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A review on Super-capacitors and Batteries integration for Power Fluctuations mitigation in PV-system

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ABSTRACT

PVenergysystemsaretypicallyintegratedintoenergystoragesystems,mostlylead-acidbatteries, to compensate for the supply of demand mismatches caused by solar energy. The life span of batteries containing lead-acid, on the other hand, raises the operating cost of PV power systems. Researchers have suggested a supercapacitor-battery HESS increases the battery bank's cycle life by reducing the charge-discharge stress because of fluctuating energy exchanges. Current HESSandtheirrelatedenergymanagementapproaches havedifferenttopologies,complexity,and application-based control algorithms in terms of complexity, control & topology algorithms. In thepaper,athoroughassessmentofthestate-of-artphotovoltaicsystemsforhybridenergystorage systems is presented and potential topologies that improve the service life of the lead-acid battery are discussed. The effectiveness of various HESS in reducing battery stress & related financial study may be quantitatively compared. In the end, the scaled-down HESSprototype.

Keywords: Hybrid topologies, Inverters, THD, CHB, PWM, sinusoidal pulse width modulation, Solar System, Solar panel, MPPT, phase shift pulse width modulation, Solar power, Renewable Energy.

I. INTRODUCTION

In the development of economy & modern society, electricity is one of the crucial elements. Reliableandaffordablesuppliesofelectricityareessentialforeconomicactivities&thedailylife of people. Electricity is available to almost 1.3 billion people by 2015, & over 95 percent live in rural areas & developing countries [1]. 32 off-grid rural communities usually have decentralized, low populations & isolation of the national grid [2]. Because of financial constraints & resources, the conventional power transmission & distribution method often makes it harder to obtain electrification in such areas. The autonomous power system, which is dependent on renewable energy sources & environmentally friendly technologies, is an auspicious solution for rural electrification. Solar Photovoltaic (PV), wind, geothermal, hydropower, biomass, tides, ocean waves & solar thermal are typical renewable energy sources, but over the last decades, photovoltaic has become one of the more significant renewable energy technologies because of low operating cost, their modularity, ease of installation, & mature technologies [3]. Applications ofPhotovoltaicwillbedividedintostandalone Photovoltaic&Photovoltaicsystemsthataregrid-connected.Off-gridcommunitiesmainlyuselow-capacitystandalonePVsystemstoproduceelectricity for basic electricity requirements including food refrigeration, lighting & other electrical appliance [4, 5].

