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A LINEAR OPTIMIZATION ENERGY MANAGEMENT SYSTEM FOR GRID-CONNECTED PHOTOVOLTAIC MICROGRIDS

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Abstract:

This paper explores microgrids, which are seen as a promising component for developing the modern and future power systems with their capability to integrate distributed energy resources, the energy storage systems, and the controllable loads. The purpose is to create optimal control methods for managing the energy of a grid-connected photovoltaic microgrid. Following an extensive review of microgrid energy management systems, two methods were developed to determine the battery charging and discharging power. Initially, a simple heuristic method was created as an benchmark for comparison. Subsequently, an optimization-based on the algorithm like the model predictive control (MPC) approach was proposed.

Keywords **—**: EMS, PV, MPC, RES, SOC, Microgrid,**.**

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I. INTRODUCTION

Now a day energy sector is experiencing an notable transition towards microgrids, which are gaining considerable attention as an innovative solution for describing energy systems. These systems are increasingly incorporating renewable energy sources (RES) into grid connected system, which can decrease losses of power and improve voltage stability, ultimately enhancing energy inexpensive and quality. Practical implementations can emerging, such as hybrid systems that integrate photovoltaic (PV) generators as an storage units, ensuring a continuous power supply during grid outages. A microgrid is a standalone, small power network comprising Distributed Energy Resources (DERs) and a group of controllable loads. These energy sources are often renewable and have variable output power to meet local demand. Properly designed microgrids can function independently or in tandem with the main power distribution system, seamlessly disconnecting and reconnecting as needed. The larger distribution network perceives the microgrid as either a net consumer or a net producer of energy, despite it being made up of multiple generators and loads.

II.LITERATURE SURVEY

The fluctuating nature of grid conditions, such as inconsistent renewable energy source (RES) outputs and islanding events, highlights the necessity of maintaining energy balance in microgrids to ensure stability[1]. The variable reliability of RES presents challenges in matching energy supply with demand, making the incorporation of energy storage solutions essential for optimal utilization. Implementing an Energy Management System (EMS) is vital for microgrids to manage energy production and distribution efficiently and economically[2]. The dependability and performance of a microgrid can be enhanced using this control system. During daytime outages, the PV array and the storage system can meet the demand. However, at night or during severe weather, when the PV array is not generating power, only the storage system can supply the necessary loads. The challenge of islanding operation is to maintain a consistent power balance between energy output and load consumption. A power mismatch will cause the system's frequency and voltage to deviate from nominal values [3]. To guarantee efficient and optimal grid performance, numerous researchers have proposed methods for energy management in microgrids. A study compared the application of technical assessment tools in EMS and HRES research [4]. Sukumar et al. [5] proposed an EMS utilizing both nonlinear and linear programming techniques.

III.PROPOSED SYSTEM

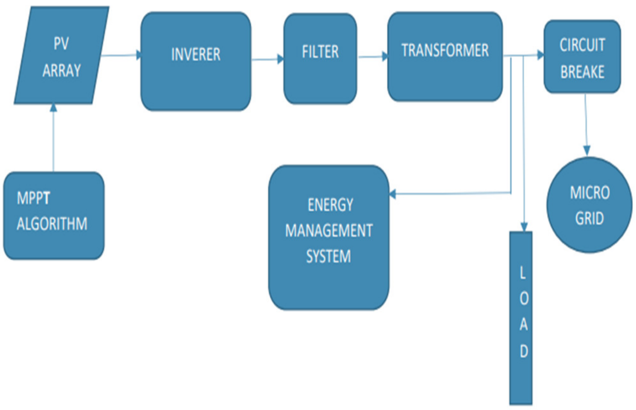

Fig1: Block diagram of proposed system.

