Latest Advancements in Renewable Energy: A State of Art

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Abstract – *Renewable energy sources and technological advancements may be able to address the persistent power crisis that emerging nations are now experiencing. The world may overcome its energy shortage by utilizing sustainable energy alternatives including wind, solar, sea, bioenergy, and fuel cell development. Possibly due to fossil fuel reserves that may run out in the upcoming years, it is necessary to adopt cleaner and renewable energy alternatives. This study examines current developments in renewable energy from several angles, including objective, methodology, benefit, components, limitations, and potential future applications. Additionally, it contains a case study that uses genetic algorithms in conjunction with Monte Carlo simulation to analyze distributed generation in the distribution network with or without electric vehicles for both static and ZIP load models. The paper's primary goal is to describe current research trends and research gaps, so additional studies have been conducted.*

Keywords – Bioenergy, Hydro energy, Renewable energy, Solar power, and Wind energy.

1. INTRODUCTION

There is a widespread problem with lowering carbon pollution because carbon dioxide makes up the majority of greenhouse gases (GHGs). In this scenario, various techniques, such as adopting renewable energy (RES) and encouraging technological breakthroughs, could be utilized to reduce carbon emissions. Infrastructure development for RES-based power production has started in many countries. The need for alternative energy sources and worries about climate change brought on by the excessive use of fossil fuels go hand in hand. The five types of RES that make up the majority of the market are hydro, solar, wind, biofuel, and tidal energy. A generator that produces energy is coupled to a turbine that is turned by flowing water. The amount of fluid that is produced and its elevation above the turbine determine how much electricity is produced. Reservoirs are necessary for large Hydro Power (HP) installations to store the water needed to generate energy. Solar Power (SP) is the heat and light that the sun emits, to state the obvious. The power that the sun provides can be used in a variety of ways: Photovoltaic cells could be used to convert sunlight into energy. In the solar thermal process, SP is utilized to produce steam or hot water. The wind is utilized to create electricity by converting the kinetic force of flowing air into electric power. The wind drives the rotor blades of contemporary wind turbines, converting kinetic force into rotational power. This rotational energy is sent to the generator, which produces electrical energy, using a shaft called Wind power (WP). "Bioenergy," or "Biogas Power (BP)" is created from biological resources that are present in nature, such as grass and trees. Three major types of bioenergy—biogas, bioethanol, and biodiesel—can be created using plants (such as corn and sugarcane), wood, agricultural waste, and bagasse. Our tides and oceans' movements cause waves to travel at a certain velocity, which can be thought of as kinetic energy-producing power called Ocean power (OP). Tidal power is gravitational hydropower, which generates energy by using the motion of water to drive a turbine. Geothermal energy is the name for the earth's heat. Originating from the Greek terms "geo" (earth) and "thermal," (heat) we get the term "geothermal". Geothermal energy is a RES due to the continuing heat production deep within the earth. People use geothermal heat to create electricity, warm up buildings, and take baths. Sustainable, inexhaustible, and becoming more and more affordable energy comes from renewable sources.

In *Section 3*, Table 2- 4, literature reviews have been done which are defined below. Zhaodi Shi, *et al.* [1] the approach is improved by using the presented simulations of a time series (TSS) technique and golden segment Fibonacci tree optimal (GSFTO) technique, which takes into account all local administrative RE resource features. Yan Li, *et al.* [2] the main technical connections for large-scale (LS) WP facilities to link to the Power System (PS) are networking and coordinated transmissions (TRANS) of LS WP sites. Yan Li, *et al.* [3] the technical specifications for RE plants that are linked to the network and operating on islands. Additionally, significant innovations for RE generation responding to AC faults are analyzed. Seyed Azad Nabavi, *et al*. [4] proposed a scheduled architecture for the integrative models and deep learning relevant to the construction of a distinct wavelet conversion and

