



# Review of Energy Management and Control Strategy of Photovoltaic-Battery System

<sup>1</sup>Oshine Saxena, <sup>2</sup>Shilpam Saxena

<sup>1</sup>Research Scholar, <sup>2</sup>Associate Professor & Head  
Department of Electrical and Electronics Engineering  
Oriental College of Technology, Bhopal, India

**Abstract :** An intelligent energy management system (IEMS) for maintaining the energy sustainability in renewable energy systems (RES) is studied. It consists of wind and photovoltaic (PV) solar panels are established and used to test the proposed IEMS. Since the wind and solar sources are not reliable in terms of sustainability and power quality, a management system is required for supplying the load power demand. The power generated by RES is collected on a common DC bus as a renewable green power pool to be used for supplying power to loads. This paper reviews of energy management and control strategy of photovoltaic-battery system. MATLAB software can be used to design and implement of such type of models and check performance parameters like input voltage, current, power, losses etc.

**IndexTerms – DC, Microgrid, Renewable, Energy, Photovoltaic, Wind, Solar.**

## I. INTRODUCTION

With the advancement of renewable energy, for example, hydrogen energy, renewable energy supplies have been a significant piece of DC microgrid. Related control and power the executives have become the focal point of current examination numerous remote networks far and wide can't be truly or financially associated with an electric power matrix. The power request in these regions is expectedly provided by little disconnected diesel generators. The working expenses related with these diesel generators might be inadmissibly high because of limited petroleum product costs along with challenges in fuel conveyance and support of generators. In such circumstances, renewable energy sources, for example, solar photovoltaic (PV) and wind turbine generator give a practical choice to enhance motor driven generators for power age in off-matrix zones. It has been exhibited that hybrid energy systems can essentially lessen the all out life cycle cost of standalone power supplies in many off-network circumstances, while simultaneously giving a dependable flexibly of power utilizing a mix of energy sources. In this day and age, the expanding requirement for energy and the components, for example, expanding energy costs, constrained stores, and ecological contamination, drives the renewable energy to be the most alluring energy source. Since these sources have boundless flexibly and they don't cause ecological contamination, they are concentrated widely recently and used increasingly more consistently. Governments put in new enactments and feed-in-leivies to urge the financial specialists to put in new renewable energy usage destinations [1–3] and investigations on this subject are bolstered by numerous establishments.

Photovoltaic (PV)/battery hybrid power units have pulled in huge exploration interests as of late. For the regular dispersed power age systems with PV/battery hybrid power units, two free power converters, including a unidirectional dc-dc converter and a bidirectional converter, are typically required. This work review an energy the board and control technique for the PV/battery hybrid circulated power age systems with just one incorporated three-port power converter. As the coordinated bidirectional converter shares power switches with the full-connect dc-dc converter, the power thickness and the unwavering quality of the system is upgraded.

Renewable energy sources comprise of solar energy, wind energy, geothermal energy, and wave energy which are viewed as interminable since they exist normally and they generally restore themselves [4]. It is one of the significant themes that specialists and researcher take a shot at to get energy from these sources and utilize this energy by changing it into the type of electrical energy.

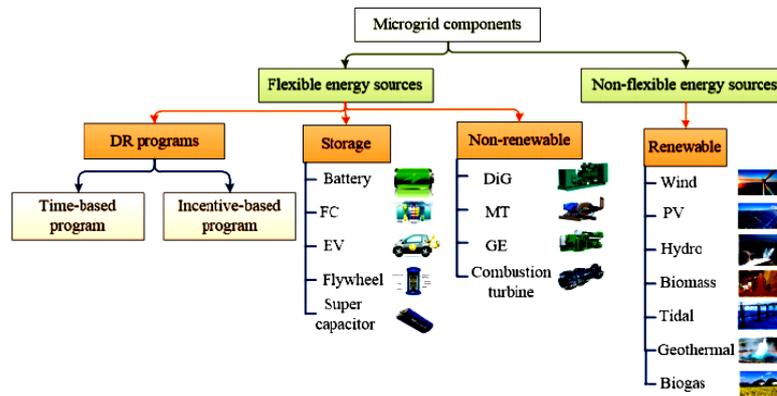


Figure 1: Microgrid Component

Solar and wind energies have a recognized spot among these energy types. There are wind and sun wherever on earth; in this manner, there is increasingly serious examination on these sources. The point isn't just to acquire the energy yet in addition to turn the energy to legitimate qualities, deal with the existent energy, and end the music. While dealing with all these, bringing down the expense of the system in each progression is thought about. Today, creating electrical energy from these renewable sources has all the earmarks of being the fundamental goal [5–7].

