



A Study about Fuel Cell Applications on Electric Vehicle Drives

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Abstract-- The study of fuel cell materials research, with a high priority on hydrogen fuel cells. The article presents a brief, up-to-date outline of fuel cell fundamentals, history and technologies. Different competitive advancements; categories; opportunities and limitations; flexible, industrial, and expanding the product and markets; current situation of R&D; potential expectations; specification levels; thermodynamic and electrochemical principles; device assessment factors; and opportunities and prospects. The latest data from developed and emerging economies were used, and the correlation between fuel cell fundamentals and applications was outlined in this document.[1]

Keywords-- Fuel cell, Proton Exchange Membrane (PEM) fuel cell, oxidation of CO, Hydrogen

I. INTRODUCTION

Conversion of electrochemical energy change the voltage of chemical energy into heat energy is known as Fuel cell. Simply we can say (from chemical to electrical) conversion.

In comparison to the multi-step (Ex from chemical to thermal to mechanical to electrical energy) processes involved in combustion-based internal combustion engines, the chemical to electrical energy. The nature of this process provides several unique advantages. For reference, modern combustion-based electricity generating systems are very dangerous to the atmosphere and are mostly linked to several international challenges, such as climate change, ozone layer destruction, toxic rains or acid rains, and therefore a decrease in plant life. Furthermore, these technological advances are variable depending on the globe's bounded and diminishing supply of fossil fuels. Fuel cells, on the other side of the coin, include an efficient and productive fuel cells mechanism. Moreover, fuel cells are suitable with energy sources and current energy transporters (example is hydrogen) for renewable production and environmental security.

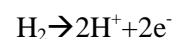
As an outcome, they have been considered the fuel cell as a "Power source".[1]

The developed theory of fuel cells permits for easy storage without loud sounds or acceleration, whereas

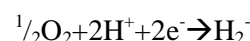
their inherent modularity enables high efficiency and a wide range of applications in foldable, office supplies, and public transit energy production. Polymer electrolyte membrane, also known as liquid electrolyte, fuel cells (Polymer Electrolyte Membrane fuel) are one of the most results provided that are already in the beginning commercialization stage. Additionally, further research is necessary. Research and Development are needed to reduce costs, increase durability, and further optimise and improve efficiency. Most of the investigation had already based on PEMFC at the membrane and construction site. Stack-level investigation, on the other hand, it is an area that requires additional research and development. [3]

II. AN OVERVIEW OF THE FUNDAMENTALS

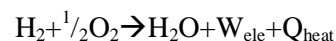
A fuel cell is grouped into three oxidizing agents: a fuel electrode (anode), an oxidant electrode(cathode), and an electrolyte that will be enclosed between a variety of materials coated with a layer of catalysts (often platinum in PEMFCs). Basic operations in a typical PEMFC are depicted in Figure 1. H₂ is delivered from a molecule. To the anode, in which it reacts electrochemically, a gas-flow stream is directed when hydrogen is combusted, hydrogen ions and electrons are generated.



The hydrogen ions transfer it through acid medium, whereas the electrons move to travel all the way to the cathode through an external circuit. As shown in Figure 2, electrons and hydrogen ions undergo oxidation delivered with an existing gaseous state at the cathode to form water.



Water, heat, and electrical work are produced by the overall reaction in the fuel cell as follows:



In order to secure steady ionisation implementation for ideal energy supply, direct drive of electricity and water by-products is required. As a result, water and thermal planning are essential.

