iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 Issue: VII Month of publication: July 2020

DOI: https://doi.org/10.22214/ijraset.2020.30714

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue VII July 2020- Available at www.ijraset.com

LFP based Solar Energy Storage System

Noorbasha Mohmed Rafiq[1], Shaikh Ashhar Ahmed Ashfaque Ahmed[2]
[1]B.Tech Students, Electronics & Communication Engineering, Geethanjali College Of Engineering and Technology, Telangana
[2]Chief Technology Officer, BharatMobi, Hyderabad, Telangana

Abstract: The electricity grid system is a complex system in which power supply and power demand must be balanced at any given point of time. Energy storage plays a key role in balancing and creating a more flexible and reliable grid system. There are different methods to store energy in an effective & efficient way. Emerging storage facilities will allow us to store energy generated from renewable energy resources such as wind & solar on shorter time frames to smooth variability, and on longer cycles to replace ever more fossil fuel. By electrifying storage facilities with energy generated from renewable energy sources, we can reduce our greenhouse gas emissions and our major dependency on fossil fuels. This paper deals with different mechanisms of energy storage from capacitor to traction batteries. LFP based energy storage system is an efficient & precise mechanism to store & regulate energy from renewable energy resources. Renewable energy extracted through solar power plant or photo voltaic systems can be stored in LFP based batteries. Using Power Electronic devices, Power & Energy can be regulated & maintained to suit different load condition.

Keywords: Energy, LFP, Renewable, Battery, Energy Storage, Grid

I. INTRODUCTION

The world is facing trouble with regards to shortage of power, power generation, cost of operation and huge demand now a days. The country has to choose power generation method, technique and economical strategy based on own available natural resources, technical expertise and economy. The power generation and energy is back bone of each & every single country to survive in this world. Electricity generation is the process of generating required electrical power from primary sources of energy. During the 1820s and early 1830s, fundamental method to produce electricity was developed by the British scientist Michael Faraday. His process is still used today. Electricity is generated by moving a loop of wire, or disc of copper between the poles of a magnet. Since 1881 world is generating electricity for various applications. . The hydroelectric power plant and coal power plant are the first power plants being developed to extract electricity. There are various methods of power generation i.e. Hydro-power, Coal Power, Nuclear, Thermal Power which depend upon of the characteristic, economy and natural resources of every country. Hydro- and Coal based power generation methodology is very suitable, economical & reliable for India, Pakistan, China, etc but worse for Saudi Arabia and Middle East etc. In Saudi Arabia, Iran & Middle East thermal power method is very economical, suitable and reliable.

A. Coal Based Power Generation

Coal or Thermal Coal is used in power plants & stations to produce electricity. Coal is converted & milled to a fine powder form, which allows it to burn more quickly. The powdered coal enters into the combustion chamber of a boiler (By Blowing mechanism) where it is burnt at high temperature. The hot gases and heat energy produced converts water present in tubes linings into steam. Steam turbine & generator are further used to extract power.

B. Thermal Based Power Generation

Small electric generators are often powered by reciprocating. Engines which uses fuel (diesel, biogas or natural gas) burning mechanism to generate power. Diesel engines are often used for secondary or auxiliary power generation, usually at low voltages. However in many cases large power grids also use diesel generators as emergency back up for a specific facility such as a hospital, to feed power into the grid during any circumstances.

C. Nuclear Based Power Generation

A nuclear reactor produces energy from splitting the atoms of uranium. Uranium-fuelled nuclear power is a clean and efficient way to boil water in order to make steam which drives turbine generators. Except for the reactor itself, a nuclear power station works similar to coal or gas-fired power stations.

D. Hydro Based Power Generation

Hydro power is generated by extracting energy from moving water. Rivers and streams are re-directed through hydro generators in order to produce energy.

E. Geothermal Based Power Generation

Geothermal energy is developed by harnessing geothermal energy from
The earth surface.

