POWER ESTIMATION OF HYBRID MODEL OF SOLAR AND WIND ENERGY AT PATIALA

By

Inderjit Singh (800841020)

Under the guidance of

Mr. Souvik Ganguli Assistant Professor (EIED)

ELECTRICAL AND INSTRUMENT DEPARTMENT

THAPAR UNIVERSITY

Patiala (Punjab)-147004

CERTIFICATE

I hereby certify that the work which is being presented in this thesis entitled, **"POWER ESTIMATION OF HYBRID MODEL OF SOLAR AND WIND ENERGY AT PATIALA"** in partial fulfillment of the requirements for the award of degree of **Master of Engineering (Power System and Electric Drives)** in the **Department of Electrical And Instrumentation Engineering,** at **Thapar University, Patiala**, is an authentic record of my own work carried out under the supervision of **Mr. Souvik Ganguli (Asst. Professor)** and refers other researcher's work which are duly listed in the reference section.

The matter embodied in this thesis has not been submitted for the award of any other degree to any other university.

Date: 15-07-2010

INDERJIT SINGH

Roll No. - 800841020

This is to certify that the above statement made by the candidate is correct and true to best of my knowledge.

Mr. SOUVIK GANGULI
Asst. Prof. (E.I.E.D)
Thapar University,
Patiala-147004

Dr. SMARAJIT GHOSH
Prof. & Head, (E.I.E.D)
Thapar University,
Patiala-147004

Dr. R. K. SHARMA
Dean of Academic Affairs
Thapar University,
Patiala-147004

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Date: **INDERJIT SINGH**

Place:

ABSTRACT

In this work we have evaluated the potential of hybrid system Patiala. The different types of renewable sources are specifically evaluated in the economical performance of the overall equipment. The presented methodology is applied to evaluate the potential of photovoltaic – wind hybrid system to produce electricity for a community and other state. Through this hybrid system we have reduce pollution and decrease the global warming. In this we have analyzing the data of wind and solar energy and evaluate the average energy. We have decrease the pollution by these resource compare to non renewable resource .by using hybrid system we have fulfil the energy demand into the future .in future by using sensor of better quality be can increase the potential. We use the small storage capacity. Because maintained cost becomes low .using the better quality data logger is can increase the energy production. In future we have to install large solar and wind plant which are cheaper as compared to small plants.

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INTRODUCTION OF HYBRID MODEL

CHAPTER 01

1.1 Hybrid system

In this chapter the hybrid system has been designed and installed to generate electricity which combines diesel generator with multiple renewable energy sources PV array and wind turbine, and operates with solar inverter and solar system software for remote power monitoring and control. The hybrid model system is renewable energy system**,** which helps conserve energy by reducing the use of diesel fuel in generator combined. We develop a new method for the economical evaluation of Hybrid Systems for electricity production. The different types of renewable sources are specifically evaluated in the economical performance of the overall equipment. Evaluate the design of a photovoltaic-wind-diesel hybrid system to produce electricity for a community and other state.

1.2 Introduction

The intensive consumption of fossil combustibles is the main cause for the negative impact on our atmosphere. In fact, the fossil combustibles are the main energetic source that sustains the worldwide development. Powers are mainly delivered by fossil combustibles. Today, due to the increasing international concern on the Earth climatic changes we are assisting to an intense research on alternative energetic sources.   We can discuss on two renewable sources: wind power and solar photovoltaic (PV). Both these energetic sources are clean and worldwide available. The comparative advantages of these energetic sources in relation to other renewable energies are demonstrated by the intense expansion of both wind and photovoltaic (PV) production plants,

This expansion is not due to direct exploration costs but mainly motivated by its reduced impact on environment. However, these renewable resources are extremely useful in low developed countries, with small needs on electricity and low density populations, where small communities are distributed along great geographical extensions The coverage of long distances by electric distribution networks are extremely expensive and completely away from the economical budget of poor countries, especially in Africa. In these cases, of distant rural communities, the electricity generation by means of photovoltaic or wind. Systems are financially advantageous, relatively to transported electricity through standard networks.

A sub-sized system obviously does not satisfy the demand on electric power and, on the other hand over-sized system can be completely prohibitive due to economical and financial indicators .The aims to hybrid System for electricity production. The different types of renewable sources are specifically evaluated in the economical performance of the overall equipment. The presented methodology was applied to evaluate the design of a PV-wind-diesel hybrid system to produce electricity.

1.3 Methodology Description

Before we begin the design of a PV-wind hybrid system we need to know the following main available natural resources: wind profile and solar radiation. In case we have suitable amplitudes of both renewable energetic sources we can actually initiate the design of the hybrid system. First of all we need to calculate the dimension of the following elements: PV-system, wind-generator, diesel generator, CC-CA converter and battery set.

1.3.1 Methodology

1) Calculate the PV-area and the wind-area needed for each month, covering the monthly account the month's average - APV and AW and the correspondent standard deviations (σ PV e W).This statistical analysis is based on the probability density associated with each natural resource.

Where: ES: Total energy supplied by the Hybrid System [KWh], PV specific PV-energy [kWh/m2], EW: specific wind-energy [kWh/m2].

2) Resize the calculated dimension APV and AW

3) Calculate the number of standard PV-models and Wind-generators according to the market availability, dividing the total power calculated by the standard power unit available in the market.

4) Calculate the life-cycle costs associated with different percentages of PV-wind composition, and optimize this cost function. The optimal Hybrid system design corresponds

to the Minimization of the cost function referring now to the evaluation of the output power that the hybrid system should deliver, this methodology accounts for the following factors:

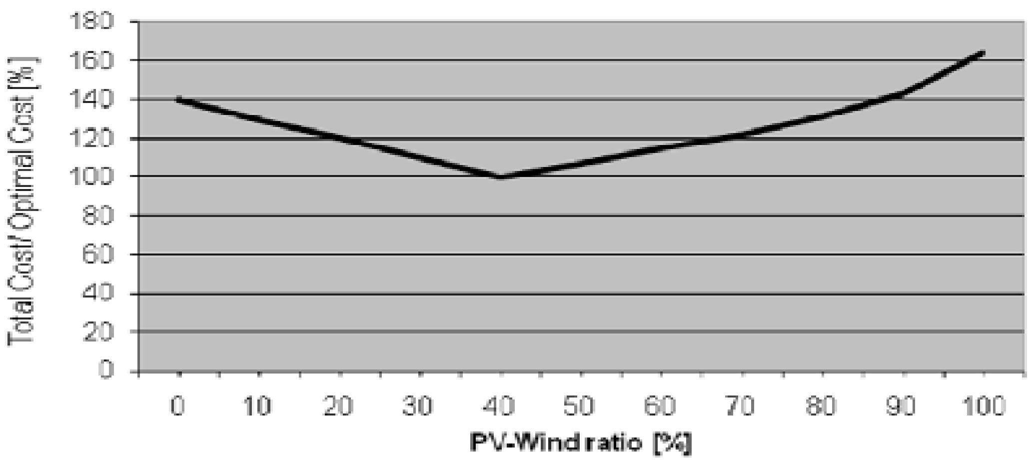
a) All known electric power needs (loads) have to be considered;

b) Power losses in the distribution network and in the inverter system are considered;

c) The technical data supplied by PV-producers and wind-generator producers as well as the site Measurements of wind profile and solar radiation are the basis for the PV and wind specific energy determination;

d) The maximum of the power load curve, added to the calculated losses in the system, determines the size of: the generator group, the power module, and the converter DC-AC.

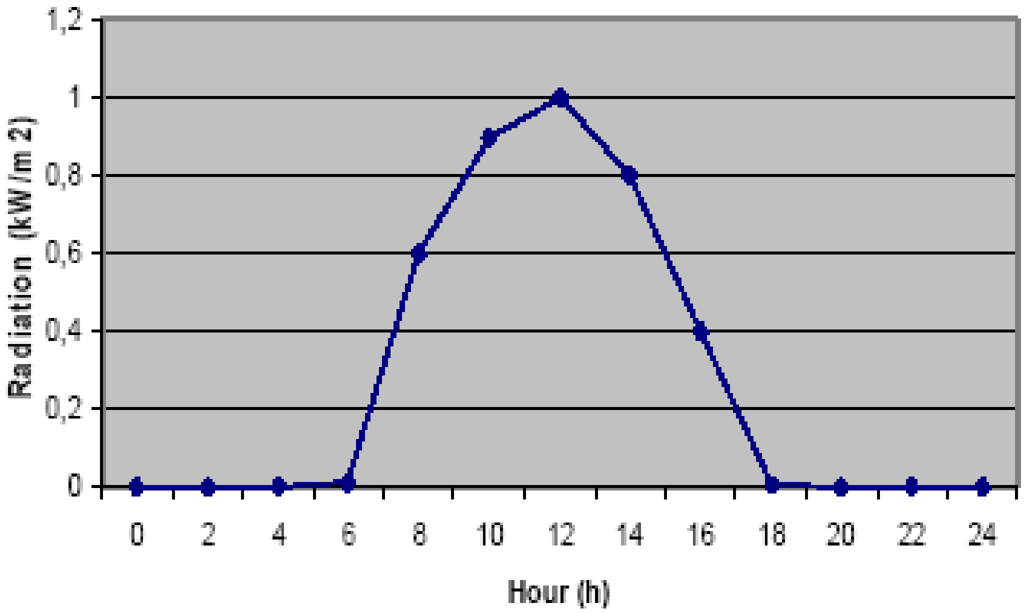
e) Finally the battery set is designed according to the autonomy required to the projected Hybrid System. The integration of the power load curve for the projected autonomy time-period gives the net output supply for the battery set. The determination of the optimal composition PV-Wind. Hybrid system is made through the fraction variation The optimal PV-Wind configuration, for PV Wind, regarding the project associated costs with each a specific site, minimum project cost as illustrated in this methodology was applied to design a photovoltaic wind- hybrid system to produce electricity for any place.



Graph 1 PV-wind ratio

1.3.2 Photovoltaic Energy

The survey on the solar potential of the community was made through the data acquisition by a solar-meter station installed on the site. The data were obtained in an hourly basis. We can consider the monthly average daily radiation in the year 2007.on a plane at an angle of 30º in relation to the horizontal position, towards south. The average daily radiation in the year 2007 was finally; to design the PV-unit we have to consider additionally, that the PV-cell performance depends on the solar radiation, on the temperature, on the tension and on the dirt located on the panel surface.



Graph 2 Solar Radiations

1.4 Wind Energy

The wind resources' survey was based mainly on experimental data acquired through a 30m-tower equipped with an anemometer. Figure the monthly average wind speed at a height of 30m, in the year 2007. The average wind speed registered shows a value of 4,1 m/s, for the year 2007. Another important data to evaluate the wind potential is the rate of the registered wind speed's occurrences. The wind resources' survey was based mainly on experimental data acquired through a 30m-tower equipped with an anemometer. Another important data to evaluate the wind potential is the rate of the registered wind speed with the final purpose of getting an estimated wind potential at different heights it was calculated the local roughness factor.

2.5 Advantage of Hybrid system

1. We can proper use natural renewable source

2. By using hybrid model we can fulfil the load demand

3. By using hybrid model we can reduce the price of electricity

LITERATURE REVIEW

CHAPTER 02

2.1 Review of Earlier Work

The following literature survey for the current report consists of various papers on hybrid system published in the IEEE conferences and the journals.

E.Muljadi, C.P Butterfied [1] presented a paper about that how wind variable speed operation with pitch control .They also discussed about control the maximum energy by minimizing the loads and the medium speed the generator are control the wind turbine speed at high speed the wind turbine control the power production. Two method can be used to control the power first is pitch control and second is generator control load. It show that wind turbine operated to optimizing energy capturing and used to control the various wind speeds.

Meei-Song Kang [2] presented a paper about power system with fuzzy wind generation into this paper he discussed how we can calculate the demand of load of different consumer at different time. We can also compare the cost of different plant and show the profile of different load by consumer. We can avoid the generation cost of wind energy by evaluating the load profile of consumer. It is found that the wind power generation can economically and effectively substitute the generation cost of the diesel power plant and provide the partial power supply capability for the net peak load demand.

T.Tanabert, T.Sato [3] discussed the control the system which can be used to full fill the requirement. Each control system was verified to be practical by simulations based on an actual network and data. Into this we can determined the capacity of Battery which can be full fills the requirement demand. They also discussed the scheduling of generation by wind and other plants by controlling and direction and speed of wind energy and how much energy we can get from the system. A control system has been developed to meet the technical requirements announced by the electric power company. These requirements will extend the acceptable limit of connecting wind power generation into the utility grid. However, these requirements demand wind power generators for the additional equipment to stabilize wind power fluctuations. By fulfilling these requirements, the economic value of wind power generation will be enhanced because the scheduled generation will be practiced in wind farms. By feature extraction of meteorological data using regression tree for wind power generation we can compare the weather condition for the production of power from wind energy.

Takaaki Kai and Akio Tanka [4], in their paper discussed a conventional power fluctuation smoothing system. This system can use doubly fed generator to control the variable speed and power factor of wind energy. This system is composed into EDLC system. In this system there are two inverters-inverter A and inverter B and also a capacitor is placed in between these inverters. P1 Active power of the stator and P2 Active power of the rotor .The sum of the wind power generation output power Pg and power fluctuation system output is defined as the composite output power. In a new wind power generation, the EDLC system is connected to the DC circuit between inverters through a bi-direction DC/DC converter, and the power fluctuation smoothing sequence is added to the control of inverter A. The rated voltage of DC circuit between Inverters is 1500V, and the capacitor of5.0F is connected to the circuit. The EDLC system is composed by cell module 600S1 (2 series and 85 parallels). The rated voltage, the capacity and the internal resistance of the cell are 150V, 4.7F and 0.55Q.

Hiroyuki Mori and Akira Await [5] presented a paper about how wind energy is affected by different variable this method can be used to detect the real data. The variable may be depending upon the winter and summer condition and it is also depending upon the sea level pressure and direction of air. Sea level pressure affected the speed of wind.

