

# Energy Management and Control System for Hybrid Wind-Solar Energy System with a Battery Storage

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**Abstract-** A hybrid wind solar energy system with battery storage and its control systems are presented in this dissertation. The proposed system consists of a wind turbine, a solar panel, a battery storage unit and a set of loads. A power electronics interface, based on various converters, is used to integrate the renewable energy sources and the storage device to the main DC-bus feeding a single phase AC load. The main challenge of the hybrid system is to maintain the load demand under constraints. The objective of the proposed controllers is to ensure a proper control and coordination between all the sources of the system. At the wind energy side, a speed controller is used to keep the rotor speed under control for safe operation of the wind turbine. At the solar energy side, an incremental conductance method approach is realized to extract the maximum power from solar irradiance. A bidirectional DC-DC converter is employed to control the charging and discharging of the battery storage system. An energy management system is developed to keep a balanced energy in the hybrid system. A load voltage regulator enables the system to fix the output voltage and frequency. An experimental setup of the hybrid energy system is developed using electrical devices from Fest (formerly Lab Volt) and rapid controller prototyping is achieved using the real-time OPAL-RT digital control system. Experimental results for various conditions are presented to validate the control algorithms developed in this work.

**Index Terms**— Wind,solar,hybrid energy systems.

## 1. INTRODUCTION

Demand for power is ever-increasing. Use of fossil fuels i.e. gas, coal, oil etc. in producing power is also increasing. Still, there are over 1.5 billion people The over the world deprived of access of electricity living mostly in remote areas. The source of electricity in those remote islands and villages is diesel generator. This is both costly and hazardous for the environment due to the global warming. Renewable energy resources like wind and solar energy are getting popularity for these reasons. Two or more renewable energy resources can be utilized in a hybrid renewable energy system(HRES) which can work as a standalone or grid connected system. A hybrid renewable energy system offers better quality in terms of reliability compared to single source based system. This is due to the fact that one power source can supply power to the load when other sources are either generating low or no power. The selection of renewable resources in HRES depends on the particular location. In this research work a wind-solar HRES is considered. Wind and solar combination is most promising source of generating energy primarily due to their complementary nature advantage. Wind power generation could be low in time when solar power generation is in its peak. On the other hand, the wind is often stronger in seasons when there is less solar irradiance. Wind and solar energy are unpredictable in nature, as they depend on climate condition. To improve the reliability of a wind-solar hybrid system other sources like battery storage, fuel cell, diesel generator can also be integrated. This research work focuses on the development of energy management system and control systems for wind-solar hybrid energy system. The proposed control algorithms are tested to validate the algorithms using RT-LAB real-time simulator. In this chapter,

detailed backgrounds of the system and literature review are discussed.

## II.BLOCK DIAGRAM OF PROPOSED SYSTEM

The main purpose of this research work is to develop an experimental model of hybrid wind solar energy system with battery storage. The main components of this system are wind turbine, solar panel, battery, converters, inverters, filter and resistive loads.

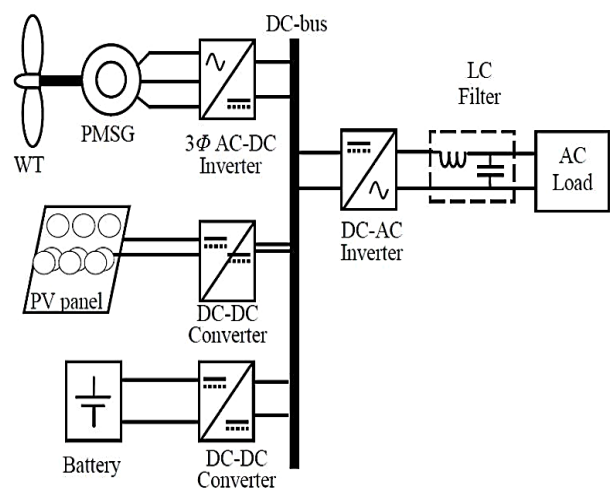


Figure 1 Proposed hybrid wind-solar energy system with battery storage

**The block diagram of proposed system consists of the following blocks:**

**A . Wind turbine**

Wind turbine is a device that converts winds kinetic energy into electrical energy. Wind turbines are manufactured in wide range of vertical and horizontal axis types. The smallest turbines are such as application for battery charging for a traffic warning signs power for boats etc.