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extended short-term memories approach (DWT-LSTM). Swaminathan Ganesan, *et al*. [5] explain how to use MATLAB/Simulink to determine the scientific technique that will get the best evaluation of the VS that can serve as a voltage and frequency benchmark for the Battery energy storage system (BESS). Zhongjie Guo, *et al.* [6] assess how the power (MW) and energy (MWh) potential of ESU will affect RE usage from two factors: RE restriction and system adaptability for risk management (MNGT), two parameterized optimization (OPT) frameworks, such as many parameters mixed-integer linear programming (mp-MILPs), are proposed. Chitralekha Jena, *et al.* [7] NSGA-II is suggested as a solution to the problem of multi-objective production planning for constant head hydro-thermal systems including pumped hydro ESS. Saniye Maihemuti, *et al.* [8] utilize the endorsed vector motor with lowest squares (LSSVM) technique and the strategy for dynamical self-adaptive differential evolving (DSADE), a theory and paradigm for a high RE saturation of interconnected electricity-natural gas systems (HRE-IENGS) centered on the N 1 secrecy standard were presented. Abdullah Al Hadi, *et al.* [9], researched a demand response (DR) technique that is straightforward but incredibly sophisticated and efficient, as well as demand side MNGT (DSM), to reduce the intermittency issue and give consumers an uninterrupted power supply (UPS). Yujun Gu, *et al.* [10] a new suggested method referring to DC link voltage assertions is made for the motor generator pairs (MGP) arrangement, which is necessary for defect pass-through during the regulation balance of power on both ends of the DC bus. Bo-Chen Lai, *et al.* [11] offer a multi-agent reinforcement learning-based local energy management system (EMS) (RL). Jun Hashimoto, et al. [12] offer an integrative testing network's conception and deployment. Huy Truong Dinh, *et al.* [13] utilizing particle swarm enhancement (PSO) and binary particle swarm augmentation (BPSO), present a novel home EMS design with RES and energy storage system (ESS) that takes grid utilization and power sales into consideration. Yushu Sun, *et al.* [14] concentrate on the use of ESS for RE output variation reduction, this paper initially examines the justification for reducing RE power fluctuation (FM). Luise Middelhauve, *et al.* [15] RES's distinct model was created using the MILP technique, which also allowed for the prompt district-scale modification of the layout. Christian Tipantuna *et al.* [16] utilize Software Described Networks (SDN) and the virtualization of network functionalities (NFV) innovations as enablers and encourage the main use of energy from RES. It also offers a new usage prototype that is subject to availability and includes customers in the management (MNGT) method. Ke Jia, *et al.* [17] Inverter-interfaced renewable energy generators (IIREGs) are used in this paper's pilot prevention scheme to address failure or decreased responsiveness of differential protection for phase faults. Zhongting Tang, *et al.* [18] the two most popular RES, WP and photovoltaic (PV), are investigated in this research to show the importance of power electronics. Fahad R. Albogamy, *et al.* [19] utilizing virtualized queuing reliability Lyapunov OPT approach, investigate real-time (RT) power improvements in grid-connected sustainable home automation with heating, ventilating, and air conditioning (HVAC) load while accounting for uncertain system input features (LOT). Yi Liu, *et al.* [20] in this article, examine how to install mobile edge computing (MEC) sub-edge network servers and ESS simultaneously at the micro base station (BS). Dunnan Liu, *et al.* [21] analyze the relationships between the PS, EVA, and REG as well as their market characteristics using the soft actor-critic (SAC) approach and the master-slave gaming (MSGM) architecture of EVA and REG. Siyuan Wang, *et al.* [22] in addition to measuring the need for ESS using MILP preparation with density-based cosine similarity-based spatial segmentation of noisy solutions (DBSCAN) technique, the article introduces a framework to describe, recognize, and remove such bottlenecks identification (BI) in the field of view of framework equilibrium for RE incorporated bulk PS. Yiqing Zhao, *et al.* [23] Focusing on alpha cut levels, the provided interval type-2 (IT2) fuzzy strategy for arrangement priority via simulating the ideal response (TOPSIS) approach is considered. Additionally, by taking into account IT2 fuzzy Vise Kriterijumska Optimizacija I Kompromisno Resenje (VIKOR), a comparison analysis is also undertaken. Dubey et al. [24], examination of the distributing channel's distributed generations (DGs) and e-mobility (EVs).

