Energy Optimization of Hybrid PV System through Matlab

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Abstract - Since solar and wind power are inherently intermittent and unpredictable, higher penetration of their types into existing power systems can lead to high technical challenges, especially for weak networks or independent people who do not have sufficient and adequate storage capacity. By integrating the two renewable resources into an optimal combination, the effects of the variable nature of solar and wind energy resources can be partially solved, and the overall system becomes more reliable and economical. This article reviews the challenges and opportunities / possibilities of hybrid solar PV and wind energy integrated systems. Grid and frequency fluctuations and harmonic effects are the main power quality problems in networked systems and independent systems and have greater influence in the case of weaker networks. This can be largely solved by proper design, advanced fast response management facilities and good hybrid system optimization. This paper reviews the most important research work on optimal size design, power electronics topology and control reported in the literature. This article describes the latest technologies for networked and stand-alone hybrid solar and wind energy systems.

Keywords **-** solar, wind power, hybrid solar PV, Energy System

I. INTRODUCTION

Photovoltaic (PV) is the name of a method of converting solar energy into direct current electricity using semiconducting materials that exhibit the photovoltaic effect, a phenomenon commonly studied in physics, photochemistry and electrochemistry. A photovoltaic system employs solar panels composed of a number of solar cells to supply usable solar power. The process is both physical and chemical in nature, as the first step involves the photoelectric effect from which a second electrochemical process take place involving crystallized atoms being ionized in a series, generating an electric current. Power generation from solar PV has long been seen as a clean sustainable energy technology which draws upon the planet's most plentiful and widely distributed renewable energy source the sun. The direct conversion of sunlight to electricity occurs without any moving parts or environmental emissions during operation. [1]

A. Wind Power - The wind turbine can be defined as a machine which is produce the electrical power by converting wind's kinetic energy. Therefore, the wind turbine would be benefited from the regions that have average annual wind. The wind turbine has been ruled as another renewable energy source used for generating electrical power energy.

Recently it has been reported by the International Energy Agency that 46% global electricity would be from renewable energy source by 2050, and 21-30% of them from the wind turbine, according to Global Wind Energy Council. Nowadays, the world is going the way of getting green energy because of the great problem of increasing greenhouse with increasing demand of electrical power plant which were most of them used burn of fossil fuels to produce the electrical power energy. The wind turbine is one of the important sources which is used in hybrid system as micro-grid renewable energy specialty in this region that have more wind annually. Because of the wind turbine depend of dynamic mechanical energy, it has more maintenance if compared with the PV panels. So, when it used with PV solar panel it must be making the PV system as a significant to avoid the maintenance. [5]

B. Modeling of Photovoltaic Panels - The direct current electricity can be generate in photovoltaic system when is exposed to sunlight without environmental impact. The solar cell is the basic building block of Photovoltaic arrays. For inducing electrical energy from sun lighting energy, the PV system depends on semiconductor PN junction. Photovoltaic solar cell characteristic depends on the sunlight (temperature and radiation), also its output voltages. Figure 1 illustrate the similar circuit of a solar photovoltaic system array.

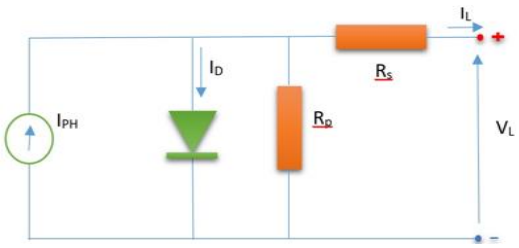

Figure 1: Equivalent Electrical Circuit of PV Array [2]

II. BACKGROUND

The relevant research reports and their conclusions in the field of renewable energy off-grid hybrid model control modeling in the literature are as follows.

