Survey on Integration of Hybrid Plant with Solar Photovoltaic and Diesel Generator

Alain Bading Epanda [1], Pierre Ele [2], Jean Maurice NYOBE YOME[3], Olivier Thierry Sosso *Mayi* [4]

[1]*Electrical Engineering Department, Advanced Teacher's Training College for Technical Education of Douala, University of Douala, Cameroon*

[2]*Electrical Engineering and Telecommunications Department, National Advanced School of Engineering, University of Yaoundé, Cameroon*

[3]*National Higher polytechnic School of Douala, University of Douala, Cameroon*

[4]*Electrical Engineering Department, Advanced Teacher's Training College for Technical Education of Douala, University of Douala, Cameroon*

ABSTRACT

Because the power generated by the solar PV array is not available during the night, the solar plant must rely on the support provided by the storage battery in order to operate effectively. However, because of the limited capacity of the storage battery, there are times when neither the power from the solar PV array nor the electricity from the storage battery nor the power from the grid are accessible. This is because storage capacity is restricted. Under these kinds of conditions, it is an absolute requirement to have a backup generator that can provide power for limited amounts of time. This article provides a thorough analysis of the incorporation of hybrid power plants that make use of photovoltaic solar panels and diesel generators. This hybrid system minimizes the diesel generator's operating time, which in turn minimizes the amount of fuel that is consumed and makes it possible for the diesel generator to satisfy the peak demand. In this section, we will have a quick discussion on a variety of different hybrid system strategies, such as solar PV and diesel generators. The advantages and disadvantages of the many different approaches that are currently being utilized in practice.

Keyword: *Solar PV, Diesel Generator, Hybrid System, Photovoltaic System.*

1. Introduction

Over the course of the last decade, the severity of the oil problem has been brought into sharper focus as a direct result of the growing dependence of the economy on fossil fuels. As a consequence of the relevance of this, the requirement for the discovery of new sources of energy is becoming an increasingly necessary necessity. The only solution to issues such as pollution of the environment, which is the primary contributor to climate change, is to move to sources of energy that can be renewed, which is also the only response to problems such as global warming. These days, there is a growing interest in conducting research into making use of these kinds of energy because they are a source of energy that is both sustainable and good to the natural environment. However, the technology has not yet advanced to the point where it can be regarded a viable alternative to the usage of fossil fuels. This is because there is still a long way to go before it reaches that position.

The collection of solar radiation, which subsequently enables the extraction of thermal energy, is the process by which solar energy is produced. The photoelectric effect is the primary mechanism that is utilized by solar photovoltaic (PV) systems [1] in order to convert sunlight into a form of electricity that can be utilized. This solar storage technique was produced with a shorter energy payback time, and the device was obtained by making use of standard silicon and carbon-based scalable material [2]. Additionally, the energy payback time was reduced. In photovoltaic (PV) systems, solar photovoltaic cells are the most fundamental sort of non-linear technology that can be employed [3]. These solar cells are arranged in a series-parallel orientation in order to facilitate the creation of an array from the cells.

A vital part for the diesel generator to perform comes into action not only at times of peak load but also during other abnormal conditions. It is possible to use it in either of two ways: either as an additional source of energy or by connecting it directly to the load. Both of these applications are viable options. An ON/OFF control method is established for a diesel generator in order to minimize the running costs of the hybrid energy system and maximize the efficiency with which electricity is delivered to the on-linear load [4]. These objectives could only be met by optimizing the power flow's efficiency to its utmost potential. In [5], it is suggested that a power pinch analysis be performed for the hybrid configuration in order to share the load with renewable energy sources in order to reduce the amount of fuel that is consumed by the diesel generator. This can be accomplished by distributing the load with renewable energy sources.

In [6], back propagation feed forward algorithm and incremental conductance-based wind-diesel micro grid are used for the purpose of adapting the frequency and voltage when DG is given to load with three phase. The majority of the components that make up the generation system for the diesel engine are the back propagation feed forward algorithm, the synchronous generator, the excitation system, and the diesel engine. The terminal voltage is supplied with variable direct current by the excitation system to preserve the level of voltage that is chosen.

