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"A Review of Grid-Connected Solar-Wind Hybrid Systems for Electrical Applications"

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Abstract- This study focuses on a grid-connected solar-wind hybrid system integrated with an electric vehicle (EV) charging station to meet the electricity demand in India. The economic viability of the proposed setup is analyzed, considering both the retail center's power needs and EV charging requirements. The system design accounts for energy purchasing and selling costs, ensuring seamless power exchange with the utility grid. Optimization techniques are applied to size system components for minimizing the levelized cost of electricity (LCOE) while enhancing power supply reliability (LPSP). Effective management of renewable energy generation and load demands emerges as crucial for creating an affordable and dependable system, particularly beneficial in reducing dependence on grid power in economically disadvantaged areas.
Keywords—Charging station, electric vehicle (EV), optimization, solar photovoltaic (SPV) panels, wind turbine.

I .INTRODUCTION

Micro grids offer an intriguing approach to enhance power utilization efficiency and the quality of electricity consumed by diverse users. The utilization of distributed renewable energy sources has been expanding to mitigate pollution, enhance network reliability, and facilitate electrification in remote areas. Micro grids powered by hybrid renewable energy resources (HRERs) such as solar arrays (PV) and wind turbine generators (WTGs) have garnered significant attention, particularly in impoverished nations, aiming to reduce carbon emissions, diversify energy sources, and stimulate local economies. Hybrid AC/DC micro grids are being explored to enhance operational efficiency by leveraging the strengths of both AC and DC sub grids while minimizing conversion stages.

Because of this, hybrid MGs offer a promising alternative for either subpar poor distant populations [16] Or even developed load center's that are isolated from primary utilities to meet their electrical needs [17]. In addition, constant population increase and rising load demand spurred aggressive strategies to ensure a sustainable and dependable power supply [18] via hybrid AC/DC autonomous MGs [19] whenever grid connection is not possible or is not cost-effective [20]. Though long-term supplemental energy storage systems (ESSs) can effectively suppress HRER irregularities [22] so that standalone MGs function as conventional power plants [23], MGs are still susceptible to notable voltage and/or frequency deviations due to climatic vagaries, such as changes in solar radiation and wind speed [21]. Hybrid energy storage systems (HESSs), which are distinguished not only by high power density but also by high energy density, are essential to handle rapid power changes and simultaneously ensure MG autonomy [24][3].

The integration of electric vehicles (EVs) into renewable energy-based systems presents both exciting opportunities and significant challenges, particularly in terms of economic analysis and power management. Research in this field primarily focuses on controlling and managing the power of EVs within micro grid or grid-connected systems. An essential aspect to consider is conducting an economic analysis that accounts for power exchange with the grid. The increasing adoption of EVs poses both opportunities and challenges for existing power infrastructure, with reliability, availability, and seamless power flow among components emerging as key factors in developing renewable energy-based systems. [1].

II. Literature Review

Sr. No.	Author/ citation []	Methodology	Features	Challenges
1.	Shakti Singh *et al.* [1]	Optimized microgrid controller	System that is reliable Affordable helps reduce dependency on the overworked grid	Grid dependency increases
2.	Bhargavi and Jayalakshmi [2]	vel control strategy	• enticing possibility to boost effectiveness • a PEV charging device and the DC bus voltage can both be regulated	• Might cause the devices to share power improperly.
3	Sayed Abulanwar *et al.* [3]	Adaptive synergistic control strategy	• show a flawless exchange of the desired load power • reduce bus voltage disturbances brought on by large load variations • increases the robustness of the microgrid against parameter uncertainty	• taking into account predetermined parameters, which reduces system performance.
4.	Dina Emara *et al.* [4]	Coordinated control	• be functional in both normal and abnormal circumstances. • Greater adaptability and dependability	• Establishes a controlled DC voltage with reliable operation and few voltage spikes.
5	Pramod Bhat Nempu and Jayalakshmi [5]	Fuzzy logic and adaptive neuro- fuzzy inference system	• The battery system's voltage and power output transients are reduced	• There has been no discussion of the comparative analysis of FLC and ANFIS with PI regulators under dynamic system conditions.
6	Oladepo Olatunde *et al.* [6]	grid-connected load-following system with EV	Improved power loss reduction dynamic energy reserve voltage regulation	due to the extensive system and high load demand, cannot operate effectively in an

				emergency
7	Asim Datta *et al.* [7]	Coordinated AC frequency vs DC voltage control (CFVC) scheme	high robustness capacity to tolerate a wide range of system loading	difficult to balance exploration and exploitation abilities
8	Peng Wang *et al.* [8]	stochastic scheduling approach	• it is conceivable to run hybrid microgrids that incorporate the high uncertainty of renewable energy sources. • dependable and consistent performance	• Plug-in electric vehicle use may have an impact on the security of hybrid microgrids.

