Implementation of Hybrid Renewable Energy Conversion and Control System

Swathy B A

Abstract - The depleting conventional energy sources and world population growth at a rapid rate predict the severe global energy crisis in near future. As an alternative, the world has started considering renewable energy sources as they are universal in nature, freely available and environment friendly. Example for such a renewable energy resources are wind, solar, hydro, bio-mass, geo-thermal, etc., Among these one of the fastest expanding renewable energy sources is wind energy. But the wind energy systems may not be technically viable at all places because of low wind speeds and with high unpredictability. Solution for such a problem is hybrid renewable energy resource. Hybrid renewable energy resource is the combination of one or more renewable energy resource. The proposed system has a combination of solar wind hybrid which will become more attractive and can be used as alternative of oil produced energy. The main aim of this project is to meet the load demand without interruption and to achieve demand based source selection. This paper also describes the Hardware kit of the proposed block diagram.

Keywords: Solar energy; Wind Energy; Hybrid systems.

1. Introduction

Electricity is one of the key factors on which the economy of the country depends and the standard of living of the people of any country is considered to be proportional to the energy consumption by the people of that country. Therefore the sustainable power generations with economically feasible solutions are the key factors for the growth of the country. Non-renewable resources is natural resource but which cannot be produced or generated and they do not replenish in a short period of time. Presently many parts of the world use fossil fuels for the generation of power but these resources are depleting fast is the cause for the concern. Due to environmental pollution, Fossil fuel based power generation is slowly being backtracked.

Most of energy comes from fossil fuels, and burning these fuels causes' environmental problems, and in particular, the global warming problem. The fossil fuel use as energy source has many limitations. There are a number of pollutants that have been identified as coming out of the use of fossil fuels and they are serious health hazards [1]. The world energy consumption pattern is also increasing as shown in the Fig.1. The energy consumption has been increasing and it will triple in a period of 50 years by 2025.

Fig 1. Energy consumption variation

One day Fossil fuels could run out. Alternative sources of energy are needed. As supplies decrease, the cost of buying fossil fuels may increase causing economic problems as well. When fossil fuels are burnt they produce the gas carbon dioxide (CO2). Carbon dioxide is known as a greenhouse gas because it traps heat from the sun, much like the glass in a greenhouse, preventing it from escaping out of the Earth’s atmosphere into space. Greenhouse gases are found naturally in the atmosphere and they are essential for keeping the Earth warm. Thus to avoid this type of problems we go for renewable energy resource to provide energy and for un-interruptible power [2].

Recent research and development in Renewable energy sources have shown excellent potential, as a form of supplementary contribution to conventional power generation systems. Renewable energy sources, such as photovoltaic, wind energy, diesel or small scale hydro [3,4] provide a realistic alternative to engine-driven generators for electricity generation.

During the past fifty years, much of the research work has been accomplished in the area of Alternative energy sources concerning their control, efficiency, modeling and simulation techniques, feasibility and experimental work. [5-6] Electrification of the electricity deprived remote and isolated areas, with no grid supply, has attained a great degree of importance for the development of their living standards. To realize this purpose, a number of power generation systems based on the Alternative energy sources have been proposed and designed. [7]

The most common drawback of Alternative energy sources is their periodic nature which accounts for their inability to harness the power for substantial duration of time over the year. This is because the Alternative energy sources are governed by the natural phenomenon which are inevitably influenced by a number of mutable factors. [8, 9, 10]
The power generation systems based on Alternative energy sources turnout to be expensive and oversized when used independently for meeting a load demand. [11] Considering the valuable benefits of these systems, system designers have started considering their integrated operation. This operation comprises of two or more than two of these Alternative energy sources complemented to make different hybrid systems for the constant power generation. [12, 13]

The hybridization process minimizes the energy storage needs and makes the power generation operation reliable and cost effective. This also diminishes the deficiency of harnessed power when one source doesn’t work due to absence of natural phenomenon driving that source (i.e. during the night time, wind will work to produce electricity when PV doesn’t work.). Load can be supplied only by wind or by solar or by wind-solar Hybrid based on demand from load side so we can meet the load without interruption. In order to meet load demands without interruption during varying natural conditions like climatic conditions, wind speed, irradiation of sun and many more, A different energy sources and converter need to be integrated with each other for extended usage of alternative energy.

In order to utilizing the hybrid systems more efficiently [14], the constituent systems which formulate the hybrid system require to be sized and combined properly which will lead to the system with improved control and dispatch and enhanced performance [15-16]. Figure 2 shows the Block diagram of the proposed work.

