

Optimization of Hybrid Energy System for Optimum Power Flow

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ABSTRACT: In recent years, there has been an energy crisis in the world, due to which the demand for energy sources has increased. By using hybrid energy systems, we can meet our energy needs as well as reduce our dependence on fossil fuels. It can also be environmentally friendly if it has renewable sources. The study presents a complete model of a continuous power generator. A simulation model was developed to study the characteristics of solar and wind energy management technologies. Power management monitoring has been developed to assess the reliability of the power system. Simple control techniques are used to adjust the number of systems. Continuation of this project will include adjusting the frequency to minimize transient effects during different types of operation.

KEYWORDS: energy system, renewable energy sources, hybrid, fossil fuels, optimization controller.

I. INTRODUCTION

As developing countries begin industrialization and consumers in developed countries buy the tools necessary to improve life, global energy consumption is increasing. If current trends continue, we may face fuel shortages in the future. All the energy in the world comes from the Sun. The energy used to power our lives can be divided into two types: renewable and non-renewable. Renewable sources are sources that are constantly replenished by solar activity on Earth. These include wind, hydro, solar, biofuels and geothermal. Most of the non-renewable resources are fossil fuels, and their supply is running out.

The use of renewable energy sources as part or main contribution to the electricity supply system can be very attractive in remote areas. It has been proven that hybrid power systems can be economical in many applications and can also provide a reliable power supply by combining different energy sources. The ability to use local energy sources, such as renewable energy sources (solar, wind, water flow, biomass, etc.), available almost everywhere, including remote areas, is a good solution from an economic and logistical point of view. The renewable energy industry can provide efficient and reliable components to integrate the power supply system, and costs are expected to decrease. However, further development of the design and production of hybrid power systems is necessary to allow the widespread use of this technology in remote electrification projects.

Every country needs energy for social, economic and industrial development. Fossil fuel is the main source of energy, the excessive use of which has harmful effects such as air pollution and destruction of the environment. When fossil fuels are burned, harmful gases are released that have serious consequences for habitats and affect human health. These are non-renewable energy sources because they come from prehistoric fossils and cannot be recovered once used. Their assets are limited and run out quickly. Renewable energy generation is a good option to deal with the availability of fossil fuels and to protect the environment.

The increase in the demand for energy, high energy prices and the problems of the environment, health and climate change, have influenced researchers and communities to study alternative energy. Solar or wind power is often used in remote areas where there is no electricity supply. The disadvantages of independent power systems using renewable energy sources are that they have to work every day and seasonal systems and they are difficult to control the power load [4]. For example, reductions in daily wind speed and solar radiation at night and on cloudy days will reduce the reliability of solar and wind systems in delivering daytime loads. Because solar or wind energy cannot be used

throughout the day, month or year, solar or wind energy systems cannot be used exclusively for electrical appliances that require uninterrupted power. Using a hybrid energy system is a great option.

II. LITERATURE REVIEW

Any. Selvakumar agus K. Thanushkodi 2007, Business optimization for power plants using the Particle Swarm Optimization (PSO) algorithm was introduced. The economic problem of power transmission systems is to find the best mix of resources for each power plant to keep total fuel consumption low and meet all the constraints. The calculation model takes into account several important factors related to the impact of the carbon price, operating parameters and energy balance. Therefore, a new modified PSO method is used to solve the financial transfer problem. The proposed algorithm is compared with other PSO algorithms. The simulation results show that the proposed method is feasible and effective [1].

Anagreh Y., &Bataineh 2011He researches the potential of renewable energy, wind and solar in Jordan. The study used long-term wind speeds and solar radiation levels in different regions of the country. Statistical and astronomical methods are used to obtain wind speeds and solar radiation patterns. The potential energy of both products was also measured. The results show that different regions of Jordan have strong wind and solar energy. Therefore, strong support is given to wind and solar energy projects in the country [2]

Anayochukwu, A.V. in guide 2013, Discuss the possibility of a diesel hybrid generator system with renewable energy sources and show the potential of renewable energy to (partially) replace diesel fuel as a power source for mobile base stations. The proposed hybrid system (solar and hydro) was simulated by the DG model, resulting in four different topologies. The solution with the highest optimization value is the best energy version (solution) for the base station location. [3]

Angelopoulos, K. 2004, Decentralized Power Generation (DG) is reported to be a developing concept in the power and resources sector that is a good alternative to the traditional concept of centralized power generation. This paper provides a basis for the integration of decentralized generation technology in low voltage networks, paying particular attention to the economics of DG equipment and the potential impact of DG on voltage management, thus improving power quality [4].

