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Hydrogen

Passenger Transport

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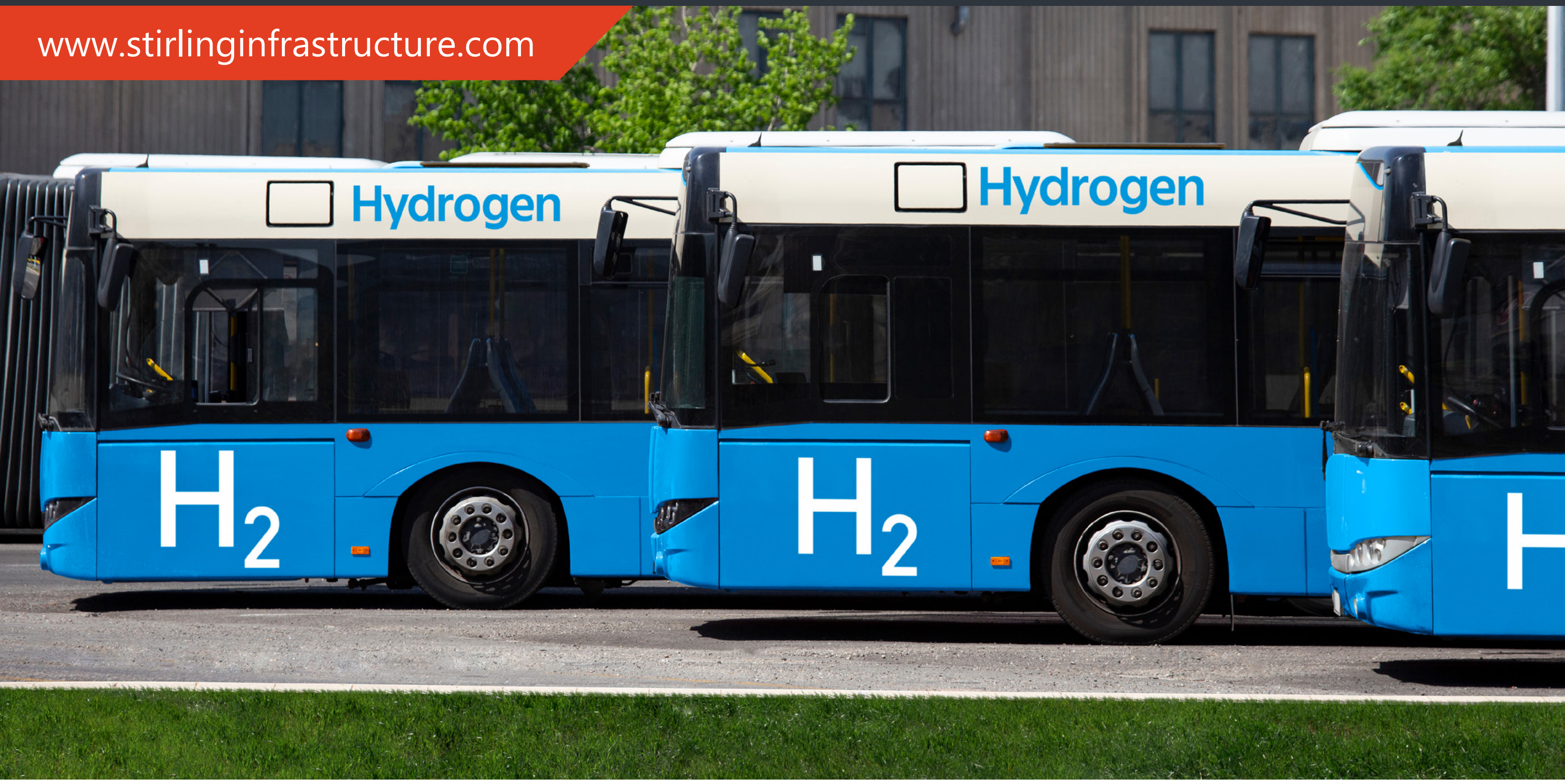


