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A Review of Multi-Objective Optimization Methods of Grid-Connected Hybrid Renewable Energy Systems Combined with Electrical Vehicle Technique

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Abstract: Renewable Energy Sources (RESs) are regarded as highly promising and rapidly advancing forms of renewable energy. The commonly used RESs are solar energy and wind energy. However, obstacles are found in designing RESs. Using vehicle-to-grid (V2G) technology in combination with electric vehicles (EVs) and RESs in smart grid are of great significance for ensuring energy security, preventing air pollution, and promoting energy saving and emission reduction. Over the past decade, V2G technology has enabled EVs to become a potential energy storage capacity for alleviating the random fluctuation in renewable energy generation. Nevertheless, the primary drawbacks of these systems are inefficient energy conversion and substantial initial investment. The sizing of each piece of equipment in the hybrid renewable energy system (HRES) is challenging. Hence, it is imperative to employ a precise sizing technique to determine an ideal arrangement and meet the requisite load requirements. Hence, before the installation of RESs, it is crucial to consider the types and arrangements of photovoltaic (PV) panels and wind turbines (WTs), mathematical models of PV modules and WTs, storage battery options, environmental-economic-technical considerations, sizing methods based on techno-economic objectives, and the ultimate selection of the most optimal configuration. This work lists the general classification of optimization formulation framework, and multi-objective optimization methods of HRESs integrated with electrical vehicle technique are reviewed. This work provided a thorough examination of the current advancements in the design optimization of HRESs using multi-objective optimization (MOO). This study aims to select the most appropriate design before installing HRESs and provides a foundational platform for scholars interested in exploring the integration of RESs with EVs for further advancement.

Keywords: Renewable Energy Sources (RESs), Electric Vehicle (EV), Vehicle-to-Grid (V2G), PV, WT, MOO, HRESs

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1. INTRODUCTION

The environment suffers a range of negative repercussions due to the consumption of readily available fossil fuels; especially, the atmosphere absorbs a significant amount of carbon dioxide (CO2) due to the combustion/burning of such fuels. CO2 emissions can be significantly reduced by maximizing the use of renewable energy sources. Renewable energy technologies have already advanced to the point where they are considered cost-competitive, have a high level of reliability, and are less harmful to the environment than fossil fuels. As well, both the constant expansion of energy demand and technological advancement are driving the global discovery of renewable energy sources [1, 2].

The rapid exhaustion of fossil resources and the increasing recognition of the imperative for environmental preservation have resulted in the energy crisis. Significant progress has been made in the past decade via the collaborative endeavors of scientists. RESs are being utilized in the power system to fulfill the energy requirements [3]. RESs and electric vehicle charging stations (EVCSs) have been extensively incorporated into distribution systems [4].

Plug-in electric vehicles (PEVs) are a very promising technology for achieving the worldwide Net-zero objective by reducing carbon emissions in the transportation sector [5]. The primary drivers for integrating distributed energy resources into conventional power networks are government incentives promoting the use of renewable energy, concerns over the escalating costs of fossil fuels, and environmental considerations. Under these conditions, the implementation of innovative technologies such as integrated cooling, heating, and power systems, energy storage systems including battery and thermal storages, and plug-in hybrid electric vehicles can enhance overall system efficiency while simultaneously decreasing operational and investment expenses, as well as emissions [6]. Centralized Charging Station (CCS) provides a convenient charging and maintenance platform for providing battery charging and delivery services to serve EVs' battery swapping demands at battery swapping points [7].

The penetration rate of electric vehicles is expected to experience continual growth. The expansion planning of charging stations includes conflicting interests in urban distribution systems [8]. Typically, energy plans for future emissions reductions involve distinct approaches for reducing carbon emissions in the transport and construction sectors. Nevertheless, the introduction and widespread use of alternative fuel vehicle technologies may lead to vehicle transportation being a significant energy burden in urban energy systems, alongside heating and electricity. Both the construction and personal transport sectors provide significant potential for reducing CO_2 emissions, but it is crucial that the energy mostly originates from renewable sources [9].

