Union of Concerned Scientists

FACT SHEET

The Importance of Both Battery Electric and Hydrogen Fuel Cell Electric Vehicles

Complementary Technologies for Cutting Oil Use and Carbon Emissions

HIGHLIGHTS

Both battery and hydrogen EV technologies reduce oil consumption and global warming emissions compared with their gasoline and diesel counterparts.

Battery electric vehicles are especially efficient and can often be refueled at home using existing electricity infrastructure.

Hydrogen fuel cell electric vehicles can store and quickly replenish a large amount of energy, making them a good option for drivers who need longer range and more cargo capability or for those who lack access to home recharging.

Personal transportation in the United States is changing as more and more car dealerships across the country sell electric vehicles (EVs) that can greatly diminish pollution and oil use. Thanks to strong national and state policies, consumers have more EV options than ever, drawn from two basic types: plug-in EVs, and hydrogen fuel cell EVs.[1] Plug-in electric vehicles include both plug-in hybrid electric vehicles, which can be powered by electricity or gasoline, and battery electric vehicles, which are powered solely by electricity drawn from the electric grid. Battery electric vehicles and hydrogen fuel cell electric vehicles produce no tailpipe pollution and thus are particularly important for our long-term air quality and climate goals. For example, California Air Resources Board analysis indicates the vast majority of new personal vehicles would need to be battery or hydrogen fuel cell EVs by 2040 to meet an 80 percent reduction in climate emissions below 1990 levels by 2050 (ARB 2012). In addition, the National Research Council concludes that moving forward with both fuel cell and battery electric vehicle technologies provides the greatest chance of meeting this level of reductions (NRC 2013).

Fuel cell EVs and battery EVs are complementary technologies and both are important for meeting our transportation needs while reducing emissions. They share three important characteristics: they produce zero tailpipe emissions because they use electric motors, they cut global warming emissions compared

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Neither plug-in (left) nor hydrogen (right) EV technologies use oil and both reduce global warming emissions compared with their gasoline and diesel counterparts.

1 Conventional hybrids, such as the Toyota Prius, have electric motors but are not classified as EVs because they get all of their energy from gasoline or diesel.

Plug-ins take advantage of existing electricity infrastructure and are especially efficient and cost-effective for urban environments.

with conventional vehicles powered by gasoline or diesel, and they can have very low net global warming emissions when renewable sources are used to produce their fuel. They also have some important differences, that make each technology useful for meeting different consumers' needs.

Battery Electric Vehicles Have Low Emissions and Many Can Use Existing Infrastructure

Battery EVs have the potential to be the cleanest vehicles on the road today. While the total global warming emissions of a battery EV depend on the source of the electricity used to charge its batteries, the majority of Americans live in a region where charging such a vehicle produces lower global warming emissions than driving even the most efficient gasoline car[2] (Anair 2014).

In addition to its advantage of lower emissions, a plug-in vehicle is convenient—many people today could simply recharge it at home. A 2013 survey conducted by the Union of Concerned Scientists (UCS) and the Consumers Union found that 56 percent of American households have an off-street parking space with access to electric power (UCS 2013). The installation of charging stations at workplaces and public parking spots would allow someone without home-recharging capability to drive a battery EV, but it may be difficult and less convenient to rely solely on recharging away from home.

At present, plug-in EV technology is being implemented most cost-effectively in sedans or hatchbacks, where higher vehicle efficiency allows for smaller and less costly battery packs. The success of plug-in EVs is evident—over 250,000 vehicles have been sold so far in the United States. However, SUVs, minivans, and pickup trucks are generally heavier and less aerodynamic than the traditional car, making them less efficient options for battery electric vehicle technology. For example, the 2014 Toyota RAV4 EV, a crossover SUV, has an efficiency of 0.44 kilowatt hours (kWh)/mile and consequently uses much more electricity than the 2014 Nissan LEAF (0.30 kWh/mile). The higher electricity use, and therefore lower efficiency, has potential drawbacks for a larger battery EV, such as a relatively short driving range or larger and costlier battery packs. In addition, batteries with capacities larger than those of today's battery electric vehicles could require upgrades to household electrical service or lengthen recharging times to the point that a fully discharged battery would not charge fully overnight.

Hydrogen Fuel Cell Electric Vehicles Can Be Refueled like a Gasoline Car and Travel 250+ Miles on a Fill-up

Like a battery EV, a hydrogen fuel cell EV has an electric motor, but instead of storing grid electricity in a battery, it produces electricity on board from stored hydrogen fuel. In another similarity to a battery electric vehicle, a hydrogen car accounts for lower global warming emissions than a comparable gasoline car. For example, UCS analyses have found that the 2015 Hyundai Tucson Fuel Cell SUV, when fueled with hydrogen meeting California's 33 percent renewable requirement,[3] achieves a reduction of more than 50 percent of global warming emissions compared with the conventional gasoline-powered Tucson.

Hydrogen fuel cell EVs are refueled much like conventional vehicles. The driver of a hydrogen vehicle can pull up to a hydrogen filling station and fill an empty tank in only a few minutes, giving the driver 200 to 300 miles of driving range. This could make a hydrogen fuel cell vehicle an attractive electric-drive option for the 44 percent of households that lack the ability to plug in a battery electric car (UCS 2013). However, such filling stations are not yet a common element of the national infrastructure. Hydrogen

Hydrogen fuel cells are a good option for larger vehicles, longer-distance driving, and drivers lacking a spot at home to recharge.

