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Modeling & Simulation of Solar-Wind Based Compound Energy System with Energy Bank

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ABSTRACT
In this article, an unconventional fusion energy system including solar, wind with battery storage using MATLAB software is studied. Ideal resource usage is observed, efficiency is improved than that of individual way of generation. Due to this performance increases and dependency on single source decreases. The output of the system varies due to seasonal weather condition and sunrays. To give the maximum power function to PV arrays, maximum power point tracking technique [MPPT] is connected in DC/DC converter. This type of systems is used for both commercial and household purposes. Some hilly areas are not yet developed for using the grid connection for the sake of economic deprivation and jagged areas. By this undeveloped the people in those areas are suffering from electric shortages. To overcome their electrical issues the renewable energy sources are more useful. Utilizing of renewable energy sources decreases pollution; also this becomes more important these years. While installing, extra care should be taken in analyzing and modeling due to rare usage of system. Battery used in the system is for storage purpose in emergency times. This research is for theoretical study of solar, wind systems with battery storage capacity. Modeling and stimulation of solar, wind with battery hybrid power plant is presented in this study.
KEYWORDS: Renewable energy, Solar power, Wind power, Battery, Hybrid energy systems, power generation, simulation and modeling.

INTRODUCTION
It is common knowledge that the world's fossil fuel stocks are rapidly depleting. The majority of today's energy demand is met by fossil fuels and nuclear power facilities. Renewable energy sources such as wind, solar, biomass and geothermal are minor portion of total. According to law of conservation of energy "Energy cannot be created or destroyed; it can only be changed from one form to another." Most of current researches focused on how to preserve and exploit it efficiently. The innovation of effective and active systems to harness energy from unconventional energy resources has also been studied.
Wind and solar power sources have grown at a galloping rate in the last decade. Both solar energy and wind energy are on the path to becoming the world's most affordable sources of energy.
Sunlight is the major resource since numerous countries in tropical and temperature climate have direct solar densities exceeding 1000W/m2.Solar cells convert sunlight directly into electricity. The amount of power generated by each cell is very low. Therefore, large numbers of cells must be grouped together, like the panels, to generate enough power. Wind turbines work on a simple principle instead of using electricity to make wind, like a fan wind turbine uses wind to make electricity. Wind turns the propeller like blades of a turbine around a rotor, which spins a generator, which creates electricity.
Wind is a form of solar energy caused by a combination of three concurrent events. The sun unevenly heating the atmosphere, irregularities of the earth's surface, the rotation of the earth. Batteries are electrochemical devices and they store energy by converting electric power into chemical energy. This chemical energy is released again to produce power. A battery energy storage system is an electrochemical device that charges (or collects energy) from the grid or a power plant and then discharges that energy at a later time to provide electricity or other grid services when needed.

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MODELLING OF WIND-SOLAR POWER SYSTEM

A. WIND POWER SYSTEM:

Wind power or *wind energy* describes the process by which the wind is used to generate mechanical power or electricity. Wind turbines convert the kinetic energy in the wind into mechanical power. The power coefficient has a theoretical maximum value of 0.59. It is influenced by two factors: tip speed ratio (TSR) and pitch angle. The pitch angle of a turbine is the angle at which its blades are aligned with its longitudinal axis. TSR is the rotor's linear speed in relation to the wind speed. Tip Speed Ratio (TSR)

$$\lambda = \omega * R/V_w$$

Where:
λ = Tip Speed Ratio
ω = Turbine rotor speed (rad/s)
R = Radius of the turbine blade
$(m)v_w$ = Wind speed (m/s)
Model of wind energy converter is made with following assumption:
- Frictionless;
-Stationary wind flow;
- Constant wind flow (shear-free);
- Free flow (rotational);
- Incompressible wind flow$(\rho = 1.22\, kg/m^3)$;
- Free wind flow around the wind energy converter.

With above given assumptions, a theoretical model of independent of the technical design of wind energy converter can be used to calculate the maximum physically convertible wind energy. An amount of energy is contained in the moving air mass. This energy is derived from the air movement caused by a pressure gradient on the earth's surface. Energy is used to generate electricity via wind turbines.

Maximum power value derived from the kinetic energy of the air masses by wind converter, provided by equation:

$$P_{max} = (8/27) * A\rho V^3$$

A fraction of incident air flow is representing theoretical power given by:

$$P_{max} = (8/27) * A\rho V$$
$$P_{wind} = 0.5A\rho v^3$$
$$P_{max} = P_{wind} * C_\rho$$

An induction generator or synchronous generator may be used as electric generator. The mechanical power generated by the wind is given by:

$$P_m = 0.5\rho A C_\rho(\lambda, \beta)v^3$$

Where:
ρ-air density;
A-rotor swept area;
$C\rho$ (λ, β)-power coefficient function;
λ-tip speed ratio;
β-pitch angle;
v_w-wind speed;

The magnetic field is generated by a shaft-mounted permanent magnet mechanism and current is induced into stationary armature, the term synchronous refers with the fact that the rotor and magnetic revolve at the same speed.