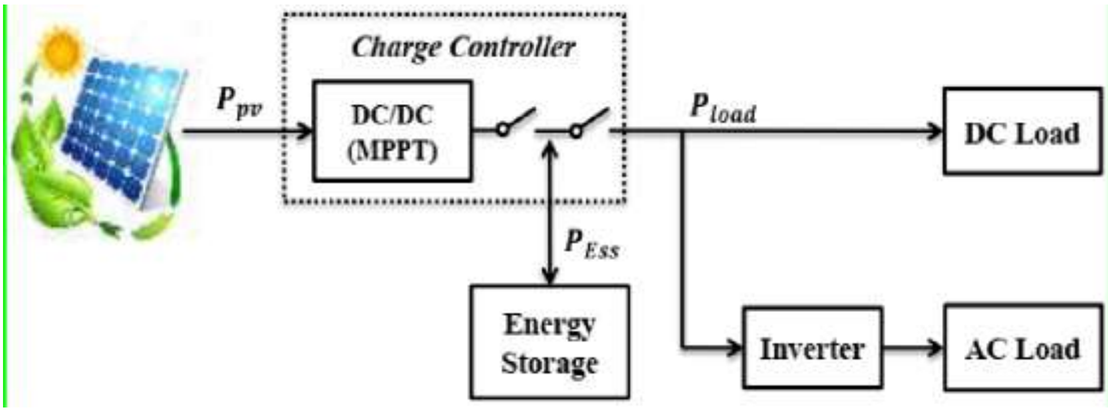

Fig. 1 Typical standalone Photovoltaic-battery power system

Solar energy is converted into electricity by interconnecting and encapsulating PV cells into modules or arrays. The nonlinear electrical features of solar radiation intermittency and photovoltaic cell necessitate the integration of an intermediate ESS to generate a stableelectricity supply to the loads. While the battery is protected against overload and overflow, the charge controller is used to control the charging operation. For converting DC to AC power for modern electrical devices like refrigerators, TV, washing machine and lighting, etc. by using the inverter. 2 more common technologies of Energy storage systems in residential energy equipment [6] are lead-acid (LA) and lithium-ion (Li-ion) batteries. Batteries of Li-Ion are more round-trip power, longer cycle life, & greater energy capacity than LA batteries, but in large-scale packaging, they aremoreexpensive&immature.Onanotherhand,LAB atteryBank,becauseofitslowercostand enhanced thermal stability is better suited for standalone Photovoltaic power systems, especially inruralelectricity.Photovoltaicpower,whichrequiresr egularcharge-dischargecycles,putsextra stress on the battery, minimized its service life [7, 8]. Hybridizing the various Energy storage system technology is one of the promising methods of mitigating battery charge-discharge stress through steering the short-term fluctuation in power into another type of energy storage system like supercapacitor (SC) [9–11]. short charging-discharging time, The Supercapacitor has a high-powerdensity,shortcharging-dischargingtime,&acloselyinfinitecyclinglife.Inasta ticelectric field that stores electricity by electrons and has a short discharging-charging time, high power density & almost infinite cycling life[12].

The net current exchanger is subdivided into 2 or more frequency elements with a hybrid energy storage system (HESS) battery- SC. The main biggest battery bank provides the low-frequency portion, frequently the nominal current profile. Owing to the intermittent solar power & sudden shifting in load demand, the Supercapacitors consume high-frequency power exchange as an ESS high power density. In recent decades, researchers have proposed several iterations of HESS and its associated energy management device[13–18]. Normally these HESS designs are studied for serving the applications of large-scale utilities, electric vehicles, smart grids, & other high- power & they need computation, communication, & extensive. It substantially enhances the implementation & complexity of the systems. However, the sequence of the easiest passive structure with complex active HESS topologies was presented and discussed iteratively. To show the feasibility & efficiency of reducing battery stress in Photovoltaic power systems on basis of case studies from a numerical simulation, remote community, & theoretical analysis of selected HESS arepresented.

II. SOLAR ENERGY

In Solar power generation, it is possible to produce either directly or indirectly usingphotovoltaic (PV) cells by collecting and concentrating solar power (CSP) to produce steam that is used for driving a turbine producing electric power. To generate direct electricity from Solar energy, the PV effect, which refers to the fact that light photons knock electrons in a greater energy state. Although photovoltaics were first used to power spacecraft, they now have a wide range of applications in everyday life, such as water extraction pumps, roadside emergency telephone, boats, remote sensing, grid-isolated houses, and electriccars.

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Concentrated Solar Thermal System (CST) uses sun-tracking systems & optical systems (usually mirrors)tofocusawideareaofsunlightintoarelativelysmallareaofreceiving.TheCSTisused for a traditional power plant as a heat source. There is a broad array of concentrated technology. The major concentrating ideas are a) solar dishes b) parabolic troughs c) solar power towers d) linear Fresnels. High temperatures and hence a high thermodynamic efficiency are the main goal of concentrating solarenergy.

1. Irradiation – For the current analysis, data from various sources was studied, & the source was defined dependent on a perception ofaccuracy.
2. Performance ratio – The performance ratio is found to depend on air temperature, irradiation, design parameters, optimal tilt angle, modular quality, inverter efficiency, etc. The results were obtained using RET screen software based on the above parameters. In India, some data on the recent installations of grid-connected power plants were comparable to the results.
3. Degradation – All manufacturers are guaranteed performance over the 25 years with 90 percent output over the first 12 years & up to 80 percent hence 25 years. Different studies of the extent of modules degradation after operation of the long-term field are carried by global renowned institutions. These results are analyzed for the actual performance in the field.
4. Life expectancy – Trends for the support structure, module, cabling & inverter, have been researched in acceleratedtesting.

2.1. Technology for Solar powerplants

The technology of Solar power generation may be generated in 2 broad types broadly: The following:

a) Solar thermal powerplants
b) SPVtechnology

2.2. Solar Photovoltaic (SPV)technologies

PV converter is a semiconductor device that transforms a portion of incident solar radiation into electricitydirectly.Singlecrystalsiliconisamorepopul arPhotovoltaiccellmaterial,buttthereare several alterations in design, cell material & manufacturing techniques. Amorphous silicon cells such as Copper Indium Gallium Diselenide (CIGS), Copper Indium Diselenide (CIDS) & Cadmium Telluride (Cd-Te), dye-sensitized solar cells (DSSC) & newer technologies such as quantumdots, carbonnanotubes CNT, andsiliconnanoparticleink,areallusedinsolarPVcells.

