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TREND EDITORIAL

Fuel cell–based electric vehicles technologies and challenges

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Abstract
Electric vehicles (EVs) are becoming popular and are gaining more focus and awareness due to several factors, namely the decreasing prices and higher environmental awareness. EVs are classified into several categories in terms of energy production and storage. The standard EV technologies that have been developed and tested and are commercially available include the fuel cell electric vehicles (FCEVs), the battery-electric vehicles, the plug-in hybrid electric vehicles, the hybrid electric vehicles, and the flexible fuel vehicles. Yet, the FCEVs show relatively small superiority over the other technologies from autonomy and refueling. The paper presents a review of EVs focusing on hydrogen FCEVs with the above matters in mind. More specifically, an examination of the FCEV technology and their prospective worldwide is investigated in this work.

Keywords Electric vehicles · Fuel cell · Storage · Range · Refueling · Infrastructure

Introduction

Nowadays, the carbon emitted by fossil fuel–based vehicles is seriously threatening the environment and directly impacts the climate (Hannan et al. 2017; Hou et al. 2021). Global warming and climate alterations are caused by pollution due to the extensive burn of diesel by diesel-based vehicles (Lipu et al. 2018; Ameyaw et al. 2019). In IEA (2020), it has been reported that transportation is at the origin of 24% of CO_2 emissions worldwide. Still worst, in 2020, the European Environment Agency suggested that about 27% of CO_2 is emitted by the transport sector, while more than 70% of emissions are mainly caused by vehicles (EEA 2020). From the 1970s, fossil fuel combustion increased the emission of CO_2, CO, SO_2, and NO by 90% to reach 36.1 Gt in 2014 (Tran et al. 2021). Accordingly, the authorities of most developed countries are encouraging the use of EVs to minimize emissions of CO_2 and greenhouse gases in general (Ajanovic and Haas 2021; Khan et al. 2021b). The transition away from fossil fuel–based vehicles is still facing some limitations, such as the relatively high cost of EVs, especially the long-range ones, on the one hand, and the range anxiety because of the shortage of charging stations from the other hand. Regardless of such limitations and although rooms for improvement still exist, all over the world, researchers and vehicle manufacturers succeeded in developing several EV technologies listed next (Alvarez-Meaza et al. 2020). In fact, up to date, the commercially available EVs could be split into various categories shown in Fig. 1.

The fuel cell electric vehicle (FCEV) (Fig. 1a) employs an electric motor powered by electricity supplied by a combination of a fuel cell and a battery. The fuel cell (FC) uses hydrogen to generate electricity instead of drawing electricity from a battery. The size of the electric motor, the FC, and the battery are appropriately sized throughout the design phase. Furthermore, FCEVs are designed to recapture braking energy for the sake of extra power during acceleration occasions. Since the primary fuel is hydrogen, the quantity of energy that the FCEV can supply to its system is determined by the volume of the hydrogen storage tank available onboard. This is to say, the quantity of energy available is not related to the battery's size.

The battery-electric vehicle (BEV) (Fig. 1b) uses a massive pack of energy storage batteries equipped with an outlet for charging purposes. Almost all liquid components such as the fuel tank, fuel lines, and fuel pump are omitted in this

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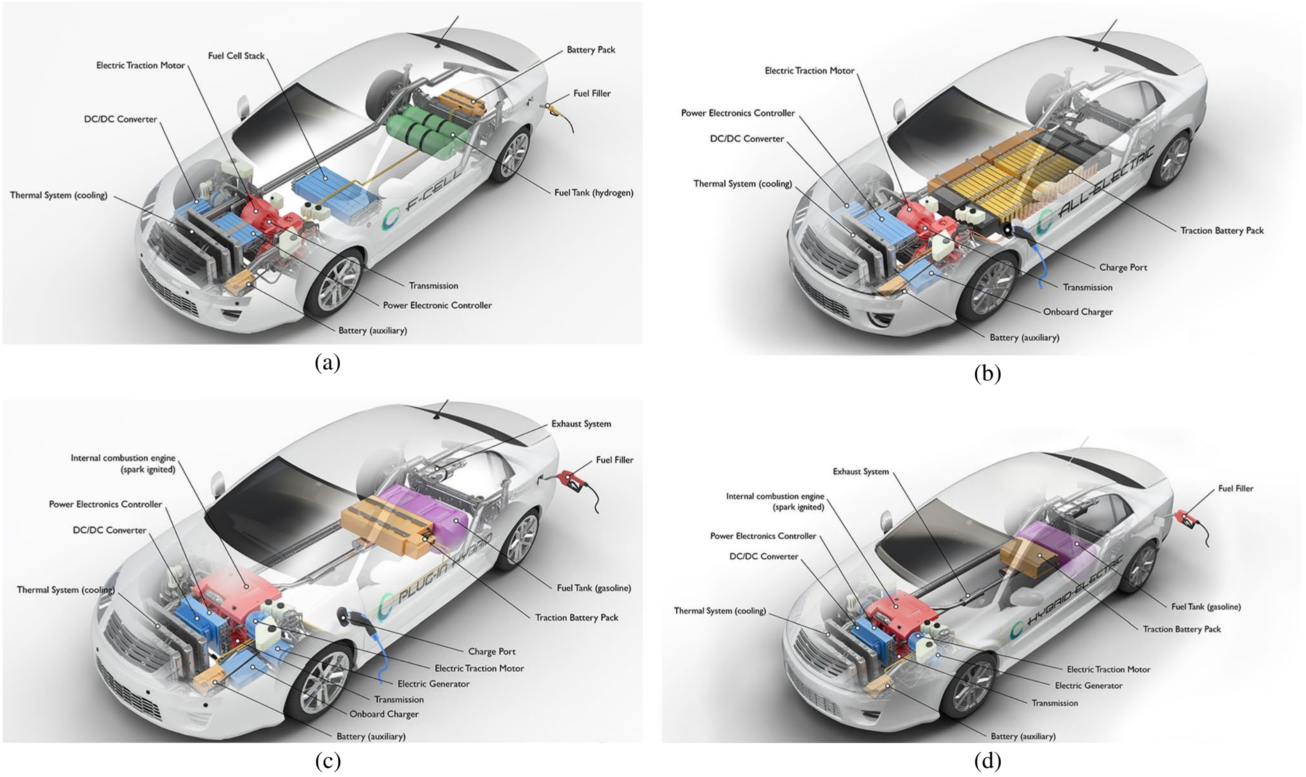

