International Journal of Electronics, Electrical and Computational System
IJEECS
ISSN 2348-117X
Volume 6, Issue 8
August 2017

A Review On Various Renewable Energy Sources

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ABSTRACT:

This paper presents a standalone hybrid power system by the use of wind/PV/diesel energy system/Geothermal source. PV & Wind are the basic power sources of the system. The most frequently used renewable energy sources are those consisting of PV module and/or wind Turbine and/or Diesel generator and/or Geo thermal energy. Multilevel inverters play a vital role in today's interconnected grid systems with renewable energy sources. Those power electronics devices which converts DC input power to AC at required output level of voltage and frequency are known as inverters. Due to the fact that solar and wind power is intermittent and unpredictable in nature, higher penetration of their types in existing power system could cause and create high technical challenges especially to weak grids or stand-alone systems without proper and enough storage capacity. By integrating the two renewable resources into an optimum combination, the impact of the variable nature of solar and wind resources can be partially resolved and the overall system becomes more reliable and economical to run. Multilevel inverter can be used with this standalone hybrid system for the electrification of rural areas to provide uninterrupted power supply.

Keywords: Grid-connected ,Hybrid renewable energy, Photovoltaic, Stand-alone ,Wind energy

I. INTRODUCTION

Uninterruptible power generation only can able to satisfy the requirements of powers. Basically requirements is differ from one another. Comparatively television is required to ON Low power and one Textile Company to operate not enough low power its required high power. Basically inverters are those devices which converts DC power to AC power at desired output voltage. Beside this it has some other advantages such as high power quality, lower order harmonics, lower switching losses, and better electromagnetic interference and frequency. But it has some disadvantages also like high switching losses, high cost and less efficiency. Hence because of these disadvantages multilevel inverters are used over conventional inverters. The output of the multilevel inverter is a staircase waveform which is similar to the sinusoidal waveform. The no. of harmonics present in the output voltage of multilevel inverter is much lesser than the conventional two-level inverter. The classification of multilevel inverter is as follows; cascaded multilevel inverter, flying capacitor inverter and diode clamped inverter.

A stand-alone power system (SAPS or SPS), also known as remote area power supply (RAPS), is an off-the-grid electricity system for locations that are not fitted with an electricity distribution system. Typical SAPS include one or more methods of electricity generation, energy storage, and regulation.

Electricity is typically generated by one or more of the following methods:

[1] Photovoltaic system using solar panels

[2] Wind turbine

[3] Geothermal source

[4] Micro combined heat and power

[5] Micro hydro turbine

[6] Diesel or bio-fuel generator

[7] Thermoelectric generator (TEGs)

This paper basically focuses on wind energy, solar energy and diesel generator.

1. MULTILEVEL INVERTERS

In today's world, multilevel inverters are widely used in power industries. It starts from three level inverter. Voltage unbalance problem is one of the major issue in working of multilevel inverter. Its major types are diode clamped multilevel inverter, flying capacitor based multilevel inverter & cascaded H bridge multilevel inverter.

2. DIODE CLAMPED MULTILEVEL INVERTER

This inverter mainly use diodes to limit the power devices voltage stress. The voltage over each capacitor and each switch is V dc. An m level inverter needs (m-1) voltage sources, (m-1) capacitors,2(m-1) switching devices and (m-1) (m-2) diodes per leg .

3. FLYING CAPACITOR MULTILEVEL INVERTER

This inverter uses capacitors to limit the voltage of the power devices. The configuration of the flying capacitor multilevel inverter is like a diode clamped multilevel inverter except that capacitors are used to divide the input

DC voltage. The voltage over each capacitor and each switch is V dc. It requires (m-1) capacitors on dc bus form level converter.

4. CASCADED H- BRIDGE MULTILEVEL INVERTER

The concept of this inverter is based on connecting H-bridge inverters in series to get a sinusoidal voltage output.The output voltage is the sum of the voltage that is generated by each cell. The number of output voltage levels are ($2n+1$), where n is the number of cells. The switching angles can be chosen in such a way that the total harmonic distortion is minimized.

