IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

A REVIEW ON SELECTION OF DIFFERENT SOURCES IN ELECTRIC VEHICLE

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ABSTRACT:

Electric Vehicles (EVs) are rapidly growing in the present automobile sector for no fuel cost, pollution free but selection of components are difficult for different types of EVs. Nowadays Electric Vehicles are coming with a suitable power electronic converter is used to charge the battery in safe mode to replace the Internal Combustion Engine. In recent developed EVs, Self-charging technique is employed with multiple sources like solar, fuel cell, battery, ultra capacitor. This multi-source based electric vehicle operated only with battery may not depend on any charging station. In this paper, selections of different electrical sources used in the EVs and current scenario of EVs usage are discussed.

KEYWORDS: Electric vehicles, solar photovoltaic, fuel cell, battery, ultracapacitor, converter

INTRODUCTION:

Inventions of motors, power electronic modulators and different sources are one of the main reasons to the increased focus towards electric vehicles [1]. Vehicle propulsion using electrical power has started in mid-18th century, but not popular due to limitations in battery storage technology [2] [3]. From the past few decades, due to fossil fuels demand, increment of carbon dioxide, and hike in the petrol/diesel prices people are likely to switch over from IC engine to EVs. While considering the efficiencies of EVs and IC engine vehicles, efficiency of EVs are comparatively much higher. This is due to the electric motor's efficiency, which is almost 91%, Lithium batteries efficiency's 90%, power electronic converter's efficiency is 94% and entire efficiency of the electric vehicle is 90%, but IC engine vehicle's efficiency is just around 10%.[4]

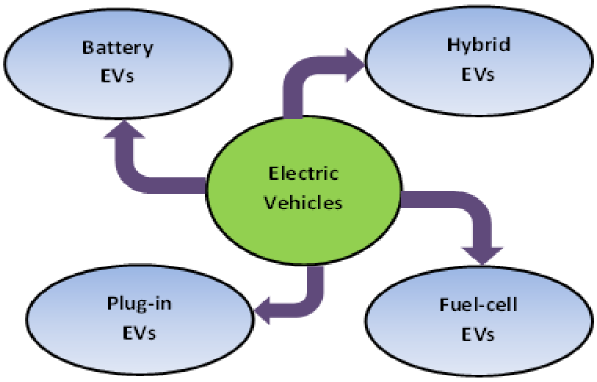

Fig.1. Types of Electric Vehicles [5]

Generally EVs are classified into four types based on the input, which is shown in figure 1. Here Battery Electric Vehicle (BEV) has a battery and it is enough to propel the EV motor. Examples of BEVs are tata tigor electric car, Nissan leaf and hero electric photon electric scooter and advanced BEVs consist of ultracapacitors, which is connected in parallel to the battery as a source. Hybrid Electric Vehicle (HEV) has both IC engine as well as the battery. Here, the batteries get charged by a mechanism called regenerative braking system. This type of EVs are reliable than BEVs and operated in two modes such as IC engine mode and Battery mode. These vehicles having fuel tank to fill with petrol or diesel, whereas there is no requirement of external electricity as the complete power source is depends on the regenerative braking system and examples of hybrid vehicles are Toyota camry hybrid, Honda civic hybrid. Plug-in Electric vehicle (PEV) is powered by both fuel and electricity, here batteries can be recharged with plug in supply as well as regenerative braking system and examples of PEVs are Toyota prius and Hyundai Ioniq plug-in. Fuel cell Electric Vehicle has compressed hydrogen as a input and it delivers electric power [6].