#### **B. PMSG (permanent magnet synchronous generator)**

A model of variable speed wind turbine using a PMSG is presented and the control schemes are proposed the model presents the aerodynamic part of the wind turbine, the mechanical and electric parts.

#### **C. 3-phase AC-DC inverter**

DC to AC converters are normally used for high power applications. The advantages of three phase inverters are the output voltage can be controlled by varying the dc link voltage. The frequency of the output voltage waveform depends on the switching rate of the switches and can be varied over a wide range

#### **D. PV Panel**

A PV module is a packaged connect assembly of typical photo voltaic solar cells. The PV system that generates and supplies solar electricity in commercial and residential applications. A photo voltaic system typically includes an array of PV module an inverter, a battery packed for storage, interconnection wiring.

#### **E. DC-DC Converter**

A DC-DC converter is an electronics circuit or electromechanical device that converts a source of direct current from one voltage level to another. It is a type of electric power converter power levels ranges from very low to very high.

#### **G. Battery**

An electric battery is a device consisting of one or more electromechanical cells with external connections provided to power electrical devices. When a battery is supplying electric power, its positive terminal is the cathode and negative terminal is anode. Battery comes in many shapes and sizes from miniature cells used to power hearing aids etc.

#### **H. LC Filter**

An LC circuit, also called a resonant circuit or tuned circuit, is an electric circuit consisting of an inductor, represented by the letter L, and a capacitor, represented by a letter C, connected together. The LC filter has the function to pass through the signal of a specific bandwidth. It is a basic filter circuit composed of LC. Therefore, it becomes possible to pass only the signal component of the band.

#### **I.AC Load**

AC loads are more commonly available, require smaller wire size and are less expensive than their dc counter parts.AC is an acronym used for alternating current which is provided by the utility and it is generated by using an alternating generator. Loads that required ac power are commonly called as ac loads.

#### **J. DC-AC Inverter**

A power inverter is an electronic device that changes DC-AC. The input voltage, output voltage and frequency and overall power handling depend on the design specific device. A power inverter may be a combination of mechanical effects(such as rotary apparatus) and electronic parts.

### **III.WORKING PRINCIPLE**

Depending on several sources of energy has become standard in recent years from growing energy consumptions to limit on fossil fuels and increasing environmental concerns to innovations in alternative and renewable energy sources to meet our needs as operators, owners, manufactures, investors of power plants, we offer a wide range of services including fossil, wind etc. HRES is a combination of two or more renewable energy resources with a storage or utility grid. In this section, a combination of wind and solar, with an energy storage is considered for HRES with a discussion from different authors about the configurations and control strategies used to operate such systems. The HRES configuration proposed of wind and solar photovoltaic (PV) connected to grid. A multi input DC-DC converter is used to implement the maximum power point tracking (MPPT). If one of the sources is unable to generate power, this DC-DC converter can still transfer the maximum power from the other source. A full bridge converter converts the DC power into the AC power. The control strategy is implemented using microcontroller.

### **IV. ADVANTAGES**

Most ECO friendly & clean source of power

- No refueling cost
- No Pollution

### **V. DISADVANTAGES**

- Its high cost
- Need for skilled operators
- Requires commitment at all levels throughout its operational life to maintain maximum effectiveness

### **VI. APPLICATION**

- Remote and rural village electrification
- Used in streetlights

### **VII. CONCLUSION**

A hybrid wind-solar energy system can provide both environment friendly and cost effective approach to generate energy. This will help remote communities where grid connected supply is unavailable. A hybrid renewable energy system (HRES), based on wind and solar energy sources with battery storage, and control schemes are detailed in this research work. Energy management and control strategies are developed to harness maximum power from the renewable sources and to coordinate the power exchange between the sources, the battery and the load. The experimental results show that the power is smoothly transferred to the battery when sources and load conditions change. Also, a stable DC-bus voltage is guaranteed during the changing conditions and the power at the load is maintained. The proposed experimental HRES can be used as an education and research tool to understand and develop various configurations of hybrid systems and advanced control applications.

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