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PRINCIPALLY ACCOMPLISHED TECHNICAL CONTRIBUTIONS IN WIND ELECTRIC GENERATORS (WEG)

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ABSTRACT

Natural processes constantly replenish the supply of what are known as alternative energy sources, but are properly referred to as renewable energy sources. Renewable energy sources include solar energy, wind energy, hydro power, bioenergy (biofuels produced sustainably), and other similar kinds of energy. Renewable energy sources include the sun, wind, water, waves, geothermal energy, and biomass. These resources have the capacity to be harnessed and used to create other valuable products. The majority of renewable energy sources are provided by the sun and the wind since they are both limitless resources. Either directly or indirectly, this may be accomplished. On the other hand, conventional energy sources like coal, oil, and natural gas provide the bulk of the world's energy needs. These fossil fuels are examples of energy sources that are not renewable. Even if these fuels seem to have an endless supply, there will come a moment when they are considered to have gone out. Also Unlike fossil fuels and nuclear fuels, which are fundamentally energy stocks, renewable energy sources are largely energy flows.

Keyword: Renewable energy, wind, hydro power

INTRODUCTION

Stated differently, wind energy is the process of producing power by harnessing the force of wind. The process of harvesting wind-borne kinetic energy results in the production of electricity. The Earth's spherical shape causes the atmosphere to warm unevenly over the globe due to incoming solar radiation. The equator is feeling more warming than the poles, where it is felt to a lesser extent. Wind is the result of the natural movement of air from warmer to colder places, and windmills and wind turbines harness these air movements to produce power for us. The idea of harnessing wind power is not new; traditional windmills have been used for generations to mill grain, pump water, and even propel sailing ships.

The advent of more advanced and efficient methods has made it possible to collect wind energy on a larger scale. Taking Advantage of Wind Power The most crucial piece of machinery for transforming wind energy into forms that may be used is the wind turbine. Although these turbines come in an overwhelming variety of shapes and sizes, they may be divided into two main groups: In one type of wind turbine, the rotor revolves around an axis that is approximately perpendicular to the ground and the direction of the wind; in another type, the rotor revolves around an axis that is approximately parallel to the ground and the direction of the wind.

WIND ELECTRIC GENERATORS (WEG)

The parts of a wind electric generator are a rotor, gear box, and generator; these parts work together to capture wind energy and convert it into electrical power. India has a large number of wind energy producing plants. These factories work along with their counterparts in other nations, including the United States, Austria, Sweden, Spain, Denmark, Germany, the Netherlands, Belgium, and the United Kingdom. Currently, our country is erecting WEGs with ratings ranging from 225 kW to 1000 kW.

Wind Energy in India

India is thought to have 20,000 MW of potential for the development of wind power, making it one of the most promising nations for this kind of growth. 23,270 megawatts (MW) of wind-powered energy generators were built worldwide as of September 2001. In terms of electricity generation capacity, the nations with the biggest capacities are Germany (8100 MW), Spain (3175 MW), the United States (4240 MW), Denmark (2417 MW), and India (1426 MW). India is thus the fifth-best nation in the world in harnessing wind power. Numerous wind potential stations can be found in the following states: Tamil Nadu (39), Gujarat (30), Andhra Pradesh (30), Maharashtra (27), Karnataka (26), Kerala (16), Lakshadweep (8), Rajasthan (7), Madhya Pradesh (7), Orissa (7), West Bengal (2), Andaman and Nicobar (1), and Uttar Pradesh (1). Out of a possible 208 sites, seven have observed wind power densities over 500 Watts/m2.

The development of civilization has been greatly aided by the effective utilization of energy. The primary sources of energy throughout the pre-industrial era were wood combustion for cooking, heating, and metal smelting, as well as work from humans and animals. The use of coal was essential to the start of the industrial revolution since it made it easier to mechanize a variety of industries, enhance transportation networks, and advance the development of steam engines. In the previous century, the discovery and use of fossil fuels served as a major driving force behind economic expansion and progress.