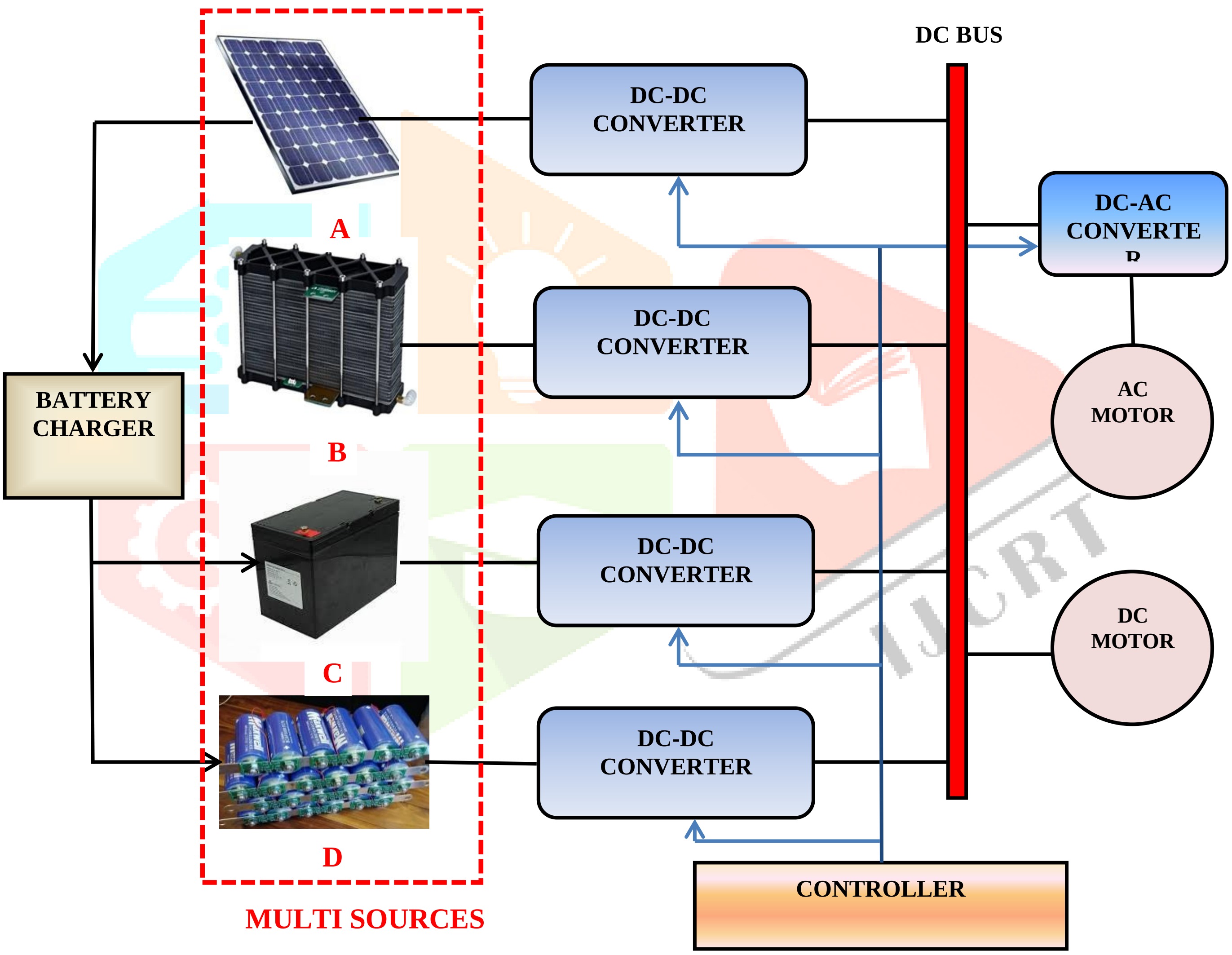

Fig.2. Block diagram of Electric Vehicle with multi input

Battery is one of the main source to drive the EV motor, In addition to battery, some other sources are also used to power the EV. Charging infrastructure is one of the biggest issue in the usage of EV, so self-charging based electric vehicles are latest one. Whereas, Renewable energy sources fed EV system gives self-charging operation without any charging stations. Solar photovoltaic cell and Fuel cell are crucial conventional energy sources. Of all the sources solar and fuel cell energies are intermittent in nature based on the solar irradiation and hydrogen input, so converter design is important to match these sources to load.

Power management system (PMS) consists of many sources like solar photovoltaic cell, fuel cell, battery and ultracapacitor, whereas battery and ultracapacitor combines Energy storage system. Figure 2 illustrates the overall block diagram of EV which consists of (A) solar photovoltaic, (B) fuel cell, (C) battery, (D) fuel cell. Solar energy is available only at daytime and variable one depends on nature. So, output of the solar photovoltaic cell is also varying with respect to insolation and temperature. To take better power from solar photovoltaic system, many types of Maximum Power Point Tracking (MPPT) controllers are used. Proton Exchange membrane fuel cell is well suited for EVs and output of the fuel cell is depends on hydrogen input of the fuel cell. Each and every source is connected to converter by means of their individual switches. These switches can operate by the control signals from the controller.

Function of the PMS is codded in the controller device and initially solar power alone is enough to run the EVs. Solar's switch is closed by the controller, but this type of operation is possible in low power operating vehicles like E-Cycles. If load demand is higher than the solar power, Solar PV and Fuel cell switches are closed to propel the EV under normal operating condition. If there is any excessive power present in the solar, charger will charge the excessive power. Controller's priority order must be from solar and fuel cell.

