technology today

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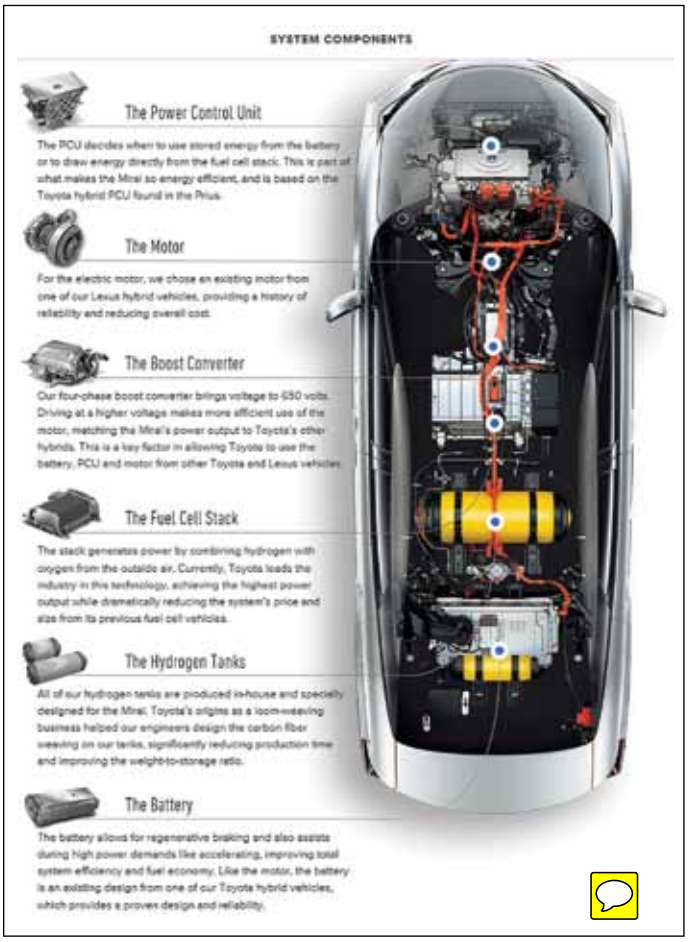
The Home Hydrogen Car Refueling Station

The fuel cell vehicle has long been considered the Holy Grail in automobile research. These cars are powered by the chemical reaction of hydrogen and air and they don't produce any of the environmentally dangerous bi-products produced by today's fossil-fueled vehicles. The only thing that spews from a hydrogen-powered vehicle's tailpipe is clean water vapor.

Toyota engineers have been developing hydrogen-powered vehicles for a quarter of a century; they started selling them in the U.S. in 2015. Their new Mirai can go 312 miles on a tank of hydrogen and has the acceleration of a gasoline-powered muscle car. The engineering that goes into their hydrogen-powered cars is amazing! You can better understand this by looking at the distribution of components in the car (Photo 1).



Toyota

Photo 1—From the outside, a hydrogen car looks like any other car. When you look at the layout and purpose of each of the components, you can really appreciate the engineering behind the fuel cell automobile.

Today, Toyota has plenty of competition, but even with good mileage per fill-up, Toyota and its competitors can't ramp up production to drive down the cost per vehicle until someone comes up with a plan to flood the landscape with hydrogen fueling stations.

If you have ever heard the phrase, "which came first, the chicken or the egg?" you might realize it is the perfect description of why there are limited hydrogen cars on the road today. Fueling station owners indicate they can't invest in thousands of hydrogen fueling stations before the vehicles are on the road, and the car manufacturers know people won't purchase their cars until they have lots of places to fill their fuel tanks.

In a January 19, 2017, joint announcement, the Fuel Cell Technologies Office (FCTO) of the U.S. Department of Energy (DOE) and the Hydrogen Education Foundation (HEF) announced SimpleFuel and Ivys the winner of their $1 million H2 Refueling H-Prize Competition. The DOE H-Prize was designed to challenge corporate, private, or university engineering teams to create a new hydrogen generating appliance which would safely generate hydrogen from water or natural gas, store it in its own storage tanks, and safely and quickly fuel hydrogen vehicles in much the same way people now purchase a tank of gasoline at their local gas station. The winner of the challenge needed to produce a final appliance that could be safely installed in homes, gasoline stations, car dealerships, community centers, and any other locations that would be convenient for people to go to refill their hydrogen vehicles' fuel tanks.

The SimpleFuel appliance (Photos 2 and 3) uses electric current to split water into hydrogen and oxygen. It then compresses the hydrogen for storage in its storage tank. Their appliance has a 700 bar dispensing pressure. The higher the compression that one achieves with hydrogen, the more gas you can store in a storage tank. A tank that can store 700 bar compressed hydrogen needs to be able to handle the 10,000 psi pressure of the compressed gas.

The SimpleFuel appliance is also designed to be scaled from a unit with the capacity to meet the needs of a single family to one that can supply a constant flow of cars at a local gasoline station. Refilling time per car is about 5 to 15 minutes. The home unit will be able to fully refill the tanks on a homeowner's vehicles every day.

The nozzle on their appliance creates a positive sealed link between the refueling storage tank and the vehicle's onboard storage tank. It prevents outside air or hydrogen from entering each other's

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SimpleFuel

Photos 2 and 3—The SimpleFuel appliance recently won the $1 million H-Prize from the DOE. When they go into full production, they might make hydrogen-powered cars very popular.

domain. The connection is also supposed to be child proof. Before refueling begins, the nozzle grounds the car to bleed off any static electricity. It is my understanding that the fuel door on these cars, when opened, shuts off the vehicle's electric motor so the car can't be accidentally driven while it is being refueled. The system actually makes it safer to refuel a hydrogen-powered vehicle than a gasoline-powered vehicle. For more information and to stay up to date on further developments, go to: ivysinc.com/simplefuel-main-page. You can also download the SimpleFuel presentation from the hydrogen prize organization website: hydrogenprize.org/materials-from-h2-refuel-h-prize-webinar-with-winner-simplefuel-available/.

