



Integrating Battery Energy Storage Systems With Solar Pv For Grid Stabilization

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ABSTRACT

A grid-connected Battery Energy Storage System (BESS) represents a vital part of the modern electrical grid because it enables the efficient management of electricity supply and demand. The intermittent nature of renewable energy sources, such as solar PV, creates significant issues like stability and reliability of the grid as their share is raised. This study focuses on demonstrating how BESS can reduce this by storing surplus electricity during low demand periods and discharging it during peak times or insufficient renewable energy generation. This feature, in turn, diminishes the need for the traditional, fossil fuel power plants by cutting down greenhouse gas emissions and operational costs. The combination of BESS with solar PV makes renewable energy adoption easier by solving problems like reductions in the energy supply and emptying of the batteries. Thus, it brings about frequency regulation, voltage control, and overall grid stabilization. Various battery technologies that include lithium-ion, lead-acid, and flow batteries are examined to understand their appropriateness for different grid applications are discussed. The main system configurations like AC-coupled, DC-coupled, and hybrid models are evaluated as well as the operational strategies like peak shaving, load shifting, and frequency control.

1. INTRODUCTION

The use of renewable energy sources to generate power and transportation has been greatly diminished the consumption of hydrocarbons. Power that is produced from renewable energy sources (RESs) can be integrated (grid-tied) to the grid or can act as an independent power island (island mode) [1]. Renewable energy provides 14.8% of the total industrial energy demand, mainly utilized in low temperature industries. However, the contribution of renewable energy in some industries, say heavy ones like iron and steel, cement and chemicals, is so small, that it almost gets unrecognizable. At present, electricity, solar, wind, and nuclear energies are the main sources of energy to relieve the loads of various parts of the world, whereas other types of energy accounted for about 1% of the total energy demand [2]. The grid's performance is affected by renewable resources'

intermittent nature, which results in problems such as system stability, reliability, and power quality. The main issues are power output variability and uncertainty which hinder the massive integration of renewable energy with the existing grid. The implementation of energy storage systems (ESSs) is a right way to deal with the issue of power variability by power generation being decoupled from load when necessary situation occurs. Besides, the ESSs improve the power quality of the grid through the issuance of ancillary services [3]. The requirement for energy storage will persist as the expansion of renewable energy in the electric grid continues year by year. ESSs are technologies that permit the realization of both traditional and new applications such as power peak filtering, electric vehicles, the integration of renewable energy sources, etc. [4].

ESSs through acting as a generation unit or carrying out such roles as spinning reserve, load leveling, power quality improvement, and power fluctuation, make the grid more in effect, more reliable.

The transition from non-renewable to renewable energy sources is changing the global energy scene, mainly due to the need to lower emissions of greenhouse gases, assure energy security, and, last but not least, contribute to sustainability. Solar photovoltaic (PV) systems have turned out to be one of the most promising renewable energy technologies, and they also help plants to decarbonize as electric power is directly produced from the sun rays without burning any fuel, thereby making the process reusable [5]. Nonetheless, the solar power generation is intermittent and variant due to natural weather and climate cycles, and also due to the day-night period, thus, it can sometimes be unstable and unreliable. Old energy infrastructures which were constructed to ensure smooth and undisturbed energy distributions and flows are helpless in front of the renewable energy market dynamical variability that gives raise to issues such as frequency deviations, voltage instability, and energy degradation. Furthermore, the implementation of load management strategies, which include peak shaving and load shifting, is crucial to improving grid performance. During peak demand periods, the use of Battery Energy Storage Systems (BESS) to reduce the loads on the grid, thus preventing overload and reducing operation costs thus contributing a great deal to the success of the electrical generation and distribution sectors. Finally, load shifting can be used to shift the consumption of electricity from the peak to the off-peak hours thereby increasing the efficiency of the whole grid while utilizing the sunlight for the exact hours of the day[6].

There are a host of battery technologies in the market today to include; the most popular lithium-ion batteries, lead-acid batteries and flow batteries, with each technology offering different advantages based on their application. Lithium-ion batteries are known for their high energy densities and their significant efficiencies; this makes them to be the most commonly used batteries in PV-BESS systems. Although flow batteries have undergone energy density but have long life spans and hence are suitable for large applications. The choice of

battery technology applied has a tremendous effect on the efficiency of the integrated system, the response time of the system, the reliability of the system among other factors and these are the various trade-offs the researcher must consider in the scope of this study.

