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SIMULATION ON HYBRID PV-WIND POWER GENERATION SYSTEM USING COORDINATED CONTROL AND FUZZY LOGIC CONTROLLER

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ABSTRACT -- The transition to renewable energy sources necessitates the integration of multiple energy generation systems to ensure a stable and reliable power supply. This paper investigates the simulation of a hybrid photovoltaic (PV)-wind power generation system, employing coordinated control and a fuzzy logic controller (FLC) to enhance performance and stability. The hybrid system leverages the complementary nature of solar and wind resources, aiming to mitigate the intermittency issues inherent in individual renewable sources.

A coordinated control strategy is developed to manage the power output from both PV and wind subsystems, optimizing the overall energy production. The fuzzy logic controller is implemented to handle the nonlinearities and uncertainties associated with varying environmental conditions. By continuously adjusting the operating parameters, the FLC ensures maximum power point tracking (MPPT) for both the PV and wind components, while maintaining system stability and efficiency.Project proposes an algorithm for tracking maximum power output and simulation will be accepted for analyze the results. The project also aims to integrate the solar photovoltaic (SPV) with wind energy conversion schemes to meet consumer load and also design a supervisory control method for wind energy system to regulate both active power and reactive power towards the load, and further analyze the system steadiness in grid-connected mode.

Key Words--Wind Power, Solar Photo Voltaic (SPV), Maximum Power Point Tracking (MPPT) and Hybrid Model.

I.INTRODUCTION

Energy comes at a cost, and the price which we intentionally or unintentionally choose to ignore is far greater than the tariffs that we pay for the quantity of electricity utilised. Unfortunately, our electricity bill does not account for the irreversible damage that we do the environment, and for that matter no quantity of money can offset for the environmental damage that has already been thrown. So, the basic need of the hour isto focus on areas which are clean sources of energy and reduce our dependence on conventional sources without compromising with the dependability of the system. The worries about deficit of fossil fuels are increasing day by day, shoot up of oil prices, effect of global warming, and environmental damage are key concerns in today`s scenario. Hence an importance is given to advance alternative resources with high efficiency and low emission.

In traditional power systems, most of the power is produced from a huge power plant situated at various geographical areas, transmits then to large consumer locations through long overhead lines of transmission. For ensuring quality of power, namely frequency and voltage, continuous monitoring of the system is needed from the control centres.

Since an operation of the power system is changing, a dispersed generation unit comprises a number of renewable sources including wind turbines and photovoltaic (PV) generators. In future, renewable sources of energy are extensively used in large consumer localities will be seen. Using renewable sources of energy, the harmful emissions are eliminated.

Apart from higher costs, uncontrollability is the key drawback. The available renewable sources have robust regular and cyclic patterns. However, consumers have different energy demand characteristics. Therefore, it would be hard to run a power installed system by having renewable generation plants only because of the characteristics differences and high ambiguity of renewable sources availability. A method adopted for fully utilizing the energy from the renewable sources is by connecting with the grid usually at the level of power distribution. Another problem which this method of system encounters is that unlike our conventional system the speed, frequency and hence generation output is not constant. So, we need to use power electronic devices and apply control schemes which will stabilize the output. This project aims to address the aforementioned issues by using various methods all integrated to do the work of a system in a proper way. To arise the power output maximum from a photovoltaic, we have designed a Maximum Power Point Tracking (MPPT) method. This photovoltaic is coupled with the electric grid using a Direct Current (DC)/Alternating Current (AC) convertor. Then a voltage and active and reactive power control model has been designed for voltage source convertor in wind power energy conversion scheme. This wind energy conversion scheme is integrated with photovoltaic system to the grid. This new integrated hybrid system gives more reliability and constant output voltage. This system is yet to acquire commercial dimensions in India because of the high installation cost needed at the start.

Simulation results indicate that the proposed hybrid system with coordinated control and fuzzy logic significantly improves power reliability and output consistency. The system adapts effectively to fluctuating solar irradiance and wind speeds, achieving higher energy yields compared to traditional control methods. Furthermore, the coordinated control strategy reduces the dependency on storage systems and enhances the economic feasibility of hybrid renewable power systems.