Table 1 Important global indicators for renewable energy

		2010	2011	2012	2013
Renewable power installed capacity (with hydro)	GW	1,250	1,355	1,470	1,560
Renewable power installed capacity (without hydro)	GW	315	395	480	560
Solar PV installed capacity	GW	40	71	100	139
Wind power installed capacity	GW	198	238	283	318
Concentrating solar thermal power installed capacity	GW	1.1	1.6	2.5	3.4

II. SYSTEM DESCRIPTION:

MODELLING OF WIND TURBINE

Wind power is rapidly becoming a mature industry as performance of wind energy conversion system (WECS) and leverage of large-scale industrial production steadily decrease cost. Measures taken by governments and other

Agencies to subsidize the costs of electricity installation and regulations in several countries concerning the purchase of electricity produced by grid-connected systems are promoting public awareness and the widespread use of environmentally friendly wind electricity. To convert wind power into electricity, many types of generator concepts have been used and proposed. The main wind turbine generators can be grouped into 2 classes: variable and fixed speed. The main difference is the electrical system where variable–speed wind turbine is more complicated than fixed-speed wind turbine. The fixed-speed wind turbine has the advantage of being simple, robust and reliable and well proven and the cost of its electrical parts is low.

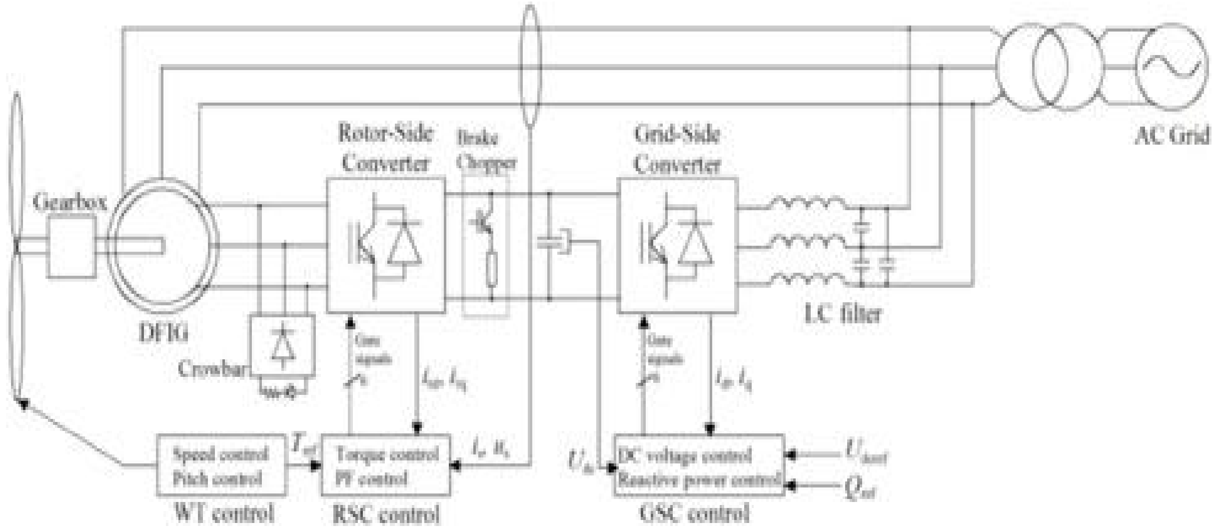

Fig :1 Wind Turbine Module

III. WIND TURBINE REQUIREMENTS

1. GRID INTERFACE REQUIREMENT

In the early development of wind power, the level of wind power penetration into the grid is very low. For an abnormal condition on the grid (under- or overvoltage, frequency dip, etc.), a wind turbine is allowed to be disconnected from the grid to ensure that a wind turbine will not be harmed by the abnormal grid condition. Early standards for grid interface requirements were covered in the Institute of Electrical and Electronics Engineers 1547, applicable for generations less than the 20-MW power rating.

1.1 VOLTAGE-RELATED REQUIREMENT

As wind power plants and the level of wind power penetration increases, the generated output power is considered significant to the overall generation pools. As such, the transmission operator requires that a wind turbine stays connected under general disturbance. This requirement is reflected in the Federal Energy Regulatory Commission Order 661 and 661A, also known as low-voltage ride-through and fault ride-through capability. This requirement covers both the voltage and frequency envelope that requires a wind turbine to stay connected to the grid. Beyond or outside this envelope, the turbine is allowed to be disconnected from the grid.

