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ANALYSIS OF MICROGRID HYBRID ENERGY SYSTEM

I. INTRODUCTION

Now more and more photovoltaic panels and wind turbines are integrated into grid, whose power fluctuation will lead to grid instability. Microgrid system is one of the solutions. There are many benefits of Microgrid including little pollution, higher reliability, better quality of power supply, and higher efficiency. This research presents hybrid DC- and AC-bus Microgrid system, which can be established in a country or island.

To avoid global warming, the consumption of fossil fuels must be reduced. Hence, the installation of renewable energy power production plants has become a burning issue not only for isolated islands but also all over the world. Among various renewable energy systems, photovoltaic power generation systems (PV systems) and wind power source are expected to play an important role as a clean electricity power source in meeting future electricity demands.

Photovoltaic (PV) power as an alternative energy resource has been becoming feasible due to Enormous research and development works being conducted. The use of Photovoltaic (PV) generators in isolated sites, where conventional generation is not practical, can pose a problem because PV output power depends on weather conditions and cell temperature, making it an uncontrollable source. Furthermore, it is not available during the night. We consider resolving this problem by installing a hybrid system using an alternative wind energy source along with the PV array. Solar arrays provide dc power.

Hence, power from a solar array cannot be directly added to an isolated power utility for using directly in residential, industrial or commercial applications. We require a DC-DC converter to step up the dc voltage from the panel and then an inverter to convert the dc into ac power which can be fed to the utility. A Photovoltaic (PV) system’s power output is not constant and fluctuates depending on weather conditions (variations in irradiation and temperature). Therefore we also require a Maximum Power Point tracker (MPPT) along with the DC-DC converter in order to obtain the maximum power output from the Solar Photovoltaic (PV) array. In the hybrid system a wind power generators along with PV generators feeds the utilities loads.

The response of the hybrid system following common disturbances such as solar insulation variations and load changes have to be is investigated for

analyzing the effects fluctuating power causes in the isolated power utility. This study is essential for devising a method for leveling the fluctuations in a PV system's power output when large output power from several PV systems has to be penetrated in the utility.

II. HYBRID POWER SYSTEM

A. Isolated Power Utility

This research presents hybrid DC- and AC-bus Microgrid system, as shown in Fig. 1, which can be established in a country or island.

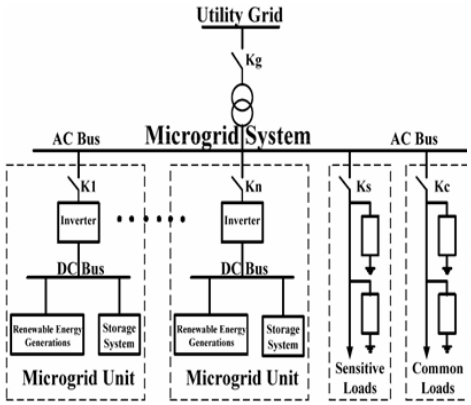

Fig. 1. Hybrid power system

There are many units in the system which can be used in a house of a country. All the renewable energy generations and storage devices in the house are connected to DC bus with different converters which can supply power to local DC loads. Inverters are used to transfer power between AC and DC buses. Common and sensitive loads can be connected to AC bus with different coupling points. If there are some faults happened in utility grid, Microgrid system can work in islanded operation. In worse condition, if renewable energy generations can’t supply enough power for local Fig. 1 Micro grid systems with hybrid DC and AC buses Loads and state of charge of storage devices are in low level, Microgrid could cut common loads to keep supplying power to sensitive loads. In hybrid DC- and AC-bus Microgrid system, fewer inverters are needed. Therefore, control strategy for parallel inverters is easier in islanded operation. In addition, DC loads can be connected to DC bus directly without rectifier. Also the system can isolate individual units if there is something wrong in the unit.

B. PV-Wind Hybrid Power System

One unit of the Microgrid system is established in the lab as shown in Fig. 2. It consists of a wind turbine, photovoltaic panels, batteries series connected and super-capacitor. The stability of DC- and AC-bus voltage is very important. When Microgrid system is connected to the utility grid, the amplitude of DC-bus voltage (200V) is regulated by the inverter, and voltage of AC bus is the same with the utility grid. However when the Microgrid works in

islanded operation, DC-bus voltage must be regulated by renewable energy generations and storage devices, and the voltage and frequency of AC bus are controlled with voltage-frequency or droop control strategy of parallel inverters.