This study highlights the potential of integrating fuzzy logic controllers and coordinated control strategies in hybrid renewable energy systems, providing a viable solution for sustainable and efficient power generation.

II.LITERATURE SURVEY

Kadam, Pranav & Ambekar, Rupalee. (2022) has developed a hybrid system using solar and wind energy. Since it low cost and also environmentally friendly, can be used in hilly areas to generate electricity. This paper used the model based on solar radiation, sunlight hours, temperature, wind velocity, wind direction and topography. Basis of data available in some parts of Kerala, a model can be developed by integrating Photo Voltaic (PV) and wind energy conversion system. The paper aims to develop Hybrid system by grid connection using PV and wind energy conversion scheme in Simulink software tool. The components include, the solar panel, the Perturbation and Observation(P&O), MPPT, DC boost converter, AC inverter, wind turbine and Permanent Magnet Synchronous Generator (PMSG). For different irradiation and temperature conditions the photo voltaic model is simulated and the output is monitored. The windsolar PV hybrid model is simulated and the Simulink results are analyzed. [1]

An-lei Zhao, Guang-chao Wang, Xin Xia, and Yao pan Yang (2020) has concentrate in this paper on energy storage device using an ultra-capacitor in hybrid PV-wind energy system. To obtain steady voltage and to reduce power variation on network side voltage, a static wind compensation is used by MATLAB/Simulink software. The method conductivity fuzzy logic algorithm is used to obtain faster state of steady with high accuracy so that battery life is improved and power consumption isreduced. In future intelligent algorithms along with MPPT can be adopted for achieving high accuracy with high-intelligence level. Further, optimization between batteries and ultra capacitors by energy management system is also included in this paper. [2]

Layth Mohammed Abdali, B.A. Yakimovich & V.V. Kuvshinov. (2019) has presented a research paper on use of Alternative energy sources such as PV& wind hybrid energy generation system to obtain uninterrupted energy supply without harming nature by integrating dual energy sources so that stable power can be provided. It includes the the primary components such as, the Wind Energy Conversion System (WECS), PV, battery and Fuel Cell (FC). This article includes overall coordination control. Energy storage systems such as batteries are used so as to act as dump load. For backup generation this paper also comprises Fuel cell and supplies power to the scheme when State of Charge (SOC) < 25%.[3]

Ranjay Singh & Ramesh C. Bansal. (2018) has reviewed a paper on current energy scenario and the possible solutions using Hybrid Renewable Energy Sources (HRES). This paper intentions to size optimization, price and dependability of HRES power generation by using several methods and limitations on which an HRES can be optimized, thus the probability of power supply loss can be reduced. This paper incorporates various forms of available units of energy storage along with advantages and their uses for reliability improvement of HRES.The techniques used for optimization may be either iterative based, artificial based and also software’s are adopted. [4]

Praveen Tiwar, Munish Manas, Pinakeswar Mahanta and Gaurav Trivedi. (2017) has developed a paper on recent developmentsfor providing electricity accessto remote areas. For this, is using microgrid with the Renewable Hybrid Energy Sources (RHES) along nearby available sources of energy for power generation. Also, the configurations of Microgrid, its modeling and control have been discussed using Homer software tool for matching Renewable Energy (RE) generation and load demand. This paper includes various forms of Energy Storage Systems (ESS) suitable in applications such as Pumped Hydro Energy Storage System (PHESS) and Compressed Air Energy Storage System (CAESS) used for energy storage in bulk, flywheel system mainly utilized for frequency regulation, whereas Battery Energy Storage System (BESS) is used in versatile application therefore by carefully selecting ESS may reduce per unit generated energy cost. [5]

Sumit Wagh and Dr. Pramod Walke. (2017) has published a review paper on renewable sources of energy like solar, wind which are widespread and environmental. The optimal use of these accessible resourcesis, incorporation of the hybrid solar PV and wind energy system. This review paper presented the divergent techniques and concepts about Hybrid Renewable Energy Sources (HRES) and its employment. The numerous features of Solar (SPV)-wind hybrid energy system are studied in this research paper and also discusses the growth of hybrid system by incorporating various schemes and its application theories. [6]

