Study of Methodology Based on Optimization of Hybrid System

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Abstract: Renewable energy systems are projected to become prevalent in the future owing to severe environmental repercussions and escalation in energy prices related with the usage of current energy sources. Solar and wind energy resources are alternative to each other which will have the genuine capacity to meet the load challenge to some degree. However, such solutions every time examined separately are not totally trustworthy because of their influence of unstable nature. In this regard, autonomous photovoltaic and wind hybrid energy systems have been discovered to be more economically feasible option to supply the energy needs of multiple isolated users globally. This article explores the general understanding of hybrid system along with various methodology based on hybrid system.

Keywords- Hybrid PV, Wind, Renewable energy

I. Introduction

There are places where renewable energy resources like solar and wind may provide a viable alternative to conventional power production that is both environmentally and economically sustainable. PV-wind hybrid power producing systems may improve the economic and environmental viability of renewable energy systems by satisfying the energy demand. There has been an increase in interest in studying alternative energy sources including solar photovoltaics, biomass, wind, and micro-hydro for various uses due to public concern about global warming as a result of greenhouse gas emissions caused by fossil fuel-based energy supplies. The global photovoltaic (PV) market has now reached a total of 27.4 GW of installations. Individually, renewable resources like solar and wind energy are less dependable. When solar and wind resources are integrated for power production, they complement each other via daily and seasonal changes. The reliability of the system might be improved by combining these two renewable energy sources, and the system costs could be reduced depending on the area circumstances. The physical features of nonlinear components, on the other hand, make energy system sizing and operation control tactics more difficult.

Sizing and optimising photovoltaic-wind hybrid power systems may be very difficult since the renewable energy resources and storage components must be tailored to the specific demand profile and predicted ease of use of solar radiation and wind speed. Many PV-wind hybrid systems are one-of-a-kind, but evaluating a hybrid system in its entirety takes a long time and costs a lot of money. Even if the time and money are available for dynamic testing, it is impossible to test all the scenarios that may be encountered over the hybrid system's life cycle. Because individual performance does not match projected simulated results, the user is left with a sense of ambiguity and confusion. It is quite difficult to concentrate on the performance of a PV-wind hybrid system without accurate high-level comparisons between actual objective performance and anticipated computer models. Accurately measuring the performance of hybrid power systems in particular locations must be an integral part of the investment process in hybrid power systems. Comparison of two hybrid power systems under certain circumstances and at one place may also be done using this method. As a result, software development and simulation tools are critical.

Several studies on the economic feasibility and technical availability of various PV-wind hybrid power system designs that meet certain reliability requirements for supplying electricity to the load have been conducted [4–11]. As the size of a PV-wind hybrid power system increases, so does the number of PV panels, wind turbines, battery cells, load profiles, and renewable resources. PV-wind hybrid power systems are often sized and simulated using deterministic and probabilistic approaches. Assumptions about time-series data, such as wind speed, solar radiation, ambient temperature, load profile and geographic location (such as latitude, longitude, and altitude), are made in the deterministic technique. Wind speed, solar radiation, ambient temperature, and load profile must be collected at least once a day for the whole year, at the very least. It's critical, too, that the data in the resources be organised according to time. The frequency of time-series resource data is determined by the time duration of the simulation phase. Resource data and load profile are presumed to be random variables in the probabilistic technique, and these variables may not be sequentially ordered. Power production and consumption stochastic models are combined in a probabilistic approach to create a hybrid system risk model for the whole system. Two approaches of scaling autonomous PV-wind hybrid power systems have been published by a group of researchers. The first one evaluates the performance of a hybrid system based on the annual average of monthly energy outputs from the hybrid system. To calculate the battery to load ratio, the second method uses the worst-case scenario.

II. Review of Literature

Paliwal et al. (2014), Reliability of renewable energy-based autonomous power systems may be maintained using battery storage. Studies on renewable energy source dependability are becoming important because of the intermittent nature of RES and the recent growth in their use. New probabilistic models for battery storage systems are proposed in this study in order to make it easier to execute the reliability analysis approach for battery-based systems including the analysis. Multiple battery state-of-charge (SOC) states are included in the proposed probabilistic battery state model, as are the probabilities associated with each of the states. Variable RES and their impact on storage systems are taken into consideration in the model. Studies on the dependability of a hypothetical self-sufficient PV-wind-storage system in Jaisalmer, Rajasthan, India, were conducted to illustrate the efficiency of the analytical approach presented. Comparisons with Monte Carlo Simulation (MCS) have been made so that we can prove that our method is better.

