything, from your cell phone to your lift truck."

How it works in the lab

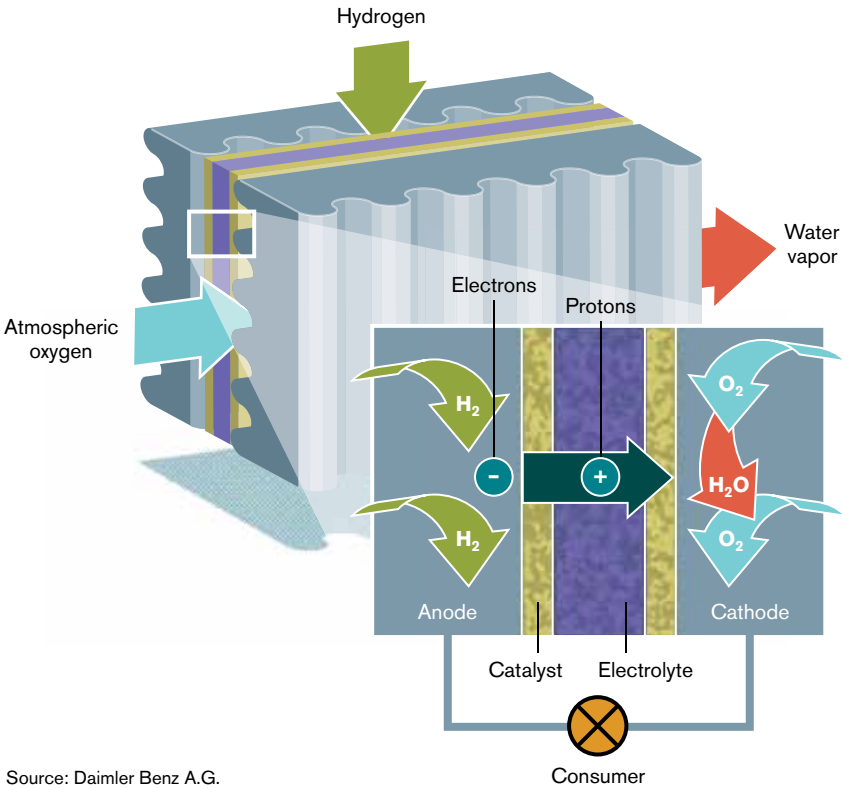
Gus Block, a former fuel cell systems engineer, is the director of marketing for Nuvera Fuel Cells, a manufacturer of fuel cell systems and hydrogen generation equipment. Block says fuel cells are energy conversion devices, like standard engines, as opposed to energy storage devices like batteries. There are a few versions of the technology, says Block, but the one best suited to materials handling applications is based on a proton exchange membrane. Hydrogen provided to the anode side of the membrane combines with oxygen from the air on the cathode side. The reaction produces electricity and water vapor as exhaust.

Over time, the membrane will age, with a slight decay rate over years of use, says Block. Nuvera estimates an up to 12,000-hour or higher lifespan for its fuel cell stack. Over 10 years of service in a materials handling application, says Block, the stack may be rebuilt once or twice. The capability to remanufacture (rather than replace) stacks is a feature unique to Nuvera's proprietary technology, he says.

Several factors must be considered when engineering a fuel cell pack to replace the battery of an electric lift truck, according to Block. In addition to an exhaust-fed humidity system, water filter and air pump, the pack must meet the minimum weight requirement specified by the truck supplier. Fuel cell packs therefore contain an appropriate amount of ballast.

Then there is the hydrogen, which is stored at 5,000 psi in fuel tanks enclosed in the power pack tray. There are a number of ways to get hydrogen on-site, says Block, each of which will impact the

Fuel cell technology: How it works



Source: Daimler Benz A.G.

This cross section illustrates a proton exchange membrane, one of several fuel cell configurations and the one best suited to the materials handling industry.

ILLUSTRATON BY DANIEL GUIDERA

carbon footprint of a fuel cell operation. It can be trucked in as a liquid or gas, or can be generated on-site from an electrolyzer, or from a steam methane reformer (SMR). The scale of the need will partly determine the best option. From a carbon emissions standpoint, on-site generation from natural gas is typically the best option.

"If you're concerned about fossil fuel, then a battery is about your worst choice, because about half of the nation's electricity comes from coal," says Block. "Not only is natural gas clean, it's widely available, there are tremendous reserves, and the prices are good."

Hydrogen supplied by on-site SMR generators will produce about 33% fewer emissions than electricity from the grid, says Block, citing a recent study by Argonne National Lab. A near zero-emissions fuel cell fleet can be achieved if renewable sources are used for the energy feedstocks.

