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A Comprehensive Review on Solar PV Based Microgrid System for Sustainable Power Supply in Commercial Buildings

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Abstract: ***Commercial buildings can now become "prosumers" that produce electricity through PV technology, and has come to function with battery electric vehicles (BEVs) as an energy management tool. The advances in these technologies enable commercial buildings to maximize their energy use and to reduce their costs. This study introduces a new energy scheduling for cost decentralized energy management of Smart commercial building. The need of demand response (DR) drivers and strategies that let operators react in real time to energy resource costs is described as the need for real-time pricing (RTP). The group teaching optimization algorithm (GTOA) is applied to optimize scheduling process, ensuring the efficiency of energy resources allocation to meet the energy demand, and maximizing the utilization of renewable energy resources. The simulation results indicated that the proposed approach significantly helps to reduce electricity cost, reduce the dependence on the energy provided by the utility companies during peak energy hours, and improve the overall energy efficiency of energy intensive commercial buildings. The conclusions highlight the energy scheduling approach enabled by DR, which can be useful for achieving greater cost savings and encouraging more sustainable energy use in smart commercial buildings.***

I. INTRODUCTION

A Solar Photovoltaic (PV) based microgrid system is an electricity network localized in area, decentralized and using solar panels as energy resource (either connected to the main electricity grid or in "island mode" operating on its own). These systems include power generation, energy storage in this case battery energy storage systems (BESS), and advanced mini-grid systems for small and specific distribution zones like communities, campuses, or industrial parks.Mini-grids for electricity supply to small and specific zones, like communities, campus and industrial parks. They are being identified as a key way to improve energy resilience, deliver energy to rural areas, and free up reliance on fossil fuels.

A tremendous amount of energy from multiple sources is required for Globalisation and long term growth. However, fossil based fuel sources are limited and therefore alternatives, such as renewables, are being considered as it helps ensure sustainable growth. However, rural people still do not have access to mainstream electricity despite the ever-growing demand for electricity in many developing countries. One billion people on Earth do not enjoy electricity and even less reliable power. Electricity is essential for fulfilling basic humanity needs in rural communities.

II. LITERATURE REVIEW

This study will also emphasize control strategies and Energy Management Systems (EMS) for the specific case of DC microgrids, and how they contribute to improving its efficiency and reliability. It highlights some of the benefits of EMS including optimised energy flow, optimised load management and dynamised stability for modifications of operational conditions. Another aspect of this research will regard aspects of enabling renewable energy sources (e.g., solar PV & wind) and energy storage systems (e.g., batteries, flywheels, capacitors) in the DC microgrids. Furthermore it explores approaches for energy generation and consumption management, lowered energy loss and easier use on pitch and off pitch for grid connected and stand-alone functioning.

Sakib, S. In this study, the emphasis is on Battery Energy Storage System (BESS) and how BESS can be used in an Energy Management System (EMS) for microgrids. It provides an overview of different control strategies for BESS, their function of a stable grid and to improve power quality. The study calls attention to the need to manage energy storage properly to mitigate the intermittency of RE and ensure continuity of power generation.

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The study underscores the great potential for the microgrid to perform better, reduce energy loss and provide greater flexibility in its operation, particularly by incorporating renewables and reducing losses in the battery systems and distributed generation units.Incorporating more sustainable and resilient energy supply systems within the study could lead to enhanced performance, less energy losses and increased flexibility in the operation of the microgrid, with the associated renewable generation and minimising losses in battery systems.

Kang, X. A different analytical model is offered in this study to build optimized size of micro-grid system of buildings and to assess the cost and carbon emissions of the system efficiency. The energy balance aspect of the framework is centered on optimum energy generation and consumption, to ensure the microgrid's efficient and sustainable operations. The methodology identifies different combinations of energy generation and storage and selects the ones that are most environmentally beneficial and at the lowest total costs for safe energy management decisions. It highlights the use of renewables, such as Solar PV systems, with intelligent controls and how these can reduce reliance on traditional fuels, carbon emissions and the sustainability of the energy systems of buildings.

The authors have reviewed extensively the Maximum Power Point Tracking (MPPT) Techniques used in Photovoltaic (PV) Systems in this paper. The MPPT techniques can be categorized into four parts: Conventional MPPT techniques, Intelligent algorithms, Optimization techniques and Hybrid techniques. Each approach is evaluated using important performance metrics like velocity tracking, overall energy consumption, cost, stability of operation, and simplicity of the implementation. The review illustrates the merits and demerits of these methods and offers some guidelines when choosing appropriate MPPT method for various PV system applications. It also focuses the attention on the efficient and practical implementation of real world systems.