The diesel engine is responsible for converting the flow of fuel into torque in the mechanical system. With the use of actuators and electromechanical devices, an internal combustion engine's speed can be adjusted by controlling the flow of fuel into the engine. This allows the engine to run at a variety of speeds. For the speed to remain consistent at all times, the utilization of a speed controller is obligatory. It is possible to make an approximation of the dynamic effect that the engine's inertia has by correlating the speed of the fuel intake to the speed of the flywheel.

The combination of multiple distinct kinds of renewable energy systems is considered as a hybrid system. The simulation of hybrid renewable energy sources is increasing importance and popularity in outlying regions, and it plays an important role in the operation of the distribution system. It is significant in the functioning of the distribution system. When proper sizing is paired with the techniques of an artificially intelligent hybrid system, the load demand can be satisfied with a cheaper overall financial expenditure. This is possible thanks to the hybrid system. Following this part will be a quick description of the main components of the hybrid system, which consists of modules that combine solar, wind, and diesel power with an energy storage device [7].

These modules also include an energy storage device. The hybrid system contains both renewable and non-renewable energy sources, as well as bidirectional and alternating current to direct current converters of diverse sorts. In addition, the system can convert direct current to alternating current in both directions. In addition to that, it consists of a DC-bus configuration as well as an AC-bus configuration, each of which has a separate connection for the source and the load. Renewable energy sources are regarded as the principal sources of power within the setting of a hybrid system. On the other hand, non-renewable energy sources are either connected to the hybrid system as a backup or are connected directly to the load. The technology for storing energy can be used not just as a backup supply of electricity but also as a way to satisfy peak demand when it is available. If there is a surplus of power created from renewable sources, it can either be kept in a storage system or injected into the grid with the assistance of a grid control unit and an energy management system in the event that there is an excess of power generated. The hybrid renewable energy integration is capable of functioning in one of two separate modes of operation, namely the freestanding mode or the grid connected mode. These hybrid systems can be operated in a variety of modes, each of which is dictated by the load demand as well as the geographic location [8].

Opportunities exist for the commercial sector as a hybrid solar PV- diesel systems to decrease the dependence on and price related with electricity supply from the merged corresponding national utilities and distributed DGs. This chance comes in the form of a solar PV system that is combined with a diesel generator. Even so, for evaluating the costs and advantages of hybrid solar diesel systems and the extent to which they aid in sustainable development in

the countries that were chosen, it is essential to assess the performances of these systems in real-life situations through the lens of a cost-benefit analysis. This analysis will consider a number of factors, including the amount of energy that can be saved, the amount of money that can be saved on fuel costs, and the amount "perspective that is integrated [9]."

It is the technique of power generation that is better suited for use in geographically dispersed populations due to the fact that it makes use of both conventional fossil fuels and sources of renewable energy. Since it involves expanding the transmission line from the national power grid, providing electricity to rural settlements that have low population densities can be expensive. Furthermore, bringing electricity to some locations is just not possible owing to topographical limitations. The utilization of renewable energy sources comes with a variety of benefits as well as drawbacks. The most major benefit is that it is an unending source of energy that does not negatively impact the surrounding ecosystem in any way. The fact that it does not always behave the same way is the most major drawback. It may be possible to devise a hybrid self-sufficient system to lessen the impact of the drawbacks brought about by this restriction. This technology would make effective use of solar electricity and would also contribute to the reduction of pollution caused by diesel generators [10].

2 Existing Survey on Hybrid System with Solar Photovoltaic and Diesel Generator

A review on the appropriate size of solar-wind-diesel energy storage systems was provided by Dharavath et al. [11]. The results of their investigation were included in the preceding sentence. In addition to this, parallels are shown between the many different problems associated with wind, solar, and control technology. The overall performance of the system may be increased by selecting from a broad variety of available hybrid and storage system configurations. This will allow for more options. The integration of hybrid systems with a system for the storage of energy creates the power balance, and it may help minimize power fluctuations produced by dynamic changes in the environment that are around the facility. The combination of solar, wind, and diesel power, in addition to other kinds of energy storage, can be of tremendous aid in the process of resolving issues related to a lack of available electricity in remote places. However, in order to achieve the continual loading of 80-85% of the rated capacity, a plan for energy management is needed.