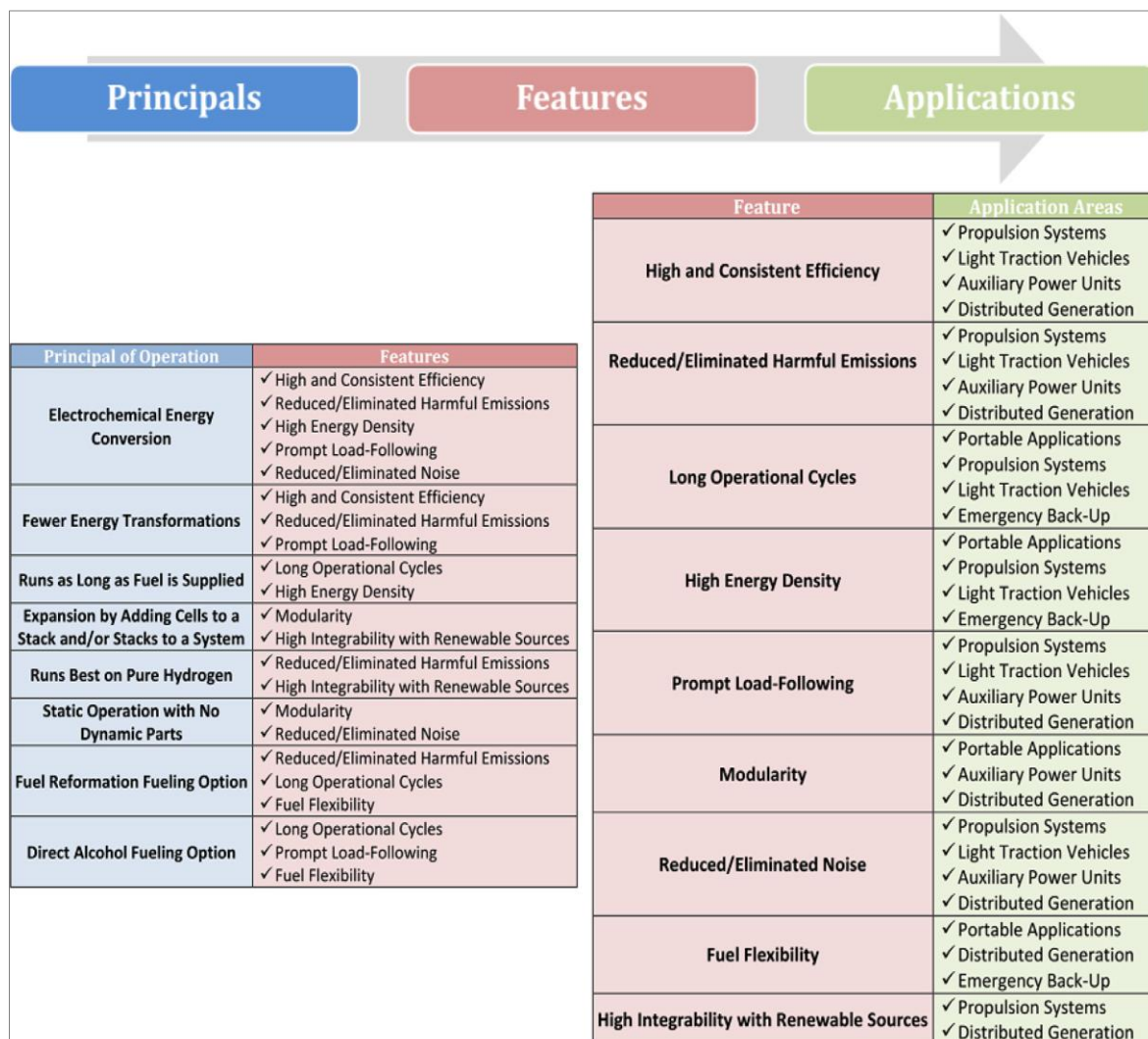


Figure 1: Depicts the correlations between the principals of investigation, possibilities and functionality, and main methodologies of a fuel cell.