Noriyuki Kimura, Tomoynki Hamada [6] gave idea about Suppression of current peak of PFC converter to induction generator for wind power generation excited by voltage source converter. Into this paper we can know about the combination of induction generator with electronic equipments. The induction generator cannot generate electricity at lower rotor wind speed. To compensate this problem, expensive synchronous generators with permanent magnets are sometimes used. The diode rectifier used to convert the real power from the induction generator to dc voltage. If we use induction generator with VSC, the cost of the wind generation system is reduced. In this paper, we can also study how we can reduce the output current of the VSC by using the duty factor control of the PVC converter in this system. A low cost cage induction motor is used instead of expensive synchronous generator. Capacitors are used to compensate the reactive power.

Lu Yuegang, Xi Peiyu [7] deal with study the layer of wind turbine system. Two layers exist into system one is supervisory layer and second one is control layer. First is based upon American company and second based upon mat lab system generation wind turbine system. They also discussed how we can control the constant- frequency and variable speed and wind power induction system. By comparing these curves correctness and feasibility system are provided. They also presented study the start-up wind speed cutting in DFIC cutting model, rated wind speed, variable pitch control.

Ming-Shun Lu, Wei-Jen Lee and Li Wang[8] presented a paper about combining the wind power generation system with energy storage equipments. With the advance in wind turbine technologies, the cost of wind energy becomes competitive with other fuel-based generation resources. Due to the price hike of the fossil fuel and the concern of the global warming, the development of wind power has rapidly progressed over the last decade. Since it is difficult to predict and control the output of the wind generation, its potential impacts on the electric grid are different from the traditional energy sources. At high penetration level, an extra fast response reserve capacity is needed to cover shortfall of generation when a sudden deficit of wind takes place. To enable a proper management of the uncertainty, this study presents an approach to make wind power become a more reliable source on both energy and capacity by using energy storage devices. Combining the wind power generation system with energy storage will reduce fluctuation of wind power. Since it requires capital investment for the storage system, it is important to estimate reasonable storage capacities for desired applications. In addition, energy storage application for reducing the output variation during the gust wind is also studied.

Bongani Malinga Dr. John E. Sneckenberger, Dr. Ali Feliachi [9] presented a paper which is is a part of a research project to study the dynamics and control of distributed resources (DRs) in the deregulated electric power industry'. It reflects the need to look at large wind farms as power plants, as a result of the increased penetration of wind energy in the power systems many places in the world. To obtain an optimal integration of high penetration of wind energy in the system, the wind farms must be able to replace other power plants, i.e. he able to participate in the control and stabilization of the power system. This research provided a different approach to wind turbine modelling and control design methodology. All the results were in close agreement with results from other studies. The main strategy of the controller was to regulate the rotor angular speed and the power demand to match the required profiles. Continued research illustrates that the optimum wind turbine has not yet been build and most of the remaining work lies in how the wind turbine is controlled.

Wijarn Wangdee, Wenyuan Li, Wahshum [10] deals with the world the use of wind energy increase because they different from another renewable source. It play important role into overall energy .the wind generation is depend upon the location and graphical condition into the hilly area the speed of wind is more so into these area we can produce the large amount of energy. The transmission of power which is generated by wind generation is also play a important role into the cost of wind power. For the transmission be can consider the load demand and transmission of power which is available for transmit. We can use MECORE software which is a composite generation and transmission system reliability analysis tool utilizing a DC-based optimal power flow algorithm, was used In the study. As previously noted, the voltage stability is dominant to limit the transfer capabilities of the system. A typical AC-based power flow program was initially used to investigate the transfer limits under system normal (N-0) and contingency (N-1) situations.

After the transfer limits based on voltage stability study .The voltage stability limit can be measure by MECORE using DC based optimal power flow solution. The load duration curve during winter period in which 1,000,000 samples were used in all MECORE studies in order to achieve the coefficient of variation and the tolerance error is less than 1.

Mohammad Zakir Hossain and A.K.M. Sadrul Islam [11] presented a paper about PV-wind hybrid system modelling for remote rural application. A PV-wind hybrid model has been developed to simulate a stand-alone power system with battery storage. The model has been applied to a typical consumer peak load of one kW at a remote community in Bangladesh. Using the model, different parameters are evaluated for one-year of full operation of the system. An economic analysis has also been undertaken to assess the feasibility of such a system at the location considered.

Mel George [12] presented a paper about As the worldwide use of renewable energy in utility scale applications continues to increase, it is important to assess the impact on the grid and conventional generation. This report combines analysis of load and generation characteristics, generation adequacy and base and peak load variations to gain insights into the future role of wind generation. A simulation of Tamil Nadu state in India which has a high penetration of wind power (27% by installed capacity) has been presented here. The savings achieved in conventional generation .due to installation of wind power are quantified as the capacity credit, using a power system reliability based approach.

Rickgonzalel,Rana Muke Ji [13] presented a paper about wind power is growing as a generation resource in New York State. The number of wind plants operating in the state has increased significantly over the past two years. Wind-powered projects also comprise a dominant portion of the proposed new generation projects in the New York Independent System Operator’s (NYISO) interconnection queue.

Florin Lov,Poul Sorensen [14] gave general overview and description of the wind turbine models. A toolbox has been developed during the research project “Simulation Platform to model, optimize and design wind turbines” and it has been used as a general developer tool for other three simulation tools: The report provides a quick overview over Matlab issues and then explains the structure of the developed toolbox. The attention in the report is mainly drawn to the description of the most important mathematical models, which have been developed in the Toolbox.

Jiang Chang and Shu-Yun Jia [15] discussed the modelling and application of wind-solar energy hybrid power generation system based on multi-agent technology. Multi-agent system is an agent society made up of several agents. By the collaboration of multi-agent, it can optimize control system and enhance its intelligence and reliability. Wind and solar energy hybrid power generation is a novel and promising power system. Randomicity and complexity of the climate make wind and solar hybrid power generation system a complicated system. In this paper, we first introduce advanced agent technology into wind and solar energy hybrid power generation system, establish the wind and solar energy hybrid power generation multi-agent system (WSHGMAS) and analyze multi agents’ collaboration relationship. At last, by the agent’ application in WSHGMAS, it can realize sea-island, remote region, unmanned operation’ wind-solar energy hybrid power generation system and enhance power system’ intelligence and reliability.

V.J.Yeshwenth, R.Udhayaprakash and Naveen Krishna [16] analysed a DC Connection for capacitor Energy Storage in Wind power Generation System. First they analysed the performance of connecting two wind power generation systems with the energy storage at the dc side. Energy storage is desirable to be installed to keep constant output from the wind power generation system. The DC connection of two wind power generation system helps to exchange power between the two systems and can suppress the disturbance of the output power to the utility systems longer than the stand alone system. The performance of connecting two wind generation systems with the energy storage at the dc side has been investigated by using the simulation. The wind power generation system is modelled and simulated by MATLAB/Simulink and the effectiveness of the dc connection of two systems is presented. This effect is easily achieved and implemented without any additional control. The controller measures only the common dc side capacitor voltage of the local system. MATLAB/simulink simulation verifies the better performance in a certain situation.

Lan Li and Guang-yu Xiong [17] discussed about the main problem for variable speed constant frequency wind power generation system is how to improve the dynamic respond as well as stability. In this paper, according to mathematical model of wind power generator and active power separate control strategy with reactive power, PI controller and fuzzy controller were used separately in the control link of active power. And active power fuzzy controller was designed. In MATLAB/Simulink, doubly-fed wind power generation systems controlled by two kinds of controller were simulated and their properties were compared, it is shown that wind power generation system based on fuzzy controller has capacity to better dynamic respond and disturb resistance.

H. Belmili, N. Matidji and fellows [18] presented a paper about Sizing a (photovoltaic/wind) Hybrid System. Combining Solar Photovoltaic systems with batteries can guarantee high supply reliability, but in cloudy weather (weak irradiation) this strategy requires large storage capacity and is expensive. It is cheaper to supply peaks of demand and the demand during this period, with either an additional wind generator. Under this objective different types of (photovoltaic/wind) hybrid systems for supplying electricity have been demonstrated in a large number of pilot and demonstrated projects. In their context, the design of hybrid systems is a relevant issue. An ideal system has to supply, at any given time in the year, an instantaneous energy that equals the consumed energy by all system loads. A sub-sized system obviously doesn't satisfy the demand on electric power and on the other hand, an over-sized system can be completely prohibitive due to economical and financial indicators. This work presented the different methods of sizing a small PV-Wind hybrid system and the choice of the method that gives the optimal technical-economic configuration.

John A. Castle, James M. Kallis, Sally M. Moite and Neil A. Marshall [19] gave a paper about analysis of merits of Hybrid Wind/Photovoltaic Concept for Stand-Alone Systems. Methods for evaluating the merits of hybrid wind/photovoltaic systems for use in stand-alone applications were developed. The optimum mix of wind and photovoltaic power with an electrochemical storage system, with or without fossil fuel generator backup, depends upon the individual subsystem economics. A computer code was developed to calculate the optimum subsystem-sizes that minimize the levelized energy cost. The actual merits of a hybrid system over a pure photovoltaic or wind system depend upon many factors: load profile; wind regime; insulation; cost and availability of backup power; the relative costs of wind rotor area, array area, and storage; and subsystem efficiency factors. Examples of optimized hybrid systems for a range of photovoltaic costs and estimated wind and storage costs are shown for an Ely, Nevada application where backup power is allowed to supply 5% of the total annual load.

CADDET Centre for Renewable Energy gave a project [20] on A PV-Wind Hybrid System on Bullerö Island, Sweden. This report give idea about The PV-wind power installation meets almost all the island's energy demand less than half the cost of installing grid connection. Thus this method is a cost-effective use of renewable energy in a remote situation.

C.A. Nwosu, M.Eng. and M.U. Agu [21] presented a paper about power and energy balance in Wind-Solar Hybrid Power System. In this paper, power and energy balance in a wind-solar hybrid power system having battery and combined heat and power (CHP) sub-units as backups, is presented. A case study for winter and summer seasons are conducted in an urban city in the Netherlands. Load profiles for the periods of winter and summer over a period of 24 hours were developed from a load pattern program developed through load research sampling (LRS). It is observed that within the period under investigation, there exists an instant when the generated energy from the wind-solar hybrid was below energy demand of the load. The battery unit supplies this deficient energy into the system so as to maintain steady power plant. This, however, depends on the state of charge (SOC) of the battery. If the SOC of the two battery sub-units is below a set point, combined heat and power (CHP) unit will be switched into the system, in the context of global energy balance. In another instant, excess energy from the hybrid after meeting the load demand, charges the battery.

Xu Zhenchao, Moon Chaejoo, Chang Younghak, Lim Jungmin and Kim Taegon presented [22] a paper about remote monitoring of wind-photovoltaic hybrid generation system using mobile phone and internet. In this paper, a remote monitoring system of wind-photovoltaic hybrid generation system using mobile phone and internet has been developed. Many kinds of data can be acquired, analyzed and saved automatically by this system. The hybrid system is composed of 1[kW] PV with DC/DC converter, battery banks and 5[kW] wind power system with power inductor and AC/DC converter. In addition, wind monitoring sensors, voltage and current meters, current transformers and potential transformers are used as accessory instruments. All of these signals are fed into DAQ (Data Acquisition) board after converting the data which have been processed by many types of converters, dividing circuits and signal conditioning circuits. These data can not only be displayed on a computer, transmitted using the server program to remote computer and saved on a computer as a file day by day but also be sent as a CDMA message. The monitored-data can be downloaded, analyzed and saved from server program in real-time via mobile phone or internet at a remote place. All of the programs were designed with Lab VIEW software.

2.1 OBJECTIVE

We compared the solar and wind energy. Into this we can know how wind and solar resource provided energy to fulfil the load requirement. Using the solar and wind energy be can reduce the pollution .The smaller capacity storage are better than large because the maintained cost is low.

CHAPTER 03

3.1 Photovoltaic System

A system used to transform solar radiation directly into electricity. At the heart of a solar power system, also known as a photovoltaic (PV) system or solar electric system, are solar cells which are interconnected to form solar module (solar panels) and solar array. The size and configuration of a system depend on its intended task. Modules and arrays cube used to charge batteries, operate motors, and to power any number of electrical loads. With the appropriate power conversion equipment, solar power systems can produce alternating current (AC) compatible with any conventional appliances, and can operate in parallel with, and interconnected to, the Among the components of a complete solar power system may be a DC-AC power inverter, a battery bank, a system and battery controller, auxiliary energy sources, and sometimes the specified electrical load (appliances).

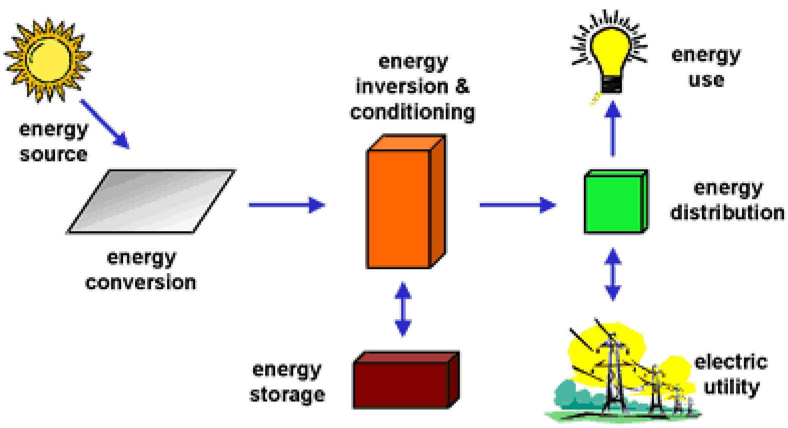


Figure (3.1) Balance of system

The two main types of solar power systems are stand-alone systems and grid-connected or utility-interactive systems. These are designed to operate independent of the electric utility grid, and are generally designed and sized to supply certain DC and/or AC electrical loads.

They may be powered by a solar array only, or may use wind, an engine-generator, or utility power as an auxiliary power source in what is called a solar-hybrid system. The simplest type of stand-alone system is a direct-coupled system.

