Generation of Power in Highways by Combination of Solar and Vertical Axis Wind Turbine

Mr.R.Arun[1] Ms.T.Pavithra[2] Ms.S.karthika[3]
[1,2,3]Department of Power Systems Engineering
[1,2,3]Kalaignar Karunanidhi Institute of Technology, Coimbatore

Abstract— In the present economic world, there is a demand for electrical energy. This demand makes us to seek new energy sources. The most important application field to meet the demand is renewable energy resources. Wind and solar energy are popular resources owing to abundant, ease of availability and convertibility to the electric energy. This work covers realization of a hybrid renewable energy system for a domestic application, which runs under a microcontroller to utilize the solar and wind power. While combining vertical axis windmill and solar panel, the initial power required for the wind turbine will be obtained from solar panel and no external power is required. The whole apparatus setup is placed in between the highways on the divider. When any vehicle passes on the highway, the vertical windmill will start to rotate and produce electrical power that is stored in the battery. It is a renewable energy source that has virtually no environmental problems and takes less space than conventional power plants. There is a great demand for usage of electricity in remote areas. By implementing this project, the shortages can be overcomed and it become a reliable source of energy.

Key words: Wind Turbine, Generation of Power

I. INTRODUCTION

One of the driving forces for social and economic development and a basic demand of nations is energy. Most of the energy production methods are one-way, which requires change of form for the energy.

In parallel to developing technology, demand for more energy makes us seek new energy sources. Researches for renewable energies have been initiated first for wind power and then for solar power. Efficiency of solar power conversion systems is 18%, whilst that of wind power is 55%. These efficiencies could be increased by 50% with beam tracking, beam focusing and wind direction adaptive motion methods.

The aim of this work is design and implementation of a solar-wind hybrid energy system under microcontroller in highway divider. This work is expected to sustain some part of the electricity consumption with an efficient utilization of solar and wind power.

II. ENERGY RESOURCES

Persistent increase in the energy demand has caused to seek new energy resources in the world. New alternative energy resources have been also utilized to minimize the energy deficit.

Energy resources are classified into two groups: primary nonrenewable and secondary-renewable resources.

A. Nonrenewable Energy Resources

Nonrenewable energy resources are the ones that decay partially or vanish with the time or needs decades for reuse, such as oil, coal and coal derivatives, natural gas, wood and radioactive atoms (uranium).

B. Renewable Energy Resources

Renewable energy resources are the ones that are persistently available and renewing itself with the time. Industrialization and increasing world population has remarked the use of renewable energy resources. Solar power, wind power, biomass, tide power, wave power, geothermal power is known ones.

C. Solar Power

Solar panels are the medium to convert solar power into the electrical power. Solar panels can convert the energy directly or heat the water with the induced energy. PV (Photo-voltaic) cells are made up from semiconductor structures as in the computer technologies. Sun beam is absorbed with this material and electrons are emitted from the atoms that they are bounded. This release activates a current. Photovoltaic is known as the process between beam absorbed and the electricity induced. With a common principle and individual components, solar power is converted into the electric power.

Solar batteries are produced by waffling p-n semi-conductors. A current-volt characteristic of the PV in the darkness is very similar to that of diode. Under beam, electron flow and current occurs. In closed-loop, PV current passes through the external load. While in open-loop, the current completes the circuit through the p-n diode structure.

Solar batteries can be represented with an equivalent circuit of a current source, a resistor and a diode in parallel, and an external load-resistor, as seen in Figure 1.

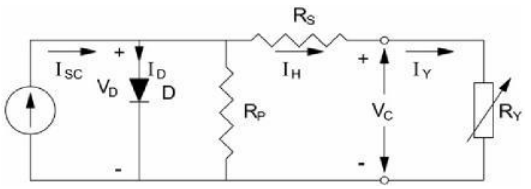

Fig. 1: Equivalent circuit of solar battery

It is possible to insert AC-DC converter, charger, accumulator, extra power source, and controller depending on the design differences in operational and functional specifications. Solar system could be categorized into two types:

1) Line-Independent Systems:

These are established in absence of line electricity to provide electricity. Since the current in these systems are DC and it must be also available overnight, energy is stored in accumulators, DC-Batteries. In case of AC-Supply requirements for the appliances, it is possible to use DC-AC invertor.

2) Line-Dependent Systems:

These systems do not need DC-Batteries, since the energy is served to the demand with the help of an invertor. Line

electricity is being switched in use in case of insufficient sun beam.