(a) (b)

(c) (d)

Fig. 1 **a–d** Electric and hybrid commercially available vehicle technologies (Alvarez-Meaza et al. 2020)

technology since the vehicle rides purely on electricity. Its motor is not bulky, making it lighter.

The PHEV (Fig. 1c) uses an electric motor drawing its energy from a battery and extra fuel powering an internal combustion engine (ICE). Like the AEVs, the PHEV is equipped with an outlet for charging and can capture braking energy. Typically, a PHEV runs on the electricity stored in the battery for more or less than 50 miles depending on the vehicles' model and the battery size; then, the vehicle switches automatically to use the ICE for several hundreds of miles as it is equipped by a fuel tank.

The working principle and design of the hybrid vehicle (HEV) (Fig. 1d) is close to the PHEV. The only difference is that those vehicles are not equipped with a charging outlet to charge the onboard pack of batteries. The onboard batteries are set through regenerative braking and by ICE. The car presents many features leading to improved fuel saving without losing performance.

Among the above-listed EVs, the BEV theoretically has higher energy efficiency. However, the batteries' pack is bulky and heavy, which is the major drawback that challenges EV manufacturers, especially for large-scale vehicles in long distances. For instance, TESLA's heavy trucks need a batteries pack of around 4.5 tons . Moreover, the refueling time is incredibly lengthy and can reach 7 h per charging cycle.

On the other hand, FCEVs do not suffer from such a problem as the amount of hydrogen onboard is much lighter than the batteries' pack for the BEVs and produces higher specific energy, about 120 MJ/kg compared to 44 MJ/kg for gasoline (Bethoux 2020; Energy, Office Energy Efficiency, and Renewable 2022). In terms of density, the situation is reversed. Indeed, the density of hydrogen is four times lower (8 MJ/L) than the density of gasoline (32 MJ/L). Thus, a hydrogen storage system of 5 to 13 kg is necessary on board for a range of 300 miles for light vehicles. This could be a downside to deal with. Two solutions appear: the short-term solution relates to the storage of compressed gas using tanks made of fiber reinforced composites. Such storage systems could allow a pressure of 700 bars. The major drawback of such a solution is its high cost.

The long-term solution focuses on two components: (1) crypto-compressed hydrogen storage to increase hydrogen density (in this situation, US Department of Energy permission is required), and (2) storage technologies based on extracted or hydrogen-based materials such as chemical hydrogen storage materials, and metal hydrides.

The difference between FCEVs and BEVs is the propulsion system. All other components are theoretically similar. Although BEVs have grown up in most presentations, they present significant limitations linked to their batteries' weight and ranges, respectively. Accordingly, researchers have turned their attention to the FCEVs expected to dominate overall shortly.

Hydrogen-powered fuel cells

Hydrogen-powered fuel cell operation techniques

Fuel cells convert the chemical energy in hydrogen to electricity-producing pure water and potentially helpful heat as the only byproducts. As shown in Fig. 2, the chemical reaction occurs between two hydrogen atoms and one oxygen atom, already found in ambient air. This reaction produces water (H_2O) and generates an electric current. FCs use a proton exchange membrane (PEM) where hydrogen is delivered to a negative electrode, called the anode, around which electrons are freed. The released electrons travel from the anode (negative electrode) to the cathode to the positive one. Reaching the cathode, the freed electrons, the oxygen, and the protons react to produce water (Oldenbroek et al. 2021). The flow of electrons through the external circuitry produces the needed electricity.

