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Evaluation of Different Optimization Techniques and Control Strategies of Hybrid Microgrid: A Review

Sk. A. Shezan [1], Innocent Kamwa [2,*], Md. Fatin Ishraque [3], S. M. Muyeen [4], Kazi Nazmul Hasan [5], R. Saidur [6], Syed Muhammad Rizvi [7], Md Shafiullah [8] and Fahad A. Al-Sulaiman [8]

1 Department of Electrical Engineering, Engineering Institute of Technology, Melbourne Campus, Melbourne, VIC 3001, Australia
2 Department of Electrical Engineering and Computer Engineering, Laval University, Quebec, QC G1V 0A6, Canada
3 Department of Electrical, Electronic and Communication Engineering (EECE), Pabna University of Science and Technology (PUST), Pabna 6600, Bangladesh
4 Department of Electrical Engineering, Qatar University, Doha 2713, Qatar
5 Department of Electrical and Computer Engineering, RMIT University, Melbourne, VIC 3000, Australia
6 Research Centre for Nano-Materials and Energy Technology (RCNMET), School of Engineering and Technology, Sunway University, No.5 Jalan Universiti, Bandar Sunway, Subang Jaya 47500, Selangor Darul Ehsan, Malaysia
7 School of Electrical Engineering, Computing and Mathematical Sciences, Curtin University, Bentley, WA 6102, Australia
8 Interdisciplinary Research Center for Renewable Energy and Power Systems (IRC-REPS), King Fahd University of Petroleum & Minerals, Dhahran 31261, Saudi Arabia
* Correspondence: innocent.kamwa@gel.ulaval.ca

Abstract: Energy consumption is increasing rapidly; hence, the energy demand cannot be fulfilled using traditional power resources only. Power systems based on renewable energy, including solar and wind, are effective and friendly for the environment. Islanded hybrid microgrid systems (IHMS) are relatively new in this industry and combine two or more sustainable sources, such as wind turbines, solar photovoltaic (PV), and other renewable alternatives, ocean, wave, and geothermal energy, etc. While sustainable, long-lasting power sources are the best choice to satisfy the growing energy demands, they are still not yet ready to be used on a large scale due to their stochastic characteristics. Furthermore, integrating these sources into the existing energy system can cause high technical difficulties, due to the stochastic nature of solar and wind in the conventional grid system and common stand-alone framework. A review of research and applications of the effective hybridization of renewable energy sources is therefore essential to address those technical and economic issues and ensure system stability, reliability, and cost-effectiveness. This article discusses the challenges that might arise when a PV plant and a wind power station are combined to produce power for the conventional main grid or in a stand-alone system. In addition, this analysis provides light on optimization approaches for improving power quality and cost-effectiveness in a solar and wind integrated IHMS. Voltage fluctuation, frequency deviation, and the uncertain nature of solar irradiation and wind sources are significant challenges for both grid-connected and standalone hybrid systems. This study then provides an overview of the control strategies which might help enhance the integration of the IHMS in producing electricity for distribution to the grid-connected load and the islanded load. In this study, the possible issues that can hinder the smooth integration of these renewable sources have been discussed. Finally, this study discusses the recent platforms being used in IHMS as well as the potential of dispatch strategies on solar and wind-integrated IHMS.

Keywords: renewable energy; IHMS; optimization; solar energy; wind energy; control strategy

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1. Introduction

The advancement of industrialization, urbanization, agricultural aspects, and overall development of a country is vastly dependent on the consistent and attenuated free electrical power supply. An extra effort from conventional power sources is required for the extended load demand to ensure uninterrupted power supply for all the ongoing sectors. This extra effort to the conventional power plants can cause a huge amount of greenhouse (GHG) gas emissions. Moreover, fossil fuel and petroleum prices are getting higher and higher day by day, which increases huge electricity production costs.

For this reason, people worldwide are searching for an alternate, long-lasting energy solutions. The most widely considered alternative energy resources are solar, wind, biomass, wave, hydro, geothermal, etc. Due to the ease of harnessing sunshine and wind and the energy system's simplicity [1], solar and wind energy systems are among the most popular renewable alternatives [2].

Over the last decade, the development of solar-wind integrated hybrid microgrid systems (IHMS) has progressed independently and individually [3]. Microgrids are distribution systems made up of decentralized energy sources such as photovoltaic and wind turbines, which have consistently been among the most widely used energy sources [4]. Because of stochastic properties, both solar and wind energy sources have their limitations [5]. The PV-wind hybrid IHMS with legitimate vitality stockpiling framework can address this issue. The PV-wind IHMS that consolidates sun-oriented and wind vitality sources have the limit of works in simultaneous, continuous, and synchronous modes [6,7]. The proper utilization of PV-wind IHMS has improved the working principles and efficiency of power sources. Tao Ma et al. [8] provided their opinions on numerous control techniques and optimization approaches to lessen several challenges, including voltage and frequency instability, net present cost, and environmental pollution [9,10]. It is necessary to analyze the impact of weather forecasting on the effectiveness and precision of hybrid renewable energy system optimization techniques as well as the uncertainty analysis of weather parameters. It is simple to analyze the benefits of using anticipated weather data in place of historical weather characteristics when optimizing a hybrid renewable energy system. This will also increase the performance of the hybrid renewable energy system. To determine the right location and environmental conditions, on-field meteorological data may be required, which is challenging to get in a distant place. As a result, an accurate streamlining technique must be developed, and a geological product must be developed to determine the probability of claiming sun-based radiation as well as wind speed.

According to the worldwide energy report published 2012–2019, it can be observed that the usage of renewable energy reached around 32% of the total energy consumption in these year [11]. Intriguingly, the report finds that the PV installation restricts wind and solar control, which is irregular and can lead to specialized challenges for network control supply, especially when the amount of wind and solar power integration increases, or the grid is unable to handle sudden changes in generation levels. Furthermore, whether wind and solar energy are used to power a stand-alone system, the energy storage system achieves a reliable power distribution [12]. Some recent academics have discussed the challenges and opportunities for integrated PV and wind energy systems. They provide an overview of basic research to determine the best control hardware topologies, measurement configurations, and control algorithms for wind and solar energy networks [13].

Mohammad Reza et al. presented a method for regulating the optimal sizing of the battery-aided energy storage system (BESS) by implementing preliminary frequency control. A microgrid is considered a part of a low voltage appropriation feeder including sources, for example, a micro-turbine, diesel generator, power module, and photovoltaic module with a moderate reaction for recurrence control. A BESS can assume a critical job in re-establishing the harmony among free market activity due to the unique quick response [14]. A New Hierarchical Energy Management System Based on Multi-Microgrid Optimization is proposed by the authors in Ref. [15]. The effectiveness of the suggested technique was evaluated using an IEEE 14 bus program. This study also seeks to create a role model to predict how dispersed energy resources on IEEE 14-node networks will behave as a result of a change in the opening protocol to the disconnect, establishing the power generation island. The micro-grid, which has dispersed tools, is a straightforward example for the investigation of energy flow and smart grid efficiency variables. The results demonstrate that, in contrast to earlier methods, the energy management system load collection utilizing the suggested strategy enhances the performance and reduces losses.

A complete change from a fossil fuel-oriented power system to a sustainable or hybrid system can be performed by comprising two or more sustainable energy resources. Sustainable sources such as biomass, hydro, nuclear, geothermal, wind, sun-oriented, hydrogen, and non-renewable energy should cooperate in various combinations as a solitary unit to take care of typical energy demand. The IHMS can be constructed by combining traditional energy sources such as diesel generators as well as inexhaustible sources such as wind turbine (WT) and photovoltaic (PV) cells in different combinations with a capacity shortage or excess energy [16]. However, without the ideal use of energy sources, the expense of the venture for a microgrid will not be defensible.

Optimization techniques are employed to search for the optimum combination of units and parameters with the categorized system cost, PV unit size, battery size, wind turbine, system stability and reliability, higher system costs, and under-sizing reasons for insufficient power distribution [12]. For a standalone microgrid with a size of a few hundred kW, this study aims to maximize the system architecture of a proposed hybrid solar-wind-pumped storage system in standalone mode.

Many researchers have already expressed their views regarding the dispatch strategies with the techno-economic analysis and optimization of IHMS [17–20].

Weirong Liu and colleagues assessed and offered a method for islanded microgrid integration using distributed economic alternative dispatch strategies [17]. Yiwei Ma et al. examined and analyzed an effective hybrid off-grid microgrid dispatch technique while discussing vehicle-to-grid (V2G) under time-of-use (TOU) pricing [21]. Chunxia Dou et al., without a communication system, developed a two-level distributed optimization power dispatch control strategy for a standalone microgrid [22]. Md Abu et al. suggested an operating power dispatch approach to improve the generating schedule of the wind-BESS hybrid system [23]. Bo Zhao and collaborators used a multi-agent system (MAS) to create an energy management system that considered real-time power dispatch methods [24]. For an interconnected gas and electricity infrastructure, Meysam Qadrdan and associates suggested a modified operational dispatch method that considers the stochastic character of wind power forecasts [25]. Yu Zhang and colleagues developed a robust energy distribution plan with a distributed economic dispatch mechanism for a microgrid to handle high renewable saturation [26]. To improve network system stability, Lin Ye et al. suggested a dynamic active power dispatch strategy for a wind-based hybrid energy system [19]. For the islanded microgrid, Yunfeng Wen et al. created an updated multi-aged dispatch model to maintain the system frequency within a reasonable range [20]. Using distributed technologies, Pedro P. Vergara et al. demonstrated and improved the best dispatch method for an unbalanced three-phase islanded microgrid [27].

The main contributions of this manuscript have been articulated as summarizing the evolutions of renewable energy resources with the problem statement and solutions, then continued with the optimization control techniques for the IHMS and HRES followed by the co-relation between the optimization techniques and control strategies. Solar radiation, wind speed, and other historical weather factors from previous years are used as the main inputs in hybrid renewable energy system sizing optimization approaches. The location, atmospheric conditions, seasons, time, etc., all affect the historical measured weather parameters, which vary significantly from the actual measured weather parameters. The impact of employing weather forecasts instead of historical data on HRES performance has not yet been thoroughly studied.

This paper outlines the different hybrid microgrid frameworks being investigated and the different advanced techniques and applications. The advancements in power electronics devices and other control units improved islanded microgrid systems [6,28]. This paper then presents a brief on the renewable energy sources evaluation in Section 2. A review of optimization techniques for IHMS is presented in Section 3 followed by a review of available control technologies of IHMS in Section 4. Section 5 contains a short description of the correlation between optimization and control techniques for IHMS. The evaluation of dispatch algorithms in IHMS optimization is discussed in Section 6 and finally, the paper concludes the work with some future directions.

2. Evolutions and Advancements of Renewable Energy Resources to Achieve Zero Emission Power Technologies

The energy that comes from renewable sources, such as sunshine, wind, tides, waves, rain, and geothermal heat, is referred to as renewable energy. The energy from renewable sources is frequently used to power four vital functions: transportation, rural (off-grid) energy services, heating and cooling of both air and water, and electricity production. The power generation from renewable energy resources in the world for the last few years is shown in Table 1. From the table, it can be easily observed that hydroelectric power generation is very high from 2019 to 2021. However, nowadays, very few countries are interested in hydropower due to its high maintenance cost and distribution problems. Moreover, only a few areas are suitable for hydropower in the world, as the mechanism and technology of hydropower demands a huge depth of water in a compact area. So, because of the great availability of solar and wind energy, both are becoming increasingly popular day by day.

Table 1. Power generation from renewable energy resources worldwide [29,30].

Energy Source	Power Generation in TWh Year	
	2019–2020	2020–2021
Hydro-Electric	114	140
Bio Energy	40	72
Solar Energy	153	145
Wind Energy	175	275

Solar energy, such as solar heating, photovoltaic, concentrator photovoltaic (CPV), concentrated solar power (CSP), artificial photosynthesis, and solar architecture, is harnessed utilizing various ever-evolving technologies. Using the photoelectric effect, a PV system turns light into electrical direct current (DC). Solar PV with CSP has grown into a fast-growing, multibillion-dollar business that continues to increase its cost-effectiveness and has the biggest promise of any renewable technology. The primary solar technology used to generate significant amounts of electricity is concentrated solar power, which can also store thermal energy and provide grids with power with high dependability, high-capacity factors, and cheap costs. However, the highest temperature permitted for the heat transfer fluids utilized (up to 565 °C utilizing molten salts) restricts their functioning [31].

High-performance perovskite solar cells have become a new trend in the research domain [32,33]. The use of machine learning algorithms and artificial intelligence (AI) has been increased for solar PV-based hybrid energy systems. An AI technique based on a multilayer perceptron artificial neural network (MLP-ANN) and a digital twin model of the solar chimney using a multivariate regression model based on the least square method and their comparison has been suggested in Ref. [34]. A machine learning-based autonomous solar wind voltage regulatory system was analyzed and proposed by Ref. [35].

A rotor with two or more blades that are mechanically coupled to an electrical generator can be used to convert the wind's kinetic energy into electrical energy. Turboelectric nano generators (TENG) based wind energy harvesting has been discussed in Ref. [36].

To conduct a territorial-scale feasibility study for various types of floaters, a floating offshore wind farm (FOWF) life cycle cost model and producibility analysis is implemented in a geographic information system. A streamlined model for a rapid life cycle cost analysis is also suggested and calibrated in Ref. [37]. Yaohua Guo et al. introduced a new evaluation of integrated installation methods for offshore wind turbines with the developmental trends and state-of-the-art [38]. Zhiguo Zhang et al. demonstrated an overview of New Zealand's wind energy development and use [39].

In this context, wind energy conversion systems (WECS) are one of the most prevalent and rapidly expanding technologies, and they are becoming more and more important in the production of renewable energy [40]. Delamination, debonding, and fractures are the most common forms of damage and flaws in wind turbine composite blades, which are determined by the inherent structural nonlinearities, manufacturing process stage, and harsh environmental impacts in service. These factors necessitate routine condition monitoring of the composite blades to gauge performance deterioration and structural health and lower the levelized maintenance costs [41].

In order to satisfy the load demand, wind and solar power fluctuate. The capacity of hydropower to regulate itself is a crucial component of energy complementarity and should not be disregarded. The paper suggests a hydropower complementarity evaluation approach for a hybrid energy system taking into account the load demand volatility of the power grid to overcome this problem. Beginning with the chance that the power output of a hybrid energy system meets the load demand, two neutrality assessment indicators, comprising time and magnitude, are provided. After that, the compatibility of a hybrid energy system is evaluated in light of the various existing capacities of wind and solar power plants [42].

In this work, the best daily operating methods for a wind-hydro hybrid system are created. An optimization model is used in conjunction with a long short-term memory network to estimate power prices in the day-ahead spot electricity market in order to optimize daily earnings. To explore the advantages of future power price estimates, many scenarios are taken into account. When projected power prices from the suggested extended short-term memory network were utilized instead of the previous day's electricity prices for the wind-hydro hybrid system with a 25 MW wind turbine, the net revenue for the one-year test period rose 3.5% [43].

This review currently examines the possibilities of wind, biomass, and hybrid technologies in the field of producing renewable energy. Our study begins by discussing the feedstocks and their potential for producing various biofuels from biomass, including bioethanol, biodiesel, biomethane, biohydrogen, and dithietane.