S.No	Module	Efficiency
1	Thin film	12-14%
2	Polycrystalline	15-16%
3	Monocrystalline	16-18%

2.3 Performance of solar powerplants

Thebestwaytodescribesolarpowerplanteffi ciencyistousethecapacityutilizationfactor(CUF) as an actual electricity o/p ratio between the plant and the extreme power o/p over the year. Solar power plant performance can be measured using standard software and measured by design parameters. However, since a plant's final production is influenced by several factors, the CUF may vary significantly. Weak panel selection/quality, module derating at greater temperatures, other design parameters such as atmospheric factors and ohmic loss for instance elongated cloud cover & mist may all be contributing factors. As a result, it's critical to make a list of the various factors that influence plant production variation. The power plant's output is influenced through a nooffactors,involvingthelocationofthesite,climaticc onditions,solarinsolationstages,mainly temperature, module mismatch, Technical cable losses, soiling losses, losses of MPPT, loss of transformers, and loss of inverters. Losses can also occur as a result of grid aging and module deterioration as a result of aging. Some of these are defined by the manufacturer, such as the temperature coefficient, which is the relationship between power output and temperature. Key performance metrics include the followingelements:

a) The plant’s designparameters
b) Losses in Photovoltaicsystems
c) Climatic & Temperatureconditions
d) Inverter efficiency

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e) Radiation at thesite
f) Module Degradation because ofaging

a) Solar radiation basics anddefinition

The primary driver is Solar radiation for several chemicals, physical & biological methods on the earth's surface & for research and application fields such as agriculture, hydrology, industry, meteorology, environment, agro-logy, limnology, ecology, and oceanography the accurate solar radiation data of any region is of considerable importance. Besides, solar radiation data are key inputs in solar energy applications like electricity-generating PV systems, solar heat collectors, solarheating,andclimatecontrolsystemsinbuilding& passivesolardevices[3].Manyempirical formulae for the calculation of solar radiation with different parameters have been developed. Others used a sunshine duration, while others used a rainy day, sunshine hours, and a factor depending on altitude & latitude. Some projects used sunshine duration. the main need for designingofsolarpowerprojectprecisearesolarradiationdata.Themethodusedtomeasuredata for a precise design is essential. Data can be measured (irradiance) instantaneously or integrated for one hour or day in a period (irradiation). For diffuse, total, and beam radiation, on an inclined orhorizontalsurface,datamaybeavailable.Thetypesof instrumentsusedforsuchmeasurements must also beknown.

b) Losses in PV Solarsystems

The device losses evaluated include all system losses, and the electrical power supply of the grid is lower than that generated by the photovoltaic modules. This loss is caused by many things like cableloss,powerinverter,dirtonmodules,ambienttemperature,differinglevelsofinsolation,etc. Thereareseveraldifferentreasonsforthisloss.Wemust takeintoaccountallpossiblelosseswhen designing PhotovoltaicSystems.

c) Reflectionlosses

In standard test conditions, Photovoltaic modules' power ratings are calculated that need perpendicular incident light. Higher incidence angles result in greater reflective losses in the field than in the nominal power ratings. Annual reflection losses with the STC are approximately 1% for equator facing modules with the tilt angle equals to latitude.

d) Soiling

The accumulation of dirt & dust may lead to the soiling of solar panels. The material is washed off in maximum cases through rainfall from the panel; further, even after heavy rainfall dirt such as bird droppings can remain. The bottom edge is the most important part of a module. Soiling at the edge of the frame happens particularly at rather low inclinations. In the shallow puddle b/w glass, & frame often repeated water collection accumulates and consecutive dirt accumulated. This dirt minimizes the power existing from the module when the cells are shaded. The usual losses are 1 percent, but when the modules are cleaned then the power isrestored.

e) Mismatcheffects

The parallel and serial interconnection of solar modules leads to Mismatch losses. Modules that have no equal or different characteristics. Mismatch losses in photovoltaic modules are a serious concern,andarraysaredefinedinthelowestoutputsolar modulebytheoutputofallphotovoltaic arrays. Therefore, when it comes to total plant performance, the selection of modules is very important.

f) Maximum Power Point Tracking(MPPT)

Solar PV module power output varies with changes in sun direction, changes in the level of solar insolation, and with varying temperatures. There is a single maximum power in the PV(power vs voltage) module curve. This means that the peak power equivalent to a current that exists & a certain voltage. Then the low module is inefficient, the module should be operated in a maximum power position to deliver the maximum power to the load under different temperatures and insolation conditions. This enhances the use of the solar photovoltaic module by maximizing power.Amaximumpowerpointtrackerextractsthemostpoweroutputfromthesolarphotovoltaic modules & transfers the power to the load. The most power is transmitted from the photovoltaic to load by the converter dc/dc (step-up/step-down). Maximum power point monitoring ensures that the panel o/p at the extreme powerpoint is always attained. The application of MPPT raises solarpowerplants'outputsubstantially.Themaximum powerpointatacross-sectionofthecurrent &voltagecurveataspecificirradiationvalueisasshown intheV-Icurvesforthemonocrystalline solar modulebelow.