Arpan Dwivedi, Yogesh Phariya 2017, The increase in demand for renewable energy is examined. By using hybrid systems, we can meet our energy needs and reduce our dependence on fossil fuels. This will help to solve the global energy crisis in a sustainable way. Non-renewable natural resources will be depleted within decades due to widespread environmental damage. Hybrid systems can be used [5].

Arun Preet Kaur jt 2014, It has been discussed that genetic algorithm is a versatile method in the field of optimization in recent years. This paper studies the economic load problem of thermal generators using a genetic algorithm (GA) method. The proposed method is applicable to 3 generator systems and 6 generator systems. The system discussed here is a lossless system. The results obtained show a significant increase in the fuel consumption of the generator while complying with some equality and inequality constraints [6].

Ashari, M. Ja Nair 1999, The deployment strategy for a solar photovoltaic (PV) battery hybrid power system using integration points is given. This involves determining the correct take-off point to start and stop the diesel generator to reduce overall system costs. For specific deployment strategies, computer programs have been developed to predict long-term energy efficiency and system lifetime costs [7].

Bishnusahu et al 2013 It has been observed that evolutionary algorithms have become an important aspect of artificial intelligence and have been successfully applied to various optimization problems. This paper uses a genetic algorithm and a quadratic programming concept to solve an economic load allocation with the total cost of the power plant that minimizes the impact of cap tip load and meets load demand without considering transmission line losses. The current work focuses on the modeling of open economic problems with distribution loss and is implemented in a test system, i.e. IEEE 14 bus and IEEE 30 bus using MATLAB [8].

Chein, X. And Lee, K. 2022, The economic multi-fuel combined heat and power conductor (MF-CHPED) is a very complex and challenging power system operation optimization problem. Conventional particle swarm optimization algorithms often have premature convergence and low efficiency when solving the MF-CHPED problem. Collective intelligence is a cutting-edge technique of evolutionary computing. In this paper, the term [9] is used.

Dufo-Lopez et al. in the year 2006 Explore the multipurpose design of discrete hybrid systems. The design is presented as an optimization problem, the solution of which is an optimization problem that minimizes the total installation cost and atmospheric emissions over the system configuration and control strategy. For example, we designed a PV-wind diesel system for two different load profiles and found a solution that the designer could choose considering the cost and pollution of each. The results obtained show the practical value of the design method used [10].

Maith, J. et al. 2014, It is the renewable energy sources that are provided. Energy from solar, wind, biomass, hydroelectric, geothermal and marine sources are technological options for producing clean energy. However, less energy is generated from the sun and wind [12].

Jaya in India and others. 2016, They proposed a new swarm information algorithm, the Gray Wolf Optimizer, for solving non-linear, non-linear and discrete economic allocation problems with parallelism and multiple parallelisms. Gray Wolf Optimizer is a new measurement algorithm based on gray wolf behavior. The optimizer is hybrid to incorporate crossover and mutation for better performance. Four problems are addressed, related to economic distribution (6, 15, 40, and 80 generators), limited operating area, valve top opening effect, and maximum speed limit of ramps, with and without cranking losses. The damage is calculated by using it For- Exchange. The results obtained are compared with other methods presented in the literature. [13].

Muhammad H. Ja Hassan Salah Kamel 2023; An economic load distribution (LD) optimization problem involves allocating thermal units to the best generation capacity to minimize costs while meeting operational constraints. LD is a high-dimensional non-convex problem that has become a more challenging problem for optimizing the output power of large systems. In this regard, Beluga Whales Optimization (EBWO) has been proposed for the management of large-scale ELD systems. Beluga Whale Optimization (BWO) is a powerful new optimization method that mimics the behavior of beluga whales (BWO) when catching, swimming and releasing fish. However, BWO may result in a loss of environmental benefits and a reduction in population diversity. [14].