Abba Bashir Muhammad, Shodiya Sulaimon and Garba Ngala. (2017) has developed Solar Photovoltaic (SPV) & Wind turbines Hybrid system (HS). In a wind energy system, a model for analytical preliminary assessment and prediction electricity generation potential is developed in this paper. And also, the developed model was merged a model for predicting/evaluating solar energy electricity potential of tropical regions like Maiduguri. The Hybrid power system (HPS) power output prediction model is obtained by combined the two models. This paper describes Modelling of HPS with simulation is performed using commercial software Homer. [7]

III.PHOTOVOLTAIC INVERTER

A PV cell is a simple p-n junction diode that converts the irradiation into electricity. Fig.3.2 illustrates a simple equivalent circuit diagram of a PV cell. This model consists of a

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current source which represents the generated current from PV cell, a diode in parallel with the current source, a shunt resistance, and a series resistance.

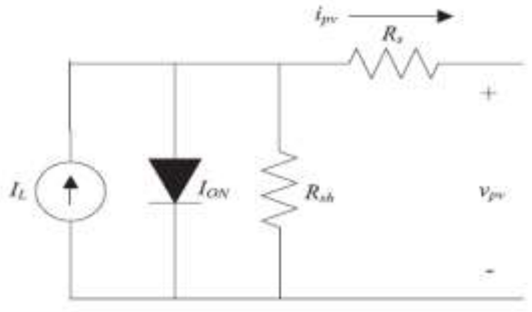

Fig.3.2 Equivalent circuit diagram of the PV cell

IV.DC-DC CONVERTERS

A DC-DC converter with a high step-up voltage, which can be used in various applications like automobile headlights, fuel cell energy conversion systems, solar-cell energy conversion systems and battery backup systems for uninterruptable power supplies.Theoritically, a dc-dc boost converter can attain a high step-up voltage with a high effective duty ratio.But,in practical, the step-up voltage gain is restricted by the effect of power switches and the equivalent series resistance(ESR) of inductors and capacitors.

Generally a conventional boost converter is used to get a high-step-up voltage gain with a large duty ratio. But, the efficiency and the voltage gain are restricted due to the losses of power switches and diodes, the equivalent series resistance of inductors and capacitors and the reverse recovery problem of diodes. Due to the leakage inductance of the transformer, high voltage stress and power dissipation effected by the active switch of these converters. To reduce the Voltage spike, a resistor-capacitor –diode snubbed can be employed to limit the voltage stress on the active switch. But, these results in reduction of effiency.Based on the coupled inductor; converters with low input ripple current are developed. The low input current ripple of these converters is realized by using an additional LC circuit with a coupled inductor. Power engineering is the method used to supply electrical energy from a source to its users. It is of vital importance to industry. It is likely that the air we breathe and water we drink are taken for granted until they are not there.

IV.WIND POWER

Wind is abundant almost in any part of the world. Its existence in nature caused by uneven heating on the surface of the earth as well as the earth's rotation means that the wind resources will always be available. The conventional ways of generating electricity using non renewable resources such as coal, natural gas, oil and so on, have great impacts on the environment as it contributes vast quantities of carbon dioxide to the earth's atmosphere which in turn will cause the temperature of the earth's surface to increase, known as the green house effect. Hence, with the advances in science and technology, ways of generating electricity using renewable energy resources such as the wind are developed. Nowadays, the cost of wind power that is connected to the grid is as cheap as the cost of generating electricity using coal and oil. Thus, the increasing popularity of green electricity means the demand of electricity produced by using non renewable energy is also increased accordingly.