How it works in the warehouse

Until fully integrated lift trucks are offered, hydrogen fuel cells replace the battery used by electric lift trucks. The hydrogen fuel cell remains in the lift truck and is refueled at a refueling station that can be installed at any location in a warehouse and connected to the outdoor hydrogen generation station. The freedom to position multiple refueling stations inside a facility is a key component of efficiency and productivity gains afforded by a fuel cell system. As compared to batteries, says Simon, fuel cells require less travel distance to a central battery station, they need fewer refueling events, and the time for each fueling could be cut from 18 minutes for a battery swap as little as 2 minutes to fully fill a hydrogen reserve.

Once the fuel tank is full, it will perform at a consistent power output until the hydrogen is depleted, much like an internal combustion lift truck. It will not gradually lose performance like batteries do as the charge weakens. But unlike any IC truck, a fuel cell will not release any toxic emissions.

"It really does change the game for air quality," says Devlin. "With fuel cells, you're greener and you're cleaner." Devlin goes on to suggest that although the initial outlay is significant, the maintenance and repair costs for fuel cell systems could be quite a bit less than an IC engine.

Hydrogen is sold by the kilogram, for about 8 to 12 dollars, and a kilogram will last 6 to 12 hours depending on whether you're using a reach truck or a pallet jack, says Devlin.

Who wants fuel cells

Current fuel cell offerings are suited to aggressive, multi-shift fleets of 15 or more trucks. The infrastructure costs will be better justified in a full-building installation as opposed to a partial fleet approach, says Devlin. At this point, cost is a key obstacle to more widespread adoption of fuel cell systems, and the technology seems stuck in a Catch 22; it needs wider adoption to lower the cost, but it needs to lower the cost to stimulate adoption.

"Fuel cells have a couple of percent of the lift truck market share, and will probably never completely supplant the [battery] electric market until there are more affordable options for smaller operations," says Devlin. "As we go forward, fuel cell solutions will be less customized and more off-the-shelf, but that could take five to seven years."

Aside from fluctuations in electricity prices and potential improvements to the cost of hydrogen capturing, federal incentives will be key to fully realizing the potential of fuel cells.

"The government is a huge part of

Fuel cells in action at UNFI

United Natural Foods Inc. (UNFI) is the largest wholesale distributor of natural, organic and specialty foods in the United States, with 28 distribution centers in the U.S. and Canada. During the past three years, the company has examined ways to reduce its energy consumption, which led it to investigate hydrogen fuel cells as a new power source for its lift trucks.

When it first began investigating hydrogen fuel cells in 2007, the company decided to wait for further testing to ensure the viability of the fuel cell technology. After extensive discussions with a lift truck manufacturer and a fuel cell manufacturer (Raymond, www.raymondcorp.com; Plug Power, www.plugpower.com), Tom Dziki, chief human resources and sustainability officer at UNFI, says the company decided to move forward with fuel cells.

"I felt very comfortable with the solutions we selected," says Dziki, "Because we knew the manufacturers had worked together to be sure the lift trucks and the fuel cells would perform the way we needed them to."

The receptiveness of Florida to help fund sustainable initiatives for businesses in the state made the decision even easier for UNFI, says Dziki. On June 25, 2010, all of UNFI's trucks at its Sarasota, Fla., plant were converted to hydrogen fuel cell technology. Following extensive training and planning, the transition was seamless.

The operations manager at the plant says operators are seeing 10 to 12 hours of continuous use on the pallet trucks, a significant improvement compared with the 5 to 7 hours of use they were seeing with the batteries. Productivity also has increased because of the short time it takes to refuel the lift trucks. UNFI is now considering using hydrogen fuel cells at its other sites.

the equation at this point," says Kenro Okamoto, electric product planning specialist for Toyota Material Handling. "Fuel cell infrastructure is much less attractive without those incentives."

However, even with sufficient federal support, the future of fuel cells is unclear. Okamoto says the limitations of batteries were a key driver in the movement of fuel cell technology from the labs to the field.

"Our customers have been looking for a way around those limitations," says Kenro. "Fuel cell technology is an answer."

But Okamoto says it is equally likely that advances in battery technology could make fuel cells obsolete. "Who knows?" says Okamoto. "It's kind of a wait and see situation."

Cesar Jimenez, national product planning manager for Toyota, says the uncertainty puts companies like his in a tough place. "It's difficult for an equipment manufacturer to make a solution for a market that hasn't really taken off yet," he says. "The technology is essentially in a beta test."

Operators of fuel cell lift trucks at one facility noted 10 to 12 hours of continuous operation per fueling, as compared to 5 to 7 with standard batteries.

Although fuel cells only make up 1% or 2% of the lift truck market, some of those customers include big players. Walmart, FedEx and Coca-Cola have begun dabbling in fuel cell lift trucks, says Jensen. Just a few years ago, there were only one or two fleets of more than 30 lift trucks that had installed hydrogen fuel cells. Now, he says, there are more than 10.

"Some of it's just traditional," he says. "You've got a paradigm and you're not ready to shift it. But for those customers who have come off the fence, to them it's very real and to us it's very real." □