III. RESEARCH METHODOLOGY

A modular controller can control generators of various types and sizes (for example, wind turbines, photovoltaic power plants, small power plants, diesel, gas turbines, etc.). The components of the operating system are autonomous and based on a separation method that supports operation according to a previously selected main objective (for example, saving fuel, reducing costs). The control system can be adjusted according to different situations, such as changes in maintenance procedure, improvement of diesel engine, adding renewable generators or increase in consumer demand, battery degradation, etc.

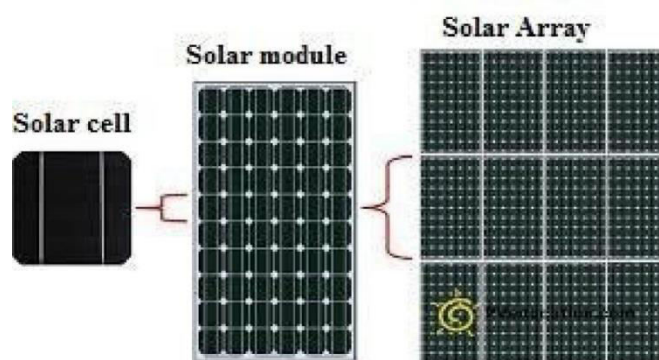


Fig. 1 Photovoltaic cell, module and array

For engineering applications, many researchers have studied simple simulation models such as energy efficiency models that can predict time series or average efficiency of PV arrays under different weather conditions. A new simulation model is presented to predict the performance of photovoltaic arrays for engineering applications based on I-V curves of photovoltaic modules. Five parameters are introduced to explain the complex dependence of PV module performance on solar radiation intensity and PV module temperature. The authors concluded that this simulation model is simple and is particularly useful for engineers to calculate the actual performance of PV modules under operating conditions when data provided by the PV module manufacturer is limited. Next, a mathematical model is described to estimate the output power of a photovoltaic module based on the equivalent circuit of a solar cell. It consists of a current source, a diode, a series resistor and a shunt resistor.

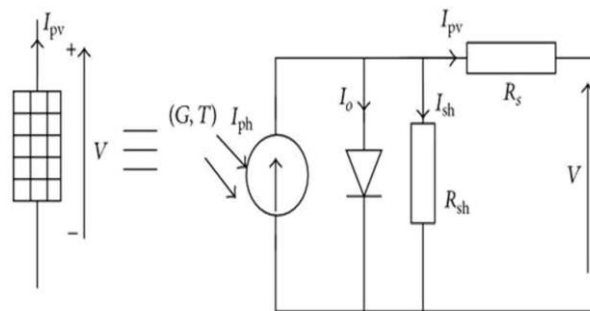


Fig. 2 Equivalent circuit of a PV cell

One of the main problems with solar and wind energy is their intermittent nature and resulting power cuts. These problems can be mitigated through the use of hybrid technologies, which use multiple energy sources and convert them into a single form of energy. Some examples include wind / photovoltaic energy systems, wind/diesel generator systems, wind/photovoltaic/hydroelectric systems, and solar/wind/biogas systems.

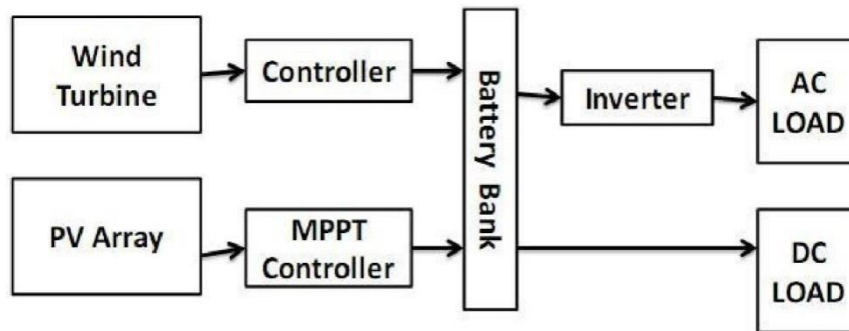


Fig. 3 Hybrid system consist in PV and Wind sources

IV. THE HYBRID POWER SYSTEMS MODELS

Electricity generation mainly includes solar cells, wind and DG. Energy is generated from the combination and distributed to the load via a hybrid controller; the function of the hybrid controller is to allow the power sources to generate loads separately or simultaneously depending on the availability of the power sources.