This study explores performance analysis and sustainability of wind energy systems and biomass-based hybrid configurations with wind, and its different design considerations, challenges, and gaps were addressed with an emphasis on long-term energy sustainability. The findings suggest that biomass-based hybrid energy systems can offer a financially sound and environmentally sound substitute, particularly for off-grid rural electrification [44].

To increase the hybrid renewable energy system's total energy efficiency, the biogas-hydrogen engine has to be intelligently controlled. In order to establish a balance between the performance and pollutant emissions of the biogas-hydrogen engine, the study offers some simulation findings of the ideal control parameters of the engine. The ideal equivalency ratio in tidy biogas fueling mode decreases from 1.05 to 1.01 as the biogas's CH_4 content rises from 60% to 80%. The best equivalency ratio almost achieves the stoichiometric value by incorporating 20% hydrogen into biogas, despite variations in CH_4 content. An increase of 10% CH_4 in biogas results in a 2°CA drop in the ideal advanced ignition angle under the same operating conditions and hydrogen concentration. However, when 10% hydrogen was added to biogas at a certain engine speed and biogas composition, the ideal advanced ignition angle fell by 3°CA [45].

The major goal of this study is to determine the best fuel cell and battery combination for a ship's power system in order to obtain the lowest CO_2 emissions while also taking into account the number of battery cycles. The vessel examined in this article is a Platform Supply Vessel (PSV), which transports supplies, personnel, and equipment to service offshore oil and gas sites. The suggested plan takes into account ship refit. The ship's original primary generators are kept in working order, and batteries and a fuel cell were fitted as backup power. Additionally, the ship's demand curve is the subject of a sensitivity study. HOMER software was utilized to create the simulations that were used to determine the CO_2 emissions for each of the new hybrid setups. The load regime has no effect on the ideal ignition angle. Auxiliary generators, three distinct battery types, and a proton-exchange membrane fuel cell (PEMFC) with various-sized hydrogen tanks are the suggested alternatives. The sizing of the auxiliary engines was based on earlier research, while the PEMFC and batteries were sized as containerized solutions. These solutions are combined to form each arrangement. One contribution of this study is the choice of the optimum configuration. The new configurations are divided into groups based on how much less CO_2 they release when compared to the old setup. The findings suggest that the categorization of the setup may change for various demand levels. This work's sizing of the battery and hydrogen storage systems is another important addition [46].

In order to increase wave energy exploitation per-unit area and lower the levelized cost of electricity, practical solutions are offered by the hybrid idea of multi-type wave energy converters. In order to be suited for both nearshore and offshore zones, a multi-degree-of-freedom hybrid system comprising an oscillating wave surge converter and two oscillating buoys is presented in this work and incorporated onto a semi-submersible platform. By constructing a three-dimensional numerical wave tank within the context of computational fluid dynamics theory, including a dynamic overset grid scheme, the hydrodynamic properties of the hybrid system are investigated, with emphasis on both its overall characteristic and the specific characteristic of each device [47].

In the framework of their technical and environmental evaluation through life cycle assessment, our research is making an attempt to offer a thorough grasp of the potential benefits and numerous uses of geothermal energy systems. An overview of the tools and analysis techniques used to look at a certain system or application is given. The use of certain geothermal technology and applications is covered in detail, along with the environmental benefits and technical challenges associated with each. A large portion of the geothermal energy potential is covered by district and home heating systems. The bulk of the studies that have been presented focus on the creation of electricity as the most significant use of geothermal energy. The study's overall finding is that geothermal energy is an incredibly feasible alternative that, when used in conjunction with other renewable energy sources, may help to lessen the detrimental consequences of the world's present energy mix [47].

3. Optimization of IHMS

Optimization is regarded as the process of selecting the best or worst item from the available alternative solutions. Mostly, in the cases of IHMS designs, the mission of different optimization techniques is to find the solutions offering the least costs, sizes, and best performance. The schematic diagram of a hybrid PV-Wind renewable network is shown in Figure 1. The basic graphic depicts the architecture of an IHMS in general [48]. It represents the block of each module with the connections and co-relation and synchronization. The AC bus is connecting the sources and loads according to the sequence of transformers and converters. The combination of AC wind turbine, AC diesel generator, DC PV, and DC BESS create the islanded/grid connected IHMS, in which the AC and DC loads converge each other in between the AC and DC bus system.

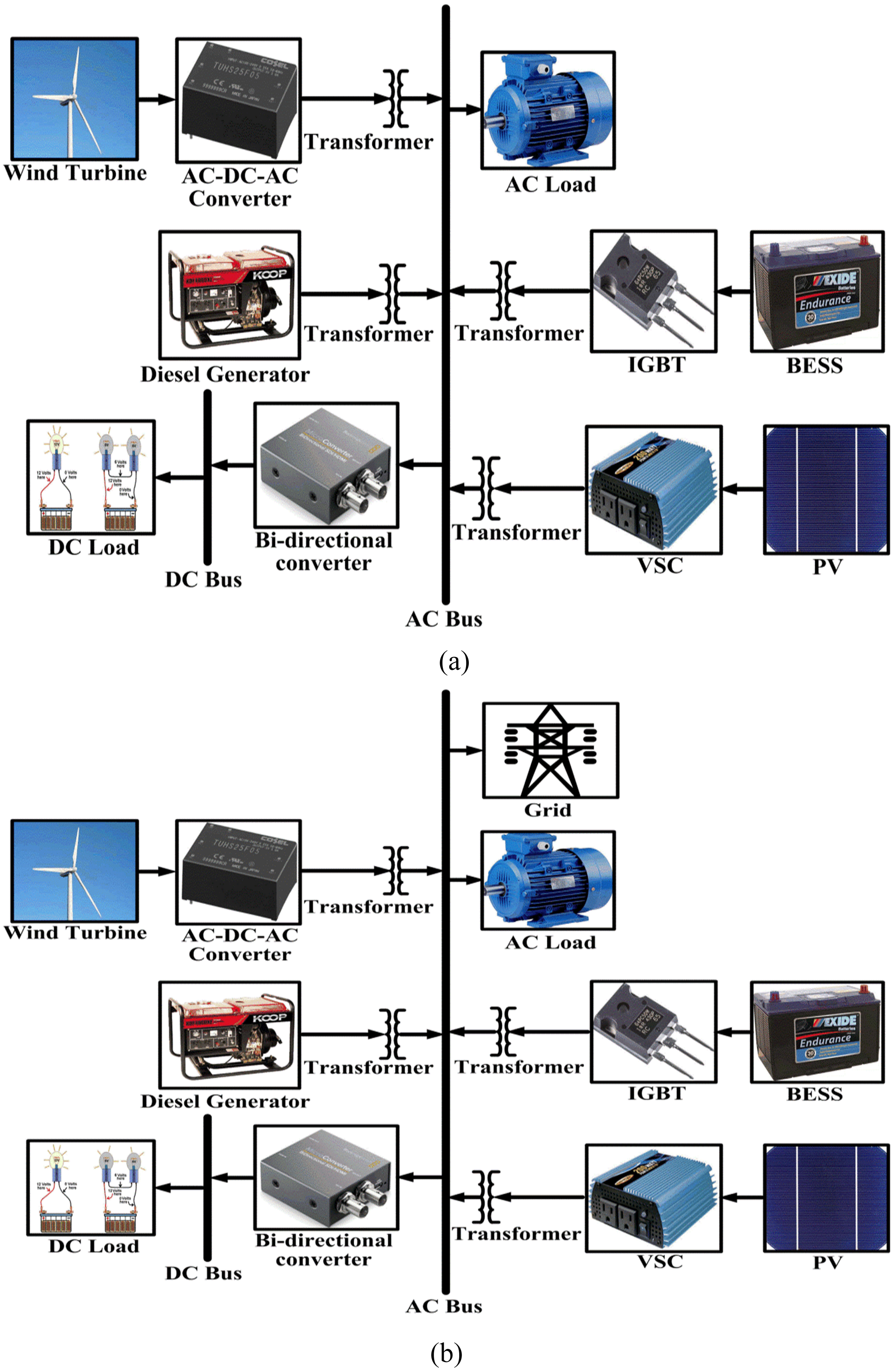

Figure 1. Schematic diagram of solar-wind hybrid microgrid (**a**) islanded and (**b**) grid-connected [49].

3.1. The Evolution of IHMS Optimization Methods

Various optimization techniques have been utilized for IHMS optimization, optimal sizing, and techno-economic analysis. To simulate the IHMS, numerous algorithms and optimization approaches are used in conjunction with the evolutionary strategy, which is presented in the next section.

3.1.1. Optimization by Heuristic Methods

The best choices for building or managing a variety of complex systems can be found using heuristic optimization algorithms for multi-objective optimization problems [50]. Streamlining of an issue alludes to finding the most extreme and least of a genuine capacity by estimating the capacity utilizing inputs methodically chosen from inside a permitted set. Heuristics incorporates experimentation arrangement discovering procedures for complex issues inside the constant breaking points.

The optimization problem is solved using a metaheuristic approach. Numerous parts of daily living might suffer from optimization issues. Ant colony optimization (ACO), genetic algorithms (GA), and particle swarm optimization are some of the several types of metaheuristic methods (PSO) [51,52]. The current metaheuristic calculations were created during the 1980s and the 1990s. Since they were developed in response to natural processes, they integrate nature-driven strategies.

Genetic Algorithm

The genetic algorithm, which is a framework for indiscriminate pursuit and improvement, is guided by the common hereditary framework. The genetic algorithm is frequently used for the optimization of many characterizations. Solar, wind, and geothermal energy sources are getting a lot of traction in terms of analysis and modeling approaches. When considering the transformative ideas of normal choice and inherited qualities, GA is a flexible heuristic search algorithm. Using heredity computation with the possibility of an energy supply loss as a constraint, Daming et al. established an elitist approach to the ideal measurement of different mixed PV-wind control frameworks, which caps the aggregate capital of the entire framework [53].

To identify the most accurate capacity model of a daylight-based wind mix with an unrestricted essentialness structure and quick overall combining, Zhao et al. employed a hereditary calculation for PSO. To supply the changeable load spotted in the vicinity of Xuzhou, China, Zhou et al. employed GA in combination with the plan [54]. Fadaee and his colleagues developed Fuzzy logic using GA that was used to create an ideal measurement of a hybrid Wind/PV battery system, which picks the best number of WT, battery, and PV panels. GA was also used to assume a flawless control design to ensure an off-network hybrid system [55]. Tutkun and the team developed genuine energy planning from an off-grid IHMS that was previously used for the hot water tank and street lighting. Within this work, double-coded GA, rather than organized basic straight customizing, is used to lower the operating unit cost of IHMS [56].

Particle Swarm Optimization

A population-based static optimization technique called particle swarm optimization (PSO) is targeted toward individual social interaction in fish schooling and winged animal flocking, where a flock is defined as the coordinated movement of several self-propelled items. Zhao et al. proposed a method for improving the PSO algorithm for an optimal limit plan based on a free wind/PV mix force supply framework [57].The PSO approach fully relied on different sorts of data sets dependent on the parameters that were used. Several researchers are using PSO as the ideal prediction tool for various reasons. An ordinary non-linear included basic streamlining difficulty might be the way out for mixing energy framework ability optimal configuration. An algorithm is also expected to look into the framework discovered on an island. Those who cause shortages have demonstrated their capability and efficacy [5]. By using particle swarm optimization (PSO), to enable the dependability indicators, Dehgan et al. provide the majority of positive position measurements of hydrogen manufactured wind/PV plants. A modified PSO technique with the creation of a multi-objective strategy in a coordinated energy system was presented by Wang et al. [58]. Affectability considerations may also be used to investigate the impacts of claiming various framework parameters on the overall configuration execution. Sanchez et al. described the solar-wind IHMS for agricultural application and harvesting. It is also possible to apply the evolutionary calculation method known as PSO with those framework costs as the goal capacity. Ardakani et al. use a PSO computation to determine the optimum optimal size of a grid linked hybrid microgrid [59]. This yields the perfect distribution of wind turbines, PV modules, and battery capacity close to the inverter. Bansal et al. demonstrated the mix PV/wind/batteries imperativeness structure streamlining using multi-target atom swarm optimization (MOPSO). An objective endeavor to cosset the mixing framework, including startup expenditures, yearly running costs, and support charges, might be defined. MOPSO is employed to deal with the issue because of the many-sided character of the mixture of renewable energy structure with nonlinear important analytics planning. Keyrouz et al. developed a bound-together MPPT to manage a combination of wind-solar and power module architecture [60]. Amer et al. employed a following calculation-built Bayesian lion's share of the information combined with swarm rapidity to delineate a streamlined, looking computation. To minimize the difficulty of ensuring imperativeness with an acceptable choice of the period taken assured nearby considering those situations, the center of planning also requests sides to reduce the expense. According to the conclusion, PSO execution may be quicker and can also offer a condensing design that recovers around 10% of the entire cost of the integrated framework. Borhanazad et al. used MOPSO to construct streamlining for micro-grid frameworks and used the energy oversaw economy method to get the optimal configuration of the mixed framework [53].

Fuzzy Logic

Nema et al. demonstrated a flawless economic operation by using a fluffy pushed quantum developing approach to establish a sharp network. Adhikari et al. introduced an independent autonomous energy system with fuzzy logic controller (FLC) for frequency regulation. In light of these fluffy base control strategies for detecting the DC voltage and current yield of the sun, as well as the updated yield voltage of a wind turbine-driven enduring request short of breath quick present generator, Chakraborty and associates created a soft-moved quantum evolving framework to offer a perspective on the sharp matrix's speculation and activity [61].

Artificial Neural Network

A neural networking system is an interconnection grouping of simulated neurons that occupy a logical prototype or computational archetype for evidence shifting in the light of a relationship with an approximation estimate. Fidalgo et al. developed a linked artificial neural networking (ANN)-based approach to deal with preventative control strategies in a large hybrid energy system. In the progressive security design population, an ANN is a basic element that is superior to conventional quantifiable methods and also assesses the degree of security [62]. After Tom's research into the distinctiveness of sun-oriented energy, and wind vitality, Martin et al. proposed a neural control system for multi-energy regular DC transport mixed energy supply. The energy component is familiar in the preparation, and the Levenberg–Marquaret method interfaced with the neural system may be used [63].

Game Theory

Ogino et al. developed a non-cooperative amusement strategy on an electric producing network that will be linked to asset and supply government-funded cooperation. The main disadvantage of this architecture may be that it lacks whatever control component the complete system requires [11].

A coalitional entertainment design for enjoyable micro-grid conveyance networks of solar panels, wind turbines, and other energy sources must also be presented. This will allow for better instrument monitoring and stock management [49]. Baeyens and Bitar both clarified that the wind energy was gathered for the sake of a coalitional amusement approach.

Those studies explored the extent to which a gathering for a wind constraint may allow creators to take use of the true benefits of the stochastic behavior of meteorological conditions, as determined by a coalitional entertainment strategy. Wang and Mei developed strategies for organizing assisted control systems. This study uses the beguilement hypothesis to model a hybrid energy system made up of wind turbines, photovoltaic panels, and storage batteries. In terms of illustrative players and their lifetime earnings as well as payoffs, both non-cooperative and cooperative amusement hypothesis models require help, which may be supplied by installing wind turbines, PV panels, and battery storage [64].