HYDROGEN FUEL CELL PASSENGER CARS

POLICY SUPPORT – DEMAND PROJECTION AND CURRENT ADOPTION

Hydrogen FCEVs (Fuel Cell Electric Vehicle) have the potential to be an important driver for the decarbonisation of the transportation sector. Many countries have set targets for the adoption of FCEVs, and Japan, Korea, China, and the U.S. are leading in the targets. In 2019, Japan announced that the country is expected to have 200,000 FCEVs by 2025 and 800,000 by 2030, of which 1,200 will be buses. Korea set a target of 2.9mn FCEVs by 2040 in its Hydrogen Economy Roadmap published in 2019. China is also ambitious in promoting FCEVs. The country targets 50,000 FCEVs by 2025 and 1mn by 2030. The state of California in the U.S. also announced that the state will have 1mn FCEVs by 2030.

COMPETITION WITH ELECTRIC VEHICLES

The tank-to-wheel energy efficiency of EVs (Electric Vehicle) can reach 70%-90%, while FCEVs have significantly lower efficiency, ranging from 25% to 35%. A source of such efficiency difference is the different working processes of their power systems. For EVs, the electric motor is directly powered by the electric battery while for FCEVs, the fuel cell battery first uses the hydrogen stored in its tank to generate electricity, and then the electricity is used to power the motor. The efficiency discrepancy leads to performance disparities between FCEVs and EVs.

Table 1 Comparison between FCEV and EV

Car Type	Toyota Mirai	Tesla Model 3	BMW 3 Series
Fuel Type	Hydrogen fuel cell	Lithium-ion battery	Petrol/Lithium-ion battery
Price	$49,500-$66,000	$39,490- $56,990	$41,450-$54,700
Acceleration 0-60mph	9.2s	3.5-5.1s	4.4-5.6s
Range	400miles	263-353miles	>400miles
Charging time	~3min	0.5-13h	~3min
Technology readiness	Infant	Growing	Matured
Infrastructure readiness	Low	Medium	High
Sustainability	High	Medium	Low

Figure 1 - Key components of an EV[1]