But using fossil fuels like coal, oil, and natural gas comes with significant costs associated with climate change, environmental damage, and public health that are not included into current market prices. In academic discourse, the expenses indicated above are frequently referred to as externalities. Externalities arise at all phases of the fossil fuel supply chain, including burning, refining, transportation, and extraction. Carbon dioxide (CO_2) is released into the atmosphere during the burning of fossil fuels. It is thought that this phenomena is the main cause of the present climate change, which is changing Earth's ecosystems and endangering the health of both the environment and human populations.

Global warming is a process caused by the greenhouse effect being amplified by the buildup of carbon in storage. Moreover, nitrogen oxides and sulfur oxides are released during the burning of fossil fuels in addition to carbon dioxide, and these emissions aid in the development of acidic precipitation.

In an effort to reduce the greenhouse impact and fulfill the rising demand for power, experts have focused their attention on alternate approaches to producing the energy needed in recent decades. The methods outlined above are predicated on the idea that most renewable energy sources are easily converted into electrical energy. Right now, renewable energy is expanding at a very quick speed. Renewable energy sources like solar photovoltaic (PV) and wind power are extensively used. With a total capacity of 843.09 GW, the grid-connected photovoltaic (PV) system has grown significantly as of 2021 and is now regarded as the renewable energy technology that is growing the fastest. In the meanwhile, wind energy has so far contributed significantly to the field of renewable energy.

Whether it is done by humans or by nature, every physical action in our world is caused by energy flowing through it in one way or another. The Greek term "en-ergon," which meaning "in-work" or "work content," is where the word "energy" originates. The energy intake determines the work output.

One of the most important resources for every nation's economic success is energy. Given that meeting the world's ever-increasing energy demands would need significant expenditures, the energy sector acquires a key relevance in emerging nations.

Based on the following standards, energy may be divided into many categories:

- Primary and Secondary energy
- Commercial and Non commercial energy
- Renewable and Non-Renewable energy
- Conventional and Non-conventional energy

LITERATURE REVIEW

Kishore et al. (2019) measured the resistance values of PV cells in accordance with MPPT. This takes into consideration the climatic circumstances such as the temperature, the amount of dust in the air, the speed of the wind, and the amount of solar radiation. Bogdan et al. (2018) developed a technique that may be used to calculate the optimal size of a photovoltaic (PV) array for a stand-alone hybrid PV/wind combination system. The solar photovoltaic array and wind turbine provided the best match when using the approach of least squares. Several researchers have investigated PV modeling and simulation and come to the same results. A hybrid power system was created via the combination of photovoltaic and wind energy, which resulted in an improvement in the system's overall efficiency.

In order to provide access to electricity in outlying regions, Muralikrishna and Lakshminarayana (2018) recommended the use of a hybrid energy system that combines wind power with solar energy. Many researchers have investigated, constructed, and experimentally tested the superiority of hybrid systems in contrast to freestanding PV and stand wind systems. As a result, hybrid systems are now the best solution. If the price of a photovoltaic module is Rs. 100 per Watt and its efficiency is more than 20%, then purchasing one will be financially worthwhile.

In the year 2020, Zahedi and Kalam developed a technique for finding the appropriate size of a hybrid system and then optimizing that size. In this hybrid system, diesel is used as a backup supply, with photovoltaics (PV) and wind functioning in the roles of major energy sources. It is a self-sufficient system that is not linked to any public power sources in any way. Calculations of the monthly load were used in the design process for this kind of power plant. Yang et al. (2019) presented a techno-economic analysis as well as an optimal design concept for a hybrid PV-wind power generating system. This research was published in Science Advances.