SOLAR PHOTOVOLTAIC SOURCE:

In General solar energy is divided into two types, such as solar photovoltaic systems and solar thermal energy systems. Solar photovoltaic system is directly converting the solar energy into electrical energy by photovoltaic effect and solar thermal energy system receives the solar heat energy to produce electric energy [7]. In solar photovoltaic system, when sunlight falls on the semiconductor materials, the photons of sun light are taken by the semiconductor crystal material, it causes a substantial number of electrons to become free within the crystal. This is the basic reason for the production of electricity by solar cells. Figure 3 explains the types of solar photovoltaic technologies.

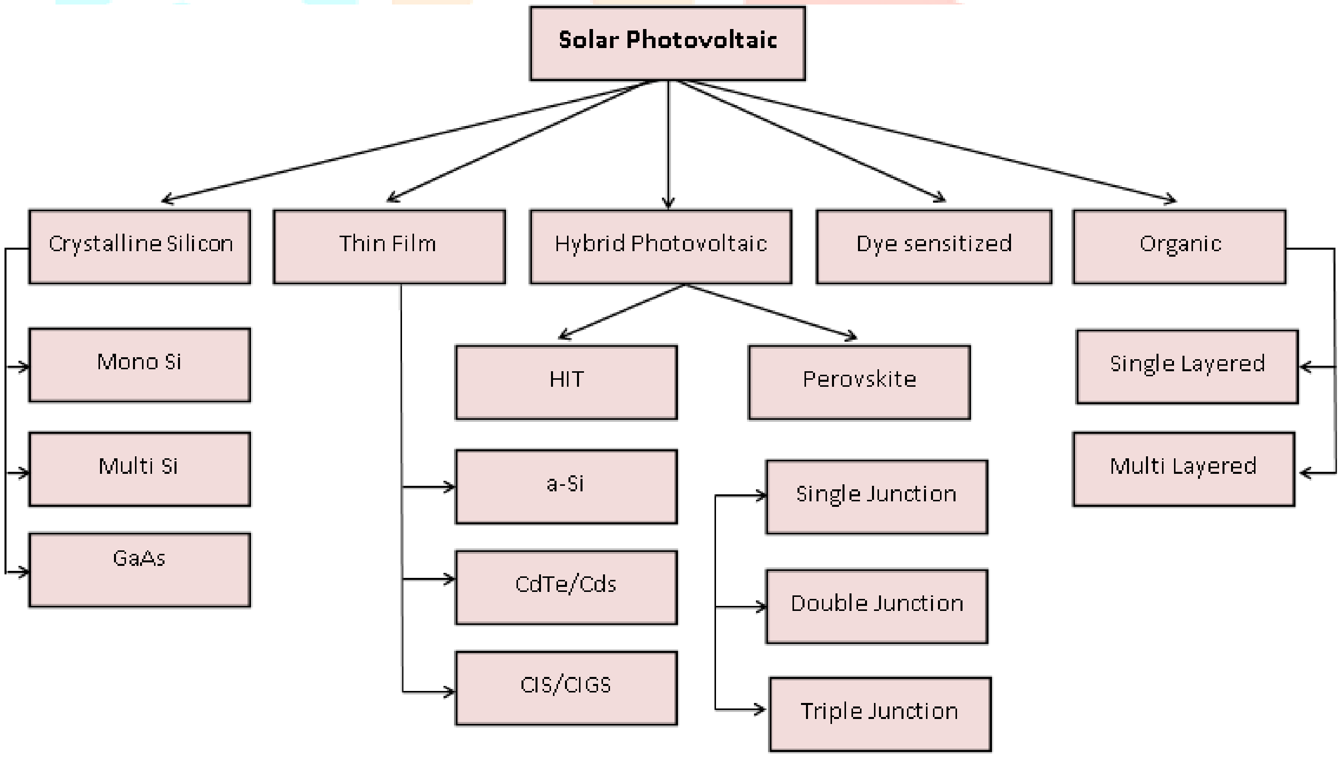

Fig.3. Different types of solar photovoltaic technologies [8]

Silicon is a material most appropriate semiconductor for PV applications due to its most plenitude on the earth. In which crystalline silicon is the famous and generally used [9]. As of now, market is overwhelmed by wafer based c-Si PV cells and modules. Single crystalline silicon cell's efficiency is crossed to 25.6% in the standard test condition [10]. Of all types of solar panels, Mono-Si panels are efficient and conventional one. Monos crystalline's conversion efficiency is from 15% to 20% and PV manufacturers are seeking for alternative materials like as tricrystalline (tri-Si). So, polycrystalline (poly-Si) that are less expensive than mono-Si. Silicon wafer fabrication accounts for 40% of the total cost of silicon solar cells. As a result, the creation of thinner wafer cells could aid in cost reduction. Because of their low production cost and improved mechanical stability, Tri-Si cells are a possible solution for lowering overall costs. Tri-Si has a conversion efficiency of 16.79% and a fill factor of 80%. Multicrystalline (multi-Si) solar cells are another name for polycrystalline solar cells. Polycrystalline silicon is a substance made up of several tiny silicon crystals that is utilized as a solar photovoltaic raw material. [11]