Furthermore, the process of integrating PV solar systems into the grid calls for an urgent need for new methods to handle the energy supply and demand effectively. If decisive actions are not taken, solar power disturbances may cause energy imbalance in the grid and, as a result, there will be a change to peaking plants, burning fossil fuels which is completely the opposite of a sustainable grid[7]. To guarantee a stable power supply, systems that can store excess energy and then release it when required are necessary.

This article is primarily concerned with the integration of Battery Energy Storage Systems (BESS) with solar PV to confront the challenges posed by the intermittent generation of green energy. The key point to be considered here is how energy storage systems can serve as a link between solar power and load in such a way that they can take the surplus solar energy during the low peak and then give it back when solar generation slows down and load peaks. Moreover, the research project outlines how BESS systems can act as contingency plans while at the same time providing frequency regulation, voltage support and grid stabilization techniques that contribute to the flexibility and resilience of modern power systems.

2. THEORETICAL FRAMEWORK

This research comprehensively investigates the integration of Battery Energy Storage Systems (BESS) with solar photovoltaic (PV) generation for the purpose of grid stabilization underpinned by various pertinent theories and concepts from energy management, power systems engineering, and sustainability science domains. An essential theoretical hierarchy has been put in place to scaffold the relationships of the core elements of interest in the study, namely energy storage capacity, solar PV production intermittency, and grid reliability while simultaneously accommodating the efforts to decarbonize and incorporate renewable energy into the wider energy system[8]. This way, BESS solar PV grid stabilization can be perceived and appreciated as a comprehensive solution to contemporary energy

challenges on the global arena, thus calling for its successful adoption.

Solar PV production is notorious for its variability going by its dependence on meteorological factors and the day-night cycle which can lead to grid instability in terms of excess electricity supply against low demand or low supply against high demand. Conventional grids solved such problems by resorting to the use of large fossil-fuel-based power generation plants, measures that negate environmental conservation, and easily deplete the fossil fuel resources, calls for the use of cleaner and more efficient technologies in the form of energy storage systems[9]. This is better explained by the energy storage theory that posits that BESS can harness excess solar power during production periods and inject the same into the grid during periods of downward load excursions or when little or no solar energy is being generated. The benefits of this stored energy are multifaceted since it ensures the provision of reliable power through cut-down fluctuations in supply, hence eliminating blackouts and faults and improving the reliability and stability of the entire electrical grid[10].

A specific aspect of the theory of frequency regulation is particularly significant as it positively matches the accelerating frequency and rapid real-time responsiveness. The need to maintain the grid frequency within the established limits is paramount to the stability of this critical infrastructure as frequency deviations may lead to damage of electrical equipment and cascades of system failures. BESSs can provide fast-response frequency regulating services either through the absorption of excess energy or the supply back to the grid charged batteries in the shortest time possible making firm frequencies and supporting the balanced and stable character of the electric frequency[11]. It is also in the light of voltage control theory that concerns itself with the maintenance of voltage levels within limits that can guarantee the smooth running of power installations to avoid scenarios of inability to supply needed voltage.

3. LITERATURE REVIEW

The transformation of renewable energy is the global energy sector's main cause as the ongoing and increasing demand clean, reliable, and environmentally friendly energy is. However, the

