Short notes on Solar PV and Wind Renewable Energy Sources

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***Abstract*— In this paper Solar Photovoltaic (PV) and Wind Renewable Energy Sources (RES) was discussed. RES plays an important role to minimise the greenhouse gases effect results to reduce the global warming and protect environment from NO2, CO2 emissions. In developing countries increases their power generation through RES (PV, Wind) also they develop their economy and stability. This paper covers the basic components and principle of Solar PV and Wind energy system. This paper will deliver the basic and special knowledge of basic and special knowledge of Solar PV and Wind energy system especially for UG and Diploma students.**

***Index Terms*— Wind Mill, Generator, PV panel, Battery, PV, RES**

I. INTRODUCTION

In this section, the sources of Renewable Energy, types of RES, advantages and disadvantages of RES and sources of Non Renewable Energy system and drawback of fossil fuel usage was discussed.

1.1 Renewable energy
Comes from sun's heat.
Example: Solar, Wind, Tidal

1.1.1 Benefits of Renewable Energy System

1. Little to No Global Warming Emissions
2. Improved Public Health and Environmental Quality
3. A surplus and Inexhaustible Energy Supply
4. Provides Jobs and Economic Benefits
5. Stable Energy Prices
6. A More Reliable and Resilient Energy System

1.1.2 Limitation of Renewable Energy Systems

1. Solar only in Daylight
2. Wind speed highly variable
3. Solutions not yet developed fully
4. Storage technology being considered

1.2 Non renewable energy
Comes from fossil fuels.
Example: Wood, Coal, Oil and Natural gas

1.2.1 Drawback of fossil fuel usage

1. Depleting supplies
2. Pollution
3. Green house gases
4. Dependent on Other Countries
5. Less Efficient
6. Will become more expensive

II. BASIC COMPONENTS AND PRINCIPLE OF SOLAR PV SYSTEM

2.1 Solar system

Energy from the sun is called collar energy.

1. The sun's energy comes from nuclear fusion.
2. The output of sun is $2.8x10^{23}$KW.
3. The energy reaching the earth is $1.5x10^{18}$KWh/Year.

2.2 Components of Photovoltaic Systems

2.2.1 Photovoltaic Systems

1. A photovoltaic cell is a semiconductor device abbreviated as PV, which directly converts sun light into electricity.
2. The most common PV cells are made from crystalline silicon wafers.
3. Other types of materials include thin film like Cadmium Telluride (CdTe), Copper-Indium-Gallium-Diselenide (CIGS), amorphous silicon (a-Si).

Photovoltaic systems are designed to convert solar energy to DC supply, regulate the electrical energy output, feed the electrical energy into an external load, and store the electrical energy in a battery subsystem. The PV system consists of PV Cell, PV Module, PV Array. The following figure 1 shows the Structure of PV System.

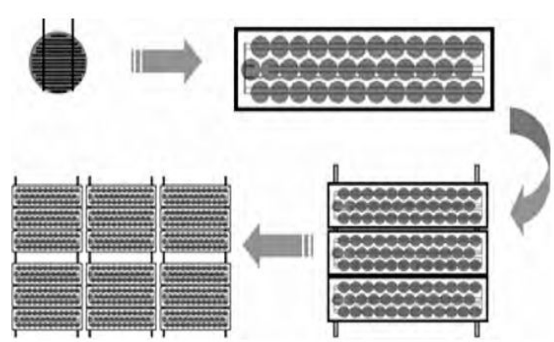

Figure 1 Structure of PV Cells, Modules, Panels and Array

2.2.2 PV Cell

The following figure 2 shows the simple structure of PV Cell.

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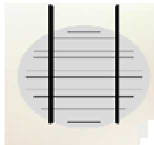

Figure 2 structure of PV Cell

1. One silicon solar cell produces 0.5 volt
2. 36 cells connected together have enough voltage to charge 12 V batteries and run pumps and motors
3. 72 cell modules are the new standard for grid connected systems having a nominal voltage of 24 V

2.2.3 PV Module

A group of PV cells connected in series or parallel and encapsulated in an environmentally protective laminate.

2.2.4 PV Panel

A structural group of modules that was the basic building of PV array.

2.2.5 PV Array

A group of Panels called PV Array.