Alskaif et al. offered an amusement constructed stochastic altering on a production ideal, providing techniques to increase the combined benefits of wind and conventional energy producers, presenting both the vitality market and a reciprocal save the market, where the save value may be chosen between wind and conventional energy producers. Applying the divergence theory would be one path to go [12]. Vikas et al. developed and tested a diversion hypothesis for sun-generated wind based on Cornet's model. IHMS also provides essential options for determining the appropriate reaction, starting with a sun-oriented and wind-powered energy system. The sun-based wind mixing framework is investigated using a game technique. Different tactics are considered and evaluated, such as diversion hypothesis logic, Nash equilibrium, and non-cooperative diversion hypothesis [65].

For the power microgrid optimum operations planning, this work proposes a new enhanced version (specifically, ESSA) of the sparrow search algorithm (SSA) based on an elite reverse learning method and firefly algorithm (FA) mutation strategy. In order to establish grid multi-objective economic optimization, scheduling cycles of the microgrid with a distributed power source's optimal output and total operation cost is modeled based on variables, such as environmental costs, electricity interaction, investment depreciation, and maintenance system.

The proposed plan offers higher performance and feasibility in addressing microgrid operation planning issues when compared to other literature methods, including Genetic algorithm (GA), Particle swarm optimization (PSO), Firefly algorithm (FA), Bat algorithm (BA), Grey wolf optimization (GWO), and SSA [66].

The research suggests an enhanced primary control technique for producing units with inverter interfaces in islanded microgrids. The proposed method develops the principal frequency regulation curve's set-points while fulfilling the power balance, frequency, and current limitations by using an off-line minimal losses optimum power flow (OPF). In this manner, generators will arrive at an operating point that is optimum and corresponds to a specific and particular power flow distribution, exhibiting the least amount of power losses. The suggested method may be particularly intriguing for diesel-based island microgrids that continually struggle to cut their reliance on fossil fuels and improve the efficiency of their generation and distribution. A crucial heuristic method for resolving the optimization issue is the Glow-worm Swarm Optimization (GSO) algorithm [67].

The primary goal of this study is to create a hybrid Non-dominated Sorting Whale Optimization Algorithm (NSWOA), which combines a multi-objective, non-dominated sorting approach with a swarm-based Whale Optimization Algorithm (WOA). This is done to create an algorithm that can search for optimal solutions quickly and efficiently. It has also been reported how NSWOA may be used to optimize the controller settings of an island microgrid with both static and dynamic load. When optimizing the controller parameters of an island microgrid model with multiple objectives, SPSS software was used to compare the performance of the proposed NSWOA method with that of the non-dominated sorting genetic algorithm-II (NSGA-II) and Strength Pareto Evolutionary Algorithm (SPEA) technique. It is discovered that NSWOA needs, on average, four iterations to arrive at the best possible outcome [68].

Figure 2 graphically demonstrates the revolutionization of the hybrid energy system's game theory strategy.

The advantages and disadvantages of the popular optimization techniques and algorithms for the hybrid solar-wind energy system are shown in Table 2. In Table 3, the optimization and prediction of solar-wind IHMS has been represented in a nutshell.

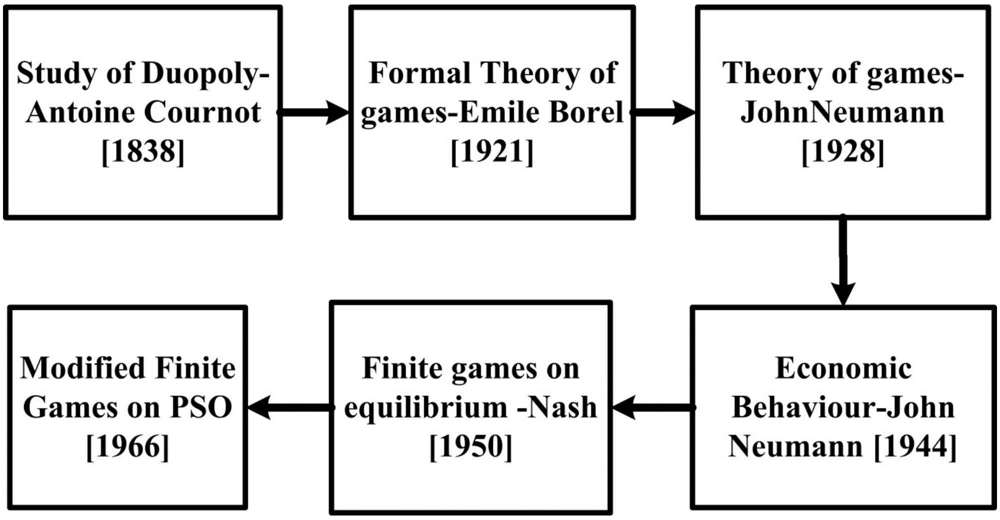

Figure 2. Game theory evolution-based optimization approach of typical IHMS [69].

Table 2. Stochastic optimization techniques adopted by researchers for IHMS.

Optimization Techniques	Advantages	Disadvantages	Convergence Rate	Complexity
Genetic Algorithm [70–72]	Can take care of issues with different arrangements, effortlessly transferable to existing re-enactments and models. Solve issues with numerous arrangements; accessible in MATLAB tool kit.	The convergence rate is slower than other stochastic calculations; it cannot guarantee consistent advancement reaction times and so on.	Faster	Simple
Particle Swarm Optimization [73,74]	The speed of the examination is quick; computation in PSO is straightforward in contrast with different techniques; it can be finished effortlessly.	It cannot work out the issues of the non-facilitated framework; effectively experiences the fractional good faith and so on.	Faster	Simple
Loss of Power Supply Probability (LPSP) [75,76]	Easy to understand; more focused on a single system	Difficult to investigate; complex; less writing accessible.	Slower	Relatively Complex
Metaheuristic search method [77,78]	Upgrades the exhibition of nearby pursuit; quick calculation.	Complex process.	Slower	Relatively Complex
Artificial Bee colony [79,80]	The calculation has a neighborhood look and worldwide hunt capacity; actualized with a few enhancement issues; simple to utilize; accessible for hybridization mix with different calculations	Irregular statement: the calculation has a few parameters.	Relatively faster	Complex
Ant colony algorithm [81–83]	The calculation has the quality in both neighborhood and worldwide pursuits; executed with a few improvement issues.	Arbitrary installation: calculation has a few parameters; parameters should be tuned; probabilistic methodology in the neighborhood search.	Relatively faster	Complex

Table 3. Optimization and prediction of solar-wind IHMS [84].

Investigation	Sizing Restraint	Yield
Probabilistic [85–87]	Loss of Power Supply Probability (LPSP)	Probabilistic analysis with optimal sizes of solar PV and BESS, COE, and NPC calculation
Techno-economic [88–90]	Total Cost/kWh, level of self-rule	The best and worst case in terms of LCOE, LNPC, and minimum CO_2 emissions.
Economic [91,92]	Net Present Value (NPV)	Lowest NPV and the best renewable energy combination for remote and decentralized areas.
Techno-economic [93,94]	Total cost and load energy requirement	Proper load supply management with minimum cost and environment friendly.
Probabilistic [95,96]	Vitality file of dependability	Calculation of probabilistically advanced IHMS for decentralized hospital and school.
Economical [59]	Lack of life cycle cost, power supply probability	Optimal sizes of solar PV, wind, DG, and BESS; cost analysis of electricity production.

Figure 3 shows the methodological approach of a typical IHMS. In the last decade, the application of different software tools for renewable energy-oriented IHMS and HRES has increased at a huge rate. The popularity of software tools has increased due to the vast industrial applications and complex free conclusions. HOMER is the most efficient and most popular software tool for renewable energy-oriented IHMS and HRES. HOMER gained popularity due to its easy iteration steps and great convergence rates with the highest accuracy. The results generated from HOMER Por have already been recognized and published by many reputed international journals.

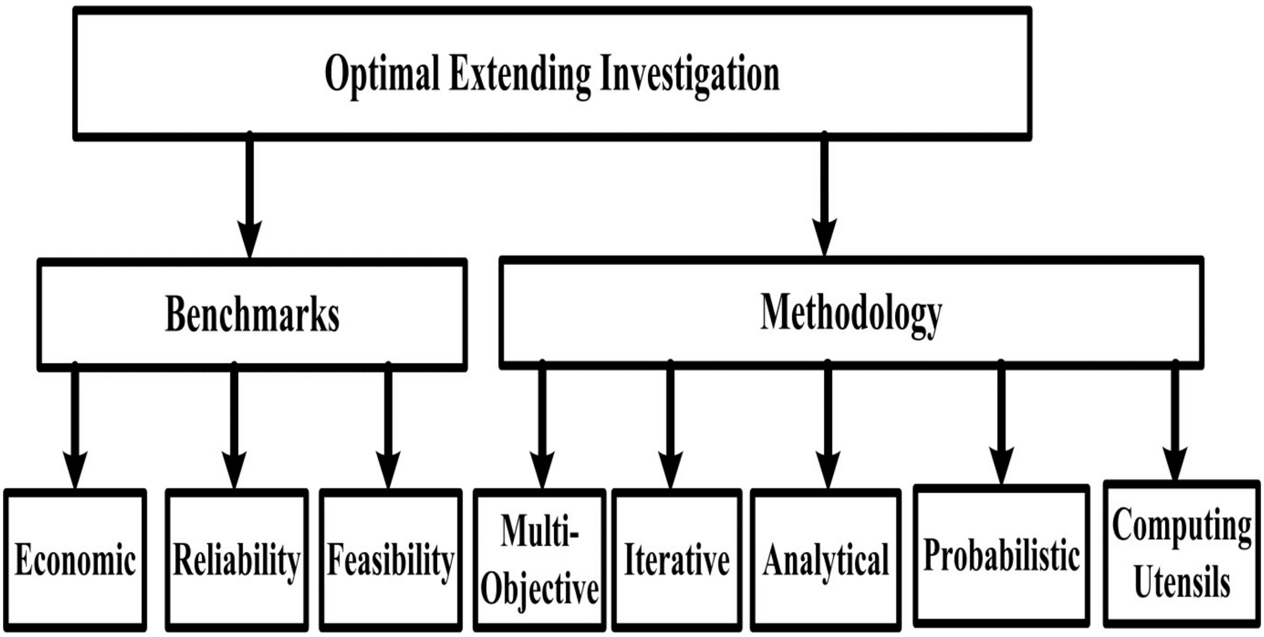

Figure 3. The methodological approach of typical IHMS [69,97–99].

Different software tools operating based on other optimization techniques are important in designing optimum hybrid systems. The most common software tools are: HOMER, HYBRID, RETScreen, etc. In Table 4, various types of software based on the optimization of the hybrid system along with their pros and cons have been described.

Table 4. Various types of software tools for the optimization of the hybrid system.

Software Used for Optimization	Advantages	Disadvantages
HYBRID 2 [100]	The model's specialized precision is exceedingly high	The model cannot advance the vitality framework
PVSYST [101,102]	It permits assurance of PV size and battery limit	Confinement for sustainable vitality sources
INSEL [103]	Adaptability in making a framework model and setup	Does not perform framework streamlining
SOLSIM [103,104]	The measurement system used to determine life cycle costs	Not able to locate the ideal size of the hybrid framework
WATSUN-PV [105,106]	The model for DC engines is a straightforward correlation between the voltage and current provided by the cluster and the engine's torque and rakish speed	Engines and siphons are not included in the database
PV-DESIGN PRO [107,108]	The database as of now incorporates most data required for the PV framework plan	The module and atmosphere of the database are extremely complete
RAPSIM [109–111]	The control elements that determine the diesel generator's on-off patterns	The effect of the battery SoC and DoD
RETScreen [112–114]	Battery life cycle cost, energy timeline	Complex calculation and high simulation time
PHOTO [115,116]	Different control systems can likewise be considered	High simulation time
SOMES [117,118]	The model includes an enhancement method that searches for the framework with the lowest power consumption.	SOMES does not provide an optimum operative approach
HOMER [119–121]	This instrument offers an amazing UI and exact measuring with a detailed examination of the framework	HOMER has a low level of specialized precision since its segmental scientific models are straight and do not include any amendment variables
RAPSYS [103,122]	This product can re-enact a wide scope of sustainable framework segments that might be remembered for a half-and-half framework setup	Usually, this tool cannot optimize the size of the components

3.1.2. Optimization by Deterministic Methods

Optimization might be integrated anytime in the islanded or connected microgrid to accomplish the best-working principles in meeting all fundamental imperatives. For setting up a microgrid, its activity, support, and planning exercises include different choice-making circumstances that require the application regions for enhancement. In science, an enhancement issue is characterized as a problem to locate the ideal system from a combination of practical implementation. For a less demanding investigation, the application zones for enhancing IHMS have been generally isolated into three classifications: control, age, and conveyance. Planning of an IHMS demands a comprehensive investigation for choosing the ideal blend of creating and capacity frameworks per the necessities. Table 5 shows the advantages and disadvantages of various types of deterministic methods for optimizing an IHMS.

3.2. Reliability Analysis in IHMS

The possibility of a contraption or structure carrying out its idea satisfactorily during the regular operating period is shown as relentless quality. It similarly describes the limitations of power distributions and load demand of the particular meteorological conditions and areas.

Table 5. Advantages and disadvantages of various types of deterministic methods on the optimization of IHMS [1,6,65].

Optimization Techniques	Advantages	Disadvantages
Linear programming optimization (LPO)	Less complex mathematics and easy to understand	LPO does not include the back-energy storage at battery or DG
Mixed-integer linear programming (MILP)	Parallel factor issues are doable for an ideal arrangement. The model was valuable for policymakers in tropical nations to assess a natural savvy eco-town	The model is progressively sensible and essentially expands the trouble in order to comprehend it
Non-linear programming (NLP)	A numerical methodology-based model empowers the arrangement of a mind-boggling issue with an incredible number of basic tasks	The numerical strategy required multiple cycle operation
Mixed-integer non-linear programming (MINLP)	MINLP can evaluate numerical and binary variable problems in both	Complex and more iterative

Many research scientists have already demonstrated their concern regarding the system reliability of the IHMS [123–127]. Xufeng et al. constructed an operational reliability index for the islanded hybrid microgrid using a model of short-term stability and outages [123]. To guarantee the viability of the system, Khare et al. provided the reliability evaluation of the distribution network of the islanded hybrid microgrid [124]. The technical feasibility of an islanded hybrid solar-diesel-battery hybrid system created to support Nigeria's typical rural and decentralized locations was examined by Mokoka et al. [120]. Ruchita et al. carried out a transient component-based reliability assessment of the islanded hybrid microgrid to ensure the viability of the distribution network [121]. Abdelsamad et al. created an inventive autonomous energy management method to ensure the system's dependability by accounting for the load voltage and converter dynamics [128]. To account for power electronic device operational failures, Abdulkarim et al. created an enhanced islanded microgrid and reliability evaluation [129]. A self-sufficient, hybrid island microgrid powered by renewable resources was developed by Zhong et al., who created a reduced-order model for the dependability and dynamic stability of the islanded hybrid microgrid by researching the band pass filter-based droop control technique [130].