In order to establish the ideal battery size for a renewable energy system that is linked to the grid, Hans et al. examined the simulation methodologies using Matlab/Simulink based on the results of the HOMER optimization tool. They came to the conclusion that solar/wind hybrid systems provide an option that is both more cost-effective and efficient in terms of energy usage when compared to purely PV or purely wind systems with battery storage units. This was the result that they arrived to. According to Nehrir (2016), the following are the motivating factors for the development of an alternative energy distributed generator (DG) spanning power production using energy sources such as wind, photovoltaic (PV), and fuel cell technology. Since 2003, Montana State University has been the host institution for this event. The author discussed the detailed discussion of the course content, as well as student projects and student responses. It is exciting that the topic of study is being taught in classes, and individuals have to be aware of how significant hybrid generation is in today's environment. Kumar et al. (2019) suggested a hybrid system that may generate electricity from a variety of sources, including diesel, solar, microhydro, and wind. This system is suitable for a variety of applications that take place in distant locations. A model was developed in order to give an efficient system design, and it is based on the hourly data that is available about the availability of energy and the usage of it. The findings of the simulation allowed for another conclusion to be formed, which was that alternative and renewable energy sources would ultimately take the place of conventional energy sources. There is a possibility that a feasible solution exists for remote and isolated places.

According to Chang et al. (2017), the full performance and potential supply time are both projected to be greater when suitable renewable energy sources are selected to be utilized in tandem rather than individually. This is because using several sources of renewable energy at the same time is expected to increase their efficiency. The study that was carried out is based on the complimentary operating system, which is comprised of photovoltaic and wind power generation systems. An analysis of the hybrid system's technical and financial potential was carried out with the help of the Homer program. Rehman et al. (2019) made an effort to study the feasibility of employing solar radiation and wind power in order to minimize the dependency on fossil fuels for the production of energy in the hamlet in Saudi Arabia. According to the findings of their research, the power system that made the most sense was a hybrid one consisting of diesel, wind, and photovoltaics. It had a penetration of 35% from renewable energy sources, with photovoltaics accounting for 9% and wind sources for 26%. It was discovered, after careful examination, that the price of diesel is a big influence in deciding how much energy is pricier in a hybrid power system than it is in a power plant that solely utilizes diesel. This was proven to be the case since the price of diesel is higher in a hybrid power system.

Milligan (2019) presented conclusions about the integration cost of solar and wind energy for outsized scale study and its ramifications. It was also inferred that the concerns with the costs of using solar and wind energy at such high levels of integration may have been the consequence of an error. In 2019, Sharaf et al. introduced a revolutionary control mechanism system that has the potential to be used on a hybrid wind and PV farm that also has a backup power supply for DC loads. For the purpose of conducting a digital simulation of the suggested innovation, the software environment known as MATLAB/SIMULINK/Sim Power was used. Verification of the control system's mechanism is accomplished by the monitoring of the dynamic performance of the hybrid system under both normal and abnormal operating conditions. A hybrid power system average model that included solar and wind energy was proposed by Soltani and Debbache (2018).

In addition to this, a model was developed in order to combine the solar power generating subsystem with the power converter losses that were experienced. It was shown that the prepared model has the potential to be used in a fascinating manner for the purpose of examining dynamic behavior and hybrid system design optimization. Karami et al. (2020) developed a hybrid architecture that shown outstanding performance while having to deal with fluctuating load power needs. The suggested idea could only be implemented in remote areas that were not linked to one another. The efficiency of the strategy that was advised for power management was shown by the results that were provided from the simulation. In order to investigate the operation of hybrid power systems, Curea et al. (2014) developed a test bench that is made up of a diesel generator, a wind generator, photovoltaic panels, storage batteries, an inverter, and a load. At first, the functioning of the system was investigated in relation to varying degrees of wind speed and the amount of solar radiation. Second, a variety of power quality-related problems that developed from differences in balanced and unbalanced loads were investigated. These concerns occurred as a result of the variations in load types. The validation of the simulation models was accomplished with the help of the test bench.