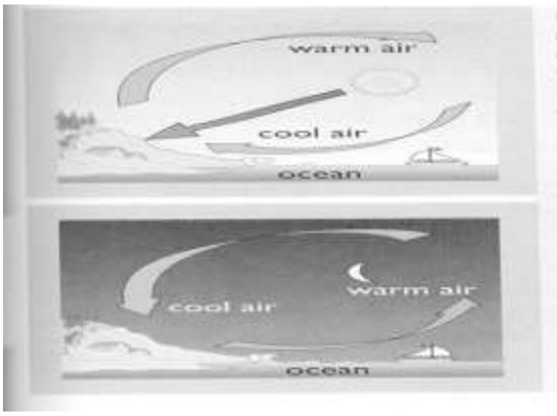

Fig: Formation of wind due to differential heating of land and sea

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Volume : 53, Issue 7, July : 2024

V.DESCRIPTION OF PV-WIND HYBRID SYSTEM POWER GENERATION

Basically, the power generation in Hybrid system is through solar PV array and wind turbines which is generally called as PV-wind Hybrid system. Presently, the quantity of electricity produced in this hybrid system depends on the entire solar resource incident on parallel plane of the solar arrays and speed of wind flow. Generally, in a typical Hybrid system, one energy source generates electricity at a lower supply level whereas other energy source generates electricity usually at a higher supply level. For example, in wintertime, solar resource is lower while the wind speed is heavy. Moreover, in the course of night solar energy is not exploited while the wind energy can be utilized efficiently. Therefore, meeting load demands can be enhanced by simultaneous utilization of multiple energy sources effectively. Also, this is critical for regulating electricity generation supply levels of the energy resources at which the respond reaches the optimum balance. The size of a Hybrid system generally depends on solar insolation and speed of wind flow on that zone.

THE PROPOSED WORK

The proposed scheme consists of wind blades, a variable speed direct-drive wind generator, a wind-side AC-DC converter, a solar PV arrays, a DC-DC converter, a common DC capacitor and an electric grid interface inverter as shown in Fig.1. Mechanical energy from the wind turbine drives the wind generator usually used is a Permanent Magnet Synchronous Generator (PMSG), which produces Alternating Current (AC) electric power, in turn converted to Direct Current (DC) electric power so that a common DC link is formed. The solar PV generates DC electric power. Generally, the DC output voltage level from solar arrays is low compared with the adequate level of the DC link. Thus, the DC-DC booster converter raises the solar array DC voltage to a higher-level equivalent to the common DC voltage level to guarantee the excellent operation of the grid interface inverter. The inverter from an electric grid side converts DC power from the output of wind turbine and solar PV arrays into AC power of which required voltage and frequency obtained for being supplied into an electric grid.

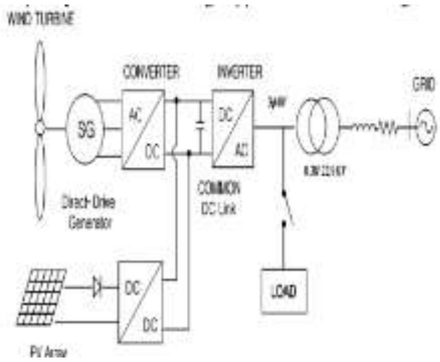

Fig. Hybrid PV-wind system connected to grid

A. SOLAR PV SYSTEM CONFIGURATION

The Fig.2 shows equivalent circuit of a simple solar cell having a current source which is in parallel with a diode(D). The current source output is directly related to the sun light falling on the cell (photo-generated current Iph). The solar cell will work as a pn junction diode during darkness. Although if an external supply of large voltage is applied to the cell produces a current which is called diode (ID) current. The current(I) Voltage(V) characteristics of the cell is determined by a diode which is given by an equation as:

$$I_{pv}=I_{ph} - Is\ [\ Exp\ (q\ (V_{pv} + I_{pv} * R_{se})/\ (k*Tc*A) - 1] - (V_{pv} + I_{pv} * R_{se})/R_{sh} \quad ... (Eq.1)$$

Where, I_{ph} = photo-generated current
Is = diode reverse saturation current
q = 1.6 ×10−19C is an electric charge
k = 1.38 ×10−23J/K is the Boltzmann constant
Tc = cell temperature
A = ideality factor
R_{sh} = shunt resistance and
R_{se} = series resistance.