Bhattacharjee & Acharya (2015), Using renewable sources like solar and wind may reduce reliance on the grid. The goal of this article is to use hybrid technology in the Indian state of Tripura to maximise the state's wind and solar resources (low wind topography). Small-scale educational building use of the photovoltaic (PV) wind hybrid simulation model has been analysed in terms of both technology and economics. It also examines how a comparable plant performs in the real-world context of the place. The analysis found that most of the energy production is coming from the PV sector, which is expected to be promising for the whole year. It is still possible to create a significant quantity of wind power in half of the year, when average PV power generation is lower than in the other half. Figures from a simulator show that $0.488/kWh of power costs, while the renewable proportion in total electricity is 0.90. Maximum wind penetration is reported to be 32.75 percent based on plant performance.

Sanjari et al. (2019), Increasing the penetration of renewable energy (RE) resources into the power grid has operational issues because of their unpredictability and intermittency. Power produced by RE units must be precisely predicted for the system to operate reliably. There is a large proportion of renewable energy resources (RE) that are used to generate electricity. To achieve high prediction accuracy under a variety of weather situations, this research provides a forecast approach for solar and wind-generated electricity. The heat index (HI) is also considered as a helpful meteorological variable in order to reach the 15-minute ahead accurate expectation of PV/wind output power from the wind and PV. As a result, the PV and wind power forecasts may be accurately predicted with the finest possible precision. When compared to historical data from real PV and wind facilities, the findings of the proposed technique indicate great accuracy in PV and wind output power forecasts. In addition, the forecast model's performance with and without HI as an input variable is evaluated.

Kaabeche et al. (2010), This research proposes an optimum sizing model for hybrid PV/wind power generating systems that use a battery bank to optimise the capacity sizes of individual components. Hybrid systems, DPSP and Life Cycle Costs are all taken into consideration when recommending a model for a hybrid system (LCC). The grid-independent hybrid PV/wind power generating system size optimization may be achieved technically and economically according to the system dependability criteria using this integrated model.

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Xu et al. (2019), In addition to reducing carbon dioxide emissions, the development and use of renewable energy sources may open more areas of the globe to power. In isolated places where the grid has not yet been expanded, a stand-alone hybrid system based on renewable sources is a viable option for providing stable and uninterrupted electricity. Paper analyses a hybrid energy system in Xiaojin, Sichuan, China using PV, wind, hydropower, and pumped storage as case studies. By pumping water from the lower reservoir to the higher one, HSPSI may take use of the river's available flow and store excess wind and PV energy. In order to build a PV-wind-HSPSI hybrid energy system, investors often utilise the techno-economic index, which attempts to maximise power supply dependability and minimise investment costs. The Pareto optimality theory and Multi-Objective Particle Swarm Optimization are used to evaluate the trade-offs between the two goals (MOPSO). As a result of regulatory mandates, this research considers the wind and PV power curtailment rate (CR). With the least LCOE, Particle Swarm Optimization (PSO) performs better than the genetic algorithm (GA) and the Simulated Annealing technique (SA). The hypervolume indicator (HV) is produced using both MOPSO and the weighted sum technique (WSA) to determine the Pareto fronts.

Rekha et al. (2019), Alternative methods of power production, such as renewable energy, play a critical part in meeting the enormous demand for electricity from different utilities. Solar radiation and temperature are used in this work to develop a novel MPPT controller for a solar and wind-integrated grid. P&O's MPPT controller uses a simulation model to determine the maximum power. The MPPT controller's outputs are sent to a DC-DC boost converter and then to the inverter in order to increase the maximum power production from the PV and wind system.

Lamedica et al. (2018), The best size of a hybrid wind-photovoltaic power plant in an industrial region may be calculated using a mixed-integer linear programming (MILP) approach presented in this work. According to the proposed methodology, several factors are considered, including: i) load requirements and physical and geometric constraints for renewable plant installation; ii) operating and maintenance costs of both wind and PV power plants; and iv) electric energy that is absorbed by the public network.

A stochastic simulation method is used to account for the change in power demand associated with manufacturing cycles. Optimization is conducted for each month of the year in order to consider the seasonality of the power plant's demand and seasonality variations. Afterwards, we'll talk about an integrated economic analysis. Analysing a railway depot and repair facility in the Rome region, the technique was utilised. Finding the best solutions and saving money was made possible by combining the plant's demands with renewable energy's availability.

III. Various Methodology Based on Optimization of Hybrid System

Other approaches of hybrid energy system design search are provided in addition to the mythology discussed below.