In-depth research on hybrid power systems (HPS) that integrate solar energy with MPPT controllers, diesel generators, and other forms of power generation was recommended by Vipin and Verma [12]. A solar power system that can function without any assistance from an outside source is the ideal answer for consistently supplying a rural region with electricity. Maximum Power Point Tracking, more commonly abbreviated as MPPT, is a technique that is generally implemented in PV systems. The purpose of maximum power point tracking, or MPPT, is to optimize the amount of power that may be harvested from PV arrays at any given time, independent of the external conditions. A quick reaction time and a high degree of tracking accuracy are two critical design criteria for MPPT control. Both of these requirements must be met. Diesel generation is a benefit that may be utilized to accomplish full-hour energy production in the event that the grid fails to function and the weather is gloomy. On the other hand, they do not take into consideration, even for a short amount of time, the ideal loading of the diesel generator.

A case study of a hybrid PV-DG system that was constructed in the Brazilian Amazon has been analyzed by Costa et al [13]. The system was put in the reserve to extract minerals from the Tapajós-Arapiuns region. The components have highly varying demand at different times of the year make up the plant that was looked at for this study. The piece of software known as HOMER PRO is used in this process as a simulation instrument. According to the data, the load following dispatch method is the most viable choice. This is because solar energy supplied 85.6% of the load demand, whereas the diesel generator set supplied just 14.4% of the load requirement. As a direct result of this, it is viable, from a technological point of view, to recreate the system as a dependable source of energy in other sections of the reserve in order to feed locations such as schools and public health centers, in addition to other community functions.

Nain and Kumar [14] have carried out research and composed a review on the hybrid PV/diesel energy system that is being used for the power generating system. When a hybrid PV/diesel system with a PV array size of 1.1 GW is employed to generate electricity, renewable sources contribute 15% of the total power supply. When the application in the actual world is taken into consideration, this penetration number makes perfect sense. The simulation has made it abundantly evident that the stand-alone diesel system has the lowest COE but the greatest CO2 gas emission. This is the case despite the fact that it has the highest CO2 emission. This was proved in a way that leaves

no room for doubt. Utilizing a PV/diesel hybrid system will result in a large decrease in the amount of carbon dioxide gas emissions, which is a positive development from an ecological point of view.

Mahesh and Sandhu [15] have made an attempt to address a systematic evaluation that is related with hybrid photovoltaic/wind energy systems that also contain battery storage. This review was conducted in an effort to better understand the pros and cons of these types of energy systems. The work investigates hybrid energy systems for the purpose of making further advancements in the areas of system design, system analysis, and the addition of hybrid energy systems into the power network. This is because the goal of the researchers' investigation is to make further progress in these aforementioned areas.

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3 Survey of Hybrid Plant System with Solar Photovoltaic and Diesel Generator

Usman and Sigalo[16] have provided a model for the optimization of a photovoltaic-diesel hybrid energy system that will be used to power a hospital in Abuja. The optimal size of a PV hybrid system as well as a way for managing it have both been developed as part of this method. In order to determine the most effective component pairing and size, a simulation was carried out making use of HOMER and PV System. The analysis reveals that a payback time is still too lengthy based on power consumption profiles and current costs; this conclusion is supported by the findings of the study. In spite of this, the hybrid system has a greater likelihood of being economically feasible in light of the anticipated decrease in the costs of solar technology over the course of the next several years as well as the continually growing costs of gasoline.

Zellagui et al. [17] have discussed a technique for reducing the Total Voltage Variation, Active Power Loss, and the Annual Losses Cost. They did this by taking into account the ambiguity of both load demand variation and the output power of PV in 24 hours. In doing so, they were able to address the optimum incorporation of concurrent incorporation of many resources at the same time. In addition, the efficacy of the PSO algorithm is proven by conducting experiments on two different electrical distribution systems. The findings reveal that these algorithms are successful in lowering the amount of active power loss while simultaneously raising the voltage profile. A diesel generator can function independently, as a backup, or in an emergency situation as a primary generator. There is a possibility that this will pollute the environment.