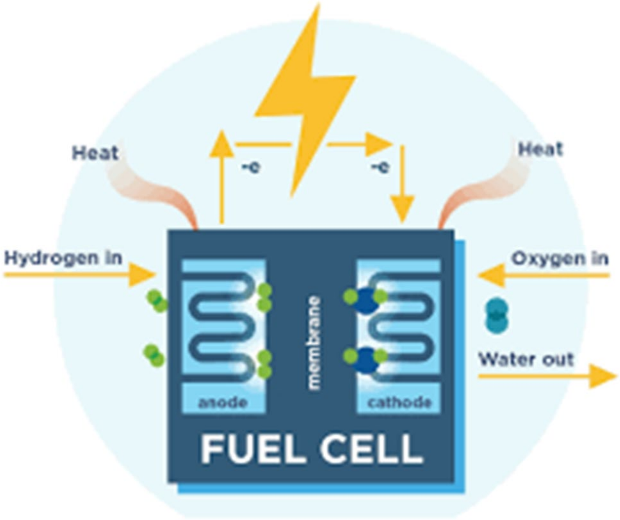

Fig. 2 Hydrogen-powered fuel cell (Li et al. 2019)

Electrons returning through the external circuitry react with the hydrogen protons (moved across the membrane) and oxygen at the cathode to produce water. The latter reaction is exothermic, causing heat that could be useful out of the FC.

Several factors can characterize the power produced by an FC: mainly the supplied gases pressure, FC operation temperature, size, and type of the FC. A unique FC could not exceed one volt, a low voltage to run a minor application like a photovoltaic cell. Therefore, a set of single FCs should be connected in series, forming a stack. This is to say, the stack of single FCs is designed regarding the application. This provides certain flexibility making FCs perfect for a large selection of appliances, such as computers (up to 100 W), residential devices (up to 5kW), FCEVs (up to 125 kW), and even power generation centers (even more than 200 MW) (Li et al. 2019).

FC technologies are generally similar in fundamental structure based on two electrodes immersed in an electrolyte. For instance, the type of electrolyte used to run the chemical reaction distinguishes the kinds of FCs and specifies the range of operation temperature. Table 1 highlights a comparison of different FC technologies (Oldenbroek et al. 2021).

The hydrogen supplied at the inlet of the FC is in general produced so far from different kinds of fuel as explained next (Li et al. 2019; Handa et al. 2021; Foorginezhad et al. 2021):

Table 1 Fuel cell technologies

Type of the FC	Operation temperature (°C)	Output power range (kW)	Electric efficiency (%)
Alkaline	Min: 90 Max:100	From 10 up to 100	70
Phosphoric acid	Min:150 Max:200	From 50 up to 1000W	42
Proton exchange membrane	Min:50 Max:100	Up to 250	60
Molten carbonate	Min:600 Max:700	Up to 1000	60
Solid oxide	Min:650 Max:1000	From 5 up to 3000	60

From methanol (CH_3OH)

Methanol undergoes direct electrochemical oxidation at the electrode, although the generated CO_2 pollutes alkaline electrolytes. Methanol reacts with the steam at a lower temperature compared to those used for hydrocarbons to form hydrogen.

$$CH_3OH + H_2O \rightarrow CO_2 + 3H_2$$
$$CO + H_2O \rightarrow CO_2 + H_2$$

From methane (CH_4)

Initially, methane is heated to around 900°C, where Ni is used as a catalyst. Then the CO reacts with the steam to form extra H_2 following the chemical reaction. Finally, lasting CO could be eliminated through conversion to methane on a ruthenium catalyst, which leads to minor hydrogen losses:

$$CH_4 + H_2O \rightarrow CO + 3H_2$$
$$CO + H_2O \rightarrow CO_2 + H_2$$
$$CO + 3H_2 \rightarrow CH_4 + H_2O$$

From hydrazine (N_2H_4)

Hydrazine is a stable liquid hydrate and very satisfactory fuel. It reacts efficiently at the electrode to produce hydrogen and releases nitrogen. Hydrazine is very compatible with alkaline-based FCs.

$$N_2H_4 \rightarrow N_2 + 2H_2$$

Hydrogen storage technologies

Table 2 (Li et al. 2019) lists a summary of hydrogen storage technologies. In fact, storing hydrogen is a widespread industry, efficient, and safe routine. The hydrogen could even be substantially saved in containers or underground caverns (Commission, European 2019; Singla et al. 2021). However, to achieve driving ranges comparable to diesel or gasoline-based modern vehicles, a large onboard hydrogen storage system/tank is required.

Hydrogen refueling stations and platforms are not widely distributed in some countries and due to the low range's capacities or hydrogen vehicles, researchers in the field are focusing on novel storing technologies to increase hydrogen-based vehicles: for instance, two solutions can be considered: the short-term solution relates to the storage of compressed gas using tanks made up of fiber-reinforced composites. Such storage systems could allow a pressure of 700 bars. The major drawback of such a solution is its high cost.

The long-term solution focuses on two components: (1) crypto-compressed hydrogen storage to increase hydrogen density (in this situation, US Department of Energy permission is required); and (2) storage technologies based on extracted or hydrogen-based materials such as chemical hydrogen storage materials, and metal hydrides.

Up to date, hydrogen is being stored in compressed gas cylinders and liquid tanks. Innovative approaches, including chemical hydrides, carbon systems, and hydrogen absorption through metal hydrides, still require significant improvement in terms of capacity and safety. Even if the storage system design becomes as efficient as expected and affordable, the refueling infrastructure needs to be widespread enough to make hydrogen available to millions of vehicle owners.

