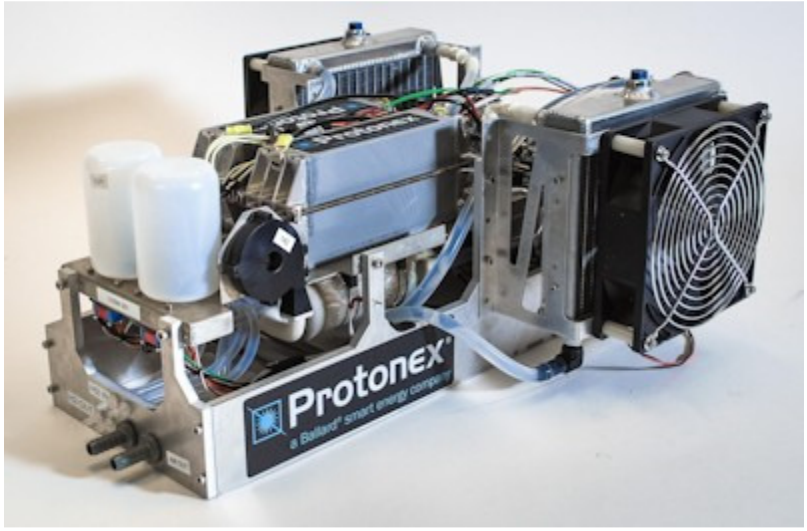
Hydrogen Fuel Cells Will Revolutionize the Mobile Robot Industry

Hydrocell for military war robots, autonomous mobile robots and more.

GEARS SMP fuel cell powered mobile robot

Robotics technology is revolutionizing nearly every industry today - from improving efficiencies of factory floors, saving lives in military and disaster response operations, self-driving cars, and even facial recognition in phone apps - just to name a few examples.

However, the field of mobile robotics is currently limited by ineffective power storage technologies. For power, robotics systems must either: be tethered by an electrical cord to a wall outlet - but that inhibits mobility; use a combustion engine such as used in cars and military drones - but this is noisy, polluting, and only effectively works at certain size scales; go nuclear powered, but for safety concerns is limited to space-faring robots; or carry a large battery - but this weighs down drones and has a very limited charge capacity.



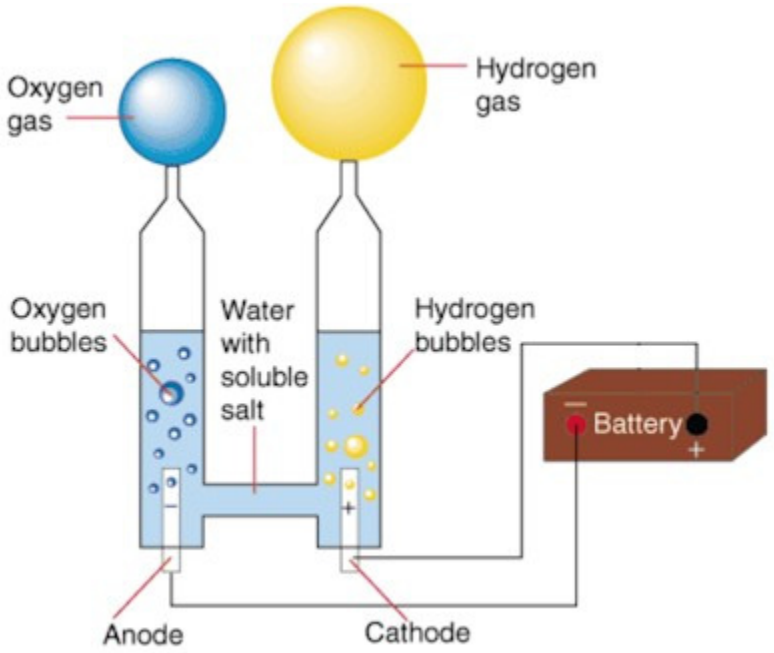
A commercial hydrogen fuel cell built by Protonex

The scaling laws of physics is advantageous to hydrogen fuel cell systems:

In physics, the various properties of an object do not scale together linearly. For example, if an object were to be made bigger, the mass of that object would increase by the cube while the surface area would only increase by the square. The peculiarities of scaling is why ants can lift objects several times their own weight, while the largest animals on the planet struggle to lift their own weight. Such scaling rules also mean different propulsion technologies work better at different scales.

Combustion engines are most efficient at scales meant for cars and larger. While combustion engines work on even hobbyist racing cars, their efficiency is rather awful compared to electrical motors at similar scales. On the other hand, while electrical motors are more efficient, scaling laws negatively affect batteries. Not only that, chemical fuels can store significantly more energy than a battery for the same volume and weight.

This is why fuel cells carry huge promise for the robotics industry. The majority of robot systems are mobile and indoors, and are at scales smaller than cars, meaning combustion engines are not ideal. Batteries are too heavy and too limiting for bipedal robots and drones. Any technology that outperforms batteries would revolutionize any industry that uses robotics technologies.