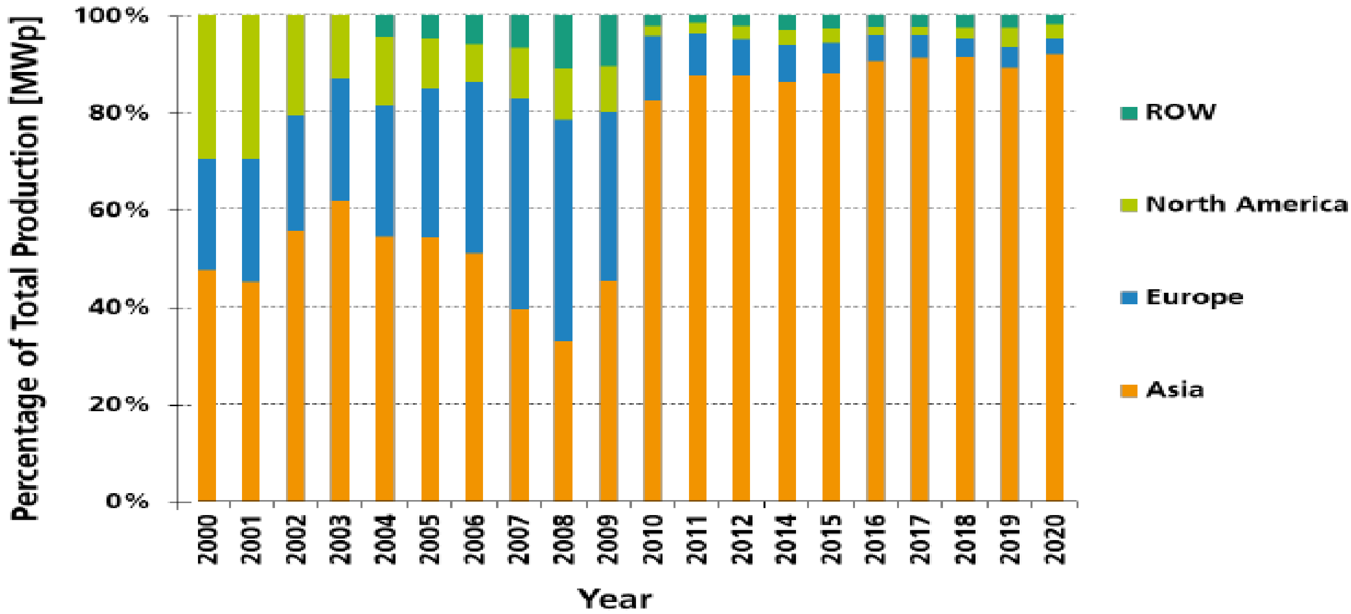

Fig.4. photovoltaic module manufacture in different place [12]