Source: This figure 1 taken from <http://dx.doi.org/10.1016/j.rser.2014.01.012>

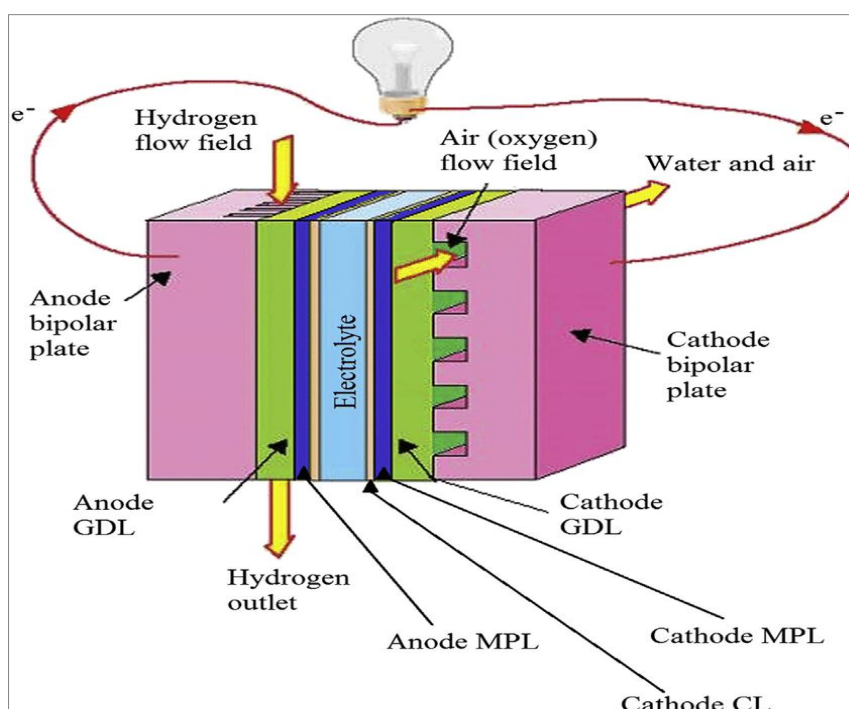


Figure 2: Typical PEM fuel cell operation [1]

A fascinated correlation of the latest market's main energy conversion devices. It depicts the typical photovoltaic and thermal renewable power efficiency. In addition to power plants, waste incineration, gas turbines, diesel engines, gas engines, Rank in cycles, combined Rank in Brayton cycles, nuclear power plants, wind turbines, and hydroelectric plant. Fuel cell, as shown in diagram, are one of the most efficient energy sources. Highest energy efficiency among competing energy conversion technologies shows fuel cells compare in terms of technology and cost. Their competitor's portable, stationary, and mobile technologies sectors of transportation, respectively.

Fuel cell and high temperature generators, in both, use a hydrogen-based fluid and climatic air as the fuel and oxygen. Fuel cells, from the other hand, merge fuel and oxygen electrochemically. Heat engines use oxidation is used in a multi-step cycle to obtain heat energy derived from the fuel's intra chemical energy. Thermal energy is converted to mechanical energy at the end of the process. Through the use of power converts pressure energy into electricity generated in a turbine.

In fact, as the total amount of generation of electricity in a hardware grows, the overall network efficiency of the machine significantly reduces. In comparative study to power propellers, fuel cells radiate fewer to zero toxic substances and have higher theoretical and practical efficiency improvements. Heat engines, from the other hand, are bounded by the Carnot efficiency of their minimum and maximum working temperatures, and are responsible for a large proportion of the world's pollution. Finally, fuel cell layers transient sensors that detect with very little distortion or pulsation. Heat engines, is from the other hand, have countless unique features (example, valves and gear boxes) that generate a lot of sounds, earthquakes.

The increasing complexity of heat engines places restrictions on about their productivity uses.

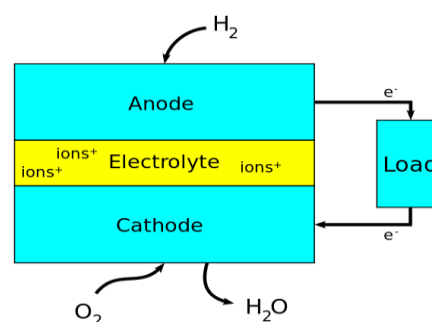


Figure 3: Representation of fuel cell [3]