Alsharif et al. (2017) Energy efficiency and renewable energy are the pillars of sustainability and environmental compatibility. This study outlines a sustainable, green cellular base station (BS) that accounts for the majority of the energy consumed by cellular networks. We reviewed the architecture and power model of BS and summarized the

trend of green cellular network research for the past 10 years. As a major contribution, this research is (i) researching the potential of system models and cellular BS renewable energy solutions, (ii) regenerating in cellular communications by determining the potential geography of renewable energy BSs Emphasize the application of potential energy. (iii) Based on our findings, case studies of mobile BS using renewable energy and direction of future research, (iv) review of current sustainable and green BS deployment, (v) Research to prevent renewable energy Barriers to widespread use of Energy BS and advice on future work

Pratap, Chiranjevi (2017) As new technologies such as hybrid electric vehicles, distributed generators, power electronics interface circuits and advanced controllers are integrated into the grid, today's power system networks are more complex than they are today. As a result, recent blackouts in some parts of the world indicate that power systems are under pressure. Real-time / online monitoring and forecasting of stability limits are necessary to prevent future power outages. The rapid increase in energy demand raises serious issues for the stability and reliability of power systems and is therefore a major concern. The shortcomings of traditional energy have paved the way to renewable energy. The latter can form part of a stand-alone system or grid-connected system. When integrated with other energy sources, a single renewable energy source is called a hybrid system. This article describes photovoltaic, wind and hydroelectric systems. In this paper, we developed an active power control strategy so that when the individual winds do not meet the energy requirements, the wind diesel mode transitions without affecting the frequency to meet the energy requirements. The mathematical model being considered uses STATCOM to meet reactive power requirements for sudden power changes. Performance and analysis are done in a user-friendly MATLAB / Simulink environment.

Hassan et al. (2016) Most of the world's population lives in remote rural areas with remote areas and densely populated areas. This study is based on modeling, computer simulation, and hybrid power system optimization in rural areas of Muqdadiyah region of Diyala, Iraq. Consider two renewable resources: photovoltaic (PV) and wind turbine (WT). The proposed hybrid energy system model was studied and designed using HOMER software. Based on the simulation results, it has been found that renewable energy can replace traditional energy sources and be a viable solution for generating electricity remotely with reasonable investment. The hybrid system solution used to energize selected areas provides the lowest cost combination of hybrid systems that can meet demand in a reliable manner at a cost of around $ 0.321 / kWh. When wind power is at a lower stage of the study area, wind power is not economically variable.

Kanagasakthive et al. (2015) this paper introduces the simulation and analysis of a hybrid energy system consisting of wind and solar power systems. The wind and solar power systems are connected to a common load via a DCIDC boost converter. Usually, in low emission PV array systems, the voltage provided by the inverter is lower than the rated voltage which affects the quality of the power. It was overcome by using a battery energy storage system. In stand-alone mode, the converter must maintain a constant voltage and frequency when the load is non-linear, regardless of load imbalance or current quality. Modeling and simulation of hybrid and PI controllers using MATLAB / SIMULINK. Simulation results show that the proposed hybrid system may meet the power requirements of the isolated system. In the past few years, renewable energy has received more attention and considerable effort has been made to develop effective energy conversion and utilization systems. The main goals of these methods are to reduce environmental damage, save energy, deplete resources, and improve safety. Renewable energy systems can be used to provide power directly to the power system or isolated loads. Stand-alone systems can be used as water pumps for rural electrification [3] and can provide power to isolated areas remote from the power grid. Solar power and wind energy systems are the most promising renewable energy technologies.

III. DESIGN THE PROPOSED MODELS BY MATLAB SIMULINK

Integration of renewable energy generation with battery storage and diesel generator backup systems is becoming a cost-effective solution for resolving less usable renewable energy during the year. However, if storage runs out, there is no way of importing energy. Therefore, a combination of PV and wind energy sources with the battery energy storage system (BESS) is a suitable alternative supporting energy source for this type of generation systems, where are fed the several of three phase resistive with inductive (RL) circuits which represents as a variable loads by opening and closing of the circuit breakers, thus it due to fluctuations in power energy. And distributed generators can help of these fluctuations in power supply since generation units will be close to the loads. However, introducing diesel generators will require an up gradation in the existing protection schemes, but it is not enough to the regulation of power because of the renewable sources depend on the weather.