How Hydrogen Fuel Cells Work

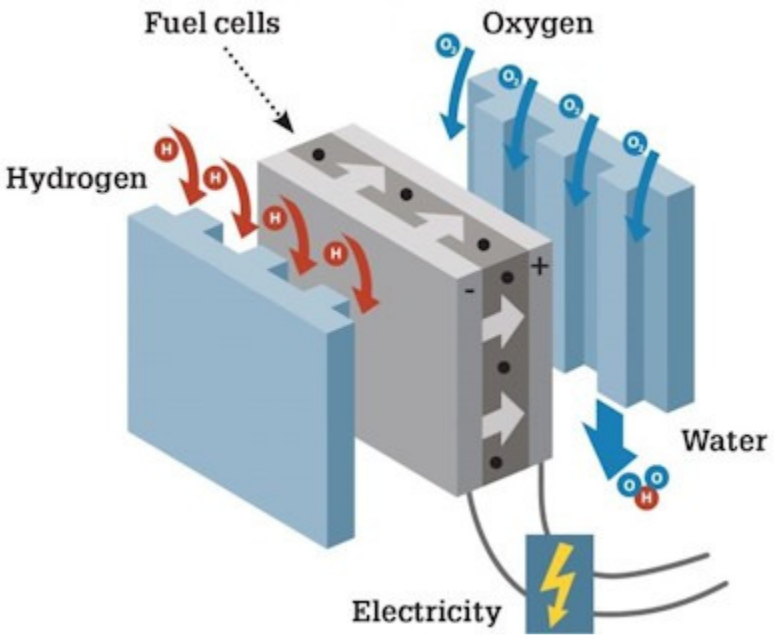
How Hydrogen Fuel Cells Work:

Most low-temperature fuel cells work by combining oxygen from the atmosphere with hydrogen from a compressed storage tank. Combining O2 with H2 creates water, but the reaction also releases energy in the form of free electrons. A fuel cell captures those electrons to power an electrical system.

While the only “pollution” created by fuel cells is water, the process of obtaining the hydrogen itself could be polluting. Combustion engines take hydrocarbon fuels, inefficiently burn the hydrogen, and release the carbon as pollution. There are industrial processes to separate the two so hydrogen may be obtained for use in fuel cells but sequestration of the carbon is still an issue. While industrial separation is still polluting, fuel cells are estimated to be 4x more efficient than combustion engines for the same amount of hydrocarbon fuel. And while combustion engines involve controlled explosions, fuel cells are relatively silent - only the sound of a small air compressor will be heard.

The least-polluting method for obtaining hydrogen is through electrolysis with solar or wind power, meaning a renewable energy converts water into O2 and H2 for storage in gas tanks. This process is incredibly slow and only effective in niche markets.

Fuel cells are sometimes jokingly called 'the technology of the future - for the last 50 years'. While the technology has been around for a long time and is rather developed, the cost to benefit ratio has rarely been competitive when compared to other competing technologies - with the exception of a few niche markets. Fuel cells require expensive rare metals such as platinum which dramatically drive up cost, so research up until recently has focused on finding alternative metals and designs to drive that cost down.



Basic hydrogen fuel cell operation (source: Energy News)

Fuel cells in the automotive industry:

It's been estimated that 20 years ago a fuel cell powerful enough to drive a car would have cost $40k - much more than the car itself! Today (2018), that price is about $20k. While still prohibitively expensive, the trend was clear enough to convince most car manufacturers to create fuel cell research divisions. Industry is now heavily investing in fuel cell technologies.

Today, the financial viability of fuel cells is being held back by a chicken and egg problem. The modern world has a vast highly efficient fossil fuel supply network, with gas stations to be found nearly every square mile. Moving to a hydrogen economy would require rebuilding that entire network from scratch, a very expensive endeavor that would only work if cars already ran on hydrogen! This is why robotics makes such a great niche market as there is no power network for robots currently available.

Note: Japan, and the state of California, have heavily subsidized the hydrogen fuel economy through government funding to bypass the chicken-egg problem.

Current niche markets of fuel cells:

Forklifts are now using fuel cells worldwide. Forklifts are often used indoors inside warehouses, where noise and exhaust present working hazards for employees. Battery powered forklifts had very long charging downtimes.

video: fuel cell powered fork lifts

Another unique niche use for fuel cells is for remote monitoring stations in undeveloped countries. Oftentimes thieves would raid the stations and steal battery units for resale in the black market. Once fuel cells were installed, thieves no longer had a profit motive.

The quiet nature of fuel cells is a benefit to military operations over combustion and jet engines, while the energy/weight ratio of fuel cells is vastly superior to battery technologies. This has led the US Navy to heavily

research ultra-light weight fuel cells for use in drones. The Naval Research Laboratory's Ion Tiger broke records, flying significantly longer than other similar sized drones of the past.

disclaimer: the author was lead engineer for Ion Tigers' fuel cell electrical power and monitoring systems

Fuel cells also have huge promise for other military robotic systems, such as for BigDog. BigDog is infamous for the very loud noise made by it's onboard combustion engine.

video: BigDog, noisy military robots that uses a combustion engine

Bipedal robots, or androids, also suffer from the extremely heavy weight of battery systems. Typical humanoid form robots today can't go more than 30 minutes on a single battery charge, making them nearly useless in most real-world applications. Battery weight heavily weighs them down - similar to how a 50 pound backpack would for humans. Fuel cells are ripe for being desirable battery placements in robots.

Typical batteries a soldier carries (source: Protonex)
[With war robots, propulsion would require even more.]

Modern US soldiers are loaded with technology, each powered by individual batteries. Military research is now focusing on ways to reduce and combine those batteries, meaning micro-sized fuel cells are a potential future option. Incredibly tiny fuel cells have already been developed for portable consumer electronics, although the lack of a hydrogen network for refills have limited its usefulness.

Conclusion
Fuel cells are on the verge of exiting the lab and becoming commercially viable. Today industry is heavily investing in the technology, with primary research being spent on making them more cost effective. The quietness, cleanliness, high energy density, and low weight of fuel cell systems gives them significant advantages for use in robotics systems.

About the Author: Taylor Welsh has worked past 15 years at Ax Control Inc. -- an automation control device service and supply company based out of North Carolina. They specialize in new and obsolete drives, PLCs, HMI and related control devices. Taylor has worked in various capacities within the industry, including government, defense, retail, manufacturing and startups. Please show your appreciation for Taylor's article by visiting their website AxControl.com.