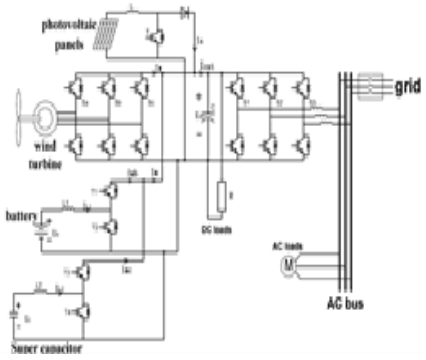

Fig. 2. The PV-Wind hybrid system model

III. MODELLING OF PV ARRAY

A. Modeling Of PV Cell

The equivalent circuit of the ideal PV cell is shown.

The basic equation from the theory of semiconductors that mathematically describes the *I–V* characteristic of the ideal PV cell is

$$I = I_{pv,cell} - I_d,$$

Where, $I_d = I_{0,cell}[\exp\left(\frac{qV}{akT}\right) - 1]$,

Therefore, $I = I_{pv,cell} - I_{0,cell}[\exp\left(\frac{qV}{akT}\right) - 1]$.

Where, $I_{pv,cell}$ is the current generated by the incident light (it is directly proportional to the Sun irradiation), *I*d is the Shockley diode equation, $I_{0,cell}$ is the reverse saturation or leakage current of the diode, *q* is the electron charge (1.60217646 × 10−19 C), *k* is the Boltzmann constant (1.3806503 × 10−23 J/K), *T* (in Kelvin) is the temperature of the *p–n* junction, and *a* is the diode ideality constant

B. Inverter In A PV System

The principle of a stand-alone inverter used in a PV-Diesel hybrid system can be explained with reference to the single-phase equivalent shown in Fig. 3.The inverter has a full-bridge configuration realized using four power electronic switches (MOSFET or IGBTs) S_1, S_4. In this scheme, the diagonally opposite switches (S_1, S_4) and (S_2, S_3) are switched using sinusoidal pulse-width modulated gate pulses. The inverter produces sinusoidal output voltage. The inductors X_1, X_2 and the ac capacitor C_2 filter out the high-switch-frequency components from the output waveform.

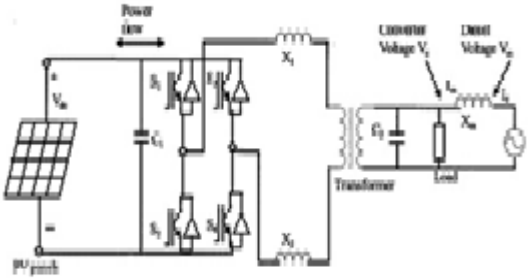

Fig. 3. Inverter in a PV system

IV. Wind turbine

The synchronous generator is currently used in WECS, especially in law power for battery charging, for example. But the use of PMSG in high power generation is recent. It is facilitated by the technologic progress realized in power electronics and permanent magnet materials used in generator rotors. The use of PMSG allows to eliminate the gearbox and to operate at variable and low speed; which is adequate with wind speed nature.

Variable speed operation of wind energy conversion system contributes to decrease the mechanical stress and acoustic noise and offers possibility to control of active and reactive powers; the PMSG is connected to the grid via two power electronics converters with an intermediate DC link bus. The generator side converter is controlled via hysteresis regulation of generator currents with zero direct current; in order to obtain a maximal torque for a minimal current.

The MPPT algorithm is used to determinate the optimal rotational speed reference for any value of wind speed under the nominal regime in order to maximizing power captured by the wind turbine. The grid side converter is controlled by pulse width modulation (PWM) obtained from proportional integral (PI) regulation of currents sanded to the electrical grid. The DC link voltage is kept at constant value with a DC/DC converter and PI regulation of DC voltage at its reference. Power limitation for high wind speed values is achieved by varying the blade angle (Pitch control) which corresponds to decrease in power coefficient.