The analysis of renewable energy in this paper takes the following factors into account:

- Combined renewable source mathematical modeling is defined.
- Different renewable energy sources have been compared and contrasted.
- A tabular discussion of recent literature on renewable energy research has been conducted.
- Comparative analysis between Static and ZIP load models for DGs with EV planning has been discussed.

The primary objective of the paper is to inform readers about current developments in the field of renewable energy source research, which can assist in the generation of ideas for future studies. The researchers have identified research gaps through the tabular examination of RES and the analysis of the limitation section, which can help them in their future investigation. They gain some understanding of the framework of research through the case study and Figure 2.

There are three parts to this article. *Section 1* is the introduction; *Section 2*, is mathematical modeling and comparison; *Section 3*, is the result and discussion in tabular form along with the case study, and *Section 4*, is the conclusion and future scope.

2. MATHEMATICAL FORMULA PROBLEM

The goal of the mathematical optimization strategy is to combine the many renewable energy sources that are present in an area while taking into account both their strengths and weaknesses. Total solar radiation in solar photovoltaics (I_s) in (kWh/m^2) is given by Eqn. (1);

$$I_s = I_b F_b + I_d F_d + F_r (I_b + I_d) \quad (1)$$

Where, I_b= direct irradiation; I_d= Diffuse solar radiation, and F_b; F_d; F_r= Tilt ratios for the sun radiation's beam, diffuse, and reflected components.

Power generation from the PV system (P_{PV}) in (kWh) is given by Eqn. (2);

$$P_{PV} = R_{PV} I_s A \quad (2)$$

Where, R_{PV}= System effectiveness; and A= Accessible panel space.

Electric power obtained by a wind turbine (P_{WT}) in (kWh) is given by Eqn. (3);

$$P_{WT} = P_w A_w R_w \quad (3)$$

Where, P_w= Power of the wind generator, A_w= entire area swept; and R_w = The gearbox, generator, and related systems' total effectiveness.

Biomass gasifier power (P_{BM}) in (kWh) is given by Eqn. (4);

$$P_{BM} = R_g (\emptyset_w - \emptyset_B) \quad (4)$$

Where, $\emptyset_w$; $\emptyset_B$= Biomass is instantly accessible (kg), biomass is needed per hour, and R_g= The overall device's effectiveness as a gasifier.

Power generated by biogas engine generator (P_{BG}) in (kWh) is given by Eqn. (5);

$$P_{BG} = R_b (BG_{total} - BG_{C-H}) \quad (5)$$

Where, BG_{total}; BG_{C-H} = At that moment, biogas is accessible and is used for baking and the production of hot water. Electricity produced by a solar thermal collector (P_{STC}) in (kWh) is given by Eqn. (6);

$$P_{STC} = I_b R_{tc} A_a - P_{loss} \quad (6)$$

The quantity of energy of type q is defined by Nq, and $P_T(t)$ reflects the overall energy production at any moment are given in Eqn. (7);

$$P_T(t) = \sum_{PV=1}^{N_{PV}} [R_{PV} A (I_b F_b + I_d F_d + F_r (I_b + I_d))] + \sum_{WT=1}^{N_{WT}} [P_w A_w R_w + R_b (BG_{total} - BG_{C-H})] + \sum_{BM=1}^{N_{BM}} [R_g (\emptyset_w - \emptyset_B)] \quad (7)$$

Where, R_{tc}= Collector optical efficiency, A_a =absorber area (m^2). P_{loss}= Power loss in the solar collector (kWh).

Maintaining the Integrity of the Specifications

2.1. *Current Scenario of Various Renewable Energies*

Table 1. Recent RES Scenario Types.

