



FUELING THE **FUTURE**

AUTOMAKERS AND CONSUMERS WEIGH ALTERNATIVE FUEL OPTIONS

BY SCOTT SOWERS, AIADA CONTRIBUTING EDITOR

Walking through an auto show reveals where auto manufacturers are placing their bets on what the public will buy and where the future of vehicles is taking all of us. A good example of this is Toyota's FCV Plus, which was officially unveiled at the Tokyo Motor Show in late October of 2015. It remains among the most conceptual of the concept cars and is still turning heads two years later.

The car is powered by a hydrogen fuel cell and can export any extra electricity it generates to the power grid. At its unveiling, Project Manager Takeo Moriai of Toyota said, "We imagined what a hydrogen-based society might look like in the fairly near future,

and decided to design a car that could be useful beyond mobility."

Honda has been tinkering with a similar concept at its "Honda Smart Home" in Davis, California, where a house equipped with photovoltaic panels on the roof provides enough juice to run the house and charge a small fleet of Honda electric vehicles in the garage.

Ryan Harty, Environmental Business Development Manager for Honda said, "For us, the Smart Home is very much about energy management in designing a home that needs as little energy as possible and integrating the transportation with the home in a way that is fundamentally a good use of energy."

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While both Toyota and Honda's visions of the future include electric-powered cars and a way to transfer energy from the vehicles to the grid, one uses a hydrogen-powered fuel cell while the other relies on batteries. Toyota's FCV seems to be taking the lead in pushing the boundary in fuel cell technology, but Honda has been leasing its own hydrogen fuel cell vehicle, the Clarity, in Southern California since 2008.

Throw Tesla, the Chevy Bolt, BMW's i3, and electrified offerings from Ford, Mercedes, Mitsubishi, Nissan, Kia, and Fiat into the mix and all this hydrogen hoopla becomes a head scratcher for some. Meanwhile, batteries have their own issues that automakers like Audi are looking to remedy.

At the National Automobile Dealers Association Convention and Expo, in late January of this year, Audi of America President Scott Keogh said, "all this fright about 'where am I going to get a charge' is going to go away extremely fast. The technology on this front is moving at a staggering pace. You're going to be looking at a marketplace in the next seven, eight, nine, 10 years where for 30 or 40 some brands their entire business is going to be battery-electric vehicles."

Range Concerns Drive Interest

If Keogh is right, why are Toyota, Honda, and Hyundai marketing hydrogen-powered fuel cell cars in a country with a very limited stretch of highway to run them on and precious few places to fuel them up? As of this writing there are 25 hydrogen filling stations open for business in California with 18 more in development. They stretch from Truckee, near Lake Tahoe to Del Mar, just north of San Diego. According to the California Fuel Cell Partnership, Germany, Japan, and Korea have "extensive" fuel cell electric vehicle (FCEV) programs underway while the UK, Denmark, Norway, China, and Australia all have "growing" hydrogen programs.

According to Craig Scott, a technology manager for Toyota, as quoted in an article in *Business Insider*, Toyota is currently building

a network of 12 hydrogen stations across New York, New Jersey, Connecticut, and Rhode Island. The same article reveals that Honda is working on a Smart Hydrogen Station that would allow folks to make their own hydrogen in their garage. Also in late January of this year, Honda cut an \$85 million deal with GM to build hydrogen fuel cells at a plant in Michigan, an agreement that was hatched in 2013.

In contrast, according to the Department of Energy there are over 40,000 electric charging outlets in the country. Most electric vehicle drivers prefer to charge at home but range restrictions sometimes predicate charging in the field. How long that takes and how much it costs depends on several factors including who owns the charging station. Some companies charge a monthly fee some are free. Some charge by the kilowatt-hour, some sell memberships. There are phone apps to help electric drivers find a charging station before they run out of range.

Range, or the lack thereof, remains the most potent negative for battery electric vehicles (BEVs), and it is helping to drive innovation toward hydrogen technology. The Tesla model X can run for 257 miles on a charge, but the car sells for over \$130,000. Most of the BEVs on the market have a range of about 100 miles. Chevy offers three ways to charge a Bolt, "basic" which is home-based and gets you four miles per hour of charge, "fast" which can be done at home or at a public station gets you 25 miles per hour of charge, and "super fast" which is only available at public stations and gets you 90 miles in 30 minutes. Tesla's "Supercharger" will give you 170 miles worth of juice in 30 minutes.

