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Review on Energy Management Strategies in Smart Nano-Grid using Optimal Control Techniques

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***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 review of various researches works on energy management strategies in Smart Nano-Grid using optimal control techniques. MATLAB 9.4 software will be used to design and implement of such type of models and check performance parameters like input voltage, current, power, losses etc.**

***Index Terms*-- Nano-Grid, 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 nanogrid. Related control and power the executives has 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-levies 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 paper 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].

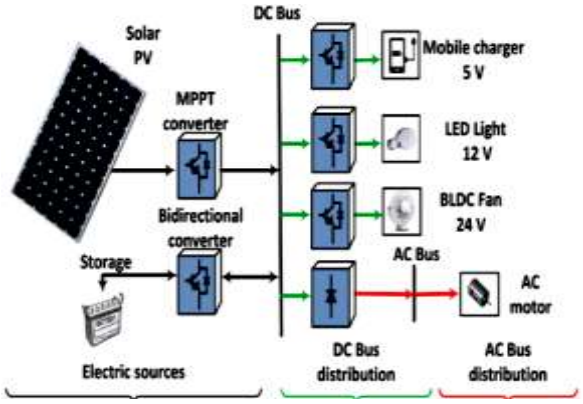

Figure 1: Micro/Nanogrid system

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 sythesis 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.

Power the executives is essential to guarantee both affordable and proficient work of the system in consolidated use of renewable energy sources. Variable climate conditions, day-night conditions, and quick change in voltages make this essential. Power the board can be accomplished by utilizing maximum power point tracking (MPPT) [8] gadgets so as to decide the most productive working point of a system in a specific climate condition and by exchanging the systems with the goal that they become dynamic to help each other progressively. It is essential to keep the reinforcement batteries full in times when there is neither sun nor wind. Without reinforcement batteries there will be no energy in the system. For this situation, for example, it is mechanized control instrument's obligation to interface the system to the lattice, associate the generator or decide, and deal with the related circumstances.

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].

II. Literature Survey

S. Yousaf et al.,[1] nano-grid is an independent hybrid sustainable framework that utilizes non-renewable and renewable power resources for supplying continuous electrical energy to the load. Considering this scenario, in this research work, photovoltaic (PV) array, wind turbine, and fuel cell are taken as the three generation resources that have been used in the nano-grid. The active and reactive power of the all three generation resources is controlled using various controllers, i.e. integral, proportional-integral, proportional derivative, proportional integral derivative, fractional-order proportional-integral, fractional order proportional integral derivative (FOPID) and sliding mode controller (SMC). An advanced optimization technique based on a genetic algorithm (GA) and particle swarm optimization (PSO) algorithm has been utilized to optimize all of these controllers. The integral square error is taken as the objective function for both optimization algorithms. Finally, a graphical and tabular comparative analysis of all optimized controllers along with their control parameters and performance indexes is evaluated to find the best optimal solution. [1]

I. Ameur et al., present an ideal power the executives for a standalone nanogrid made out of a Photovoltaic cluster (PV), a Fuel-Cell system (FC) and an electrochemical battery dependent on the Pontryagin's Maximum Guideline (PMP). The three sources are interfaced in corresponding to a typical DC-connect by means of DC/DC converters and are intended to satisfy the heap need particularly in zones outside the power inclusion. The goal of the proposed procedure is to decrease the fuel utilization by causing the system to work in its ideal working point regarding load request and climate conditions. Some recreation results are introduced to affirm the optimality of the proposed procedure [2].

L. Liu et al., Presents photovoltaic power age has issues, for example, irregularity, intermittentness, and inadequate power gracefully. A little PV-Battery-SOFC" hybrid power age system was intended to take care of these issues. The system comprises of photovoltaic clusters (PV), high-temperature Strong Oxide Fuel Cell (SOFC), battery, DC load, power transformation circuit, PLC controller and different segments. Another sort of SOFC was utilized as a solid advantageous power gracefully for the photovoltaic exhibit [3].