**Figure 2: Block diagram of proposed work**

The block diagram of the proposed work is presented in figure 1. The block diagram is divided into various blocks which are briefly explained below:

**Solar Panel:** Solar power source. 20W, 12V, 1.12A

**Wind generator:** Wind power source. 20W, 12V, 1A

**Source Router:** Selects the source of electricity depending upon the load demand. Source routing and control circuitry built into. The control unit is so designed that the load supplied with continuous power either from solar or wind or from both depending upon the demand from the load side.

**Microcontroller:** This unit is the main parts of the proposed system in which the power input from solar and wind generators is acquired and processed to handle the system. The electrical quantities are estimated and control actions are initiated according to the load requirement. The voltage, current data are acquired and processed by the microcontroller. The processed data would be displayed over a Liquid Crystal Display for monitoring purpose at the point of site.

**Inverter:** It is an optional module required for conversion. The pure sign wave inverter is recommended in other to prolong the lifespan of the inverter. Inverter is need to convert DC power into AC power. As our load working on the AC supply so we need to convert DC power. The input voltage Output voltage and frequency, and overall power handling depends on the design of the specific device or the circuitry. The inverter does not produce any power. The power is provided by the DC source. [21]

**Load:** The expected Ac load could be Laptop charging or rural electrification.

Rest of the paper has been arranged as follows: Section 2 discusses the Wind energy. Section 3 discusses solar energy. Section 4 discusses the hybrid power generation systems.

2. **Wind Energy**

Wind power systems convert the kinetic energy of the wind into other forms of energy such as electricity. Wind mills or wind turbines extract wind energy from air.

Most commercially available wind turbine uses a horizontal axis configuration with two or three blades, a drive train, including a gear box and a generator and a tower to hold the rotor. The extraction of the wind’s kinetic energy is accomplished by a blade-rotor system. The mechanical energy which is in a form of rotation of a shaft connected to the rotor system is then converted to electricity using a generator. Normally a gearbox is employed between the main shaft and the generator to step-up the shaft’s speed to the electric generator [17]. The doubly fed induction machine is the most widely machine in these days.

The induction machine can be used as a generator or motor. With the use of power of the wind, wind turbines produce electricity to drive an electrical generator. Usually wind passes over the blades, generating lift and exerting a
turning force. Inside the nacelle the rotating blades turn a shaft then goes into a gearbox.

The gearbox helps in increasing the rotational speed for the operation of the generator and utilizes magnetic fields to convert the rotational energy into electrical energy, then the output electrical power goes to a transformer, which converts the electricity to the appropriate voltage for the power collection system. [17, 18, 19]

Wind energy represents an alternative energy source to conventional fuels. Wind is abundant, broadly distributed, renewable, clean, emission less source of energy and requires less land For extraction we use wind mill. The wind energy needs less cost for generation of electricity [20]. Maintenance cost is also less for wind energy system. Wind energy is present almost 24 hours of the day. It has less emission. Initial cost is also less of the system. Generation of electricity from wind is depend upon the speed of wind flowing.

The major disadvantages of using independent renewable energy resources are that unavailability of power for all time. For overcoming this we use solar and wind energy together. So that any one source of power fails other will take care of the generation. In this proposed system we can supply load with continuous power only by using solar, or wind, or solar- wind hybrid. This will make system reliable [20]. The main disadvantages of this system are that it needs high initial cost. Except that it is reliable, it has less emission. Maintenance cost is less. Life span of this system is more. Efficiency is more. A main advantage of this system is that it gives continuous power supply. Figure 2 shows wind energy distribution system.

3. Solar Energy

The solar cells are well identified as Photovoltaic cells. Solar panels are the medium to convert solar power into the electrical power. It generally converts Irradiances of sun into electricity, Whose Output is DC and then it is further converted to AC by using Inverter (DC-AC conversion). Photovoltaic cells are generally a semiconductor usually made up of Si (silicon), those are especially used for creating an electric field that is +ve on one side and -ve on other side. Direct current is produced when the sun ray or radiation falls on the cell.

Solar energy is present on the earth continuously and in abundant manner. Solar energy is freely available. It doesn’t produce any gases that mean it is pollution free. Nigeria, like most other countries is blessed with large amount of sunshine all the year with an average sun power of 490W/m²/day. It is affordable in cost. It has low maintenance cost. Only problem with solar system it cannot produce energy in bad weather condition and during night times. But it has greater efficiency than other energy sources. It only need initial investment. It has long life span and has lower emission.

4. Hybrid Power System

The hybrid means, which is the combination of two or more than two renewable energy sources. In energy system the electricity can be generated by more than one source at a time like Wind, solar. There are various module to generate hybrid energy like wind-solar hybrid, Solar-diesel, Wind- hydro and Wind–diesel.