Battery Type

In the relation to a possible range of BESS parameters, the battery type is of utmost importance. The battery types were not explicitly, rather implicitly used in the model, for some technical specifications. This section outlines both technical specifications for certain types of batteries commonlyusedingridstorageandlesscommonly-usedones—toprovidethereaderwithasense of perspective and why some quality is preferred over other qualities when choosing a battery configuration for a particular system. The corresponding range of model parameters is given for each of these types in relation to the chemical or physical composition of the batterytype.

1. Nickel-cadmium (NiCd)
2. Molten saltbatteries,
3. Lead-Acid(Pb-Acid)
4. Lithium-ion(Li-ion)
5. Sodium-sulfur (NaS)
6. Nickel-metal hydride (NiMH)
7. Lead-Acid(Pb-Acid)

2.4 Charging and grid connections

With various external control measures labeled as Charging Plans, The electric vehicle's battery canbegridrecharged.Asysteminwhichthevehiclestartschargingimmediatelyafterconnection to the grid is a simple or uncomplex charging system. Delayed battery charging compensates for 3 hours of charging. Night-time charging schedules will delay charging during the night, with batteriesfullyrechargedforusemorningwhenelectricitypricesarelowest.Smartchargingmeans thattheoperatorortheoperatorofthesystemhassomeintelligentcontroloverthevehicle’s charging. This may be used for the design of the vehicle to react to price signals, either indirect charging or direct control of the vehicle direct charging. Wietschel & Dallinger proposed that indirect charges are the most challenging since they tend to lead to consumer acceptance instead of direct external controls [6]. The concept behind intelligent charging is that the automobile shouldbechargedthemostadvantageouswayifelectricityattheirlowprice,ifthevolumeexceeds efficiencyorwhensomeanothermetricsareused.Thechargeratemayvarywithincertaindriver-specificlimitsandismainlylimitedinthefactthatthevehiclesmustbechargedfullybymorning.

2.5 Chargingcharacteristics

Charges at various PHEV locations are simply the charges. Charging features include voltagedrawn,circuittypes,loadaddedandthetimerequiredforthecharge.Thesecharacteristics will be important in future studies to build accurate PHEVs, particularly given that big car manufacturers will spend a great deal of time and money on developing test and battery procedures.Thesechargingcharacteristicsaredefined. Thesechargingcharacteristicswillalsobe required to be refined continuously to reflect more accurately real-world situations. No one type of vehicle or battery is available. There is no assumption. The type of vehicle or battery used to simulate the grid effects is defined in every study, as demonstrated in the studies. The impact of PHEVcharging,whichintegrateseconomicfactors,includingcostandtheavailabilityofcharging stations, is, therefore, an interesting approach. Since all type of batteries is distinct, mostly vehicles may have batteries with at least distinct charging profile & which is implausible that customers will own a single PHEV model from a single manufacturer in each region, future researchshouldfocusondistributingbatteriesandvehiclesfordifferenttypesandfleetsofPHEVs. This is very important because competitors compete for battery life, charging time, and loading time. These vehicle mixes must be based on economic data, which establish charging characteristics on the basis that the consumer is willing to spend more money to refill them faster[18]. The effects of PHev charging profiles on the aging effects should be modeled by other simulations. Perhaps it simulates how mixed Fleets of PHEVs can impact the distribution grid, where several are brand new, others are 1 year old & some yearsold.

III. CONCLUSION

One of the favorite solutions in the wide range of obtainable solar energy & the advances in sustainable techniques was the photovoltaic battery power system. Solar energy’s nature does thoughhaveafurtherinfluenceonthebatterywhichspeedsupbatteryperformanceandcyclelife deterioration. In the last decades, scientists have proposed the hybridization of different energy storage devices to extend battery life in a large number of high-energy applications. A comprehensive review of the HESS and its feasibility on the PV system was presented in this paper.Thefollowingpaperdiscussedthreepossibletopologiesforhybridenergystoragesystems, a related power allocation strategy, and a controlsystem.

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