Different strategies and methodology adopted to ensure effective energy management in micro grid is discussed. It explores methods of maximising the power generation, storage and power transmission efficiencies and the challenges that renewable energy sources variability and fluctuations create. Advanced control techniques (model predictive control, intelligent scheduling) are highlighted to increase the efficiency of the system. The study also showcases the importance of distributed energy resources and energy storage in providing reliable and stable operation. Finally, the future paths and innovations that are being explored in Energy Management Systems (EMS) are discussed to increase the performance capabilities, sustainability and resilience of the microgrids.

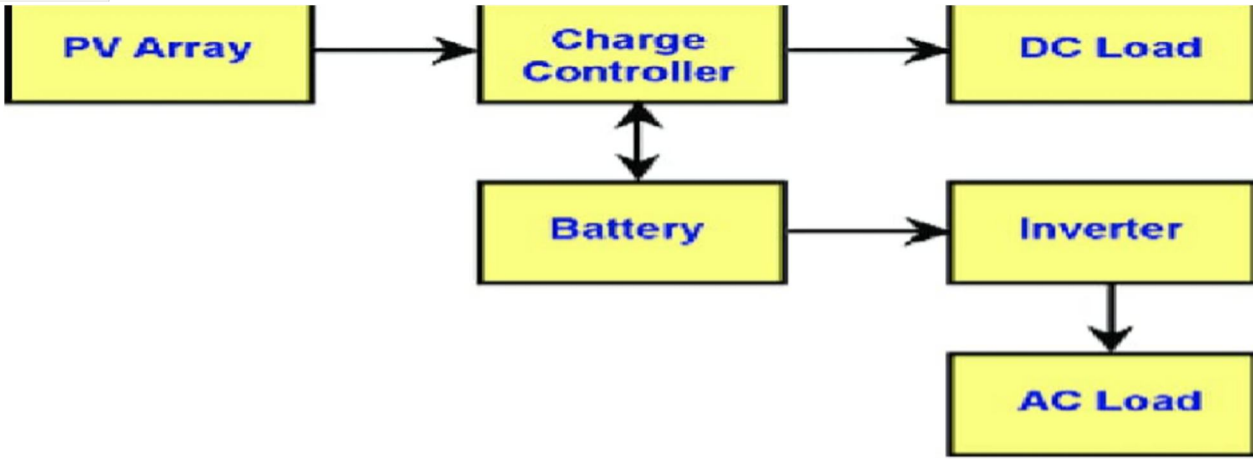
A. Research Gap

Although solar PV systems-based microgrid technologies show considerable progress, there are still several challenges in its implementation for commercial buildings. Scattered PV-RS studies primarily address singular PV integration with a single renewable energy source, but do not include full scale EMS frameworks incorporating PV generation, battery storage and intelligent load prioritization. MPPT techniques may be effective in ideal conditions, but perform poorly when weather conditions drastically change.

Have lower performance at partial shading and shifting weather conditions. There is very little work focused on the realtime classification of loads in the ‘secured/non-secured' classification space so as to ensure continued power to critical loads. Moreover, opportunities for energy sharing between several commercial buildings via micro-grid networks are not well explored. Also inadequate integration is expected in currently available EMS designs, as they lack the ability to monitor and make decisions based on IoT. Further, there are very few simulation-based studies that consider system.

B. Research Methodology

At the commercial building, significant power is required to operate HVAC systems, lighting, elevators, computing systems and security systems. Relying on the grid to power most of the products we use can result in high costs and high carbon footprints. Solar PV is a clean, plentiful and sustainable energy source providing an ideal solution for decentralised energy generation. But due to the intermittent nature of solar energy, efficient storage solutions and intelligent management systems are required. Microgrid will provide localized generation, storage and distribution, and, as a result, better reliability and lower losses. The use of the Energy Management System (EMS) in conjunction further improves system efficiency by optimizing power flow and critical loads. Energy demand in commercial buildings growing, aim to make electricity more reliable, fossil fuel independent and shift to sustainable building infrastructure, availability of Ab and feasibility of low-carbon emissions, requirement for integrating battery storage with 24×7 electricity supply, requirement for intelligent load management and energy management system, potential for energy efficiency and cost savings, and smart use of energy in modern buildings.



III. DISCUSSION

Solar PV based microgrids with rooftop solar panels, battery storage (BESS) and intelligent Energy Management Systems (EMS) can supply sustainable, reliable energy for a commercial building. They offer the ability for peak load shaving, mitigation of carbon footprints, or even for seamless switching between grid connected and independent operations, while providing energy security and also supports economic feasibility.