Hydrogen fuel cell electric vehicles

Fuel cell electric vehicles: overview

The use of FC vehicles in the transportation sector has rapidly grown worldwide to reach almost 35,000 FCEVs, and nearly 600 hydrogen refueling stations began working by the end of 2020. Figure 3 shows the distribution of FCEVs in developed countries as of the end of 2020 and indicates that South Korea is taking the lead in FCEV deployment,

Table 2 Comparison of hydrogen storage technologies

Storage technology	Type	Advantages	Disadvantages
Gas storage	Compressed hydrogen	Efficient and mature technology	Immature technology of fast filling Expensive cylinder
Liquid storage	Liquid hydrogen	High storage efficiency and liquid density	Low temperature and large consumption of energy and time.
Metal organic framework	Porous coordination network	High acceptance of H_2	Very low temperature required
Chemical storage	NaH; CaH_2; MgH_2	High purity and safety of hydrogen	Absorbs impurities which reduces the quality of hydrogen and the lifetime of the tank
Carbon nanotubes	Gaseous hydrogen	High porous structure	Immature technology

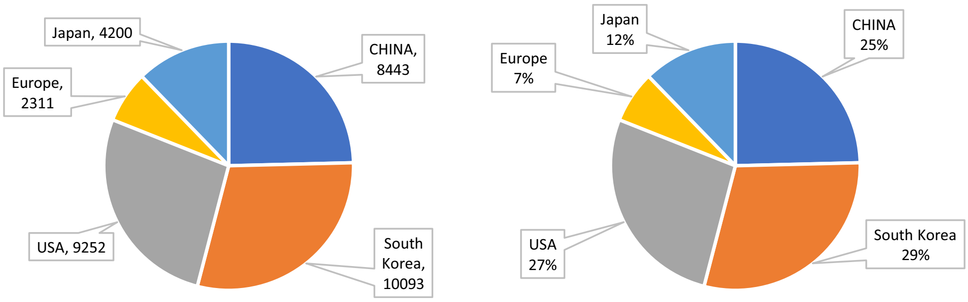

Fig. 3 Distribution of FCEVs over developed countries as of the end of 2020

followed by China, the USA, Japan, and Europe (Samsun et al. 2021; Muthukumar et al. 2021).

A simple computation demonstrates that almost 66% of the FCEVs are already circulating in Asia, against 27% in the USA, and only 7% in Europe. In Samsun et al. (2021), it has been reported that passenger vehicles are almost 26,000 FCEVs, followed by 5670 FC electric busses, against only 3185 FC electric medium-duty trucks. Between 2017 and 2020, the number of FCEVs had increased five times from 7186 FCEVs in 2017 to almost 35,000 FCEVs in 2020 (Samsun et al. 2021; Ahn and Rakha 2022).

In Ala et al. (2021), it was reported that currently, in Europe, the emissions of CO_2 represent one-third of the total emissions and that electric mobility is compulsory for decarbonization purposes. In McNichol et al. (2010), authors matched the number of repurchased FCEVs with ICE-based vehicles, BEVs, and HEVs. They found that the hydrogen or methanol FCEVs are the best answers to the modern transportation exigency. The growth rate of EVs in Europe differs from one country to another. For instance, surveys indicate that Norway, the UK, and the Netherlands are the most European countries prepared for EVs (Leaseplan. E. V Readiness 2020, Collett et al. 2021). This survey focused on 22 countries regarding refueling stations, infrastructure, country regulation, and policies, especially vehicle registrations. Overall, most of the countries considered in the survey have shown increased maturity in registration platforms compared to the past years. Still, the Netherlands and Norway are leading market maturity and refueling infrastructure (Duan et al. 2022). In the USA, Toyota has sold its Mirai model for the first time in 2015, and in Europe, ix35 was the first introduced FCEV. Hyundai has also begun selling its Tucson model in 2014 with 61a 24-kW battery capacity and 61a 100-kW FC system (Duan et al. 2022). Even in the aircraft sector, hybrid hydrogen FCEVs are being tested. Emre Ozbek et al. (2021) have developed and evaluated a Li-Po battery-based hybrid system for an unmanned aerial vehicle. The experimental data were used on the propulsion tests. It was reported that the system has shown promising results and could pass to massive production and commercialization. By January 2021, Japan had the world's most excellent hydrogen station infrastructure that attained 4600 hydrogen FCVs already riding, as matched to the 9000 hydrogen FCVs in the USA, for no more than one-third of the hydrogen refueling stations in Japan. This aligns with Japan's vision of a carbon-neutral society by 2050 (Khan et al. 2021a). Ajanovic et al. (2021) suggested that hydrogen, as well as FCs, can be used for a wide-ranging selection of applications and that, shortly, they shall turn to be an appropriate replacement to fossil fuel– and battery-based electric heavy-duty vehicles, especially for extended transporting ranges, such as busses. They reported that, up to date, the significant obstacles against FCEV's fast penetration remain the high cost and readiness and popularity of the refueling infrastructure. In Li et al. (2021), the authors believe that the low popularity of hydrogen refueling stations (HRSs) has slowed the sale of hydrogen FCEVs in the Chinese vehicle market. They reported that choosing an adequate and appropriate strategy for HRSs can increase EV sales by at least 40% and boost market diffusion efficiency by 76.7%. Compared to BEVs, hydrogen FCEVs have a range of 500 km, close to the range of ICE-based vehicles, and longer than the range of an EV by almost 200 km (Wróblewski et al. 2021).