2 Toyota Prius, 50-mpg combined fuel efficiency.

3 Emissions depend on the specific source and process used to make and deliver the hydrogen. See UCS 2014 for details.

stations are currently concentrated in California, with over 50 expected to be in operation by the end of 2015 (ARB 2014). For a fleet of hydrogen fuel cell EVs to be viable elsewhere in the country, hydrogen filling stations need to be installed in other states as well. A number of states are currently building or seriously considering hydrogen infrastructure (Connecticut DEEP 2014; ZEV Program Implementation Task Force 2014).

> ***Neither EV technologies use oil and both reduce global warming emissions compared with their gasoline and diesel counterparts.***

An onboard hydrogen tank enables a fuel cell EV to store large amounts of energy and replenish it quickly. The 2015 Hyundai Tucson Fuel Cell stores up to 5.6 kg of hydrogen, which can produce about 113 kWh of electricity[4] (U.S. DRIVE Partnership 2013). This is significantly more storage than the largest-capacity battery electric car, the Tesla Model S (85 kWh), and yet the Tucson Fuel Cell can be refueled in a fraction of the time of the Model S. Such superior storage capacity means that fuel cell vehicles have excellent range, and the short fueling time allows one station to service many vehicles—features providing convenience similar to that of existing gasoline vehicles. Another advantage of the hydrogen fuel cell EV technology is that its ability to store and replenish a great deal of energy should allow larger electric-drive vehicles, such as SUVs and trucks, to be practical.

Complementary, Not Competitive, Technologies

Battery electric vehicles and hydrogen fuel cell electric vehicles have often been portrayed as competitors, with the assumption that only one technology will ultimately be successful. But battery and fuel cell EVs can actually *both* be utilized to address different consumers' needs and provide the greatest opportunity for market penetration. Battery EVs take advantage of the existing electricity infrastructure and are especially efficient and cost-effective for urban environments.

TABLE. Summary of Battery and Hydrogen Fuel Cell Electric Vehicle Attributes

Battery electric vehicles	Hydrogen fuel cell electric vehicles
Convenience of home recharging and use of existing infrastructure	Fast central refueling similar to that of current gasoline vehicles, once infrastructure is in place
Lower global warming emissions than the average new compact gasoline vehicle	Lower global warming emissions than the average new compact gasoline vehicle
Highest energy efficiency	Highest energy storage capacity for electric drive, facilitating scalability to larger and heavier vehicles
Increased benefits when using renewable electricity	Increased benefits when using renewable hydrogen[5]

Because plug-in battery and fuel cell vehicles produce zero tailpipe pollution, both of them are key technological solutions for cutting oil use and global warming emissions. The two technology types are complementary in that each has different attributes, which make them suited to different consumers' needs.

Hydrogen fuel cells are a good option for larger vehicles, longer-distance driving, and drivers lacking a spot at home to recharge. Neither EV technologies use oil and both reduce global warming emissions compared with their gasoline and diesel counterparts.

Plug-in electric vehicle sales are off to a strong start, taking advantage of the existing electricity grid and an expanding public network of chargers. Hydrogen vehicles, on the other hand, have only recently been offered to consumers in select regions and their present refueling infrastructure is limited. It is still too early to predict which vehicle technology will become more prevalent in the coming decades, but with over 15 million new cars and trucks sold in the United States in 2013, there is certainly room in the market to support both. However, to ensure the best chance of overall success, we need state and federal policies that strongly support all types of EVs. In the

4 *Assuming 60 percent fuel cell efficiency.*
5 *Hydrogen made using a renewable and low carbon emissions method such as wind or solar power.*

Types and Models of Electric-Drive Vehicles Currently Available

PLUG-IN HYBRID ELECTRIC VEHICLES

Plug-in hybrid vehicles have a battery that stores grid electricity in order to help power the vehicle. They also have a gasoline tank and internal-combustion engine that provide power when the battery is not in use. The batteries on these vehicles store enough energy for some 10 to 40 miles of driving on electric power, depending on the model. The Chevy Volt, Toyota Plug-in Prius, and Ford Fusion Energi are examples of this type of vehicle.

PLUG-IN BATTERY ELECTRIC VEHICLES

Battery electric vehicles are powered solely by a battery that stores grid electricity and produces zero tailpipe emissions. Many battery electrics have a range of 70 to 100 miles, though the Tesla Model S can be driven between 210 and 270 miles on a full charge. Other examples of battery electric vehicles include the Nissan LEAF and Fiat 500e.

HYDROGEN FUEL CELL ELECTRIC VEHICLES

Hydrogen fuel cell electric vehicles are refueled by filling an onboard tank with high-pressure hydrogen. The hydrogen is then used by a fuel cell to generate electricity, which powers a motor just as in a battery electric vehicle. Fuel cell vehicles have no tailpipe emissions except water vapor. The Hyundai Tucson Fuel Cell is currently the only mass-produced fuel cell vehicle in the United States, but Toyota will be introducing a hydrogen-powered model of its own to the California market in 2015.

end, the winners will be consumers who benefit from a variety of clean vehicle choices at the dealership and are able to avoid the gasoline pump when they need to fill up.

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