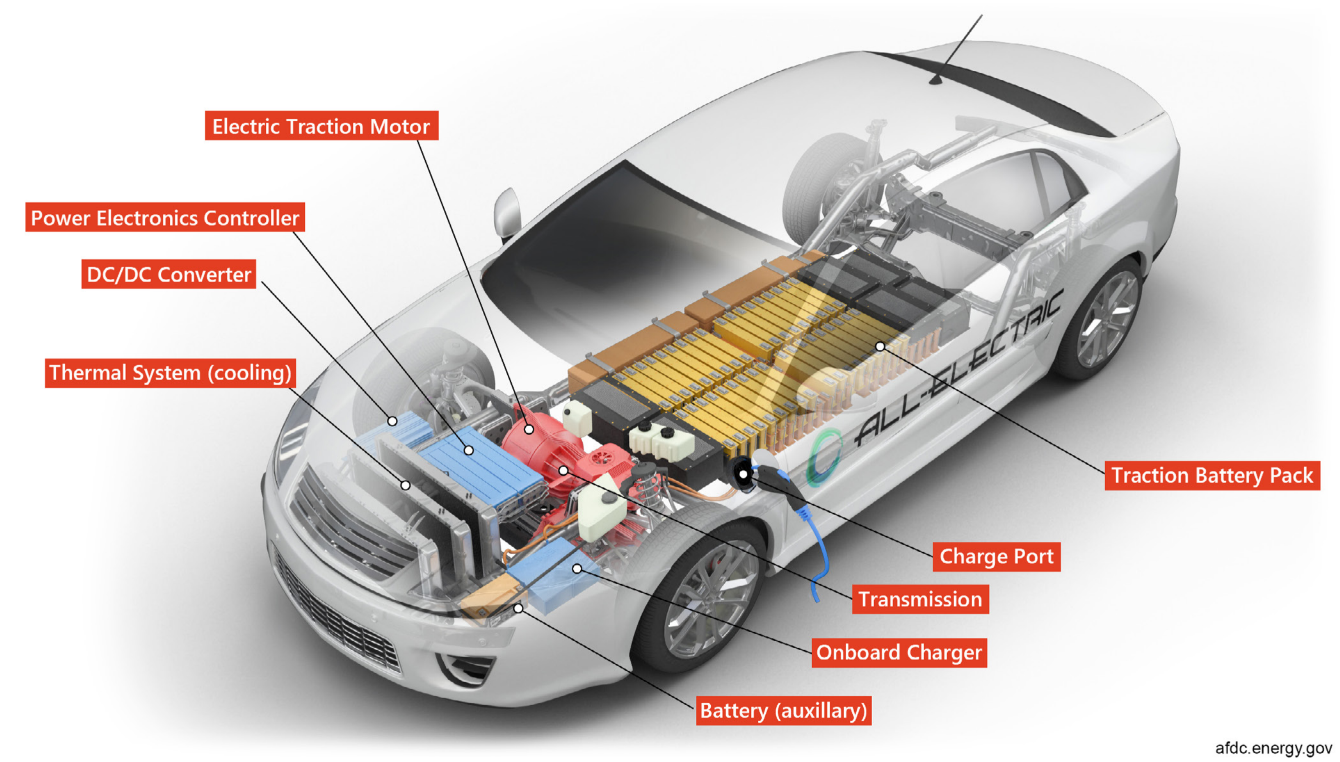
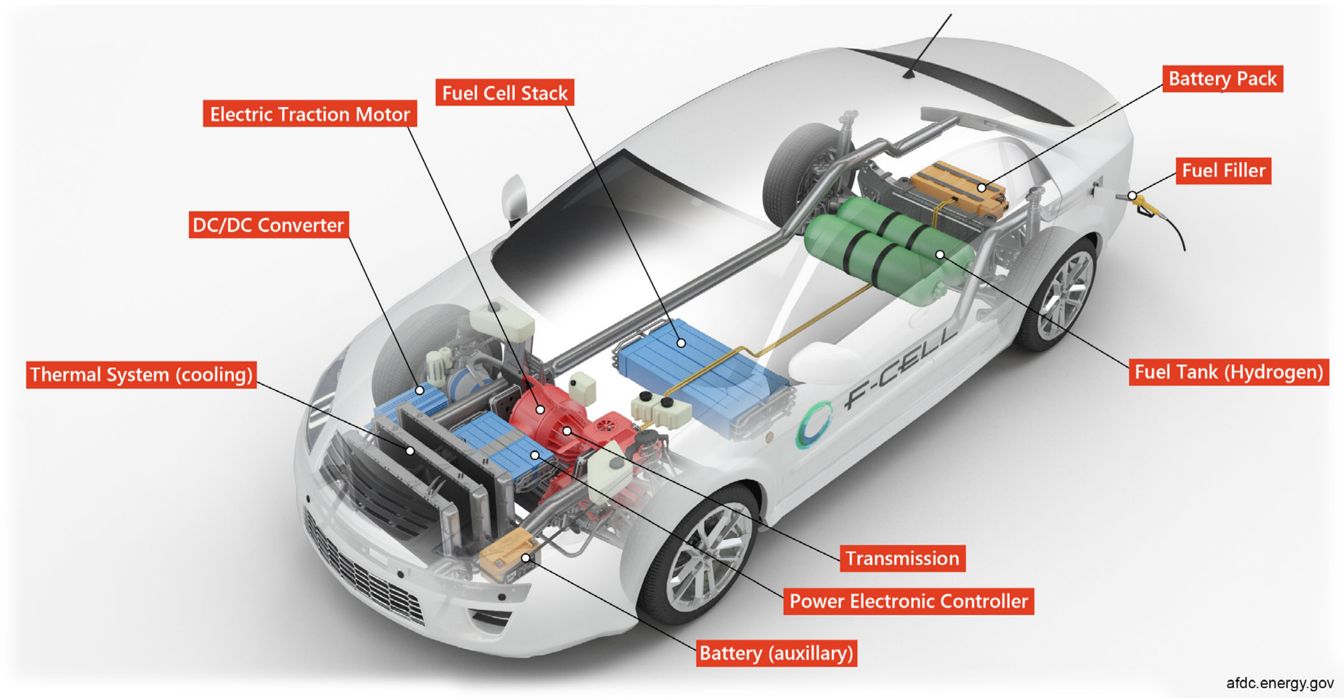