F. Wind Based Power Generation

Wind power is generated by extracting the kinetic energy of wind. Wind energy is now becoming popular as a large scale energy resource, although it still only contributes less than one percent of total energy consumption requirements of globe.

G. Wave Based Power Generation

Electricity generators are placed on the surface of the ocean at different levels. Through wave motion, electricity is produced. This energy is mostly used in desalination plants, power plants and water pumps. Energy output depends on wave height, wave speed, wavelength, and water density.

H. Bio Mass Based Power Generation

Through consumption habits of modern consumers a huge worldwide waste is generated which is a global problem. Local landfill capacities are overfilled. Electricity can be generated while recycling landfill waste.

I. Tidal based Power Generation

Tidal energy is produced through tidal energy generators. Underwater turbines of large capacity are kept in high tidal movement areas so as to extract the kinetic motion of ocean tides in order to produce electricity. Tidal power has great production potential for future power and electricity generation.

J. Solar based Power Generation

Solar power is produced by collecting sunlight and converting it into electric power by means of photo voltaic systems. This is done by using solar panels, which are large panels made up of many individual photovoltaic cells.

II. DIFFERENT ENERGY STORAGE METHODS

The operation of electric power grid is based on an accurate balance between supply (Power Generation) and demand (Power Consumption). One way to rectify or reduce fluctuations in electricity supply and demand is to store electricity during periods of high production and low demand, then release it back to the grid mechanism during times of higher demand with lower production. . Energy Storage may give provisions like economic, reliability, and environmental benefits.

A. Pumped Hydropower

Pumped Hydropower Storage uses electricity in excess to pump water from one reservoir (at lower level) up to a higher level reservoir (Hill/Mountain) where it is stored. When electricity is required, the water is then released from the higher reservoir through a typical hydro-power turbine to generate electricity. Pumped hydro is one of the largest-capacity type of power storage and it accounts for 99% of all bulk storage globally. While pumped-hydro storage is reliable & efficient having capability of holding huge capacity, its main challenge is it requires a suitable mountain or hill to be converted into a giant storage. Unsurprisingly, not every landscape offers that.

B. Flywheels and Supercapacitors

Some of the most-fast responding forms of energy storage are flywheel and Supercapacitors storage. Both gets discharge and recharge at faster rate than most conventional forms of batteries. In Flywheel Storage, there will be spinning a rotor (or flywheel) to very high speeds using electrical energy input. This process creates kinetic energy. This produced kinetic energy is effectively stored within the spinning rotor until it’s required. When needed, stored kinetic energy is converted back into electricity. Supercapacitors works in a similar manner but store power electrically. Exhibiting joint properties of a battery and a capacitor, Supercapacitors store energy as a static without actual chemical reaction.

C. Lithium-ion Batteries

Lithium-ion batteries are already part of many electronic systems because of high-energy density and low self-discharge rates. But with advancement of technology, they are being used as energy storage system for EVs & Huge Power Systems. Lithium-ion batteries are now the most widely used batteries for Electric Vehicle Application, but manufacturers are still facing the challenge of lowering the cost of their manufacture to a considerable point so that EVs will be easily accessible to all.

D. Solid State Batteries

The main complaint for most domestic batteries today, be they in electronic appliances or EVs, is they just don't last long enough. This is where solid-state batteries have a good advantage. Solid State Batteries are smaller in size, cheaper in cost and have a greater energy density as they use solid electrodes and electrolytes rather than liquid electrolytes (used in most commercial batteries). They can also be recharged much faster and with less heat emission. In an EV, solid state battery technology can result to better efficiency, lower costs and safer operation. The only issue is the technology isn't quite viable at large scale yet.

E. Hydrogen Fuel Cells

Hydrogen is the most attractive fuel for any power-generation technology as it is one of the most-abundant elements on earth. Hydrogen Fuel cells are gaining very fast popularity in the automotive space. The fuel cells work similarly manner of batteries having two electrodes separated by an electrolyte. Hydrogen fuel cells can produce electricity as long as a constant supply of hydrogen and an oxidizer are pumped through it. We need to feed regular supply of hydrogen to generate power. Apart from powering cars, hydrogen fuel cells have also been used to power buildings and NASA satellites.