1.2 FREQUENCY-RELATED REQUIREMENT

In an interconnected power system, all the synchronous generators connected to the grid are synchronized to the grid frequency. The grid frequency is affected by the balance between the generation and the demand. If the level of generation is higher than the power demand, the grid frequency rises. Similarly, if the level of generation is lower than the total loads, the grid frequency drops. The rate of change of the frequency is affected by the total inertia of the rotating mass connected to the grid. The higher the inertia available in the grid and the lower the difference between the generation and load, the smaller the rate of change of frequency will be. As a result, the slower the change of the grid frequency will be. The grid frequency is controlled to be as constant as possible via the automatic generation control and governor control, thus balancing load and generation all the time.

1.3 INERTIAL RESPONSE REQUIREMENT

As wind power penetration increases, and conventional power plants are retired from the generation pools, the total inertia in the grid will be reduced. At higher levels of wind power penetration, there is concern that the total inertia will be too small to support the frequency stability in a power system. Transmission system

operators in many regions, including the Electric Reliability Council of Texas and Hydro Quebec are starting to require the additional capability of wind turbines to provide inertial response, thus helping to impede the change of frequency in the grid.

1.4 HIGH-WIND RIDE-THROUGH REQUIREMENT

In the future, some transmission system operators may require that a wind turbine stays connected to the grid during high wind speeds to ensure that there is no sudden drop in generation when the wind speed increases above the rated wind speeds. Obviously, wind turbine manufacturers design and decide the cut-off wind speed to ensure safe operation of normal wind turbines. However, in anticipation of future requirements, in which transmission system operators mandate operation above the rated wind speed, wind turbine manufacturers can include this requirement in the design and provide wind turbine customers with the option of high-wind ride-through capability.

1.5 IMPACT OF GRID INTERFACE REQUIREMENT

Although all of the aforementioned grid requirements can technically be provided by turbine manufacturers, the impacts (thermal, electrical, magnetic, structural stresses, and strains) on the mechanical and electrical turbine components, and on its integrity and lifetime, are yet to be fully understood and will be known further as the industry gathers years of experience. The electrical aspects can utilize several modules available in Simulink, such as SimPowerSystem.

2. ELECTRICAL COMPONENT REQUIREMENT

Electrical component requirements are mostly on voltage and current limits. The voltage limit is related to the level of dielectric and insulation necessary to withstand the electrical field imposed on them. The voltage blocking capability of a component is specified in the data sheet, and the component must be protected from operating beyond the allowable voltage range. The current limit is usually related to the amount of current passing through the device without generating so much heat that it will degrade the dielectric and insulation of the components. The electrical components that form the linkages to convert and transfer mechanical energy into electrical energy to customers must be carefully designed to bear the loads and stresses of the process.

The rise of temperature above a critical point (specified in the data sheet) can be very damaging (irreversible degradation) to the electrical insulation and magnetic characteristics. The requirements for electric machines (rotating machineries, transformers, inductors, etc.) are usually easier to maintain because the technology, the size of the mass to store and conduct thermal losses to the ambient air, the auxiliary efforts to dissipate the heats, and the filtering/screen of the dust are very well established. Also, electric machines can better tolerate overloads (overcurrent) and overvoltage conditions. However, the power electronic components (IGBT, diodes, etc.) are very sensitive to the temperature because the electronic components are based on p-n junction. The bottleneck in electrical components is mostly dictated by the power electronic design ratings (voltage and current).

Because modern wind turbines must provide a good grid interface, the impact of providing fault ride-through capability and providing other ancillary services must be investigated to ensure that these requirements will not shorten the lifespan of the electrical components of a turbine and to better understand how grid interface requirements will drive the future design of wind turbines. Because requirements differ from region to region, it is probable that the same turbine types will be built at different enhancements to keep the costs of turbines as affordable as possible.