Type Parameter	SP	HP	WP	BP
India Capacity	61.9 GW	46 GW	42 GW	10GW
Indian State	Rajasthan	Uttarakhand	Gujarat	Maharashtra
Percentage Contribution in India's Power Sector	16%	11.5%	9%	2.3%
No. 1 Country with Capacity	China 300 GW	China 400 GW	China 328.48 GW	China 29.8 GW
Rank of India	4	5	4	7
Efficiency	15-20%	80-85%	20-40%	5-7%

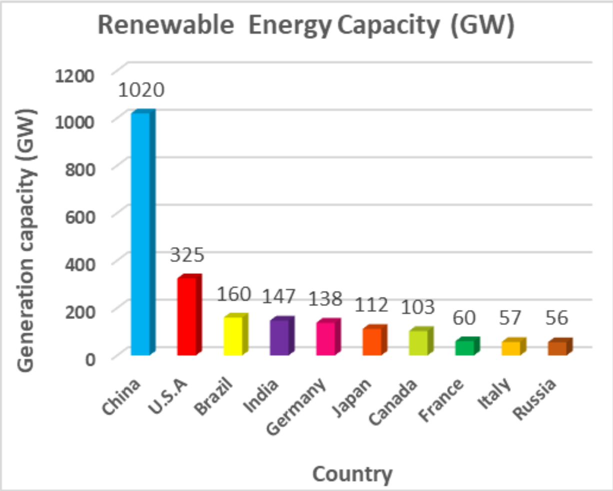

Fig. 1. Renewable power generation capacity of various countries.

Comparison of the projected global energy use for solar, wind, hydro, biomass, etc. as of December 4, 2022, in Figure 1 and Table 1 by Madhumitha Jaganmohan and Statista, which conclude that China is the biggest renewable energy producing country [27].

Systematic diagram of case study *Section 3 B*, coordinating control of DGs with EVs in DNs.

In Figure 2, the basic research setup is discussed as per *Section 3.2* case study, which includes optimization techniques, bus system, system performance parameters, and load models [28].

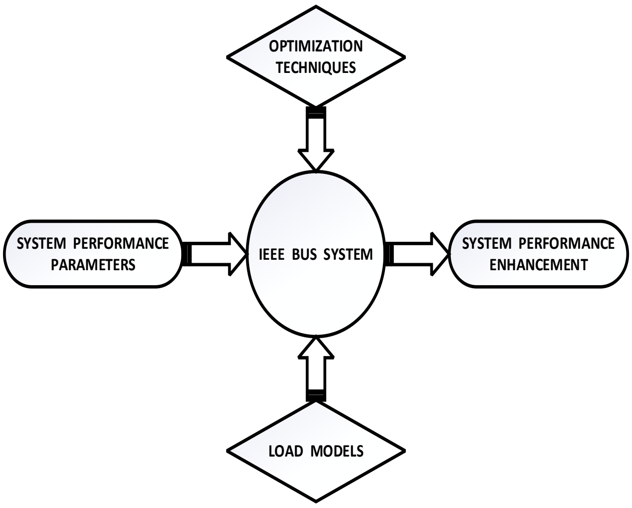

Fig. 2. Framework of research structure of DGs with EVs planning.