Mnisi et al. [18] developed the Grid Integration system of Solar PV for Green Energy, and it functioned under typical conditions of 800 kW/m2 irradiation. It will have the capability of satisfying a maximum critical load requirement of 40 kVA. A constant supply of energy will be maintained to the load by the system regardless of whether it is the only source of power, is operating in conjunction with the grid through the inverter load outputs, or is working in conjunction with a battery backup. A margin of safety of 33.3% is achieved by providing electricity to the 40 kVA load using six distinct inverters rated at 10 kW each. The cost of the system was not taken into consideration at any point in the process. Because the modelling of the system involves a significant number of components, the system cost might potentially be rather high.

Ghenai et al. [19] have created an environmentally friendly hybrid renewable power system that is combined with a desalination unit. This system is intended to fulfil the primary and auxiliary electric demands of the ferry boat. The objective is to create marine transportation less harmful to the environment and more sustainable. This construction utilizes modelling, simulation, and optimization. The research concluded that it has a 20% of more electricity is generated by fuel cells and solar photovoltaics and 15% fewer emissions in comparison to ferry boats powered by diesel engines). The system does not suffer from either an underproduction or an overproduction of power. The cost of putting the system into action may be more than expected.

Salameh et al. [20] studied the operations of seven different (off-grid) power systems in order to fulfil the needs of the system in terms of the amount of electrical energy that it required (wind-photovoltaic-diesel-battery). The HOMER programme was utilized in order to carry out the process of doing the techno-economic analyses of the systems. The energy needs of the reverse osmosis system that was investigated in this study was, on the other hand, determined with the assistance of the reverse osmosis system analysis model. The cost of electricity for the ideal system, which included wind turbines with a 10-kW rating, while the cost of water was $2.20/m3. The ideal system also included a diesel generator of 8.90 kW. The findings also showed that merging a hybrid power system with a system for reverse osmosis might be a financially feasible strategy for remote locations that have excellent potential

for wind and solar electricity. However, the actual process of putting the system into place was not examined in this study.

Kotb et al. [21] have developed a conceptual design model to determine how the project's electrical requirements may be satisfied. The model thoroughly assesses the viability of many HRSES possibilities and generates a fuzzy-based multi-criteria decision-making model in order to make an informed choice regarding which energy solution will prove to be the most effective. Both the turbine-pumped hydro energy storage system and the zinc-bromine flow battery have the potential to be independently combined with other types of power sources, including wind, solar, and diesel. It investigates the practicability of nine different HRSES choices and the appropriate sizes of their component parts, begins with an energy-economic ecological optimization study carried out with the HOMER programme. After that, the optimal design is chosen by combining the Fuzzy-AHP and Fuzzy-VIKOR decision-making techniques while simultaneously taking into consideration 10 different performance criteria. In the second step, the fuzzy environment is utilized to assist decision-makers in expressing their ratings in a more linguistically and time-efficient manner, as well as in providing more rational and accurate judgments. According to the findings, out of the ten plausible solutions, the optimal system consists of five wind turbines. Future load rise as well as low interest rates are both adverse to future investments; nevertheless, the predicted drop in the price of energy storages is beneficial to financing choice options.

Ghenai et al. [22] have presented an off-grid solar PV/Fuel Cell/DG power system for university buildings. This was done in order to create a power system that has a low greenhouse gas emission, high renewable proportion, and a cheap COE. The goal is to make the switch from a power system that is grid-tied and uses fossil fuels to one that is cleaner and relies increasingly on renewable energy. The power system’s efficiency and cost were put to the test through the use of optimization and control strategies in the hourly computations that were carried out. According to modelling and performance study, the best results may be obtained from the proposed renewable energy system, 24% of its total energy from fuel cells, and 3% of its total energy from diesel generators. There is no power shortage (0.1%), and all of the building's electrical load requirements have been satisfied. The stand-alone hybrid renewable power system has a maximum renewable component of 66.1%, making it both cost-effective (92 cents per MWh) and ecologically friendly (24 kilograms of carbon dioxide per MWh). Its cost is calculated at 92 cents per MWh. However, aspects such as the quantity of land required for the generation of renewable energy were not able to be taken into consideration.