The consolidated activity of these systems is unquestionably more perplexing than working them independently. In a system with just solar or wind energy, only one component is controlled. In a hybrid plan, the two sources are controlled exclusively and all the while relying on the working conditions and energy request. During low daylight conditions, photovoltaic (PV) solar board can't flexibly reliable power. Likewise, wind turbine won't work in conditions without wind. For this situation, the necessary energy must have the structure to make up the absence of energy in conditions when this system doesn't work consistently or the synthesis delivers less energy than the prerequisite. Power the board guarantees that the system works effectively while forestalling the absence of energy in loads. Here it is planned for getting spotless and economical energy in stable recurrence and positive voltage. While or in the wake of acquiring the energy, music must be unquestionably controlled.

These days renewable energy sources are organized in two different ways as framework associated and standalone. Renewable energy sources as solar energy and wind energy can be utilized to take care of burdens a long way from the network particularly the home sort ones. Nonetheless, there are issues in these sorts of systems when there is no sun or wind. Clients become completely powerless after the batteries are level which are utilized as reinforcement systems. An elective circumstance to this is to associate the heaps to the matrix on the off chance that they are near it, in conditions that there is no sun or wind and the batteries are unfilled [9].

Also, energy the executives programming can quickly and persistently react without being limited to ecological conditions, which keep constantly some measure of power available for later and during immediate burden changes control the system effectively. This investigation is unique in relation to the others in its being proficient administration approach and having extraordinary, less expensive, and more straightforward pinnacle power point tracking.

## II. BACKGROUND

A. Kumar et al.,[1] The different energy resources, for example, sunlight based chargers and batteries assist electrical architects with overseeing and satisfy the rising need. The blend of environmentally friendly power assets with man-made consciousness is the vital focal point of giving high energy productivity elective sources. This arrangement won't just fulfill power need yet additionally help in decreasing ozone depleting substance emanations subsequently the proficient, supportable and eco-accommodating arrangement can be accomplished which would contribute a ton to the shrewd grid climate. Here, a changed dark wolf enhancer approach is used to foster an original energy the executive's framework for SPV-based microgrid thinking about current power grid cooperations. The proposed approach means to give a capable microgrid that uses sun oriented photovoltaic innovation, and energy stockpiling frameworks utilizing a man-made reasoning calculation based microgrid control for ideal dispatch of energy in grid-associated frameworks.

Z. Zhang et al.,[2] Three-port canny transformation frameworks, communicating photovoltaic (PV) exhibits and electric vehicles (EVs), with an electrical grid, are a promising adaptable foundation for future savvy grids. In this framework, multi-energy, direct current (DC), and alternating current (AC) power are decoupled by a bigger DC-connect capacitor. In any case, mass capacitors forestall the accomplishment of high power thickness and high dependability of this framework. To resolve this issue, dynamic power decoupling control for a solitary stage three-port change framework is proposed in this work. Inferable from its low inward impedance, the innate twofold line-recurrence swell power in a solitary stage framework can be effectively consumed by a Li-particle battery pack, with a sinusoidal charging/releasing procedure, in the proposed control methodology.

A. M. Mahfuz-Ur-Rahman et al.,[3] presents an energy the board procedure for a microgrid having sun powered PV clusters and a battery energy capacity framework (BESS). The vast majority of the energy the board methodology utilized for business photovoltaic (PV) inverters and battery inverters don't think about the future burden conduct and can't guarantee the energy versatility for a PV and battery capacity based microgrid. This article proposes the utilization of a model prescient control technique that considers future burden conduct and energy cost profile to decide an ideal power stream direction to accomplish energy flexibility, limit the working expense and boost the benefit of the microgrid. The proposed control procedure of the energy the executives framework (EMS) is approved involving the two recreations in MATLAB/Simulink climate and via doing research center examinations on a created lab test stage. For the converters of the test stage, this article fosters an attractively connected seven-level staggered converter (going about as the sunlight based PV inverter) and a full-span inverter with a high level pulsewidth regulation strategy (going about as the BESS inverter). Business inverters ordinarily require enormous and massive power recurrence transformers for the grid mix of environmentally friendly power sources.