Zhang et al. tended to the unwavering quality examination of little segregated sustainable power source framework by decisive and probabilistic strategy [131]. Zhao et al. manage the far-reaching target capacities that incorporate the speculation cost and the dependability and ideal operation of the framework. The main contribution of this manuscript is the optimal sizing, system stability analysis, along with reliability analysis [57]. Ardakani and Richy built up an outline of an ideal IHMS considering unwavering quality files subjected to budgetary and logical imperatives. The analogous misfortune factor verbalizes the criteria linked with the foundation's unshakable quality [132]. The technique gets the progressive execution of a conspicuous evidence unwavering quality examination. Kishore and Fernandez demonstrate a relentless evaluation of a wind-PV structure utilizing Monte-Carlo re-foundation. The paper features the diverse elements of HES, considering a sunlight-based and wind vitality change framework (WECS), exhibiting immovable quality appraisals. In this study, a few methods for constant quality evaluation have been considered [133]. Monfared et al. introduced enhancements of unwavering framework quality with the assistance of energy hardware. Pradhan and Karki build up a probabilistic reliability study of a matrix crossover control structure for a location in Nepal. The article is related to the investigation of hybrid renewable structure steadiness in the context of different continuing quality records corresponding to the cost of load request, energy once-over of unfaltering quality (EIR), expected centrality not served (EENS), and predictable client intrusion cost (ECOST), which are assessed using a probabilistic technique utilizing authentic strategy [134]. Wang et al. demonstrate the feasibility of constructing a structure that integrates power storage, PV, and wind [58]. The dependability assessment models of wind control and sun-oriented energy extraction are utilized as a part of successive Monte-Carlo re-enactment. In addition, the framework's streamlining depends on factors such as sunlight-based radiation, wind speed, and so forth. Kekezoglu et al. provided an unwavering quality investigation of a crossover framework introduced on the Davutpasa grounds of the Yildiz specialized college. Unwavering quality records are ascertained for the context [135]. Figure 4 presents the characterization flow of the techno-economic feasibility process of the hybrid energy system in terms of COE, NPC, and other objectives.

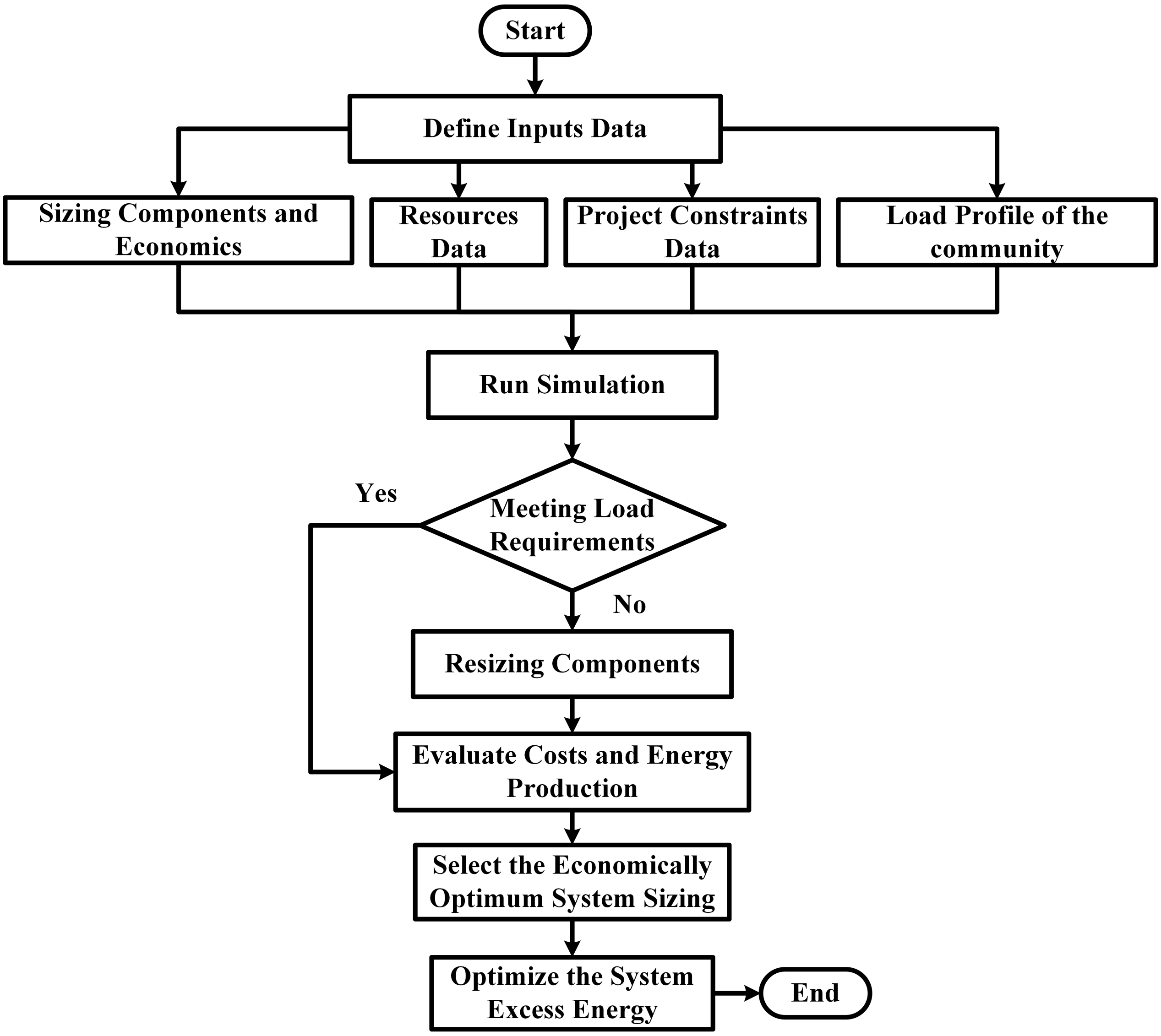

Figure 4. Characterization flow of the reliability process of the hybrid energy system in terms of COE, NPC, and other objectives [136].

4. Control Strategies of Solar-Wind IHMS

Because a hybrid sustainable power source microgrid combines various sustainable power sources, diesel-oriented power sources, and energy-saving bulk, achieving the highest productivity and reliability is difficult without employing ideal control methodologies [137]. The controller completes the variable, checking, and control supply stack for the need in the mixed sustainable power source architecture. Because the system may be unstable due to the stochastic behavior of the power sources as well as unexpected changes in the load profile, the dedicated voltage, current, and frequency are frequently regulated using various control techniques. Different types of controllers are connected in a crossover sustainable power source framework as indicated by the necessity of different vitality sources, yield power, and control system. Unified, appropriated, hybrid control, and various control frameworks are the most common types of controllers [138].

Each source must have a distinct controller that can concentrate on the best course of action for the related unit based on the most recent facts for each circumstance. The total essentiality source's signs and limit system are confined by the unified (ace controller) plan in the tied-together control game plan. In the context of every available datum, a multi-target imperativeness unit structure can achieve overall development [139]. This consolidated unit's disadvantage is that it has an overwhelming count stack and is vulnerable to single-point dissatisfactions. The second generation control unit is the one that has been appropriated; at this point, the imperativeness source is connected to the person and the local control unit, and as a result, the control units are connected to exchange estimation banners and make an accurate assessment of overall progress [140].

This control strategy might be more profitable when contrasted with the concentrated control unit since it requires a base computational load with no disappointment that the few conditions can figure. On the other hand, this control structure suffers from a lack of multi-faceted correspondence networks among the neighborhood controllers. Fake estimate frameworks can bring this problem of the distributed control unit to light. The third generation control technique is the multi-expert system, which is a victor among the most consoling procedures for an appropriated control unit [141]. The hybrid control unit is a strategy that combines dispersed and gathered control units. The hybrid control unit collects sustainable sources within a coordinated framework. The hybrid control technique allows tuning the voltage and power in contrast with the components and worldwide meteorological conditions. This hybrid control technique allows the proper load management steps within the dedicated voltage range [142,143].

A multi-level control unit is used in the fourth-generation control. The working activity of this control unit is virtually identical to that of the crossover control unit, but it has the advantage of having manager control, which considers the continual task of each vitality unit based on the control objective within milliseconds [144].

Different types of the controlling method have been presented in Table 6.

A brief overview of the control strategy for IHMS has been given in Table 7.

Communication-based control and droop strategy-based control for IHMS and HRES Tables 8 and 9 summarize the potential benefits and drawbacks of communication-based approaches and droop methods, respectively.

Droop control strategies depend on nearby estimations of the system state factors that make DG appropriate and total excess, as they do not depend on links for dependable activity. It has numerous alluring highlights, for example, expandability, particularity, and adaptability. A droop strategy-based controller has some drawbacks in terms of voltage and frequency regulation under stochastic conditions of meteorology.

In any case, examination of these control methods will help enhance the plan and use of future dispersed solar thermal and geothermal-based microgrid models. The future patterns in charge methodologies for microgrids are identified with vitality administrations and insurance, which incorporate the interest reaction, ideal power stream, showcase support, stockpiling administration, etc. These advancements could be intriguing while interfacing microgrids to the fundamental network or conveying various microgrids. In this manner, multi-agent frameworks and hierarchical control could arrange the trade of vitality between microgrids or, on the other hand, microgrid groups. Subsequently, the multi-agent control and hierarchical controllers are turning into an unmistakable pattern of research in microgrid innovations, while correspondence frameworks are becoming more imperative to make these applications possible.

Table 6. Summary of the IHMS solar wind control technique [145].

Objective	Method	Main Contribution
A data logger and remote control of IHMS	By data logger and model predictive controller	Examination of the vitality creation and execution of IHMS is contemplated in detail
Maximizing hybrid availability	• Battery power hourly accumulation gives significant pay over-voltage dependent on system control • Average battery voltage methods of system control for IHMS Ampere hour accumulation	Ampere hour gathering offers noteworthy pay over-voltage-based techniques for framework control for IHMS
Microprocessor-based control of IHMS	Microprocessor-based, Motorola 6800, 'C' Programming	The life expectancy of the battery is expanded by controlling the condition of the charge of the battery
Power control of an IHMS	By archetype system strategy	1. The framework has a few task modes: ordinary activity, control dispatching, and control normal to facilitate the control of the battery vitality stockpiling framework 2. The BESS functions as a power cushion to smoothly transition away from fossil fuels without stopping and starting to recharge batteries.
Control of microgrid and optimal sizing	RHAPSODY Software, Linear Programming	1. This investigation enables the client to consider the association between financial, activity, and ecological factors. 2. It offers a valuable apparatus for the plan and investigation of IHMS.
Petri-nets control design of IHMS	Petri-nets controller	A supervisory control technique streamlines the vitality exchange as indicated by the source control variety and the heap attributes
Dynamic control of IHMS	Particle swarm optimization (PSO)	A numerical model is produced and another PSO calculation because of the uniform outline and idleness change is utilized to illuminate the scientific model that is used to control the activity of PV-wind IHMS
Design and control of smart IHMS	Genetic Algorithm (GA) and direct design control	Using modified GA, a useful tool for selecting the section of the energy framework is developed with two important selection criteria (price and number)
Digital signal controlling of Wind-PV IHMS	MATLAB/embedded emulator	This IHMS can withstand sudden fluctuations under typical circumstances and muffles the effect of variation on the voltage under the acceptable range

Table 7. Control strategy for PV-wind IHMS [146].

Authors	Hybrid System	Control Techniques
Sara Ghaem et al. [147,148]	PV-Wind-Engine-Battery	TRANSYS and Dispatch strategy control algorithm
Nicu Bizon et al. [149]	PV-Wind-Fuel Cell	LF Strategy and MEPT loops with Matlab Simulink
L. Suganthi et al. [150]	PV-Wind-Biomass-Engine-Battery	Fuzzy Logic controller with MATLAB
Narsa Reddy et al. [151]	PV-Wind-Battery	DC link voltage regulation control
Dan Wu et al. [152]	PV-Wind-Battery	Smooth switching droop control

Table 8. Prospective advantages and disadvantages of the communication-based control techniques.

Communication-Based Control	Prospective Advantages	Prospective Disadvantages
Concentrated control	• Frequency and voltage regulation are always constant • Better power quality in transients and steady-state	• A high volume of bandwidth is required • Reliability and expandability are poor
Master/Slave control	• Output voltage recovery is easier • In a steady state, power-sharing is smooth	• Redundancy is very low • High bandwidth communication is required
Distributed control	• Constant voltage and fundamental power-sharing • Symmetrical for every module	• The modularity of the system can be degraded • A complex communication bus is required

Table 9. Prospective benefits and shortcomings of droop-strategy-based control techniques.

Droop Strategy-Based Control	Benefits	Shortcomings
Conventional frequent droop control	Expandability, modularity, and flexibility are high	Voltage and frequency regulation is very poor
VPD/FQB droop control	The implementation is easy without communication	Can be affected by the physical parameters
Complex line impedance	Active and reactive controls can be decoupled	Line impedances and X/R ratio are required to be known earlier
Angle droop control	Frequency regulation is constant	Poor performance in power-sharing
Simulated output impedance control	Improved and upgraded performance in power-sharing and system stability	Requires higher bandwidth for a controller
Adaptive voltage droop control	Improved voltage regulation	The physical parameters need to be known earlier
Q-V dot control technique	Robust communication delay	Depends on the initial conditions
Common variable-based control technique	Accurate reactive power-sharing	Due to the large distance it is hard to measure the common voltage
Droop control with the constant power band	Avoid voltage limit violation	Micro-source requires despatched abilities
Signal injection method	Can handle nonlinear and linear loads	Causes harmonic distortion of the voltage

5. Correlation between Optimization Techniques and Control Strategies of Solar-Wind IHMS by Implementing the Dispatch Strategies

A basic task of any IHMS and HRES is the propelled monitoring ability and control of its benefits and functions for fulfilling the ongoing load demand with technical and economic feasibility. Enhancement and control calculations for IHMS coordinate administration of the supply side, BESS, and request side to locate the ideal (or close ideal) unit responsibility and dispatch of the sustainable power source with the goal that specific destinations are accomplished. A commonly sought-after target for a remaining solitary method of the task is to monetarily supply a nearby load, while under a matrix-associated mode the boost of benefit is regularly looked for as an alternative solution. Extra goals, for example, the minimization of GHG emissions by applying heuristic and multi-objective improvement systems, have been accounted for by the IHMS and HRES. Prior investigations have detailed power administration methodologies that are receptive, acting in light of the intensity and awkward nature between age and request. Previous research has attempted to consolidate expectations to convey proactive unit responsibility. Huge cost funds have been exhibited when the heap expectations and climate/encompassing condition estimates are being considered [153]. The levelized cost of energy, CO_2 emissions, and net present cost (NPC) of the suggested microgrids have all been reduced. Following an investigation of the five dispatch techniques for the four microgrids in HOMER Pro, MATLAB Simulink was used to examine the power system reactions and the viability of the microgrids. The study's findings recommend estimating component prices and sizes for the best performance of the suggested microgrids under various load dispatch scenarios [154]. The study's test microgrid was on South Australia's Kangaroo Island. Four different dispatch systems were considered for sizing the Kangaroo Island hybrid microgrid system, consisting of wind, solar PV, battery storage, and a diesel engine. The generator order, cycle charging, load following, and combination dispatching dispatch techniques were all applied in this investigation. The islanded microgrid's NPC, CO_2 emissions, and cost of energy (COE) were all optimized. All four dispatch algorithms were created using the HOMER microgrid platform, and the responsiveness and reliability of the power system were examined using DIgSILENT PowerFactory. The findings offer a framework for figuring out the right balance of power sources and resources for an island microgrid [155]. This study offers recommendation for estimating various component sizes and likely costs for the best performance of the suggested microgrids under different load despatch scenarios. According to the simulation findings, "Load Following" is the optimal dispatch method for the suggested microgrids since it provides a reliable response from the power system while having the lowest NPC, Levelized COE, operational cost, and CO_2 emission rate. The suggested off-grid hybrid microgrid architecture is shown to have the poorest dispatch method, with the combined dispatch strategy having the highest levelized COE, NPC, operational cost, and CO_2 emission [98]. The suggested methods can be applied in companies that combine solar and cogeneration power plants for improved optimization and to adhere to IEEE 1547 specifications. The voltage ramp index has been developed to calculate the voltage ramp up and down with intermittent solar irradiation. The efficiency of the cogeneration plant at various loads and the solar irradiation under different weather conditions are also predicted using a machine learning approach. The success of the modified heuristic approach and a few recommendations, including solutions for industrial usage, are suggested as a conclusion to this study [156].