Salameh et al. [23] have provided an analysis where the system includes single-axis and dual-axis solar trackers in addition to a diesel generator (DG). On the basis of the study area's daily power usage of 37.75 MWh, the hybrid energy system (HES) modelling, simulations, and optimization analysis were done with the HOMER software. A HES with dual-axis solar trackers is the most efficient design for a power system when taking into consideration the proportion of renewable energy (48.55%) and the LCOE (0.25 dollars per kilowatt-hour). The hypothetical HES meets the whole annual energy requirements of the city (13,778 MWh) without any interruptions and generates an electrical surplus equal to 9.81% of the total demand. In addition, the HES offers the lowest GHG emission reduction. The evaluation of carbon emissions might be stretched even further if a life cycle perspective is taken into consideration.

The study conducted by Ji et al [24] focuses primarily on two primary areas: the best model of a stand-alone hybrid energy system and a techno-economic analysis of how such a system might function in a typical rural hamlet in northwest China. The objective of this presentation is to offer a model for the optimization of mixed-integer linear programming with the objective of reaching the lowest possible yearly cost. It is based on an analysis of the patterns of power and heat use, as well as a calculation of the capability of renewable energy sources in the area. The various configurations of the system are analyzed from a technological and economic perspective, and the results are compared. LCOE production and the LCOE consumption are two concepts that have been offered as methods for analyzing the financial COE from the supply side and the demand side, respectively. In addition, scenario and sensitivity analysis are carried out for demonstrating how the overall system cost as well as its performance are impacted by a lack of clarity on environmental policy. The hybrid energy system also includes thermal energy storage. There is a significant opportunity for local electrification and more adaptable heat/power output machinery. In order to develop a model of an energy system that is more targeted, other technical possibilities, such as various CHP systems, ORC, and so on, might be taken into consideration.

Harajli et al. [25] analyze hybridized solar PV energy with the help of first-hand data and data gathered from the commercial and/or industrial sectors of Palestine, Lebanon, and Iraq while adopting a number of scenarios adopted

from monetizable and globally applicable life-cycle impact assessment methods. Their financial performance is also good in Palestine and Lebanon, but less so in Iraq, mostly because of that country's significantly subsidized electricity rate. The progressive phase-out of fossil fuel subsidies, the proper implementation of net metering, the provision of subsidized sustainable energy loans, and carefully planned energy management systems were the main areas of attention for boosting solar PV in the commercial and/or industrial sectors.

Das et al. [26] have examined the financial and environmental advantages of stand-alone and grid integration with various system configurations for HES for various climatic zones (HOMER). By incorporating the grid-connected alternative, a thorough techno-economic analysis of optimized hybrid systems is further investigated. The advantages of HESs for the environment are explored. Investigated is the sensitivity of various sell-back prices to the national grid. The difficulties and possibilities of implementing such projects in off-grid areas are also covered. Results show that, when cost and environmental emissions are taken into account, Rajshahi region has somewhat lower COE ($/kWh) and net present cost ($) than other regions. Over the other climate zones, the similar system in Chattogram exhibits considerable promise on both a financial and environmental level. Grid-connected PV/Battery systems can generate comparable profits because they can supply a sizable amount of extra energy to grid facilities. The impact of battery charging and discharging cycles on battery longevity and associated energy costs are not explored, though.

Integrated freestanding hybrid fuel cell, solar PV, and DG power systems with supercapacitor energy storage systems (SCESS) or battery energy storage systems (BESS) have been analyzed and their performance in Khorfakkan city has been described by Salameh et al. [27]. The hybrid energy system (HES) was modelled and simulated on the basis of the Khorfakkan city's daily energy usage using the HOMER Pro programme. The HES with SCESS has a 0.346 $/kWh LCOE and a 68.1 percent renewable portion. With a small electricity surplus and an unmet electrical load of 1.38%, the HES is able to fulfil the city's yearly AC primary load of 13.6 GWh. With SCESS, HES's GHG emissions were reduced by 83.2%, saving 814,428 gallons of fuel in the process. However, the DG's effectiveness reduced while feeding nonlinear loads.