3. ENERGY-HARVESTING REQUIREMENT

The main purpose of wind generation is to harvest as much energy as possible as soon as the wind speed available increases above the cut-in wind speed. Maximum power point tracking is generally implemented indirectly through passive mapping of output power commanded to the power converter to the rotational speed of turbine rotor. Because the grid interface requirement affects the reliability of a power system, and electrical disturbances usually last for a very short time, the grid interface controller takes precedence over the maximum power point tracking operation controller.

As wind power penetration levels increase, there will be times when the output of a wind power plant must be reduced to maintain the reliability of a power system. This is called curtailment, and it is a common practice when the available transmission capacity of the transmission lines is exceeded. Curtailment is also needed when the output power of a conventional generator falls short of its minimum because the wind power is high but the load connected to the grid is low. This condition often occurs at nights. Curtailment might also be profitable when the cost of energy to operate as spinning reserves is sufficiently higher than generating the output power at normal operation. Because curtailment as a spinning reserve is not currently common practice, the impact of this operation on the stresses and strains on mechanical and electrical components of a wind turbine needs to be investigated.

4. MECHANICAL COMPONENT REQUIREMENT

Mechanical components of wind turbines are the main path to transfer wind energy into electrical energy. The mechanical link between the turbine rotor and generator are mostly the blades, low-speed shaft, gearbox, yaw drives, and the generator high-speed shaft. The mechanical linkages are very rigid, and the conversion of mechanical energy into electrical energy occurs via electromagnetic conversion at the air gap of the generator. All the aforementioned requirements may impact the mechanical components linked together to convert aerodynamic input power from the wind into mechanical power into electrical output power.

IV. MODELLING OF PV MODULE

The solar energy has the great potential as a power generating energy source, because of its many advantages like zero emission of pollutant gases, zero cost of fuel, inexhaustible and easy availability of this energy source. But this system has some disadvantages like dependency on weather conditions.

A single solar cell cannot provide required useful output. So to increase output power level of a PV system, it is required to connect number of such PV solar cells. A solar module is normally series connected sufficient number of solar cells to provide required standard output voltage and power. One solar module can be rated from 3 watts to 300 watts. The solar modules or PV modules are commercially available basic building block of a solar electric power generation system. Actually a single solar PV cell generates very tiny amount that is around 0.1 watt to 2 watts. But it is not practical to use such low power unit as building block of a system. So required number of such cells are combined together to form a practical commercially available solar unit which is known as solar module or PV module.

