7th National Conference on
"Role of Engineers in Nation Building" organized by VIVA Institute of Technology, Mumbai
(1st and 2nd March 2019)
International Journal of Engineering Research & Science (IJOER)
ISBN: [978-93-5321-411-1] ISSN: [2395-6992] [Vol-5, Issue-3, March- 2019]

Analysis and Simulation of Battery, Ultracapacitor, Fuel Cell, Hybrid Electric Vehicle

Siddhesh Desai[1], Kaustubh Bhavsar[2], Sanket Kamble[3], Akshay Bagul[4]

Department of ELECTRICAL ENGINEERING, MUMBAI University, MAHARASHTRA

Abstract— *This paper presents the MATLAB Simulation model of the Ultra Capacitor, Battery, Fuel cell for EV. As the demand increases efficiency and performance plays important role in energy storage system of EV. In this paper new battery, ultracapacitor, fuel cell is used to meet the requirement. To minimize the weight of storage system battery is used with ultracapacitor and fuel cell of high power. The important task is to improve efficiency and performance of EV in terms of electric power density and energy capacity. MATLAB simulation is used to evaluate and analyze its function of battery stress, efficiency of fuel cell and voltage response of ultracapacitor. Simulation model of hybrid energy source is made to design and implement the electric vehicle in terms of energy efficiency and storage mass.*

Keywords- MATLAB, Electric Vehicle (EV) Hybrid EV, Ultra Capacitor, Battery, Fuel Cell.

I. INTRODUCTION

The electric vehicle was implemented in 1830s and commercial EV was made available by 19th century and now it has entered as a 3rd century available commercially and it has been very successful, outgrowing many technical ideas that has come. They have certain advantage over combustion engine as they do not emit gases and is pollution free which maks it ideal for warehouse, buildings, golf course, where pollution and noise is prohibited

II. PRINCIPLE

2.1 Battery Electric Vehicle

The vehicle has electric battery for energy storage, electric motor, controller. The battery is normally recharged with electricity by a plug and a battery charging unit is taken onboard or fitted at charging point. The controller will control the power applied to the motor, and hence the vehicle speed, is forward and reversed. This is a 2 quadrant controller, forwards and backwards. It is desirable to use regenerative braking to recoup energy and convenient form in frictionless braking. In addition the controller has regenerative braking in forward, reverse direction and its called 4 quadrant controller.

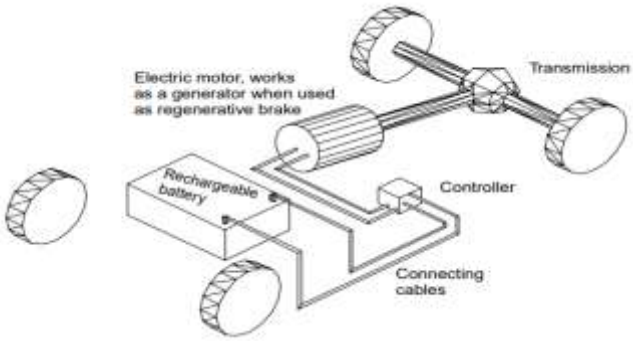

Fig.1. Battery Electric Vehicle

2.2 Ultracapacitor

Capacitor is a device in which two conducting plates is divided by an insulator. A DC voltage is connected to the capacitor, one plate is positive the other is negative. The opposite charges in the plates attract and thus store energy. The charge Q is stored in a

International Journal of Engineering Research & Science (IJOER)
ISBN: [978-93-5321-411-1] ISSN: [2395-6992] [Vol-5, Issue-3, March- 2019]

capacitor and capacitance of C Farads and voltage V Volts is given by the equation: Q = C × V. The energy stored in capacitor is given by: E = 1 2CV 2 where E is energy stored in Joules. The C is capacitance in farads given by C = ε A d where ε is the is the permittivity between plates, A is the area of plate d is separation with high specific power and low specific energy. This can be used in energy storage.