A hybrid renewable system is a particular type of energy systems that can be used as Distributed Generation (DG) resources to reduce network losses and increase its efficiency [10]. Energy hubs are widely used as poly-transfer approaches to increase power proficiency, reliability, and productive gain. Therefore, the schedule can technically and commercially improve the inhabitable department [11]. Despite encountering several hurdles and issues, electric vehicle (EV) technologies have garnered significant interest for use in multiple sectors, such as power systems. These cars' charging and discharging capabilities can contribute to the power grid, addressing typical issues in the field like peak hour challenges. Furthermore, the utilization of these vehicles can assist operators in improving the environmental efficiency of power systems [12].

The design of the HRES is highly influenced by meteorological data, including sun irradiation, ambient temperature, and the electrical demand that has to be satisfied. Meteorological data has an impact on the output of the HRES. Additionally, it is necessary to create methods to optimize the size of HRES to fulfill client needs based on techno-economic and environmental parameters. The ideal configuration of an HRES involves determining the appropriate number of Photovoltaic (PV) modules, Wind Turbines (WT), storage battery size, and inverter capacity. This design aims to enhance the system's dependability while minimizing the initial cost. To address the issue of determining the appropriate size for the HRESs, a thorough examination was conducted on several sizing approaches that rely on technical and/or economic factors. Several approaches were acquired to determine the most efficient size for the HRES. The majority of studies were completed using numerical and software tools methodologies. Additionally, intuitive approaches were employed to first estimate the quantities of PV panels and storage batteries, which were deemed imprecise. Furthermore, analytical approaches were employed because of their straightforwardness in computing mathematical models. Nevertheless, the challenge is in accurately determining the coefficient of these equations, which vary depending on the location. Thus, stochastic techniques were employed to overcome the limitations of earlier approaches due to their capacity to explore feature space more efficiently, resulting in precise outcomes in less time. Nevertheless, these strategies encounter challenges when applied to a substantial quantity of input data. To overcome the constraints of stochastic techniques, hybrid methods were devised to enhance the efficiency of the HRESs. MOO methods are commonly used for attaining an optimal set of Pareto front solutions while considering both technological and economic factors.

In this paper, the broad categorization of optimization formulation framework is presented, together with a study of MOO techniques for a HRESs linked with electric car technology. The purpose of this study is to fully analyze the present progress in the design optimization of HRESs using MOO techniques. This will aid designers and customers in choosing the most suitable design prior to installing of a HRESs. This study intends to establish a fundamental basis for researchers interested in investigating the integration of RESs with EVs for further progress. The rest of the paper is organized as follows. In Section 2, a categorization of the optimization formulation framework is displayed. Multi-objective optimization methods of grid-connected HRESs integrated with EVs technique are offered in Section 3. Finally, the conclusion is discussed in Section 4.

2. CATEGORISATION OF OPTIMIZATION FORMULATION FRAMEWORK

The main elements of the Hybrid grid-connected renewable energy system with V2G technology are the PV array, WT, energy management strategy (EMS) control, storage battery, unidirectional converter, bidirectional converter, grid, building load, and electric vehicle charging station (EVCS), as shown in Figure 1. The variations can be substantial and are influenced by several aspects, such as the accessibility of meteorological information, the characteristics related to renewability, economics, technology, and the desired power consumption.

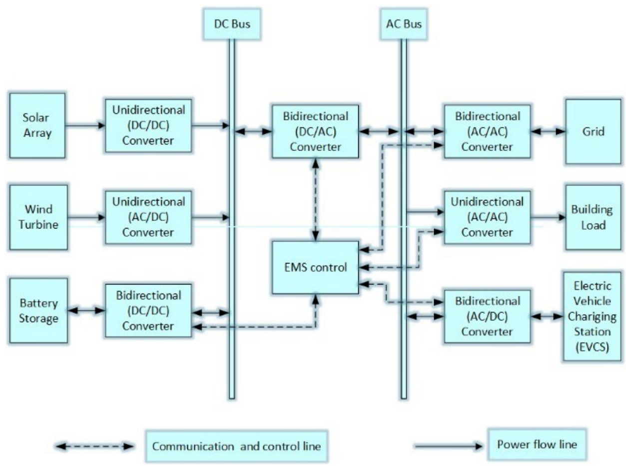

Figure 1. A Hybrid grid-connected renewable energy system with V2G Technology

Due to the use of the V2G technology within the proposed system, in the operation of the proposed system, the power flows in a bidirectional way (bidirectional path). In V2G operating mode, the system's power flows from the electric vehicle to the grid; that operating mode is called discharge mode. In discharge mode, the electric vehicle supplies power for the grid (V2G–Sell–Discharging) when grid demand is high, and batteries and RESs are unavailable. The flow of power will be bidirectional.