Block diagram of hybrid system of PV/Wind/ Diesel Generator are integrated and simulated in MATLAB Simulink as sown in Fig 2.

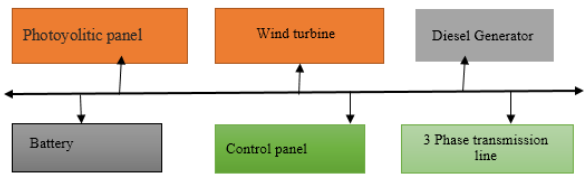

Figure 2: Block Diagram of Hybrid Model

A. PV-Wind System Model - Photovoltaic is a combination of more than one solar panel array of several solar cells, connected in series and parallel with large

voltage and current output of one solar cell, which it can be simplified to a diode in parallel with a current source. The current generation is directly proportional to the sun radiation falling on the cell, as shown in Figure 2. [3]

Description: From Figure 3, the 100KW of photovoltaic solar panel system array connected with the Micro-grid hybrid power system to feeding the loads demand with other sources in the same net.

PWM inverter convert the DC output of PV system into AC. Control of inverter system control the inverter that it automatic operate when external power supply is gone.

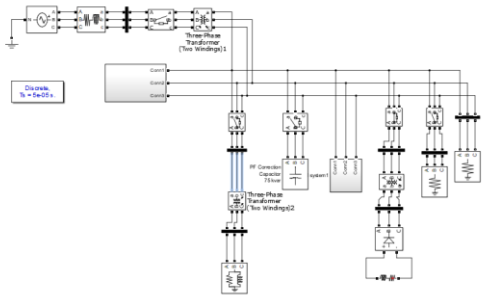

Figure 3: Top level Model

This system is consist of: The PV array, which depends on 2 panels that are connected to gather in parallel to generate DC voltage in 11 string that connected in series to supply power, which produce power it is equal to 9.464 Kwh, which is used to regulate DC output voltage from the PV array by MPPT controller, this converter it is necessary to connect with any solar system energy conversion because of the non-arrangement of sunlight used to vary of induced voltage during days.

IV. RESULTS AND DISCUSSION

The designed simulation system has been used to carry out the measurements and tests, to verify the predicted results of the system. The results obtained from the MATLAB simulations and practical implementations are compared. [4]

A. The Simulation Results of Standalone Hybrid Micro-Grid System - The SIMULINK MATLAB package version 2013a has been used for modeling and simulating of the system.

MPPT subsystem track the maximum power point as shown in fig. 4.