If solar power and grid are available, the battery is powered by solar power. If wind and grid are available, electricity is used to load. Materials coming from three sources – solar, wind and grid – are collected to avoid waste. Electricity is used when there is no spare power. With this method, we can eliminate waste and ensure less consumption of electricity from the network. The control system is done using a 12V relay where we adjust the voltage to 12V. Diodes are connected to relays for control. Two diodes connected to relay 1, relay 2, relay 1 and relay 3 ensure that relay 1 does not operate when relay 2, relay 3 or both operate. This means that if there is no source of renewal, the power stops. When solar wind is available, relay 3 and relay 2 are powered from the same source and fed by the battery. Only if the power of the mice works, there is another way. Three LED lights are connected to solar, wind and grid. These are

provided as a signal to identify the incoming source available in real time. An LED light is provided along with the output to indicate the flow of power from the control unit to and from the controller while the battery is charging.

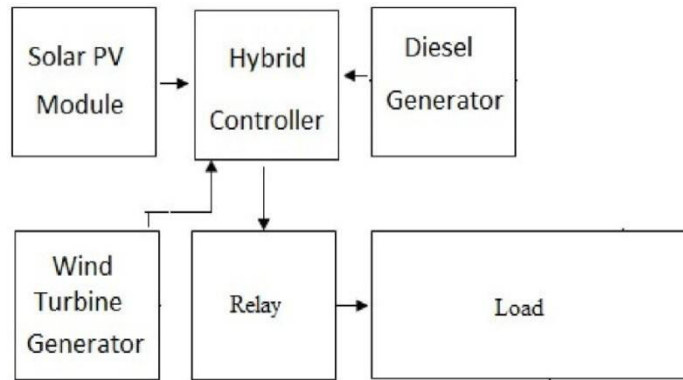


Fig. 4 Hybrid block diagram

Solar	Wind	Grid	Modes
ON	OFF	ON	PV
OFF	ON	ON	Wind
ON	ON	ON	PV and wind
OFF	OFF	ON	Grid

Table. 1 The algorithm based on controller adopted for optimal power flow

V. SIMULATION OF HYBRID POWER STATION

A hybrid power source consisting of solar, wind and diesel generators was simulated in MATLAB and the simulation was validated in the laboratory using an experimental setup. Hybrid power products are controlled by multiple gate controllers that operate in a variety of ways.

The availability of wind energy is very high compared to other renewable energy sources. In this example, wind power is preferred because it can produce electricity both during the day and at night. However, solar cells are also considered efficient on a load basis. Initially, the diesel engine provides support until solar panels, wind power or total power generation reaches at least 5 kW. When the total output power reaches 5 kW, the monitoring system will turn off the diesel engine. Depending on the total power generated, two additional load resistance ranges can be added. When the total power reaches 10 kW, the control system closes the circuit for additional preload. When the total power reaches 12.5 kW, the second auxiliary burner will turn off. Therefore, the maximum power that can be used for hybrid electricity is 15 kW.