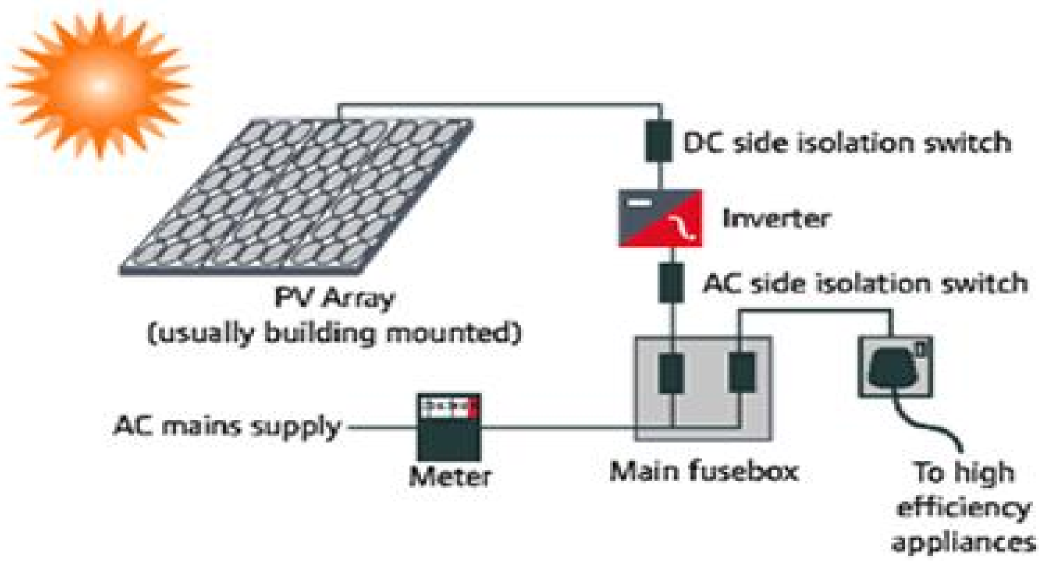

Fig.2 PV Array Module

International Journal of Electronics, Electrical and Computational System
IJEECS
ISSN 2348-117X
Volume 6, Issue 8
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Solar energy is radiant light and heat from the Sun that is harnessed using a range of ever-evolving technologies such as solar heating, photovoltaics, solar thermal energy, solar architecture, molten salt power plants and artificial photosynthesis. It is an important source of renewable energy and its technologies are broadly characterized as either passive solar or active solar depending on how they capture and distribute solar energy or convert it into solar power. Active solar techniques include the use of photovoltaic systems, concentrated solar power and solar water heating to harness the energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favourable thermal mass or light-dispersing properties, and designing spaces that naturally circulate air.

The potential solar energy that could be used by humans differs from the amount of solar energy present near the surface of the planet because factors such as geography, time variation, cloud cover, and the land available to humans limit the amount of solar energy that we can acquire.

Table .2 Yearly solar fluxes & human consumption

Yearly solar fluxes & human consumption	
Solar	3,850,000
Wind	2,250
Biomass potential	~200
Primary energy use[2]	539
Electricity[2]	~67

[1] Energy given in Exajoule (EJ) = 10^{18} J = 278 TWh
[2] Consumption as of year 2010

Geography affects solar energy potential because areas that are closer to the equator have a greater amount of solar radiation. However, the use of photovoltaic's that can follow the position of the sun can significantly increase the solar energy potential in areas that are farther from the equator. Time variation effects the potential of solar energy because during the night time there is little solar radiation on the surface of the Earth for solar panels to absorb. This limits the amount of energy that solar panels can absorb in one day. Cloud cover can affect the potential of solar panels because clouds block incoming light from the sun and reduce the light available for solar cells.

In addition, land availability has a large effect on the available solar energy because solar panels can only be set up on land that is otherwise unused and suitable for solar panels. Roofs have been found to be a suitable place for solar cells, as many people have discovered that they can collect energy directly from their homes this way. Other areas that are suitable for solar cells are lands that are not being used for businesses where solar plants can be established.

Solar technologies are characterized as either passive or active depending on the way they capture, convert and distribute sunlight and enable solar energy to be harnessed at different levels around the world, mostly depending on distance from the equator. Although solar energy refers primarily to the use of solar radiation for practical ends, all renewable energies, other than Geo thermal power and Tidal power, derive their energy either directly or indirectly from the Sun.

Active solar techniques use photovoltaic's, concentrated solar power, solar thermal collectors, pumps, and fans to convert sunlight into useful outputs. Passive solar techniques include selecting materials with favourable thermal properties, designing spaces that naturally circulate air, and referencing the position of a building to the Sun. Active solar technologies increase the supply of energy and are considered supply side technologies, while passive solar technologies reduce the need for alternate resources and are generally considered demand side technologies.

V. TYPES OF SOLAR POWER STATIONS

There are mainly four types of solar power stations.

1. Stand Alone or Off Grid type Solar Power Plant
2. Grid Tie type Solar Power Plant
3. Grid Tie with Power Backup or Grid Interactive type Solar Power Plant
4. Grid Fall-back type Solar Power Plant.

1. STAND ALONE OR OFF GRID SOLAR POWER STATION

This is most commonly used photo-voltaic installation used to provide localized electricity in absence of conventional source of electric power at certain location. As the name prefers this system does not keep any direct or indirect connection with any grid type network.

In standalone system the solar modules produce electric energy which is utilized to charge a storage battery and this battery delivers electricity to the connected load. Standalone systems are normally small system with less than 1kilowatt generation capacity.