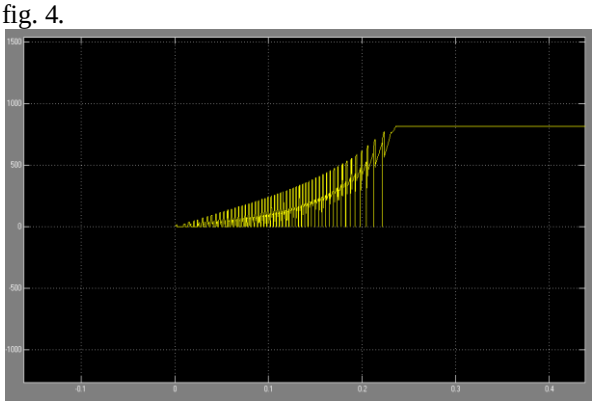

Figure 4: output current of MPPT system

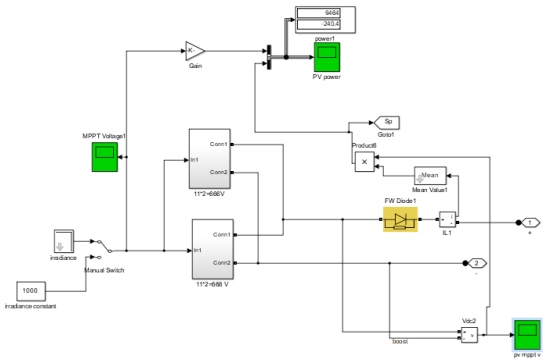

Figure 5: PV Subsystem

Wind subsystem is shown in fig. 6 a wind turbine is connected with PMSG and produce electricity. Permanent magnet synchronous generator (PMSG) convert mechanical energy from turbine into electric energy. Wind power graph is shown in Fig 7.

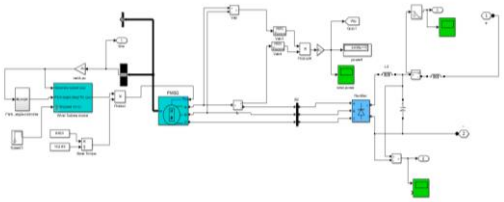

Figure 6: Wind subsystem

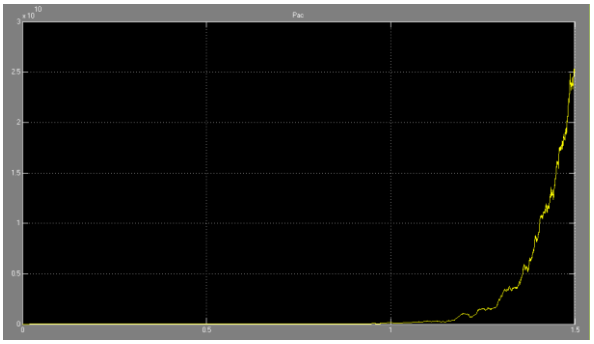

Figure 7 Wind power

V. CONCLUSIONS

This work is presented design and simulation of standalone hybrid micro grid power system and modeling of remote area electric distribution system. This paper investigates the three important works in one project by using MATLAB Simulink.

Throughout the results obtained, the following conclusions can be made:

1. The work shows a connection four different generation system that consists of PV/Wind/Diesel and operated together to support the load, and illustrated that can be operated more than one sources in one network otherwise they are different in conversion energy sources which in this network it benefited from four different type. The PV

system generate electrical energy from the sunlight, the wind turbine system generate electrical energy from wind kinetic energy, the diesel generator induced electrical energy from fuel chemical energy, and the battery that used as a storage energy system, from charging and discharging by a bi-direction converter device can be injected and absorbed power of the system model. This system was tested in a period of simulation time to showing the performance of the system with any varying from the load demand and natural sources. In the standalone mode during operation in the micro-grid system, the voltage and frequency in the system rapidly changed because of the unbalance between the loads with the sources generate, because of it is necessary to compensator system and controlling on it. [7]

2. Ability to transfer maximum power from photovoltaic system by using MPPT with (P&O) techniques, which is controlled of the duty cycle to regulate the booster and DC voltage in the PV array system to be constant with changing accorded by the sunlight energy.

3. These systems were friendly to the environment, because of using renewable sources instead of the fossil fuel engine system. And these systems were healthy by zero polluting emissions and had minimal operation cost

4. This type of system has the difficulty of control because of the different sources and independent on the main grid system, and by fluctuations in the air that effects to it during of annual and period of day and night.

The future work of this study can be extended to design:

1. A standalone hybrid PV-Wind-Diesel-Battery with Artificial Neural Network (ANN) controller can be studied, and compared it to the Fuzzy logic controller.

2. The modeling and intelligent control can be done for the grid connected mode of operation.

3. The present study work can be enlarged by using another renewable sources to get more energy from nature and increasing generating electrical power to covering load demand.

4. The purpose control system in this work, can enlarge it by controlling the sources in which situation can be operated or shut down according to changing each of the weather and the load. [20-27]

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