A storage system along with hybrid renewable power plant is designed by Mendecka et al. [28]. For a commercial building in the United States, the advantages of sizing and energy management are evaluated under eight different climatic circumstances. Photovoltaic panels and a unitized regenerative solid oxide fuel cell are connected in the system under consideration. A thorough electrochemical design of the fuel cell and electrolyze modes is used to study the utilization of biogas to feed the fuel cells. The plant has a battery pack as a supplementary storage system and a diesel engine that runs in backup mode. Four scenarios with varying biogas amounts and the battery's starting state of charge were assessed. The usage of the diesel generator is unavoidable if the availability of biogas is reduced or if it starts out with a low state of charge. According to the study, this plant is possible technically and could be used to provide dependable and clean energy in other locations and structures. However, implementation is not regarded as a control approach that reduces or eliminates the use of diesel fuel. This system will be evaluated economically and environmentally to determine the initial investment and energy costs.

Private companies in and around Lagos State that now have rather large daily electricity demands that are supplied by captive diesel generation have been the subject of research by Adesanya and Pearce [29]. Discounted payback times for the systems were under a year, and ROIs were greater than 100% in five of the six industries. The findings showed that the levelized cost of power is cheaper for every industry studied when solar PV is included, even cheaper when batteries are coupled, and more dependable than the electricity currently supplied by the grid. The broad use of solar hybrid systems will also benefit Nigeria as a whole because it will improve the country's trade balance by lowering the importation of refined petroleum. Solar hybrid systems have the potential to boost the profitability of Nigerian businesses of all sizes. This strategy, however, does not take a sensitivity in cost into account and is restricted to this fictitious battery cost.

For a distant area of India, Chauhan et al. [30] have thought about using a hybrid solar PV/DG/battery-based system. Utilizing a Biogeography-based Optimization method, the energy cost of a hybrid system is reduced while adhering to restrictions on power reliability, carbon emissions, and the percentage of renewable energy sources. For the performance analysis, cycle charging and load following strategies have been taken into consideration. The market's various component combination specifications are also offered for in-depth study. This hybrid system's lowest energy cost is calculated to be 0.225 $/kWh. However, it is not taken into account that the utility grid and the conversion of trash from the campus into energy will lessen the sustainability of the hybrid system.

Singh et al. [31] have combined a solar PV array, a battery energy storage (BES), a diesel generator (DG) set, and a grid-based EV charging station to achieve continuous charging in islanded, grid-connected, and DG set-connected modes (CS). The primary function of the charging station is to supply electricity to the battery of an electric vehicle (EV) via a battery energy storage system (BES) and a solar PV array. In the case that the storage battery is depleted and the solar PV array is unable to provide enough power, the charging station will intelligently switch to using energy from the grid or a DG (Diesel Generator) set. However, electricity is pulled from DG sets in such a way that they are constantly operating at 80-85% of capacity in order to ensure best fuel efficiency under all loading situations. In addition, a mechanical speed regulator is unnecessary since the charging station uses the storage battery to regulate the generator's voltage and frequency. It also ensures that the power taken from the grid or DG set is at unity power factor, even while operating under nonlinear loads (UPF). The voltage at the PCC (Point of Common Coupling) must also be synchronized with the grid/generator voltage for continuous charging to be possible. Active/reactive power transfers are also performed at the charging station, connecting cars to the grid, residential buildings, and other vehicles to increase the station's efficiency. The charging station's efficacy is put to the test in the lab by way of a prototype.

