

## **AN OVERVIEW OF HYDROGEN FUEL CELL**

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### **Abstract**

Lithium ion batteries release dangerous chemicals. Hydrogen fuel cell cars are less efficient than electric ones but more than fossil fuels. Elon musk calls hydrogen fuel cell cars stupid and Japan wants to be the first hydrogen society. The Hyperion XP-1 is a sports car that runs on hydrogen. First Hydrogen Fuel Cell Vehicle was Created in 1966. Hydrogen can become fuel for airplanes. Hydrogen is produced through methane and natural gas reforming.

1. **Introduction**-Hydrogen is a fuel that can finally stop reliance on fossil fuels. The wind doesn't always blow nor does the sun always shine. Geothermal vents, rivers, and Waterbodies cannot be found everywhere. And that's why to get rid of fossil fuels and move towards a green future we need better batteries. Climate change is becoming a bigger problem every minute with dry places becoming drier and wet places wetter. Climate change is global warming caused by human emissions(basically no good). We can't stop climate change without stopping using fossil fuels but only doing this will not stop climate change.

Energy demand varies during the day and unlike fossil fuels, we can't produce how much ever we want. Whenever we want thus we need to store the energy. We think batteries are only the ones that store electrical energy(cell) but a battery is anything that can store and release energy.

lithium-ion batteries are not going to cut it they are not energy-dense enough and worst off when they became waste they release harmful chemicals like-

- potentially toxic gas phosphoryl fluoride (POF<sub>3</sub>)
  - and they are made of lithium hexafluorophosphate.
  - To power electric motors in cars, there are only 2 ways Batteries or fuel cells
- Hydrogen as a fuel for vehicles-  
Fig 1 news articles on hydrogen

Robert Ferris | @RobertoFerris  
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**CNBC**

Elon Musk is no fan of hydrogen fuel cell technology, but some of the world's major automakers still think it is a bet worth making.

The Tesla CEO has called fuel cells "mind-bogglingly stupid," "incredibly dumb" and "fool cells."

Musk's complaint is that using hydrogen as a mechanism for storing energy would be less efficient (i.e., result in more electricity lost) than simply using electricity to charge batteries. Other critics have variously cited such things as costs, safety and the lack of supporting infrastructure, among other things.

### Japan venture aims to build 80 hydrogen fuelling stations by 2022

Reuters Staff 3 MIN READ

TOKYO (Reuters) - An alliance of 11 Japanese firms, including automakers and energy firms, has pledged to build 80 fuelling stations for hydrogen fuel cell vehicles by 2022 to help accelerate take-up of the next-generation fuel technology.

Japan H2 Mobility LLC, whose backers include Toyota Motor Corp and JXTG Nippon Oil & Energy, said on Monday it would oversee the construction and operation of the new fuelling stations, nearly doubling the number at present.

Japan wants to have 160 hydrogen stations and 40,000 FCVs on the country's roads by March 2021. By 2030, it aims to have 900 stations to service some 800,000 FCVs, buses and forklifts.

By then, it expects the price of hydrogen to fall to around 30 yen per normal cubic

- Hydrogen is a really simple element with just one proton and one electron. it is found in water, hydrocarbons, etc. it makes up 75% of the universe.
- George W Bush loved hydrogen so much he offered 1.3 million dollars in funding.
- Hydrogen can be used as an energy carrier which can be used in fuel cells or internal combustion engines. When combusted with oxygen it produces no greenhouse gas emissions and The only significant emission is water vapor.
- Hydrogen-powered Hyperion XP-1 can go from 0 to 66 miles (0 to 106 KM. 217) in 2.2 seconds. with a top speed of 220 miles an hour, but it is not publicly available now and when it will be it would be very expensive. so hydrogen technology is capable of going fast.

### The World's First Hydrogen Fuel Cell Vehicle was Created in 1966

The first use of a hydrogen fuel cell to power a vehicle is the Electrovan from General Motors. A fuel cell that combined super-cooled liquid hydrogen and liquid oxygen was a ground-breaking design. Powered by fuel cells using pressurized hydrogen combined with native oxygen from ambient air sources. This early prototype began the technology evolution resulting in the new generation of hydrogen-powered vehicles.

Pros and cons of using hydrogen as a fuel source-

**Pros-**Hydrogen is a non-toxic, clean energy carrier that features high output energy on a mass basis. e.g., the energy content of 25 kg of gasoline is 9.5 kg of hydrogen

- Hydrogen can also be transported in pipelines safely.
- Hydrogen can be generated from various energy sources, including most renewable ones.
- Hydrogen can be stored over relatively long periods. Compared to electricity.
- Hydrogen vehicles take 5 minutes to get charged unlike most electric vehicles which take 30 mins to charge
- Hydrogen cell technology provides quite a high-density source of energy with good energy efficiency.

- Hydrogen has the very best energy content of any common fuel by weight. High pressure gaseous and liquid hydrogen have around 3 times the gravimetric energy density (around 120 MJ/kg) of diesel and LNG and a uniform volumetric energy density to gas
- Hydrogen has a 40000Wh/kg while lithium-ion batteries have 278Wh/kg
- Combustion Engine cars are only 25-35% efficient(how much energy is being used from the source) while hydrogen is 38%
- Hydrogen fuel cells can power cars for extended ranges without adding much weight which was not allowing it to be incorporated in the aviation industry. The thing with electricity is that to increase range they need to increase the motors torque, the power of the brakes, and structural weight.
- which leads to adding more batteries.