Among the above hybrid energy generation module the wind-Solar hybrid module are more important because it is abundant in nature and it is very much environment friendly. Hybrid energy generation is more important because the wind not flow continuously and sun radiation is only present approx. 8 to 10 hours in a day (usually morning 6 to evening 6). So for continuous power it is important to hybridize the solar and wind power. The hybridization in India has large prospect because over 75 % of Indian household face the problem like power cut specially in summer. Cost of the Wind-Solar Hybrid system is to be minimized. For minimize the cost of the system we need to increase the use of non-conventional energy sources. So that production of solar and wind power generator will be increase. That will reduce cost of the whole system.

5. Methodology

This project deals with the Energy conversion which is a combination of two Non-conventional sources of energy, i.e. Solar and Wind Energy. Solar and wind are the two promising renewable energy resources to mitigate the crises of environmental issues, and the power generation. These energy sources have environmental benefits over the use of fossil fuels. These sources are not used to their fullest extent because of climatic conditions. From the economical point of view, a
particular choice of renewable energy source is not advisable. In this perspective a work on “Implementation of Hybrid Renewable Energy Conversion and Control System” has been proposed.

The proposed protocol has wind-solar hybrid system, the hybridization process minimizes the energy storage needs and makes the power generation operation reliable and cost effective. This also diminishes the deficiency of harnessed power when one source doesn’t work due to absence of natural phenomenon driving that source (i.e. during the night time, wind will work to produce electricity when PV doesn’t work.). Solar convert irradiation of sun into electricity which will be given as input to the source router which is a DC input. Similarly wind will converts the kinetic energy from wind into electricity which will also be given as input to source router which is also a DC input. Source router is nothing but a control unit which is designed to supply load with continuous power. Here solar capacity of 20W and wind capacity of 20W is used to provide 40W load but for concept proving 20W load is considered. As mentioned earlier the main aim of proposed protocol is to achieve demand based source selection and meeting up the load without interruption, So Source router is designed based on morning and night condition. If the load demand is 20W or less than 20W like 15W, 10W or 5W, the source router will start to operate. During morning hours, the load demand is supplied only by solar, during night hours load demand is supplied only by wind. When stand-alone solar or stand-alone wind cannot supply the load, a wind -solar hybrid system will supply the load. So load can be supplied only by wind or by solar or by wind-solar hybrid based on demand from load side so we can meet the load without interruption. In order to meet load demands without interruption during varying natural conditions like climatic conditions, wind speed, irradiation of sun and many more. A different energy sources and converter need to be integrated with each other for extended usage of alternative energy.

7. Statement of Problem

In view of the above, Solar and wind are the two promising renewable energy resources to mitigate the crises of environmental issues, and the power generation. However, the power generation from these resources is largely dependent on the locations and climatic conditions. The literature survey reveals that the various renewable energy sources are proposed for limited and specific applications. These sources are not used to their fullest extent, High initial investment, less conversion efficiency, Poor power quality because of high frequency components in inverter, Cannot meet the load demand at bad environmental conditions. The choice of a renewable energy source to use at a particular place depends upon various factors such as the site, climatic conditions, wind speed, irradiation and many more.

From the economical point of view, a particular choice of renewable energy source is not advisable. To have an economically practical and successful renewable energy solution at any place for any application is hybrid system. In this perspective a work on “Implementation of Hybrid Renewable Energy Conversion and Control System” has been proposed.

8. Experimental setup with result

The developed Project kit is shown in figure 4. Which is integrated by using a Microcontroller with LCD (To display messages), Power supply, Buck converter (to buck Voltage in case of lower load demand), Relays (to switch inputs according to the demand), and a Signal conditioning circuit for voltage and current (to condition signal from higher voltage analog signal to readable microcontroller signal). The developed kit with both AC and Dc loads are shown in fig 5 and 6. and 20W solar panel and wind generator is shown in fig 7 and 8.
9. Conclusion

The implementation of hybrid renewable energy systems was designed and developed with the help of source routers and basic parameters. The source router was implemented with firmware of PIC16F877A. The developed hardware prototype was tested for its satisfactory operation. The firmware was tested for its operation.

10. Future Scope

The use of renewable energy systems will reduce the environmental pollution that will reduce the greenhouse gases, will reduce the global warming that help in avoiding melting of glacier & increase of sea level. The use of renewable energy systems will reduce the dependence on the central grid power which is being distributed over long distances with heavy energy losses that can be avoided. The Hybrid renewable energy systems will enhance the utilization factor and reliability factor of renewable energy systems.

11. References