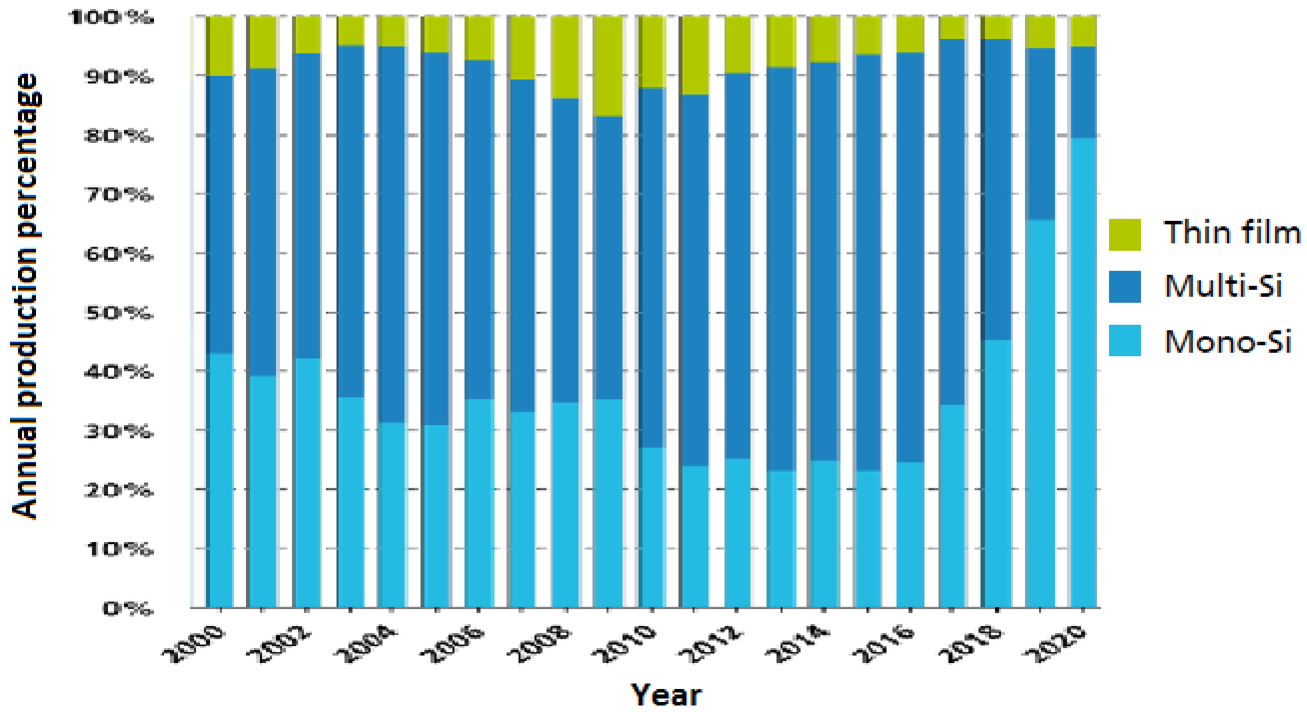

Fig.5. photovoltaic production by technology [12]

FUEL CELL SOURCE:

Fuel Cell is an electrochemical device, which converts the chemical energy of fuel to electric and heat energy. The electrochemical transformation is a chemical reaction between oxidant and reductant that produces electricity and water in stack. According to their chemical characteristics and working temperatures, FCs are classified into several types. Table 1 shows the comparison between the types of FCs in electric vehicles, in which Proton Exchange Membrane Fuel Cell (PEMFC), Alkaline Fuel Cell (AFC), Phosphoric Acid Fuel Cell (PAFC), molten Carbonate Fuel Cell (MCFC), Solid Oxide Fuel Cell (SOFC) and Direct Methanol Fuel Cell (DMFC) are highly recommended for the transportation applications [13]

Table.1. Comparison table of different FCs used in EVs [13,14,15,16]

Types	**PEMFC**	**AFC**	**PAFC**	**MCFC**	**SOFC**	**DMFC**
Cell voltages	1.1V	1V	1.1V	0.7V-1V	0.8V-1V	0.2V-0.4V
Stack power	1-250KW	1-100KW	50-100 KW	300-3000 KW	1-3000KW	0.001-100KW
Efficiency	40%-60%	60%	60%	50%	60%	40%
Operating Temperature	<100C	90C-100C	150C-200 C	600C- 700C	500C-1000C	60C-200C
Advantages	Quick starting, Low temperature operation, Minimum corrosion	Operating temperature is less, material cost is low, High performance	High efficiency	Fuel flexibility	Higher efficiency, Fuel flexibility	Low cost
Disadvantages	Catalyst cost is high	Sensitive to CO2 levels in oxygen and hydrogen	Expensive catalyst cost, slow start time	High operation temperature, Long start	High operation temperature, corrosion and Long start time	Intermediate adhesion to the catalyst surface
Invented year	Early 1960s	Mid 1960s	Early 1961s	Late 1960s	In 1985	In 1990s
Invented by	Willard Thomas Grubb	Francis Thomas Bacon	G.V. Elmore and H.A. Tanner	Francis T. Bacon	Kyosera	-

BATTERY SOURCE:

Battery is an energy storage device which converts the chemical energy into electrical energy, in which chemical energy is used to store the electrical energy. Batteries are generally dived into two types, such as primary and secondary. Furthermore, the primary battery cannot be rechargeable and secondary battery can recharge many times. So, secondary batteries are appropriate to use a number of applications and it is well suited for electric vehicle [13]. A battery's capacity is measured in ampere-hours (Ah), whereas the amount of energy stored in the battery is measured in watt-hours (Wh). Figure 6 illustrates the internal structure diagram of secondary battery.

The State of Charge (SOC) is measured in percentage, which indicates the amount of charge present in the battery. 100% of the SOC represents the fully charged and 0% of the SOC indicates the fully discharged. State of Health (SOH) is condition level of the battery, which is compared with fresh battery and it is expressed in terms of percentage [17]. This SOH value is decreased during life time of the battery.