Du et al. (2021) reported that the transport sector is responsible for 25% of global carbon dioxide emission in 2016 and almost 29% of global energy consumption as of the end of 2017. They highlighted those authorities in developed countries have firmly endorsed the manufacturing of FCVs, and this shall undoubtedly turn out to be the upcoming change within automotive production.

Fuel cell electric vehicles: technology

Hydrogen-powered fuel cell vehicles, also called fuel cell electric vehicles, are electric vehicles that depend on an electrochemical system to convert hydrogen to electricity (Sorlei et al. 2021). FCEVs are equipped with a hydrogen storage tank compressed at 700 bars instead of storage batteries for the BEVs. In Li et al. (2019), Sinha and Brophy (2021), and König et al. (2021), it was reported that Hyundai, Toyota, and Honda are using polymer electrolyte membrane fuel cell (PEMFC) technology. It is the most common type of fuel cell in transportation applications.

Currently, driving ranges, power, and tank capacity for hydrogen-powered FCEV 2022 models are listed in Table 3 (H2 2022), Sanguesa et al. 2021, Hames et al. 2018).

Based on Table 3, the efficiency of the Hyundai ix35 vehicle has increased from 75 km/kg in 2014 to 105 km/kg in 2022, and that of the Hyundai NEXO vehicle has increased from 89 km/kg in 2018 to 119 km/kg in 2022. This is equivalent to an annual increase of 5% and 4.82% for the two models, respectively.

On June 30, 2022, after long and sometimes complicated marathon negotiations, the 27 countries of the European Union took a decision to ban the sale of petroleum and diesel vehicles in 2035 (Fung 2022). The European Council aims for a 100% reduction in the emission of dui CO_2. An agreement of this type between 27 countries was not so easy with some rumblings of discontent surfacing recently. A week earlier, Germany's finance minister expressed skepticism over the phase-out date and voiced support for synthetic fuels, while Italy and four other countries sought to push back the ICE phase-out date to 2040. A few states have won a small concession, with small vehicle manufacturers, such as Ferrari and Lamborghini, exempted from the new interim limits, which reduce CO_2 emissions from new cars by 50% to 42.75 g/km in 2030. The European Commission has also been asked to investigate the development of plug-in hybrid vehicles in 2026 to conclude whether they can help the Union achieve its carbon reduction targets.

Ford and Volvo have weathered the 2035 deadline very well; ACEA, which represents European carmakers, has called for a drastic improvement in electric vehicle charging infrastructure in the EU to support energy reduction targets of CO_2. Oliver Zipse, Chairman of ACEA and CEO of BMW, said "The Council's decision raises important questions which have not yet been answered, such as how Europe will ensure strategic access to raw materials essential for electric mobility. If the EU wants to be a pioneer in sustainable mobility, the availability of these materials must be guaranteed. Otherwise, we will be threatened with new dependencies because other economic regions have already positioned themselves upstream" (Manning 2022).

Table 3 FCEV range per full charge

Model (year)	Power (kW)	Range (km)	Tank capacity (kg)	km/kg
Citroën ë-Jumpy (2022)	100	400	4.4	91
PEUGEOT e-Expert (2022)	100	400	4.4	91
Opel Vivaro-e (2022)	100	400	4.4	91
Mercedes-Benz GLC (2022)	141.6	478+51 (battery mode)	4.4	120
Honda Clarity (2022)	130	589	5.0	118
Honda FCX Clarity (2008)	100	384	3.6	107
Toyota MIRAI II (2022)	136	650	5.6	116
Toyota MIRAI (2022)	186	650	5.6	116
Toyota MIRAI (2015)	115	499	5	100
Hyundai ix35 (2022)	100	594	5.64	105
Hyundai NEXO (2022)	120	756	6.33	119
Hyundai ix35 (2014)	100	424	5.64	75
Hyundai NEXO (2018)	120	566	6.33	89

Information given previously conclude that the EV is not an option anymore, rather than a reality that has already started to come true, and all countries shall review their vehicles' registration and infrastructure policies. Before nations, passengers' approaches should comply with the massive transition in the transportation sector. Passengers may perceive that FCEVs are complex and inefficient and that the FCEV technology is not mature yet and cannot be trusted.

The FCEV structure (Fig. 4) and block diagram (Fig. 5) use hybrid electric sources. A FC is a primary source linked to a unidirectional converter DC-DC converter to stabilize the output current. A process system based on electrolysis is used to produce hydrogen and oxygen from water. A battery, as a second power energy source, is connected to a bidirectional converter. Otherwise, all the energies powers are controlled by an EMS that guaranties the hydrogen reduction power distribution.