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B. SOLAR POWER SYSTEM:

Solar power is the conversion of energy from sunlight into electricity, either directly photovoltaic's (PV) or indirectly using consent_rated solar power. Photovoltaic cells convert light into an electric current using the photovoltaic effect. Photovoltaic's were initially solely used as a source of electricity for small and medium-sized applications, from the calculator powered by a single solar cell to remote homes powered by an off-grid roof top PV system.

To determine how many solar panels you need, you'll need to know: your annual electricity consumption, the wattage of the solar panels you're considering, and the estimated production ratio of your solar system**.** You can calculate the number of solar panels you'll need by dividing the system size by the production ratio, and again by the panel wattage.

The actual number of panels you'll need to install depends on factors including your geographic location, panel efficiency, panel rated power, and your personal energy consumption habits.

According to the Shockley equation, which defines the dependency of current and voltage in a solar cell, the open circuit voltage increases logarithmically?

$$I = I_{pv} - I_o[\exp\left(\frac{qU}{kT}\right) - 1]$$

$$U = kTq\ ln1 - I - I_{pv}I_o$$

Where:
K-Boltzmann constant (1.3806* 1023 J/K);
T-Reference solar cell temperature;
Q-Elementary charge (1.6021 *1019 AS);
U-Solar cell voltage;
I_o-Diode saturation current;
I_{pv} -Photovoltaic current.

SIMULATION OF SOLAR AND WIND POWER SYSTEM

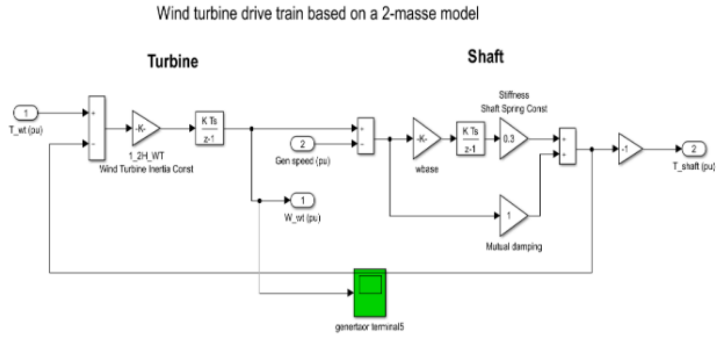

Fig.1: Simulink model of wind turbine.

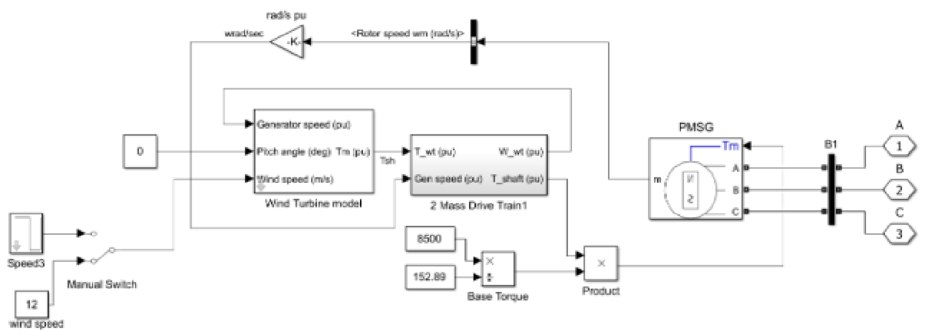

Fig.2: Wind power system model

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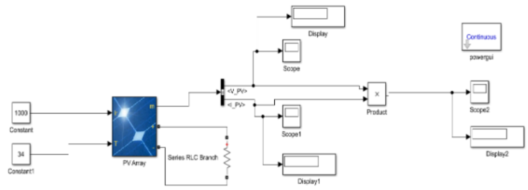