F. Vehicle-to-grid systems

EVs can themselves start acting as Energy Storage. Between journeys, all cars spend long periods of stationary time. Vehicle-to-grid (V2G) systems can take advantage of this time and give EVs the ability to discharge their stored electricity for distribution across the grid, helping meet power demand. Cars can become mini power plants. Smart charging systems will assist to automate this give-and-take of electricity further promoting a green environment.

G. Compressed Air Energy

Compressed air energy storage works in a similar way of pumped hydropower system, but instead of pushing water uphill, excess electricity is used to compress and store energy underground. When electricity is needed, the pressurized air is heated which results it to expand and released, driving a turbine. Behind pumped hydro-energy, compressed air is the second-largest form of energy storage mechanism. Development is being going on to make it more efficient and less dependent on fossil fuels to heat air.

H. Lead-acid Batteries

Their technology might be an old one, but lead-acid batteries are still used today for the simple reason that they still work. Lead-acid batteries are cheap to produce and highly reliable compared to new innovations in battery tech. Today, they are most commonly used as car batteries, but they have also long served as off-grid storage for solar arrays. Their main disadvantages are toxic nature of the involved chemicals and the short lifespan of 300 to 500 cycles. While the world is hunting for more-efficient, longer lasting, faster charging and lighter batteries, lead-acid models remain the cheap, tried-and-tested, system for small-scale storage.

I. Redox flow Batteries

If we focus on renewable energy storage, Redox flow batteries are significantly cheaper than lithium-ion grid-scale storage while offering a longer lifecycle. Flow batteries they have two tanks of liquids that are pumped into a reactor where they generate a charge. The capacity of the storage facility depends on the size of the tanks holding their respective liquids. Compared to other grid-scale storage systems, Redox flow batteries are more economical. They suffer less vulnerabilities. And they have potential to store large amounts of energy for long periods of time

J. Liquefied air

Storing Air, by cooling air down to -196oC & turning it into a compressed liquid. When ambient air is exposed to this liquid it re-gasifies and expands in volume rapidly resulting in rotation of turbine. One of the main advantages of this form of storage is its very high capacity. Around 700 litres of ambient air can be reduced to just one litre of liquid air.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue VII July 2020- Available at www.ijraset.com

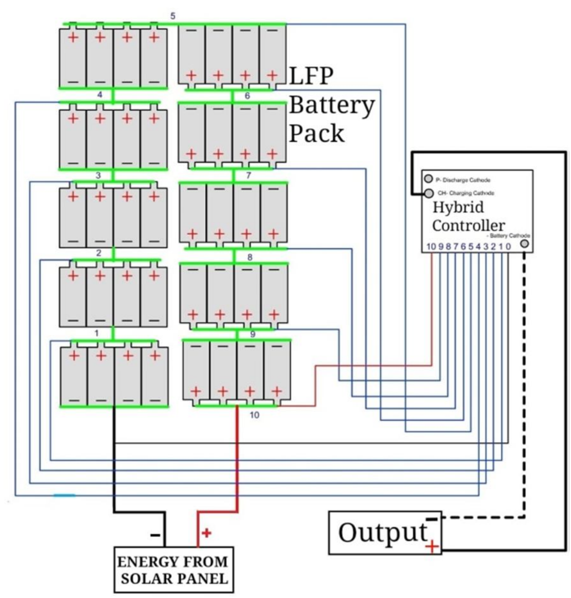
III. LFP BATTERIES

The lithium iron phosphate battery is a kind of lithium-ion battery. It uses LiFePo4 as the cathode material, and metallic backed graphitic carbon as anode. These LFP batteries are made with natural materials which are non-toxic and abundant in nature. LiFePO4 can be applicable in various places like in vehicle use, utility scale stationary applications, and backup power. The Cathode composition (weight) used is 90% of C-LiFePO4, grade Phos-Dev-12, with5% carbon EBN-10-10 (superior graphite), and with5% of polyvinylidene fluoride (PVDF). The Cell voltage of the individual battery is