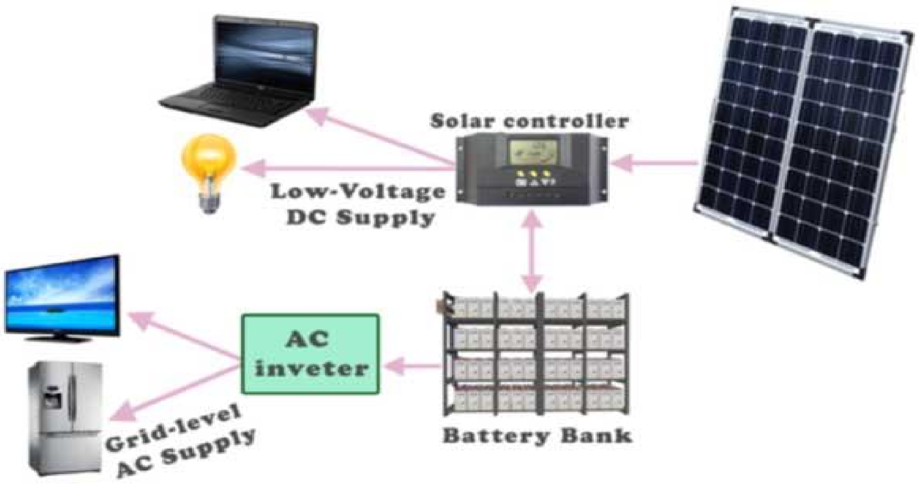

Fig.3 Stand Alone Power System

2.GRID TIE SOLAR POWER STATION

In some countries facility is available of selling power to the local or national grid. This is gaining popularity in Europe and the United States. This system facilitates both electric utility companies as well as the consumers. Here consumers can generate electricity by their own plant and can sell the surplus to the electricity utility company through grid connected to their plant. As the consumers sell the power they can earn money as return of their investment for installation of captive power plant on the other hand electric utility companies can reduce their capital investment on their own plant for power generation. In a grid-tie solar system, consumers consume electricity produced by solar captive power plant during sunny day time and also export surplus energy to grid but at night while solar plant does not produce energy, they import electric energy from grid for consumption. The main disadvantage of this system is that if there is a power cut in the grid, the solar modules should be disconnected from the grid. This system is not always very profitable especially where overall maximum demand of the system does not occur at the peak sunny period of the day. In hot climate where the power demand for air conditioning machines becomes maximum during peak sunny period of the day, this grid tie solar power generation system works most efficiently.Grid tie solar systems are of two types one with single macro central inverter and other with multiple micro inverters. In the former type of solar system, the solar panels as well as grid supply are connected to a common central inverter called grid tie inverter as shown below. The inverter here converts the DC of the solar panel to grid level AC and then feeds to the grid as well as the consumer’s distribution panel depending upon the instant demand of the

International Journal of Electronics, Electrical and Computational System
IJEECS
ISSN 2348-117X
Volume 6, Issue 8
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systems. Here grid-tie inverter also monitors the power being supplied from the grid. If it finds any power cut in the grid, it actuates switching system of the solar system to disconnect it from the grid to ensure no solar electricity can be fed back to the grid during power cut. There is on energy meter connected in the main grid supply line to record the energy export to the grid and energy import from the grid.