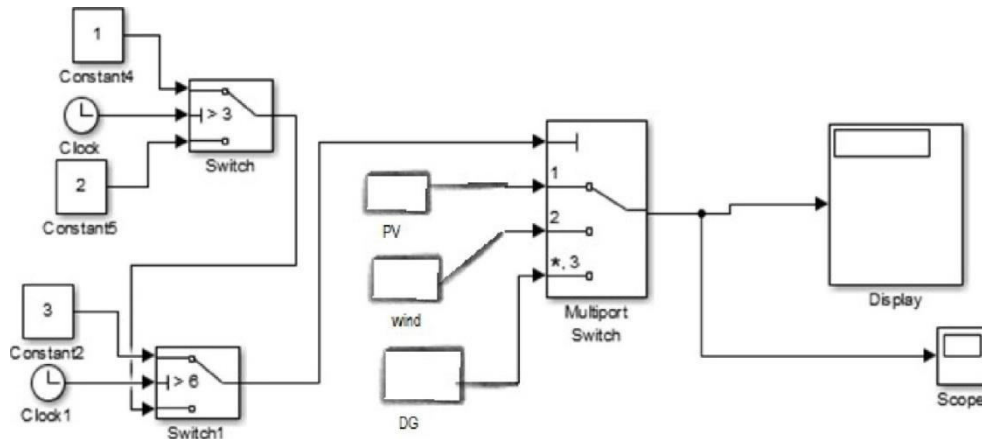


Fig.5 Simulation of hybrid operation controller

Mode-1

In this situation, the PV power alone is sufficient to meet the load demand when other sources are operating. This method is valid from $t=2$ to $t=5$ seconds. The output is permanent and is fed by a transformer. As the PV load alone was sufficient to meet demand, other sources were shut down.

Mode-2

In this situation, only WTG is sufficient to meet the load demand when other sources are operational. This method works from $t=5$ to $t=10$ seconds. Download found. Because there was enough air to meet the load demand, other sources were shut down.

Mode-3

In this mode, both PV and wind will operate as the load demand increases. This situation lasts from $t = 10$ to $t = 15$ seconds.

Solar	Wind	Diesel	Modes	Operating time(sec)
ON	OFF	OFF	PV	2-5
OFF	ON	OFF	Wind	5-10
ON	ON	OFF	PV and wind	10-15
OFF	OFF	ON	Diesel	15-20

Table. 2 The algorithm based on operation controller for optimal power flow

VI. RESULTS AND DISCUSSION

Power from the hybrid power plant is fed to a multi-link relay-based controller. The regulator's mandate is to minimize the use of diesel power plants and maximize the use of renewable energy sources. The controller has been tested for practical use in a variety of environments. The average power generated by solar cells is about 6 kilowatts. Depending on load requirements, wind capacity can be up to 10 kW. When the total power reaches 5 kW, the diesel engine will turn off. Load power in kilowatts is expressed as ohmic primary load, secondary load and residual load.

When the solar and wind conversion system is active, the first auxiliary switch in the load bank closes, increasing the primary load by 10 kW. When the total output power reaches 12.5 kW, the second switch closes to load another load. All waste is added with additional weight between 0.8 seconds and 1.5 seconds to adjust the frequency. After 1.5 seconds when it stabilizes at 60 Hz, the frequency controller turns it off. When solar and wind power are supplied for 0.6 to 0.8 seconds, some fluctuations in load voltage are observed. This operation also affects the system frequency.