R. Ando et al.,[4] an arranged power age that coordinates the arranged qualities submitted ahead of time with the genuine upsides of PV power age is expected by introducing battery energy capacity frameworks (BESS). Currently, since the expense of BESS is still high, killing the awkwardness which equivalents to the contrast among arranged and genuine upsides of PV power age by BESS isn't financially practical, and suitable participation is expected to impart the job of adjusting to managing generators. Notwithstanding, factor sustainable power sources can cause steep lopsided characteristics which can't be repaid by directing generators because of their generally sluggish reaction times. To resolve this issue, this work proposes an arranged power age technique that can decrease the weight on managing generators by acquainting a system with relieve the changing pace of unevenness, (hereinafter called "lopsidedness evening out") by deciding the ideal booking of BESS utilizing the transient conjecture of PV power age. Mathematical reproductions were directed utilizing a model in view of Japanese recurrence control to contrast the proposed technique and the ordinary strategy without lopsidedness evening out.

A. A. A. Alahmadi et al.,[5] the plan of an astute energy the executives regulator is required. The current work proposes a wise energy the executives regulator in light of consolidated fluffy rationale and fragmentary request corresponding fundamental subordinate (FO-PID) regulator techniques for a shrewd DC-microgrid. The hybrid energy sources incorporated into the DC-microgrid are comprised by a battery bank, wind energy, and photovoltaic (PV) energy source. The source-side converters (SSCs) are regulator by the new wise fragmentary request PID system to extricate the greatest power from the environmentally friendly power sources (wind and PV) and further develop the power quality provided to the DC-microgrid. To make the microgrid as practical, the (wind and PV) energy sources are focused on.

A. Sorour et al.,[6] presents a prescient Energy The executives Framework (EMS), planned to work on the presentation of a homegrown PV-battery framework and boost self-utilization by limiting energy trade with the utility grid. The proposed calculation works with a self-utilization approach, which diminishes power bills, transmission misfortunes, and the necessary focal age/stockpiling frameworks. The proposed EMS utilizes a mix of Fluffy Rationale (FL) and a standard based-calculation to ideally control the PV-battery framework while considering the day-ahead energy estimate including figure blunder and the battery Territory of Wellbeing (SOH). The FL expands the lifetime of the battery by utilizing SOH and Province of Charge (SOC) in dynamic calculation to charge/release the battery.

R. K. Sharma et al.,[7] manages the equal activity of photovoltaic (PV), battery energy capacity (BES), and diesel generator (DG) for independent ac/dc framework. It is known that the greatest entrance of PV frameworks in DG-based power framework is restricted in the scope of 40%-60%. At the point when the PV limit becomes similar to DG limit, the framework experiences dependability and synchronization issues. Thus, this article proposes a dc hang based various leveled control of the PV-BES-DG framework in light of dc coordination at a typical dc transport. The dc coordination eases as far as possible on PV and works with better control of the hybrid framework than ac partner. Also, an ideal controller based optional control is proposed to guarantee ideal burden dividing between DG and BES. Further, a power the board plot (PMS) is intended to guarantee solid activity of the independent framework during source and burden power lopsided characteristics and activity under basic condition of charge limit state of BES.

Q. Li et al.,[8] convey the energy of battery, power device, electrolyzer and outside grid, and augment the result of disseminated power supply while guaranteeing the power equilibrium and cost optimization of the framework. In light of the super transient estimate, the result power of photovoltaic cluster and the interest power of framework load are anticipated. The disconnected worldwide optimization of conventional unique writing computer programs is supplanted by the continued moving optimization in a restricted timeframe to get power upsides of every unit in the energy stockpiling framework. Contrasted and the conventional DP, MILP-MPC and the rationale based constant administration technique, the proposed energy the board strategy is ended up being possible and powerful.

S. S. Ahmad et al.,[9] an energy the executives framework (EMS) has been created in view of model prescient control (MPC) to ideally dispatch the power units and especially handle the duck bend quick sloping occasions. The system is explicitly evolved considering higher infiltration of sun oriented photovoltaic power exposed to practical actual limitations. Battery energy capacity, load shedding and sunlight based shortening have been used to really control the duck bend quick sloping occasions. The proposed framework has been surveyed with the assistance of a contextual investigation utilizing a 24-transport RTS framework. Thusly, definite adaptability examinations were completed and it has been demonstrated that the given energy the board and control framework is fit for dealing with quick inclining occasions of duck bend.