2.3 Function of PV System

The following figure 3 shows the Circuit diagram of Solar Photovoltaic system. It consists of Voltage regulator, Battery subsystem, Auxiliary Power device and Inverter.

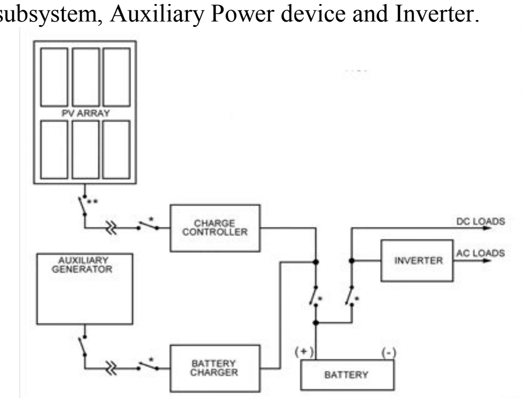

Figure 3 Circuit diagram of Solar Photovoltaic system

Voltage regulator or charge controllers are used to control the charging of the battery subsystem and also prevent the battery from overcharging. Battery stores excess energy generated by the solar array during bright days and discharges this stored energy back into the load at night. For a continuous power output capability, the battery is a very essential component. When the battery voltage drops below a predetermined value the auxiliary dc power supply meets the load and recharges the battery system. Thyristor based Inverter is used convert DC supply into AC supply.

2.4 Types of PV Systems

1. Grid-connected PV System
2. Grid-tie with battery backup system
3. Standalone Solar photovoltaic Grid system
4. PV Direct System

2.4.1 Grid Connected PV System

The following figure 4 shows the Grid Connected System.

1. Simple design
2. Does not provide battery backup
3. Also called as net-metered systems or grid-tie system

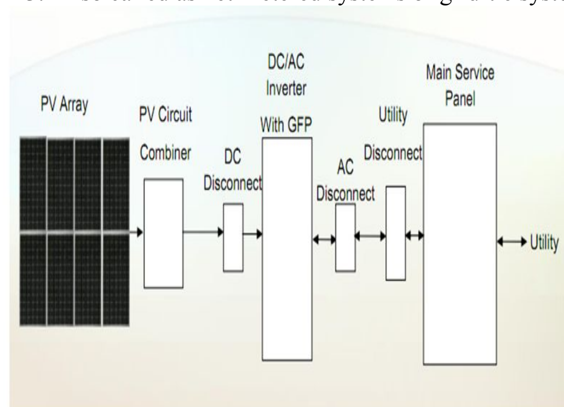

Figure 4 Grid Connected System

2.4.2 Grid-Tie with Battery Backup System

The following figure 5 shows the Grid – tie with battery backup system

1. Provides battery backup
2. Can push excess electricity produced to the electric utility
3. Increased complexity, cost and maintenance requirement

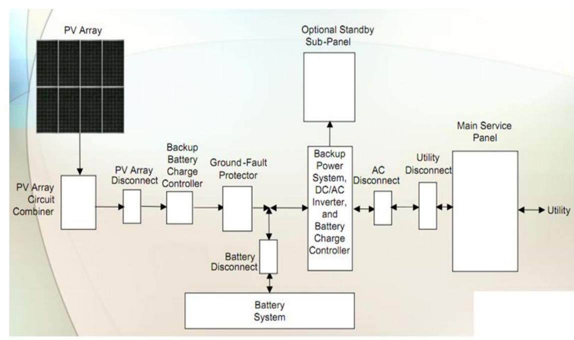

Figure 5 Grid – tie with battery backup system

2.4.3 Standalone Solar Photovoltaic system

The following Figure 6 shows the Standalone Solar Photovoltaic System.

1. Is the one which is not connected to the power grid
2. This system has Battery support to supply the load requirements during the night hours or even when sunshine is not adequate.
3. MPPT (Maximum Power Point Tracking) or charge controller block is used to control voltage variation of SPV module and make it suitable for use.

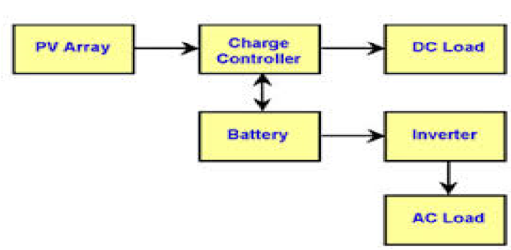

Figure 6 Standalone Solar Photovoltaic System

2.4.4 PV Direct system

The following figure 7 shows the PV Direct System.