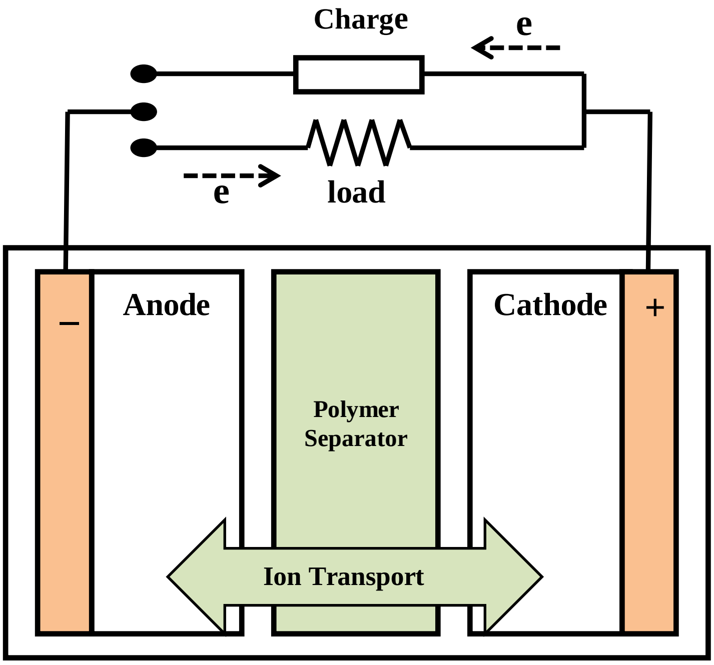

Fig.6. Schematic of battery structure [18]

While comparing with the other batteries used in electric vehicle, lithium ion battery has more advantages over other types of batteries. Whereas, extreme damage would be caused by an overvoltage in a single cell. So, the lithium ion batteries requires Battery Management System, which monitors the SOC, SOH, temperature and protect the battery from over voltage and over charging.

Table.2. comparative analysis between batteries used in EVs [19, 20, 21, 22, 23, 24]

Type	**Ni-MH**	**Ni-Cd**	**Na-s**	**VRLA**	**Zn-br2**	**Zn-C12**	**ZEBRA**	**Li-ion**	**Li-Po**	**Li-FeS**
Energy efficiency (%)	50-80	60-70	80	70-90	68-76	-	80	70-80	70	80
Power density (W/Kg)	150-300	150-350	120	200-400	90-130	60	150	200-300	315	240
Energy density (Wh/L)	100-140	80-100	150	60-100	60-70	90	149	240-280	200-250	220
Specific energy (Wh/Kg)	50-70	40-50	100	30-50	65-75	65	86	120-140	155	130
Life cycle (80% DOD)	500-3000	2000-3000	2500-4500	2000-4500	300	200	2500-3000	1500-4500	1200<	1200<
Advantages	Long life, safety, high specific energy	Specific energy is high, no degradation for deep charging and discharging	Higher energy density and specific power	High efficiency, specific power, cheap	Fast charging, low cost, higher specific energy	Energy density is high	Low cost, high energy and power density	High power, high specific energy, less weight, efficiency is high, low self-discharge rate, long life	Less weight, long life, high power and energy density, specific energy is high	High energy and power density, less weight, long life
Disadvantages	Expensive, high self-discharge	Expensive, low specific energy	Temperature effect, costly, safety issue	Low specific energy, bulky in size	Require temperature control, lower specific power, size is large	Low specific power, require more maintenance	Specific energy is low, self-discharge	Expensive, need over charge and under charge protection	Costly, need thermal management system	Costly, need thermal management system
Production cost ($/kWh)	200-250	250-300	250-450	150	-	-	-	150	150	110

Battery is an efficient energy source compare to other types of energy storage devices, furthermore ten types of batteries are convenient to use in electric vehicle applications. Table 2 shows comparative analysis of different types of batteries, such as Nickel metal hydride (Ni-MH) battery, Nickel Cadmium

(Ni-Cd) battery, sodium sulfur (Na-s) battery, Valve regulated sealed lead acid (VLRA) battery, Zinc-bromine flow (Znbr2) battery, Zinc-Carbon (Zn-C12) battery, Sodium Nickel chloride (ZEBRA) battery, Lithium ion (Li-ion) battery, Lithium polymer (Li-Po) battery and lithium iron disulfide (Li-Fes) battery.