3. RESULTS AND DISCUSSION

3.1 Recent Trends in the Field of Renewable Energy Sources

Table 2. Analysis of Renewable Energies

S. No.	Topics	Objective	Component	Limitation	Performance parameter	Method Utility	Future Scope	ROC
1	ESS and RES capacity can be used simultaneously under hierarchical MNGT.	Improve the computational accuracy.	RES.	Further performance is possible.	The calculating time is shortened by 45.63 percent and 1.14 percent respectively.	GSFTO.	GWO.	4
2	Evaluation of the requirements for the LS RES DC gathering and TRANS TECH.	Raising operational capabilities.	WP.	It is a weather-dependent source so less feasible.	Costs associated with building and operating wind farms should be reduced by 10% to 20%.	DC networking technology scheme.	Additional research on RE and HVDC incorporation with systems engineering is required.	1
3	Requirement for LS islanded RE linked to the VSC-HVDC system's primary TECH for hazard ride-through.	Improve fault clearance capacity.	RES.	Short-circuit capacity is small.	Controllability improved by 1.6 times than conventional ones.	Fault ride-through, and VSC-HVDC.	Technique for controlling transient voltage when operating on an island.	1
4	Usage of deep learning in power modeling in DG-enabled smart houses.	Raises the use of RES by 57%.	DGs, WP, and SP.	According to financial analysis, it is non-economically beneficial.	The error margin for hourly statistics forecast for a month is 3.63–8.57%.	DWT-LSTM, and deep learning method.	Focus on net-zero smart buildings with RES.	4
5	VS scaling research for a BESS in a microgrid incorporating RES.	It is practical to use a UPS with a 35–45 percent kVA rating as the VS.	RES.	The effect of intermittent RE is missing.	Overload capacity of 150-200%.	An analytical method, and VSC-based battery ESS.	Consequences of intermittent RE on VS size.	16
6	Impact of ESS on RES utilization: A geometric description.	Reducing RES curtailment.	RES.	The generation and transmission section effects are missing.	To provide practical versatility, the ESU's proper energy-power ratio should be between 3 and 6 p.u.	mp-MILPs, Nash bargaining criterion, and Decomposition algorithm.	Choices about the extension of generation and TRANS.	10
7	Hydro-thermal system multi-objective production planning with ESS and	Compared to SPEA 2, the CPU time decrease with NSGA-II is	Hydro-Thermal System.	Less environment is friendly.	About 0.0021 and 0.051 percent of the cost ($) and emission (lb) are reduced,	NSGA II.	Latest OPT techniques.	3

	DSM taking into account RES uncertainty.	around 19.95 percent.			respectively.			
8	IENGS State's adaptive protection and stable area under various RES permeabilities.	Aiming for global optimal solutions is a task that DSADE is ideally suited for.	RES.	Less accurate.	DSADE has having lower standard deviation like 1.49e32 in comparison to other 0.0082.	DSADE, LSSVM, and HRE-IENGS.	GSO.	7

Table 3. Analysis of Renewable Energies

S. No.	Topics	Objective	Component	Limitation	Performance parameter	Method Utility	Future Scope	ROC
17	Pilot safety for RES teed lines depending on amplitude comparisons.	Decreased susceptibility to phase breakdown differential prevention.	RES.	-	The defective phase drops to 0.297 p.u. from 0.87.	IIREGs, and pilot protection.	Real-Time Analysis.	4
18	The main innovation for integrating RES is power electronics.	It is possible to increase conversion effectiveness, grid resiliency, and cost of the system.	RES.	Security issues are missing.	Controllability improved by 2 times.	Advance Control Strategy.	Upcoming prospects in grid-forming functioning, sophisticated management, and dependability of power semiconductors.	8
19	Planning RT for best energy OPT for a smart grid with RES integration.	Estimated energy and discomfort costs over MIN.	RES.	Complex.	Lowers the 20.15 percent reduction in time-average energy cost.	LOT.	Investigate online commercial facility HVAC MNGT.	1
20	DR control and joint compute offloading in the RES-MEC system.	OPT methodology and feasible modeling of the MEC system with RES.	RES.	Theoretical analysis.	Reduce system cost by 12%.	MEC.	Real-Time Analysis.	3
21	The strategy of LS EVs absorbing RE abandoned electricity based on MSGM.	Reduces the electricity purchase cost of EVs.	WP, and PV, RES.	Less accurate.	Promote about 93.89% of the WP, 96.00% of the PV system, and 97.41% of the WP-PV.	MSGM, and SAC.	Grey wolf OPT.	2
22	Operational BI-based ESS investment requirement analysis for RES integration.	The best method for getting rid of BI in the energy downward adjustments margin is ESS.	RES.	Fail in non-linear analysis.	Cost-effectiveness analyses.	DBSCAN, and MILP.	MNILP.	3
23	For the technology acceptance life cycle pattern classification of RES options, the IT2 fuzzy decision tree with extended integer code series is	Investments in SP will be significantly more effective than others.	SP, BP, and HP.	Very high initial costs	Compared to WP, BP, and their values of 0.515 and 0.464, respectively, SP's computational closeness to the ideal solution is superior at	VIKOR, IT2 fuzzy techniques, and TOPSIS.	Assessment can be performed regarding various energy types' technical advancements.	4

	augmented with alpha cuts.				0.549.			
24	Review on DGs with EVs in DN.	Overall research idea formulation.	SP, BP, and WP.	Software based.	A diesel generator is the best DG in terms of power loss MIN.	GA, MCS, GA-MCS, etc.	Hardware-based.	24