Figure 2 - Key components of a FCEV[1]



However, FCEVs have 2 major advantages over EVs. The energy density of fuel cells can reach 33 kWh/kg, while that of EVs is around 0.25 kWh/kg. This allows FCEVs to have a much longer range (>400 miles) than EVs (around 300 miles) given that they carry batteries of the same size. Another advantage of FCEVs is that they have much shorter refuelling time (around 3-5 minutes), compared to the charging time of EVs (30-720 minutes, depending on types and charging method). It is important to note that the relative refuelling convenience of FCEVs also depends on the availability of hydrogen refuelling stations, considering that EV charging stations experienced rapid development across major markets over the past 5 years, while the construction of hydrogen stations is still in the early stage.

1 US Department of Energy

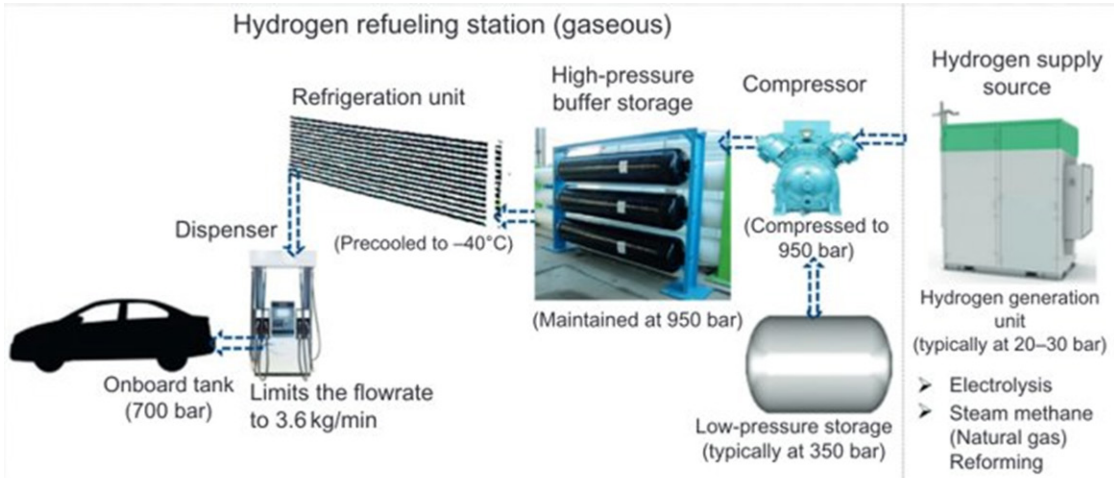
PASSENGER VEHICLE INFRASTRUCTURE: HYDROGEN REFUELING STATIONS

Hydrogen refueling station (HRS) components

Hydrogen refuelling stations (henceforth HRS) can be divided into 2 broad types depending on the source of its hydrogen supply. For those with on-site hydrogen production, a hydrogen generation unit is fitted within the station and hydrogen can be produced either by electrolysis or steam methane reforming. For those with off-site hydrogen production, hydrogen is transported to the HRS using pipelines or trucks.

As the HRS relies on pressure differences to move hydrogen into the tank of FCEVs, the compressor is a core component for the station, and accounts for 32% of the cost for a HRS with off-site hydrogen production. Another major cost component is the dispenser, which accounts for 14% of cost. Parts like pipelines and storage tanks take 13% and 11% of the total cost respectively.