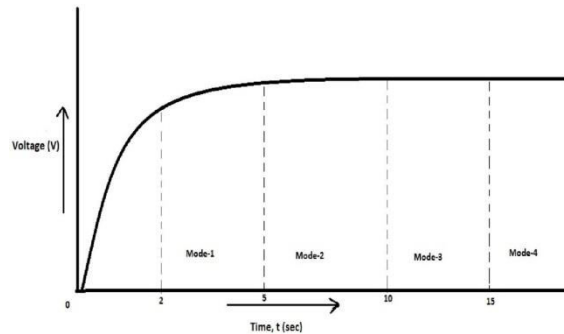


Fig.6 Output voltage of continuous mode hybrid power station

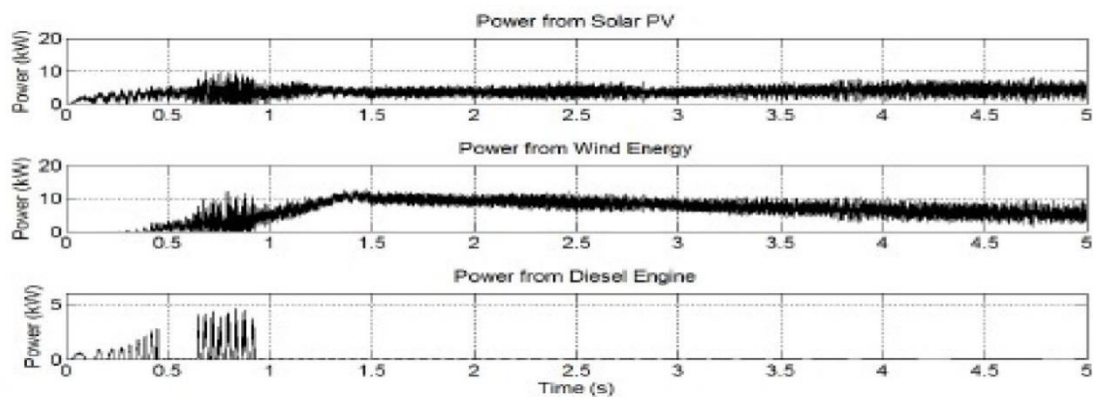


Fig. 7 Power generated by solar, wind and diesel generator

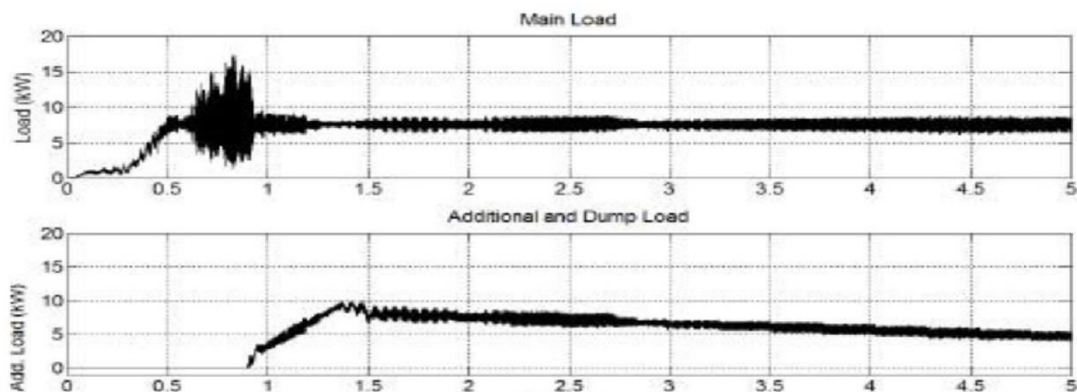


Fig. 8 Power consumed by resistive main load, additional load and dump load in KW

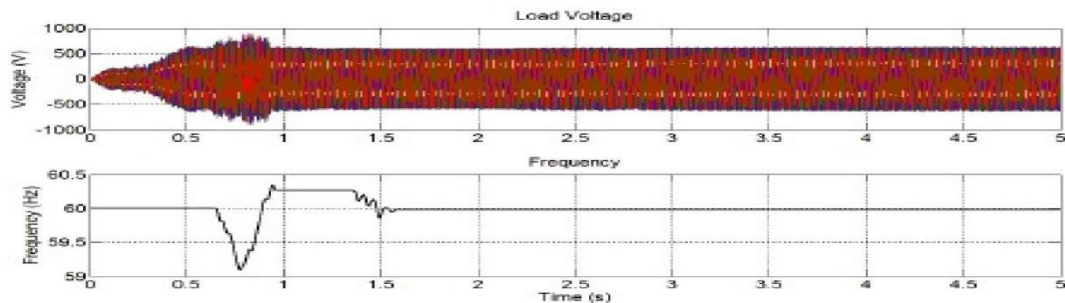


Fig.9 Voltage regulation at load side and status of system frequency

VII. CONCLUSIONS AND FUTURE SCOPE

This study provides a descriptive model of a sustainable hybrid power plant. The simulation model consists of investigating the behavior of the solar wind diesel system in continuous operation. This study describes a mathematical model of solar and wind energy conversion systems. Both solar power conversion systems and wind power conversion systems incorporate peak load zone monitoring and voltage control technology. A simple power control strategy is developed to analyze the reliability of hybrid power systems. A series of fixed representative loads are used to control the frequency of the system. The continuation of this research includes control systems to reduce transient effects in different operating modes and frequency control through energy conservation.

The proposed controller and continuous-mode hybrid power plant use additional optimization techniques to reduce manufacturing costs and improve system conversion efficiency and reliability. Such continuous mode hybrid plants are also used in off-grid systems in remote areas to meet load requirements. Currently, there are no guidelines to address power quality issues in hybrid power plants, hence further improvements can be made by considering guidelines for improving power quality in hybrid power plants connected to the grid.

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