Onboard a fuel cell electric vehicle, the FC consists of a fuel cell stack (FCS) and associated subsystems. As seen in Figs. 4 and 5, the FCS is the central part that converts chemical energy to the electrical one to supply the electric motor. The additional four extra subsystems include air supply, hydrogen supply, heat management, and water management. The primary function of the hydrogen supply system is to stream the hydrogen coming from the tank to the stack. Meanwhile, oxygen is being provided to the FCS from the air supply system, which comprises an air filter, humidifiers, and an air compressor. Meanwhile, the essential function of heat and water management systems is to separate water and recycle heat to the vehicle's cabin. Finally, the control unit will provide the flow of the generated electrical power from the FC to the electric motor. Finally, as shown in Figs. 4 and 5, the battery is bidirectionally connected to the rest of the components, and this is to say that, in addition to the power generated by the FC, the battery also delivers additional electrical power to the power control unit as soon as required.

PEMFCs are the most common option to replace batteries in transport applications as well as in embedded systems. Figure 6 represents a Matlab-Simulink model of a PEMFC that is made up of three parts: a cathode and an anode, with a membrane acting as an electrolyte (Fig. 6). The PEMFC is integrated into the electric vehicle system

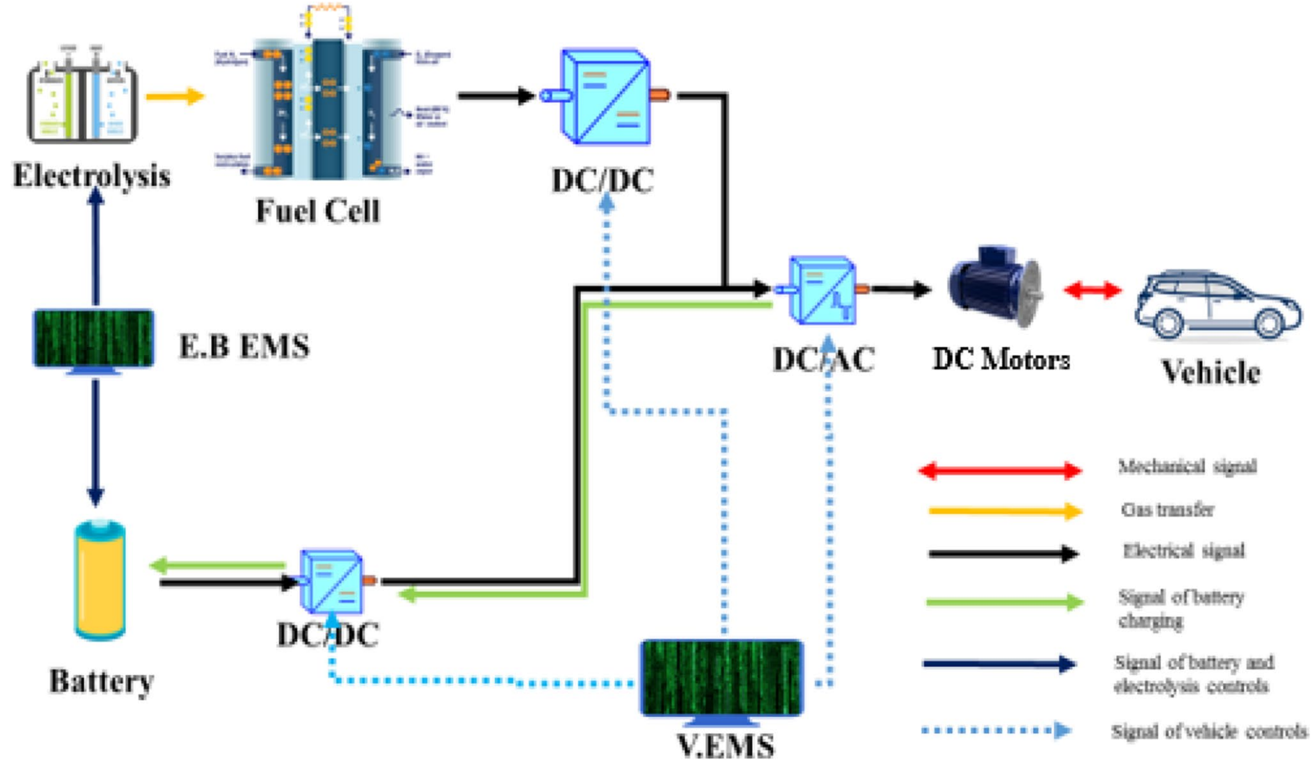

Fig. 4 The FCEV structure

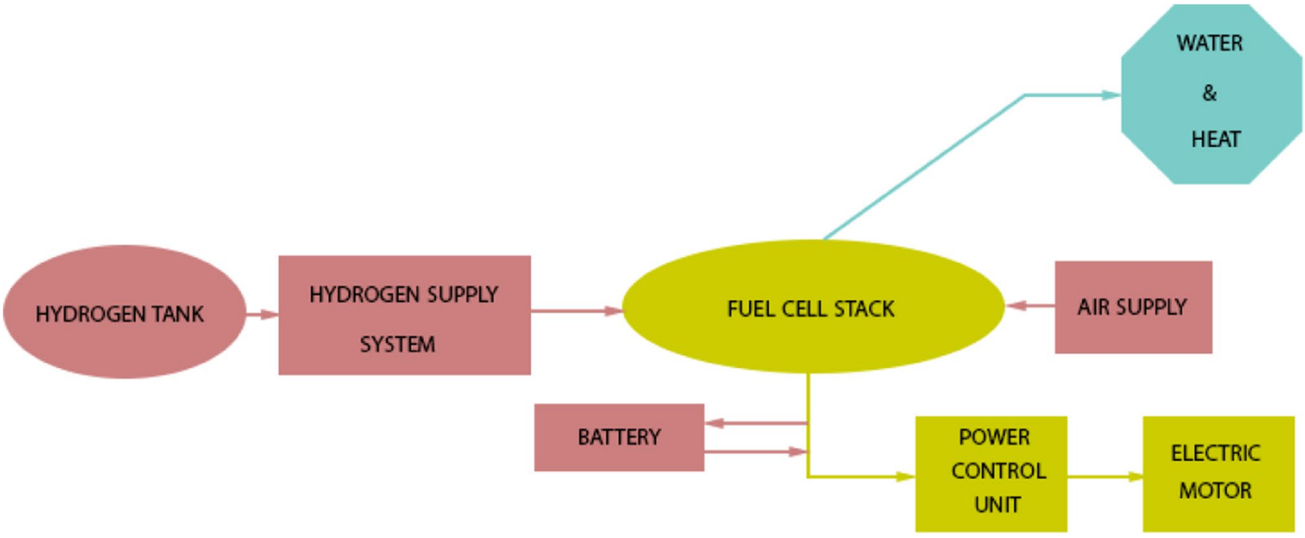

Fig. 5 FCEV block diagram

with auxiliary components such as the electric control unit and the cooling fan to ensure better operations to produce electricity. At the anode, the hydrogen molecules are divided into electrons and protons.

The production of hydrogen is represented in Fig. 7 according to the water electrolyzer Simulink modeled.

Fuel cell electric vehicles: limitations

Although FCEVs seem to be the best alternative to fossil fuel–based ones, still room for improvement exists. The major drawback that slows down the penetration of FCEVs is its low power response and power density, respectively (Manoharan