The classifications of optimization problems can be delineated in Figure 2 and as listed below. The optimal size problem of a hybrid renewable energy system becomes a restricted combinatorial optimization problem due to its highly nonlinear and stochastic properties. This problem involves a multi-objective function and discrete/integer variables, along with several nonlinear/linear restrictions [13] and [14]. The renewable energy sizing issue is supposed to have a multimodal modality, with several local optima and a single global optimal solution [14]. The classifications of optimization problems can be divided into five types: decision variables, objectives, constrainity, convexity, and modality. Decision variables consist of continuous, discrete, binary, and mixed. While objectives include single objective and multi-objective. Whereas constrainity includes constraints and unconstraint. Whilst convexity consists of convex and non-convex. While modality includes unimodal and multimodal.

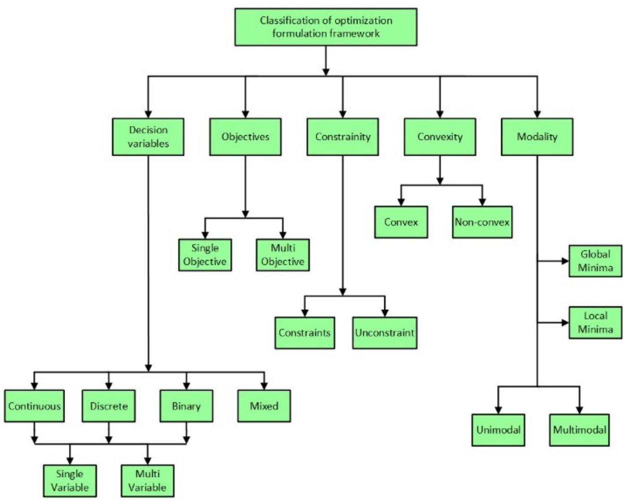

Figure 2. Classification of optimization formulation framework

In section 3, one of the optimization methods mentioned previously is reviewed. This method is multi-objective optimization. A multi-objective optimization method for the RESs integrated with the electrical vehicle technique has been reviewed in section 3.

3. MULTI-OBJECTIVE OPTIMIZATION METHODS OF GRID-CONNECTED HRESs INTEGRATED WITH EVs TECHNIQUE

In this part, a comprehensive review of multi-objective optimization methods for the RESs integrated with the electrical vehicle technique has been done. The RESs maybe one renewable energy source or hybrid renewable energy sources.

The work of [15] proposed a multi-objective economic, environmental, and technical optimization for EV charging and discharge. For the first time, power costs, battery deterioration, grid interface, and carbon dioxide emissions are simulated and simultaneously optimized in the context of a residential microgrid while supplying frequency regulation. In comparison to uncontrolled EV charging, the suggested solution decreases energy costs, battery deterioration, carbon emissions, and grid utilization by 88.2 percent, 67 percent, 34 percent, and 90 percent, respectively. Additionally, using multiple optimal solutions, the system operator must pay the end user of electricity and the owner of an electric vehicle compensation for the benefit losses they suffered of 27.34 percent and 9.7 percent, respectively, to improve grid utilization by 41.8 percent and encourage participation in energy services.

The author of [5] presented a versatile multi-objective optimization method for evaluating and implementing vehicle-to-grid and grid-to-vehicle technologies while considering technical, economic, and environmental factors. The driving behaviors, battery life cycle, and charging routines of PEV users are also considered. The modified IEEE 69-bus radial distribution test system is used to conduct simulations. The simulations utilize the heuristic-based Firefly Algorithm within a stochastic optimization framework. The uncertain parameters considered in the simulations are renewable generation, load consumption, and PEV charging/discharging timing. The simulation's objective is to minimize operating costs and carbon dioxide emissions. The findings showed notable drops in operating expenses and CO2 emissions, and the network's voltage profile was correctly adjusted. Additionally, PEV owners save significant operational expenses by integrating the PEV discharging plant into the network.

