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Design of Energy Management Systems in Multiple Renewable Generation Sources Using An External Controller

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ABSTRACT:
The challenges faced by hybrid micro grid design include system cost and service quality. In this paper, we address these challenges through optimal utilization of renewable resources while maintaining the state of charge (SOC) in the batteries. The proposed system also defines the minimum energy exchange rate between the AC/DC micro grids. Photovoltaic and wind energy are used as key resources in the system. Storage banks are coupled to both micro grids and the fuel cell acts as a back-up resource to maximize the consistency of the generation system. The supervisory controller ensures maximum resource utilization and, by maintaining the SOC, manages energy exchange between micro grids. This research focuses on energy management in AC/DC micro grids, and its optimization has been investigated using the Multi-Objective Particle Swarm Optimization (MOPSO) algorithm. The results show that MOPSO offers positive performance, and the proposed system is recommended as the best alternative for improving electrical energy use in remote areas.

Keywords: BESS, circuit breaker, disconnection time period, ESS.

1. INTRODUCTION:

The growing population explosion predicts an increase of 2 billion people by 2040. This increase is primarily observed in Africa, India, and several developing countries. This has significant implications for energy demand. Energy demand is projected to increase by 30% by 2040. Developing countries have experienced rapid population demand for energy. Available energy sources, such as oil and natural gas, hydroelectricity, coal, and nuclear power, are insufficient to meet demand. Furthermore, the population is increasingly turning to alternative energy sources. Renewable energy sources and the technology to obtain them have grown rapidly. Driven by economic development and the associated growing demand for energy, countries are looking for ways to use available natural resources to meet demand. Our study focuses on photovoltaic (PV) power generation in India as the primary energy source [1]. The complementarily of wind and PV resource availability was clearly specified for the year 2016 [1]. This demonstrates the urgent need for increasing energy resources to drive the expansion of renewable energy plants. Therefore, this research proposes the integration of PV and wind energy. The traditional power system requires more flexibility, which changes the regulatory and financial situation. Energy reserves and ecological collision drive the growth of micro grids, which are expected to play an important role in future energy systems. Micro grid is a unique grid procedure that combines dispersed production and power electronics. We believe that the use of micro grids with improved performance could meet the high energy demand of the Indian population. The article is organized as follows: the next section presents a brief review of the relevant literature, followed by a detailed presentation of the proposed methodology in Section 3. Section 4 describes the optimization process using MOPSO for HMG. Section 5 describes the experimental evaluations performed to validate the proposed approach, along with a detailed analysis of the results obtained. The article concludes with suggestions for future research

2. OVER VIEW:

For hybrid micro grids including dispersed, scattered, and categorized control schemes in grid-connected and islanded modes, micro grid technology is adopted to organize the different electricity sources and provide improved power supply solutions to smart grid-based projects in India. Guerrero et al. [2] proposed grid architectures with advanced control techniques. In their research, the problems of droop-based control techniques were eliminated. The other complementary controller is set in the central control of the micro grid, which restores the frequency and magnitude in the micro grid. Sung woo and Alexis [3] presented a dynamic control and design strategy for a micro grid, mainly for power generated by wind turbines and solar energy.

A current-fed multi-input DC-DC converter is used to combine these renewable energy sources with the key DC bus system [3]. Kantamneni et al. [4] conducted a comprehensive study on the use of multi-agent systems for micro grid control. They presented and analyzed the context of multi-agent system design architectures as step-by-step frameworks for micro grids. In 2015, Derksen et al. [5] introduced a novel energy agent for future hybrid energy systems for systematic development. They presented a design pattern that enables the use of energy agents in large-scale testbed simulations and real in-situ devices. In the same year, Dibangoyee et al. [6] explored the problem of unit commitment and economic dispatch, determining the required power to be generated and the optimal schedules to respond to the energy demand. They also proposed a new distributed approach to address unit commitment problems by considering the uncertainty of privacy-preserving constraints and supply and demand

The problem was posed as a bi-objective problem, including flow time and time lag for optimization. Subsequently, two improved variants were presented that demonstrated the efficiency and performance of GAs in computational mesh planning problem.. [8] developed a new method called canonical RST structure for 2DOF, and successfully implemented it based on MOPSO approach. Various tests were performed on benchmark functions to validate the presented MOPSO algorithm. With the results obtained from the conducted experiments, the superior capability of MOPSO approach was demonstrated through its Pareto dominance. El Dor et al. [9] presented the dynamic topology called DC luster by combining the four clusters and fitness to avoid premature convergence in traditional PSO algorithm.