K. Longo et al., presents a procedure and an instrument to reproduce a little scope energy creation. The nanogrid is disengaged and displayed in DC current, including the accompanying parts: photovoltaic modules, converters, MPPT calculation, stockpiling system and a DC load. The model is actualized in MATLAB/Simulink condition. Two situations are mimicked to cover the fundamental control objective, for example the harmony between power creation and burden request through DC transport. [4]

J. Kang et al., presents control and power the board system steadily manage the transport voltage and well parity the power, principally through programmed control of every module's voltage and power. Under the influence and Power the executives system, when the heap changes out of nowhere, the transport voltage stay stable and power stay adjusted. The reproduction is done to confirm the exhibition of the proposed technique. [5]

Y. Singh et al., presents adaptable control methodology for voltage source converter (VSC) in network tied mode (GTM) and standalone voltage control mode (SVCM) utilizing mixed order sinusoidal integrator phase locked loop (MOSSI-PLL) based control. The nanogrid depends on voltage source converters (VSC) goes about as a functioning power channel, music and accomplishes the symphonious disposal pay and receptive power pay. [6]

H. Mahmood et al., presents control system is created to accomplish completely self-sufficient power the executives of numerous photovoltaic (PV)/battery hybrid units in islanded nanogrids. Likewise, the created procedure can self-sufficiently organize with dispatchable hang controlled units. The power provided by the hybrid units is independently decided dependent on the accessible PV power from every single hybrid unit, the absolute age limit of the accessible dispatchable units, the complete burden request, and the condition of-charge (SOC) of all batteries in the nanogrid. [7]

A. Shukla et al., The rapid increase in global energy consumption and the impact of greenhouse gas emissions has accelerated the transition towards greener energy sources. The need for distributed generation (DG) employing renewable energy sources such as wind, solar and fuel cells has gained significant momentum. Advanced power electronic systems, affordable high performance devices, and smart energy management principles are deemed to be an integral part of renewable, green and efficient energy systems. [8]

S. Umashankar et al., presents the control and power the executives of a hybrid nanogrid system that involves Photovoltaic (PV) cluster, battery, and nearby air conditioning load, associated with the utility network. This work centers around the remuneration of PV power decrease because of incomplete concealing utilizing bidirectional half extension converter with battery stockpiling. This system considers satisfying the neighborhood load request through PV creation and, at that point, to deal with the power among the battery and matrix. In the proposed system, the considered power molding gadgets region support converter, 3 phase full-connect inverter, and bi-directional converter. The outcomes are gotten from the MATLAB/SIMULINK condition. [9]

Dongxu Wang et al., presents the displaying and recreation of the use of virtual simultaneous generator(VSG) innovation in a bidirectional DC/Air conditioning converter and a PV/battery system in a hybrid air conditioning/DC nanogrid. The battery unit in the DC sub-nanogrid keeps up DC transport voltage stable and the DC transport is equal to a capacity system. [10]

Yanping Zhu et al., presents nanogrid recurrence, another photovoltaic (PV)/battery (BA)/fuel cell (FC) hybrid energy the board procedure with altered hang control for islanded application is proposed in this paper. This technique empowers the fitting and plays ability in the dispersed units with voltage control mode and makes it conceivable to abstain from utilizing the correspondence line or a focal boss. [11]

Y. Guan, et al., presents hybrid photovoltaic (PV)-battery-hydropower nanogrids (MGs) can be considered to upgrade power openness and accessibility in remote zones. In any case, the concurrence of various renewable-energy sources with various dormancies and control techniques may influence system security. In this paper, a progressive controller for a hybrid PV-battery-hydropower MG is proposed so as to accomplish the equal activity of the hydropower and PV-battery system with various rates and to ensure power sharing execution among PV voltage-controlled inverters, while the necessary power to the hydropower-based neighborhood network is provided. [12]

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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. Optimal Control Techniques

Optimal control techniques play a critical role in the effective operation of smart nano grids. Smart nano grids are highly complex systems that require precise control to ensure efficient power management, maintain grid stability, and optimize energy consumption. Optimal control techniques can help achieve these objectives by providing accurate control of power flows and optimizing energy management.

One of the primary benefits of optimal control techniques is their ability to account for uncertainties and disturbances in the system. These techniques use mathematical models and algorithms to predict future system behavior and optimize control actions accordingly. This can help reduce energy consumption, lower costs, and minimize the impact of power disturbances.

Some commonly used optimal control techniques in smart nano grids include:

1. Model Predictive Control (MPC): This technique uses a mathematical model of the system to predict future behavior and optimize control actions accordingly. MPC is well-suited for systems with constraints, such as energy storage limits or power flow limits.
2. Fuzzy Logic Control (FLC): FLC uses a set of linguistic rules to make control decisions based on inputs from sensors in the system. FLC is useful when the system is highly nonlinear or when traditional control techniques are difficult to apply.
3. Artificial Neural Networks (ANNs): ANNs are machine learning algorithms that can learn to predict future system behavior based on past data. ANNs can be used to optimize control actions based on real-time sensor data, making them well-suited for dynamic systems.

IV. Conclusion

Smart nanogrid energy management 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 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. Future requests were likewise not considered in numerous models. Abundance power produced was not considered in recently evolved systems. Lack of power flexibly likelihood and cost were not considered at the same time for improvement of hybrid system.

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