On the other side of the discussion, Honda's hydrogen-fueled Clarity has a range of about 350 miles. Toyota's Mirai will get about 300 miles to the tank. It takes about three minutes to fill a hydrogen vehicle in a procedure that's very similar to pumping gas.

Safety, Cost Considerations

The safety of filling up with hydrogen has been questioned since the Hindenburg caught on fire in 1937 and killed 36 people. However, according to Toyota, those days are long gone. The Mirai's fuel tank

Honda has been leasing the Clarity in Southern California since 2008. It has a range of about 350 miles.





Hydrogen fueling stations are limited, but automakers are working on solutions.

is made from carbon fiber and equipped with sensors to detect collisions and stop any gas from leaking.

Gasoline is by nature explosive and yet we've managed to use it relatively safely in internal combustion engines. While BEVs don't carry gasoline, they do carry lithium ion batteries, which come with their own safety baggage in terms of exploding phones and flaming laptops. Two people have been killed in Teslas but not because of overheated batteries.

Safety is often quantified with costs. We assume more expensive cars will be inherently safer. If you live in a place where you could safely fill up with hydrogen or plug in your battery, which option would be the better deal from a cost of ownership angle? Setting the cost of the vehicle aside, moving to a BEV will get buyers up to a \$7,500 tax credit from the federal government depending on the size of the battery in the car. For example, a smaller-sized 4kW battery will only secure buyers with a \$2,500 credit.

Many utilities provide a break on the electricity consumers will be using to charge their car. EV drivers may also be eligible for insurance discounts and credits for buying their own home-based charging system. Many states and the District of Columbia offer additional incentives for getting off gasoline. In September of 2016, Governor Jerry Brown's administration in California extended a \$5,000 cash rebate for consumers buying or leasing a BEV or a fuel cell electric vehicle (FCEV).

The feds also offer tax credits for FCEVs, topping out at \$8,000, which the Mirai qualifies for. Many states also have FCEV credits in place - even if there isn't anyplace to buy the hydrogen yet.

According to a 2016 road test in *Car and Driver*, the Mirai averaged 56 miles per kilogram of hydrogen on a 400 mile trip which netted out to 25 cents a mile — nearly 4 times the cost of driving a Toyota Camry hybrid. According to an article in *Edmunds*, the price of hydrogen on their 2016 road trip ranged from \$12.85 to \$16.63 per kilogram that also netted them about a quarter per mile in fuel costs. To sweeten the pot, Toyota and Honda are giving early adopters three years or 15,000 worth of free hydrogen.

Environmental Considerations

Environmental policy is the foot on the accelerator of EVs. BEVs and FCEVs don't emit hydrocarbons. But hydrocarbons may be created in generating the electricity needed to charge a battery or to make the hydrogen. Hydrogen can also be made using solar energy. Solar can likewise be used to charge batteries, as seen in the Honda Smart Home. So, which is actually cleaner?

According to a recent study by Stanford University, BEVs are better when comparing vehicle costs to climate benefits. Markus Felgenhauer, lead author of the study said, "in terms of overall costs, we found that battery electric vehicles are better than fuel cell vehicles for reducing emissions. The analysis showed that to be cost competitive, fuel cell vehicles would have to be priced much lower than battery vehicles. However, fuel cell vehicles are likely to be significantly more expensive than battery vehicles for the foreseeable future."

Mirai means "future" in Japanese. On February 15 of this year, Toyota issued a recall of all of its 2,800 cars of the future because of a problem with the output voltage of the fuel cell system that might happen if you nailed the throttle on a long descent while using cruise control.

Ten days later, Toyota began delivering the first batch of 100 buses that run on a combination of hydrogen fuel cells and batteries to Tokyo's Bureau of Transportation. The fuel cells charge up nickel-metal hydride batteries and power two electric motors. In addition to carrying passengers, the buses can also be used to supply emergency power from the batteries.

As Toyota, Honda, and other automakers continue to push the edge of fuel cell innovation, the future still remains unclear. Where will our automotive power of the future come from — fuel cells or batteries? Time will tell. **AD**