Fig.3: Solar power system model

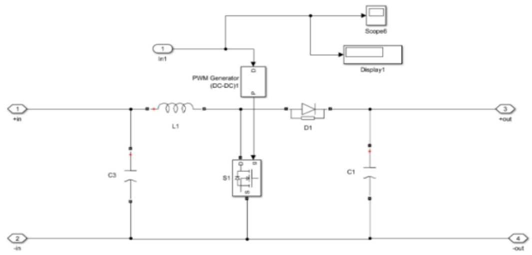

Fig.4: Boost converter

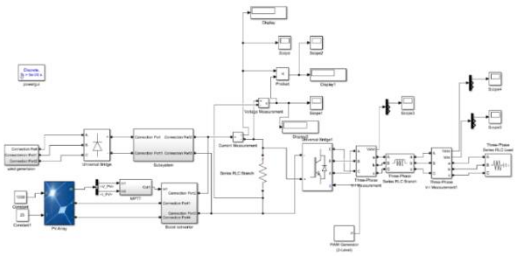

Fig.5: Existing model of solar and wind-based hybrid system

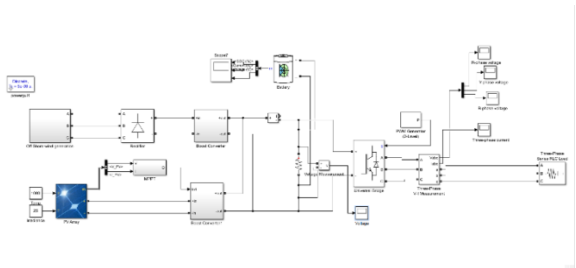

Fig.6: Proposed model of solar and wind-based battery connected hybrid system.

RESULTS

The research focuses on a PV-wind battery connected hybrid system with a DC load. We require a current and voltage sensor for each of them to ensure the maximum power delivered is maintained with environment variations. Hybrid system is chosen for higher effective rate than single source system.

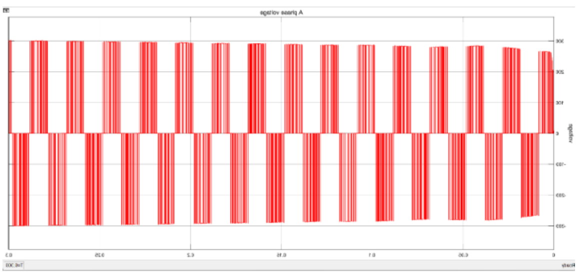

Fig-7: R-Phase voltage

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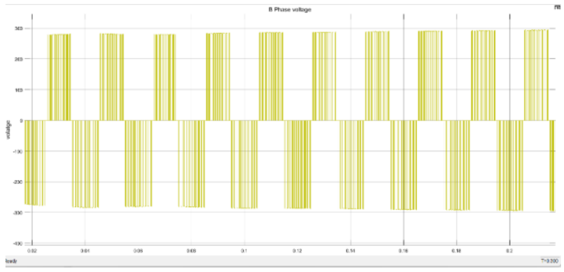

Fig-8: Y-Phase voltage

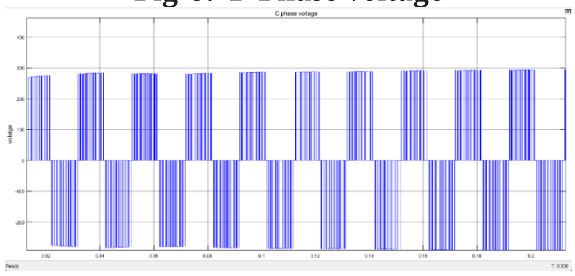

Fig-9: B-Phase voltage

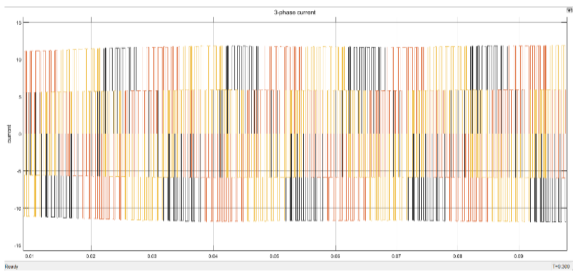

Fig-10:3-Phase current

CONCLUSION

Individual renewable systems have limitations but hybrid power system can meet energy demand due to combination of two or more renewable sources. These systems are more beneficial for rural and hilly areas. Hybrid systems are the best answer for clean and distributed energy. Several advantages of wind and solar electricity generation are mentioned, as they are environmentally friendly, easy installation. In this model, a MATLAB simulation was run, and numerous output graphs were generated, demonstrating the performance of a wind and solar energy system. Different graphs are obtained as a function of time, such as turbine angular velocity, rotor speed, mechanical torque, electrical torque, output line to line (L-L) voltage, de output of solar PV, ac output of the inverter, and output root mean square (R.M.S.) voltage. Finally, the output voltage of a hybrid system combining solar and wind power is demonstrated through graph.

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