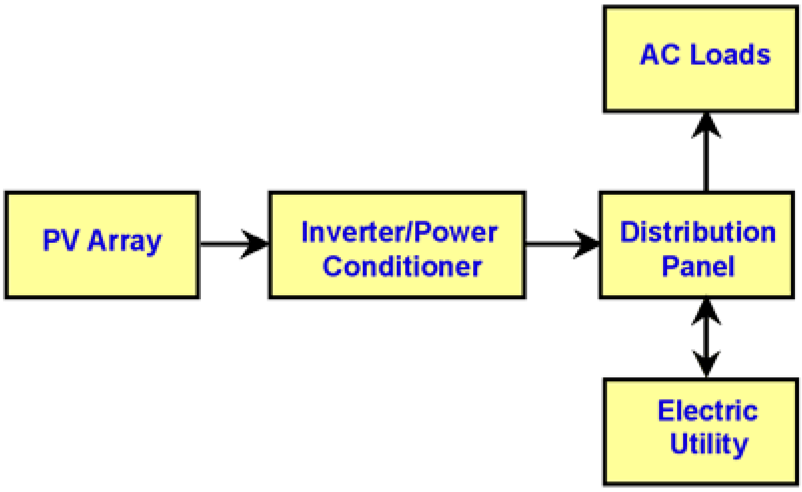


Figure (3.2) Grid-connected systems

A bi-directional interface is made between the solar power system AC output circuits and the electric utility network, typically at an on-site distribution panel or service entrance. This allows the AC power produced by the solar power system to either supply on-site electrical loads or to back-feed the grid when the solar power system output is greater than the on-site load demand. At night and during other periods when the electrical loads are greater than the solar power system output, the balance of power required by the loads is received from the electric utility.

Solar power systems are able to operate normally in grid-connected mode and still operate critical loads when utility service is disrupted, providing that battery storage is used. This type of system is popular for homeowners and small businesses where a critical backup power supply is required for critical loads such as refrigeration, water pumps, lighting, and other necessities. Under normal circumstances, the system operates in grid-connected mode, serving the on-site loads or sending excess power back onto the grid while keeping the battery fully charged. In the event the grid becomes de-energized, control circuitry in the inverter opens the connection with the utility through a bus transfer mechanism, and operates the inverter from the battery to supply power to the dedicated loads only. In this configuration, the critical loads must be supplied from a dedicated sub panel. The diagram be shows how a solar power system might be configured to operate normally in grid-connected mode and also power critical loads from a battery bank when the grid is de-energized.

3.2 Hybrid PV System

A hybrid system combines PV with other forms of power generation, usually a diesel generator. Biogas is also used.

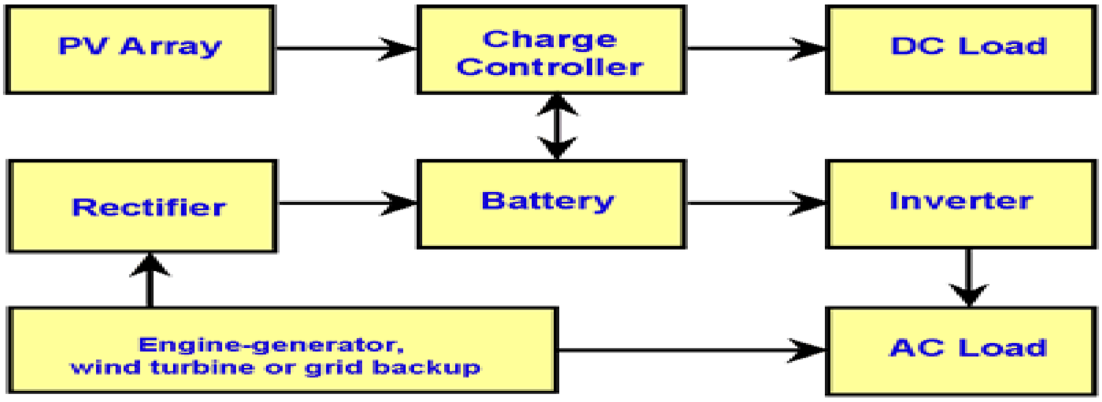


Figure (3.2) A hybrid PV system.

The other form of power generation is usually a type which is able to modulate power output as a function of demand. However, more than one form of renewable energy may be used for example wind and solar. The photovoltaic power generation serves to reduce the consumption of non renewable fuel.

3.3 Merits of Solar and PV Systems

There are a lot of advantages of solar photovoltaic systems. They are listed below:

1. Since the solar energy is free of cost it involves no operational cost.
2. More flexibility is available in solar photovoltaic systems. Therefore SPV plants of different sizes may be designed and implemented as desired.
3. Solar energy systems are not location specific. In almost every place sun radiation is available.

4. Electricity is the most convenient and the most general form of energy which can be generated by using SPV systems and also be converted into other forms of energies as per requirement.

5. SPV systems do not have any moving systems which results in low maintenance and repairing.

6. SPV systems are eco-friendly since they do not pollute the environment unlike other power plants.

7. Only supporting systems like inverters, batteries etc require some maintenance.

8. SPV systems are very durable. They have a life span of more than twenty years.

3.4 Wind system

Wind energy is an indirect form of solar energy. About 1 per cent of the to all solar radiation that reaches the earth is converted in the atmosphere into the energy of the wind. Winds result from the differential heating of the earth and its atmosphere by the sun. As the sun heats different parts of the earth at different rates air circulates from the cold to the warm areas producing winds. The total quantity of this resource is extremely large and varies with time at any given location. Wind energy is renewable and poses no major environmental problems Wind energy potential for different applications cannot be overlooked in a country like India where considerable amount of wind power is available an estimate of the wind resource potential in India indicates a potential in excess of 20,000 MW for power generation. According to a recent assessment, India ranks very high among developing countries where wind energy potential seems more promising. Thus, the prospects of wind energy in India may be considered cost effective to conventional sources of electric power.

During the past 20 years outstanding progress has been made in the technology used to convert wind energy to electrical energy. More than 15,000 wind turbines in California and 2,800 in Denmark have been integrated into existing utility grids and routinely operated in conjunction with conventional sources such as hydroelectric, fossil-fuel fired, and nuclear generating stations.

There is no fundamental reason why wind turbines cannot be a major part of any utility grid where there are good wind resources, provided they can compete with more familiar systems on the basis of cost, reliability and public acceptance. Although wind energy technology demands careful attention to scientific and engineering detail, it is well within the capabilities of most if not all countries and is becoming economically competitive in many regions around the world.

3.5 Wind Energy Technology

The kinetic energy, U, of a sample of air, and density p, moving with velocity u, where A is a unit area perpendicular to the wind stream is parallel to the wind stream, is: The energy flux P w or wind energy density, is given by the time rate of change o U/A Not all of the wind power density is available for useful work, the maximum power that can be extracted from a wind stream is 16/27 x P w =0.593 x P w: this quantity is known as the Betz limit. Because wind power density varies as the cube of the wind velocity, a wind turbine must be able to function over larger variations in P w to accommodate typical variations in wind speed. For example, if an area has characteristic average wind velocity for wind speed of 0.5avg the available power density is only one -eighth that at V avgas while at 2 V the power density is eight times that at V avg. Thus, the wind velocities that are less than the average yield little useful power, while velocities much above the average can overstress turbine components. Thus the technical challenge is to design a wind turbine that can function efficiently and reliably over the large variation in P w, despite extreme of weather, with a minimum amount of maintenance for as low an initial capital cost as possible wind speed in any given region is not constant .but varies over periods of seconds hours days month The wind speed and frequency distribution may vary with elevation .Generally wind measurement are made at angle elevation. Often near 10 meter which is different from the possible hub of modern wind turbine to extrapolate these data to the required height it is often assumed that wind speed increases as the one-seventh power of the elevation energy is a source of renewable power which comes from air current flowing across the earth's surface. Wind turbines harvest this kinetic energy and convert it into power. The electricity is sent through transmission and distribution lines to customers. Wind generation is one of the fastest growing sources of electricity and one of the fastest growing markets in the world today. With an average annual growth rate of more than 25 percent over the past decade, wind is the fastest-growing sector of the energy industry all over the world. The advantages of wind energy are numerous and clear, and the technology itself has taken a leap forward in recent years.

3.6 Modelling and Control of a Wind Turbine as a Distributed Resource

The dynamics and control of distributed resources (DRs) in the deregulated electric power industry It reflects the need to look at large wind farms as power plants, as a result of the increase penetration of wind energy in the power systems many places in the world to obtain an optimal integration of high penetration of wind energy in the system. The wind farms must be able to replace other power plants, i.e. he able to participate in the control and stabilization of the power system. If large wind farm trips due to a grid fault, the power system will suffer from a severe loss of supply The main result of the project is a verified model of a wind farm, which can be used to study and improve the power plant characteristics of the wind farm, and a tentative assessment of the power quality of The wind farm, based on simulations with the developed model and verified by measurements. This research provided a different approach to wind.

Turbine modelling and control design methodology: All the results were in close agreement with results from other studies. The main strategy of the controller was to regulate the rotor angular speed and the power demand to match the required profiles. A simple wind turbine model was linear about an operating point and it was used to systematically

Perform trade-off studies between minimization parameters. The robust nature of the PID controller was illustrated and optimal operating conditions were determined. Continued research illustrates that the optimum wind turbine has not yet been build and most of the remaining work lies in how the wind turbine is controlled. Control strategy improvements can be expected as experience is gained with wind turbine operations. The main sources of electrical power have been fuel engines, which use the energy from non-renewable fuels to mate a shaft connected to an electric generator. These systems have seen vast improvements in the areas of efficiency, emissions and controllability because they have always been the primary power sources. The deregulation of electricity in the US has seen rise in research geared towards alternative energy sources. Some of the major sources being investigated include fuel cells. Micro-turbines and wind turbines. Wind turbines will be the main focus of this research. The most special feature about wind turbines is the fact that, unlike other generation systems. The power inflow rate is not controllable. In most power generation systems, the fuel flow rate, or the amount of energy, applied to the generator controls the output voltage and frequency. However, wind speed varies with time and so does the power demand. The basic fact states that one has no control over the energy source input.

The unpredictability of wind and the varying power demand are more than enough concerns to justify the need for a controller, which will regulate all the parameters that need to be controlled for a matched operation of the wind turbine.

3.7 Wind Turbine Modelling

In deriving a wind turbine mathematical model A specific constant-speed pitch-control wind turbine was selected. One of the key factors is to find values for the constant parameters in the transfer functions representing the wind turbine system at operating conditions. The variation of the coefficient of torque C, with the pitch angle, 6, and the tip speed ratio, h. is highly nonlinear and unique for each wind turbine. It would be useful to obtain some experimental data for the variation of C, with P and h because there are no general linear equations relating these parameters. It would be better to choose a wind turbine whose experimental data is available. The geometry and aerodynamic characteristics of the simulated wind turbine resemble those of a GmmmanWindstream-33, 10-m diameter, 20 kW turbines. The National Renewable Energy Laboratory's (NREL) National Wind Technology Centre modified this wind turbine to operate at variable speeds using blade-pitch regulation.

3.7.1 Wind Turbine Mathematical Model

The wind turbine plant model was divided into two main parts. The first part was the wind turbine, which included a turbine rotor on **a** low-speed shaft a gearbox and high-speed Shaft. The second part was the electric generator whose input was constant angular rotation from the turbine plant and whose output was electrical power.

3.7.2 Actuator Model

The actuator dynamics where C(s) is the Laplace transform of the input pitch angle change from the controller and P(s) is the Laplace transform of the output pitch angle change.

3.8 Electric Generator Model

The generator was modelled using the Power System. In the synchronous generator, the Power System Block set has the mechanical power as its input. The voltage output is controlled through the excitation field voltage. This produced the magnetic flux that induces the e m f on the coils. This research focused more on the mechanical control of wind turbines. Also a lot of studies have been done in the Modelling and control of synchronous generators Therefore, the existing generator models that are built within the Power System Block set were used the modelled synchronous generator was a 150 kW generator.

3.9 Controller design methodology

Gain selection for PID controllers has generally been a trial-and error process relying on experience and intuition from the field control engineers. A systematic approach to gain Selection provides visualization of the potential performance enhancements to the system control. This work presents a methodology for selecting gain values for a PID controller that regulates the rotor speed of a constant-sped wind turbine by adjusting the blade-pitch angle. Visual inspection of the rotor speed response and the pitch angle response may be used to determine the best combination of and gains to achieve appropriate damping of the system. However, when the third gain is introduced this trial and error method becomes much more tedious and complicated. This method does not provide the control designer with a feel for the sensitivity of the controller to slight variations in the gain values and a best possible range gain values is not easily identified. Therefore a different PID tuning method was used.

3.9.1 Controller Design: Gain Selection

The main controller requirement is to compensate the wind speed deviations by changing the pitch angle, p, to keep the rotor angular speed, w. constant. A Mat lab code was written in order to determine the best combination of the controller gains. The design was based on the minimization of two parameters.

The root mean square of the error indicates the capability of the controller to reject the wind speed fluctuations. The second parameter was the actuator duty cycle (ADC), which was proposed by Kendall. et al. (1997) as a measure of actuator motion during a simulation run. It is simply the total number of degrees the blades are pitched over the time period of the simulation. In order to prevent over-heating of the hydraulic fluid, this value must remain below a certain value provided by the manufacturer. For each simulation run, these two parameters were analyzed, and both were considered in determining acceptable operating conditions. In order to systematically determine combinations of the three gains that produce acceptable operating conditions, the simulation was used repeatedly. Each of the gains was varied over a wide region, and the two minimization parameters were analyzed for each run.. Trade-off studies between the series of surfaces were performed to determine the region where acceptable operating conditions existed.

Speed and pitch angle for gain combinations within this region were produced to verify acceptable operation. All of the contour plots indicate wide, flat surfaces for the RMS of the rotational speed error. This surface illustrates that a wide range of gain value combinations may be chosen with similar results. Thus, the controller is robust and relatively insensitive to changes in the values of the gains. However, choosing the most acceptable operating set points for the gains requires a closer examination of the surfaces. The output angular speed satisfactorily tracks the reference angular speed. This shows the robustness of the controller and the fact that wind turbine operation heavily depends on the control strategy.

3.9.2 Synchronous Generator Control

The wind turbine system in this research has already been controlled to track the desired angular speed and them technical power profile. The voltage controls only depended on the exciter of the synchronous generator. Synchronous generator voltage regulator combined to an exciter [Z]. The control strategy was simpler for the generator because the mechanical power input and the angular rotation of blade.