power sources of green energy (RES), called wind, solar, and hydropower, have the biggest challenges, such as the resuming air of the greenhouse gases, affects the grid and makes it more sensitive. Hybrid energy storage systems (HESS), which contain multiple energy storage devices (ESDs), that make it possible for each technology to contribute using their strengths, are the promising answer[12]. This comprehensive review examines recent advancements in grid-connected HESS such as targeting their components, design considerations, control strategies, and applications. It provides a detailed analysis of technological progress in different ESDs and the crucial role of power conversion, control, energy management, and cooling systems in enhancing the performance of HESS. By presenting real cases of the most successful HESS projects all over the world, we do not only give some examples but also explain real-world applications while showing the pros and cons of these projects. HESS, through mitigating these issues, could considerably increase the efficiency and stability of renewable energy systems (RES), thus, fostering a shift towards sustainable and resilient energy infrastructures. This paper ends with the identification of possible future research directions of the intelligent control systems, sustainable materials and efficient recycling processes to ensure the widespread adoption and long-term viability of HESS[13]. This paper [14] shows how we manage a battery energy system at an offshore island microgrid that uses a lot of solar and other renewable energy. We setup an intelligent energy management system to monitor and control diesel generators, power lines, solar panels and the battery system. A smart system is created which helps the battery to quickly release power during big disturbances like when the generators and solar panels trip off. We also control the battery charging and discharging so that the diesel generators can work smoothly despite fluctuations in solar power. The battery system also helps to manage the net load of the microgrid by shaving peaks and filling valleys based on forecasts of daily load and solar power. Simulations and field tests have shown that these control strategies work effectively.

This paper [15] portrays an occasional management system for an individual solar PV with real-time data as well as a Hybrid Energy

Storage System. Stormy clouds cause sudden leaning. This disturbs the energy quality and stability of the system as solar radiation is scattered. There is a remedy for this problem using a ramp-limit controller in conjunction with a DC link controller for stable DC link voltage. The battery supplies continuous power but sudden charging and discharging creates stress. This stress can be eliminated by the super capacitor (SC) unit which regulates the fast DC in the link voltage. The system sends stable power in the battery and SC as high energy and power density devices. The control scheme is tested in the MATLAB with real-time HIL tester using one-year solar plant data.

The new environmental rules require more energy from renewable sources. Wind and solar are the most popular but have ups and downs. They affect the stability of the electric grid. To fix this, storing energy from these sources can help. Using both flywheel and battery storage reduces these ups and downs by over 80%. This paper looks at the cost of a 2 MW wind turbine with the flywheel-battery system. The hybrid storage is cheaper than just wind. Including the cost of providing reserves, using batteries and flywheel cuts costs by more than 5% compared to not having storage. Energy generation from renewable sources, as well as energy storage systems, are the two most crucial sustainable technologies that are used to mitigate climate change. A more reliable method would be systems that also take into account the wastage of batteries because of charging and discharging cycles[16].

In this study [17], a statistical model is presented for forecasting a day-ahead photovoltaic (PV) generation which considers irradiance and weather conditions. Additionally, the other technical features of the energy storage system (ESS) should be evaluated by taking battery degradation that is happening during the charge and discharge cycles of the battery into account. Battery degradation's data-driven method of modeling is used in this study. It is experimentally validated and proven that the state of charge (SOC), 0.45 is the optimal threshold that can decide the low and high SOC. At the end of the day, the results of the simulation would lead to the conclusion that the battery degradation in different operation modes should be taken into account to extend the efficiency.

The battery energy storage system (BESS) is

becoming widespread for providing grid services such as frequency regulation, voltage support, energy arbitrage, etc. For that purpose, the implementation of advanced control and optimization algorithms is done to meet the operation requirements and to retain the battery lifespan. Although basic research has led to a better understanding of the battery features, the applications of BESS and the data transparency are still lacking or insufficient. This work gains insights to the possibilities of how to apply battery energy during grid operations as well as the interactions with other system components, after surveying the literature[18]. With the key parameters of hardware being evaluated in detail, a quantitative description of the BESS usage pattern in the long term time frame is then developed providing an overview of the BESS duty profiles in grid applications. Specifically, the frequency regulation service is mainly concentrated on the story, and the synergies of cross-cutting integrations with energy storage, energy production, and energy consumption are

briefly overviewed. One additional way of enlisting the utilization of BESS grid applications easily contributed to the state of charge, state of health, and technical and economic research used last 10 years[19]. A comprehensive overview of applications and integration of BESS grid is thereby provided, and this work integrates another source of data which are the activities conducted within the actual technical and economic profiles such as battery usage optimization and degradation research. The paper gives a picture of the different ways BESS could be applied in grid as a potential pathway for future research for battery.

3.1 Hypotheses and Research Model

This framework provides the hypotheses for the study, which is better done in the following way:

H₀₁: BESS-based PV solar systems are better at frequency and voltage regulation, as compared to solar PV systems that are based on battery technologies that would operate alone.

