



PLTW Engineering

10-12/Fuel Cell Applications

April 27, 2020



10-12/DE

Lesson: **4/27/2020**

Students will be able to explain how a fuel cell functions and identify machines that would be suited for their application.



What is a hydrogen fuel cell?

A hydrogen fuel cell is an electrochemical power generator that combines hydrogen and oxygen to produce electricity, with water and heat as by-products.

Hydrogen fuel cells form energy that can be used to power anything from commercial vehicles to drones.



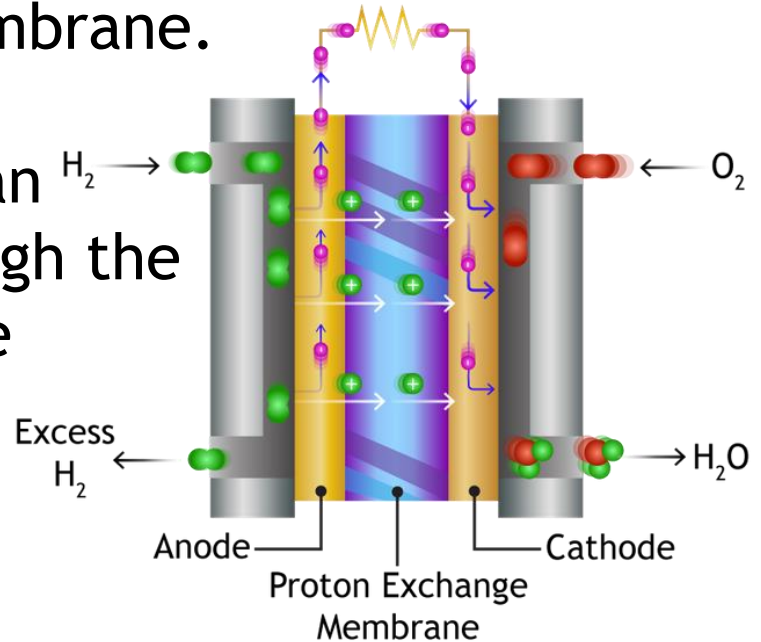
What can a fuel cell power?

Hydrogen fuel cells can offer a clean and reliable alternative energy source to customers in a growing number of applications - electric vehicles including forklifts, delivery vans and cars, primary and backup power for a variety of commercial, industrial and residential buildings.

How does a fuel cell work?

A fuel cell is composed of three main components: an anode, a cathode, and an electrolyte membrane.

In the diagram to the right, you can see H_2 entering, and passing through the proton exchange membrane where the molecules are split.





How does a fuel cell work?

On the anode side, the hydrogen molecules are split into electrons and protons. The protons pass through the electrolyte membrane, while the electrons are forced through a *circuit*, generating an electric current and excess heat.

On the cathode, the protons, electrons, and oxygen combine to produce water molecules.



Emissions of a fuel cell

Fuel cells are very clean, with their only by-products being electricity, a little heat, and water.

Additionally, fuel cells do not have any moving parts, so they operate very quietly.

Hydrogen fuel cells utilize environmentally-benign hydrogen as a fuel source, which eliminates the environmental impact of fuel spillage, leaks or air pollution.



Reliability of a fuel cell

Hydrogen fuel cells can operate in cold environments as low as -40 degrees F, weather environments like hurricanes, deserts and winter storms given the proper enclosure.

Depending on the style of fuel cell and the quality of components, a fuel cell has a life span of between 5,000 to 10,000 hours.



How efficient is a fuel cell

According to the U.S. Department of Energy, fuel cells are generally between 40-60% energy efficient.

This is higher than some other systems for energy generation.

For example, the typical internal combustion engine of a car is about 25% energy efficient.



How much does a fuel cell cost?

Compared to batteries and internal combustion generators, fuel cells save money.

They eliminate the need to change, charge and manage batteries - saving both labor/time and space normally allocated to a battery room.

The units run longer than lead-acid batteries and can be fueled in as little as two minutes, substantially reducing vehicle and personnel downtime.



How much does a fuel cell cost?

Even with limited production volume, the price of fuel cell vehicles—especially buses— has been reduced by 65% over the past 10 years.

Today, a 100kW fuel cell can cost as little as \$5,000 and up to \$9,000.

The price for the hydrogen to operate it costs around \$15 per kg. The equivalent in gasoline would be about \$5.60 per gallon



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Quiz yourself

1. What are the bi-products or emissions of a fuel cell?
2. List the 3 main components of a fuel cell
3. How many moving parts does a fuel cell have?
4. Compared to an internal combustion engine, how efficient is a fuel cell?
5. How much per gallon does hydrogen cost?



Video clips about fuel cell technology

[How a PEM type fuel cell works](#)

[Hear from a company that makes fuel cells](#)

[Battery vs Fuel Cells for powering transportation](#)