The study conducted by Lew et al. (2019) concentrated on the western region that spans the borders of Colorado, New Mexico, Arizona, Nevada, and Wyoming. It is one of the biggest grids of wind and solar integration that has ever been observed, with an operational effect of up to 35% coming from the wind. The unexpected and variable nature of solar and wind PV presented a challenge that needed to be overcome in order to achieve the goal of understanding the observed operational consequences and cost variances. The cost of generating electricity from wind or solar sources was not the primary focus of this research; rather, it was the operational expenditures and the savings from fuel and pollution. In 2017, Jeon et al. put up the idea of a multifunctional hybrid power generating system that is grid-connected and uses PV, wind, and BESS. A description was given of the core principle that underlies the proposed structure as well as the workings of its multi-operation mode control mechanism. The concept of geo-thermal heating was the basis for a revolutionary space heating system that was created by Fargali and his colleagues in a remote region of Egypt. In order to provide electricity to the electrical loads that were linked to the heating system, PV and wind energy sources were employed. The many components that may be discovered in the electrical and geothermal subsystems have each been represented by a MATLAB/SIMULINK model in addition to a full mathematical model. The results revealed that the expected control approach was implemented to maintain the planned system's ability to operate accurately and continuously.

In their research, Onar and colleagues (2016) focused on the use of several power generating technologies, such as fuel cells, wind turbines, and ultracapacitors, in conjunction with one another to accomplish continuous power generation. According to the notion that they have developed, wind turbines will be able to satisfy the demand for electricity when the wind speed is sufficiently high. In the event that it is inadequate, a fuel cell system may fulfill the demand for the extra amount of electricity. For a condensed amount of time, the load requirement that is sought may be satisfied by ultra-cell. It was stressed that the one-of-a-kind design that has been offered is capable of withstanding fast fluctuations in wind speed, and that the consequences of these variations on the voltage on the equipment side are reduced. In 2018, Chedella et al. released the findings of the first research that aimed to develop a model for a small independent air conditioning system that used fuel cells and solar panels as its primary source of energy. Solar energy is now the most widely used form of energy for the generation of electricity throughout the day. During the night, both the fuel cells and the battery contribute to its improvement. Jacob and Arun (2019) came up with an idea for a novel converter topology that could be used in a hybrid energy system that included solar and wind power sources. The dynamic simulation model that Doumbia et al. (2017) developed using the Matlab/SIMULINK program was used to investigate the efficiency of renewable energy systems in relation to hydrogen storage. Combining distinct components, such as fuel cells, power conditioning units, wind turbines, battery arrays, and photovoltaic arrays, results in the production of an all-encompassing model. This model is validated by using a strategy based on the current condition of the charge. The results that were obtained using this approach verified and corroborated the findings of earlier test bench trials.

Solar power, wind power, and battery storage were incorporated into a hybrid power production system by Chen et al. (2017). This was done in order to develop a hybrid power generating system. Because all of these components are interconnected, it is much simpler to comprehend that the amount of load that any given system is capable of supplying is reliant on the climate. The results of several tests carried out in a variety of climatic and temperature circumstances are presented here in their entirety. Kim et al. (2016) explored how to control the power of a hybrid generating system that mixes solar and wind energy in their study, and they offered suggestions for connected operation in the electric distribution system as a result of their findings. When studying the control strategy using power system transient tools like PSCAD/EMTDC, modeling and simulation are used as research methods. The findings that were provided by the simulation helped to explain both the control performance and the dynamic behavior of the wind/photovoltaic system. Giraud and Salameh (2018) conducted an investigation on the operational concept and performance of a 4 kW grid-connected residential wind-photovoltaic hybrid system with battery storage situated in Lowell, United States of America. The research conducted by Jain and Agarwal (2018) focused on integrated hybrid power supplies for distribution generating applications that were powered by unconventional energy sources. Because of its small size, cheap price, and high level of dependability according to the specified model, the system is well suited for usage in modular assembly configurations. Phrakonkham et al. in (2019) studied not only the current condition of electrification but also its history and the many renewable energy sources that are now accessible. The case study on economic optimization that makes use of HOMER and HOGA, both of which are separate simulation software packages, is still in the process of being carried out.