Taking it a Step Further

Tech Challenge: Your mission, if your teacher assigns it, is to build alternative-powered vehicles. Specific design elements, size restraints, construction materials, and method to determine the fastest vehicle will all be determined by your teacher.

Photo 1 - In error the link to a readable copy of this image doesn't exist in the column's text.

SYSTEM COMPONENTS

The Power Control Unit

The PCU decides when to use stored energy from the battery or to draw energy directly from the fuel cell stack. This is part of what makes the Mirai so energy efficient, and is based on the Toyota hybrid PCU found in the Prius.

The Motor

For the electric motor, we chose an existing motor from one of our Lexus hybrid vehicles, providing a history of reliability and reducing overall cost.

The Boost Converter

Our four-phase boost converter brings voltage to 650 volts. Driving at a higher voltage makes more efficient use of the motor, matching the Mirai's power output to Toyota's other hybrids. This is a key factor in allowing Toyota to use the battery, PCU and motor from other Toyota and Lexus vehicles.

The Fuel Cell Stack

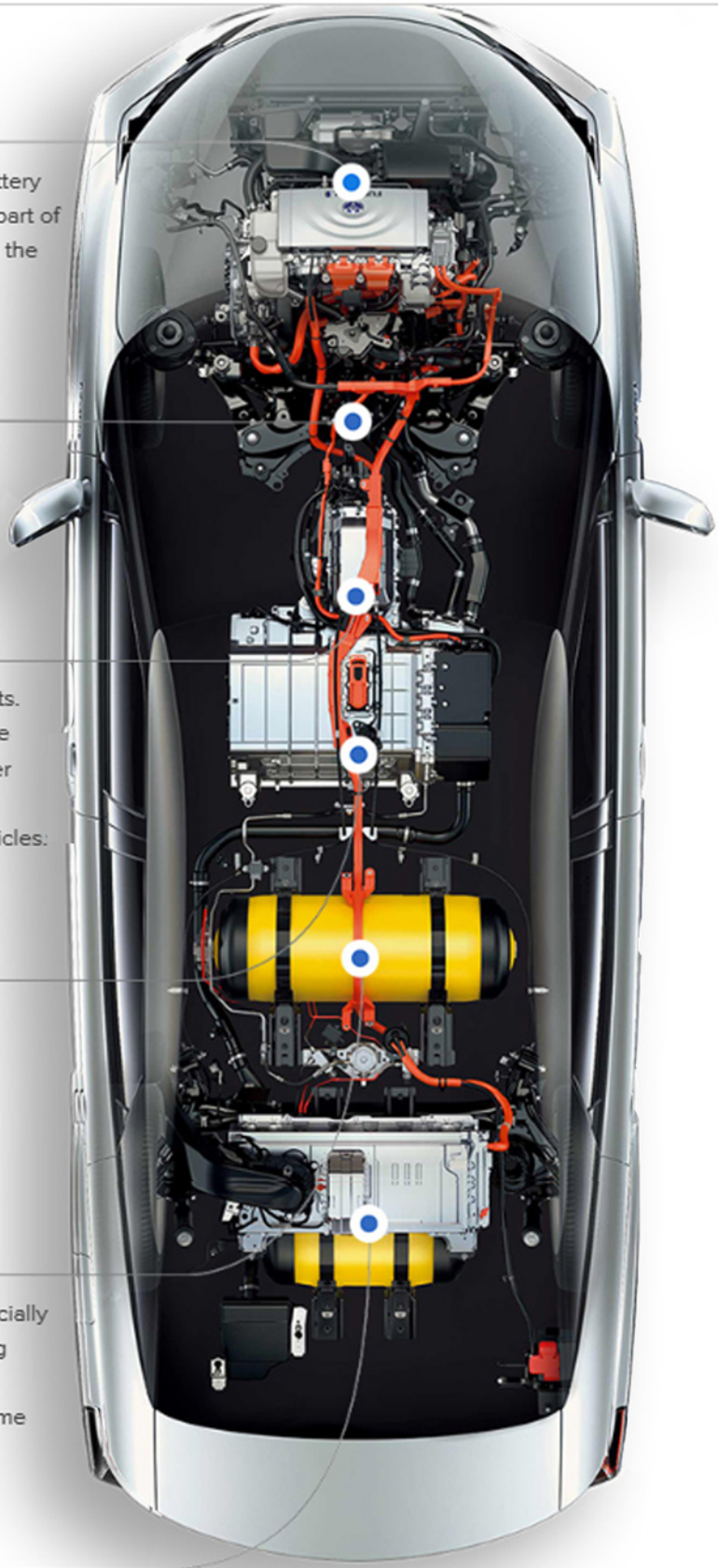
The stack generates power by combining hydrogen with oxygen from the outside air. Currently, Toyota leads the industry in this technology, achieving the highest power output while dramatically reducing the system's price and size from its previous fuel cell vehicles.

The Hydrogen Tanks

All of our hydrogen tanks are produced in-house and specially designed for the Mirai. Toyota's origins as a loom-weaving business helped our engineers design the carbon fiber weaving on our tanks, significantly reducing production time and improving the weight-to-storage ratio.

The Battery

The battery allows for regenerative braking and also assists during high power demands like accelerating, improving total system efficiency and fuel economy. Like the motor, the battery is an existing design from one of our Toyota hybrid vehicles, which provides a proven design and reliability.



Toyota