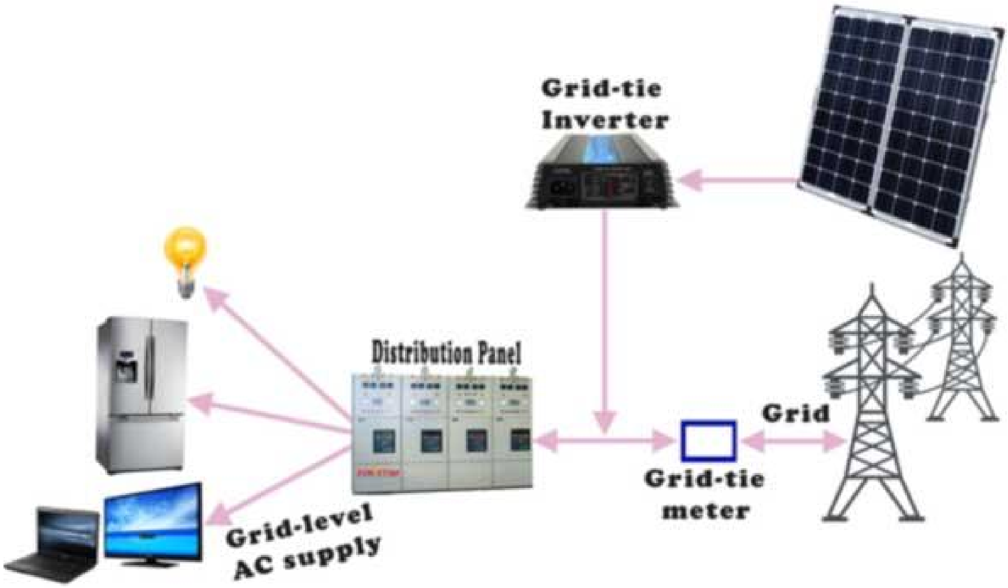


Fig.4 Grid Tie Solar Power System

As we already told there is another type of grid-tie system where multiple micro-inverters are used. Here one micro inverter is connected for each individual solar module. The basic block diagram of this system is very similar to previous one except the micro inverters are connected together to produce desired high AC voltage. In previous case the low direct voltage of solar panels is first converted to alternating voltage then it is transformed to high alternating voltage by transformation action in the inverter itself but in this case the individual alternating output voltage of micro inverters are added together to produce high alternating voltage.

3.GRID TIE WITH POWER BACKUP SOLAR POWER GENERATION

It is also called grid interactive system. This is a combination of a grid-tie solar power generation unit and storage battery bank. As we said, the main drawback of grid tie system is that when there is any power cut in the grid the solar module is disconnected from the system. For avoiding discontinuity of supply during power cut period one battery bank of sufficient capacity can be connected with the system as power backup.

4.GRID FALL-BACK SOLAR POWER GENERATION

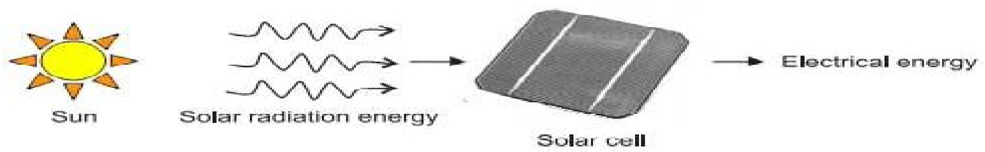
Grid fall-back is most reliable and stable system mainly used for electrifying smaller households. Here solar modules charge a battery bank which in turn supplies distribution boards through an inverter. When the batteries are discharged to a pre-specified level, the system automatically switches back to the grid power supply. The solar modules then recharge the batteries and after the batteries are being charged up to a pre-specified level again the system switches back to solar power. We do not sell electricity back to the electricity utility companies through this system. All the power that we produce is utilized for ourselves only. Although we do not have any direct earning benefit from this system but the system has its own big advantages. This system is most popular where there is no facility of selling power to the grid. Grid fall-back system has all advantages of grid interactive system except power selling, but it adds benefit of using own power whenever it is required irrespective of position and condition of sun in the sky.

Table .3 Main challenges and possible solutions for grid-connected system

S.No	Challenges	Solutions
1	High storage cost	Combining both PV solar and wind powers will minimize the storage requirements and ultimately the overall cost of the system.
2	Less usable energy during the year.	Integration of renewable energy generation with battery storage and diesel generator back-up systems.
3	Intermittent energy / power quality	Integration of renewable energy generation with battery storage or fuel cell and in some cases with diesel generator back-up systems.
4	Protection	Suitable protection devices need to be installed for safety reasons including up gradation of existing protection schemes in particular when distributed generators are introduced.
5	Storage runs out	Integrate PV and wind energy sources with fuel cells.
6	Environmental and safety concerns of batteries and hydrogen tanks.	Integrating PV and wind energy sources with fuel cells instead of large lead-acid batteries or super storage capacitors, leads to a non-polluting reliable energy source and reduces the total maintenance costs.

