Electric Vehicle : an Overview

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Abstract - Electric traction has garnered growing attention in recent years. Electric vehicles (EVs) have quickly gained traction in the global automotive industry due to their high fuel efficiency and substantial reduction in greenhouse gas emissions, all while becoming more affordable. Automakers are actively engaged in developing new models of hybrid electric vehicles (HEVs) and EVs, with a key challenge being the design of propulsion systems that fulfill criteria such as energy efficiency, reliability, durability, and cost-effectiveness.

Keywords - Electric vehicle, Traction chain, electromechanical connection

I. INTRODUCTION

The transportation industry, particularly electric traction, is at the forefront of adopting cutting-edge technologies in the field of electrical engineering. In recent years, research and development efforts in the transportation sector have focused on creating safe, affordable, and eco-friendly modes of transportation. In response to these demands, electric vehicles (EVs) have emerged as a viable solution and are increasingly gaining traction in the automotive market as a potential replacement for traditional combustion-engine vehicles [1]. Moreover, EVs are relatively straightforward to model, simplifying their control from an automation standpoint.

With the increasing number of vehicles on the roads, the risk of traffic accidents has become a significant concern. To mitigate this risk, there is a growing integration of electronic and automatic systems in vehicles aimed at preventing or minimizing accidents [2].

This study aims to provide a concise definition of electric vehicles, explore their historical background, delve into their operation and concept, examine various architectures and components, and highlight their significance [3].

II. DEFINITION OF AN ELECTRIC VEHICLE

An Electric Vehicle (EV) is a type of vehicle that operates solely on electric power, utilizing one or more electric motors to provide propulsion. This means that the wheels are driven by the electric motors, eliminating the need for a traditional internal combustion engine. The choice of transmission solution determines the number of electric motors used in the vehicle [4].

III. HISTORY OF ELECTRIC VEHICLES

- 1832-1839: First electric vehicle invented by Robert Anderson.
- 1835: Construction of a small electric locomotive by Thomas Davenport.
- 1838: A similar model runs up to 6 km/h by Robert Anderson..
- 1859: Invention of the rechargeable lead-acid battery by Gaston Planté.
- 1881: Improved rechargeable battery by Camille Faure.
- 1884: Electric car driven by Thomas Parker.
- 1891: The first true electric car by William Morrison.
- 1896: Andrew Riker's electric Riker wins a car race.
- 1897: The first electric taxis on the streets of New York.
- 1899: in Belgium, a company builds "The Never Contented" the first electric car to exceed 100 km/h (it will reach 105 km/h) [5,6]. The car was driven by the Belgian

Camille Jenatzy, and equipped with Michelin tires.

- 1902: Wood's Phaeton could travel 29 kilometers at a speed of 22.5 km/h and cost 2000 dollars.
- 1972: Victor Wouk the godfather of the hybrid vehicle builds the first hybrid car, the General Motors Buick Skylark.
- 1974: The Vanguard-Sebring CitiCar, which looks a lot like an electric Golf cart, debuts at the Electric Vehicle Symposium in Washington, D.C. It can travel 40 miles at a speed of 30 mph.
- 1997: Toyota launches the Prius, the first hybrid car to go into series production. 18,000 copies will be sold in Japan the first year.
- 1997 - 2000: Many manufacturers launch hybrid electric models: the Honda EV Plus, the G.M. EV1, the Ford Ranger pickup EV, Nissan Altra EV, Chevy S-10 EV and the Toyota RAV4 EV.
- 2007: there were still 100,000 electric vehicles on the road in the United States.
- Currently: all electric vehicles offered by manufacturers have a range of between 70 km and 200 km. All these vehicles being equipped with batteries. [7]
- However, new perspectives are emerging with the use of the fuel cell. The latter makes it possible to considerably increase autonomy (400 to 450 km for the moment) to reach values close to those of conventional thermal vehicles. [8]
- The power range extends from about 15 kW up to about 100 kW. However, the choices are guided by the use of these vehicles; generally, 20 to 30 kW is sufficient for an urban vehicle while 40 to 50 kW is preferable for a road car. [9]

IV. TRACTION CHAIN OF AN ELECTRIC VEHICLE

The traction system of an electric vehicle (EV) encompasses all the components involved in transferring mechanical power from the energy source to the mechanical transmission, ultimately enabling the vehicle to move. It includes all the necessary elements that ensure the delivery of mechanical power for propulsion.

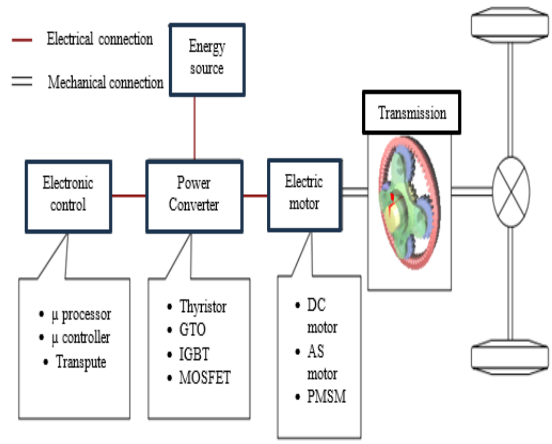

Fig. 1. Functional diagram for an electric propulsion system [11].