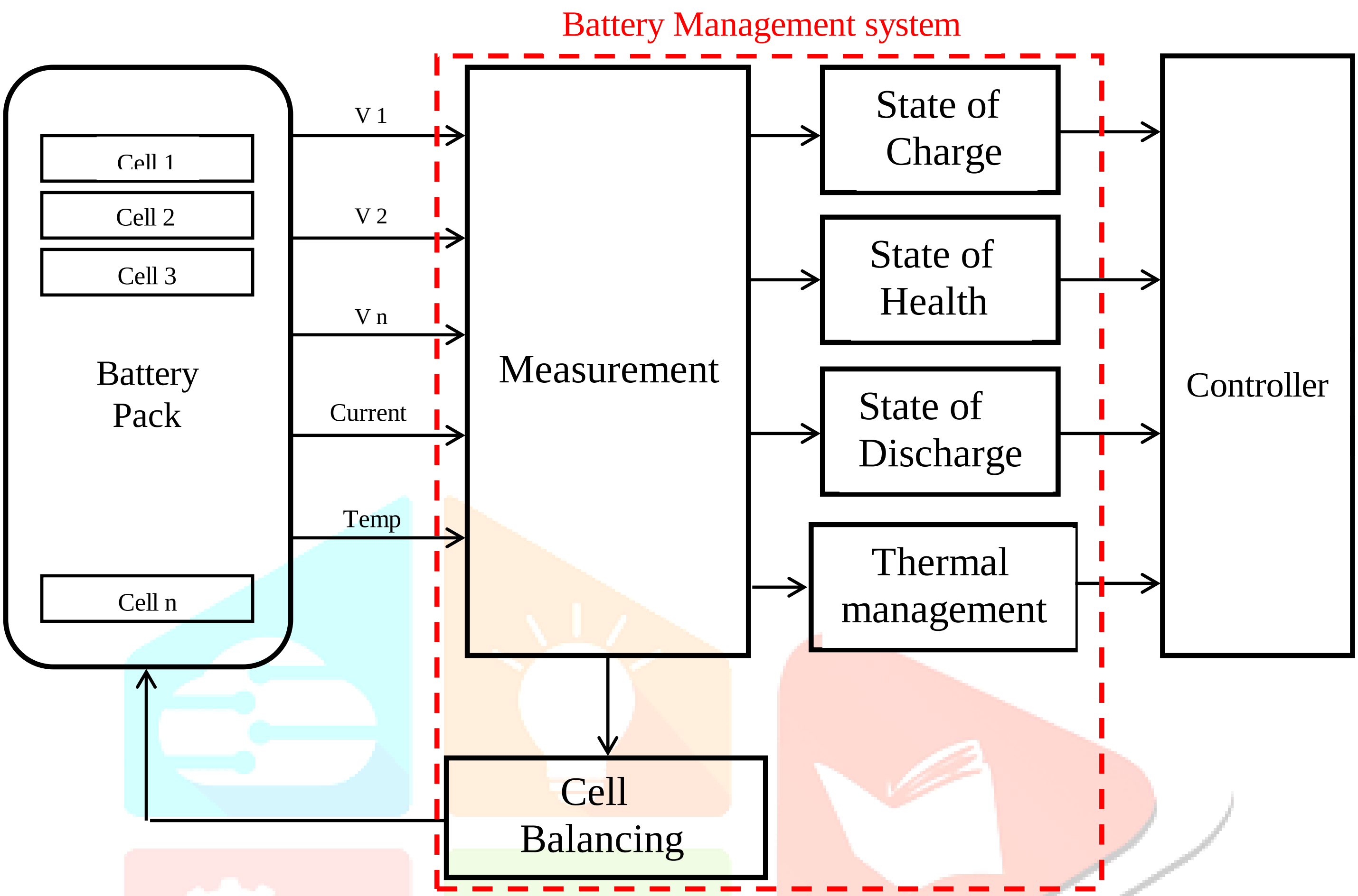

Fig.7. Block diagram of Battery management system

Battery management System (BMS) is crucial for every battery, which is used in electric vehicle and this entails choosing the right materials for energy storage, cell balancing, monitoring state and health condition, charge/discharge control and improvement of efficiency in the battery. Cell balancing circuit balances the every individual cell in the battery to improve the health and life time of the battery. Furthermore cell monitoring systems monitors the cell voltage, cell current and temperature of the every single cell. BMS gives exact SOC level of the battery like fuel display in internal combustion engine vehicle. To estimates the SOC, direct and indirect methods are used, in which indirect method give high accuracy than direct method.