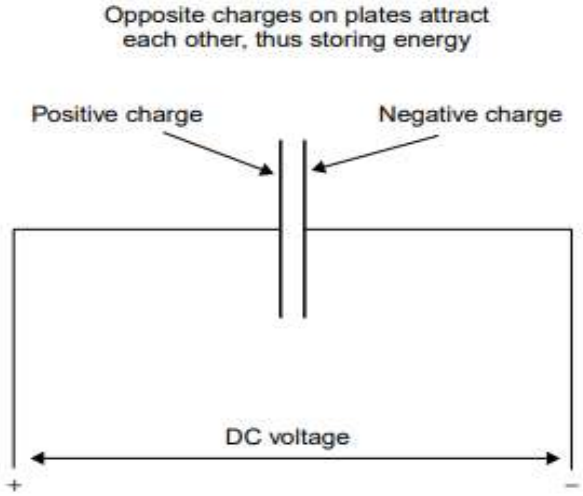

Fig. 2 Ultracapacitor

2.3 Fuel Cell

The basic working of fuel cell is it uses hydrogen fuel in a device of battery type to generate electrcicity and the chemical reaction of fuel cell is given by 2H2 + O2 ⟶ 2H2O, where product is water and energy. The types of fuel cell to be used in vehicles work at modest temperatures of (85◦ C). There is no nitrous oxide generated by reactions between the components of the air and cell. A fuel cell vehicle has zero-emission. Henceforth, They run on a normal chemical fuel where reasonable energies is being stored, and the range of fuel cell vehicles is quite satisfactory. Thus it offers the only real idea of a silent zero-emission vehicle comparable with IC engine vehicles. Fuel cell technology shows great scope and it can make combustion engine lesser in usage.

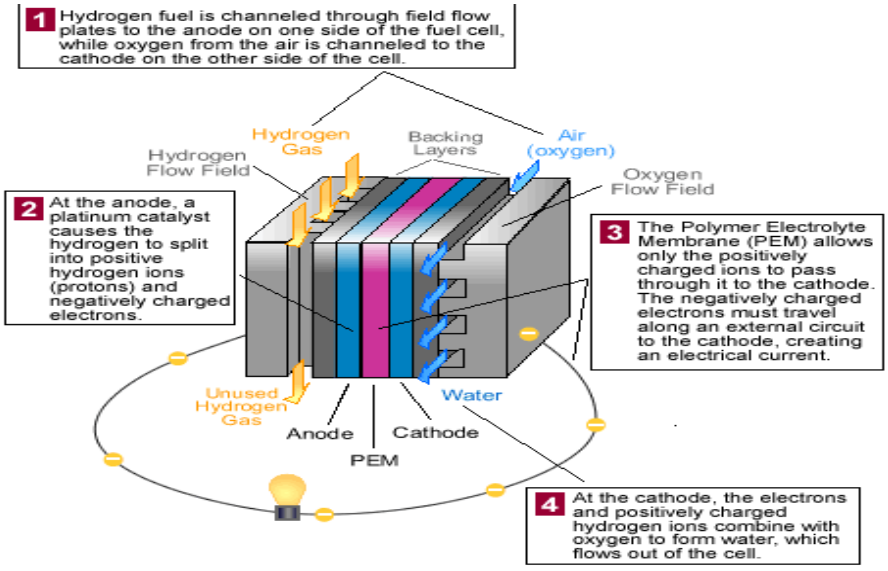

Fig 3. Fuel Cell

International Journal of Engineering Research & Science (IJOER)
ISBN: [978-93-5321-411-1] ISSN: [2395-6992] [Vol-5, Issue-3, March- 2019]

2.4 Hybrid EV

The manufacturers develop vehicles in which the engine and motor are used in synchronous to analyze the vehicle economy. The vehicles are Honda Insight and Toyota Prius, which have made an impact on car designing, and has made electric cars easily usable. And thus its manufacturing is increasing.