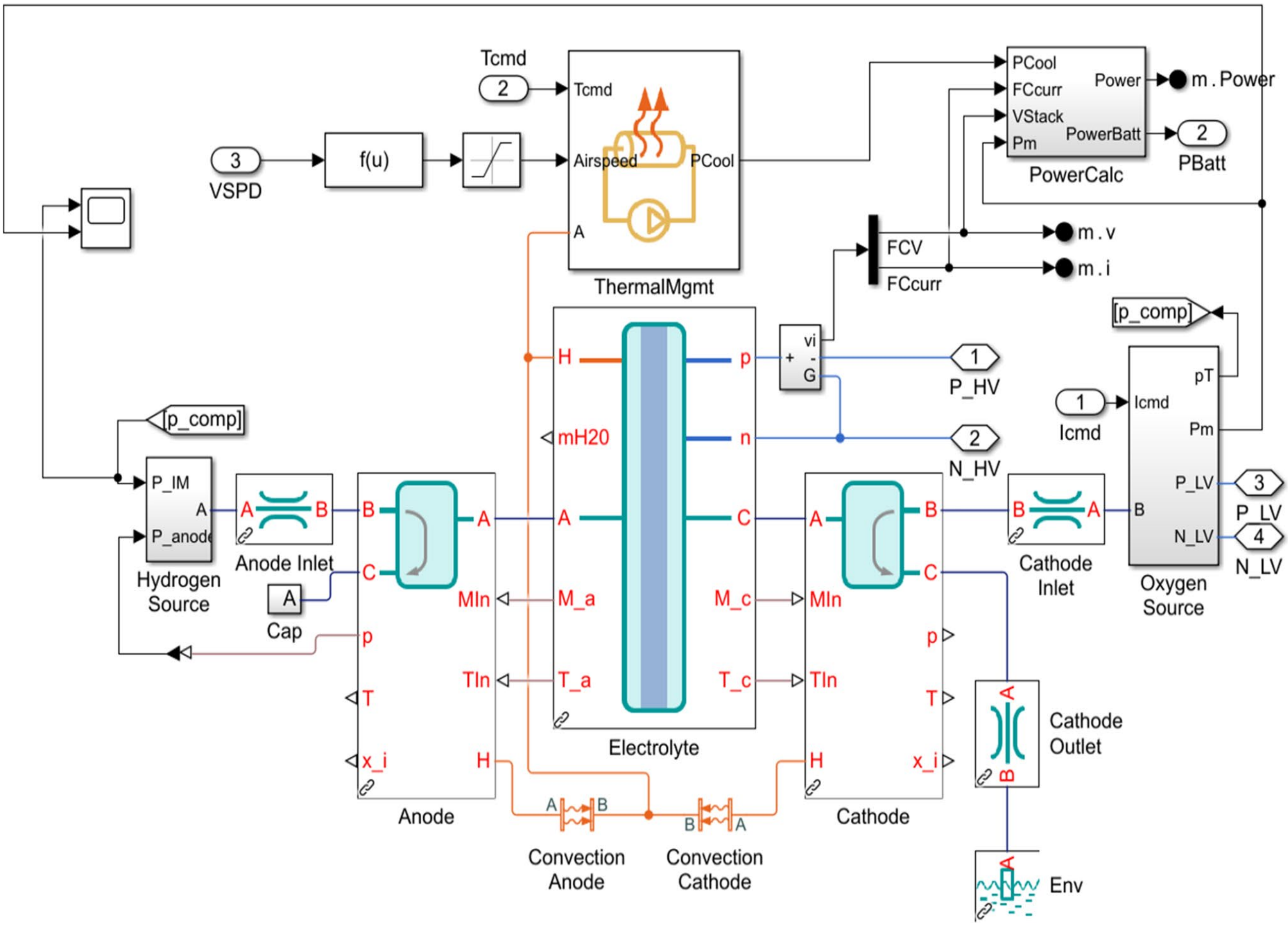

Fig. 6 Matlab-Simulink model of a proton exchange membrane fuel cell

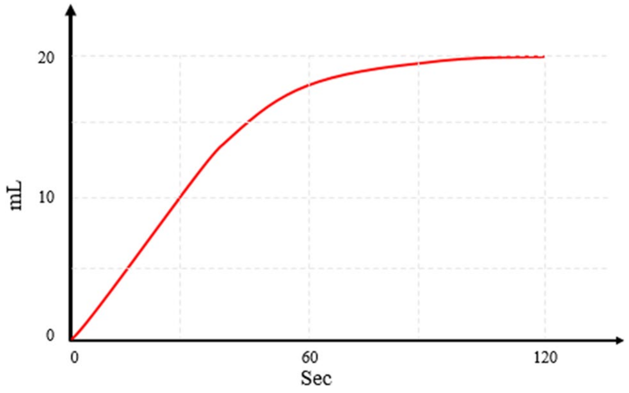

Fig. 7 Hydrogen production: Simulink results

et al. 2019). Such liability could be addressed by combining supercapacitors, battery, and fuel cells onboard an EV(Habib et al. 2021) . The whole fuel system is the so-called FC-Bat-SCAP, and the FC remains the primary vehicle's power source. The super capacitor (SCAP) interferes at the start-up of the ride for the sake of faster power response, then the vehicle switches to rely on the FC as the power source. In Manoharan et al. (2019), Zhang et al. (2022), Sun and Li (2021), Di Ilio et al. (2021), and Mallon and Assadian (2022), the authors suggested that the power is transmitted through the combination FC-BAT-SCAP. The DC-AC inverter controls and matches the SCAP and the electric motor (Zhang et al. 2022; Komsiyska et al. 2021). In Enrique-Luis Molina-Ibáñez et al. (2021), the authors suggested the replacement of the SCAP by superconducting magnetic energy storage. The issue could be solved by applying an appropriate energy control strategy at the inverter side (Lipu et al. 2021; Podder et al. 2021; Şahin et al. 2022; Wu et al. 2019).

Advances in power electronics: promoting electric vehicles

Sanguesa et al. (2021) and Hames et al. (2018) have extensively reviewed power electronics for electric vehicles. They focused on the development of power electronic converters DC/DC used in electric vehicles which are improving thanks to the maturity of new semiconductor devices such as silicon carbide (SiC)–based transistors. They suggest, for further improvement in DC/DC converters dedicated for FCEV, the following:

For high reliability

- Use proper topologies to reduce input current ripple to extend the fuel cell stack's lifespan.
- Select proper semiconductor which achieves good thermal performance.
- Realize close loop control during the EIS detection period to ensure the stability of DC bus voltage.

For high power density

- Optimize magnetic component structure to minimize total volume and weight.
- Select high switching frequency to minimize magnetic component.