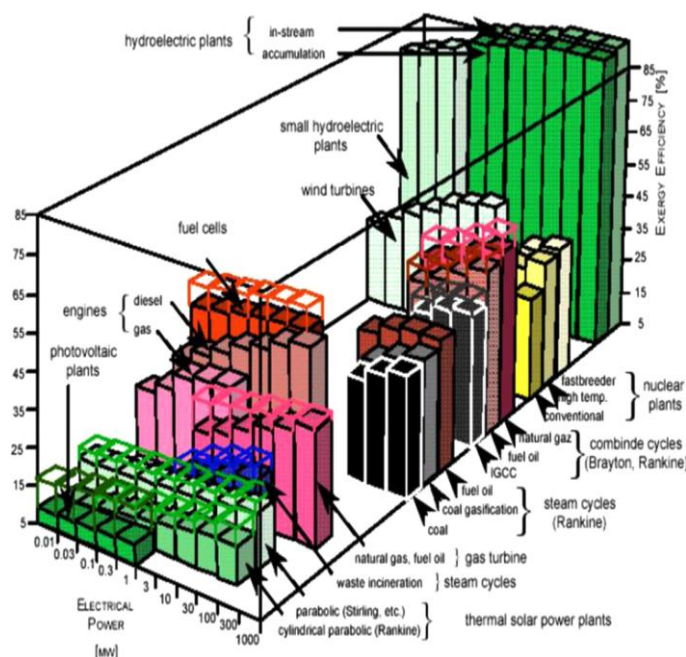


Figure 4: The main energy conversion devices' energy efficiencies

Source: The figure 4 taken from
<http://dx.doi.org/10.1016/j.rser.2014.01.012>

Table 1: In stationary power/ CHP sector, there is a technological and economic comparison between fuel cells and their competitors.

Stationary power/ CHP technology	Power level (MW)	Efficiency (%)	Life time (years)	Capital cost (\$/kW)
Phosphoric acid fuel cell	0.2-10	30-45	5-20	1500
MCFC/ gas turbine hybrid	0.1-100	55-65	5-20	1000
SOFC/ gas turbine hybrid	0.1-100	55-65	5-20	1000
Integrated gasification combined cycle	10-1000	43-47	>20	1500-2000
Gas turbine cycle (natural gas)	0.03-1000	30-40	>20	500-800

Combined gas turbine cycle (natural gas)	50-1000	45-60	>20	500-1000
Microturbine	0.01-0.5	15-30	5-10	800-1500
Nuclear	500-1400	32	>20	1500-2500
Hydroelectric	0.1-2000	65-90	>40	1500-3500
Wind turbine	0.1-10	20-50	20	1000-3000
Geothermal	1-200	5-20	>20	700-1500
Solar photo voltaic	0.001-1	10-15	15-25	2000-4000

Taken as energy input to electrical output

Table 2: Techno economic comparison between fuel cells and their competitors in the portable power sector

Portable power technology	Gravity metric energy density (W/kg)	Volumetric energy density (W/L)	Power density (W/kg)
Direct methanol fuel cell	>1000	700-1000	100-200
Lead-acid battery	20-50	50-100	150-300
Nickel-cadmium battery	40-60	75-150	150-200
Nickel-metal hybrid battery	60-100	100-250	200-300
Lithium-ion battery	100-600	200-300	200-400
Flywheel	50-400	200	200-400
Ultracapacitor	10	10	500-1000

In \$/kW [4]