A) Battery

The battery serves as the storage device for electricity in the electric vehicle. It is connected to the electric motor through a regulator and a converter. During periods of inactivity, the battery is charged from an external power source to replenish its energy.

B) Electric Converters

In the majority of electric vehicles (EVs), there is a need to address the compatibility between direct current (DC) and alternating current (AC) power sources. This compatibility issue necessitates the inclusion of converters onboard EVs, which are responsible for resolving operational incompatibilities. As a result, the following converters can be found onboard EVs:

AC/DC converter : In an electric vehicle (EV), the AC/DC converters serve the purpose of converting the incoming alternating current (AC) electrical energy. This energy can be obtained from either the general distribution network or an onboard alternator that is connected to a heat engine. The converters transform the AC electrical energy into direct current (DC) electrical energy, which can then be stored in an electrochemical accumulator battery and/or a high-capacity battery. This conversion process enables efficient storage and utilization of electrical energy within the EV's system.

Inverter (DC/AC): The DC/AC inverter plays a crucial role in an electric vehicle (EV) by converting direct current (DC) electrical energy from the battery side into alternating current (AC) electrical energy on the stator side of the machine. This inverter enables precise control of the machine's torque, allowing for adjustments to the vehicle's speed. By facilitating the conversion and control of electrical energy, the DC/AC inverter contributes to the overall performance and functionality of the EV's propulsion system.

DC/DC converter : DC/DC converters serve two important functions in an electric vehicle (EV):

- They play a crucial role in supplying direct current (DC) to the motors when they require this type of electrical energy.
- They are necessary to adjust the voltage of the main battery to match the voltage requirements of electronic auxiliary components used in the vehicle, such as sensors and regulators. By adapting the voltage, the DC/DC converters ensure that these auxiliary systems receive the appropriate electrical power for their operation.

C) Electric motor

In the automotive industry, various electrical machine technologies are utilized, including asynchronous motors, permanent magnet synchronous motors (PMSM), and variable reluctance synchronous motors.

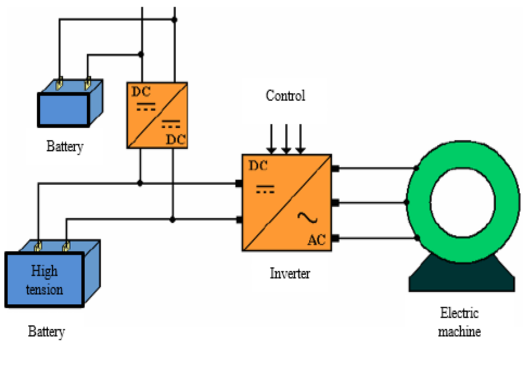

Fig. 2. Simplified EV power system diagram [13].

These technologies offer different characteristics and performance capabilities, catering to the diverse needs and requirements of electric vehicle propulsion systems [12].

V. ELECTRIC VEHICLE CONCEPTS

An electric drive vehicle, also known as an electric vehicle (EV), relies on one or more electric or traction motors for its propulsion. The level of electrification can differ from one vehicle to another.

Essentially, there exist various categories of electric vehicles [14] :

A) All Electric Vehicle (AEV) or Battery Electric Vehicle (BEV)

The AEV or BEV employs large-capacity batteries and an electric motor for its movement. It exclusively draws power from its battery pack and does not incorporate an internal combustion engine, fuel cell, or fuel tank. The sole method to replenish its batteries is by connecting the vehicle to a charging station [14,15,16,17].

B) Hybrid Electric Vehicle (HEV) or Plug-in Hybrid Electric Vehicle (PHEV)

The second category is the Hybrid Electric Vehicle (HEV), which utilizes a combination of an Electric Motor (EM) designed for low-speed operation, primarily for city driving, and a traditional Internal Combustion Engine (ICE) for use outside urban areas. When the ICE mode is engaged, the EM disengages, and the batteries begin recharging through an alternator powered by the same ICE. The HEV can be upgraded to a Plug-in Hybrid Electric Vehicle (PHEV), which introduces a new battery charging system that can be externally charged.

The combustion engine serves as a backup when the batteries are depleted, allowing the driver to continue driving without taking a break for recharging [14,18,19].

C) Extended Range Electric Vehicle (EREV)

The main third category is the Extended Range Electric Vehicle (EREV or REEV). In this configuration, the vehicle's propulsion relies solely on an electric motor, which is powered by high-capacity batteries. These batteries are kept charged by a compact engine-generator unit.

This efficient system consumes less than two liters of fuel per 100 kilometers, providing an extended range of autonomy and distance that can be covered [14,18,20].