H₀₂: The effectiveness and reliability of the grid are determined by the battery technology used and system configuration (AC, DC, or hybrid).

H₀₃: Increased storage capacity and proper dispatch of the battery energy storage system (BESS) will greatly increase the stability of high solar penetration

4. METHODOLOGY

The section consists of thoroughly describing every activity that was carried out in the study and how Battery Energy Storage Systems (BESS) were integrated with solar PV for grid stabilization. The methodology adopt an approach that comprises system design, data collection, analysis, and performance assessment which will ensure the interpretation of insights is valid.

4.1 System Design & Architecture

The study investigates a hybrid solar photovoltaic battery energy storage system that has been modeled and developed for the purpose of this project. Different design configurations are thoroughly examined including AC-coupled, DC-coupled, hybrid setups, all with a view to determining the most appropriate architecture for

grid-connected applications. In AC coupled system setup, solar PV and battery are connected through two different inverters. This allows for the flexible and independent operation of the two systems, which makes it possible to easily retrofit batteries to existing solar installations. In the dc-coupled system, both solar PV and batteries operate on a single inverter, which results in reduced conversion losses and improved efficiency[20]. The DC coupled system is more flexible than this, it is, however, restriction with future expansion and this have to be considered. Hybrid system combines the features of both AC and DC coupling thus having the advantage of flexibly optimizing operation for grid stabilization purposes.