Their test experiments showed that DC power presents the best performance compared to the other traditional topologies tested for all the analyzed problems, and premature convergence in PSO has a very low probability. Similarly, field and Fleming [10] developed a multi-objective evolutionary design of robust controllers for the grid and evaluated it through a computer simulation process. [11] presented a two-step disturbed voltage droop control method for the bidirectional power flow of the hybrid AC/DC micro grid. By calculating the micro grid operating frequency of the AC source (f) and the micro grid operating voltage of the DC source (V dc), the electrical power management approaches can generate the power reference. The set power reserve can support both micro grids regularly and also allows a minimum power reserve for each one. In India, smart grid technologies are constantly growing, with numerous projects underway using new smart technology, from kW to MW, covering all types of consumers.

The aforementioned works mainly focus on DC or AC micro grids. Technically, the concept of a hybrid AC/DC micro grid is novel and combines AC sources with AC loads, and DC sources with DC loads [14]. It is worth noting that uncertainties in resource output power cause changes in generated power to be higher or lower than the actual demand. Such uncertainty in the generated output power generates fluctuations in the DC bus voltage level, so these variations should be considered a risk factor for energy imbalance [15]. This crucial problem can be addressed by using a controller to control the DC bus voltage in the power generation system. The proposed approach is designed to be robust enough against generation prediction error problems and uncertainties in resource output power. While restricting power sharing between micro grids can improve power quality, it cannot maximize the utilization of available wind or solar energy. Therefore, this article proposes a balance between energy quality and power generation system efficiency. The proposed balance determines the minimum amount of energy that should be exchanged between micro grids.

3. PROPOSEDSYSTEM:

The main advantages of the hybrid AC/DC micro grid system are: (1) the elimination of avoidable multiple disturbance procedures, minimizing transmission losses; and (2) the elimination of embedded rectifiers for DC batteries in existing AC grids, resulting in simple installation and a reduction in the cost of power electronic converters. Despite the aforementioned advantages, for the hybrid micro grid to operate efficiently, a supervisory control technique is required to meet power demand and distribute it among the various energy resources. Furthermore, a fuzzy logic-based control scheme is required to regulate the charging and discharging currents in the battery. The structure, control, and energy management strategy of the hybrid micro grid (HMG) are analyzed in the following sections.

This paper proposes a renewable energy-based hybrid AC/DC micro grid model and its energy management. This is a novel idea that frees up DC resources through DC batteries and AC resources with A Cheap, while the generated power is exchanged between the AC and DC ends using a bidirectional converter. Depending on the power exchange needs, AC-DC or DC-AC conversion is used Photovoltaic panels and wind turbine generators are used as key resources in this energy production system. Furthermore, storage banks are coupled to AC and DC micro grids, and the fuel cell is considered a backup resource to maximize the consistency of the generation system. When the power supplied by the input DC sources is greater than the DC demand, the inverter operates and introduces DC power into the AC sub grid system and also into the power grid. When total power production is less than the total demand from the stack on the DC source side, the inverter acts as a converter and introduces power from the AC sub grid system and the power grid into the DC side. At the same time, the DC source bus voltage is stabilized by a PI controller. Micro grids are an assembly of DC and AC stacks, dispersed renewable energy resources, and storage devices such as batteries. The development of a hybrid micro grid will reduce the process of numerous reverse conversions associated with individual AC and DC grids. For the proper functioning of the micro grid technology, an energy management system is required to control the flow of electrical energy in the micro grid system It is essential that the electrical power flow identify the output power of generating services to address energy issues on the load side. It should be noted that, considering all the limitations in power switching between AC and DC micro grid schemes, power quality issues may arise and the maximum existing wind or solar power consumption cannot be achieved. Therefore, this research presents a relationship between power system quality and the overall efficiency of generation schemes. The wind generation system presented consists of a wind turbine, a permanent magnet synchronous generator (PMSG), a diode rectifier for AC-to-DC conversion, and a DC-to-DC boost converter. The block diagram in Fig. 1 shows that the power produced by the wind system is regulated by a DC-to-DC boost converter. The photovoltaic system is connected to the DC bus via a DC-to-DC boost converter. To calculate the state of charge of storage banks in AC and DC micro grids, the current summation (Coulomb counting) method is used.