The study of [16] looked at how hydrogen fuel cells may be used in conjunction with other energy sources to create a hybrid energy system. The integration of energy storage, the associated optimization techniques, the control of energy flows, and the sizing methodologies are all explored. Few published case studies delve further than the underlying technological concerns. Hydrogen fuel cells, which utilize hydrogen as an energy source, are the primary focus of this investigation on integrating hydrogen energy technology into hybrid energy systems. Software setup, energy flow management, size strategies, and the incorporation of energy storage are all covered. Almost no published case studies address anything except purely technical concerns.

The work of [17] proposed a multi-objective model that incorporates electric vehicles (EVs) and responsive loads for feeder reconfiguration, capacitor switching, and efficient dispatching. The recommended approach utilizes active power losses, running expenditures, greenhouse gas emissions, and voltage stability index as objective functions. A microgrid incorporating a combined cooling, heating, and power system has been outfitted with non-dispatchable distributed generating (wind turbine and solar cells) together with electrical and thermal energy storage devices. The stochastic behavior of non-dispatchable generating, thermal and electrical needs, and electric vehicles are taken into account to provide precise modeling. Additionally, the modeling accounts for the stochastic behavior of both the non-dispatchable generators and EVs. By considering these factors, the modeling aims to represent the system dynamics and optimize its operation accurately. EV and electricity needs are taken into account. The multi-objective hybrid big bang big crunch algorithm, max geometric mean operator, and fuzzy scaling are used to get the best results. According to the simulation, the energy management system's operation emissions and costs may be reduced by 18.12 percent and 4.91 percent, respectively, where EV and responsive loads are considered.

The suggested model of [18] is solved using Multi-objective Sand-Cat Swarm Optimization (MSCSO), which is employed by ETH-IES for their daily stochastic economic scheduling. The objective of this scheduling is to reduce operational expenses. Simulation results indicate that the recommended model and algorithm can achieve a win-win situation for electric vehicle (EV) owners and microgrid operators. Moreover, as reported in reference, the proposed approach's operating cost is 16.55 percent lower than that of the disorderly charging and discharging method.

The study of [19] focused on the microgrid's (MG) environmental and economic optimal functioning under various situations. An AC/DC hybrid MG with a diesel generator, solar, lithium battery, and charging outlets for EVs is examined. A constrained multi-objective optimization problem (CMOP) is developed considering the MG operation constraints. The dispersed generators' fuel costs, depreciation costs, and emission costs are the optimization goals of the suggested CMOP. The introduction of the fuzzy comprehensive assessment enables the transformation of a multi-objective problem into a single-objective problem. The distributed generator outputs are then resolved using the comprehensive learning particle swarm optimization (CLPSO) algorithm. The results obtained from optimizing in both grid-connected and islanded modes demonstrate the effectiveness of the provided models, approaches, and algorithms.

In [20], the Active Distribution System's operating expenses and power losses are minimized by utilizing a multi-objective optimization technique with Normalized Normal Constraints (NNC) in this study (ADS). Meanwhile, factors like the sporadic nature of wind and solar activity and the irregular schedules of EV are factored in. The proposed model is a multi-objective problem split into two stochastic phases, and it is simulated using an updated version of the IEEE 18-bus test system. The results clearly show the compromise between the ADS's financial and technical benefits. It is also shown how the system's operational expenses change depending on the pace at which EV are charged and discharged.

In study of [12], a bi-objective optimization model for the performance of an intelligent parking lot (IPL) with EVs and time-of-use (TOU) rates of a demand response program has been suggested (DRP). Fuzzy decision-making and ε-constraint approaches are used to tackle this problem, and results showing the efficiency and efficacy of the applied strategies are offered for comparison. The researched example model in this paper consists of an IPL connected to an upstream net and renewable and non-renewable resources. Additionally, a hydrogen storage system is included. The previously described bi-objective problem has been formulated using a Mixed Integer Programming (MIP) model and subsequently simulated using the General Algebraic Modelling System (GAMS). The simulations' findings showed that the total emission and operation cost of IPL had decreased by 1.83 percent and 3.99 percent, respectively, as a consequence of the DRP's successful deployment. This demonstrates that both economic and environmental goals are met.