The shaft was already controlled at the wind turbine. Synchronous generators are a common platform for most electricity production. The only difference between generation devices is the reliability and controllability of the mechanical power system. This research has shown that a wind turbine can replace a diesel engine and electric power production will continue satisfactorily, using the same generator. This also shows the extent of wind turbine applicability. Wind turbines have reached a stage where their operation and controls have matched that of traditional electric generators.

3.10 Actual situation and demands for the further increase of wind power

The increased installation renewable energies and their further expansion is one of the main drivers for the restructuring of today’s transmission and distributions systems. Within the renewable energies, wind energy plays today in most systems a major role to demand such changes. In the last decades wind power has developed to a mature stage and today is available from small scale distributed generation size, to wind power plants in range of hundreds of megawatts installed capacity. Today wind energy converters (WECs) are available with a rated capacity of 6 MW for a single unit e.g. the as an example actual data from Germany illustrates this situation. Till the end of 2008 approx. 24 GW of wind power were installed in Germany, producing approx. 40TWh of electrical energy per year. Due to the available wind resources most installations are located in the northern part of the country while most load centre are located in the centre and the southern part of Germany some hundreds kilo meters away.

Besides the transmission systems distribution systems are also strongly influenced b the increased installation of distributed generation. The amount of installations in a distribution system may be as large as a major power plant that may affect strongly the stability and security of the whole power system. The impact on network operations protections voltage control, fault levels and rating of assets are further relevant issues. Actually attend is recognizable showing that distribution systems are changing from pure load distribution to distributed "virtual" (renewable) power plants.

Already today it can been seen how wind power is obliged to participate in maintaining quality of supply, power system security and power system stability. Strong indicators are the recent changes for the connection requirements in Germany for wind power and other renewable energies. In 2008 the general requirements from BDEW for the connection of generation plants to medium voltage distributions systems have been developed to a new stage. Riding through voltage dips caused by faults is now required for all generation plants resp. generation units. Detailed specifications also describe the characteristics of the minimum reactive fault current that shall be injected in the distribution system depending on the type of fault and the remaining voltage. During normal operation, a variable power factor down to 0.95 shall be available for voltage control and/or loss optimization in the distribution system. Control strategies may vary from project to project from types of power factor control to voltage control. Set points may be either with fixed or provided online. Before these changes in 2008 such requirements were only mandatory for the connection to high and extra-high voltage networks (110kV to 400kV) in Germany as determined in the VDN Transmission Code from New certificates for generating units and complete generation plants - based on studies utilizing validated models - shall secure, that these new performance requirements are met. A further example for actual changes in connection conditions are the actual minimum technical requirements from 2008 for the connection to the transmission system of Vattern fall Europe Transmission (VET). Approx. 25% of the actual installed generation capacity in the VET system is provided by wind power. VET's latest requirements are based on the actual VDN Transmission Code. According to the VDN Transmission Code, a reactive power requirement to provide rated power with a power factor of 0.9 at the point of connection can be made applicable. VET's reactive power requirements demand the availability of a minimum amount of reactive power capability under all loading conditions. As wind power plants can already be operated at very low loading levels, this requirement would demand from wind power plants to be able to provide a constant minimum level of reactive from practical 0 MW output to full rated output. These examples give an impression of new tightened connection requirements in a system with a relative big amount of wind energy installed. The technology for the WECs and wind farms must reflect this to fulfil such requirements. ENERCON has experience since the early 1990s with the design of variable speed gearless WECs with full scale power electronics. The performances of these WECs and especially their power electronics have been recently increased and include now FACTS Capabilities to address latest grid code requirements for wind power. FACTS (Flexible AC Transmission Systems) are power electronic devices to resolve various types of stability problems in power systems. Very common types of FACTS are shunt devices like Static VAR Compensators (SVC) and Static Synchronous Compensators (STATCOM).

3.11 WECs with FACTS Capabilities – Performances during normal operation

The provision of reactive power for voltage control purposes is a main performance of WECs with FACTS Capabilities. As a default performance, these ENERCON WECs can provide constant reactive power for the operation between 20% and 100% rated active power. Quantities vary from the type and configuration of the WEC. Within 0% and 20% rated active power output, the reactive capability is proportional to the available active power. This default performance can be further extended with the STATCOM Option. The STATCOM Option allows the provision of reactive power completely independent from the provision of active power resp. the availability of wind. It utilizes the already available IGBT-based power electronics in the WEC and extends its performance by further hard- and software. If the power from the wind is to low to provide any active power to the system, the WEC can still provide reactive power as an ancillary service to the power system. Please refer also to As this is provided by the power electronics of the WEC, the performance can be compared with the performance of a conventional external STATCOM. WECs with FACTS Capabilities address with their default capability reactive power requirements that demand a minimum power factor or a specific reactive power capability between a minimal active power and rated active power The extension with the STATCOM Option can be the basis to fulfil such demanding requirements like from VET (please see above) or from the Canadian system operators and. An expansion of the reactive power capability with the same dynamic performance is available with the Q+ Option for some WEC types. Please refer also to Depending on applicable market structures, wind power plans can benefit from payments for reactive power under ancillary service agreements. General capability chart of ENERON WECs with FACTS Capabilities:

a) Default capability b) extended capability with the STATCOM Option c) expanded capability with the Q+ Option Besides the pure provision of reactive power for loss optimization, voltage control or maintaining system stability, the appropriate control of available reactive power sources has also to be resolved. As a key design principle, ENERCON WECs with FACTS Capabilities can follow a given fixed set point for power factor or reactive power set during commissioning. Additionally to this, the WECs can follow an online provided set point given from a remote control room or dispatch centre. ENERCON SCADA and additional communication interfaces, like the ENERECON PDI Process Data Interfaces can be used to provide these set points from a control centre to the WECs. A very powerful and beneficial method to utilize the reactive power capability from the WECs in a wind farm is the implementation of a voltage control scheme. This can be realized by combining the WECs in the wind power plant with a central controller like the ENERCON Farm Control Unit FCU (Please refer to Structure of ENERCON FCU Farm Control Unit for wind farm voltage control.

This single central controller can be provided with measurement values from the preferred measurement point (e.g. point of connection or other points of reference) determined in connection rules or specific connection agreements. The FCU communicates via a high speed fibbers optic FCU BUS with the WECs in the wind power plant. Based on the difference between actual voltage and voltage set point the FCU provides set points for reactive power to the WECs. Set points can be implemented during commissioning of the FCU. As an option, set points may be provided online via ENERCON SCDADA from a remote control room. The online communication gives the responsible system operator a high degree of flexibility to utilize the voltage control capabilities in the most beneficial way for the power system. Figure 3 shows an example measurement for a step change in the voltage set point of a wind farm. Short settling times for the reactive power less than one second can be achieved with the combined performance of the FCU and the ENERCON WECs. Though the single controller design is very robust compared with a possible design approach based on voltage control for the individual WECs parameters the FCU must be determined project specifically to be suitable for the dedicated project under all relevant system conditions step response of a voltage control scheme with ENERCON FCU and ENERCON.

3.11.1 WECs with FACTS Capabilities - Performance during disturbances in the power system

One key characteristic of the FACTS Capabilities of actual WECs during disturbances are their performances to deal with frequency changes in the system. Beside the absolute change in frequency the rate of change is an important performance criterion for generating units during power system disturbances.

A further performance criterion of WECs and wind power plants during disturbances is their capability to withstand temporary voltage dips caused by short circuits – typically level in the industry as fault-ride-through (FRT) capability. Though FRT requirements are common since the beginning of this decade for high-voltage and extra-high voltage grids, there is still ongoing development and discussion about specific needs and requirements from the system operators.

Requirements from the system operators may vary depending on the identified needs and characteristics of the power system, e.g. installed generating capacity, load characteristics, topology of the networks, transfer distances and capacities, earthling, protections, voltage and angle stability, fault levels, etc. Specific requirements for the preference for active or reactive power during faults or post fault clearance may be a consequence from that. Additional to the various requirements wind power is very often facing the situation, that good wind resources are available in remote, less populated areas with a weak power system infrastructure. Therefore a flexible technology is needed for WECs to deal successfully with the power system's needs, to deal with various types of disturbances and to support power system security and stability. ENERCON WECs are addressing these requirements with their FACTS Capabilities. The additional Under Voltage Ride through (UVRT) Option provides the necessary hard- and software to ride though faults for up to five seconds at zero volts at the WEC's terminals even at full rated active power. This performance gives the WEC the flexibility to deal even with unsuccessful auto-reclosing schemes. The WEC utilizes internal choppers for the necessary flexibility to control active power while a special UPS supplies safely all necessary auxiliaries to operate the WEC during a voltage dip, e.g. controls, drives, fans, etc.. Setting options give the WECs with FACTS Capabilities the necessary to deal with a wide range of requirements, system conditions and all types of faults. Voltage trigger levels to enter and to leave UVRT operation mode can be set individually between 95% and 80% rated voltage. As for conventional plants the specific WEC performance during a specific fault depends also on the interaction between the WEC and the power system and can hardly be generalized. From a simplified high level point of view some settings for an ENERCON WEC with FACTS Capabilities may give preference to the provision of active current, reactive current or maintaining a defined current phase angle. Of course the impedances and voltages during a fault also co-determine the performance of the WEC significantly. Dynamic project studies under the relevant individual conditions are recommended for each wind farm project for proper determination. Measurement examples for special UVRT Modes Some measurement examples shall express which performances are available today from WECs with FACTS Capabilities to ride through voltage dips. A first example is shown with the measurement. The full scale tests were performed with an ENERCON E-48 WEC with a rated of 800 kW. For these examples the WEC was set to provide a reactive fault current during asymmetrical fault proportional to the voltage reduction as required in the response of the WEC to a variation of voltage dips with more or less remaining voltage during the fault. According to the required proportional characteristic curve the WEC provides higher reactive current during deeper voltage dips. Accordingly to this control scheme, a reduction of active power may be required during the fault, as the available maximum apparent current is limited by the rating of the power electronics. Provision of a voltage depending reactive fault current For each sub-figure: Graph A (black line): voltage at WEC terminals; Graph B: (blue line): reactive current at WEC terminal Depending on the severances of the fault resp. voltage dip the WEC contributes to the desired support of the voltage with a reactive current to avoid voltage collapse or similar severe instabilities. A very different setting option of ENERCON WECs with FACTS Capabilities to ride through faults is the Zero Power Mode (ZPM). Triggered on the actual voltage level, the WEC stops to feed in a fault current to the grid. During ZPM, all power is transferred to choppers while the WEC stays fully in operation. ZPM is stopped if the voltage is exceeding a minimum threshold. The trigger levels to enter and to leave ZPM are settable in a range from 0% to 95% rated voltage. The very different

UVRT strategies can be combined to make FRT capabilities available even under very challenging conditions where other power plant technologies may have to trip. These examples and their specific characteristics and advantages show that WECs with FACTS Capabilities can contribute in a lot of ways to support the power system during disturbances.

3.12 Advantages & Disadvantages of Wind Energy

3.12.1 Advantages

Wind power is the most mature and cost effective renewable energy technologies available today, costing between 3 and 5 cents per kilowatt-hour, depending upon the wind resource and financing of the particular project. It is competitive with traditional power plants. Unlike electricity from fossil fuel powered sources which depends on fuels whose prices are costly and may vary considerably, the cost of wind power is relative stable. Wind is a converted form of solar energy. Wind power is inexhaustible and requires no "fuel". Wind turbines don't produce greenhouse gasses that may cause global warming. Wind turbines can be erected on farms or ranches, thus benefiting the economy in rural areas. Farmers and ranchers can continue to work on the land because the wind turbines use only a fraction of the land.

3.12.2 Disadvantages

Good wind sites are often located in remote area; it may require significant infrastructure improvement to deliver the wind power to the load centre. Although wind power plants have relatively little impact on the environment compared to other conventional power plants, there is some concern over the noise, aesthetic (visual) impacts, and sometimes birds have been killed by flying into the rotor blades. Most of these problems have been resolved or greatly reduced through technological improvement or by properly sitting wind plants Due to its intermittent in nature and partly unpredictable; wind power production introduces more uncertainty into Operating a power grid. The major challenge to use wind as a source of power is that wind power may not be available when electricity is needed.

ESTIMATIONOF POWER FROM HYBRID PLANT AT PATIALA

CHAPTER 04

4.1 Why do we need Hybrid System

The conventional energy sources are decrease day by day and they may produce pollution which is very harmful for world and increasing the global warming. So the aim of world is to reach the 20 percent rate of the Renewable energy sources in the energy production until 2020. One option to achieve this aim is to increase the rate of the solar and wind energy in the energy Production. These energy sources are provided 22.1% electricity for the consumption. These targets can be realised by Growing the green energy production. This target can be realised by member states in function of geographical and economical ability. Recently in Eastern part of Europe we can find a lot of farms, situated in remote area, which electricity supply is not solved. One obvious solution for electrification of these regions is the installation of small-scale stand-alone solar, wind and hydro energy production systems. The importance of this topic is timely because we can find a lot of applications, which energy supplying is resolved by renewable energy sources. For a god performance application is necessary to realise a preliminary planning, a feasibility study, which indicate an optimal technical solution for this application sites. It is necessary to elaborate one optimal model for which can be answered for this technical solution for the energy system.

4.2. Aim of the work

The detailed aims are as follows:

1. Find out the potential of solar and wind energy at Patiala
2. Comparison between solar and wind energy.
3. Supply the electricity to a rural application in remote area.
4. Study the small scale turbine for stores the energy.
5. Analysing the data of wind and solar energy.

4.3 Material and Method

Into this system following material are used.

1. PV Module.
2. BCC Charger, Steal tearoom
3. Inverter
4. Conductors and mounting elements
5. Wind generator

4.4 Wind energy measurement

The wind energy measurements depend upon the geographical condition where the wind potential and wind speed is high give the good power. The wind speed may be depend upon the height .if the height of tower is high than power production may be increase as compare to low height. Into this we can analyse the half year data. we can use the sensor in cup anemometer which exposed the wind and the cup begin to rotated in the direction of wind .through the sensor we can find out the average speed of the wind. The measurements depend upon height and height of tower used into this measurement is 10m. The sensors are placed upon 10 and 20m height at this height we can use the low wind power generator. The sensors which are fixed to the tower are not affected by the wind direction and anemometers. The wind direction and wind speed are precision measured. The sampling time fixed 15 minute. The average speed is evaluated by analysing the average speed of one day. Into this system we can measured the one speed and one direction. These instruments are generally expensive.