Verma and Singh [32] have tackled the multimode operations of a PV array, a battery, the grid, and the DG set based charging station in order to offer continuous charging and uninterruptible supply to the home loads (CS). In this CS, a single voltage source converter (VSC) controls the CS in all three operating modes (islanded mode, grid connected mode, and DG set connected mode) and performs a variety of tasks, such as balancing power between energy sources and charging electric vehicles (EVs), getting the most energy out of the PV array, controlling the generator's voltage and frequency, required to compensate for harmonic currents in the current flowing through nonlinear loads, and so on. CS is programmed to run mostly on power from a battery and a PV array. When neither of these options is viable, the charging station will fall back on a DG set based on a squirrel cage induction generator. Because the DG set can generate up to 33 percent more energy than its rated capacity without exceeding the rated current in the windings, its physical footprint may be reduced. There is no need for a mechanical speed governor, and the generator's output voltage and frequency remain constant at their design levels. In all modes, the CS achieves less than 5% THD of voltage and current, making it compliant with the IEEE 1547 standard. The charging station is powered by the DG set; thus its use should be maximized as much as possible for maximum efficiency.

4 Comparison

Table 1. Comparison Table

Author name [ref]	**Performance Metrics**	**Advantages**	**Disadvantages**
Usman and Sigalo [16]	COE, principal cost, state of battery charge	Low maintenance cost	Diesel cost is high, so overall cost is high
Zellagui et al [17]	Population size and number of iterations	Enhanced voltages profile and low active power loss	Lead to environmental pollution effects
Mnisi et al [18]	Module power output, Module area, irradiance ratio	Maintain constant power supply to the load	High cost of the modelling system
Ghenai et al [19]	Power output	Low greenhouse gas emissions, high renewable fraction, no power shortage	The price of system implementation may be higher.
Shalameh et al [20]	Levelised cost of water, net present cost, diesel fuel burned, electricity production	Economically feasible for the site	No practical system implementation
Kotb et al [21]	COE, capacity shortage ratio, net present cost, payback period, carbon emission impact, internal rate of return	Provide optimum energy solution	Owing to its poor economic and emission performances, is regarded as the worst energy scenario.
Ghenai et al [22]	Greenhouse gas emissions, COE	High proportion of	Did not consider land used

	and renewable fraction	renewables, low GHG emissions, and inexpensive power.	for renewable energy generation
Salameh et al [23]	LCOE, renewable fraction, GHG emission reduction, electricity cost	Greater decrease in greenhouse gas emissions and lower electricity prices	Carbon emission is not analysed for a life cycle perspective
Ji et al [24]	Levelized cost of energy, installed capacity, carbon emission, system cost	More adaptable tools for producing heat and electricity locally	Different CHP technologies are not considered
Harajli et al [25]	Internal rate of return, net present value, LCOE, dynamic payback period	Evaluate the entire environmental, energetic, economic, and financial performances of hybrid systems	The implementation cost is high.
Das et al [26]	COE, Net present cost, net grid purchase, sell back price	Lower net present cost and energy cost	Not explored the impact of battery charging cycles on battery longevity and related energy costs
Salameh et al [27]	LCOE, annual cost, and GHG emission	Fulfil the city's yearly AC primary load of 13.6 GWh and reduce GHG emissions by 83.2%	DG's effectiveness reduced while feeding nonlinear loads
Mendecka et al [28]	Total site electricity, daily radiation	Provide dependable and clean energy and technically possible	The initial investment and energy costs are not analysed.
Chauhan et al [30]	Renewable fraction, COE, DG's operating hours, carbon emission	Minimum cost of energy is obtained as 0.225 $/kWh	Not considered utility grid and waste utilization
Singh et al [31]	THD, grid power, VSC power, load power, EV power, generator power	Efficiently apply energy sources and provide economic and constant EV charging	The performance is less compared to the other hybrid systems.
Verma and Singh [32]	THD, battery power	THD of voltage and current < 5%	No optimal application of the DG set and fuel efficiency is low

5 Conclusion

This article gives a complete review of the integration of hybrid plants that use solar photovoltaics and diesel generators. This hybrid system cuts down on the amount of time that the diesel generator is operating that minimizes the amount of fuel that is spent and allows the diesel generator to meet peak demand. We will briefly go over a number of different hybrid system techniques, including solar PV and diesel generators. The analysis takes into account both the benefits and the drawbacks of the currently available methods. The purpose of creating the comparison table is to get a better understanding of the techniques that are related to each other.

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