This study of [21] employed multi-objective optimization to identify the best combination of transportation and energy technologies while maximizing economic and environmental effects. This study solved multi-objective mixed integer linear programming MOMILPs precisely using an enhanced version. The optimal solutions were distinguished with and without subsidies to check for the effect of policy. The work distinguished between essential investments and minimizing economic life cycle costs (full rationality) (bounded rationality). An example of the method is used with a Belgian corporation that has transportation and electrical needs. Transportation options include BEVs driven by the grid, and solar-powered BEVs. Although grid-powered BEVs have a limited effect on lowering GHG emissions, they are still less expensive than solar panels. In contrast to private (possibly constrained rational) investors, who frequently just think about required investments, present policy approaches can effectively target rational investors who take life cycle costs into account.

Taking into account uncertainties in plug-in electric vehicle (PEV) load demand, wind speed, and solar irradiance, the work of [22] suggested optimization methodology for sizing and siting wind-distributed generation WDGs, solar-distributed generation SDGs, and capacitor banks (CBs) in an electrical system. The greenhouse gas emissions and overall cost are the study's primary goals. The associated uncertainties are managed using an unconventional point estimate method (PEM), while the smooth constraints are managed by a chance-constrained programming approach. The output variables' associated corresponding probability distribution functions are computed using the greatest entropy approach. Furthermore, Monte Carlo simulation is used for robustness analysis (MCS). Third, a three-stage hybrid intelligent solution technique is suggested that combines the fuzzy satisfaction theory, the entropy weight approach, and the PSM algorithm. The findings demonstrate that PEV usage dramatically raises load demand, which causes voltage breakdown in the power distribution system in the absence of distributed power generation. The suggested probabilistic strategy, however, guarantees the secure operation of the distribution system with the best distribution of CBs and distributed renewable energy.

Additionally, the outcomes of deterministic and probabilistic situations are contrasted under various PEV penetration rates. The fuzzy satisfactory approach chose the Pareto front's optimal tradeoff solution.

In [23], a novel approach to solving uncertainty in EV aggregators is presented. The profit function of uncertainty is changed into a MOO problem, where average profits standard deviations are viewed as competing objective functions, aiming to increase the profit and decrease the deviations. The two-dimensional issue is also solved using the ε-constraint approach to get the best Pareto solutions. Finally, fuzzy satisfaction provided a trade-off with Pareto solutions. To show the effectiveness of the suggested interval optimization strategy, the deterministic approach is also contrasted with it. Results from interval multi-objective optimization demonstrate that electric vehicle aggregators' average profit is reduced by 2.94 percent compared to the deterministic, while the deviation profit is reduced by 50 percent. The solution to the MILP model is found by using the CPLEX solver included in the GAMS optimization package.

The research of [24] gave the blueprint for an islanded hybrid system (HIS) that included a wind turbine, solar panels, a diesel generator, and both fixed (batteries) and mobile (EVs) forms of ESS. This suggested technique employs an MOO with two distinct target functions to cut down on the expense of installing and operating sources and ESSs inside the IHS while simultaneously lowering the system's emission level. Planning and operational constraints associated with the sources, ESSs, and power all have a role in exacerbating the problem. This is a nonlinear problem concerning load, renewable power, and the power needs of mobile ESSs. Adaptive robust optimization is described as a hybrid meta-heuristic method that combines the sine-cosine algorithm (SCA) and the crow search algorithm (CSA) to develop an ideal resilient configuration for the proposed technique. One novel component of this study is the use of a hybrid meta-heuristic algorithm (HMA)-based adaptive robust optimization (ARO) technique to describe the functioning of mobile storage systems inside an islanded hybrid system (HIS) while accounting for uncertainties and prediction mistakes. Power consumption and climate data in Rafsanjan, Iran, are considered after confirming the method's ability to extract a robust IHS for sources and ESSs under ideal economic and ecological circumstances. The HMA can arrive at an ideal solution with a final response SD of 0.92 percent, demonstrating its capacity to achieve approximations of unique responsiveness circumstances. With the proposed method, optimal economic and environmental values may be determined, with a 22 percent difference between the minimum compromise point values for pollution and costs. The HIS does this by methodical planning and management of sources and stores. For prediction errors of uncertainty parameters of 17 percent, the method accomplishes a stable structure for the IHS.