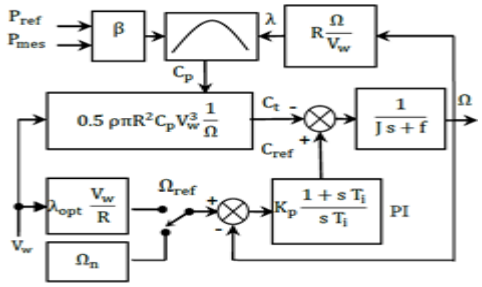

Fig. 4. Control diagram of wind turbine

The speed reference allows to maximizing the power captured by the wind (MPPT strategy) is given by:

When the wind speed reached the nominal value, the pitch angle regulation (based on fuzzy logic algorithm) enter in operation in order to decrease the power coefficient. The simplified representation of wind turbine control diagram is shown in Fig. 4.

V. GRID CONNECTED OPERATION

Micro grid works in grid-connected operation. In this case, the wind and solar generators should work in Maximum Power Point Tracking (MPPT) strategy to get higher energy efficiency. In order to reduce the influence of fluctuation to utility grid, energy storage system should be controlled to supply the power difference between renewable energy generations and loads. Fig. 5.

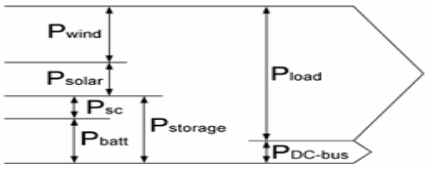

Fig. 5. Power Flow in the system

Pstorage = Pbatt + Psc = Pwind + Psolar – P load

In grid-connected operation voltage of DC bus is controlled by inverter and amplitude and frequency of AC-Bus voltage are the same with utility grid. When power from renewable energy generations is fluctuant or loads change quickly, hybrid storage system including batteries and super-capacitor must absorb or release power difference very fast. According to the character of different storage devices, high frequency power is released or absorbed by super-capacitor

VI.SIMULATION RESULTS

Integration Of Wind and Solar

The power obtained from the solar and the wind energy conversion systems are given to an inverter as shown in Fig 6.

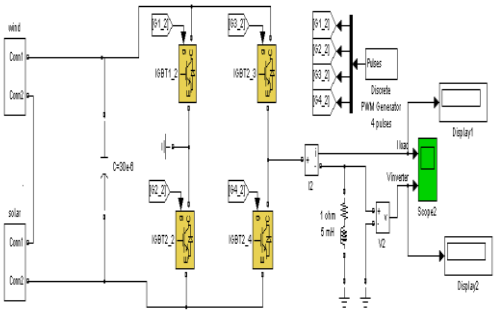

Fig. 6. Integration of wind and solar

The voltage and current waveforms obtained at the inverter ends are shown in Fig 7.

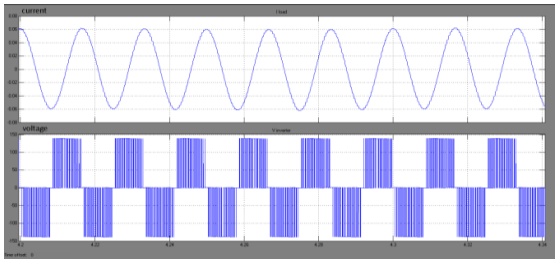

Fig. 7. Output voltage and current of PV-wind

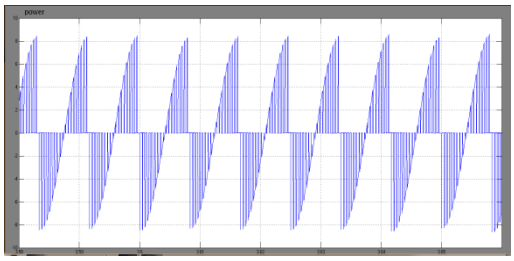

Fig. 8. Combined output power of two PV-plants and wind turbine

VIII. CONCLUSION

This paper aims at implementing a PV Wind, hybrid system connected to an isolated power utility. The basic concepts of solar array, DC-DC boost converter, PWM inverter, Wind turbine are discussed. The modeling methods of all components of the hybrid system are described. Simulation studies are done for the standard test conditions using MATLAB/Simulink. The response of a PV-Wind hybrid system connected to an isolated power utility following common disturbances such as solar insulation variations and wind speed change and load changes were simulated to understand the power fluctuation caused.

References:

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