2.1. Case Study: Coordinated Control of DGs without, and with EVs in DS

In the research paper by Dubey et al. [25], the sole source of motivation for this case study was a study that addressed a novel method for the detailed comparison of DGs and electrical vehicles (EVs) in the distribution system (DS). This work uses hybrid optimization techniques, such as a genetic algorithm (GA) and Monte Carlo simulation (MCS), to examine the impact of DGs without and with EV coordination in terms of ideal sizing, placement, and types, to reduce overall power losses. This case study uses a 16-bus network and employs both static (SLMs) and constant impedance, constant current, and constant power (ZIP-LMs) load scenarios. In this case study, the percentage reduction in power losses for both load models is compared [28].

Renewable energy is a combination of combined heat and power as well as distributed generation (DGs). There are four sorts of DGs. DG1 is made up of solar power, DG2 is made up of diesel generators, DG3 is made up of capacitor banks, and DG4 is made up of wind power. The four types of EVs include fuel-cell electric vehicles (FCEVs), extended-range electric vehicles (EREVs), plug-in hybrid electric vehicles (PHEVs), and battery-based electric vehicles (BEVs). By properly coordinating DGs with EVs using GA-MCs techniques to achieve the best possible types, sizes, and locations for minimizing power loss.

Table 5. Percentage Reduction In Power Loss Due To DGs with EVs Coordination

Types of DGs with EVs	SLMs Power loss reduction (%)	ZIP-LMs Power loss reduction (%)
DG1 with BEVs	9	8
DG1 with PHEVs	9.25	8.5
DG1 with EREVs	9.5	8.7
DG1 with FCEVs	9.75	9
DG2 with BEVs	12	10
DG2 with PHEVs	12.7	11
DG2 with EREVs	14	12
DG2 with FCEVs	14.25	15
DG3 with BEVs	7	6
DG3 with PHEVs	7.3	6.7
DG3 with EREVs	8	7
DG3 with FCEVs	9	7.5
DG4 lg pf with BEVs	8.5	8
DG4 lg pf with	8.75	8.5

PHEVs		
DG4 lg pf with EREVs	9	8.7
DG4 lg pf with FCEVs	9.75	9
DG4 ld pf with BEVs	10	9.6
DG4 ld pf with PHEVs	11	10.2
DG4 ld pf with EREVs	11.5	10.7
DG4 ld pf with FCEVs	12	11
DG3 with EREVs	8	7
DG3 with FCEVs	9	7.5
DG4 lg pf with BEVs	8.5	8
DG4 lg pf with PHEVs	8.75	8.5