The authors of [25] used a multi-objective framework to take into account two objectives. Considering the scheduling of the charging/discharging process for EV and battery energy storage systems, a multi-objective mixed-binary linear programming is proposed in this respect to reduce the overall energy consumption cost and peak load in communal residential buildings. Then, the provided multi-objective model's Pareto front (PF) solutions are obtained using the Pascoletti-Serafini scalarization method. By modeling the suggested model under two different situations, the model's performance is finally examined and reported. According to the findings, the residential building's overall consumption costs have decreased by 35.56 percent, and the peak load has decreased by 45.52 percent.

In [26], the multi-objective power dispatching issue discussed and made used of PEV as storage units. As a MILP issue, the work designed the energy storage planning while considering PEV needs, minimizing three separate objectives, and examining three different criteria. To examine the volatility of the energy storage schedules, two brand-new cost-to-variability measures based on the Sharpe Ratio are presented. Energy storage planning is made more efficient by using these extra factors, which aim to reduce the following: total Microgrid (MG) expenses, PEV battery utilization, maximum peak load, the difference between extreme situations, and two Sharpe Ratio indices. Due to the inherent uncertainty of prediction, several scenarios developed through probabilistic forecasting are considered. According to information supplied by lower and upper bounds retrieved from probabilistic projections, energy storage planning scenarios are scheduled. The analysis is done on a Microgrid (MG) scenario that includes two renewable energy sources, a wind turbine and solar cells, a home MG user, and several PEVs. The pool of possible solutions acquired from various Branch and Bound optimizations is explored for potential non-dominated solutions. Different scenarios for energy storage are presented, and Pareto fronts are examined. The study's most significant finding may be that schedules that reduce the overall system cost may raise the maximum peak load and its unpredictability under various conditions, making them potentially less reliable.

The study conducted by [27] proposed a multi-objective framework to efficiently handle the day-to-day operations of a Smart Grid (SG) with a significant proportion of unpredictable loads. The Virtual Power Player (VPP) oversees the pre-planned allocation of energy resources in the intelligent power grid, considering the extensive use of Distributed Generation (DG) and Vehicle-to-Grid (V2G) technology while guaranteeing a high level of power reliability for essential loads. This study focuses on industrial processes with a significant presence of sensitive loads. These operations require exceptional power quality, great dependability, and few disruptions. The weighted-sum strategy is used with distributed and parallel computing methods to address the multi-objective issue effectively. The suggested optimization strategy employs a two-stage approach that combines Particle Swarm Optimization (PSO) with a deterministic technique based on mixed-integer linear programming (MILP). A feasible mathematical formulation is proposed for the day-ahead scheduling model that considers the restrictions imposed by the electric network. Utilizing a parallel and distributed computing platform might potentially reduce the execution time of the extensive task. The Pareto front methodology is employed to identify the collection of solutions that are not dominated by any other solution. The mathematical formulation aims to maximize the minimum reserve capacity while simultaneously minimizing the expenses required to fulfill the dependability needs of sensitive and fragile loads. The efficacy of the suggested methodology is demonstrated by a case study with a distribution network of 180 buses and a fleet of 1,000 electric vehicles capable of connecting to the power grid. Utilizing distributed computing might potentially decrease the time needed to resolve the optimization problem.

This work of [28] proposed initial research into the multi-objective optimal dispatch of the smart grid by using an estimate of the capacity of EV aggregators. To foretell how EVs would act and estimate their limits, a statistical model is used. Then, set restrictions and several goals for the multi-objective optimal dispatch. Using the multi-objective genetic particle swarm optimizer, we can solve the high-dimensional multi-objective optimization problem and arrive at the Pareto front. The optimum dispatch issue is solved by rescheduling EV charging to occur outside of the peak demand period, as shown by the multi-objective optimization findings.