Figure 5 shows the comprehensive flow diagram used to describe and represent the correlation between the optimization and control strategies with the dispatch strategy for the IHMS. It expresses the operational sequence and interrelation between the optimization tools and the control techniques that refer to the proper energy management system with a proper techno-economic assessment as well as system analysis and evaluation.

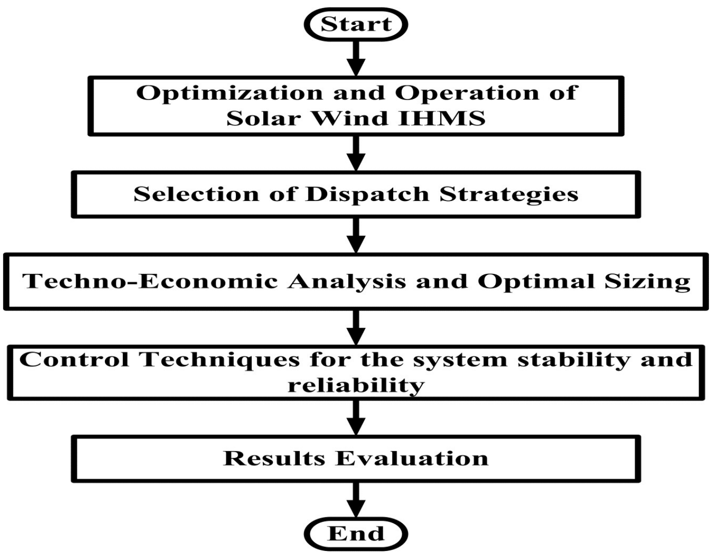

Figure 5. A flow diagram of the correlation between the optimization technique and control strategy for the solar-wind IHMS.

6. Evolution of Dispatch Strategies in Microgrid Optimization

Integrating various renewable energy sources and loads within a certain locality forms a microgrid [157]. The research works on microgrid operation and assessment have become scattered and common in the last decade, but the implementation of dispatch strategies has not yet become more common and scattered due to the lack of application of dispatch strategies based on microgrid and IHMS solutions [97]. Dispatch strategies are defined as some control approaches that can be implemented within the microgrid to efficiently control the generation and distribution of electrical energy [158]. This model is used to transform the micro-grid power dispatch issue into a multi-objective optimization issue (MOP) that takes into account economic cost, voltage variation, and frequency stability. A multi-objective optimization strategy based on penalty-based boundary intersection (PBI) is created with an advanced learning mechanism to solve this issue. In the method described above, a deep deterministic policy gradient (DDPG) is suggested to learn evolutionary parameters with grid-tied alternating weight vectors, which may improve transmission and distribution capacity and convergence ability [159]. According to simulation findings, the suggested optimization technique may achieve the least economic cost while simultaneously meeting voltage and frequency stability. This offers a workable and promising solution to the micro-grid dispatch issue [160]. Both real-time pricing and time-of-use techniques can be used with the concept. Demand response and economic energy storage dispatch are implemented in microgrids to improve resource self-coordination and self-balancing. The trade between a microgrid and external microgrids is organized by taking into account various transaction pricing and use rights, depending on whether there is still an imbalance between supply and demand after coordination inside a microgrid. The Lagrange multiplier approach and a co-evolution algorithm are used to solve and evaluate a variety of cases in three distinct schemes, proving the method’s accuracy and applicability in this study [159]. One of the crucial strategies to raise the effectiveness of renewable energy use is to optimize th micro-grid dispatch. This study uses the PSO technique to optimize a micro-grid system that includes PV, wind, diesel, and battery power. The optimization scheduling issue of the microgrid is solved using multi-objective PSO (MOPSO), which is constrained by the operating conditions and includes costs for fuel, operations, and pollutant gas emissions. The simulation results demonstrate that the model can support micro-grid dispatch optimization [161]. The network loss sensitivity is used to calculate the network loss to increase the accuracy of the normal network loss calculation. In order to verify the effectiveness of the proposed technique, a test model based on the IEEE 33 and 69 node distribution systems is constructed. The simulation outcomes show that the proposed method may produce an overall ideal result that is overall more cost-effective than the centralized calculation method. This technique is suitable for use afterwards in the actual power grid system [162]. This paper proposes a technique for the best rule-based management strategy training. This approach is directly applicable to the industrial controller of hybrid off-grid microgrids. Based on the anticipated operating circumstances, the parameters defining the control rules are best optimized using various evolutionary algorithms. Comparisons are made between the performance of the generated management heuristics and that of more traditional methods for scheduling optimization, such as Mixed Integer Linear Programming (MILP) optimization, direct evolutionary scheduling optimization, and conventional non-trained heuristics. The results demonstrate that trained heuristics outperform other approaches and provide a single-layer commitment and dispatch algorithm that is simple to implement in the microgrid controller. This performance is extremely near the global optimum discovered by the MILP solution [163]. A model predictive control integrated with the droop approach is created at the device level to enable load sharing and flexible power dispatching among the distributed energy resources, which is practical for both islanded and grid-connected modes. Additionally, a system-level evolutionary PSO algorithm is created to provide the ideal active and reactive power setpoints, which are then sent to the device level for operating inverters. Voltage deviations may be reduced and the operating costs of the microgrid can be kept to a minimum using the suggested power optimization strategy. The suggested power control and optimization strategy's viability and effectiveness are shown through in-depth case studies and a real-time simulator test [164]. It is suggested to use historical similarity to formulate the microgrid's regulation strategy in a new dispatching cycle using a method of matching the image similarity of the source-load-storage component of the microgrid based on CNN (Convolutional Neural Network) and ORB (Oriented FAST and Rotated BRIEF). The characteristics are then extracted using the ORB method, which then compares the picture similarity to the historical similarity. To reduce the size of the historical operational state picture library's searchable database and increase the matching effectiveness, the CNN model is initially utilized to label and categorize photos of microgrid source-load-storage integrated features [165]. This research considers the commissioning of three various electrochemical energy storage systems, including lead acid, lithium-ion, and vanadium redox flow battery systems, in order to satisfy the electricity requirements of a town in Australia. Different ratios of solar PV, wind turbines, and tiny gas turbines would be used in these systems. The non-dominated sorting genetic algorithm II approach is used to optimize each of these hybrids with the twin objectives of reducing energy prices ($/kWh) and life cycle emissions (kg CO_2-eq/kWh) while adhering to a pre-set reliability limitation, the likelihood of a power supply failure [166,167]. A summary for the present state-of-art of the research domain in dispatch strategy based microgrid design and optimization is summarized in Table 10. A summary for the present state-of-art of the research domain in a dispatch strategy based microgrid design and optimization is summarized in the following table.

Table 10. Dispatch strategy oriented research on hybrid microgrids.

Reference	Year	Contribution	Research Gap
C.D. Barley, C.B. Winn in [158]	1996	Proposed an idealized predictive dispatch strategy and compared dispatch strategies according to costs in, a quasi-state time series model.	A diesel generator has been used but no environmental impact (such as emissions) was considered.
M. Ashari, C. V. Nayar in [168]	1999	Using 'set points', optimum dispatch strategies have been proposed for a hybrid PV- diesel generator-battery system. A program has been developed for the control of the generator operation for overall cost minimization.	The system had low efficiency and the inverter used had a larger size. No environmental impact was considered in the study.
A. Nosrat, J.M. Pearce in [169]	2011	A new simulation method and dispatch strategy applicable for PV-combined cooling, heating, and a power system based (CCHP) hybrid system. The dispatch strategy has been named the PV-CCHP dispatch strategy. For developing the dispatch methodology, MATLAB coding platform has been utilized. Thus, a new simulation algorithm and dispatch strategy for modeling hybrid PC-CCHP systems is developed. A comparison with HOMER-provided results to the proposed technique is also presented, showing a negligible difference between them.	The implementation of the proposed system should cover more geographic locations considering various variable load profiles to validate its significance. Although a comparison with HOMER is shown, other established optimization techniques and various dispatch strategies should have been compared with the proposed work.
G. Li et al. in [170]	2017	An optimal dispatch strategy has been proposed for integrated hybrid energy systems utilizing wind power and CCHP. In this case, the optimization model has been designed to minimize the total operation cost. In addition, in this research work, the natural gas network and CCHP are mathematically modeled. According to case studies, the suggested approach may successfully cut costs in the PJM 5-bus power system with seven node gas system and the IEEE 118-bus power system with a Belgian natural gas network.	To validate the proposed strategy's performance, a comparison between the proposed method and other established methods could have been studied.

Table 10. *Cont.*

Reference	Year	Contribution	Research Gap
Toopshekan et al. in [171]	2020	A PV/wind/diesel/battery-based on-grid microgrid performance has been evaluated by using MATLAB coding for load following and cycle charging dispatch strategies. The proposed strategy also performs better than HOMER's pre-defined Load-following and Cycle Charging strategies. In addition, sensitivity analysis is presented in the study considering various sensitive parameters.	Off-grid or islanded mode operation of the proposed microgrid with the proposed dispatch control could have been studied. In addition, other dispatch strategies, such as HOMER predictive strategy, Combined Dispatch strategy, and Generator Order dispatch strategy, could have been taken into consideration.
Ishraque et al. in [154]	2021	An integrated hybrid microgrid system was proposed, considering five default dispatch strategies offered by HOMER. Load Following, Cycle Charging, Combined Dispatch, HOMER predictive dispatch, and Generator Order dispatch strategies have been taken into consideration. The best and worst strategies for a certain location (considered for four divisional areas in Bangladesh) have been determined by comparing the dispatch strategies' performances.	The consideration of a multiyear analysis or sensitivity analysis would enrich the study. The study could be taken to a further level if grid-connected microgrids had been considered.
Fatin et al. in [98]	2021	A techno-economic and power system response (voltage, frequency) based assessment of the designed microgrid (off-grid) on top of dispatch strategy-based control has been discussed. HOMER has been utilized for designing the microgrid and MATLAB/Simulink has been utilized for the power system response assessment. The best and the worst strategies for the proposed test sites have been found in the study according to their performances, showing a relative comparison between the strategies as well as with the work of other researchers.	Only HOMER optimizer has been utilized in the work. Although the HOMER optimizer is a well-accepted optimizer, a comparison with other techniques such as PSO or some other intelligent approaches such as ANN, etc., would enrich the contribution of this study.
Ishraque et al. [172]	2021	A load following dispatch strategy-based upgradation of a previous microgrid design by different researchers utilizing HOMER optimizer for the same location has been shown. A significant amount of reduction is obtained in terms of different costs and harmful gas emissions than in the previous study.	Sensitivity analysis, multiyear analysis, grid performance, etc., were not considered in the study. In addition, the integration of biomass-based energy production would greatly impact the research domain.
Shezan et al. in [173]	2022	The optimized design and performance evaluation based on optimal sizing, system costing, and power system performances and a reliability study of a free-standing microgrid using four dispatch controls is presented in the study. As the simulation platform, HOMER Pro and DIgSILENT PowerFactory, were used. Three-phase short circuit fault has been implemented and analyzed according to different dispatch strategies.	Grid-connected mode analysis has been skipped in the research work. In addition, the impact of sensitive parameters has not been evaluated. A demonstration of the proposed design on basis of multiyear performances would be appreciated.
Aziz et al. in [174]	2022	An improved and new dispatch strategy has been proposed by using MATLAB and HOMER, which offers a 12-h foresight on the load demand and solar irradiation (improved cycle charging strategy). In addition, a comparison of the newly proposed algorithm and default Cycle Charging strategy is shown to demonstrate a better performance of the new strategy. The proposed algorithm offers better battery management (charging/discharging cycle) as the future irradiation profile is already predicted.	An off-grid Diesel-PV-Battery hybrid system has been investigated in this study. A grid-connected microgrid could also have been taken into consideration. The upgrade to other default dispatch strategies such as load following or generator order strategies available in HOMER could be a new research topic.

Table 10. *Cont.*

Reference	Year	Contribution	Research Gap
Laetitia et al. in [175]	2022	A new dispatch strategy utilizing a Matlab control link file compatible with HOMER Pro offers better performance than Cycle Charging and Load Following strategies, which are two default strategies available in HOMER. Fuel cells have been considered to offer maximum usage compared to any other components in the proposed microgrid.	A PV/battery/fuel cell hybrid system was considered. A system considering more renewable sources could have been integrated to overcome the intermittency issue of renewable sources. A grid-connected microgrid could also have been analyzed considering the other default dispatch methodologies.

7. Conclusions and Future Scope

Because of the expansion of human society, the electrical load demand, use, and acceptability of wind-solar IHMS has grown in recent decades, in order to ensure an uninterrupted power supply for the advancement of the civilized world as well as to confirm system stability and economic and environmental feasibility of the IHMS and HRES. Several operational and quality challenges have arisen as a result of recent breakthroughs in the realm of wind-solar IHMS. Some technical, economic, and environmental issues have already been pointed out and reported to resolve the upcoming environmental pollution due to the current power production procedure and energy shortage. There are a significant number of drawbacks in the field of optimization techniques and proper control strategies to create an energy management system with adequate system stability and system reliability, and that is also cost-effective and environment friendly. The summary of the evolution of renewable energy resources, the problem statement, and potential solutions, followed by the optimization control techniques for the IHMS and HRES, and finally the relationship between the optimization techniques and control strategies, are the main contributions of this manuscript.

There is a requirement to assist various types of solar radiation and wind speed measurement and predictions, such as the iterative approach, counterfeit consciousness method, and so on. These solutions do not speak to the precise dynamic implementation of a sun-oriented and wind-powered energy system. It will be necessary to develop a unit measurement system that avoids the multidimensional character of the framework's planning and clearly explains the framework's recurrent reaction as a result of altering the execution criteria in the future.

It will be necessary to develop an integrated and layered controlling approach that avoids the potential complexities of the correspondence architecture as well as the large computation load that will be subjected to a single side of the point of failure. Nonetheless, the voltage fluctuation problem caused by variable average wind speed and solar radiation has been overcome in a realistic and viable manner. An alternative energy storage system may be implemented to overcome this problem with the right control technique.