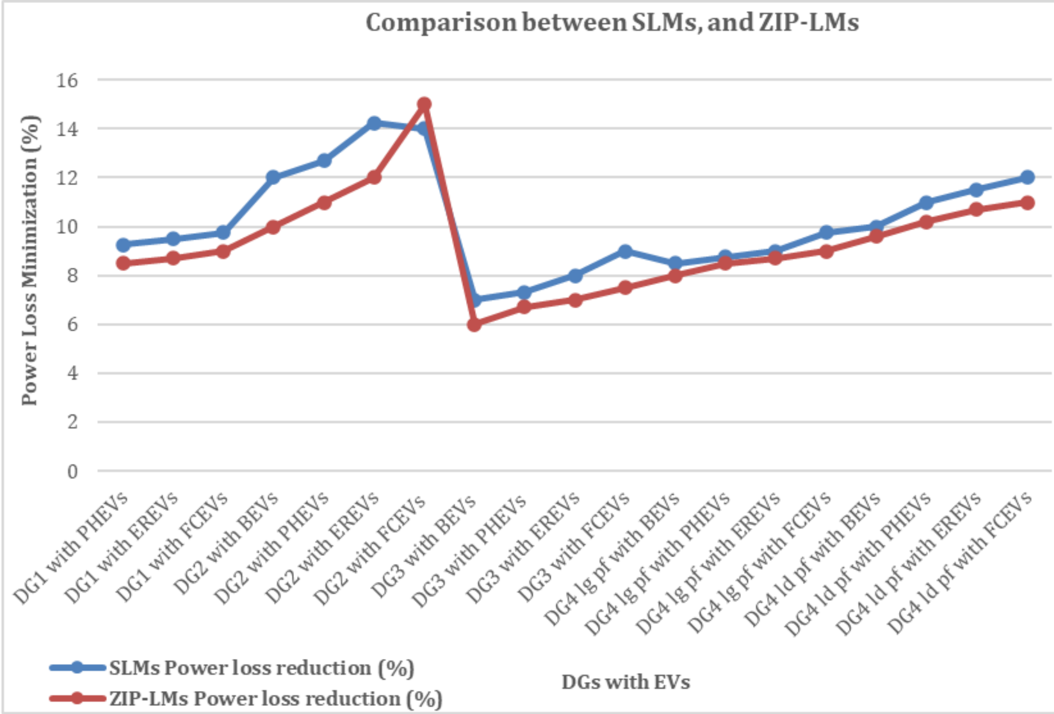

Fig. 3. Comparison of DGs with EVs pair to reduce power loss in percentage for both SLMs and ZIP-LMs

The above table is the summarization of DGs with EVs interaction with GA-MCS methods for power loss MIN which is shown in reference [25], and shown in Figure 3. From the above analysis, it is shown that DG2 with FCEVs is the best type of DG with EV pairs for power loss minimization.

4. CONCLUSION AND FUTURE SCOPE

The scheme modeling, power converter designs, and the best design methods for the wind-solar hybrid RES (HRES) now in use are all reviewed in this work. Other RES would be encouraged, claims NAPCC. Some of the specific initiatives that have been explained are promoting plain (direct) bioenergy ignition and gas production advancements, inspiring the design and deployment of tiny wind electric generators, enhancing the regulatory/tariff regime, and eliminating barriers to the advancement and commercial implementation of bioenergy, hydroelectric, photovoltaic, and wind technics. Consequently, more emphasis is being placed on using sustainable power, which is projected to make up roughly 5% of the electrical stability by 2032. HP generation is the most suitable unit for producing RE while BP-generating plants are the least efficient. However, in terms of accessibility, SP generation is the most appropriate. The highest power loss decrease in SLMs is approximately 14.25%, whereas in ZIP-LMs, it is approximately 15%. For real power loss minimization, DG2 with FCEVs is the best form of EV pair, DG2 is the best type of DG, and FCEVs are the best type of EV.

In summary, it can be said that research into renewable energy is still very much in its infancy, both in terms of scientific advancements and its application and related laws.

- The cost of HRES will be greatly reduced as wind-solar technology continues to progress. HRES will therefore become more affordable in the future.
- Artificial intelligence in EMS can improve HRES effectiveness.
- Extensive research should be done on grid code compliance and the potential to provide extra services to the grid while designing and operating HRES.
- To evaluate the effectiveness and cost of HRES, constructing a RE optimization framework or toolset that surveys and analyses market and asset constraints is necessary.
- Installing various grid systems for renewable energy and energy storage devices, such as BESS.
- Modern weather forecasting methods will significantly minimize the unpredictability of HRES production and prevent HRES energy restriction.
- In the future, research will be done on high bus systems with recent optimization techniques for more performance parameters enhancement in DGs with EV coordination controlling.
- Reducing pollutants and greenhouse gas emissions into the environment is one of the main advantages of the RES integration grid system.

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