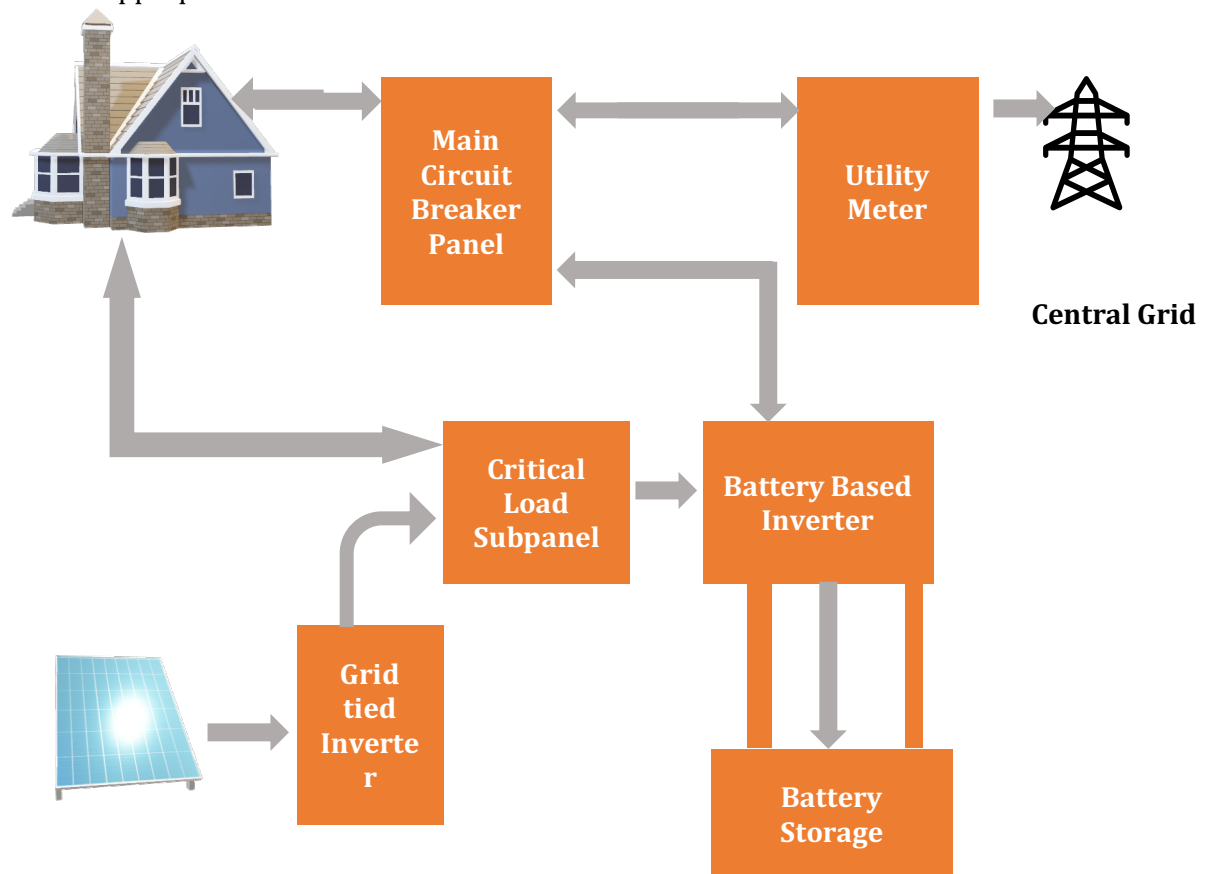


Figure 1: Proposed Block Diagram of AC coupled BESS

4.2 Battery Selection

The research systematically evaluates various battery technologies including lithium-ion, lead-acid, and flow batteries to establish their adequacy in integrated systems comprising a BESS and solar Photovoltaic Systems (PV) for grid stabilization. Below are some of the key parameters that were

examined during the study.

Energy density: This is the amount of energy that can be stored per unit volume. In practice, it is desirable to employ battery technologies with higher energy densities in applications requiring heavy loads because this decreases the weight or size of the storage system.

Cycle life: This is another factor that is considered in criteria, which refers to the number of times the batteries can be charged and discharged as this will affect their longevity. Cells with longer cycle lives are preferred since this would ensure a reliable service over an extended period of operation.

Efficiency: This refers to the ratio between energy output and energy input through which it influences qualitative performance of the whole system and thus plays an important role when evaluating performance of solar PV-battery storage integration. Low-efficiency batteries lead to wastage of energy hence high operating costs.

Response time: This implies how soon the battery can start discharging electricity in order to handle fluctuations in the grid. Batteries with short-response times are useful for applications calling upon their delivery power to the grid almost in an instant.

When carrying out extensive research, the use of lithium-ion batteries is recommended because of their high energy density, quick response, as well as general utilization in grid-type applications. Lithium batteries are known to have more energy density than other battery systems currently in the market giving them the advantage of being the lightest batteries to be used.

4.3 Grid Stabilization

The operation of a Battery Energy Storage System (BESS) is an intricate process that aims to ensure the grid's stability and reliability. Various operational strategies are implemented to guarantee that the BESS works effectively in achieving this goal. A major strategy used by BESS for stabilizing the grid's general supply and demand is frequency regulation. During frequency regulation, BESS is capable of absorbing or supplying power within milliseconds, which is faster than any other technology, in order to maintain frequency of the electrical grid within this acceptable band of 50 and 60 Hz. In these times of increased utilization of green energy, and the problems of high-voltage electrical grids on the mentioned area, this ability of fast response can play a role of a fireman that solves the problems without being noticed by residents of a city. Another important operation principle of BESS capable to significantly improve the grid's overall performance is the stabilizing of the voltage by reactive power compensation which aims at improving the grid's inefficiency during sudden

changes in solar output. This combination of fast bursts of reactive power discharge and shifts available materials of the high capacity of the system will certainly return the grid to normal and safe values of voltage and current flowing through grids. Another aspect that plays a crucial role in ensuring load and supply balance in high-strain periods on the grid due to consumer demand is the BESS peak shaving mechanism. This specific technique allows BESS to discharge energy in peak load times and to relieve the grid's active reverse current by proper management of the 'fighting peaks' state[21]. It has been found that the system is not only suitable for reduced levels of use as the load is mast and for the improvement of unit economizing but also it is useful and cheap. Furthermore, load shifting is another operational strategy which is employed by BESS to enhance grid efficiency. Implementation of these strategies is carried out through testing of various scenarios such as peak and off-peak hours, solar irradiance fluctuations, and load conditions change, to assess the performance of the system fully.