III. SOLAR TECHNOLOGIES OVERVIEW

Photovoltaics directly convert photon energy into electricity. These devices use inorganic or organic semiconductor materials that absorb photons with energy greater than their bandgap to promote energy carriers into their conduction band. Electron-hole pairs for organic semiconductors, are subsequently separated and charges are collected at the electrodes for electricity generation.

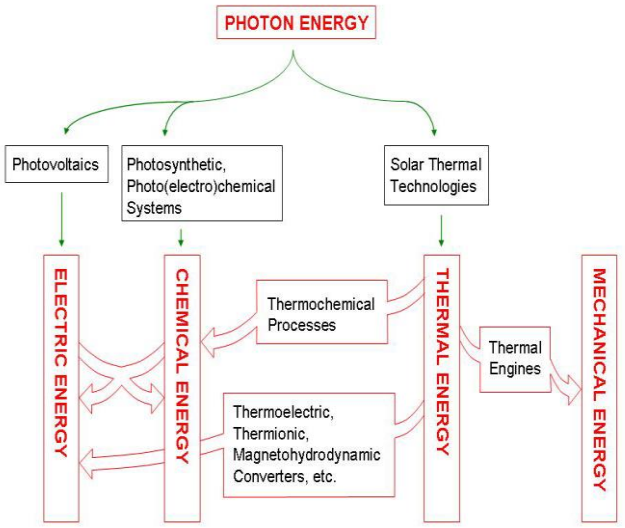

Fig. 2: Solar Technologies Overview

Solar thermal technologies convert the energy of direct light into thermal energy using concentrator devices. These systems reach temperatures of several hundred degrees with high associated energy.

Photosynthetic, photo(electro)chemical, thermal, and thermochemical processes are used to convert solar energy into chemical energy for energy storage in the form of chemical fuels, particularly hydrogen.

IV. WIND POWER

Wind turbines are used to convert the wind power into electric power. Electric generator inside the turbine converts the mechanical power into the electric power. Wind turbine systems are available ranging from 50W to 2-3 MW. The energy production by wind turbines depends on the wind velocity acting on the turbine. Wind power is used to feed both energy production and consumption demand, and transmission lines in the rural areas.

Wind turbines can be classified with respect to the physical features (dimensions, axes, number of blade), generated power and so on. For example, wind turbines with respect to axis structure: horizontal rotor plane located turbines, turbines with vertical or horizontal spinning directions with respect to the wind. Turbines with blade numbers: 3-blade, 2-blade and 1- blade turbines.

On the other hand, power production capacity based classification has four subclasses.

- Small Power Systems
- Moderate Power Systems
- Big Power Systems
- Megawatt Turbines

A. Wind Turbine Operation

- ~ 10 mph - Wind speed is too low for generating power. Turbine is not operational. Rotor is locked.
- 10 ~ 25 mph - 10 mph is the minimum operational speed. It is called "Cut-in speed". In 10 ~ 25 mph wind, generated power increases with the wind speed.
- 25 ~ 50 mph - Typical wind turbines reach the rated power (maximum operating power) at wind speed of 25mph (called Rated wind speed). Further increase in wind speed will not result in substantially higher generated power by design. This is accomplished by, for example, pitching the blade angle to reduce the turbine efficiency.
- 50 mph - Turbine is shut down when wind speed is higher than 50mph (called "Cut-out" speed) to prevent structure failure.

V. DESIGN AND IMPLEMENTATION OF HYBRID ENERGY SYSTEM IN HIGHWAY DIVIDER

Hybrid systems are the ones that use more than one energy resources. Integration of systems (wind and solar) has more influence in terms of electric power production. Such systems are called as "hybrid systems".

Hybrid solar-wind applications are implemented in the field, where energy is to be consumed without any chance for an interrupt. It is possible to have any combination of energy resources to supply the energy demand in the hybrid systems, such as solar and wind. This project is similar with solar power panel and wind turbine power. Differently, it is only an add-on in the system.

Photovoltaic solar panels and small wind turbines depend on climate and weather conditions. Therefore, neither solar nor wind power is sufficient alone. A number of renewable energy expert claims to have a satisfactory hybrid energy resource if both wind and solar power are integrated within a unique body.