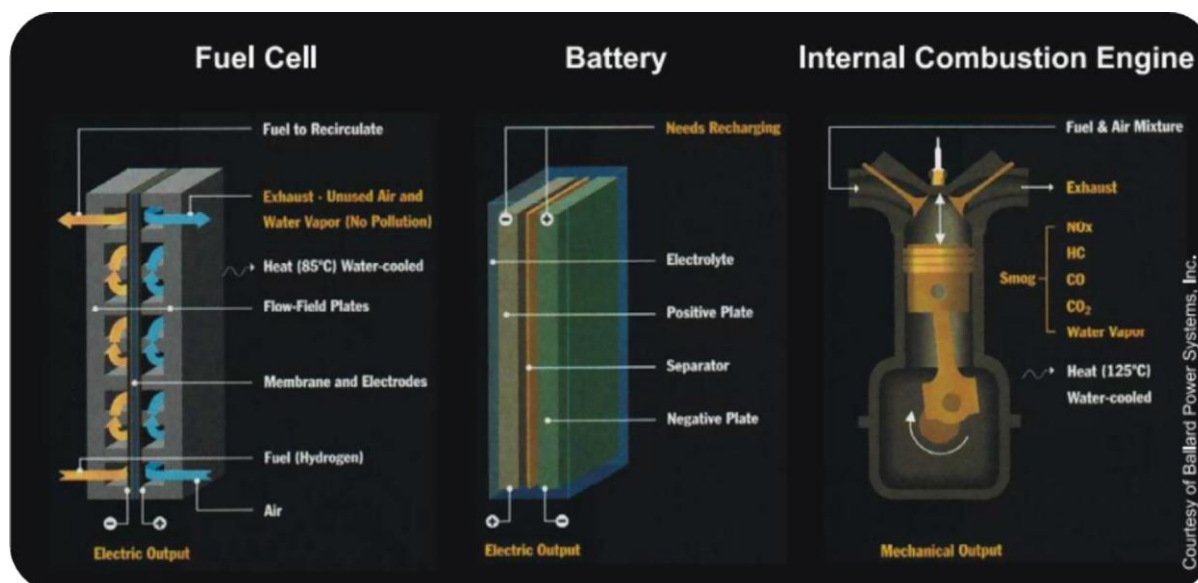


Figure 5: General structures of fuel cells, batteries, and internal combustion heat engines

Source: The above figure 5 taken from <http://dx.doi.org/10.1016/j.rser.2014.01.012> [3]



Table 3: The similarities and differences between fuel cells, batteries, and heat engines are summarised below:

Comparison	Fuel cell	Battery
Function	Energy conversion	Energy storage & conversion
Technology	Electrochemical reactions	Electrochemical reactions
Typical fuel	Pure hydrogen	Stored chemicals
Effective performance	Direct current (solar energy)	DC High voltage (fuel)
Main benefits(profit)	High efficiency Contraction of toxic chemicals Energy consumption	Higher pumping More capabilities and abilities
Losses	Low durability	Low durability
	High cost	Low operational cycles

Many technical problems limit use of such lithium batteries. Solar concentrator and many other challenges are examples of these issues. Detection capacity, load complexity, and charge/discharge number [four] intervals It was not an issue of concern of liquid fuels. When another fuel cell is transformed on, there is no leakage or condensation of its materials. Unlike battery cells, isn't usable the above tables summarize the results. The similarities and the differences between fuel cells, solar heat, and battery technology the power supply.

There are several other multiple types of vehicles in the world right now. Fuel cells are normally categorized based on their electrode materials. They vary widely in their power requirements and how they continue operating. Temperature changes, inverter efficiencies, and suitable positions are just a few examples. PEMFCs have the widest possible variety of opportunities because they are highly customizable able to adapt the most promising candidates for PEMFCs are because of their highest power density and quick start-up times, transportation applications are ideal, high availability, reliability, low temperature conditions, and comfort of using it controlling with care. PEMFCs, on the other hand, are still too expensive to be widely used challenging viable.

III. REDUCED HARMFUL EMISSIONS

Emissions of harmful substances are reduced. Water, heat, and DC power generation are the only components of a hydrogen-fuel steam generator. A hydrogen fuel cell stack is carbon pollution, apart from easily controlled Co₂ emission from moderate fuel cells. However, the

highly talented of such a fuel system is determined by the fuel's production path (ex. hydrogen). For example, the outputs of a total battery system. It includes a fuel metamorphosis stage which really accounts for carbon dioxide emissions (For instance -, CO and CO₂). Whenever the fuel cells Is delivered with hydrogen, pure (i.e., pseudo hydrogen that is always condensed) corrupted with CO), the fuel cell's quality and reliability. In comparison to when the fuel cell was first founded, there has been a great improvement. This one is based on enlightenment period hydrogen. [1]

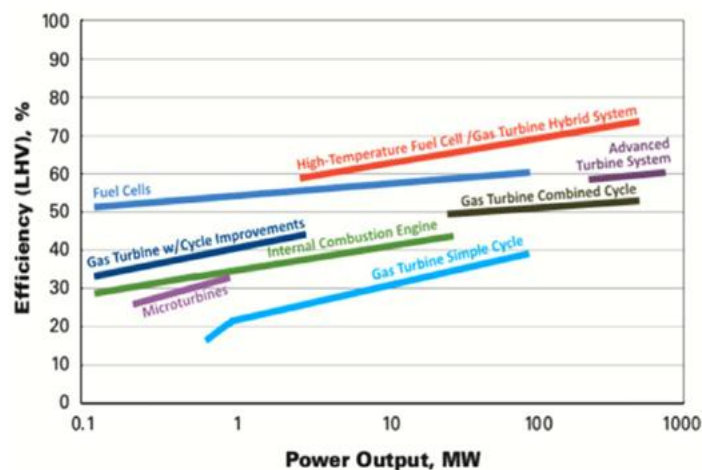


Figure 6: Efficiency gains of fuel cells and other power conversion devices in part related to system size