4.4.1 Performance evaluation of PV wind Hybrid energy system

If we produce the energy by only PV module which is very expensive .because for this we require a large surface and into winter period the radiation may be decrease and energy production also decrease which cannot full fill the consumer demand so to complete this demand we can use the other storage device which is very expensive .so by using the hybrid we can reduce the price of power which is economical compare to the single PV module. Into this hybrid system we can use the servable type of generator. Into this hybrid system we can use the wind generator which cut at low speed .the energy produce by hybrid system stored by batteries which is supply to consumer through an inverter at constant voltage and frequency. stud type inverter used for the low power an island used for more production. It is compatible with a local network and has connection ports for directly switch the wind or diesel generator in the system. During the Measurement in this thesis work, I used a small wind turbine.

4.5 Results

4.5.1. Analysing the data of location

For estimation data are analysing which are measured. By using this data we can find out the results. For find out the result we can take the reading from station installed on the spot after every 15 Minute measured solar radiation and wind speed temperature. Average hourly data were calculated from these reading. Which are compare with each other.

4.5.2 Analysing wind speed data

The measurements for wind energy potential were realised at Patiala. The wind speed distributions for 10 and 20 m level height are measured. In fact the location has an annual average wind speed between 5, 5-5.1 m/s range at the height 10m the speed may be increase when the height of speed is increase. We can use low wind turbine generator.

4.5.3 Used Equation in performance Evaluation Power of wind

Wind speed distribute

F (V) = −

V is wind speed

F (V) is frequency

K is swept factor

K=2

4.6 Characterised parameters for Hybrid PV wind energy system are

The important factor of storage system characteristic is storage capacity of battery and value of state of charge. The battery capacity is determine by the loss probability at any point in the time that the load will be not satisfied by hybrid system .if we know the parameter than we calculate the cost of system.

4.7 The specific parameters for analysis hybrid system

1. PV and wind generator nominal power
2. Ratio of two power supply in produced energy by both sources.
3. The number of autonomy day of hybrid system.
4. Storage capacity of batteries.

4.8 Initial Investment

A hybrid wind-solar electric system demands a higher initial investment than single larger systems. Large wind and solar PV systems are proportionally cheaper than two smaller systems. But the hybrid solution is the best option whenever there is a significant improvement in terms of output and efficiency - which happens when the sun and the wind resources have opposite cycles and intensities during the same day or in some seasons.

4.9 Result Tables

4.9.1 Variation of Wind Speed Distribution for various months

Table 1: Wind Speed Distribution of September

DATE	WIND SPEED	WIND SPEED DISTRIBUTION
1/09/09	6.75	0.048
2/09/09	4.35	1.67
3/09/09	9.15	0.061
4/09/09	4.65	1.81
5/09/09	6.03	0.76
6/09/09	6.75	0.48
7/09/09	7.8	0.21
8/09/09	4.95	1.33
9/09/09	4.05	1.8
10/09/09	4.65	1.5
11/09/09	7.35	0.31
12/09/09	7.05	0.39
13/09/09	8.7	0.09
14/09/09	6.45	0.06
15/09/09	8.1	0.16
16/09/09	4.95	1.33
17/09/09	4.35	1.66
18/09/09	5.55	1.01

19/09/09	3.75	1.9
20/09/09	4.2	1.74
21/09/09	5.7	0.93
22/09/09	5.25	1.17
23/09/09	7.8	0.21
24/09/09	7.05	0.39
25/09/09	9.15	0.061
26/09/09	4.05	1.8
27/09/09	5.7	0.93

Table 2: Wind Speed Distribution of October

DATE	WIND SPEED	WIND SPEED DISTRIBUTION
1/10/09	3.75	1.9
2/10/09	4.65	0.85
3/10/09	5.7	0.93
4/10/09	8.7	0.09
5/10/09	5.4	1.09
6/10/09	0	0
7/10/09	6.45	1.33
8/10/09	4.95	1.09
9/10/09	5.4	0.93
10/10/09	5.7	0.35
11/10/09	7.2	0.54
12/10/09	6.6	1.17
13/10/09	5.25	0.19
14/10/09	7.95	0.061
15/10/09	9.15	0.19
16/10/09	7.95	0.061
17/10/09	8.85	0.19
18/10/09	8.7	0.082
19/10/09	8.25	0.09
20/10/09	7.45	0.14
21/10/09	6.6	0.29
22/10/09	4.95	0.54
23/10/09	8.7	1.33
24/10/09	11.1	0.095
25/10/09	4.8	0.04
26/10/09	4.9	1.42

Table 3: Wind Speed Distribution of November

DATE	WIND SPEED	WIND SPEED DISTRIBUTION
1/11/09	4.05	1.81
2/11/09	3.75	1.94
3/11/09	2.85	2.14
4/11/09	1.65	1.73
5/11/09	1.8	1.83
6/11/09	3.6	2
7/11/09	2.55	2.12
8/11/09	6.15	0.72
9/11/09	4.95	1.33
10/11/09	6.75	0.48
11/11/09	6.45	0.59
12/11/09	2.25	2.04
13/11/09	4.95	1.79
14/11/09	6.15	0.72
15/11/09	4.65	1.5
16/11/09	4.05	1.8
17/11/09	9.15	0.061
18/11/09	10.5	0.95
19/11/09	8.55	0.11
20/11/09	4.8	1.42
21/11/09	5.55	1.01
22/11/09	8.85	0.082
23/11/09	6.45	1.42
24/11/09	6.45	1.01
25/11/09	7	0.082
26/11/09	8	0.59
27/11/09	8.15	0.16

Table 4: Wind Speed Distribution of January

DATE	WIND SPEED	WIND SPEED DISTRIBUTION
1/01/10	8	0.0183
2/01/10	9	0.071
3/01/10	9.45	0.074
4/01/10	8.85	0.082
5/01/10	2.1	1.9
6/01/10	5.4	1.09
7/01/10	2.25	2.04
8/01/10	4.35	1.67
9/01/10	3.75	1.9
10/01/10	5.55	1.01
11/01/10	7.8	0.21
12/01/10	8.7	0.09
13/01/10	8.85	0.082

14/01/10	3.9	1.9
15/01/10	3.15	2.11
16/01/10	3.75	1.9
17/01/10	3.45	2.04
18/01/10	3.75	1.9
19/01/10	3.9	1.9
20/01/10	4.05	1.8
21/01/10	2.55	2.12
22/01/10	3.45	2.04
23/01/10	5.25	1.17
24/01/10	5.15	1.01
25/01/10	4.15	1.76
26/01/10	9.45	0.04
27/01/10	7.65	0.24
28/01/10	6.75	0.048
29/01/10	2.4	1.79

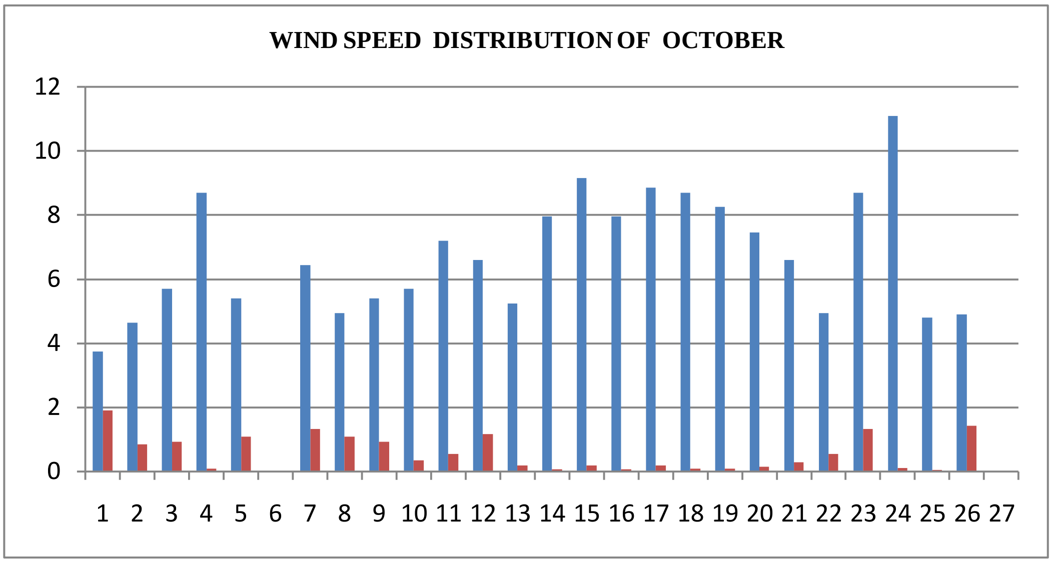
Table 5: Wind Speed Distribution of February

DATE	WIND SPEED	WIND SPEED DISTRIBUTION
1/02/10	6.6	0.54
2/02/10	7.8	0.21
3/02/10	10.2	0.019
4/02/10	8.7	0.09
5/02/10	6.7	0.5
6/02/10	7.35	0.31
7/02/10	12.75	0.006
8/02/10	12.15	0.005
9/02/10	2.85	2.14
10/02/10	5.55	1.01
11/02/10	5.4	1.09
12/02/10	6.9	0.44
13/02/10	7.05	0.39
14/02/10	4.8	1.42
15/02/10	4.8	1.42
16/02/10	9.15	0.061
17/02/10	10.35	0.016
18/02/10	9.15	0.13
19/02/10	10.05	0.076
20/02/10	10.95	1.17
21/02/10	6.15	0.723
22/02/10	6.45	0.6
23/02/10	8.85	0.082
24/02/10	9.6	0.037
25/02/10	8.85	0.082
26/02/10	8.55	0.22
27/02/10	9.05	0.11

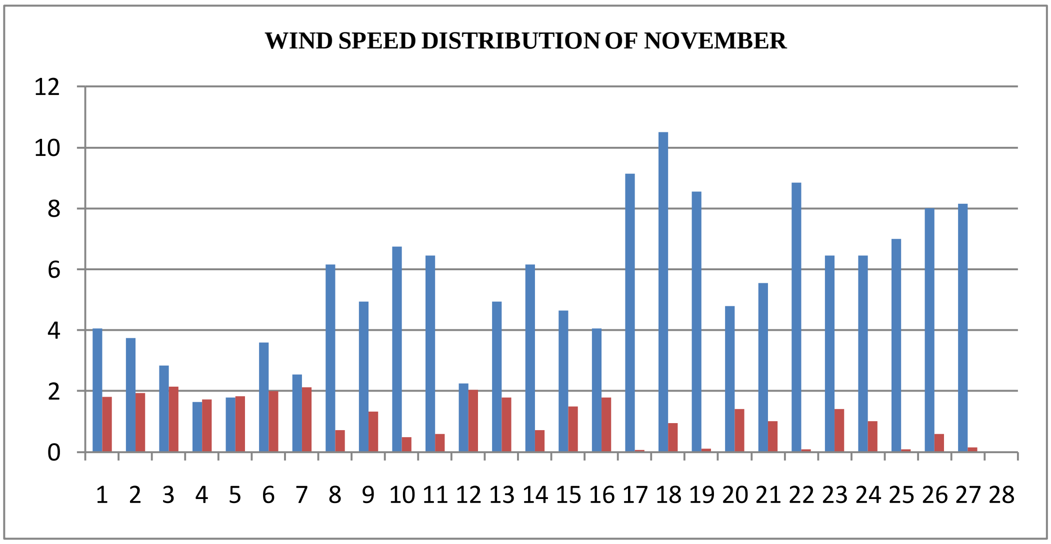
Table 6: Wind Speed Distribution of March

DATE	WIND SPEED	WIND SPEED DISTRIBUTION
1/03/10	5.4	1.09
2/03/10	9.45	0.21
3/03/10	7.05	0.39
4/03/10	9	0.09
5/03/10	10.35	0.016
6/03/10	7.05	0.39
7/03/10	8.7	0.09
8/03/10	7.95	0.19
9/03/10	11.4	0.042
10/03/10	9.75	0.032
11/03/10	8.85	0.082
12/03/10	10.35	0.016
13/03/10	9	0.071
14/03/10	8.7	0.09
15/03/10	8.25	0.14
16/03/10	5.7	0.93
17/03/10	7.65	0.24
18/03/10	8.7	0.09
19/03/10	7.2	0.35
20/03/10	7.5	0.27
21/03/10	7.8	0.21
22/03/10	5.85	0.86
23/03/10	4.35	1.67
24/03/10	4.65	1.5
25/03/10	5.4	1.09
26/03/10	7.35	0.031
27/03/10	8.85	0.082
28/03/10	9	0.071
29/03/10	8.7	0.09
30/03/10	6.9	0.04

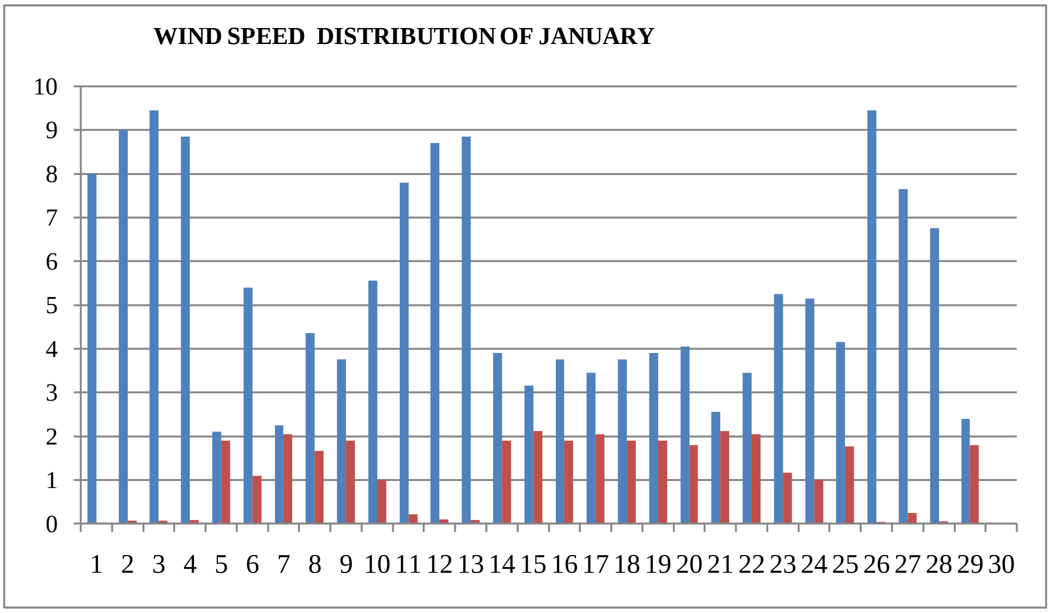
4.9.2 Graphs of Wind Speed Distribution for various months