The study of [29] developed a mixed-integer linear programming (MILP) framework for evaluating the degree of adaptability in a large business park. The proposed mathematical model takes into consideration renewable energy sources like solar power, central energy storage, and smart loads like heat pumps and electric vehicle charging stations. To tackle the challenge of quantifying flexibility, we pose it as a bi-objective optimization problem and use the epsilon-constraint method to approximate the set of Pareto-efficient solutions. The well-tested optimization approach is used to run numerical simulations spanning a full calendar year at an hourly time step. The maximum peak shavings range from 9.6 to 61.4 percent, while annual savings expectations range from 1.5 to 30.8 percent, all with different capacities of centralized energy storage.

The purpose of the study conducted in [30] was to optimize three key objective functions in distribution networks: voltage imbalance factor, voltage deviation, and power loss. This was achieved by concurrently allocating electric car charging stations and smart photovoltaic inverters. A unique approach is suggested to address a complex optimization issue involving many objectives. This approach combines a hybrid fuzzy Pareto dominance notion with a differential evolution method. The model incorporates a scenario-based framework to account for uncertainties related to loads, PVs' generation, and the need for electric car charging stations. The efficacy of the stochastic multi-objective strategy is then evaluated and validated on an imbalanced 37-bus network across several case scenarios. The results explained that integrating smart photovoltaic inverters with charging stations in the network led to a considerable improvement in network performance. This includes maintaining the voltage imbalance factor below the required two percent value.

The authors of [6] modeled a residential microgrid that includes combined cooling, heating and power, plug-in hybrid electric vehicles, a photovoltaic unit, and battery energy storage systems. The objective is to determine the optimal scheduling state of these units, considering the uncertainty associated with distributed energy resources. In order to accomplish this objective, a scenario-based approach is employed to represent uncertainties in the electrical market price, electrical and thermal demand, and solar irradiance. This is achieved by utilizing Normal, Weibull, and Beta probability distribution functions, respectively. The scenario tree is employed to produce a range of possibilities, and representative scenarios are chosen using scenario reduction procedures. The task at hand is expressed as a mixed-integer nonlinear programming problem, with the aim of minimizing both operation cost and total emissions. The Augmented 3-constraint technique is used to solve this multi-objective issue, and the optimum solution on the Pareto front set is identified using a fuzzy approach. The time-of-use demand response program is implemented to ensure system dependability during peak hours by encouraging a shift in energy consumption patterns. Plug-in hybrid electric cars are regarded as electrical energy storage rather than relying solely on batteries for efficient energy and emissions control. An energy management system is implemented on a home microgrid, and the model's efficiency is tested. Research has shown that uncertainties lead to a 12.2% rise in costs. On the other hand, energy storage systems have been shown to decrease costs by 4.7% and emissions by 23%.

The paper of [31] proposed a multi-objective planning framework for EV charging stations in emerging power networks to help bring about the electrification of green transportation. The impact of EV adoption on environmental and economic metrics is analyzed across four case studies. To facilitate the rollout of EV charging infrastructure, the proposed model seeks to include ESSs, the planning models of transmission lines, renewable energy systems, and thyristor-controlled series compensators in the EV-based planning problem. While the second objective function strives to lessen environmental damage by decreasing carbon dioxide emissions from fossil fuel-based generation units, the first function aims to increase the market share of EVs by increasing the availability of charging stations at all hours of the day. To meet the financial requirements, the third objective is to cut down on the capital outlay and operating costs of the deployed equipment. As a multi-objective optimization issue, the proposed model is best tackled with the help of the multi-objective version of the Gazelle optimization technique (MGOA). Four standard test functions and the proposed challenge were addressed to gauge the MGOA's performance. Based on the findings, the MGOA is superior to other popular optimization algorithms when it comes to handling multi-objective optimization problems in terms of robustness and solution quality. With a robustness of 20%-30%, the MGOA outperformed competing algorithms by 5%. When compared to competing algorithms, the MGO provided the best possible outcome.

In [32], a multi-objective optimization model is created to lessen the impact of microgrids on the environment by decreasing transmission losses, operating costs, and carbon emissions. First, a unique method is suggested for forecasting the demand for electric vehicle charging, one that makes use of a back propagation neural network with the help of deep learning for short-term memory. Based on the projections, a two-tiered approach to solving the problem is proposed. Finally, the proposed method is tested through simulation on a case study model system consisting of four linked IEEE microgrids, and its results are compared to those obtained using standard, decomposition-based, multi-objective evolutionary algorithms. The simulation findings illustrate the effectiveness of the proposed improved method with respect to both global search and fast convergence.