It is essential to redirect emphasis on alternative and renewable energy sources rather than conventional energy sources, which have a finite supply, according to Rahman Saifur (2017). Energy has emerged as a component that is absolutely essential to the development of human civilization. Over the last several years, there has been a widespread and persistent push toward research as a result of the growing need for contemporary renewable energy sources. Standalone systems usually make use of renewable energy sources such as wind, geothermal, biogas, and photovoltaic (PV) alone. The financial results of using these methods for the generation of renewable energy are not favorable. Investigations into alternative forms of energy are now being carried out. When building integrated renewable energy systems, it is essential to take into consideration the financial constraints that are imposed by the unique properties of renewable energy sources such as wind and solar photo voltaics (PV). In this investigation, we propose a strategy for improving the performance of renewable energy sources such as solar panels that are equipped with photovoltaic (PV) capabilities, roller speed breakers, and the noise that is generated by moving vehicles. Street lighting is usually powered by hybrid electricity, which is created by combining the output of many different renewable energy sources. This kind of electricity is widely employed.

AN EXAMINATION AND BREAKDOWN

In the present circumstance, power system engineers give priority to creating more electricity in order to offset or balance the growing demand for electrical energy. This not only helps to minimise the impact on the environment, since renewable energy sources are used, but it also helps to satisfy the expanding demand for electrical energy. Renewable energy sources have the potential to be used in a variety of contexts, including large-scale applications in where resources are abundant and high-rating conversion systems are utilised, as well as small-scale applications that are located in remote areas away from large-scale power plants.

The integration of decentralised energy sources into the distribution network, on the other hand, is where problems and challenges manifest themselves. The existing system is intended to operate in a cyclical pattern; however, there are no plans to include further generations into the system in the foreseeable future. On the basis of the existing availability of fossil fuels and their predicted preliminary end time, policymakers and scholars have come to the conclusion that it is essential to keep fossil fuel reserves for a longer length of time than was previously thought.

The primary objective of the proposed research project is to create a hybrid power producing system that can be linked to the power grid and that makes use of solar photovoltaic, wind, and energy storage technologies. In the software environment provided by HOMER, the performance of the recommended system will be evaluated using both the simulated and the actual test systems. Analysing the performance of the system will include using metrics such as voltage profile, network losses, efficiency, cost consideration, life cycle analysis, payback time, greenhouse gas emissions, and carbon credits, amongst others. The method of fuzzy logic was used in order to figure out the best DRE locations and sizes for incorporation into distribution networks.

The Use of Fuzzy Logic in Applications

In order to infer the behaviour of the system, the method of fuzzy logic is used. The method of fuzzy logic primarily consists of three different kinds of operations. The first phase, known as "fuzzification," involves converting the input data into values that are acceptable for the language. The second step is to base your judgements on certain previously established parameters. The final step is called defuzzification, and it involves converting the findings into information that a computer can understand. The use of a Mamdani-based fuzzy logic controller has the advantage of being able to manage complex and non-linear systems without necessitating the modification of the whole system from its beginning point in the event that changes occur while the process is being carried out (84). In this particular research endeavour, the first and second variables to be considered as inputs and outputs, respectively, are the power capacity of distributed generators per unit and the impedance of the line linking DGs to consumers. The result variables are the real power loss that is the least amount possible while maintaining a stable voltage index.

In this instance, y1, y2,..., and yn are considered to be output fuzzy sets, while x1, x2,..., and xn are considered to be input fuzzy sets. The FLC rules are constructed on the basis of two input variables, and the output shows which DGs need to be allocated first as a direct consequence of this. PV = minimum of (Rkdg + Xkdg) plus maximum of (VIk)

The priority of DG installation is determined according to the output set equation, which states that the minimum impedance of the line connecting the DGs to that bus and the maximum voltage indexing of the k bus are the two factors that are taken into consideration. An illustration of the connection between two sets of input voltage magnitude and branch impedance that links the DGs to the radial feeder is provided by the fuzzy logic controller method that has been recommended. The FLC takes two inputs and separates the branch impedance and voltage magnitude into three categories: low, medium, and high. When the capacity of the DG is high, integrating the DG takes precedence, and the use of low-impedance lines that connect the DG to specified buses is recommended.