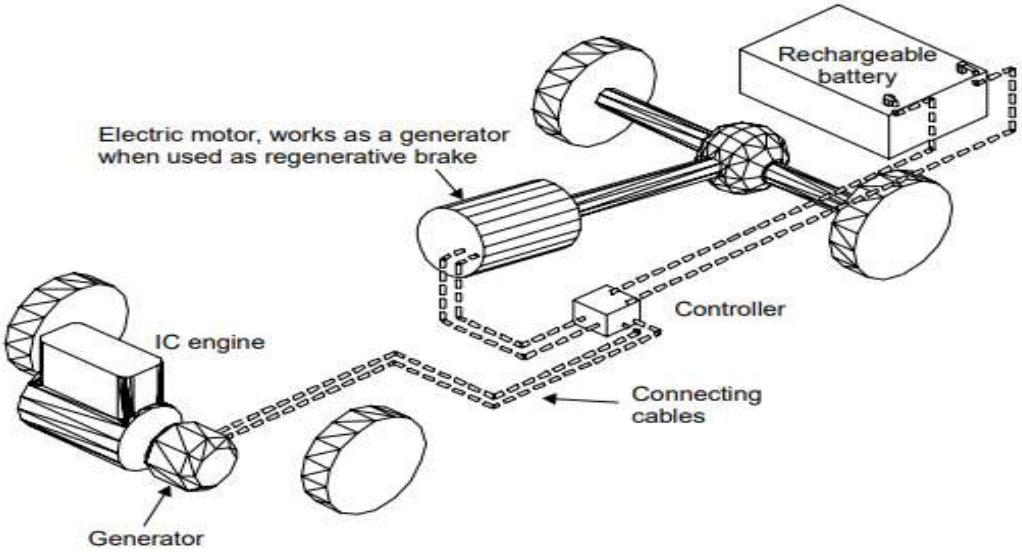

Fig.4. Series Hybrid

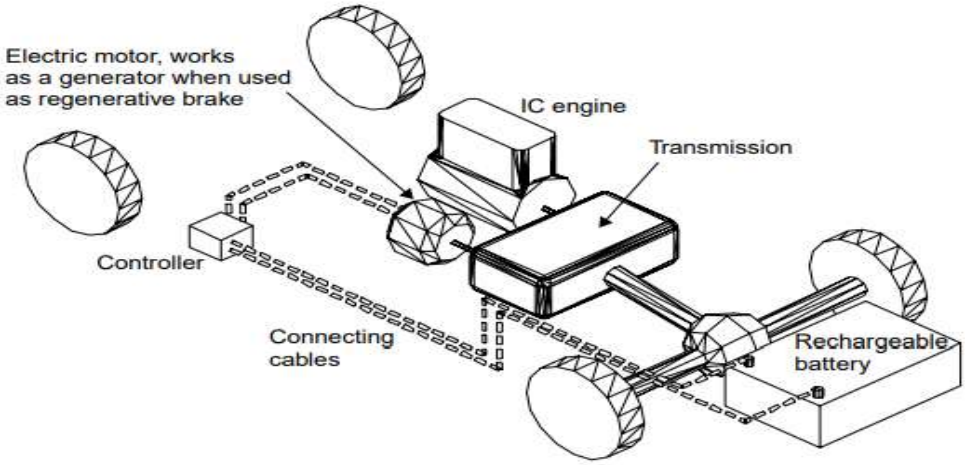

Fig.5.Parallel Hybrid

III. DETAILS OF COMPONENTS

3.1 Battery

3.1.1 Lead Acid Battery

For electric vehicles, the strong lead acid batteries can withstand deep usage of gel than liquid electrolyte.These batteries are expensive to produce. They have negative plates which are spongy and lead is an active material with lad dioxide. And the plates

International Journal of Engineering Research & Science (IJOER)
ISBN: [978-93-5321-411-1] ISSN: [2395-6992] [Vol-5, Issue-3, March- 2019]

are put into dilute sulphuric acid which combines with lead and lead oxide to produce lead sulphate and water where reaction is: $Pb + PbO2 + 2H2SO4 \leftarrow\!\!-\!\!-\!\!\rightarrow 2PbSO4 + 2H2O$

Nominal battery parameter lead acid batteries

Specific energy 20–35 Wh.kg−1

Energy density 54–95Wh.L−1

Specific power ~250 W.kg−1

Nominal voltage 2 V

Amphour efficiency ~80%, low, ~0.022

Self-discharge ~2% per day,

Number of life cycles Up to 800 to 80% capacity

Recharge time 8 h (but 90% recharge in 1 h possible)

3.1.2 Nickel Metal Hydride Battery

The nickel metal hydride (NiMH) battery was introduced in 20th century. It is similar to the NiCad battery, and the difference is that in the NiMH battery the negative electrode use hydrogen, absorbed in metal hydride, which makes it cadmium free, having a considerable advantage. Here negative plates acts as a fuel cell.