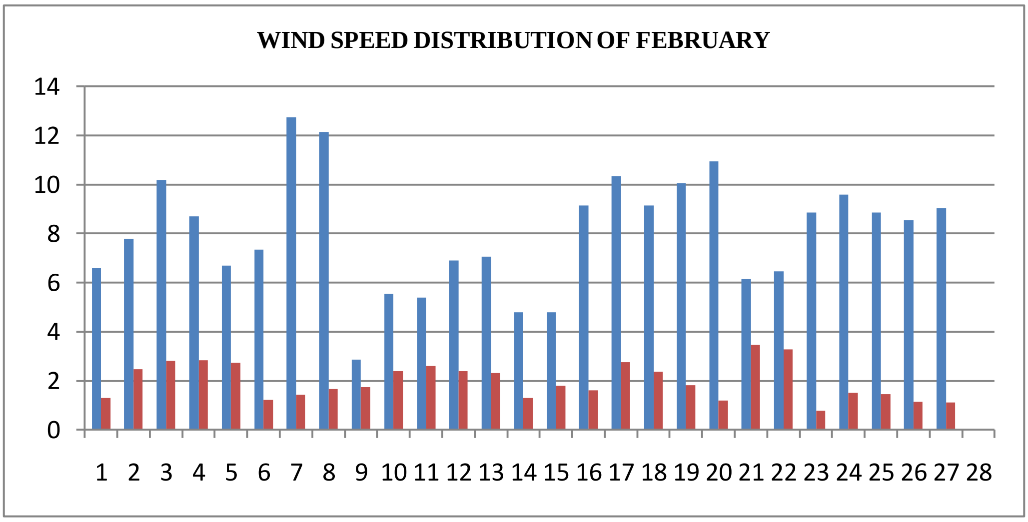
Graph 3



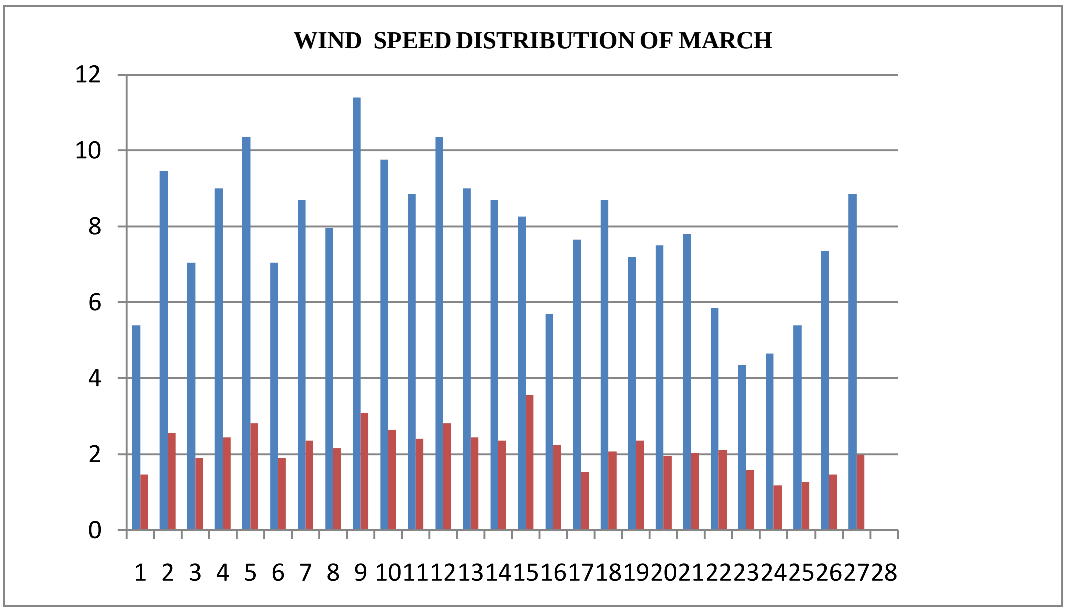
Graph 4



Graph 5



Graph 6



Graph 7

4.9.3 Variation of Average Wind Speed Distribution for Various Months

Table 7: Average Wind Speed Distribution of September

DATE	WIND SPEED	AVERAGE WIND SPEED DISTRIBUTION
1/09/09	6.75	1.73
2/09/09	4.35	2.19
3/09/09	9.15	2.36
4/09/09	4.65	2.19
5/09/09	6.03	1.31
6/09/09	6.75	1.18
7/09/09	7.8	1.5
8/09/09	4.95	1.01
9/09/09	4.05	1.14
10/09/09	4.65	1.54
11/09/09	7.35	1.42
12/09/09	7.05	2.11
13/09/09	8.7	1.79
14/09/09	6.45	1.83
15/09/09	8.1	1.75
16/09/09	4.95	1.18
17/09/09	4.35	2.48
18/09/09	5.55	1.26
19/09/09	3.75	1.63
20/09/09	4.2	1.34
21/09/09	5.7	1.09
22/09/09	5.25	1.26
23/09/09	7.8	1.99
24/09/09	6.4	1.9

25/09/09	4.7	2.36
26/09/09	6.45	1.83

Table 8: Average Wind Speed Distribution of October

DATE	WIND SPEED	WIND SPEED DISTRIBUTION
1/10/09	5.25	1.42
2/10/09	7.95	2.15
3/10/09	9.15	2.39
4/10/09	9.95	2.7
5/10/09	8.85	2.4
6/10/09	8.7	2.42
7/10/09	8.1	2.25
8/10/09	8.7	2.36
9/10/09	8.25	2.24
10/10/09	7.45	2.02
11/10/09	6.6	1.79
12/10/09	4.95	1.34
13/10/09	8.7	2.36
14/10/09	8.25	2.24
15/10/09	7.45	2.02
16/10/09	6.6	1.79
17/10/09	4.95	2.38
18/10/09	8.7	2.36
19/10/09	11.1	3.02
20/10/09	3.75	1.01
21/10/09	4.65	1.26
22/10/09	5.7	1.54
23/10/09	8.7	2.36
24/10/09	5.4	1.46
25/10/09	5.7	1.54
26/10/09	7.2	1.95
27/10/09	6.6	1.79

Table 9: Average Wind Speed Distribution of November

DATE	WIND SPEED	AVERAGE WIND SPEED DISTRIBUTION
1/11/09	4.05	1.09
2/11/09	4.05	1.09
3/11/09	3.75	1.01
4/11/09	2.85	0.77
5/11/09	1.65	0.44
6/11/09	1.8	0.48

7/11/09	3.6	0.97
8/11/09	2.55	0.69
9/11/09	6.15	1.67
10/11/09	4.95	1.34
11/11/09	6.75	1.83
12/11/09	6.45	1.75
13/11/09	2.25	0.61
14/11/09	4.95	1.34
15/11/09	4.95	1.34
16/11/09	8.34	2.21
17/11/09	6.15	1.67
18/11/09	4.65	1.26
19/11/09	4.05	1.09
20/11/09	9.15	2.48
21/11/09	10.5	2.85
22/11/09	8.55	2.32
23/11/09	4.8	1.3
24/11/09	5.55	1.5
25/11/09	8.85	2.4
26/11/09	6.45	1.75
27/11/09	7	1.9
28/11/09	8	2.17
29/11/09	8.15	2.21

Table 10: Average Wind Speed Distribution of January

DATE	WIND SPEED	AVERAGE WIND SPEED DISTRIBUTION
1/01/10	8	1.13
2/01/10	9	2.44
3/01/10	9.45	2.56
4/01/10	8.85	2.4
5/01/10	2.1	0.57
6/01/10	5.4	1.46
7/01/10	2.55	0.69
8/01/10	4.35	1.18
9/01/10	3.75	1.01
10/01/10	5.55	1.5
11/01/10	7.8	2.11
12/01/10	8.7	2.36
13/01/10	8.85	1.83
14/01/10	3.9	2.4
15/01/10	3.15	1.05
16/01/10	3.75	0.85
17/01/10	3.45	1.01
18/01/10	3.75	0.93
19/01/10	3.9	1.05

20/01/10	4.05	1.09
21/01/10	2.55	0.69
22/01/10	3.45	0.96
23/01/10	5.25	1.42
24/01/10	5.55	1.53
25/01/10	4.15	1.12
26/01/10	9.45	2.56
27/01/10	7.65	2.07
28/01/10	6.75	1.53
29/01/10	9.04	2.33
30/01/10	4.45	1.22

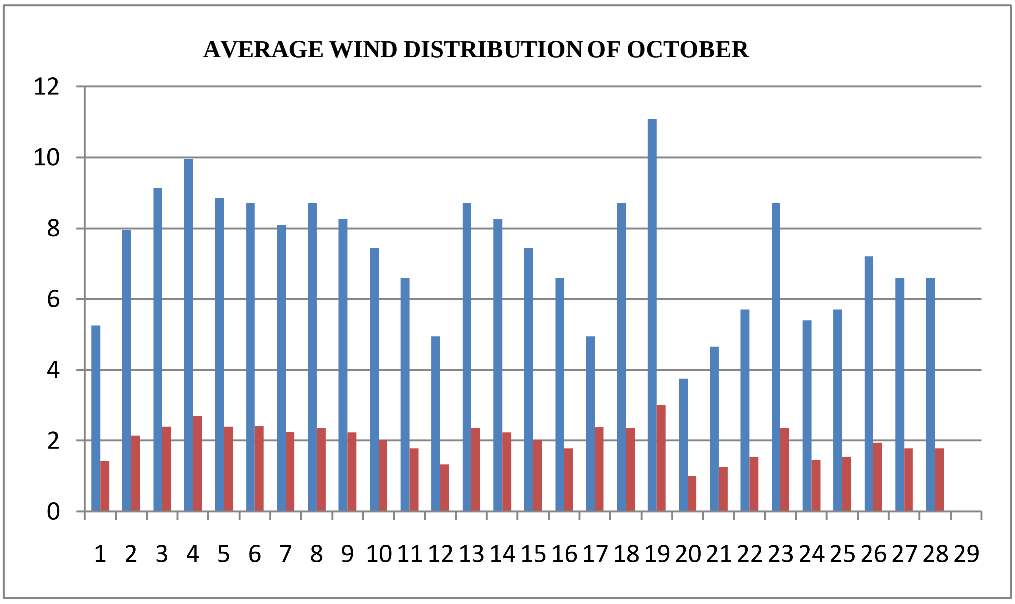
Table 11: Average Wind Speed Distribution of February

DATE	WIND SPEED	AVERAGE WIND SPEED DISTRIBUTION
1/02/10	6.6	1.3
2/02/10	7.8	2.48
3/02/10	10.2	2.81
4/02/10	8.7	2.84
5/02/10	6.7	2.72
6/02/10	7.35	1.21
7/02/10	12.75	1.42
8/02/10	12.15	1.66
9/02/10	2.85	1.75
10/02/10	5.55	2.4
11/02/10	5.4	2.6
12/02/10	6.9	2.4
13/02/10	7.05	2.32
14/02/10	4.8	1.3
15/02/10	4.8	1.79
16/02/10	9.15	1.6
17/02/10	10.35	2.76
18/02/10	9.15	2.36
19/02/10	10.05	1.81
20/02/10	10.95	1.18
21/02/10	6.15	3.45
22/02/10	6.45	3.29
23/02/10	8.85	0.77
24/02/10	9.6	1.5
25/02/10	8.85	1.46
26/02/10	8.55	1.14
27/02/10	9.05	1.12

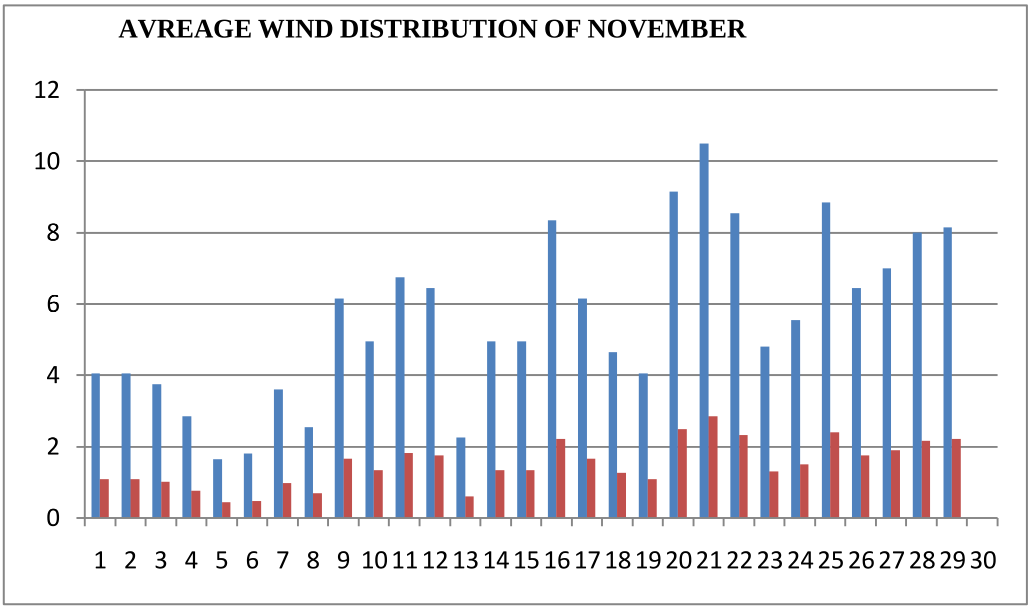
Table 12: Average Wind Speed Distribution of March