PRINCIPALLY ACCOMPLISHED TECHNICAL CONTRIBUTIONS

The construction of a hybrid energy system that bridges the gap between sustainable power demand and supply is the primary technical contribution that can be attributed to the thesis. This gap may be bridged by combining conventional electricity generation with distributed energy resources. With the help of the fuzzy logic method, it is possible to accurately calculate both the size of DERs and the appropriate location for them inside distribution networks. Application that generates distributed output inside a system network:

- offers voltage assistance,
- Postpones the need for additional production and transmission from power facilities that rely on fossil fuels,
- decrease in network outages,

A system of electric power will need DERs with the right capacity and placement. The ultimate objective is to create a hybrid energy system that accounts for efficiency gains, lower greenhouse gas emissions, and power costs—all without compromising supply security. It is necessary to create mathematical models in order to provide an enhanced analysis under the most recent producing situations.

Developing a grid-connected hybrid energy system is the main goal of the study that is being presented. The thesis's mathematical models are based on a few simplifying presumptions. Proposed hybrid power production has included mathematical modeling of the power system components and power generation from dispersed energy resources. Maximizing the production of energy using renewable technologies is a crucial step in determining if the suggested hybrid power generating system is feasible. Ancillary services can be implemented to impact the performance of the proposed grid-connected hybrid power production system, however this is not fully detailed.

The underlying premise of hybrid power generating system modeling is that each unit may be turned on and off in accordance with available resources. Intertemporal limitations are disregarded. The majority of the modeling is carried out with an emphasis on the dynamic behavior of supply and demand for power. The model frameworks in this thesis are adaptable and expandable to take into account certain additional technical factors.

Using HOMER software, the performance of the proposed grid-connected hybrid power generating system was examined, and fuzzy logic was used to determine the ideal position and size. The proposed grid-connected hybrid power generating system produced a number of intriguing findings, which are fully discussed in the thesis' result chapter.

Every country needs energy to maintain its political stability as well as its economic growth. Both the growing need for energy and the depletion of traditional energy sources have contributed to the sector's constant growth in renewable energy. Since fossil fuels are running out at an alarming pace, finding new and alternate sources of energy to fulfill the rising need for electricity is becoming more and more crucial. The most potential renewable energy source is solar energy, which is expanding quickly and has little effect on the environment. Even on a clear, bright day, a photovoltaic (PV) system may not be able to supply the whole load demand due to variations in irradiance. This is particularly true in the evenings and during periods of cloudy or rainy weather. The PV system may be integrated into a hybrid system together with appropriate energy storage components and many additional renewable energy sources to address the problem. Under the current conditions, scientists are gradually shifting their attention from large renewable sources such as solar and wind to a hybrid system that incorporates smaller and less-explored renewable sources. This shift is occurring within the framework of the existing circumstances. The system consists of a solar photovoltaic (PV) system, which is used as the main system, as well as a number of lesser-known and underused renewable energy resources, the research on which is still in its early stages. These subjects are still relatively new to investigation. The data shown here emphasizes how crucial it is to cut down on energy usage from a variety of renewable sources, not only solar energy. One part of the whole system is dependent upon the inefficient use of kinetic energy that takes place in cars. The path to using high decibel sound beneath a source of usable electrical energy has been cleared by the most recent findings. The list of opportunities for using renewable energy has grown by one as a result of these recent developments in the field of acoustics research. The authors provide a variety of ideas and recommendations for using the piezoelectric effect or a diaphragm to transform sound into energy. The diaphragm of a microphone is one of the most well-known mechanisms for converting sound waves into electrical impulses. This research proceeds in a way that makes sense. The authors begin by describing the problem and then go on to talk about the methods they used to address it, the model they finally provided, and the conclusions they came to.

CONCLUSION

The study will also be beneficial in highlighting the gaps that are present in the current energy policy and plan. This will make it much simpler to cut emissions of greenhouse gases and develop technology that is not only more appealing but also feasible from an economic point of view. This finding has significant ramifications for the trajectory of research in the years to come, not just in public universities but also in private businesses. Further in-depth experimental study is necessary in order to answer the question of whether or not variations in the weather have an influence on the efficiency of PV systems. It is feasible that future research may demonstrate the fact that the climatic conditions that prevail in each of India's states are distinct from those that prevail in the other states.

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