1. PV Direct systems are usually very simple systems
2. Photovoltaic panel is connected directly to a motor or pump
3. When the sun shines and the PV panel produces electricity, the device runs directly
4. The operation of the motor and pump depend upon sunlight production

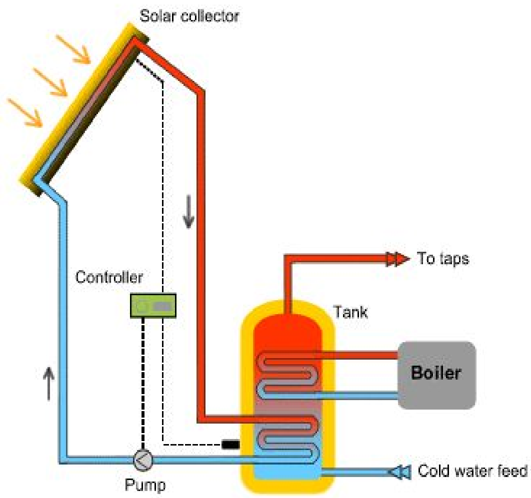

Figure 7 PV Direct System

2.5 Advantages of PV system

Sunlight is free
Quick to install
Easy to add on to the system
No pollution from energy production
Little disturbance of land
Photovoltaic cells last for several Decades

2.6 Disadvantages of PV system

1. High costs at present
2. Need access to the Sun about 60 percent of time
3. Needs energy storage system
4. May need energy backup system
5. Some homeowners do not like solar panels' appearance
6. Manufacturing produces hazardous silicon wastes.

III. BASIC COMPONENTS AND PRINCIPLE OF WIND MILL

3.1 Wind Energy

A small portion of the total solar radiation reaching the earth's surfaces causes movement of the gas molecules in the atmosphere. The motion of the gas molecules is called wind. Energy available in the wind depends upon shape of the local landscape, height above the ground level and climatic cycle at location.

3.2 Wind Mill

Are also called wind turbine generator or aero generators. In a wind generator system, the wind mill rotor coupled mechanically to an electrical generator. Usually a gear arrangement is provided to match the high rpm of the generator to the relatively slower speed of the wind mill rotor.

3.3 Wind Mill consists of the following main Components

1. Tower
2. Wind turbine
3. Yaw mechanism
4. Speed Control Unit
5. Drive train system
6. Electrical generator

The following figure 8 shows the structure of Wind Energy conversion System

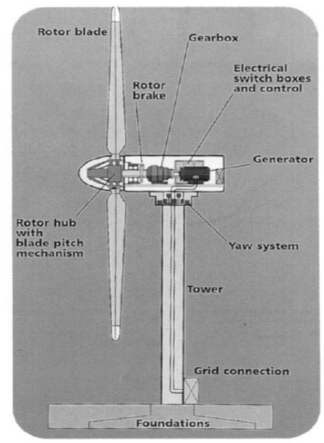

Figure 8 shows the structure of Wind Energy conversion System

3.4 Tower

1. The construction can be tubular or lattice (or truss).
2. Both steel and concrete towers are available and are being used.
3. The tower height is typically 1 to 1.5 times the rotor diameter.
4. Towers must be at least 25 to 30 m high to avoid turbulence caused by trees and buildings.

3.4.1 Spacing of the Towers

1. The spacing depends on the terrain, the wind direction, the speed, and the turbine size.
2. The optimum spacing is found in rows 8 to 12-rotor diameters apart in the wind direction, and 1.5 to 3-rotor diameters apart in the crosswind direction.

A wind farm consisting of 20 towers rated at 500 kW each need 1 to 2 square kilo meters of land area.

3.5 Turbine Blades

1. Modern wind turbines have two or three blades.
2. The blades are made from composites, primarily fibreglass reinforced plastics (GRP), and sometimes wood/epoxy laminates are used.
3. Extensive design effort is needed to avoid premature fatigue failure of the blade.
4. The mechanical stress in the blade under gusty wind is kept under the allowable limit. This is achieved by controlling the rotor speed below the set limit (the stall control).
5. This not only protects the blades, but also protects the electrical generator from overloading and overheating.