DATE	WIND SPEED	WIND SPEED DISTRIBUTION
1/03/10	5.4	1.46
2/03/10	9.45	2.56
3/03/10	7.05	1.91
4/03/10	9	2.44
5/03/10	10.35	2.81
6/03/10	7.05	1.91
7/03/10	8.7	2.36
8/03/10	7.95	2.15
9/03/10	11.4	3.09
10/03/10	9.75	2.64
11/03/10	8.85	2.4
12/03/10	10.35	2.81
13/03/10	9	2.44
14/03/10	8.7	2.36
15/03/10	8.25	3.55
16/03/10	5.7	2.24
17/03/10	7.65	1.54
18/03/10	8.7	2.07
19/03/10	7.2	2.36
20/03/10	7.5	1.95
21/03/10	7.8	2.03
22/03/10	5.85	2.11
23/03/10	4.35	1.58
24/03/10	4.65	1.18
25/03/10	5.4	1.26
26/03/10	7.35	1.46
27/03/10	8.85	1.99

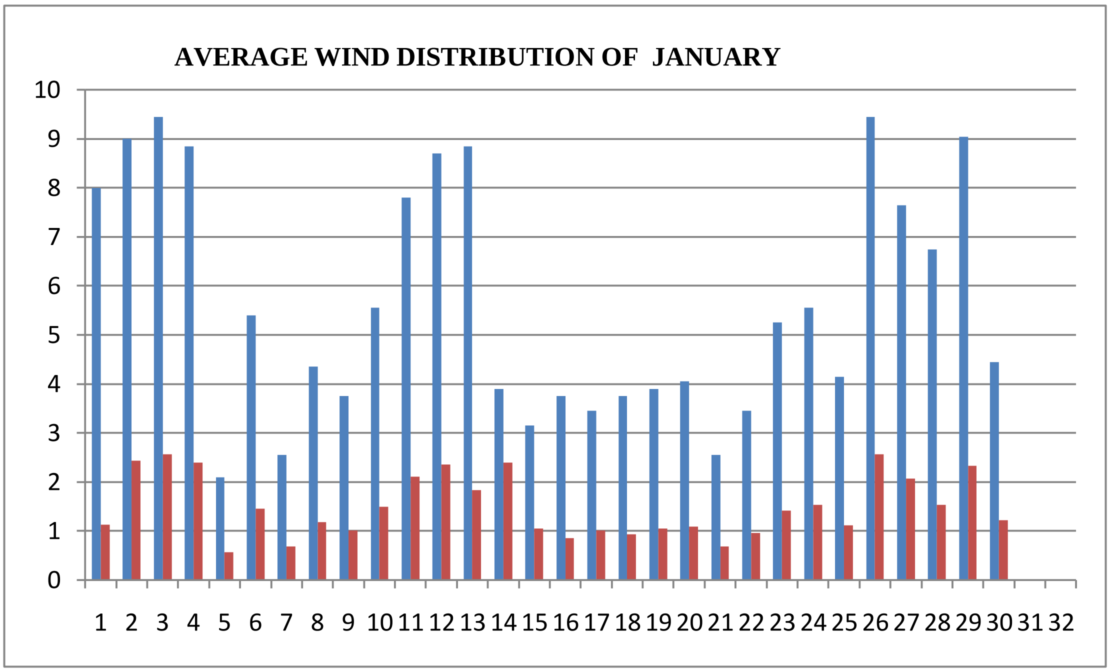
4.9.4 Graphs of Average Wind Speed Distribution for Various Months



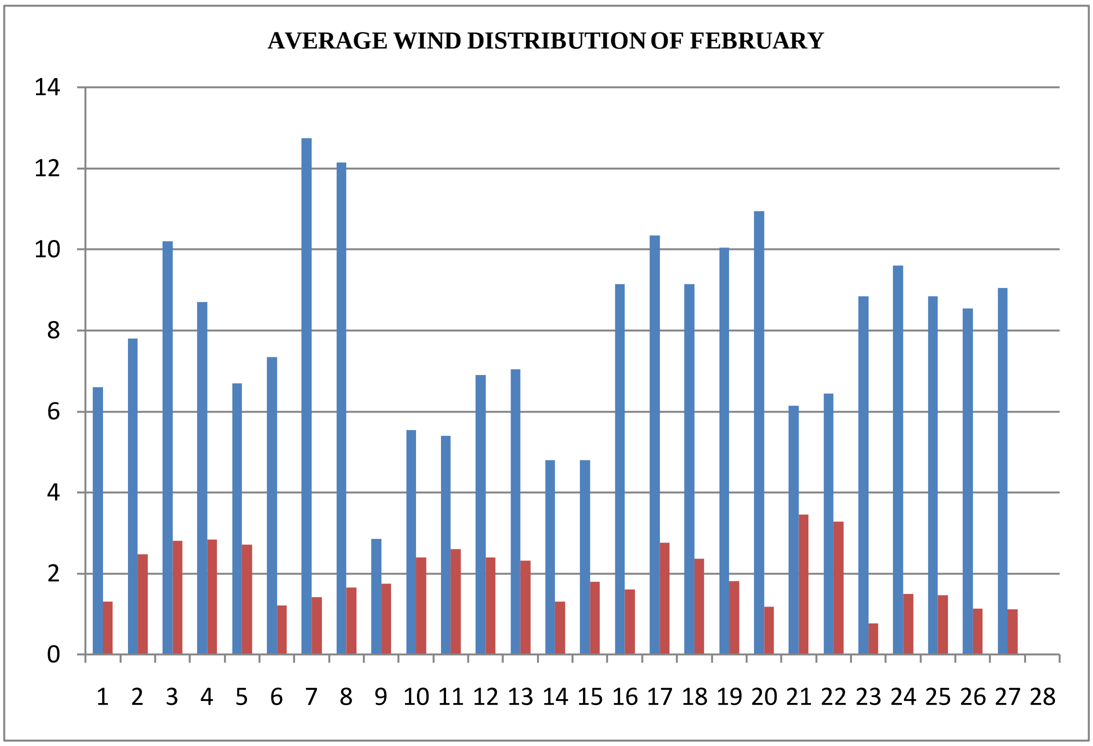
Graph 8



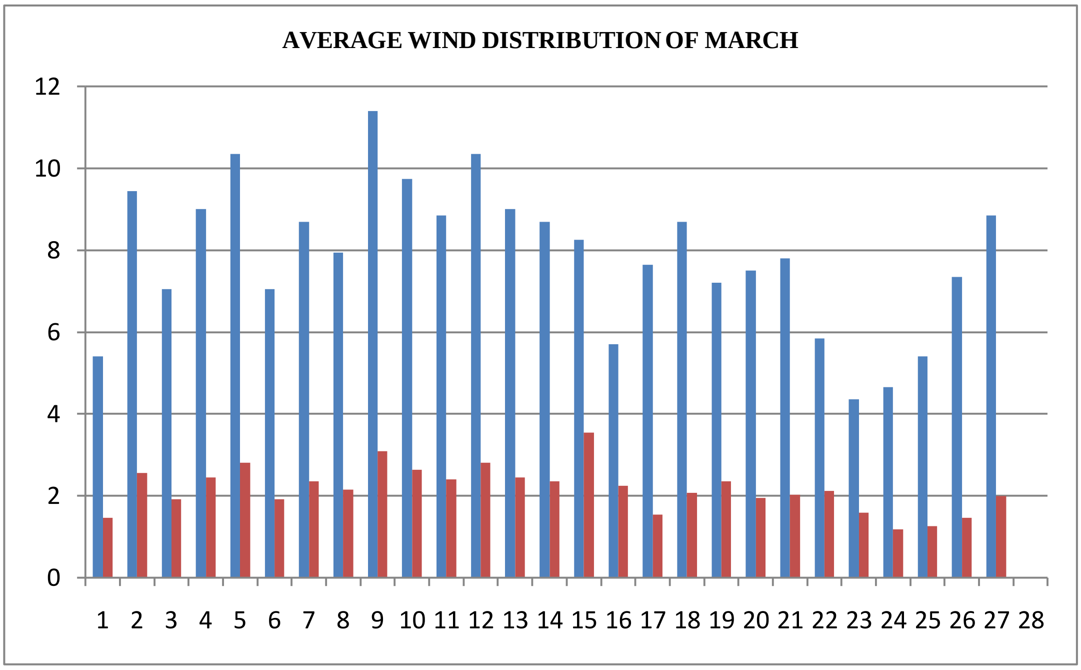
Graph 9



Graph 10



Graph 11



Graph 12

4.10 Comparison of Solar and Wind Energy based upon average for various months

Table 13: Wind and Solar Energy of September

WIND ENERGY OF TURBINE	SOLAR ENERGY
1.73	37.60
2.19	54.45
2.36	59.95
2.19	61.`15
1.31	48.75
1.18	47.35
1.5	59.35
1.01	62.76
1.14	56.25
1.54	61.95
1.42	43.56
2.11	68.75
1.79	47.66
1.83	53.45
1.75	57.78
1.18	63.60
2.48	49.15
1.26	44.95

1.63	38.95
1.34	66.45
1.09	64.45
1.26	59.17
1.99	55.325
1.9	60.15
2.36	59.65
1.83	47.34

Table 14: Wind and Solar Energy of October

WIND ENERGY OF ONE TURBINE	SOLAR ENERGY
1.42	57.10
2.15	44.80
2.39	49.15
2.7	61.20
2.4	43.54
2.42	57.77
2.25	69.05
2.36	52.45
2.24	36.04
2.02	51.90
1.79	55.94
1.34	58.75
2.36	60.12
2.24	59.10
2.02	67.38
1.79	53.60
2.38	59.55
2.36	65.95
3.02	45.76
1.01	56.87
1.26	44.88
1.54	59.07
2.36	52.25
1.46	63.01
1.54	58.6
1.95	57.34

Table 15: Wind and Solar Energy of November

WIND ENERGY OF ONE TURBINE	SOLAR ENERGY
1.09	47.60
1.09	50.0
1.01	49.78
0.77	41.50
0.44	63.54
0.48	67.87
0.97	59.65
0.69	42.70
1.67	46.34
1.34	41.30
1.83	51.04
1.75	48.85
0.61	30.11
1.34	32.16
1.34	47.38
2.21	53.60
1.67	59.55
1.26	65.95
1.09	45.76
2.48	56.87
2.85	44.88
2.32	59.07
1.3	52.25
1.5	56.01
2.4	45.7
1.75	47.39
1.9	46.56
2.17	55.7
2.21	37.39

Table 16: Wind and Solar Energy of January

WIND ENERGY OF ONE TURBINE	SOLAR ENERGY
1.13	51.76
2.44	65.15
2.56	55.75
2.4	51.535
0.57	63.65
1.46	52.375
0.69	49.25
1.18	62.25
1.01	43.125
1.5	41.425
2.11	43.525

2.36	58.875
1.83	59.365
2.4	51.45
1.05	63.5
0.85	41.5
1.01	49.125
0.93	34.225
1.05	38.555
1.09	61.845
0.69	44.435
0.96	69.5
1.42	35.325
1.53	50.375
1.12	55.875
2.56	54.575
2.07	55.67
1.53	43.52
2.33	53.89
1.22	44.87I

Table 17: Wind and Solar Energy of February

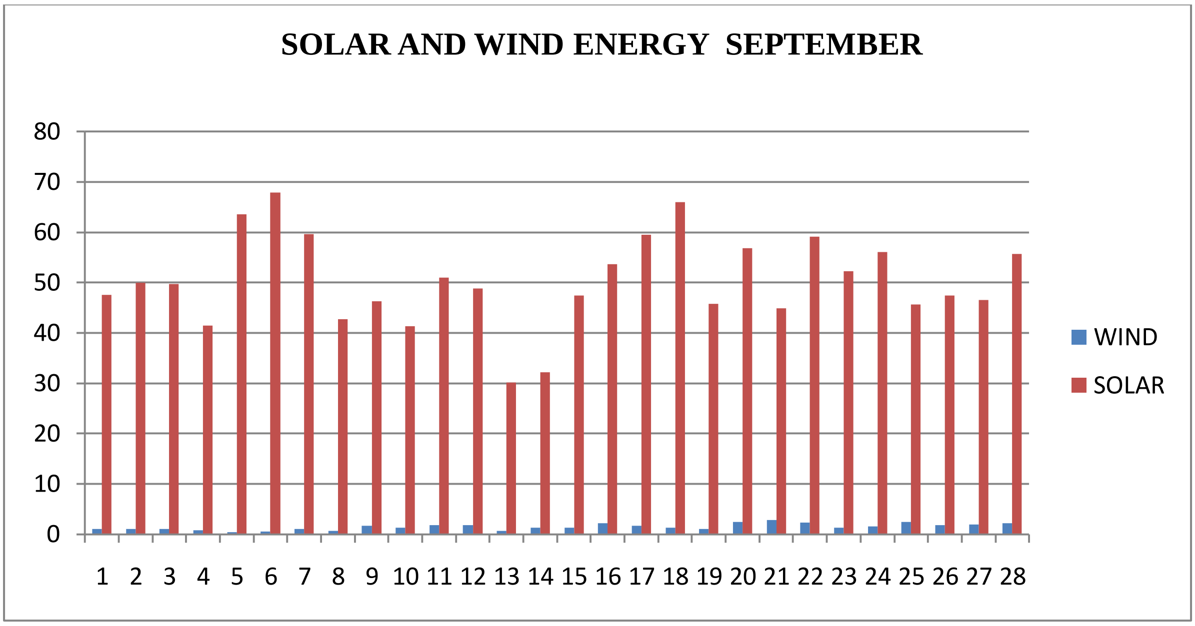
WIND ENERGY	SOLAR ENERGY
1.3	61.26
2.48	72.215
2.81	59.775
2.84	61.625
2.72	73.61125
1.21	52.375
1.42	59.16625
1.66	62.8625
1.75	73.198125
2.4	71.425
2.6	53.545625
2.4	68.875
2.32	59.365
1.3	81.45
1.79	63.625
1.6	61.675
2.76	49.125
2.36	34.225
1.81	38.555
1.18	61.845
3.45	44.435
3.29	69.17625
0.77	45.325
1.5	50.375