A. Minimum discharge voltage = 2.5 V.
B. Working voltage = 3.0 ~ 3.2 V.
C. Maximum charge voltage = 3.65 V.
D. It stores energy per unit volume is 220 Wh/L (790 kJ/L)
E. The 100% Depth of Discharge cycle life (number of cycles to 80% of original capacity) = 2,000–7,000.
F. The10% Depth of Discharge cycle life (number of cycles to 80% of original capacity) > 10,000.
G. The specific power or loading capability is >90 Wh/kg.

IV. STORAGE IN LFP

In LFP batteries the energy is stored in a chemical form and converts that stored chemical energy into electrical energy when needed. When the solar panel is activated then LPF starts storing the energy using battery management system (BMS), because of BMS the lifespan of the battery increases, which helps to decrease the maintenance cost. Batteries are connected in series and parallel fashion to give the desire amount of voltage and this connection helps easy storage of energy. A hybrid power controller is used to maintain constant power supply.



V. SOLAR POWER PLANT & PV SYSTEM

Since the starting of time, people have been fascinated by Sun & Solar Energy. Looking at history, farming and agriculture efforts have significantly relied upon the sunlight to grow crops and sustain populations. However humans have developed the ability to harness the sun's power. The resulting technologies have promising future for renewable energy and sustainable development. Solar power is a form of energy that we harness from the power and heat of the sun's rays. It is renewable and green source of energy. A solar power plant is known for converting sunlight into electricity using photovoltaic effect. Concentrated Solar Power Systems focuses on a large area of sunlight via a small beam using lenses, mirrors, and tracking systems Photovoltaic converts sunlight into electric current using the photoelectric effect.

VI. SOLAR ENERGY STORAGE IN LFP BATTERIES

The solar energy starts storing in the form of chemical energy in the LFP battery pack. It charges using BMS seeing that all the batteries are charged completely and are not over charged, it cuts off the power supply after the battery packs are completely charged. According to Electricity Board of India the annual residential consumption of average electricity used is 1,181 kWh per capita. Residential consumption per day is 90kWh. So we need to use battery pack more than 90kWh

VII. ADVANTAGES OF LFP BASED STORAGE MECHANISM

As the lifespan of these batteries is larger than lithium ion batteries .the long cell life is useful in solar energy storage units. These batteries are maintenance free as their longer shell life means lesser expenses for the house owner. LFP batteries are highly unlikely to overheat or worse - catch fire, even if they are overcharged. Since solar power setups are often installed in homes or office buildings, safety is a top priority. The advantage is stability is particularly pronounced in higher temperature environments and situations where a high voltage like the ability to run a microwave or refrigerator is needed. These are highly safe because they can be used even in highly temperature environment. LPF batteries are Earth friendly compared to any other batteries available. They contain common and readily available materials like iron, graphite and copper. This makes them easier to recycle and in fact, some lithium Ferro phosphate batteries are already made from recycled materials. With their increased safety, longer life span, and environmental advantages, lithium Ferro phosphate batteries are uniquely suited to the solar power industry. Consumers will undoubtedly be happy with this alternative to other battery options on the market

VIII. CALCULATION FOR POWER CONSUMPTION DEMAND

First of all we need to determine the power consumption demand. Based on that PV System, Inverter & Energy Storage System can be figured out. The very first step is to calculate the total power and energy consumption of all loads that need to be supplied by the solar PV system.