3.6 Yaw Control

1. The yaw control continuously orients the rotor in the direction of the wind.
2. An active yaw drive contains one or more yaw motors, each of which drives a pinion gear against a bull gear attached to the yaw bearing.
3. This mechanism is controlled by an automatic yaw control system with its wind direction sensor usually mounted on the nacelle of the wind turbine.
4. However, rotating blades with large moments of inertia produce high gyroscopic torque during yaw, often resulting in loud noise.

3.7 Speed control

3.7.1 No speed control

In this method, the turbine, the electrical generator, and the entire system are designed to withstand the extreme speed under gusty wind.

3.7.2 Yaw and tilt control

In this method the rotor axis is shifted out of the wind direction when the wind speed exceeds the design limit.

3.7.3 Pitch control

This changes the pitch of the blade with the changing wind speed to regulate the rotor speed.

3.7.4 Stall control

When the wind speed exceeds the safe limit on the system, the blades are shifted into a position such that they stall. The turbine has to be restarted after the gust has gone.

3.8 Drive train System

The drive train consists of the rotating parts of the wind turbine. These typically include a low-speed shaft (on the rotor side), a gearbox, and a high-speed shaft .Other drive train components include the support bearings, one or more couplings, a brake, and the rotating parts of the generator.

3.8.1 Gear Box

The purpose of the gearbox is to speed up the rate of rotation of the rotor from a low value (tens of rpm) to a rate suitable for driving a standard generator (hundreds or thousands of rpm). Two types of gearboxes are used in wind turbines: parallel shaft and planetary. For larger machines planetary gearboxes become more pronounced. Low-speed generators requiring no gearbox.

3.9 Generator

The conversion of the mechanical power of the wind turbine into the electrical power can be accomplished by any one of the following types of the electrical machines.

1. Direct current (DC) machine.
2. Synchronous machine.
3. Induction machine.

3.10 Types of Turbines

VAWT (Vertical Axis Wind Turbine)

HAWT (Horizontal Axis Wind Turbine)

3.11 Working Principle of Wind Mill

1. A wind turbine converts the kinetic energy of the wind motion to mechanical energy transmitted by the shaft.
2. A generator converts mechanical energy into electrical energy.
3. Most of the units have the conventional gear box to step up the rotational speed of the turbine to the speed of an electric generator of reasonable size.
4. Wind mills are provided with brakes. These are used to slow down or stop the wind mill at high velocity to prevent breakup of the rotor in a turbulent wind storm or to prevent damage of the support structure.

3.12 Advantages of Wind Energy system

1. It is a clean fuel source
2. No fuel is required
3. No pollution
4. Negligible maintenance cost
5. Efficient converting of wind to electrical energy
6. Land below wind turbines can be used for other activities
7. Easy construction

3.13 Disadvantages of Wind Energy System

1. Little power output in low winds
2. Extensive land needed for wind farms
3. View of wind turbines
4. Injures and kills migratory birds and predatory birds
5. Noise pollution

IV. NECESSITY OF RENEWABLE ENERGY SOURCES

The following figure 9 neatly shows the necessity of RES in simple manner.

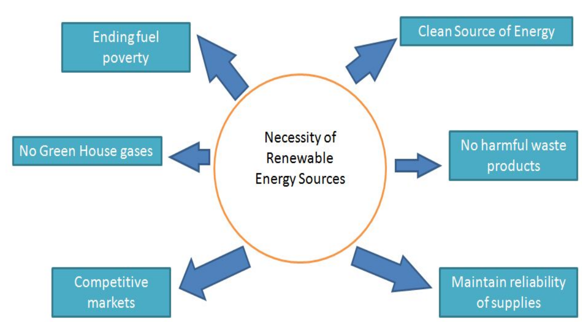

Figure 9 Necessity of Renewable Energy System

V. CONCLUSION

The concept of Renewable Energy Sources (RES), principle of RES, advantages and disadvantages of RES were discussed in this paper. In addition the comparison of RES and Non-RES were discussed. The concept explained in simple way with clear diagrammatic representation. The necessities of RES were discussed in simple.The paper surely enrich the knowledge in the field of Renewable Energy Sources for UG students, Diploma students and small scale industrialist and Entrepreneurs.

VI. REFERENCES

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