METHODS FOR ENERGY MANAGEMENT SYSTEM

HEURISTIC METHOD

To begin with, a heuristic method is created for energy management system in the microgrid, serving as an benchmark for assessing the performance to the proposed optimized algorithm. This heuristic method algorithm determines the reference as battery power used as a set of rules designed to define the system always operates within defined constraints. It is a straightforward method considers only with in the present time and does not account for a long-term predictions. Additionally, no cost function is incorporated in the algorithm. The flowchart of the heuristic algorithm is shown in Figure. The algorithm receives an energy and power data from the energy management system to calculate the total power. It first checks the sign of the total power. If the total power is negative, indicating insufficient Photovoltaic power to meet the loads and the battery must discharge to cover the demand and also provided it does not breach the minimum SOC constraint to the maximum discharge rated power. If these conditions are violated, it satisfies the load demand by power from the main grid. Conversely, if the total power is positive, the excess Photovoltaic power can be used to charge the battery, but if the maximum limit not reached by SOC and so the charging rate does not exceed the maximum allowable rate. The implementation script of the heuristic algorithm is included.

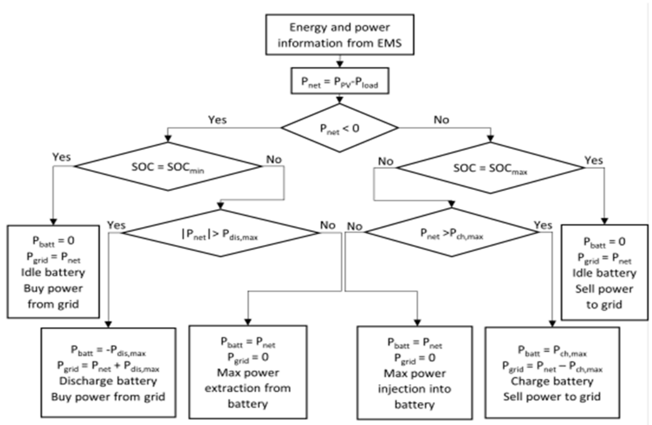

Fig2: flow chart for heuristic method

LINEAR OPTIMIZED METHOD

Linear programming is a mathematical technique used to solves the problem by using the optimization function of multiple standalone variables. This action is, known as the objective function, can represent measures such as the profit, the cost, or capacity of production, which need to be optimized by linear methods. The technique focuses on the optimal allocation of limited resources among competing activities, all should adhering to a set of specific constrains to the problem. Linear optimized programming is more versatile than traditional methods that rely on solving systems of equations for energy management. It allows for a final solution to be obtained in a single computer run for a given set of conditions and objectives, eliminating the need for numerous solutions typical of the case study approach. However, when 25 nonlinear variables are introduced, linear programming becomes impractical due to the nonlinear nature of energy balance equations.

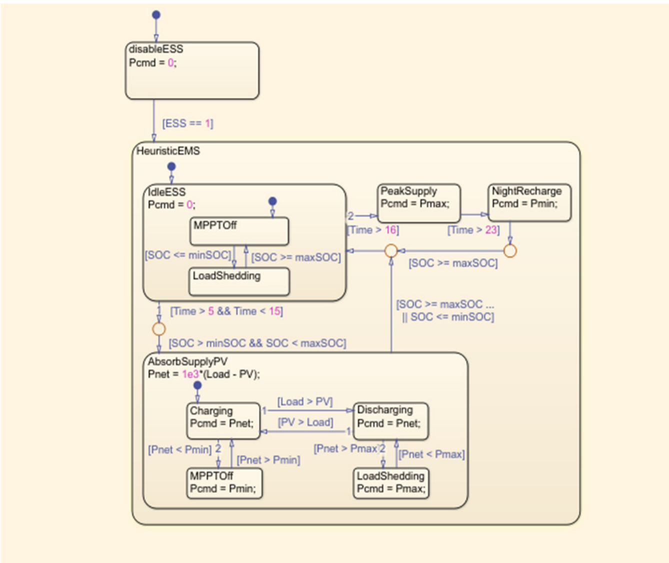

Fig3: Linear Optimization Method

IV.RESULT AND DISCUSSION

Linear programming optimization methods offer rapid tools and techniques for the integration of microgrids. These include the data analysis, the data processing, the simulation, the control, the decision making, and the optimal management hybrid models for energy generation systems. Such strategies help justify the cost of investing in a microgrid by enabling cost-effective and predictable resource use.