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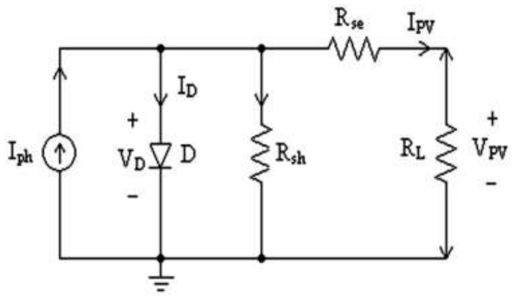

Fig.2 Equivalent circuit diagram of a simple solar cell

Maximum Power Point Tracking (MPPT)

For a local climatic conditions and performance of solar PV systems, this paper provides a comprehensive analysis of the system. The key drawback of this system low energy conversion efficiency. This problem can be conquered by operating solar PV system near the Maximum Power Point (MPP) to increase the efficiency of solar PV arrays.

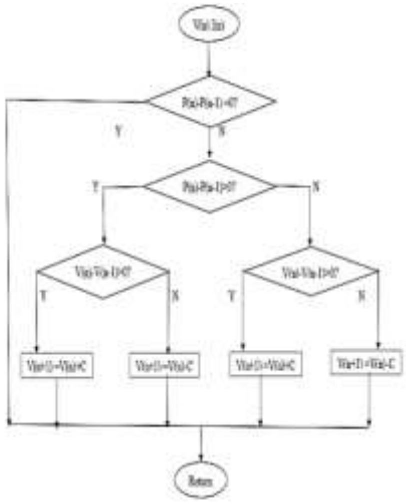

Fig.3 Proposed Algorithm for MPPT

B. WIND ENERGY SYSTEM CONFIGURATION

Wind energy conversion system mainly consist of two parts one is mechanical part and other is electrical part. Mechanical part mainly consists of wind blades and drive train. Wind power system's performance depends on the wind blade characteristics. Electrical parts are mainly consisting of Permanent Magnet Synchronous Generator (PMSG), Power converters, PWM firing control strategy, transformer and a grid.

VOLTAGE SOURCE CONVERTER CONTROLLERS

In wind turbine applications Back-to-Back Voltage Source Converter (VSC) is mainly used which may be employed in numerous ways like, six-step, Pulse Amplitude Modulated (PAM) or Pulse Width Modulated (PWM). However, the PWM VSC can be implemented by harmonic elimination, sinusoidal PWM or space vector strategy methods.

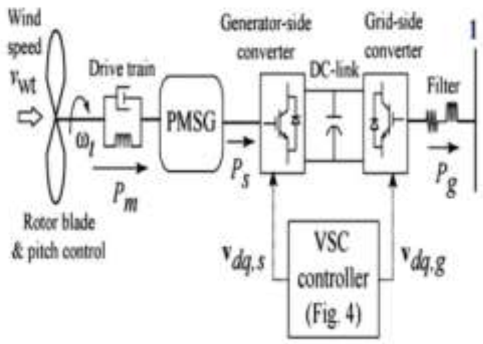

Fig.4 Basic wind energy system connected to grid.

VI.SIMULATION MODEL AND RESULTS

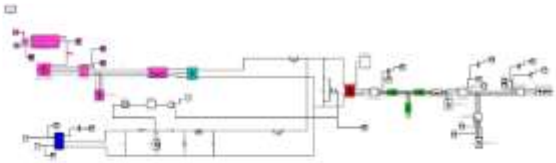

Fig.6 Simulation Model of a Photo Voltaic (PV)-wind Hybrid system

SIMULATION RESULTS

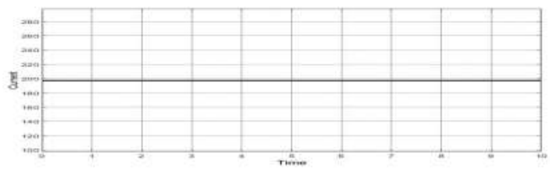

Fig.7 Value of current at Maximum Power Point (MPP)