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References

1. Khare, V.; Nema, S.; Baredar, P. Solar–wind hybrid renewable energy system: A review. *Renew. Sustain. Energy Rev.* **2016**, *58*, 23–33. [CrossRef]
2. Chauhan, A.; Saini, R. A review on Integrated Renewable Energy System based power generation for stand-alone applications: Configurations, storage options, sizing methodologies and control. *Renew. Sustain. Energy Rev.* **2014**, *38*, 99–120. [CrossRef]
3. Ishaq, S.; Khan, I.; Rahman, S.; Hussain, T.; Iqbal, A.; Elavarasan, R.M. A review on recent developments in control and optimization of micro grids. *Energy Rep.* **2022**, *8*, 4085–4103. [CrossRef]
4. Vadi, S.; Padmanaban, S.; Bayindir, R.; Blaabjerg, F.; Mihet-Popa, L. A review on optimization and control methods used to provide transient stability in microgrids. *Energies* **2019**, *12*, 3582. [CrossRef]
5. Al-Falahi, M.D.; Jayasinghe, S.; Enshaei, H. A review on recent size optimization methodologies for standalone solar and wind hybrid renewable energy system. *Energy Convers. Manag.* **2017**, *143*, 252–274. [CrossRef]
6. Sinha, S.; Chandel, S. Review of software tools for hybrid renewable energy systems. *Renew. Sustain. Energy Rev.* **2014**, *32*, 192–205. [CrossRef]
7. Wang, G.; Konstantinou, G.; Townsend, C.D.; Pou, J.; Vazquez, S.; Demetriades, G.D.; Agelidis, V.G. A review of power electronics for grid connection of utility-scale battery energy storage systems. *IEEE Trans. Sustain. Energy* **2016**, *7*, 1778–1790. [CrossRef]
8. Ma, T.; Yang, H.; Lu, L. A feasibility study of a stand-alone hybrid solar–wind–battery system for a remote island. *Appl. Energy* **2014**, *121*, 149–158. [CrossRef]
9. Hossen, M.D.; Islam, M.F.; Ishraque, M.F.; Shezan, S.A.; Arifuzzaman, S. Design and Implementation of a Hybrid Solar-Wind-Biomass Renewable Energy System considering Meteorological Conditions with the Power System Performances. *Int. J. Photoenergy* **2022**, *2022*, 8792732. [CrossRef]
10. Shezan, S.A.; Ishraque, M.F.; Paul, L.C.; Sarkar, M.R.; Rana, M.M.; Uddin, M.; Hossain, M.B.; Shobug, M.A.; Hossain, M.I. Assortment of dispatch strategies with the optimization of an islanded hybrid microgrid. *MIST Int. J. Sci. Technol.* **2022**, *10*, 15–24. [CrossRef]
11. Al Busaidi, A.S.; Kazem, H.A.; Al-Badi, A.H.; Khan, M.F. A review of optimum sizing of hybrid PV–Wind renewable energy systems in oman. *Renew. Sustain. Energy Rev.* **2016**, *53*, 185–193. [CrossRef]
12. Sinha, S.; Chandel, S. Review of recent trends in optimization techniques for solar photovoltaic–wind based hybrid energy systems. *Renew. Sustain. Energy Rev.* **2015**, *50*, 755–769. [CrossRef]
13. Wagh, S.; Walke, P. Review on wind-solar hybrid power system. *Int. J. Res. Sci. Eng.* **2017**, *3*, 71–76.
14. Aghamohammadi, M.R.; Abdolahinia, H. A new approach for optimal sizing of battery energy storage system for primary frequency control of islanded microgrid. *Int. J. Electr. Power Energy Syst.* **2014**, *54*, 325–333. [CrossRef]
15. Alhasnawi, B.N.; Jasim, B.H. A Novel Hierarchical Energy Management System Based on Optimization for Multi-Microgrid. *Int. J. Electr. Eng. Inform.* **2020**, *12*, 3. [CrossRef]
16. Fathima, A.H.; Palanisamy, K. Optimization in microgrids with hybrid energy systems—A review. *Renew. Sustain. Energy Rev.* **2015**, *45*, 431–446. [CrossRef]
17. Liu, W.; Zhuang, P.; Liang, H.; Peng, J.; Huang, Z. Distributed economic dispatch in microgrids based on cooperative reinforcement learning. *IEEE Trans. Neural Netw. Learn. Syst.* **2018**, *29*, 2192–2203. [CrossRef]
18. Liu, G.; Jiang, T.; Ollis, T.B.; Zhang, X.; Tomsovic, K. Distributed energy management for community microgrids considering network operational constraints and building thermal dynamics. *Appl. Energy* **2019**, *239*, 83–95. [CrossRef]
19. Ye, L.; Zhang, C.; Tang, Y.; Zhong, W.; Zhao, Y.; Lu, P.; Zhai, B.; Lan, H.; Li, Z. Hierarchical model predictive control strategy based on dynamic active power dispatch for wind power cluster integration. *IEEE Trans. Power Syst.* **2019**, *34*, 4617–4629. [CrossRef]
20. Wen, Y.; Chung, C.; Liu, X.; Che, L. Microgrid dispatch with frequency-aware islanding constraints. *IEEE Trans. Power Syst.* **2019**, *34*, 2465–2468. [CrossRef]
21. Ma, Y.; Chen, Y.; Chen, X.; Deng, F.; Song, X. Optimal dispatch of hybrid energy islanded microgrid considering V2G under TOU tariffs. In *Proceedings of the E3S Web of Conferences*; EDP Sciences: Les Ulis, France, 2019; Volume 107, p. 02007.
22. Dou, C.; An, X.; Yue, D.; Li, F. Two-level decentralized optimization power dispatch control strategies for an islanded microgrid without communication network. *Int. Trans. Electr. Energy Syst.* **2017**, *27*, e2244. [CrossRef]
23. Abdullah, M.A.; Muttaqi, K.M.; Sutanto, D.; Agalgaonkar, A.P. An effective power dispatch control strategy to improve generation schedulability and supply reliability of a wind farm using a battery energy storage system. *IEEE Trans. Sustain. Energy* **2014**, *6*, 1093–1102. [CrossRef]
24. Zhao, B.; Xue, M.; Zhang, X.; Wang, C.; Zhao, J. An MAS based energy management system for a stand-alone microgrid at high altitude. *Appl. Energy* **2015**, *143*, 251–261. [CrossRef]
25. Qadrdan, M.; Wu, J.; Jenkins, N.; Ekanayake, J. Operating strategies for a GB integrated gas and electricity network considering the uncertainty in wind power forecasts. *IEEE Trans. Sustain. Energy* **2013**, *5*, 128–138. [CrossRef]

26. Zhang, Y.; Gatsis, N.; Giannakis, G.B. Robust energy management for microgrids with high-penetration renewables. *IEEE Trans. Sustain. Energy* **2013**, *4*, 944–953. [CrossRef]
27. Vergara, P.P.; Rey, J.M.; Shaker, H.R.; Guerrero, J.M.; Jørgensen, B.N.; Da Silva, L.C. Distributed strategy for optimal dispatch of unbalanced three-phase islanded microgrids. *IEEE Trans. Smart Grid* **2018**, *10*, 3210–3225. [CrossRef]
28. Qu, B.Y.; Zhu, Y.; Jiao, Y.; Wu, M.; Suganthan, P.N.; Liang, J.J. A survey on multi-objective evolutionary algorithms for the solution of the environmental/economic dispatch problems. *Swarm Evol. Comput.n* **2018**, *38*, 1–11. [CrossRef]
29. Bogdanov, D.; Ram, M.; Aghahosseini, A.; Gulagi, A.; Oyewo, A.S.; Child, M.; Caldera, U.; Sadovskaia, K.; Farfan, J.; Barbosa, L.D.S.N.S.; et al. Low-cost renewable electricity as the key driver of the global energy transition towards sustainability. *Energy* **2021**, *227*, 120467. [CrossRef]
30. Hoang, A.T.; Nižetić, S.; Olcer, A.I.; Ong, H.C.; Chen, W.H.; Chong, C.T.; Thomas, S.; Bandh, S.A.; Nguyen, X.P. Impacts of COVID-19 pandemic on the global energy system and the shift progress to renewable energy: Opportunities, challenges, and policy implications. *Energy Policy* **2021**, *154*, 112322. [CrossRef]
31. Arias, I.; Cardemil, J.; Zarza, E.; Valenzuela, L.; Escobar, R. Latest developments, assessments and research trends for next generation of concentrated solar power plants using liquid heat transfer fluids. *Renew. Sustain. Energy Rev.* **2022**, *168*, 112844. [CrossRef]
32. Lin, N.; Gong, Y.; Wang, R.; Wang, Y.; Zhang, X. Critical review of perovskite-based materials in advanced oxidation system for wastewater treatment: Design, applications and mechanisms. *J. Hazard. Mater.* **2022**, *424*, 127637. [CrossRef] [PubMed]
33. Yang, J.; Lim, E.L.; Tan, L.; Wei, Z. Ink Engineering in Blade-Coating Large-Area Perovskite Solar Cells. *Adv. Energy Mater.* **2022**, *12*, 2200975. [CrossRef]
34. Tariq, R.; Torres-Aguilar, C.; Xamán, J.; Zavala-Guillén, I.; Bassam, A.; Ricalde, L.J.; Carvente, O. Digital twin models for optimization and global projection of building-integrated solar chimney. *Build. Environ.* **2022**, *213*, 108807. [CrossRef]
35. Ibrahim, M.; Alsheikh, A.; Awaysheh, F.M.; Alshehri, M.D. Machine learning schemes for anomaly detection in solar power plants. *Energies* **2022**, *15*, 1082. [CrossRef]
36. Ren, Z.; Wu, L.; Pang, Y.; Zhang, W.; Yang, R. Strategies for effectively harvesting wind energy based on triboelectric nanogenerators. *Nano Energy* **2022**, *100*, 107522. [CrossRef]
37. Maienza, C.; Avossa, A.M.; Picozzi, V.; Ricciardelli, F. Feasibility analysis for floating offshore wind energy. *Int. J. Life Cycle Assess.* **2022**, *27*, 796–812. [CrossRef]
38. Guo, Y.; Wang, H.; Lian, J. Review of integrated installation technologies for offshore wind turbines: Current progress and future development trends. *Energy Convers. Manag.* **2022**, *255*, 115319. [CrossRef]
39. Zhang, Z.; Liu, X.; Zhao, D.; Post, S.; Chen, J. Overview of the development and application of wind energy in New Zealand. *Energy Built Environ.* 2022, *in press*. [CrossRef]
40. Mousavi, Y.; Bevan, G.; Kucukdemiral, I.B.; Fekih, A. Sliding mode control of wind energy conversion systems: Trends and applications. *Renew. Sustain. Energy Rev.* **2022**, *167*, 112734. [CrossRef]
41. Kong, K.; Dyer, K.; Payne, C.; Hamerton, I.; Weaver, P.M. Progress and Trends in Damage Detection Methods, Maintenance, and Data-driven Monitoring of Wind Turbine Blades—A Review. *Renew. Energy Focus* 2022, *in press*. [CrossRef]
42. Huang, K.; Luo, P.; Liu, P.; Kim, J.S.; Wang, Y.; Xu, W.; Li, H.; Gong, Y. Improving complementarity of a hybrid renewable energy system to meet load demand by using hydropower regulation ability. *Energy* **2022**, *248*, 123535. [CrossRef]
43. Ercan, E.; Kentel, E. Optimum daily operation of a wind-hydro hybrid system. *J. Energy Storage* **2022**, *50*, 104540. [CrossRef]
44. Amjith, L.; Bavanish, B. A review on biomass and wind as renewable energy for sustainable environment. *Chemosphere* **2022**, *293*, 133579. [CrossRef] [PubMed]
45. Bui, V.G.; Bui, T.M.T.; Ong, H.C.; Nižetić, S.; Nguyen, T.T.X.; Atabani, A.; Štěpanec, L.; Hoang, A.T.; et al. Optimizing operation parameters of a spark-ignition engine fueled with biogas-hydrogen blend integrated into biomass-solar hybrid renewable energy system. *Energy* **2022**, *252*, 124052. [CrossRef]
46. Vieira, G.T.; Pereira, D.F.; Taheri, S.I.; Khan, K.S.; Salles, M.B.; Guerrero, J.M.; Carmo, B.S. Optimized Configuration of Diesel Engine-Fuel Cell-Battery Hybrid Power Systems in a Platform Supply Vessel to Reduce CO2 Emissions. *Energies* **2022**, *15*, 2184. [CrossRef]
47. Cheng, Y.; Dai, S.; Dai, S.; Ji, C.; Collu, M.; Yuan, Z.; Incecik, A. Energy conversion and hydrodynamic analysis of multi-degree-of-freedom wave energy converters integrated into a semi-submersible platform. *Energy Convers. Manag.* **2022**, *252*, 115075. [CrossRef]
48. Arul, P.; Ramachandaramurthy, V.K.; Rajkumar, R. Control strategies for a hybrid renewable energy system: A review. *Renew. Sustain. Energy Rev.* **2015**, *42*, 597–608. [CrossRef]
49. Bhandari, B.; Lee, K.T.; Lee, G.Y.; Cho, Y.M.; Ahn, S.H. Optimization of hybrid renewable energy power systems: A review. *Int. J. Precis. Eng. Manuf.-Green Technol.* **2015**, *2*, 99–112. [CrossRef]
50. Singh, P.; Pasha, J.; Moses, R.; Sobanjo, J.; Ozguven, E.E.; Dulebenets, M.A. Development of exact and heuristic optimization methods for safety improvement projects at level crossings under conflicting objectives. *Reliab. Eng. Syst. Saf.* **2022**, *220*, 108296. [CrossRef]
51. Abualigah, L.; Elaziz, M.A.; Khasawneh, A.M.; Alshinwan, M.; Ibrahim, R.A.; Al-qaness, M.A.; Mirjalili, S.; Sumari, P.; Gandomi, A.H. Meta-heuristic optimization algorithms for solving real-world mechanical engineering design problems: a comprehensive survey, applications, comparative analysis, and results. *Neural Comput. Appl.* **2022**, *34*, 4081–4110. [CrossRef]