Nominal battery parameters

Specific energy ~65 Wh.kg−1 depending on power

Energy density ~150 Wh.L−1

Specific power 200 W.kg−1

Nominal cell voltage 1.2 V

Very low, ~0.06 per cell for a 1 Amphour cell

up to 5% per day Number of life cycles ~1000 to 80% discharge

Recharge time 1 h, rapid charge to 60% capacity 20 mins

3.1.3 Sodium Sulphur Batteries

The negative electrode consists of molten sodium, and the positive electrode consists of molten sulphur polysulphides. The electrolyte is beta alumina ceramic, which conduct the sodium ion which separates the two electrodes. The actual cells are small and they are joined and placed in a evacuated chamber to reduce heat losses. The design of the container is carefully and it doubles the mass of battery. Before the batteries they are heated on a working temperature. While they are self heating and electric current passes through battery resistance. The battery interior is kept hot by electric heaters. The energy is produced by sodium sulphide with chemical reaction as $2Na + xS \leftarrow\!\!-\!\!-\!\!\rightarrow Na2Sx$

Nominal battery parameters for sodium sulphur batteries.

Specific energy 100 Wh.kg−1 (Potentially 200 Wh.kg−1)

Energy density 150 Wh.L−1

Specific power 200 W.kg−1

Nominal cell voltage 2 V

International Journal of Engineering Research & Science (IJOER)
ISBN: [978-93-5321-411-1] ISSN: [2395-6992] [Vol-5, Issue-3, March- 2019]

Operating temperature 300–350◦ C

Self-discharge Number of life cycles ∼1000 to 80% capacity

Recharge time 8h

3.1.4 Lithium Batteries

Lithium battery was manufactured in early 1990s and for positive electrode it used lithiated metal oxide and for negative it uses lithiated carbon. With solid polymer or liquid organic as an electrode. Electricity is generated by the combination of lithium carbon and lithium metal oxide with reaction as C6Lix + MyOz ←−−→ 6C + LixMyOz

Specific energy 90 Wh.kg−1

Energy density 153 Wh.L−1

Specific power 300 W.kg−1

Nominal cell voltage 3.5 V

Operating temparature, ∼10%

Number of life cycles >1000

Recharge time 2–3 h

3.1.5 Metal Air Batteries

Here in positive electrode oxygen reacts with electrolyte which is liquid alkaline. Here the negative electrode is zinc which reacts with oxygen and forms zinc oxide. Zinc hydroxide with aluminium air cell is also produced Nominal battery parameters for zinc air batteries

Specific energy 230 Wh.kg−1

Energy density 270 Wh.L−1

Specific power 105 W.kg−1

Nominal cell voltage 1.2

Number of life cycles >2000

Recharge time 10 min, while the fuel is replaced

3.2 Ultracapacitor

The ultra capacitor having high specific power up to 5000 W/kg and cycle life of over 300,000 cycles but a low energy density of 5 Wh/kg

Ultracapacitor:Current-200A
Capacitance-3178
RC sec- 1.51

3.3 Fuel Cell

Data for different types of fuel cell Fuel cell type Mobile ion Operating temp.

Alkaline − 50–200◦ C

Proton 30–100◦ C V

7th National Conference on
"Role of Engineers in Nation Building" organized by VIVA Institute of Technology, Mumbai
(1st and 2nd March 2019)
International Journal of Engineering Research & Science (IJOER)
ISBN: [978-93-5321-411-1] ISSN: [2395-6992] [Vol-5, Issue-3, March- 2019]