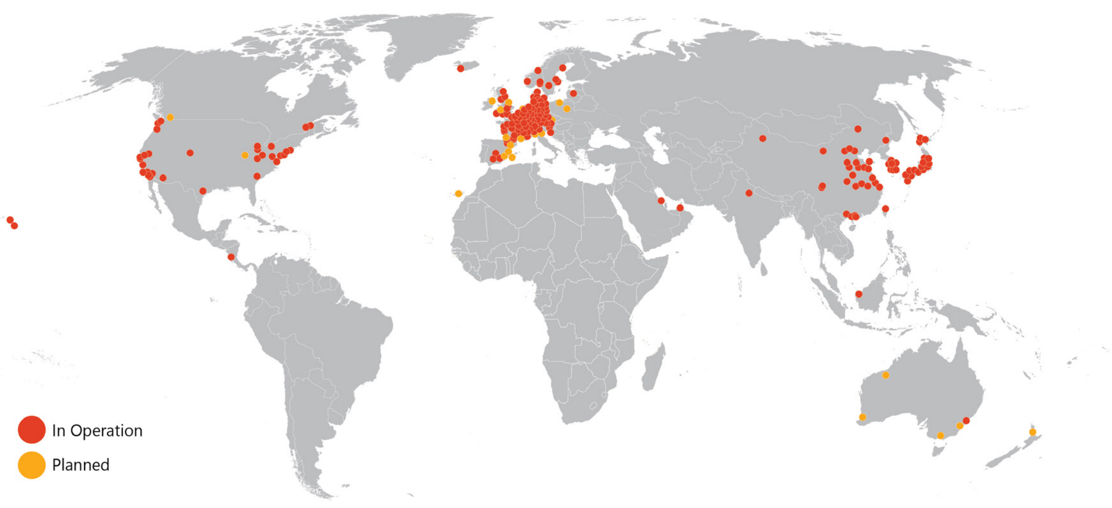
Figure 3 - Overview of a hydrogen refueling station



Hydrogen station volume projection

By the end of 2020, Asia had 275 HRS in operation and is the continent with the highest amount of HRS, accounting for nearly half of world's total. Japan is leading the construction of HRS within Asia, with 142 HRS in operation and it is expected to have 900 HRS by 2030. Korea has 60 HRS and China has 69 HRS. However, most of the HRS in China are supplying hydrogen to commercial vehicles including fuel cell buses and trucks, considering the small amount of fuel cell passenger vehicles in the country. China targets 5,000 HRS by 2035 and this implies a period of rapid development for HRS over the next 15 years. Europe had 200 HRS by the end of 2020, with 100 in Germany and 34 in France. The European Union is expected to have 3,700 HRS by 2030. There are 75 HRS in North America, where 49 of them are in the state of California.

Figure 4 - Hydrogen refueling stations worldwide locations



Source: www.lbst.de

OPPORTUNITIES

The passenger FCEVs might not have strong growth within the next decade. Commercial FCEVs, instead, is more promising in applying hydrogen to decarbonise in the near term. However, we would not neglect the market of passenger FCEVs, considering the huge market size and potential. There could be greater growth momentum when the performance and relative cost of hydrogen FCEVs becomes more competitive than battery electric vehicles and broader network of hydrogen refuelling infrastructure is in place.

RISKS

Slow Adoption of FCEVs

Currently, the sales figure of FCEVs is significantly lower than EVs. By the end of 2020, there were around 33,398 FCEVs (including both passenger and commercial ones) in use around the world, while the figure for EVs is more than 10mn. Considering such a difference, it is hard for FCEVs to catch up with EVs in sales in the near term. The slow adoption of FCEVs relative to EVs may become an important risk in investing in the FCEV industry, as the demand might remain low for the next decade.

Lack of Convenient Infrastructure

The current development of hydrogen refuelling stations is in the early stage. The convenience of hydrogen refuelling is far less than the charging electricity and gas, considering the huge volume difference between hydrogen stations and charging point and gas stations.