1.46	55.875
1.14	64.575
1.12	55.67

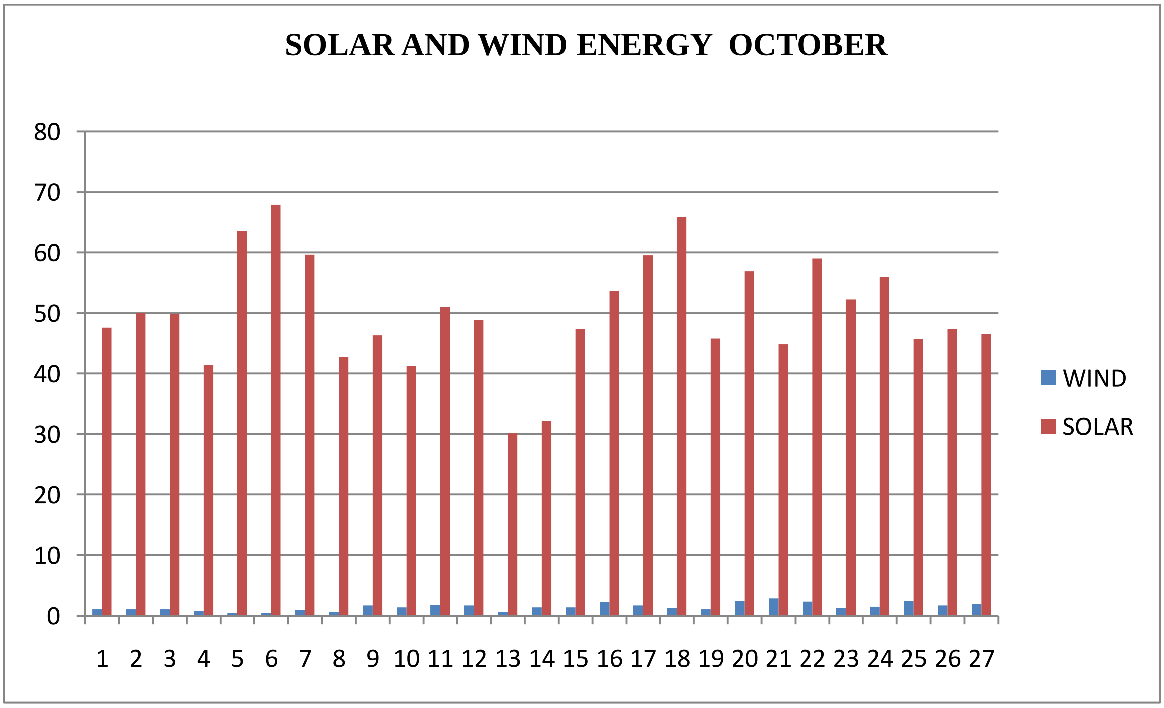
Table 18: Wind and Solar Energy of March

WIND ENERGY OF ONE TURBINE	SOLAR ENERGY
1.46	67.26
2.56	62.15
1.91	49.05
2.44	51.65
2.81	58.625
1.91	57.375
2.36	69.15
2.15	52.8625
3.09	53.105
2.64	61.425
2.4	53.56
2.81	48.785
2.44	49.35
2.36	61.45
3.55	56.65
2.24	61.675
1.54	49.125
2.07	34.225
2.36	38.555
1.95	61.845
2.03	44.435
2.11	59.17
1.58	65.325
1.18	50.315
1.26	55.865
1.46	54.575
1.99	65.67

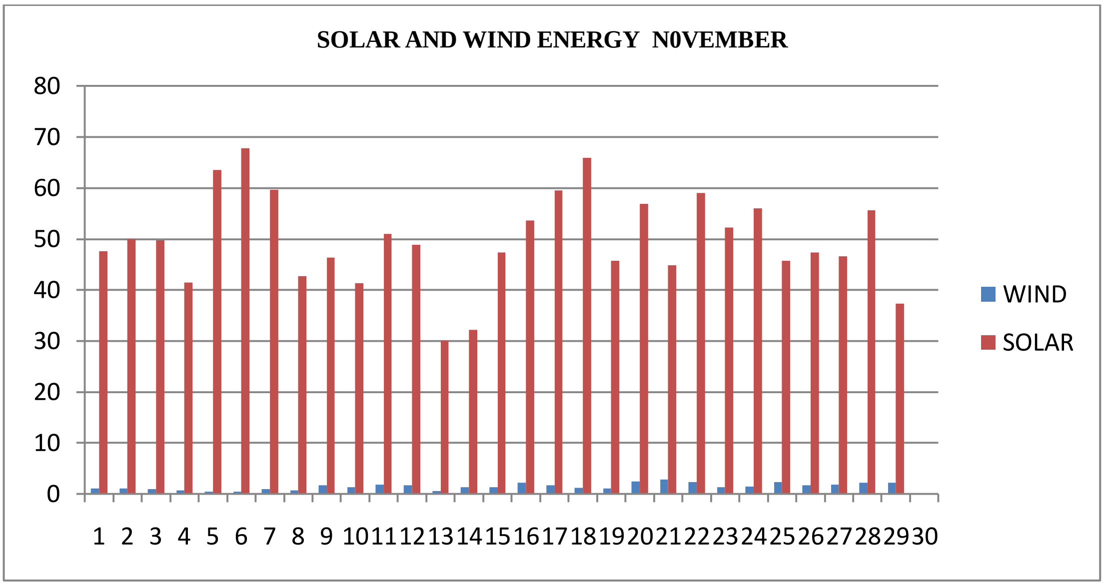
4.10.1 Graphs of Comparison of Solar and Wind Energy based upon average for various months



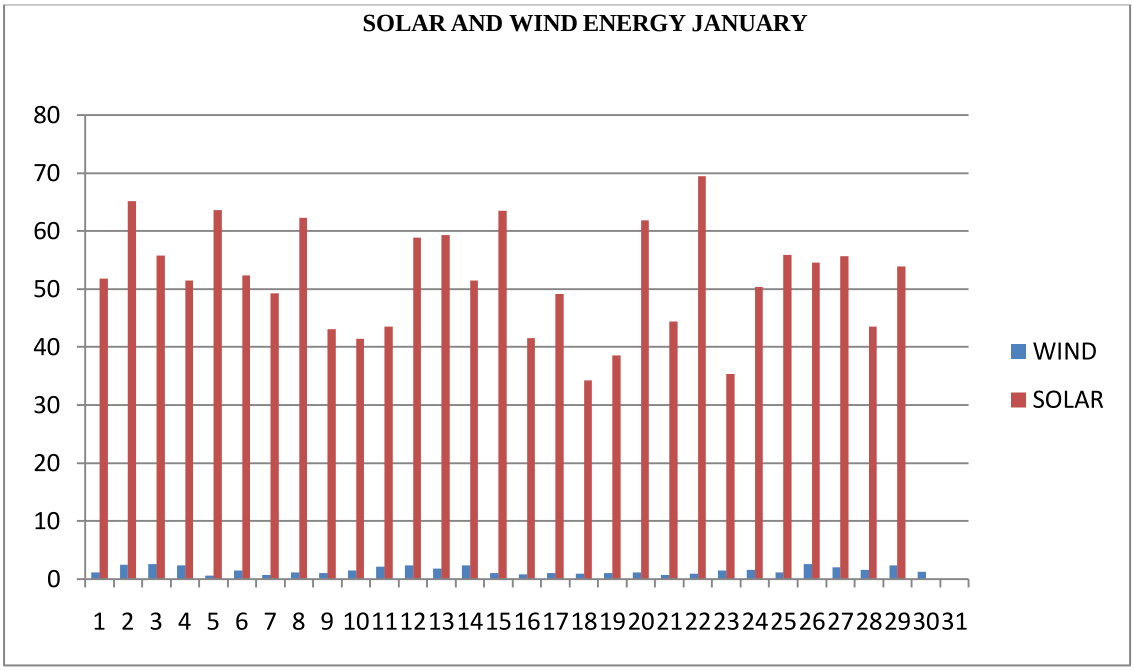
Graph 13



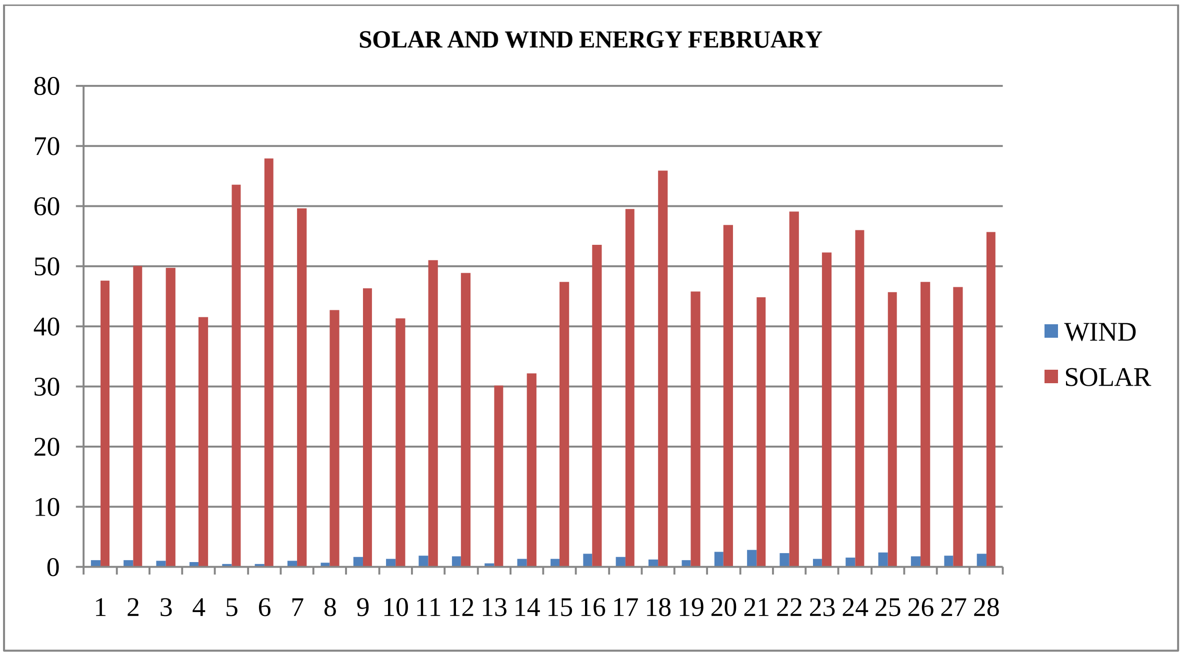
Graph 14



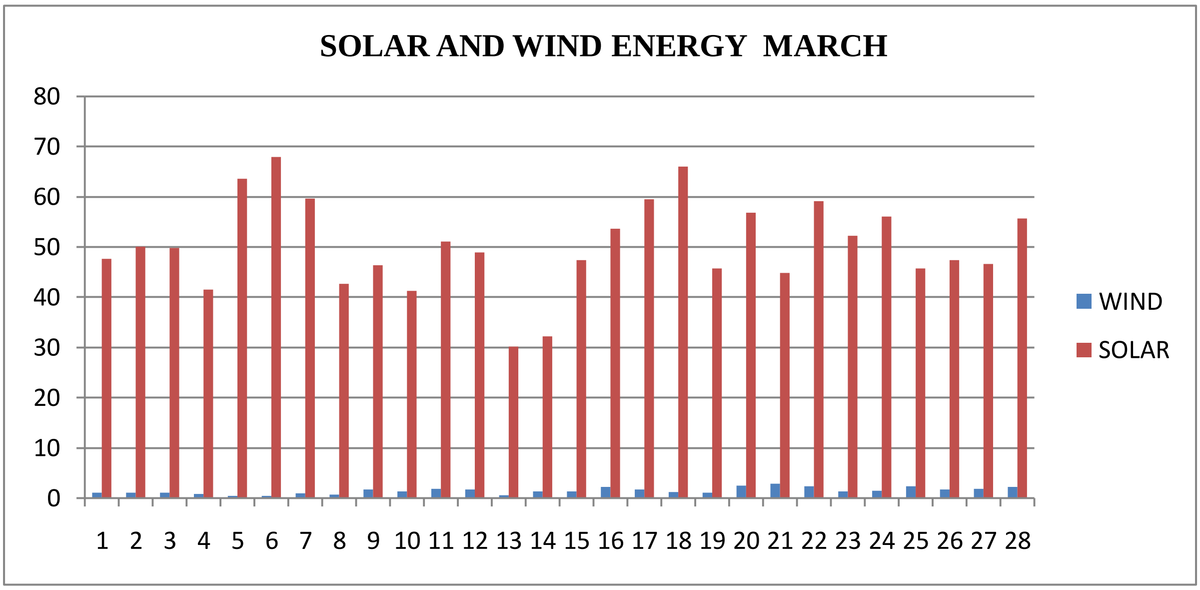
Graph 15



Graph 16



Graph 17



Graph 18

CONCLUSION AND WORK IN FUTURE

Chapter 05

5.1 Conclusions

From the above results we can find out that hybrid model of solar and wind energy can full fill the load demand wind energy support the solar energy to full fill load demand. So through this system we can supply the energy rural area where the sufficient energy cannot produce. Using these technical solutions the electrical energy supply can be resolved for small farms and hoses sited in this remote area. We can get good energy by increasing the height of tower. The measurements of this parameter, dates are indicated to realise for six month period. Analysing the meteorological data we can obtain a favourite solution for the applicability of the green energy sources in this proposed application. We can use small optimal storage capacity. Because into large storage the cost is increased .through this system we can decrease the unit rate of energy. And reduce the pollution level. And proper utilize the natural sources.

5.2 Work In Future

We can produce the large amount energy from the renewable resources into future by using the proper locations. Many locations are available into India where large potential of solar and wind energy. Into future we can install the small plant into rural area where solar and wind is available by using this energy. We can fulfil the load requirement of the consumer of these rural areas. We can decrease the pollution by these resources compare to non-renewable resources. By using hybrid system we can fulfil the energy demand into the future. In future by using sensor of better quality we can increase the potential. We have used the small storage capacity. Using the better quality data logger we can increase the energy production in future. In future we can install large solar and wind plant which are cheaper compare to small plants.

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