Direct methanol H+ 20–90◦ C

Phosphoric acid H+ ∼220◦ C

Molten carbonateCO3 2− ∼650◦ C

MW capacity Solid oxide O2− 500–1000◦ C

Size 2 kW to multi MW

IV. MATLAB SIMULATION

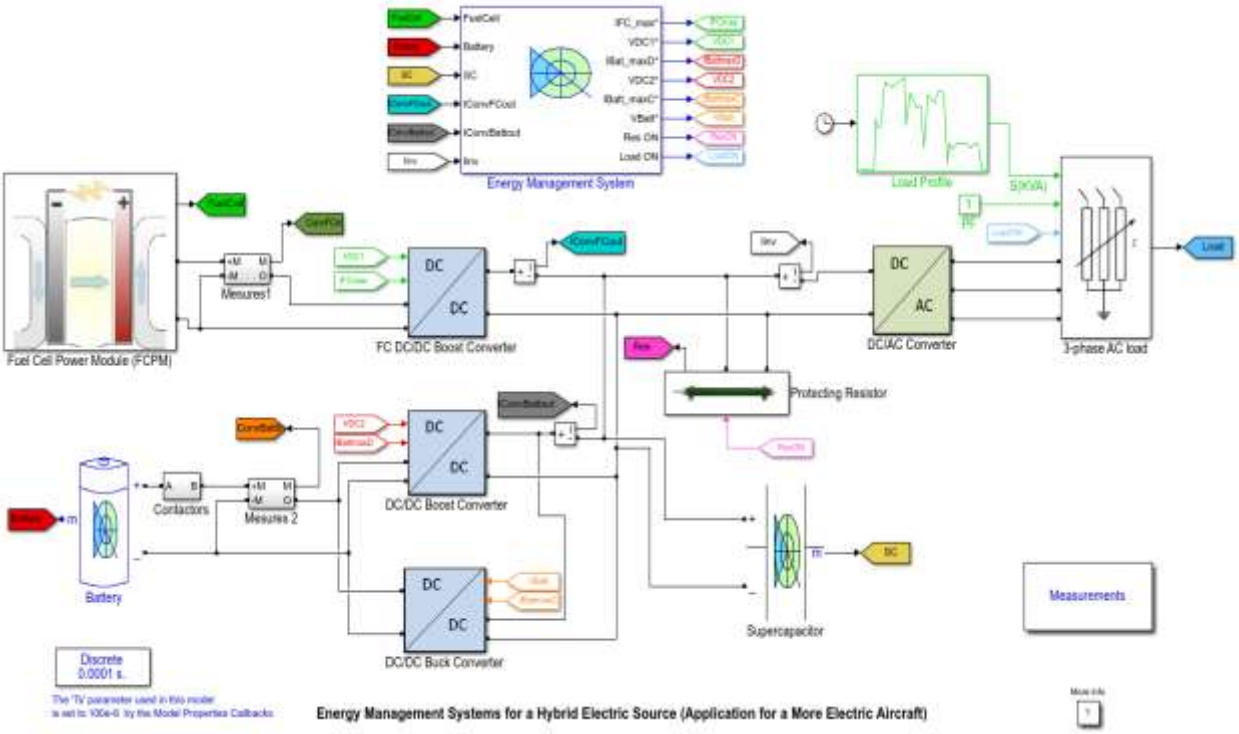

Fig.6. Energy management system for Hybrid Electric source

V. CONCLUSION

Environment Friendly ,No Green house gas, Alternate of IC Engine, High Fuel Economy, EV has a big Market,India is developing EV and is in the world market, Petrol and diesel usage is not needed, Huge Scope for Advancements. Public & Private Transportation, Ultra Capacitor can be used for energy density controller, Battery can be used in Auxillary Equipments, Fuel Cell is the alternate energy source. Battery stresses, ultracapacitor efficiency and hybrid use for regenerative braking and Fuel cell use and future in EV industry is being known and studied. Efficient performance of energy providing components are studied.

ACKNOWLEDGEMENTS

We have done this Project by referring IEEE papers and Books Refrences of those papers and books is given below.

REFERENCES

[1]. Ioan Aschilean et.al,''One such hybrid system is the tandem hydrogen and proton-exchange membrane fuel cell''.

[2]. Li Q Yang et.al,''applications of supercapacitors''.

International Journal of Engineering Research & Science (IJOER)
ISBN: [978-93-5321-411-1] ISSN: [2395-6992] [Vol-5, Issue-3, March- 2019]

[3]. Jarminie,'' Electric vehicle technology explained'',2003 jarminie.

[4].Vinaykm:-''Series hybrids can be assisted by ultracapacitor which can improve the efficiency by minimizing the losses in the battery''.

[5].Sanjeevanikumar Padmanban,Lucian Mihet-Popa,''A comphrehensive study of key electric vehicle (ev) components, technologies, challenges,impacts,and future direction of development''2017.

[6].SIAM,''Adopting Pure Electric Vehicles:key policy enablers''.

[7].AVALON,''Electric vehicles in india''.

[8].jian,''methods to asses the power quality of plug in electric vehicles,power deliv 2014.

[9]. Melo n, mira f, de almeida, ''Integration of PEV'',October2011.

[10].yu.xe,xue,ysirouspour,s,emadi,''a microgrid and transportation electrification'',18-20june 2012.

[11].mahila,t.m.i,saktiaahdan,tj,jannifar,a hassan,''a review of available methods and development of energy storage'',2014.

[12].bolund b,bernhoff,h,leijon,m,''flywheel energy and power storage system'',rev.2007.

[13].luo,x,wamg,dooner,m,clarke''overview of current development of electrical energystorage technologies and applications,2015.