Safety Concerns

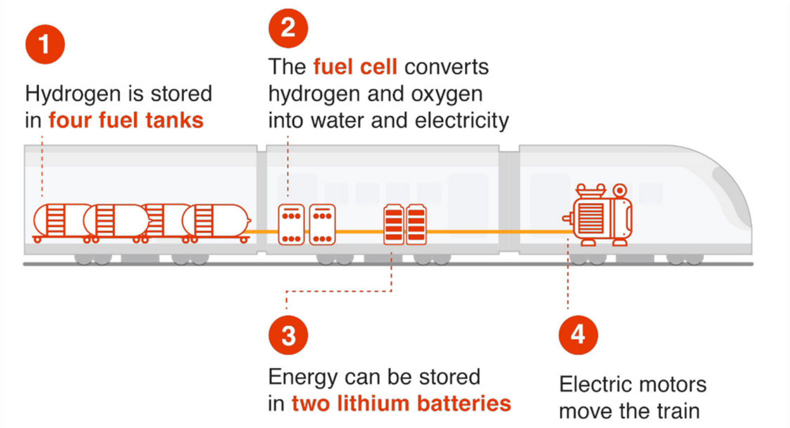
The chemical property of hydrogen makes it a flammable and unstable gas. This leads to safety concerns towards hydrogen FCEVs and hydrogen stations. Several accidents have happened due to hydrogen leakage in hydrogen refuelling stations. Some indoor parking spaces and tunnels may ban FCEVs due to hydrogen leakage concerns. For example, the Eurotunnel bans FCEVs from using it but does provide free charging points for EVs, indicating the current gap in infrastructure development and public adoption between FCEVs and EVs.

HYDROGEN FUEL CELL TRAINS

INTRODUCTION

Hydrogen fuel cell trains function similarly to FCEVs. Hydrogen is used for energy storage and can be converted into electricity to power electric motors. It is a promising area where hydrogen can be used for the decarbonisation of passenger transportation in the near term. At the current stage, hydrogen fuel cells are mainly used to power multiple units, and there are less attempts for shunters and mainline locomotives.

Figure 5 - How a zero-emission train works



Source: University of Birmingham

OPPORTUNITIES

Deployment convenience

Hydrogen trains are best suited for longer distances (>100km) where lines have not been electrified or are hard to electrify (e.g., due to lack of urban space). It requires less electrical infrastructure change and could be an ideal replacement for the diesel fleet.

Less Downtime

Hydrogen trains have less downtime than electric trains. It takes around 20 minutes to refuel, and hydrogen trains can run for 18 hours without more refuelling. There could be centralised hydrogen refuelling stations ready to cut down cost of infrastructure.

Competitive Total Cost of Ownership

At the current stage, the total cost of ownership for hydrogen trains are lower than electric trains but are higher than diesel trains. The fuel in hydrogen trains accounts for 40-50% of cost today, and the fraction is expected to decrease to 20-30% in 2030, with a hydrogen cost of $4.5/kg.

RISKS

The use of hydrogen fuel cell trains faces less barriers than FCEVs, mainly due to its competitiveness in cost, environment, and convenience aspects. However, hydrogen fuel cell trains are not suitable for high-speed services (> 90mph), and the efficiency loss of fuel cells should be considered.

EXAMPLE PROJECT – ALSTOM'S CORADIA ILINT[2]

The Coradia ILint developed by Alstom is the world's first hydrogen fuel cell passenger train. It started commercial use in 2018 in Germany. With up to 160 passenger seats and 1,000 km autonomy, the train has already been on service for 200,000 km in Germany and Austria.

The fuel cell on the train supplies electricity for both traction and on-board equipment, with a lithium-ion battery to store part of the extra energy and kinetic energy recovered during braking. The train is equipped with an on-board energy storage and intelligent management system to control its energy consumption.

The USD 9.4 million funding of the development comes from Germany's National Innovation Program for Hydrogen and Fuel Cell Technology. The trains are ordered by several companies in Europe. For example, in May 2019, RMV's subsidiary Fahma had a USD 558.4 million order for 27 fuel cell trains to replace its diesel fleets in the Taunus region. The delivery is expected in September 2022.[3] The order also includes the supply of hydrogen, reserve capacities and maintenance for the next 25 years.

2 https://www.alstom.com/solutions/rolling-stock/coradia-ilinttm-worlds-1st-hydrogen-powered-train
3 https://www.railway-technology.com/projects/coradia-ilint-regional-train/

FOR FURTHER INFORMATION

This paper provides insights into allocating capital into the hydrogen value chain.

The firm provides a comprehensive range of services which includes M&A transaction services and raising both debt and equity to finance hydrogen projects globally.

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