Source: The above figure 6 taken from
<http://dx.doi.org/10.1016/j.rser.2014.01.012>

IV. RANGE OF APPLICATIONS AND FUEL FLEXIBILITY

Fuel cells are used in a wide range of applications, from micro-fuel cells with outputs values of less than 1 watt to multi-MW prime power plants for generation. This is due to their customization and static existence and a wide range of power generation technologies. This classifies fuel cell batteries for storage. In consumer technology and auxiliary vehicle power, it is used. These are the same features also qualify a fuel cell to be used in place of steam turbines infrastructure and energy production. Fuel cells are also extremely well-integrated. Able to maximize the renewable energy generation technologies. Fuel cells, which moderate operations involve quick comforting times. This is critical for portable and electric power applications. [1]

V. HYDROGEN INFRA STRUCTURE

Hydrogen infrastructure is a kind of infrastructure necessary hydrogen to be obtained. One of the most significant obstacles to fuel battery commercial production is the evidence that we still manufacture 96% of the world's hydrogen. Derived from evidence that we still manufacture hydrogen transformations [14]. Hydrogen is generated from renewable sources (primarily natural gas) and then using it in fuel cells is technologically undesirable because the price supplied



from hydrogen provided from a fossil fuel is higher than the charge if we're using the fuel effectively.

Facilitating sustainable energy hydrogen is thus the only viable solution for supporting the transfer from a fossil-based to a sustainable energy, hydrocarbon economy. Consequently, the advancement of hydrogen production strategies that provide a high electrical conductivity per unit of space is absolutely vital. [4]

Table 4: Advantages and disadvantages of hydrogen infra structure

Advantages	Disadvantages
Less/no pollution	Immature hydrogen infra structure
Higher thermodynamic efficiency	Sensitivity to contaminants
Higher part-load efficiency	Expensive platinum catalysts
Modularity and scalability	Delicate thermal and water management
Excellent load response	Dependence on hydrocarbons reformation
Fewer energy transformations	Complex and expensive BOP components
Quiet and static	Long-term durability and stability issues
Water and cogeneration	Hydrogen safety concerns
Applications	
Fuel flexibility	High investment cost-per-KW
Wide range of applications	Relatively large system size and weight

VI. FUEL CELL SYSTEM EVALUATION FACTORS

A. Physical Factors: *That should be considered when gauging hydrogen fuel technologies*

Many other considerations influence perceptions and variety of various hydrogen fuel stacks for a specific application. These characteristics are particular instance; however, it is necessary to integrate them around each other. Total header weight capacity, along with cell activity, are personal characteristics. Total BOP sub-area, number of cells, number of stacks, and area size and weight of systems. Whenever it comes to evaluating

the outcome of a company, these are essential factors to take into account. A fuel cell device's size and weight are design constraints. This is a very common occurrence. When the weight and transportation and portable applications or the size of the storage battery are critical constraints, as we have seen. [4]

CONCLUSIONS AND PROSPECTS

This research is a concise summary of latest types of fuel cells, with an impact upon this fundamental but crucial link between them. Opportunities, capabilities, and properties, as well as principles of the process. An investigation of the modern times of fuel cell, Numerous renewable power advancements and hydrogen fuel types are competitive environment has been allocated. The positives and negatives of defining upsides and downsides of defining benefits and weaknesses of defining advantages and disadvantages. The most important aspects of fuel cells have been briefly described, leading to a review of the most important aspects of fuel cells. Recent fuel cell pilot missions and capacity development, as well as with current market and expectations in the suitable, stationary, and deep public transit business sectors. Evidently, fuel cells will provide highly coveted period of strength reliability and eco-friendly operation that most other power conversion technologies lack; however, the development and deployment of fuel cells has been slow. The commoditization of fuel cells has been a time – consuming effort. This is largely due to the fact that heat has emerged. [1]. The importance of engines, fuel cells, and smart system has been clouded. For the simple reason that we have often been engrossed in fuel cells cost, efficiency, and believability of electricity generation and technology conversion at the expense of the environmental component.

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