52. Reddy, A.K.V.K.; Narayana, K.V.L. Meta-heuristics optimization in electric vehicles-an extensive review. *Renew. Sustain. Energy Rev.* **2022**, *160*, 112285. [CrossRef]
53. Maleki, A.; Pourfayaz, F. Optimal sizing of autonomous hybrid photovoltaic/wind/battery power system with LPSP technology by using evolutionary algorithms. *Sol. Energy* **2015**, *115*, 471–483. [CrossRef]
54. Zhou, Q.; Shahidehpour, M.; Li, Z.; Che, L.; Alabdulwahab, A.; Abusorrah, A. Compartmentalization strategy for the optimal economic operation of a hybrid ac/dc microgrid. *IEEE Trans. Power Syst.* **2019**, *35*, 1294–1304. [CrossRef]
55. Maleki, A.; Khajeh, M.G.; Rosen, M.A. Weather forecasting for optimization of a hybrid solar-wind–powered reverse osmosis water desalination system using a novel optimizer approach. *Energy* **2016**, *114*, 1120–1134. [CrossRef]
56. Zhou, T.; Sun, W. Optimization of battery–supercapacitor hybrid energy storage station in wind/solar generation system. *IEEE Trans. Sustain. Energy* **2014**, *5*, 408–415. [CrossRef]
57. Zhao, C.; He, J.; Cheng, P.; Chen, J. Analysis of consensus-based distributed economic dispatch under stealthy attacks. *IEEE Trans. Ind. Electron.* **2016**, *64*, 5107–5117. [CrossRef]
58. Wang, R.; Li, Q.; Li, G.; Liu, H. A gossip-based distributed algorithm for economic dispatch in smart grids with random communication link failures. *IEEE Trans. Ind. Electron.* **2019**, *67*, 4635–4645. [CrossRef]
59. Khare, V.; Nema, S.; Baredar, P. Optimisation of the hybrid renewable energy system by HOMER, PSO and CPSO for the study area. *Int. J. Sustain. Energy* **2017**, *36*, 326–343. [CrossRef]
60. Maleki, A.; Ameri, M.; Keynia, F. Scrutiny of multifarious particle swarm optimization for finding the optimal size of a PV/wind/battery hybrid system. *Renew. Energy* **2015**, *80*, 552–563. [CrossRef]
61. Athari, M.; Ardehali, M. Operational performance of energy storage as function of electricity prices for on-grid hybrid renewable energy system by optimized fuzzy logic controller. *Renew. Energy* **2016**, *85*, 890–902. [CrossRef]
62. Fetanat, A.; Khorasaninejad, E. Size optimization for hybrid photovoltaic–wind energy system using ant colony optimization for continuous domains based integer programming. *Appl. Soft Comput.* **2015**, *31*, 196–209. [CrossRef]
63. Ou, T.C.; Hong, C.M. Dynamic operation and control of microgrid hybrid power systems. *Energy* **2014**, *66*, 314–323. [CrossRef]
64. Belmili, H.; Haddadi, M.; Bacha, S.; Almi, M.F.; Bendib, B. Sizing stand-alone photovoltaic–wind hybrid system: Techno-economic analysis and optimization. *Renew. Sustain. Energy Rev.* **2014**, *30*, 821–832. [CrossRef]
65. Siddaiah, R.; Saini, R. A review on planning, configurations, modeling and optimization techniques of hybrid renewable energy systems for off grid applications. *Renew. Sustain. Energy Rev.* **2016**, *58*, 376–396. [CrossRef]
66. Nguyen, T.T.; Ngo, T.G.; Dao, T.K.; Nguyen, T.T.T. Microgrid Operations Planning Based on Improving the Flying Sparrow Search Algorithm. *Symmetry* **2022**, *14*, 168. [CrossRef]
67. TT Tran, Q.; Luisa Di Silvestre, M.; Riva Sanseverino, E.; Zizzo, G.; Pham, T.N. Driven primary regulation for minimum power losses operation in islanded microgrids. *Energies* **2018**, *11*, 2890. [CrossRef]
68. Islam, Q.N.U.; Ahmed, A.; Abdullah, S.M. Optimized controller design for islanded microgrid using non-dominated sorting whale optimization algorithm (NSWOA). *Ain Shams Eng. J.* **2021**, *12*, 3677–3689. [CrossRef]
69. Askarzadeh, A.; dos Santos Coelho, L. A novel framework for optimization of a grid independent hybrid renewable energy system: A case study of Iran. *Sol. Energy* **2015**, *112*, 383–396. [CrossRef]
70. Mirjalili, S. Genetic algorithm. In *Evolutionary Algorithms and Neural Networks*; Springer: Berlin/Heidelberg, Germany, 2019; pp. 43–55.
71. Katoch, S.; Chauhan, S.S.; Kumar, V. A review on genetic algorithm: past, present, and future. *Multimed. Tools Appl.* **2021**, *80*, 8091–8126. [CrossRef]
72. Kumar, M.; Husain, D.; Upreti, N.; Gupta, D. Genetic algorithm: Review and Application. 2010. Available online: https://ssrn.com/abstract=3529843 (accessed on 25 December 2022).
73. Marini, F.; Walczak, B. Particle Swarm Optimization (PSO). A Tutorial. *Chemom. Intell. Lab. Syst.* **2015**, *149*, 153–165. [CrossRef]
74. Lazinica, A. *Particle Swarm Optimization*; BoD–Books on Demand: Paris, France, 2009.
75. Bilal, B.O.; Sambou, V.; Ndiaye, P.; Kébé, C.; Ndongo, M. Optimal design of a hybrid solar–wind-battery system using the minimization of the annualized cost system and the minimization of the loss of power supply probability (LPSP). *Renew. Energy* **2010**, *35*, 2388–2390. [CrossRef]
76. Sarkar, T.; Bhattacharjee, A.; Samanta, H.; Bhattacharya, K.; Saha, H. Optimal design and implementation of solar PV-wind-biogas-VRFB storage integrated smart hybrid microgrid for ensuring zero loss of power supply probability. *Energy Convers. Manag.* **2019**, *191*, 102–118. [CrossRef]
77. Papadimitrakis, M.; Giamarelos, N.; Stogiannos, M.; Zois, E.; Livanos, N.I.; Alexandridis, A. Metaheuristic search in smart grid: A review with emphasis on planning, scheduling and power flow optimization applications. *Renew. Sustain. Energy Rev.* **2021**, *145*, 111072. [CrossRef]
78. Askarzadeh, A. A novel metaheuristic method for solving constrained engineering optimization problems: Crow search algorithm. *Comput. Struct.* **2016**, *169*, 1–12. [CrossRef]
79. Karaboga, D.; Gorkemli, B.; Ozturk, C.; Karaboga, N. A comprehensive survey: Artificial bee colony (ABC) algorithm and applications. *Artif. Intell. Rev.* **2014**, *42*, 21–57. [CrossRef]
80. Gao, W.; Liu, S.; Huang, L. A global best artificial bee colony algorithm for global optimization. *J. Comput. Appl. Math.* **2012**, *236*, 2741–2753. [CrossRef]
81. Blum, C. Ant colony optimization: Introduction and recent trends. *Phys. Life Rev.* **2005**, *2*, 353–373. [CrossRef]

82. Dorigo, M.; Stützle, T. Ant colony optimization: overview and recent advances. In *Handbook of Metaheuristics*; Springer: Berlin/Heidelberg, Germany, 2019; pp. 311–351.
83. Di Caprio, D.; Ebrahimnejad, A.; Alrezaamiri, H.; Santos-Arteaga, F.J. A novel ant colony algorithm for solving shortest path problems with fuzzy arc weights. *Alex. Eng. J.* **2022**, *61*, 3403–3415. [CrossRef]
84. Baghdadi, F.; Mohammedi, K.; Diaf, S.; Behar, O. Feasibility study and energy conversion analysis of stand-alone hybrid renewable energy system. *Energy Convers. Manag.* **2015**, *105*, 471–479. [CrossRef]
85. Zhou, W.; Lou, C.; Li, Z.; Lu, L.; Yang, H. Current status of research on optimum sizing of stand-alone hybrid solar–wind power generation systems. *Appl. Energy* **2010**, *87*, 380–389. [CrossRef]
86. Yang, H.; Zhou, W.; Lu, L.; Fang, Z. Optimal sizing method for stand-alone hybrid solar–wind system with LPSP technology by using genetic algorithm. *Sol. Energy* **2008**, *82*, 354–367. [CrossRef]
87. Nema, P.; Nema, R.; Rangnekar, S. A current and future state of art development of hybrid energy system using wind and PV-solar: A review. *Renew. Sustain. Energy Rev.* **2009**, *13*, 2096–2103. [CrossRef]
88. Yang, H.; Wei, Z.; Chengzhi, L. Optimal design and techno-economic analysis of a hybrid solar–wind power generation system. *Appl. Energy* **2009**, *86*, 163–169. [CrossRef]
89. Shezan, S.; Saidur, R.; Ullah, K.; Hossain, A.; Chong, W.T.; Julai, S. Feasibility analysis of a hybrid off-grid wind–DG-battery energy system for the eco-tourism remote areas. *Clean Technol. Environ. Policy* **2015**, *17*, 2417–2430. [CrossRef]
90. Shezan, S.; Al-Mamoon, A.; Ping, H. Performance investigation of an advanced hybrid renewable energy system in Indonesia. *Environ. Prog. Sustain. Energy* **2018**, *37*, 1424–1432. [CrossRef]
91. Celik, A.N. Optimisation and techno-economic analysis of autonomous photovoltaic–wind hybrid energy systems in comparison to single photovoltaic and wind systems. *Energy Convers. Manag.* **2002**, *43*, 2453–2468. [CrossRef]
92. Chong, W.; Naghavi, M.; Poh, S.; Mahlia, T.; Pan, K. Techno-economic analysis of a wind–solar hybrid renewable energy system with rainwater collection feature for urban high-rise application. *Appl. Energy* **2011**, *88*, 4067–4077. [CrossRef]
93. Al-Sharafi, A.; Sahin, A.Z.; Ayar, T.; Yilbas, B.S. Techno-economic analysis and optimization of solar and wind energy systems for power generation and hydrogen production in Saudi Arabia. *Renew. Sustain. Energy Rev.* **2017**, *69*, 33–49. [CrossRef]
94. Patel, A.M.; Singal, S.K. Economic analysis of integrated renewable energy system for electrification of remote rural area having scattered population. *Int. J. Renew. Energy Res.* **2018**, *8*, 258–265.
95. Maleki, A. Design and optimization of autonomous solar-wind-reverse osmosis desalination systems coupling battery and hydrogen energy storage by an improved bee algorithm. *Desalination* **2018**, *435*, 221–234. [CrossRef]
96. Kalinci, Y.; Dincer, I.; Hepbasli, A. Energy and exergy analyses of a hybrid hydrogen energy system: A case study for Bozcaada. *Int. J. Hydrog. Energy* **2017**, *42*, 2492–2503. [CrossRef]
97. Rana, M.M.; Rahman, A.; Uddin, M.; Sarkar, M.R.; Shezan, S.A.; Ishraque, M.F.; Rafin, S.S.H.; Atef, M. A Comparative Analysis of Peak Load Shaving Strategies for Isolated Microgrid Using Actual Data. *Energies* **2022**, *15*, 330. [CrossRef]
98. Ishraque, M.F.; Shezan, S.A.; Rashid, M.; Bhadra, A.B.; Hossain, M.A.; Chakrabortty, R.K.; Ryan, M.J.; Fahim, S.R.; Sarker, S.K.; Das, S.K. Techno-economic and power system optimization of a renewable rich islanded microgrid considering different dispatch strategies. *IEEE Access* **2021**, *9*, 77325–77340. [CrossRef]
99. Ishraque, M.F.; Shezan, S.A.; Nur, J.N.; Islam, M.S. Optimal sizing and assessment of an islanded photovoltaic-battery-diesel generator microgrid applicable to a remote school of Bangladesh. *Eng. Rep.* **2021**, *3*, e12281. [CrossRef]
100. Longe, O.M.; Ouahada, K.; Ferreira, H.C.; Chinnappen, S. Renewable Energy Sources microgrid design for rural area in South Africa. In Proceedings of the ISGT 2014, Washington, DC, USA, 19–22 February 2014.
101. Hasarmani, T.; Holmukhe, R.; Tamke, S. Performance analysis of grid interfaced photovoltaic systems for reliable agri-microgrids using PVsyst. In Proceedings of the 2019 International Conference on Information and Communications Technology (ICOIACT), Yogyakarta, Indonesia, 24–25 July 2019; pp. 894–898.
102. Ahirwar, P.; Kori, A.K.; Kapoor, S. Pre-Installation Analysis via "PVsyst" & "HOMER Pro" to Design & Simulate a 50kWp Solar Grid-Tied PV System for Rural Area Electrification, India. In Proceedings of the 2021 5th International Conference on Electrical, Electronics, Communication, Computer Technologies and Optimization Techniques (ICEECCOT), Mysuru, India, 11–12 December 2021; pp. 388–394.
103. Arefin, S.S. Optimization techniques of islanded hybrid microgrid system. In *Renewable Energy-Resources, Challenges and Applications*; IntechOpen: London, UK, 2020.
104. Ramli, M.A.; Bouchekara, H.; Alghamdi, A.S. Optimal sizing of PV/wind/diesel hybrid microgrid system using multi-objective self-adaptive differential evolution algorithm. *Renew. Energy* **2018**, *121*, 400–411. [CrossRef]
105. Jatzeck, B.; Robinson, A. WATSUN-PV 4.0 modifications to include wind turbine generator, AC load shedding, and operation with zero-capacity diesel generator. In Proceedings of the 1996 Canadian Conference on Electrical and Computer Engineering, Calgary, AB, Canada, 26–29 May 1996; Volume 2, pp. 655–658.
106. Sheriff, F.; Turcotte, D.; Ross, M. PVTOOLBOX: A Comprehensive Set of PV System Components for the Matlab/Simulink Environment. In Proceedings of the 2003 Conference of the Solar Energy Society of Canada Inc., Kingston, ON, Canada, 18–20 August 2003; Volume 20.
107. Best, S.R.; Rodiek, J.A.; Brandhorst, H.W. Comparison of solar modeling data to actual PV installations: Power predictions and optimal tilt angles. In Proceedings of the 2011 37th IEEE Photovoltaic Specialists Conference, Seattle, WA, USA, 19–24 June 2011; pp. 001994–001999.