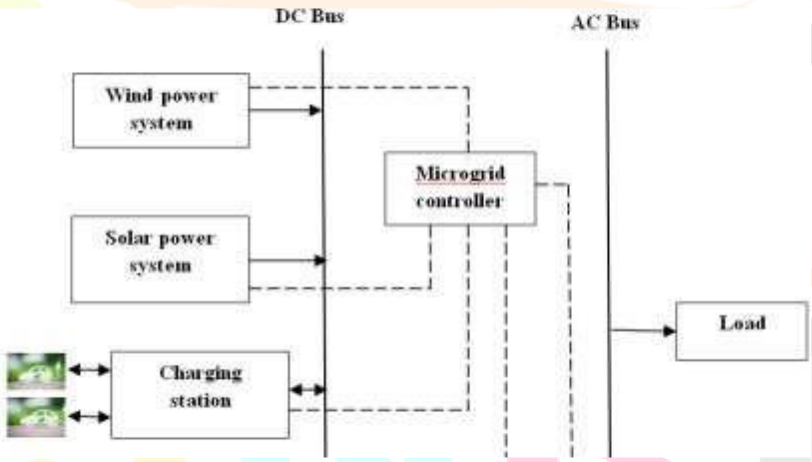
III. Methodology

The final goal of the research that is being presented is to carry out cost minimization when switching between AC and DC power microgrids. The suggested model includes an electric vehicle charging station, a hybrid AC/DC microgrid system, a wind power generation system, and a solar power generation unit. Wind turbines, SPV panels, and a charging station are connected to the DC bus, whilst the electrical load is connected to the AC bus. To convert AC into DC and vice versa, a dual converter is proposed. In a hybrid AC/DC system, as opposed to a single AC or DC system, power management is more important in terms of cost. As a result, the suggested research's goal of cost minimization is combined with a smooth power flow between the system's numerous components. To achieve the lowest levelized cost of electricity (LCOE) while minimising the loss of power supply probability (LPSP), the Aquila Marine optimization (AqMar) Algorithm is suggested [1]. The marine predator optimization algorithm (MPA) [25] and the aquila optimization algorithm (AOA) [26] have been integrated into the development of the proposed AqMar. Multiple energy sources make up the planned hybrid renewable energy system. Due of the numerous decision factors in this subject, complex optimization problems occur. The main goal of the suggested algorithm is to maximise converter, wind, and SPV capacity in order to satisfy the fitness functions of LCOE and LPSP. For the AC load and EV charging station to receive an uninterrupted power supply, this issue necessitates the identification of energy sources. Consequently, the optimization problem includes economic goals. Additionally, to find the best balance between LPSP and LCOE, long-term system performance must be calculated. The suggested AqMar algorithm reduces LCOE by dynamically searching for an ideal system configuration and keeping LPSP within specified bounds. As a result, an ideal power exchange between the utility grid and other system components is guaranteed.

TABLE I : SPECIFICATION AND COST OF SYSTEM COMPONENT

Sr. No.	Component	Parameter	Value
1.	SPV panel	Maximum power Pmax	100 W
		Maximum voltage Vmp	18 V
		Maximum power current Imp	5.56 A
		Open circuit voltage Voc	22.3 V
		Short-circuit current Isc	6.1 A
		Number of cells	36
		Nominal operation cell temperatur	45
		Capital cost and replacement cost	1084 $/kW
		O&M cost	5 $/year

		Life time	20 year
2.	Wind turbine	Rated power	1 kW
		Capital and replacement cost	1098 $/kW
		O&M cost	2 $/kW/year
		Cut-out speed Vco	20 m/s
		Cut-in speed Vcin	5 m/s
		Hub height	50 m
		Life time	20 year
3.	Others	DC bus voltage Vbus	120 V
		Project life N	20 year
		Interest rate i	6 %
4.	Converter	Rated power	1 kW
		Rectifier and invert efficiencies	90 %
		Capital and replacement cost	127 $/kW
		O&M cost	1 $/year
		Life time	20 year
5.	EV battery specification	Battery ampere-hour	210 Ah
		Battery type and variant	Lithiumion
		Number of modules	16
		Number of cells	48
		Battery energy capacity	5 kWh
		Maximum charging rate	0.5 kWh/h
		Maximum number of vehicles/bays	20



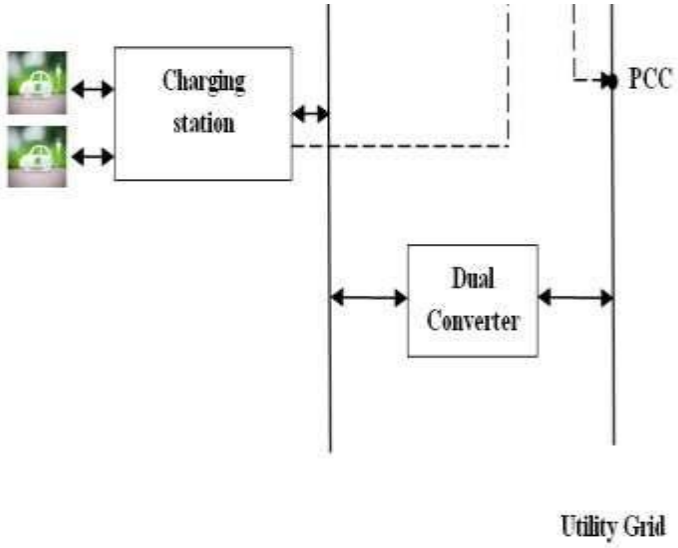


Figure 1. Schematic diagram of proposed system

IV. EXPECTED OUTCOMES

The proposed model, implemented in MATLAB and utilizing a hybrid AqMar optimizer, will undergo simulation prior to experimental testing and analysis. In the performance evaluation of the study, the proposed model is compared against several standardized models. It is found to outperform them significantly in terms of both cost and power loss.

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