AH method

PV-battery–diesel hybrid systems may be sized most easily using the AH approach. Sandie National Laboratory's PV design techniques manual explains this approach in depth (SANDIA, 1995). For a certain number of autonomous days (usually 3–7 days), the battery's storage capacity is measured by its ability to power the load without sunlight for a continuous period. For peak demand, a larger diesel generator is chosen. This approach ignores the interrelationship between the output of photovoltaic panels, the capacity of backup generators, and the amount of storage available. Oversized components and poor performance might easily come from selecting the value for autonomous days without using very precise data.

Trade-off method

In the context of multi-objective planning, the trade-off technique. Designing isolated systems using renewable energy sources is the planned usage of this concept. The first stage is to create a database that covers all potential combinations of PV plants, wind generators, and batteries, given ranges and steps of component sizes. Next, all conceivable futures are simulated, including variations in the wind speed of 1 m/s and the worldwide solar insolation of 10 percent. The author then develops a trade-off curve by graphing investment costs and LOL probability (LOLP) for all potential scenarios, removing alternatives with LOLP larger than 10%, and locating the knee-sets in the curve. The frequency with which discrete option values appear in the conditional decision set identifies robust strategies. This strategy produces a limited number of sturdy designs that are predicted to operate well under most of the anticipated circumstances. this method. The decision-makers are ultimately responsible for choosing the distinctive design.

Analytical method with LPSP technique

Using a closed-form solution technique, Abouzahr and Ramakumar give an assessment of the LPSP of a standalone PV system with energy storage and a stand-alone wind power conversion system, respectively (1990). The authors of this article, like those of Borowy and Salameh (1996), have defined the LPSP as the chance of a battery bank's SOC dropping below a particular minimal value. Instead of utilising long-term historical data, the probability density function of power input to the storage is integrated to calculate LPSP. In addition to the articles, numerous more use LOL probability to examine and estimate the dependability of a stand-alone PV system (LOLP).

Simulation approach

This technique uses the same principle as HOMER to construct a hybrid renewable energy system that includes PV, wind, and storage technologies. Before any further combinations may be identified, a simulation is run with a time step of one hour (albeit this is not always the case). Economic criteria are then used to identify an ideal combination from these possibilities. It is possible to estimate a system's dependability by dividing the total number of load unmet hours throughout a simulated period by this amount. Variations in wind and PV energy fractions from zero to one, as well as the battery to load (the number of days that the battery can provide the load when fully charged) at 1.25, 1.5, and 2.0 are used to run simulations (the ratio of the energy produced by renewable component to energy demand).

Linear programming method

To determine the optimal scale of renewable energy systems, a lot of studies employ this technique. Markvast provides a thorough breakdown of how the LP approach may be used to determine the optimal size of a PV–wind hybrid energy system's wind turbine and photovoltaic system (1997). Graphical representation is used to assess the best arrangement of two renewable energy producers to meet a user's year-round energy consumption. The absence of a battery bank and a diesel generator is an important distinction to note. Swift and Holder (1988) utilised the LP approach to design a PV–wind system while taking the dependability of the power supply system into consideration. Energy deficit to total energy demand is used to calculate a dependability index.

Non-linear programming method

This technique uses a fundamental methodology that takes into consideration the interdependency between system sizing and operating strategy. As a result, a renewable hybrid energy system's size and operation may be optimised at the same time.

Particle swarm optimization

Kennedy and Eberhart (1995) were the first to propose the particle swarm algorithm as a solution to non-linear optimization issues. This method was influenced by the way people behave in social situations. Using a swarm of p particles, where each particle represents a potential solution point in the design problem space D, we can see how this technique works. In an iterative process, each particle continually notes the best answer it has come up with thus far along its journey. As an illustration of how PSO may be used to determine the ideal size of hybrid energy systems.

IV. Conclusion and future Work

Renewable energy systems are expected to become more prominent in the future as a result of the severe environmental consequences of existing energy sources, as well as the rise in energy costs associated with the use of current energy sources. Solar and wind energy resources are complementary to one another and will each have the true potential to satisfy the load problem to a certain extent, if not entirely. However, due of the effect of unstable nature, such solutions, when analysed individually, are not completely dependable in all circumstances. In this respect, it has been revealed that autonomous photovoltaic and wind hybrid energy systems are a more economically realistic solution for meeting the energy demands of many isolated customers around the world. This article examines the broad knowledge of hybrid systems, as well as numerous methodologies that are based on hybrid systems discussed in this research.

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