108. Rodiek, J.; Best, S.; Still, C.; Brandhorst, H. Auburn University's Solar Photovoltaic Array Tilt Angle and Tracking Performance Experiment. In Proceedings of the 46th AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit, Nashville, TN, USA, 25–28 July 2010; p. 7098.
109. Pöchacker, M.; Khatib, T.; Elmenreich, W. The microgrid simulation tool RAPSim: Description and case study. In Proceedings of the 2014 IEEE Innovative Smart Grid Technologies-Asia (ISGT ASIA), Kuala Lumpur, Malaysia, 20–23 May 2014; pp. 278–283.
110. Jdeed, M.; Sharma, E.; Klemenjak, C.; Elmenreich, W. Smart grid modeling and simulation—Comparing GridLAB-D and RAPSim via two Case studies. In Proceedings of the 2018 IEEE International Energy Conference (ENERGYCON), Limassol, Cyprus, 3–7 June 2018.
111. Newbolt, T.M.; Mandal, P.; Wang, H. Implementation of Battery EVs and BESS into RAPSim Software to Enrich Power Engineering Education in DER-Integrated Distribution Systems. In Proceedings of the 2021 North American Power Symposium (NAPS), College Station, TX, USA, 14–16 November 2021.
112. Psomopoulos, C.S.; Ioannidis, G.C.; Kaminaris, S.D.; Mardikis, K.D.; Katsikas, N.G. A comparative evaluation of photovoltaic electricity production assessment software (PVGIS, PVWatts and RETScreen). *Environ. Process.* **2015**, *2*, 175–189. [CrossRef]
113. Moya, D.; Paredes, J.; Kaparaju, P. Technical, financial, economic and environmental pre-feasibility study of geothermal power plants by RETScreen–Ecuador's case study. *Renew. Sustain. Energy Rev.* **2018**, *92*, 628–637. [CrossRef]
114. Pan, Y.; Liu, L.; Zhu, T.; Zhang, T.; Zhang, J. Feasibility analysis on distributed energy system of Chongming County based on RETScreen software. *Energy* **2017**, *130*, 298–306. [CrossRef]
115. Khan, F.A.; Pal, N.; Saeed, S.H. Optimization and sizing of SPV/Wind hybrid renewable energy system: A techno-economic and social perspective. *Energy* **2021**, *233*, 121114. [CrossRef]
116. Kavadias, K.A.; Triantafyllou, P. Hybrid Renewable Energy Systems' Optimisation. A Review and Extended Comparison of the Most-Used Software Tools. *Energies* **2021**, *14*, 8268. [CrossRef]
117. Rezaei, M.; Dampage, U.; Das, B.K.; Nasif, O.; Borowski, P.F.; Mohamed, M.A. Investigating the impact of economic uncertainty on optimal sizing of grid-independent hybrid renewable energy systems. *Processes* **2021**, *9*, 1468. [CrossRef]
118. Das, B.K.; Hassan, R.; Tushar, M.S.H.; Zaman, F.; Hasan, M.; Das, P. Techno-economic and environmental assessment of a hybrid renewable energy system using multi-objective genetic algorithm: A case study for remote Island in Bangladesh. *Energy Convers. Manag.* **2021**, *230*, 113823. [CrossRef]
119. Krishna, K.M. Optimization analysis of microgrid using HOMER—A case study. In Proceedings of the 2011 Annual IEEE India Conference, Hyderabad, India, 16–18 December 2011.
120. Çetinbaş, İ.; Tamyürek, B.; Demirtaş, M. Design, analysis and optimization of a hybrid microgrid system using HOMER software: Eskisehir osmangazi university example. *Int. J. Renew. Energy Dev.-IJRED* **2019**, *8*. [CrossRef]
121. Montuori, L.; Alcázar-Ortega, M.; Álvarez-Bel, C.; Domijan, A. Integration of renewable energy in microgrids coordinated with demand response resources: Economic evaluation of a biomass gasification plant by Homer Simulator. *Appl. Energy* **2014**, *132*, 15–22. [CrossRef]
122. Sawle, Y.; Gupta, S.; Kumar Bohre, A. PV-wind hybrid system: A review with case study. *Cogent Eng.* **2016**, *3*, 1189305. [CrossRef]
123. Xu, X.; Mitra, J.; Wang, T.; Mu, L. Evaluation of operational reliability of a microgrid using a short-term outage model. *IEEE Trans. Power Syst.* **2014**, *29*, 2238–2247. [CrossRef]
124. Khare, V.; Nema, S.; Baredar, P. Reliability analysis of hybrid renewable energy system by fault tree analysis. *Energy Environ.* **2019**, *30*, 542–555. [CrossRef]
125. Mokoka, O.K.; Awodele, K.O. Reliability evaluation of distribution networks using NEPLAN & DIgSILENT power factory. In Proceedings of the 2013 Africon, Pointe aux Piments, Mauritius, 9–12 September 2013.
126. Nale, R.; Biswal, M.; Kishor, N. A Transient Component Based Approach for Islanding Detection in Distributed Generation. *IEEE Trans. Sustain. Energy* **2019**, *10*, 1129–1138. [CrossRef]
127. Petreus, D.; Etz, R.; Patarau, T.; Cirstea, M. An islanded microgrid energy management controller validated by using hardware-in-the-loop emulators. *Int. J. Electr. Power Energy Syst.* **2019**, *106*, 346–357. [CrossRef]
128. Abdelsamad, A.; Lubkeman, D. Reliability Analysis for a Hybrid Microgrid based on Chronological Monte Carlo Simulation with Markov Switching Modeling. In Proceedings of the 2019 IEEE Power & Energy Society Innovative Smart Grid Technologies Conference (ISGT), Washington, DC, USA, 18–21 February 2019; pp. 1–5. [CrossRef]
129. Abdulkarim, A.; Faruk, N.; Oloyede, A.O.; Olawoyin, L.A.; Akorede, M.F.; Madugu, I.S.; Abdelkader, S.; Morrow, J.; Adediran, Y.A.; et al. Reliability study of stand-alone hybrid renewable energy microgrids. *Iran. J. Sci. Technol. Trans. Electr. Eng.* **2019**, *43*, 411–425. [CrossRef]
130. Zhong, W.; Wang, L.; Liu, Z.; Hou, S. Reliability evaluation and improvement of islanded microgrid considering operation failures of power electronic equipment. *J. Mod. Power Syst. Clean Energy* **2019**, *8*, 111–123. [CrossRef]
131. Qi, X.L.; Zhang, S.C. Topological insulators and superconductors. *Reviews of Modern Physics* **2011**, *83*, 1057. [CrossRef]
132. Ren, Y.; Suganthan, P.; Srikanth, N. Ensemble methods for wind and solar power forecasting—A state-of-the-art review. *Renew. Sustain. Energy Rev.* **2015**, *50*, 82–91. [CrossRef]
133. Lei, M.; Shiyan, L.; Chuanwen, J.; Hongling, L.; Yan, Z. A review on the forecasting of wind speed and generated power. *Renew. Sustain. Energy Rev.* **2009**, *13*, 915–920. [CrossRef]
134. Jacobson, M.Z.; Delucchi, M.A.; Cameron, M.A.; Frew, B.A. Low-cost solution to the grid reliability problem with 100% penetration of intermittent wind, water, and solar for all purposes. *Proc. Natl. Acad. Sci. USA* **2015**, *112*, 15060–15065. [CrossRef]

135. Yang, Y.; Wang, H.; Sangwongwanich, A.; Blaabjerg, F. Design for reliability of power electronic systems. In *Power Electronics Handbook*; Elsevier: Amsterdam, The Netherlands, 2018; pp. 1423–1440.
136. Albarbar, A.; Teay, S.; Batunlu, C. Smart sensing system for enhancing the reliability of power electronic devices used in wind turbines. *Int. J. Smart Sens. Intell. Syst.* **2017**, *10*, 407–424.
137. Olatomiwa, L.; Mekhilef, S.; Ismail, M.S.; Moghavvemi, M. Energy management strategies in hybrid renewable energy systems: A review. *Renew. Sustain. Energy Rev.* **2016**, *62*, 821–835. [CrossRef]
138. Bhandari, B.; Poudel, S.R.; Lee, K.T.; Ahn, S.H. Mathematical modeling of hybrid renewable energy system: A review on small hydro-solar-wind power generation. *Int. J. Precis. Eng. Manuf.-Green Technol.* **2014**, *1*, 157–173. [CrossRef]
139. Wang, X.; Palazoglu, A.; El-Farra, N.H. Operational optimization and demand response of hybrid renewable energy systems. *Appl. Energy* **2015**, *143*, 324–335. [CrossRef]
140. Krishna, K.S.; Kumar, K.S. A review on hybrid renewable energy systems. *Renew. Sustain. Energy Rev.* **2015**, *52*, 907–916. [CrossRef]
141. Zhao, H.; Wu, Q.; Hu, S.; Xu, H.; Rasmussen, C.N. Review of energy storage system for wind power integration support. *Appl. Energy* **2015**, *137*, 545–553. [CrossRef]
142. Mahesh, A.; Sandhu, K.S. Hybrid wind/photovoltaic energy system developments: Critical review and findings. *Renew. Sustain. Energy Rev.* **2015**, *52*, 1135–1147. [CrossRef]
143. Nehrir, M.; Wang, C.; Strunz, K.; Aki, H.; Ramakumar, R.; Bing, J.; Miao, Z.; Salameh, Z. A review of hybrid renewable/alternative energy systems for electric power generation: Configurations, control, and applications. *IEEE Trans. Sustain. Energy* **2011**, *2*, 392–403. [CrossRef]
144. Zhou, B.; Li, W.; Chan, K.W.; Cao, Y.; Kuang, Y.; Liu, X.; Wang, X. Smart home energy management systems: Concept, configurations, and scheduling strategies. *Renew. Sustain. Energy Rev.* **2016**, *61*, 30–40. [CrossRef]
145. Merabet, A.; Ahmed, K.T.; Ibrahim, H.; Beguenane, R.; Ghias, A.M. Energy management and control system for laboratory scale microgrid based wind-PV-battery. *IEEE Trans. Sustain. Energy* **2016**, *8*, 145–154. [CrossRef]
146. Dufo-Lopez, R.; Cristobal-Monreal, I.R.; Yusta, J.M. Stochastic-heuristic methodology for the optimisation of components and control variables of PV-wind-diesel-battery stand-alone systems. *Renew. Energy* **2016**, *99*, 919–935. [CrossRef]
147. Kumar, K.; Babu, N.R.; Prabhu, K. Design and analysis of an integrated Cuk-SEPIC converter with MPPT for standalone wind/PV hybrid system. *Int. J. Renew. Energy Res. (IJRER)* **2017**, *7*, 96–106.
148. Li, J.; Xiong, R.; Yang, Q.; Liang, F.; Zhang, M.; Yuan, W. Design/test of a hybrid energy storage system for primary frequency control using a dynamic droop method in an isolated microgrid power system. *Appl. Energy* **2017**, *201*, 257–269. [CrossRef]
149. Li, J.; Yang, Q.; Robinson, F.; Liang, F.; Zhang, M.; Yuan, W. Design and test of a new droop control algorithm for a SMES/battery hybrid energy storage system. *Energy* **2017**, *118*, 1110–1122. [CrossRef]
150. Powell, K.M.; Rashid, K.; Ellingwood, K.; Tuttle, J.; Iverson, B.D. Hybrid concentrated solar thermal power systems: A review. *Renew. Sustain. Energy Rev.* **2017**, *80*, 215–237. [CrossRef]
151. Ciocan, A.; Balan, M.; Pislaru, M.; Rizoiu, A.; Constantin, A. A hybrid energy storage system and control strategy for stand-alone applications using renewable energy sources. *Smart Energy Sustain. Environ.* **2017**, *20*, 79.
152. Derrouazin, A.; Aillerie, M.; Mekkakia-Maaza, N.; Charles, J.P. Multi input-output fuzzy logic smart controller for a residential hybrid solar-wind-storage energy system. *Energy Convers. Manag.* **2017**, *148*, 238–250. [CrossRef]
153. Trifkovic, M.; Marvin, W.A.; Daoutidis, P.; Sheikhzadeh, M. Dynamic real-time optimization and control of a hybrid energy system. *AIChE J.* **2014**, *60*, 2546–2556. [CrossRef]
154. Ishraque, M.F.; Shezan, S.A.; Ali, M.; Rashid, M. Optimization of load dispatch strategies for an islanded microgrid connected with renewable energy sources. *Appl. Energy* **2021**, *292*, 116879. [CrossRef]
155. Shezan, S.A.; Hasan, K.N.; Rahman, A.; Datta, M.; Datta, U. Selection of appropriate dispatch strategies for effective planning and operation of a microgrid. *Energies* **2021**, *14*, 7217. [CrossRef]
156. Koti Reddy, B.; Singh, A.K. Optimal Operation of a Photovoltaic Integrated Captive Cogeneration Plant with a Utility Grid Using Optimization and Machine Learning Prediction Methods. *Energies* **2021**, *14*, 4935. [CrossRef]
157. Ishraque, M.F.; Shezan, S.A.; Rana, M.S.; Muyeen, S.; Rahman, A.; Paul, L.C.; Islam, M.S. Optimal sizing and assessment of a renewable rich standalone hybrid microgrid considering conventional dispatch methodologies. *Sustainability* **2021**, *13*, 12734. [CrossRef]
158. Barley, C.D.; Winn, C.B. Optimal dispatch strategy in remote hybrid power systems. *Sol. Energy* **1996**, *58*, 165–179. [CrossRef]
159. Gao, Y.; Ai, Q. Demand-side response strategy of multi-microgrids based on an improved co-evolution algorithm. *CSEE J. Power Energy Syst.* **2021**, *7*, 903–910.
160. Zhang, H.; Yue, D.; Dou, C.; Hancke, G. PBI based multi-objective optimization via deep reinforcement elite learning strategy for micro-grid dispatch with frequency dynamics. *IEEE Trans. Power Syst.* **2022**, *38*, 488–498. [CrossRef]
161. Wang, N.; Li, H.; Zhang, Q.; Shi, L.; Geng, X. Research on optimal Dispatching Strategy of micro-grid based on Particle Swarm optimization algorithm. In Proceedings of the IOP Conference Series: Earth and Environmental Science, Jakarta, Indonesia, 25–26 September 2021; Volume 647, p. 012046.
162. Li, X.; Zeng, Y.; Lu, Z. Decomposition and coordination calculation of economic dispatch for active distribution network with multi-microgrids. *Int. J. Electr. Power Energy Syst.* **2022**, *135*, 107617. [CrossRef]

163. Moretti, L.; Meraldi, L.; Niccolai, A.; Manzolini, G.; Leva, S. An innovative tunable rule-based strategy for the predictive management of hybrid microgrids. *Electronics* **2021**, *10*, 1162. [CrossRef]
164. Shan, Y.; Hu, J.; Liu, H. A holistic power management strategy of microgrids based on model predictive control and particle swarm optimization. *IEEE Trans. Ind. Inform.* **2021**, *18*, 5115–5126. [CrossRef]
165. Wu, N.; Wu, X.; Chen, W.; Guo, M.; Hou, D. Development of Renewable Energy Consumption Strategies for Microgrids Based on CNN and ORB Image Matching Methods. In Proceedings of the 2021 IEEE Sustainable Power and Energy Conference (iSPEC), Nanjing, China, 23–25 December 2021; pp. 3792–3797.
166. Das, B.K.; Hassan, R.; Islam, M.S.; Rezaei, M. Influence of energy management strategies and storage devices on the techno-enviro-economic optimization of hybrid energy systems: A case study in Western Australia. *J. Energy Storage* **2022**, *51*, 104239. [CrossRef]
167. Dey, B.; Raj, S.; Mahapatra, S.; Márquez, F.P.G. Optimal scheduling of distributed energy resources in microgrid systems based on electricity market pricing strategies by a novel hybrid optimization technique. *Int. J. Electr. Power Energy Syst.* **2022**, *134*, 107419. [CrossRef]
168. Ashari, M.; Nayar, C. An optimum dispatch strategy using set points for a photovoltaic (PV)–diesel–battery hybrid power system. *Sol. Energy* **1999**, *66*, 1–9. [CrossRef]
169. Nosrat, A.; Pearce, J.M. Dispatch strategy and model for hybrid photovoltaic and trigeneration power systems. *Appl. Energy* **2011**, *88*, 3270–3276. [CrossRef]
170. Li, G.; Zhang, R.; Jiang, T.; Chen, H.; Bai, L.; Cui, H.; Li, X. Optimal dispatch strategy for integrated energy systems with CCHP and wind power. *Appl. Energy* **2017**, *192*, 408–419. [CrossRef]
171. Toopshekan, A.; Yousefi, H.; Astaraei, F.R. Technical, economic, and performance analysis of a hybrid energy system using a novel dispatch strategy. *Energy* **2020**, *213*, 118850. [CrossRef]
172. Ishraque, M.F.; Hussain, M.S.; Rana, M.S.; Roni, M.H.K.; Shezan, S.A. Design and Assessment of a Standalone Hybrid Mode Microgrid for the Rohingya Refugees Using Load Following Dispatch Strategy. In Proceedings of the 2021 6th International Conference on Development in Renewable Energy Technology (ICDRET), Dhaka, Bangladesh, 28–30 December 2021.
173. Shezan, S.A.; Ishraque, M.F.; Muyeen, S.; Arifuzzaman, S.; Paul, L.C.; Das, S.K.; Sarker, S.K. Effective dispatch strategies assortment according to the effect of the operation for an islanded hybrid microgrid. *Energy Convers. Manag. X* **2022**, *14*, 100192. [CrossRef]
174. Aziz, A.S.; Tajuddin, M.F.N.; Zidane, T.E.K.; Su, C.L.; Alrubaie, A.J.K.; Alwazzan, M.J. Techno-economic and environmental evaluation of PV/diesel/battery hybrid energy system using improved dispatch strategy. *Energy Rep.* **2022**, *8*, 6794–6814. [CrossRef]
175. Uwineza, L.; Kim, H.G.; Kleissl, J.; Kim, C.K. Technical Control and Optimal Dispatch Strategy for a Hybrid Energy System. *Energies* **2022**, *15*, 2744. [CrossRef]