A. Imran et al.,[10] proposes a heuristic-based programmable energy the board regulator (HPEMC) to deal with the energy utilization in private structures to limit power bills, diminish fossil fuel byproducts, expand UC and decrease the top to-average proportion (Standard). We utilized our proposed hybrid genetic particle swarm optimization (HGPO) calculation and existing calculations like a genetic calculation (GA), double particle swarm optimization calculation (BPSO), insect settlement

optimization (ACO), wind-driven optimization calculation (WDO), bacterial scrounging calculation (BFA) to plan savvy machines ideally to accomplish our ideal targets. In the proposed model, purchasers utilize sunlight based chargers to create their energy from microgrids.

H. Rezk et al.,[11] expects to give point by point plausibility, a techno-financial assessment, and energy the executives of independent hybrid photovoltaic-diesel-battery (PV/DG/B) framework. The proposed framework can be applied to supply a particular burden that is far away from the utility grid (UG) association, and it is situated in Minya city, Egypt, as a genuine contextual analysis. The day to day required desalinated water is 250 m<sup>3</sup>. The all out harsh water requests are 350-500 m<sup>3</sup> and 250-300 m<sup>3</sup> of water in summer and winter seasons, separately. Two unique sizes of opposite assimilation (RO) units; RO-250 and RO-500, two energy control dispatch procedures; load following (LF) and cycle charging (CC); two sizes of DG; 5 kW and 10 kW are viewed as for the situation study.

U. R. Nair et al.,[12] this work evaluates the utilization of MPC for energy the executives in an islanded microgrid with PV age and hybrid stockpiling framework made out of battery, supercapacitor and regenerative power module. The goal is to work on the use of sustainable age, the functional productivity of the microgrid and the decrease in pace of corruption of capacity frameworks. The enhancements in energy booking, accomplished with MPC, are featured through examination with a heuristic based technique, as Fluffy deduction. Recreated conduct of an islanded microgrid with the MPC and fluffy based energy the executive's plans will be read up for something very similar. Aside from this, the concentrate additionally completes an examination of the computational interest coming about because of the utilization of MPC in the energy the board stage. It is presumed that, contrasted with heuristic strategies, MPC guarantees further developed execution in an islanded microgrid.

Table 1: Characteristics of power technologies

Source	Unit Capacity	Resource	Comment
Wind Power	1 kW – 5 MW	Kinetic energy of the wind	Fluctuating, supply defined by resource
Photovoltaic	1 W – 5 MW	Direct and diffuse irradiance on a fixed surface tilted with latitude angle	Fluctuating, supply defined by resource
Biomass	1 kW – 25 MW	Biogas from the decomposition of organic residues, solid residues and wood	Seasonal fluctuations but good storability, power on demand
Geothermal (Hot Dry Rock)	25 – 50 MW	Heat of hot dry rocks in several 1000 meters depth	No fluctuations, power on demand
Hydropower	1 kW – 1000 MW	Kinetic energy and pressure of water streams	Seasonal fluctuation, good storability in dams, used also as pump storage for other sources
Solar Chimney	100 – 200 MW	Direct and diffuse irradiance on a horizontal plane	Seasonal fluctuations, good storability, base load power
Concentrating Solar Thermal Power	10 kW – 200 MW	Direct irradiance on a surface tracking the sun	Fluctuations are compensated by thermal storage and fuel, power on demand
Gas Turbine	0.5 – 100 MW	Natural gas, fuel oil	Power on demand
Steam Cycle	5 – 500 MW	Coal, lignite, fuel oil, natural gas	Power on demand
Nuclear	1000 MW	Uranium	Base load power

### III. CONCLUSION

Hybrid power generation system is acceptable and viable answer for power age than customary energy assets. It has more prominent effectiveness. It can give to remote spots where government can't reach. With the goal that the power can be use where it created so it will diminish the transmission losses and cost. Cost decrease should be possible by expanding the creation of the hardware. Individuals ought to persuade to utilize the non ordinary energy assets. It is exceptionally ok for the earth as it doesn't create any outflow and hurtful waste item like customary energy assets. It is financially savvy answer for age. It just need starting venture. It has additionally long life expectancy. Generally speaking it great, dependable and moderate answer for power age. Audits and enhancement models created by different analysts on standalone solar photovoltaic, wind and hybrid systems were explored. The different affecting boundaries on structure of PV hybrid system were recognized.