D) Fuel Cell Electric Vehicle (FCEV)

In addition to these three primary categories, there is the Fuel Cell Electric Vehicle (FCEV), which has been introduced to cater to long-distance travel needs. The FCEV employs a fuel cell system to drive its onboard electric motor. These fuel cells, often referred to as Polymer Electrolyte Membrane (PEM) fuel cells, use stored hydrogen fuel onboard and oxygen from the air to generate electricity. As long as fuel is supplied, fuel cells continue to produce electricity, operating in a manner similar TO conventional internal combustion engines [20,21,22].

However, it's important to note that fuel cells are significantly cleaner; they convert fuel into electricity through an electrochemical process that doesn't involve combustion.

The power generated by a fuel cell stack depends on the quantity and size of individual fuel cells within the stack, as well as the surface area of the Polymer Electrolyte Membrane. A hydrogen-fueled vehicle equipped with a fuel cell emits only water and heat, providing a clean, highly efficient, and dependable means of green transportation.

Fuel cells have emerged as a crucial technology in the development of electric vehicles by offering clean, high-efficiency, and reliable mobility solutions [14,23,24].

E) Solar Electric Vehicle (SEV)

A Solar Electric Vehicle (SEV) is an electric vehicle that relies significantly or entirely on direct solar energy for power. This energy is harnessed through solar arrays, often equipped with photovoltaic (PV) cells, located on the vehicle's surface. These PV cells directly convert solar energy into electric power.

As the sole energy source, solar power is used to drive all or a portion of the SEV's propulsion system, as well as its electronic components, communication systems, navigation tools, security features, and other auxiliary functions [25].

Sensors are integrated into the SEV to assist the driver, similar to what is found in traditional vehicles. These sensors collect data to monitor energy consumption, solar energy capture, and other relevant parameters.

SEVs can also be equipped with a battery pack to provide backup power, ensuring continuous operation during periods of shade or nighttime driving, there by extending the vehicle's range for users.

In practical terms, SEVs are most reliable when they are used infrequently for driving and spend most of their time parked in the sun.

From a commercial perspective, photovoltaic modules are utilized as supplementary power sources for various electric vehicles, particularly Plug-in Hybrid Electric Vehicles (PHEVs). Depending on the powertrain design, solar panels typically supply electric power to batteries or an energy management system (EMS) through a charge controller.

One notable drawback of pure solar electric vehicles is their dependence on sunlight. Solar arrays installed on the vehicle's surface may not be able to generate a sufficient amount of electric power quickly. Current solar cell technology imposes limitations on what can be achieved with SEVs. Despite improvements compared to first-generation PV panels, newer Concentrating Photovoltaic panels (CPV) offer a 29% panel efficiency, nearly double that of an average PV panel, and incorporate advanced temperature management to maintain optimal cell performance in high-temperature conditions [14,26].

VI. ADVANTAGES OF AN ELECTRIC VEHICLE

The utilization of electric vehicles (EVs) offers substantial advantages in terms of economy, environment, and reliability. Firstly, EVs are remarkably straightforward to operate as they eliminate the need for a manual gear lever, making driving much simpler. Additionally, EVs are known for their silent operation, emitting fewer hydrocarbons, smoke, and particles compared to traditional combustion-engine vehicles. This non-polluting nature of electric vehicles means there is no need for carburation and regular maintenance tasks such as oil changes, providing convenience to owners. Moreover, EVs start smoothly, even in cold weather conditions, with just a quarter turn of the key, and the engine never stalls as there is no clutch mechanism [27].

VII. DISADVANTAGES OF AN EV

However, electric vehicles also come with certain drawbacks. Firstly, the charging time for electric vehicles is considerably longer compared to refueling conventional vehicles. It typically takes at least 8 hours to fully recharge the battery using a household outlet. In terms of range, most electric vehicles offer an autonomy of around 150 kilometers with lithium batteries, although there are a few exceptions. Additionally, electric cars are generally more expensive to purchase than traditional vehicles. Furthermore, the silent operation of electric vehicle engines may pose challenges for road users, particularly those with visual impairments who rely on auditory cues to detect approaching vehicles.

However, efforts are already underway to address this issue. Manufacturers like Zoé and Renault have implemented enhanced noise systems in their electric cars, creating audible alerts at moderate speeds. Another disadvantage to consider is the speed limitations of electric cars, except for a few high-performance models. In general, the maximum speed of electric cars is typically lower compared to that of combustion-engine vehicles [27].

VIII. CONCLUSION

In this study, we provided an overview of electric vehicles, including a brief historical background and an exploration of their constituent elements. We also discussed the advantages and disadvantages associated with electric vehicles.

Given their environmentally friendly and clean nature, electric vehicles are expected to gain increasing prominence in the transportation sector in the near future. They are poised to gradually replace combustion-engine vehicles, which are significantly more polluting and not sustainable in the long term.

However, it is important to consider that the production and operation of electric vehicles still contribute to global warming, primarily due to the energy required for their manufacturing and charging. Therefore, it can be argued that the ecological impact of electric vehicles ultimately depends on the source of the energy used. To truly maximize their environmental benefits, it is crucial to produce and operate electric vehicles using renewable energy sources such as solar or hydropower.[28]

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