It is two-step process to find the power consumption demand

1) *Power Consumption Demand Calculation*
   a) Calculate total Watt-hours per day usage for each appliance
   b) Calculate total Watt-hours per day required from the PV modules
2) *Let us suppose we are going to have solar based system for one house. House has the following electrical Appliance Usage*
   a) 4, 18 Watt fluorescent lamp used 6 hours per day.
   b) 2, 60 Watt fan used for 8 hours per day.
   c) 1, 75 Watt refrigerator that runs 24 hours per day with compressor run 12 hours and off 12 hours

Total appliance use = (4 x 18 W x 6 hours) + (2 x 60 W x 8 hours) + (1 x 75 W x 24 x 0.5 hours)

=432+ 960+ 900= 2292 Wh/day

Total PV Panel Energy Needed= 2292*1.3

=2979.6

Note: 1.3 we have multiplied to consider energy losses

IX. CALCULATION FOR PV PANEL SIZE

Once we have got the power consumption demand & what power we need from PV Module, then we can proceed to find the PV Panel Size.

First we will calculate the watt peak needed & with that value we can decide PV Panel Size & Quantity.

Total Wp of PV panel capacity required= 2979.6/PGF

=2979.6/2.93=1016.93 Wp

Note: PGF is Panel Generation Factor

PGF for EU region is 2.93

Based on best available resources we can110 Wp PV modules

Number of Panels Needed= 26887.3/110

=9.244

= 10 Modules

X. CALCULATION FOR INVERTER SIZE

Total Watt of all appliances = 4*18+2*60+1*75=267
The inverter must be considered 30% bigger size for safety.
The inverter size should be about 347.1 W or greater.
We can consider power for inverter as 350 W.

XI. CALCULATION FOR BATTERY SIZE

Total appliances use = (18 W x 6 hours) + (60 W x 8 hours) + (75 W x 12 hours)
Nominal battery voltage = 12 V
Days of autonomy = 4 days
Battery capacity =
{4*[(18 W x 6 hours) + (60 W x 8 hours) + (75 W x 12 hours)]}/ (0.85 x 0.6 x 12)
= 972.5 Ah
Factor 0.85 we have used for battery loss.
Factor 0.6 we have sued for depth of discharge.
Total Ampere-hours required 1000 Ah
So the battery should be rated 12 V 1000 Ah for 4 day autonomy.

XII. CALCULATION FOR SOLAR CONTROLLER SIZE

PV module specification
Pm = 110 Wp
Vm = 16.7 Vdc
Im = 6.6 A
Voc = 20.7 A
Isc = 7.5 A
Solar charge controller rating = (10 strings x 7.5 A) x 1.3 = 97.5 A
So the solar charge controller should be rated 100 A at 12 V or greater.

XIII. CONCLUSION

We can conclude that LFP based Solar Energy Storage System is one of the effective way to store energy. And it is offers series of advantages. Longer life span, no maintenance, extremely safe, lightweight, improved discharge and charge efficiency etc.

REFERENCES

[1] Dincer, I. Renewable energy and sustainable development: A crucial review. Renew. Sustain. Energy Rev.2000, 4, 157–175.
[2] Chen, H.; Cong, T.N.; Yang,W.; Tan, C.; Li, Y.; Ding, Y. Progress in electrical energy storage system: A critical review. Prog. Nat. Sci. 2009, 19, 291–312.
[3] Vazquez, S.; Lukic, S.M.; Galvan, E.; Franquelo, L.G.; Carrasco, J.M. Energy Storage Systems for Transport and Grid Applications. IEEE Trans. Ind. Electron. 2010, 57, 3881–3895.
[4] Ferreira, H.L.; Garde, R.; Fulli, G.; Kling, W.; Lopes, J.P. Characterisation of electrical energy storage technologies. Energy 2013, 53, 288–298.
[5] Rebours, Y.G.; Kirschen, D.S.; Trotignon, M.; Rossignol, S. A Survey of Frequency and Voltage Control Ancillary Services—Part I: Technical Features. IEEE Trans. Power Syst. 2007, 22, 350–357.
[6] Liu, G.; Tomsovic, K. Quantifying Spinning Reserve in Systems with SignificantWind Power Penetration. IEEE Trans. Power Syst. 2012, 27, 2385–2393.