In the summer time, when sun beams are strong enough, wind velocity is relatively small. In the winter time, when sunny days are relatively shorter, wind velocity is high on the contrast. Efficiency of these renewable systems show also differences through the year. In other words, it is needed to support these two systems with each other to sustain the continuity of the energy production in the system.

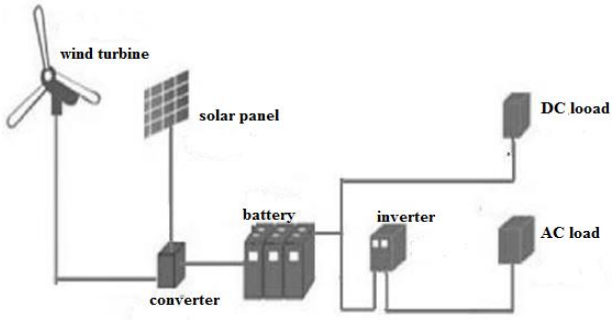

Fig. 3: Design

Depending on the environmental conditions, required energy for the system can be supplied either separately from the wind or solar systems or using these two resources at the same time.

Wind turbine first converts the kinetic energy to mechanical energy and then converts it to the electricity.

The wind turbine in the system consists of tower, alternator, speed converters (gear box), and propeller.

The kinetic energy of the wind is converted to the mechanical energy in the rotor. The rotor shaft speed, 1/18, is accelerated in the reduction gear and then transmitted to alternator. The electricity that comes from the alternator can be directly transmitted to DC receivers as well as it can be stored in the batteries.

The solar panels in the system convert the day light directly in to electricity. The properties of the PV module (PM 065, Solen Energy Corporation) in the system

The solar panels can generate major amount of electricity even in the cloudy weathers.

MPPT regulates the energy coming from these panels and ensures a continuous high power generation. The current from the MPPT is used to charge the battery.

The batteries in the system provide to store the electricity that is generated from the wind or the solar power. Any required capacity can be obtained by serial or parallel connections of the batteries. The battery that provides the most advantageous operation in the solar and wind power systems are maintenance free dry type and utilizes the special electrolytes. These batteries provide a perfect performance for long discharges. The storage and usage of the electricity that is generated from the wind and solar power are controlled in the real time control system.

Fig. 4: A picture of the constructed hybrid system.

The block diagram shown below shows the generation of power by combination solar and vertical axis wind turbine.

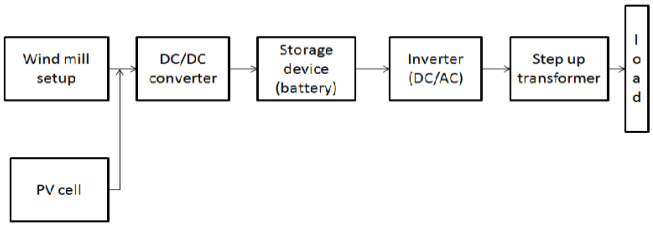

Fig. 5: block diagram

Invertor in the system is used to convert the direct current to 220V alternative current. External invertors can use 12V and 24V direct current from the batteries and by converting it to 220V alternative current, they provide a safe operation for any electrical device. Depending on the output voltage, invertors have different output waves like square wave, modified sinusoidal wave and exact sinusoidal wave. The alternator provides a continuous output of 29V and 250ma for continuous wind blow. Minor disturbances in the direction of the wind cause little depressions in the voltage. There are major decreases in the current value due to variations in the alternator speed. If the wind speed falls below the critical value, the alternator output voltage falls below 24V and the control system take out the wind turbine from the system.

Fluctuations in the current value of wind turbine can be corrected by current filter of a high power turbine. There is no need any correction in the implemented system.

When both the solar panels and the load are engaged to the system at the same time, MPPT continuously keep running the search algorithm. If both the load and battery engaged to the system, this cause an increase in the current which is being pulling out from the system while the voltage values decreases. Measurements which were taken for 8 minutes at the highest sunshine hour, 01:30pm, show that the current changes 0.3A due to the load.

Fig. 6: Solar Panels

This shows the power generation by combination of solar panel and vertical axis wind turbine placed in highway divider.

VI. Conclusion

In this project, the power is generated by combining vertical axis wind turbine and solar panel. Depending upon the vehicle speed the turbine tends to rotate and power is produced. The electrical power is stored in the battery. Since the wind and solar are renewable source of energy, the system is pollution free. And also the capital cost and the cost of power generation is quite low. It gets wide range of applications, such as powering street lights to satellites.

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