5. DISCUSSION ON THE RESULTS

The interaction between a Battery Energy Storage System (BESS) that is seamlessly integrated alongside the solar PV will be very complex in term of control and monitoring in order to act as a system with components or parts that act in harmony. The proper integration of these functions ensures the most outstanding performance management of energy, real-time operation, as well as its ability to communicate with the network and the part of the network that is actually the most energy-intensive, which is why the system responds as fast as possible to the demands of the grid and the environmental conditions. The operational paradigm that the Energy Management System (EMS) is based on it that the EMS serves as the main contributor to the stable performance of the whole system, where the energy flowing between solar PV generation, battery storage, and grid demand is balanced. It programs charging and discharging cycles that are considered as the most suitable solutions integrating them with energy forecasts, electricity rates, and load demand conditions. Through the observance of weather patterns and historical records of energy use, the EMS can predict how to store the surplus solar energy and when to give it to the grid. The EMS also

handles the communication with the grid, making sure the system meets the utility standards besides thereby enabling ancillary services like frequency and peak regulation.

Moreover, Supervisory Control and Data Acquisition (SCADA) systems are the integral part of real-time monitoring through which the operations of the system can be regulated promptly. SCADA is a digital technological aid that makes it feasible for personnel to be away from a site and still be in control of transmitter/receivers, charge/discharge cycles, PV modules, and grid connections. The system takes in and presents data collected through different instrumentation in the form of bar graphs on the main control stations and thus the operators can observe and follow the various data units such as torque, speed, battery state of charge, and inverter operation. It may call the attention of the maintenance department by generating alerts when irregularities or faults are apparent, therefore, the necessary intervention will bring up malfunction activity. For a large-scale solar PV installation, without a doubt, continuous and accurate supervision is the most basic necessity for the sustained operation and to meet the regulatory requirements.

The Internet of Things (IoT) sensors in Batteries, inverters, and PV modules the usage of the monitoring capability as they integrate smart sensors within these. Monitoring sensors control the battery's performance indicators e.g. charge level, temperature, voltage values, and load. The information gathered from the sensors is communicated to the EMS for the study of the data and decision-making process which through the response system can cope with the new environmental conditions as well as the changes in the grids. For example, if the battery's temperature exceeds a safe value, the EMS can start the cooling process or reduce the charging rate to prevent thermal runaway. The data derive from the IoT sensors and assist in predictive maintenance by

spotting pre-signs of equipment degradation thus it lessens downtime and repair expenses[22].

The effective communication that exists between different system parts is achievable thanks to the usage of common communication protocols. Protocols like Modbus or IEC 61850 insulate the flawlessness of the information flow among the batteries, inverters, solar PV modules, and utility grid [23]. Modbus is not only an industry standard, but also makes communication more reliable over short distances allowing real-time control of individual devices. IEC 61850 on the other hand is a more sophisticated and application specific protocol introduced for energy systems, that infact enables collaboration with the power grid. It serves as a protocol layer between devices from different manufacturers and exchange of information between the BESS, PV systems and grid operators all of which is done rapidly. These protocols work to ensure the data are available without obstruction, and in a secure manner which is essential to system stability and complying with utility systems.

Solid-state batteries (SSBs) have appeared at the forefront of energy storage technology showcasing great potential and advantageous features like greater longevity, enhanced safety, and superior energy density compared to standard lithium-ion batteries. The comparative table 1 created below — exhibit the key performance benchmarks of solid-state batteries, contrast these with the more conventional battery types, and discuss their importance in the stabilization of grids as well as the integration of solar photovoltaic energy systems. The information presented in the table will cover results that exemplify those exceptional characteristics of SSBs that contribute to better performance and more reliable service, which are critical in meeting up with today's energy demands, as well as in the future.

Table 1 Comparative Analysis of Batteries

Parameter	Solid State Batteries	Lithium-ion Battery	Lead Acid Battery	Flow Battery (Vanadium Redox)	Sodium Sulphur (NaS) Battery
Energy Density (Wh/kg)	300-500	150-250	30-50	20-30	150-240
Efficiency (%)	90-98	85-95	70-80	65-75	75-90
Response Time	Milliseconds	Milliseconds	Seconds	Seconds to minutes	Milliseconds to seconds

Operating Temperature (°C)	-20-60	0-45	0-40	10-40	300-350
Key Points	High energy density, high safety	High energy density, fast response time	Low cost	Long duration, scalable	High energy needs