- Replace power IGBT module with advanced power MOSFET to reduce semiconductors' volumes, while compact heat sink can be utilized.

For high energy efficiency

- Use semiconductor based on SiC material to reduce power losses.
- Use auxiliary soft-switching circuit to reduce switching losses.
- Employ magnetic component with a compact structure promising to decrease core losses.

Conclusion

In this paper, the authors reviewed the EV technologies and challenges and their superiorities compared to the ICE vehicles. A particular focus has been given to the FCEVs and proposed solutions to the existing limitations. The FCEV driving range and power have been reviewed and compared to conventional ICE vehicles. Meanwhile, the driving range to tank mass has increased for selected vehicles. Although the FCEVs suffer from minor issues such as the electric car's slow power response delay and associated power electronics, promising solutions have already been proposed and utilized. Such solutions include the combination of SCAPs, BATs, and FCs.

The authors conclude that as some countries such as the Netherlands have set up banning deadlines for fossil fuel–based cars, passengers shall be ready for a significant shift in the transportation sector and migrate to electric vehicles due to new developments in power electronics and control strategies.

Author contribution All authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by Tarek Selmi. Some data has been prepared by Ahmed Khadhraoui. The first draft of the manuscript was written by Tarek Selmi and Ahmed Khadhraoui. Before submission, Adnen Cherif, as the team leader, has reviewed the paper and suggested some amendments. All authors commented on previous versions of the manuscript and have approved this current final version.

Data availability Not applicable

Declarations

Ethical approval The submitted work should be original and should not have been published elsewhere in any form or language (partially or in full).

Consent to participate Not applicable

Consent to publish Not applicable

Competing interests The authors declare no competing interests.

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