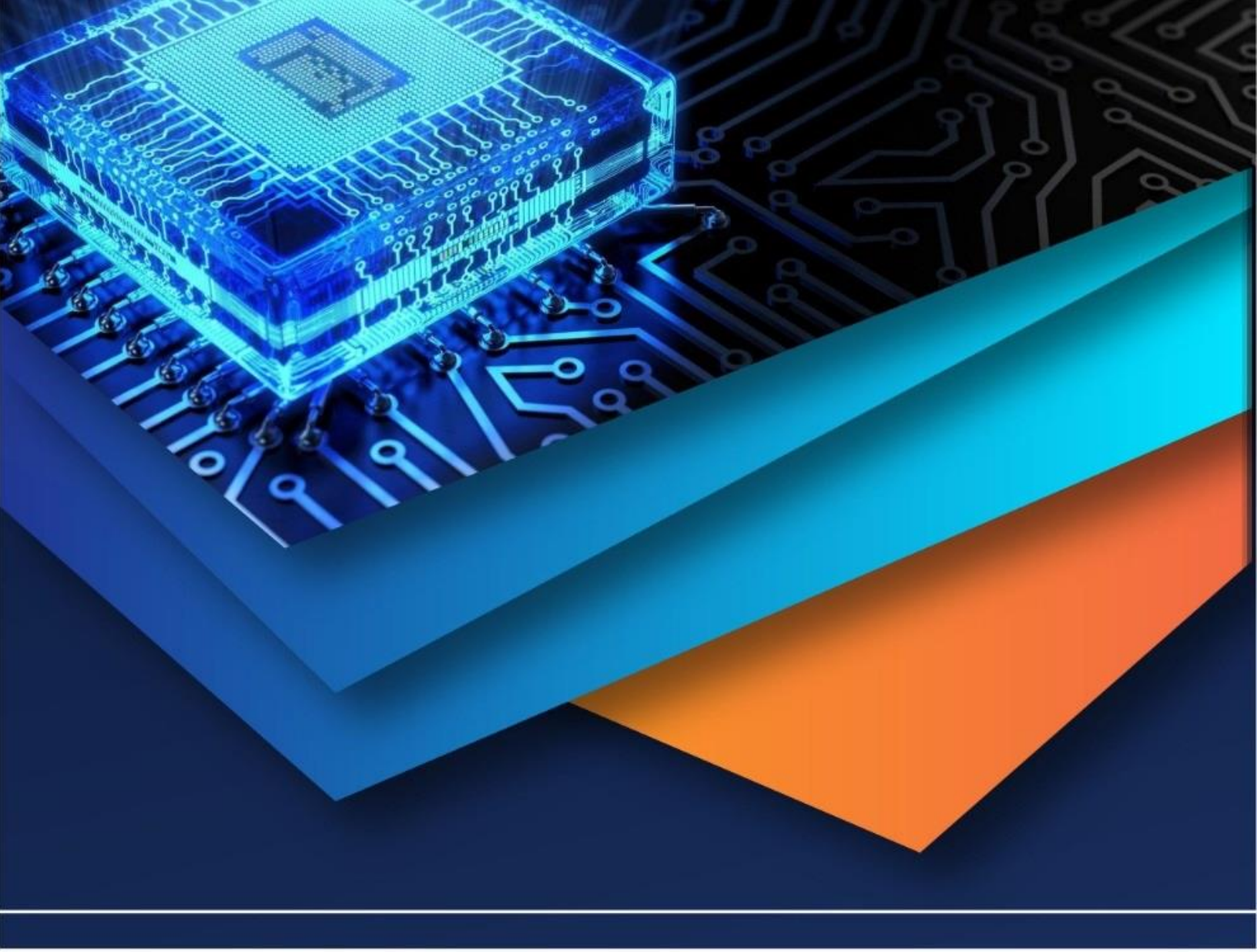
Commercial buildings are mostly powered by conventional fossil-fuel based power plants and the existing power supply configuration is based on that of the centralized grid power [1]. The goal of electrical distribution systems is to deliver electrical power to all buildings to satisfy the demands of lighting, HVAC systems, elevators and electronic equipment within the building. During grid outages, back-up power is usually supplied by either diesel generators or simple UPS systems [2]. A few buildings have small scale PV installations on their premises; however most of these installations are used to heat water or for small lighting loads and are therefore under utilizing the PV potential [3]. Without integrated energy storage and intelligent energy management systems, energy is not used efficiently and operating costs go up.

IV. CONCLUSION

Microgrids with solar PV can make commercial buildings more secure with energy supplies, more cost-effective with electricity bills and less carbon-laden with emissions, and are a very effective, sustainable, reliable solution to these problems. These solutions optimize rooftop space for diurnal demand, allow them to reduce the stress on the central power grid, limit peak demands and supply power in off-grid periods, while simultaneously offering integration with storage solutions. Solar photovoltaic (PV) based microgrid systems are gaining in significance as an energy solution for commercial building's energy demand. Combining renewables with Energy Management Systems (EMS) and Battery Energy Storage Systems (BESS) simplifies energy reliability, energy efficiency and energy sustainability. There is evidence from the literature of the important role that advanced EMS strategies will have in the optimization of power flow performance, in balancing supply and demand, as well as in stabilizing the operation in grid-connected and standalone modes. Technique Maximum Power Point Tracking (MPPT) shows significant improvement in the extraction of solar energy, especially in different environmental conditions.

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