4. RESULTS:

The Energy Management System (EMS) contains a main processing unit with the data obtained for all micro grid modules, which helps identify effective approaches for energy transfer between renewable sources. The minimum and extreme energy in storage tank charge/discharge mode, and the minimum allowable energy exchange between the AC and DC micro grids, must be reported based on real-time measurements. Likewise, the EMS output instructions are set points for the production units, the source energy charged/discharged from the storage tank, and the amount of source energy to be switched within the micro grids. The delivery instructions are directed to the controllers so that the micro grid system modules follow the obtained set points. The power flow between the AC and DC grids using a bidirectional converter is shown in the figure when considering only wind power. Implementing the above approach generates enormous benefits.

These include:

1. Maximizing the use of renewable resources to meet AC and DC load demand in the micro grid system,
2. Maintaining the battery state of charge (SOC) in the micro grids, and
3. Monitoring the power transfer between the AC and DC micro grids.

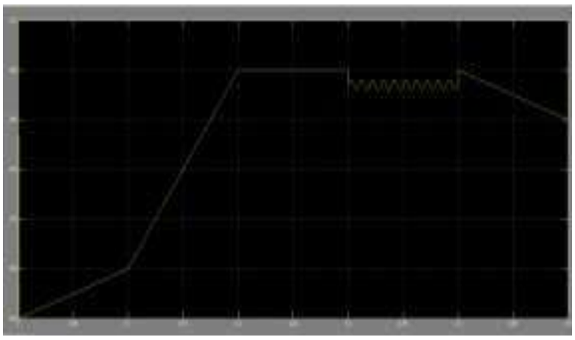


Fig.1.Simulation circuit

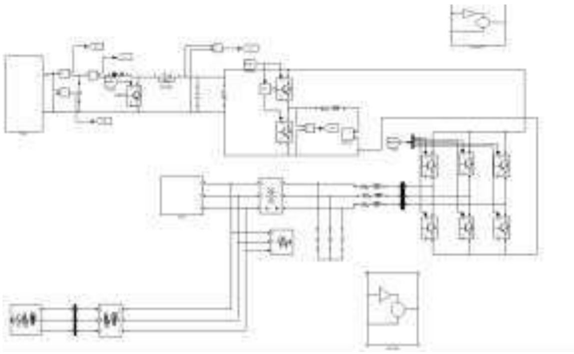
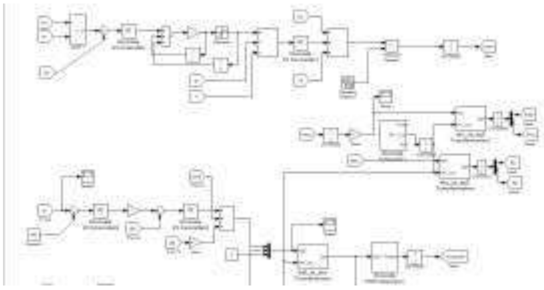


Fig.2.Controller circuit



.Fig.3. Voltage across the PV system

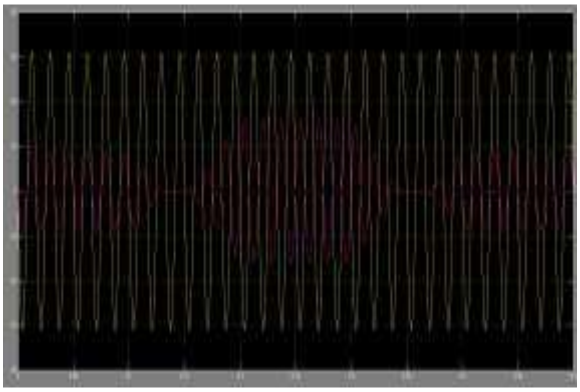


Fig.4. Output power.

CONCLUSION:

In rural electrification, the implementation of micro grids is considered a promising solution that improves supply quality by reducing implementation costs. This research presents a control scheme for a HMG structure that maintains uninterrupted electricity supply to consumer demand in fifteen operating modes. The combination of photo volcanic, fuel cells, wind power, and battery storage with adjustable parameters is analyzed. Using a state machine approach, the supervisory controller sets reference values for the generation subsystems following a predefined scheme. The fuzzy controller determines the charging and discharging of the battery banks, considering the difference between generated and demanded power, and the state of charge (SOC). To achieve optimal system configuration and better component sizing, the MOPSO methodology was applied, defining objective functions for the cost of energy and the probability of power loss. The simulation results show the rising price of electricity, which leads to substantial growth in the use of HMGs based on renewable resources. Therefore, the use of renewable resources is a viable alternative for energy development in isolated areas of India. The presented methodology can be extended to develop a modernized electricity grid using advanced information and communication technologies (ICT). Incorporating ICT to analyze consumer and supplier behavior through automation powered by artificial intelligence can generate enormous benefits in the production and distribution of efficient, reliable, and sustainable electricity.

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