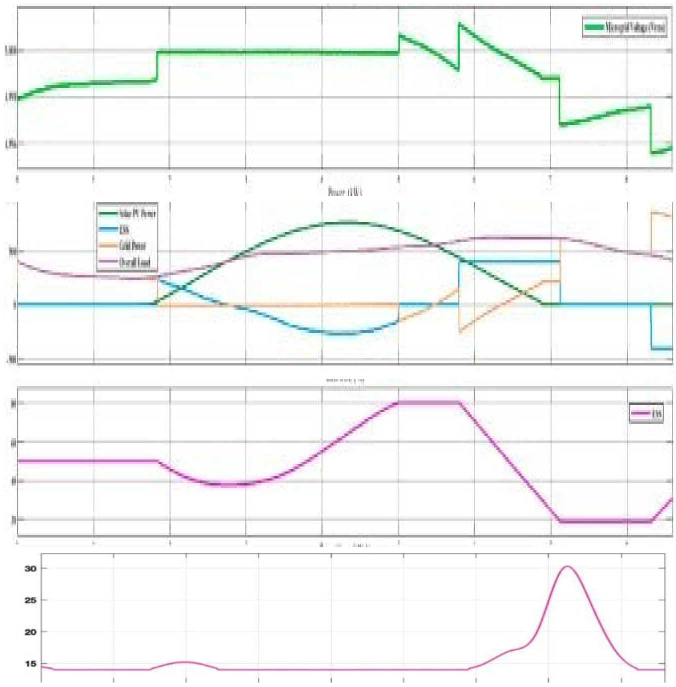

Fig 4: Linear optimized output for microgrid.

It is evident to that an battery charges were solely when there is surplus photovoltaic power, as the established the main grid prohibited charging rules. The available excess photovoltaic power is enough to charge the battery up to were the SOC reach the maximum state of charging limit of 80%. The heuristic strategy avoids long-term energy storage in the battery, opting instead to utilize the stored energy to supply the microgrid loads whenever demand surpasses generation. Interestingly, this happens to coincide with periods of high electricity prices, despite no cost function being minimized.

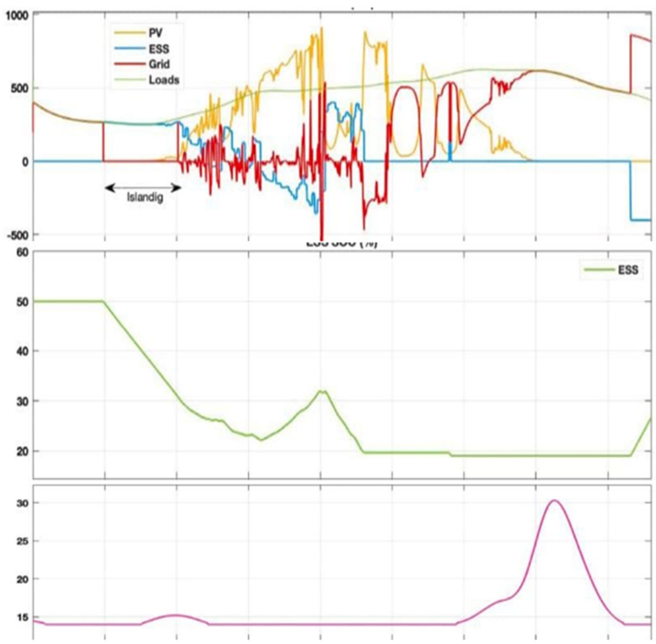

Fig5: Heuristic Output For Microgrid

CONCLUSION

This research presents an energy management system within a microgrid that includes the photovoltaic generator, the storage system, the grid connection, and the load distribution. The system's reliability is influenced by challenges such as islanding and the intermittent nature of PV generation. The primary goal is to minimize operating costs while managing variable generation, during a particular time the interruption is10,000-second. The study finds that, under clear weather conditions, the heuristic method results in a 4.567% increase in operating costs over a 24-hour period compared to the linear programming method. Under cloudy conditions, the heuristic approach leads to an 8.5232% higher operating cost, resulting in a 20% overall increase in expenses.

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