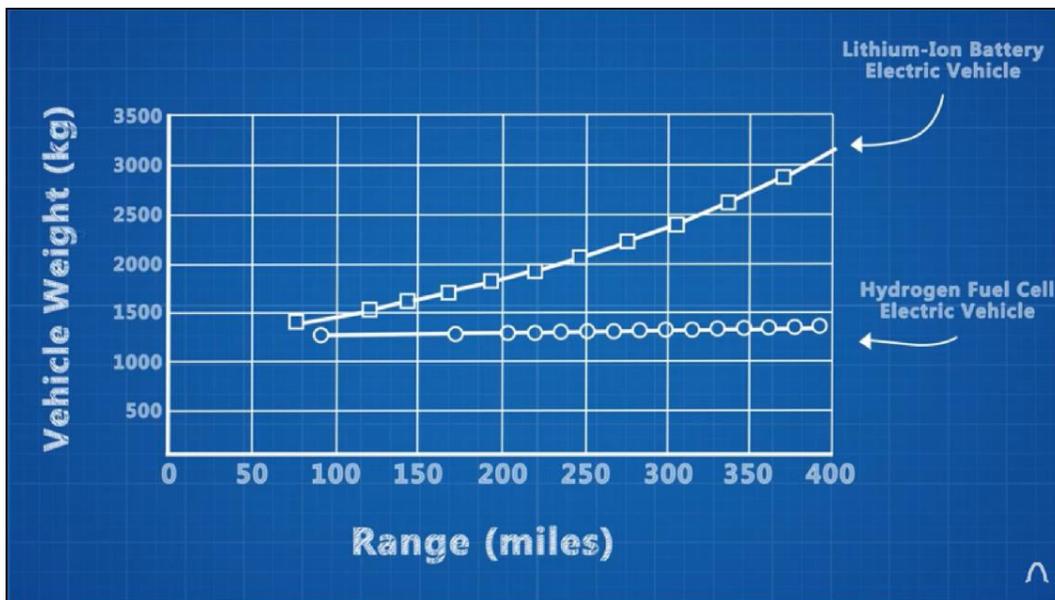


Fig 2 weight fule proportion

**Cons-**When mixed with air, hydrogen can burn in lower concentrations and this will

- Storage of hydrogen in liquid form is hard because to liquefy hydrogen you need very low temperatures.
- Not found freely in nature
- Very low density
- Hydrogen has a really small customer base and it takes 2 million dollars to make one refueling station.
- Electric cars are 80% efficient while hydrogen cars are only 38% efficient so they may not be as environmentally friendly.

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**Improvements that can be made-Reducing the cost of electrolyzers**

- Increasing understanding of electrolyzer cell and stack degradation processes and developing mitigation strategies to increase operational life.
- Improving energy efficiency for converting electricity to hydrogen over a wide range of operating conditions.
- Reducing the cost of hydrogen refueling station
- Commercial cars speed up faster

	<b>Tesla Model 3</b>	<b>Toyota Mirai</b>
<b>Price to fully charge</b>	<b>7.65 \$</b>	<b>85 \$</b>
<b>Range</b>	<b>500 km</b>	<b>480 km</b>
<b>Price per kilometer</b>	<b>2-2.4 cents</b>	<b>17.7 cents</b>
<b>Time to charge</b>	<b>5.45hr</b>	<b>4 mins</b>

Fig 3 statistics of Toyota mirai and tesla model 3

How does a hydrogen fuel cell work

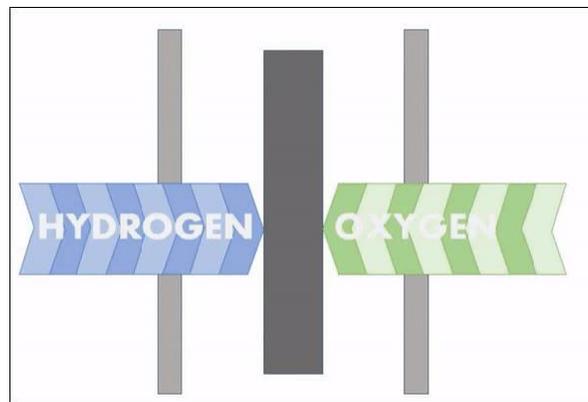


Fig 4 how does a fuel cell work

A cell is that the power source that converts energy from fuel (in our case hydrogen) and an oxidizing agent (in our case oxygen)

In the fuel cell, there is hydrogen on one side and oxygen on the other and a semipermeable barrier which only allows protons to pass. when the protons go to the other side to the oxygen electrons want to go to so that we give the electrons a path through a wire

How is hydrogen produced?

Hydrogen is the most abundant element in the universe(75%) but as it is highly reactive it is stored in water, hydrocarbons like methane, and organic matter. the biggest challenge is to extract the hydrogen efficiently.

Electrolysis-Electrolysis is the process of using electricity to split water into hydrogen and oxygen, it is a promising option for carbon-free hydrogen production from renewable and nuclear resources. Electrolyzers can come in size from small, appliance-size equipment that's well-suited for small-scale distributed hydrogen production to large-scale, central production facilities that would be tied on to renewable or other non-greenhouse-gas-emitting forms of electricity production.

This reaction takes place during a unit called an electrolyzer. Like fuel cells, electrolyzers contain an anode and a cathode separated by an electrolyte. Different electrolyzers function in several ways, mainly thanks to the various sorts of electrolyte material involved and therefore the ionic species it conducts.

Natural gas reforming-Natural Gas Reforming is a crucial technology pathway for near-term hydrogen production. Today, 95% of the hydrogen produced within the united states of America is made by gas reforming in large central plants. Natural gas reforming may be a complicated and mature production process that builds upon the prevailing gas pipeline delivery infrastructure.

This requires a lot of heat and the hydrogen has less energy than the natural gas itself.

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