6. CONCLUSION

The integration of battery energy storage systems (BESS) and solar power generation can provide the necessary support to resolve the issues of renewable energy intermittency and amp up the stability of the grid. This text demonstrates the importance of BESS in making renewable energy sources running nicely by the capability to maintain the varying availability of energy, the storage of the energy produced at peak times, and the regulation of the voltage and frequency with this stored energy. Using energy storage, surplus solar energy generated during low demand periods could be stored and provided during high demand periods, lessening the need for conventional power plants and thus lowering greenhouse gas emissions. The combination of solar PV and BESS will result in a more reliable and impressively self-reliant energy infrastructure. It significantly contributes to the energy decarbonization campaign, and the improvement of grids credibility in modern times

The research-based study underlines the fact that BESS not only makes the grid stable but also becomes economically beneficial through energy height, frequency regulation, and black-start capabilities. BESS makes the system more effective mainly by load shifting and voltage control which in turn leads to less utilization of power plant and thus grid reliability will improve and overall power usage will be augmented. Additionally, a relative overview of different battery technologies revealed that lithium-ion batteries spoke of improved output when it comes to quick response, whereas flow batteries became the most preferred option for a much longer-term energy storage. Lead-acid and nickel-cadmium batteries are two low-cost alternatives for backup power, while solid-state batteries have the potential to be a future technology because of their high safety and compact energy storage.

But the critical hindrance in the way of popularization of BESS is the steep cost of investment, thermal management in lithium-ion batteries being safe to use, and the fact that some

battery

chemistry (like lead-acid and nickel-cadmium) being environmentally harmful. Such issues can be resolved by policy measures, technology improvement, and market stimuli. This is crucial to attain maximum benefits of solar PV-BESS integration.

• Recommendations

An important recommendation is to expedite the development of advanced battery technologies by the need to go beyond conventional lithium-ion systems. Research and investment in solid-state batteries need to be put at the top of the list, as they give the best of both worlds – additional energy density, safety, and cycle life, and wait times to the lithium-ion batteries. Solid-state batteries, the non-liquid electrolyte of which is replaced with a solid electrolyte, are replacing a step in the process of Tier 2, high temperature cycling and potentially longer lifespan of the storage system. The change would make it possible to implement large-scale solar PV and BESS integration, especially in cases that need high energy capacity. An alternative is the use of grid-forming inverters, and it also is a revolutionary development that can alter the network role of BESS for grid stabilization. These inverters ensure that BESSs are functioning optimally alongside renewable energy resources by providing the necessary grid services and controlling the voltage and frequency without the aid of synchronous generators. Via empowering energy storage drivers to actively become part of the solution to the grid's support, inverters can enhance the reliability of solar PV installations and result in more renewable energy penetration.

The integration of artificial intelligence (AI) and machine learning algorithms for optimizing the operation of BESS is the new and modern approach for grid stabilization. It is the integration of the said AI that allows grid operators to read and interpret huge amounts of data in real-time to foresee the energy demand, store and discharge batteries in the best possible ways based on the grid operations. These implemented technologies can provide smart energy management, save on

operational costs, and make BESS work better by stabilizing the grid. In addition, the promotion of distributed energy resource management systems (DERMS) is suggested. These systems can fully encompass various distributed energy resources like solar PV and BESS, thus better energy flow control and management can be achieved within the grid. Just by using data that is real-time from multiple sources, DERMS can optimize energy dispatch, provide more resilience to the grid, and pave the way for a more sustainable, decentralized energy system. The innovation of battery recycling technologies can make the recovery of valuable materials such as lithium, cobalt, and nickel as it is a solution that reduces the environmental impact of battery production and promotes a circular economy. The research for the new methods of battery recycling that is more effective can make a great reduction in the harmful factors that are ascertained in the usage of battery. The Internet of Things (IoT) technology integrated into the management and control of BESS allows for a greater extent of activity monitoring. There are sensors and devices enabled with IoT that can give information in the real-time mode about battery condition, health, and energy consumption patterns, thus they can undertake proactive maintenance and optimization of the storage systems. This way of application of the mentioned technology can implicate enhanced efficiency, reduced downtime and extending the battery life cycle, and thus will ensure the full capability of BESS in being the means for solar PV implementation.

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