The size and number of components of the microgrid (MG) system are calculated using a reliability-constrained optimization technique in [33]. In order to do this, the predicted energy supply is not met, and the loss of load expectation is added as issue reliability indicators. The Monte Carol sampling method is employed to estimate the uncertainties related to load forecasting, modeling of all MG units, and modeling of the random outage of all units. The major objective of the presented work is to find the ideal MG size to reduce MG investment, operation, and emission costs. In addition, a bi-objective optimization model for MG-containing EVs operating at optimal economic and environmental efficiency while utilizing demand response program time of use (TOU) rates has been presented (DRP). Methods for producing fuzzy and - constraint decisions are used to resolve this issue. The Tabu search algorithm is used to handle the optimization problem of long-term planning. The results of simulations show that the total emission and operation cost of MG has decreased by up to 3.99 and 1.83 percent, respectively, as a consequence of the successful implementation of the TOU of DRP. This demonstrates that both economic and environmental goals are met.

The work of [34] created a MOO approach for the household of EV owners in this study and compared the results of stationary batterie (SB) and vehicle-to-home (V2H). We used a case study of a typical Japanese detached house to assess the financial and environmental benefits of solar electricity self-consumption utilizing SB or V2H. According to the findings, non-commuting EV owners should invest in V2H if a bidirectional charger would cost one-third as much in 2030 as an affordable SB. Our findings, however, indicated that commuter EV owners did not benefit in any way. The findings of this study help to rationally determine investment fees so that more EV owners will adopt V2H.

In the paper of [35]RIES is proposed to reduce the system's environmental and economic base concerns by using MOO and considering EV charging uncertainties. First, the impact of elements such as disorderly approach and EV charge/discharge on system performance is taken into account. Next, an EV charging and discharging model that complies with driving regulations is created. The multi-objective function of reducing operation costs and carbon emissions is also constructed. Finally, an actual RISE does the validation. The case studies show that the suggested strategy may effectively balance system economy and environmental protection, improve resilience against uncertainty, and realize system economy and optimal operation.

The study of [36] inspected how well a commercial PV charging station with ten electric vehicle chargers operates. Due to its connection to the primary distribution network, the charging station has the ability to buy and sell power to the grid. It has been suggested to use a MOO algorithm to reduce both the operating expenses of the charging station and the costs associated with power losses in the distribution grid. The interests of the charging station's owner and the distribution system's operator were considered in the suggested solution. The technical restrictions of the grid and constraints relating to user convenience, such as the minimum amount of charge required when a vehicle exits a charging station, were also taken into account. One day with a fifteen-minute resolution is the study period. According to the simulation results, regulated "smart" charging lowers the operational expenses of charging stations and lessens the impact of charging on the grid.

4. CONCLUSION

This article provided a comprehensive overview of the categorization of optimization formulation frameworks, aiming to enhance the reader's comprehension of the fundamental principles of optimization. This study examined the multi-objective optimization techniques used in integrating RESs with EV technology. The purpose of this work is to provide a thorough examination of the current advancements in the design optimization of HRESs using multi-objective optimization (MOO). To address the issue of determining the appropriate size for the HRESs, a thorough analysis was conducted on several sizing approaches that rely on technical and/or economic factors. Several strategies have been acquired for determining the most efficient sizing of the HRESs, such as numerical, software tools, intuitive, analytical, and stochastic methods. Stochastic approaches were employed to overcome the limitations of prior methods due to their capacity to explore feature space more efficiently, resulting in precise outcomes in less time. Nevertheless, these strategies encounter challenges when applied to a substantial quantity of input data. To overcome the constraints of stochastic techniques, hybrid methods were devised to enhance the efficiency of the HRESs. Multi-objective optimization methods are commonly used for obtaining a range of Pareto front solutions that optimize both technological and economic criteria. Multi-objective optimization methods are highly effective in obtaining a collection of Pareto fronts and may handle many goals simultaneously, resulting in a desired and appropriate design of the HRESs. In conclusion, it is expected that this review article is thorough and succinct in presenting readers with valuable information and the latest research progress in the field of renewable energy systems, specifically in terms of the optimization of HRESs.

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