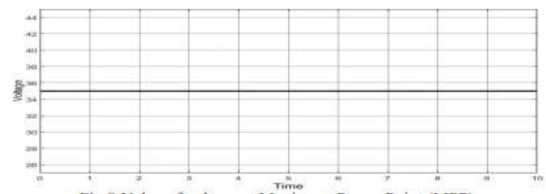

Fig.8 Value of voltage at Maximum Power Point (MPP)

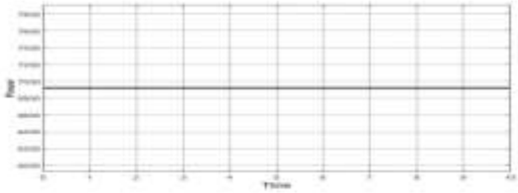

Fig.9 Value of Maximum Power

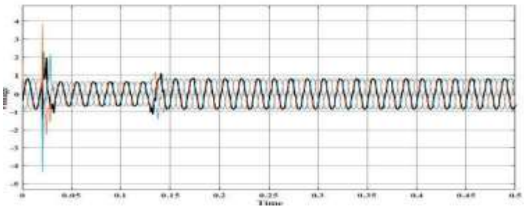

Fig.10 Wind turbine output voltage in hybrid system (per unit)

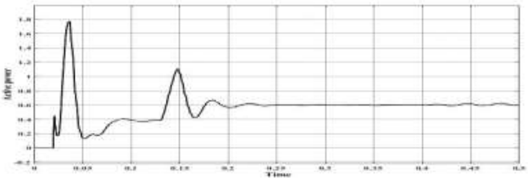

Fig.11 Wind turbine output active power in hybrid system (per unit)

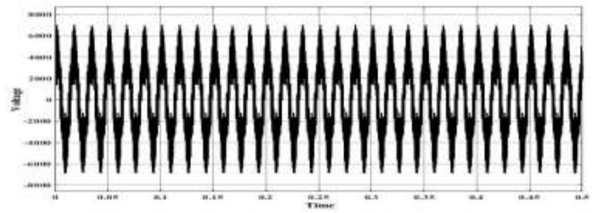

Fig.12 Photo Voltaic (PV) output voltage in hybrid system (per unit)

VII.CONCLUSION

This study presents a detailed simulation of a hybrid photovoltaic (PV)-wind power generation system employing coordinated control and a fuzzy logic controller (FLC). The integration of these two renewable energy sources, coupled with advanced control strategies, demonstrates significant potential in addressing the challenges of intermittency and variability inherent in renewable energy generation.

As a part of the solution, our report deals with an algorithm designed for extracting maximum output power from solar PV arrays under all possible climatic conditions. For the wind energy system, we have designed a supervisory control method for active power and reactive power flow to ensure reliable operation. This overall scheme can be applied to larger farms and network configuration.

The various blocks in the hybrid system were modelled and are proposed control strategies for different parts. The simulation is carried out using MATLAB-Simulink software. The simulation results illustrate the currents and voltages in different blocks of the system with different input condition like solar resource, wind speed and temperature. The system control objective is achieved and the controllers are designed. For the efficient exploitation of this novel method, we need a careful surveillance of the meteorological conditions of the proposed area where the system to be installed which is about five years, to get a fair idea of the conditions like solar irradiances, wind speed, temperature etc. So, this scheme is our solution to all the problems which our environment faces due to existing conventional sources of energy being used.

FUTURE SCOPE

Combining a PV source with a wind generator can reduce the zero-power intervals. The PV system can supply energy only when the solar radiation is available. Since, the intensity of solar insolation received by the PV array varies continuously, which affects the performance of the load. This paper has developed modified PV configuration block that extract maximum output power under all climatic conditions. In wind energy system, Permanent Magnet Synchronous Generator (PMSG) is directly coupled to the turbine shaft without gear. Also does not make use of power electronics. So that, the benefit of lower nacelle weight, reduced noise and lower power loss can be obtained.

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