### REFERENCES

1. A. Kumar, M. Alaraj, M. Rizwan and U. Nangia, "Novel AI Based Energy Management System for Smart Grid With RES Integration," in IEEE Access, vol. 9, pp. 162530-162542, 2021, doi: 10.1109/ACCESS.2021.3131502.
2. Z. Zhang, B. Liu and S. Song, "Power Decoupling Control for V2G/G2V/PV2G Operation Modes in Single-Phase PV/Battery Hybrid Energy System With Low DC-Link Capacitance," in IEEE Access, vol. 9, pp. 160975-160986, 2021, doi: 10.1109/ACCESS.2021.3131626.

3. A. M. Mahfuz-Ur-Rahman, M. R. Islam, K. M. Muttaqi and D. Sutanto, "An Effective Energy Management With Advanced Converter and Control for a PV-Battery Storage Based Microgrid to Improve Energy Resiliency," in *IEEE Transactions on Industry Applications*, vol. 57, no. 6, pp. 6659-6668, Nov.-Dec. 2021, doi: 10.1109/TIA.2021.3115085.
4. R. Ando, H. Ishii, Y. Hayashi and G. Zhu, "A Planned Power Generation for Battery-Assisted Photovoltaic System Using Short-Term Forecast," in *IEEE Access*, vol. 9, pp. 125238-125246, 2021, doi: 10.1109/ACCESS.2021.3110950.
5. A. A. A. Alahmadi et al., "Hybrid Wind/PV/Battery Energy Management-Based Intelligent Non-Integer Control for Smart DC-Microgrid of Smart University," in *IEEE Access*, vol. 9, pp. 98948-98961, 2021, doi: 10.1109/ACCESS.2021.3095973.
6. A. Sorour, M. Fazeli, M. Monfared, A. A. Fahmy, J. R. Searle and R. P. Lewis, "Forecast-Based Energy Management for Domestic PV-Battery Systems: A U.K. Case Study," in *IEEE Access*, vol. 9, pp. 58953-58965, 2021, doi: 10.1109/ACCESS.2021.3072961.
7. R. K. Sharma, S. Mudaliyar and S. Mishra, "A DC Droop-Based Optimal Dispatch Control and Power Management of Hybrid Photovoltaic-Battery and Diesel Generator Standalone AC/DC System," in *IEEE Systems Journal*, vol. 15, no. 2, pp. 3012-3023, June 2021, doi: 10.1109/JSYST.2020.3032887.
8. Q. Li, X. Zou, Y. Pu and W. Chen, "A real-time energy management method for electric-hydrogen hybrid energy storage microgrid based on DP-MPC," in *CSEE Journal of Power and Energy Systems*, doi: 10.17775/CSEEJPES.2020.02160.
9. S. S. Ahmad, F. S. Al-Ismail, A. A. Almezizia and M. Khalid, "Model Predictive Control Approach for Optimal Power Dispatch and Duck Curve Handling Under High Photovoltaic Power Penetration," in *IEEE Access*, vol. 8, pp. 186840-186850, 2020, doi: 10.1109/ACCESS.2020.3030100.
10. A. Imran et al., "Heuristic-Based Programable Controller for Efficient Energy Management Under Renewable Energy Sources and Energy Storage System in Smart Grid," in *IEEE Access*, vol. 8, pp. 139587-139608, 2020, doi: 10.1109/ACCESS.2020.3012735.
11. H. Rezk, M. Al-Dhaifallah, Y. B. Hassan and H. A. Ziedan, "Optimization and Energy Management of Hybrid Photovoltaic-Diesel-Battery System to Pump and Desalinate Water at Isolated Regions," in *IEEE Access*, vol. 8, pp. 102512-102529, 2020, doi: 10.1109/ACCESS.2020.2998720.
12. U. R. Nair and R. Costa-Castelló, "A Model Predictive Control-Based Energy Management Scheme for Hybrid Storage System in Islanded Microgrids," in *IEEE Access*, vol. 8, pp. 97809-97822, 2020, doi: 10.1109/ACCESS.2020.2996434.