ULTRA CAPACITOR SOURCE:

Conventional capacitor with an exponentially high energy density is called as ultracapacitor or supercpacitor and sometimes it is called as Electric double layer capacitor (EDLC). In 1957, the EDLC's effect was discovered by testing with porous carbon electrode devices and the energy was thought to be stored in the carbon pores. So, capacitor consists of electrolyte between two electrodes, but supercapacitor has the carbon technology instead of conventional electrolyte. Ultracapacitor is used in many applications, such as electric vehicle, computer, UPS, cameras, LED systems, medical systems, inverters, welders, emergency lighting, diesel engines, etc. Due to the advancement of ultracapacitors, more efficiency and more capacity, it functions as a battery replacement. It is employed in regenerative braking applications because of its speedy charging ability. Figure 8 gives the different types of ultracapacitors.

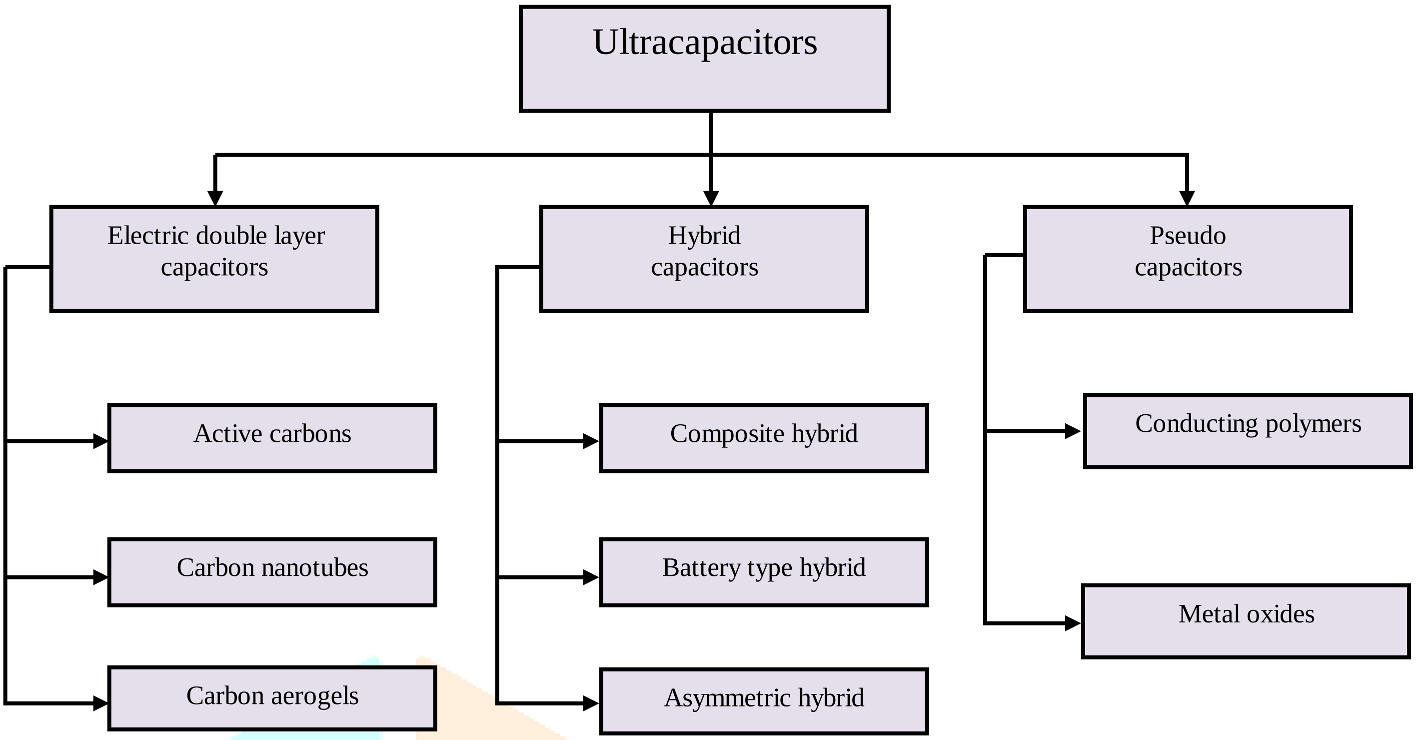

Fig.8. classification of ultrcapacitor

CONCLUSSION:

This article gives a step-by-step selection of solar photovoltaic and comparisons of fuel cell and battery sources used in EVs. In addition to different sources, power management system in EVs is explained. On a commercial basis, the c-Si and thin film technologies are the most extensively utilized in EVs. Photovoltaic module manufacture in different place and PV panel's production by technology wise were shown. Different types of fuel cells are compared with their cell voltage, efficiency, stack power, operating temperature, advantages and disadvantages, which results PEM fuel cell is the best for EVs, because of quick start with low operating temperature. From the battery's comparative table, lithium-ion batteries provide a number of advantages over others.

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