VI. COMPONENTS OF A SOLAR ELECTRIC GENERATING SYSTEM

1. Solar Panels:



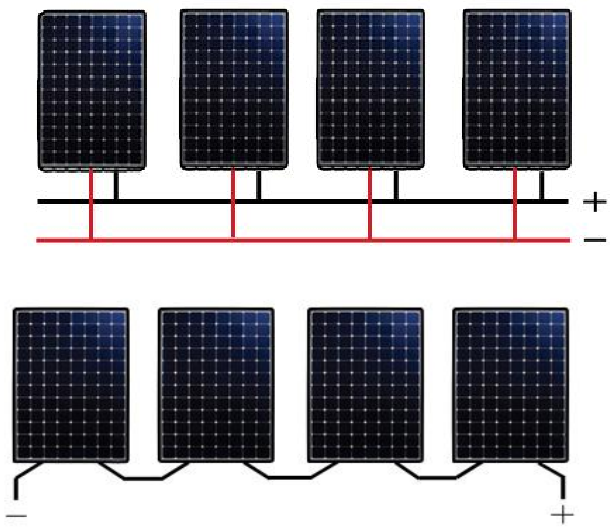


Fig.5 Battery Arrangements

The main part of a solar electric system is the solar panel. There are various types of solar panel available in the market. Solar panels are also known as photovoltaic solar panels. Solar panel or solar module is basically an array of series and parallel connected solar cells. The potential difference developed across a solar cell is

about 0.5 volt and hence desired number of such cells to be connected in series to achieve 14 to 18 volts to charge a standard battery of 12 volts. Solar panels are connected together to create a solar array.Multiple panels are connected together both in parallel and series to achieve higher current and higher voltage respectively.

2. Batteries:

In grid-tie solar generation system, the solar modules are directly connected to inverter not with load. The power collected from solar panel not in constant rate rather it varies with intensity of sunlight. This is the reason why solar modules or panels do not feed any electrical equipment directly instead they feed an inverter whose output is synchronized with external grid supply. Inverter takes care of the voltage level and frequency of the output power from the solar system it always maintains it with that of grid power level. As we get power from both solar panels and external grid power supply system, the voltage level and quality of power remain constant. As the stand-alone or grid fall-back system is not connected with grid any variation of power level in the system can directly affects the performance of the electrical equipment fed from it. So there must be some means to maintain the voltage level and power supply rate of the system. A battery bank connected parallel to this system takes care of that. Here the battery is charged by solar electricity and this battery then feeds a load directly or through an inverter. In this way variation of power quality due to variation of sunlight intensity can be avoided in solar power system instead an uninterrupted uniform power supply is maintained. Normally Deep cycle lead acid batteries are used for this purpose. These batteries are typically designed to make capable of several charging and discharging during service. The battery sets available in the market are generally of either 6 volt or 12 volts. Hence number of such batteries can be connected in both series as well as parallel to get higher voltage and current rating of the battery system.

3. Controller:

This is not desirable to overcharge and under discharge a lead acid battery. Both overcharging and under discharging can badly damage the battery system. To avoid these both situations a controller is required to attach with the system to maintain flow of current to and fro the batteries.

4. Inverter:

It is obvious that the electricity produced in a solar panel is DC. Electricity we get from the grid supply is AC. So for running common equipment from grid as well as solar system, it is required to install an inverter to convert DC of solar system to AC of same level as grid supply. In off grid system the inverter is directly connected across the battery terminals so that DC coming from the batteries is first converted to AC then fed to the equipment. In grid tie system the solar panel is directly connected to inverter and this inverter then feeds the grid with same voltage and frequency power.

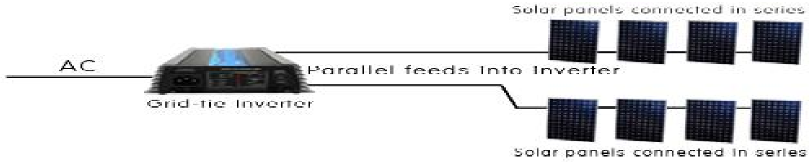


Fig.6 Grid Tie System the solar panel is directly connected to inverter

In modern grid tie system, each solar module is connected to grid through individual micro-inverter to achieve high voltage alternating current from each individual solar panel.

Fig.7 Modern Grid Tie System

International Journal of Electronics, Electrical and Computational System
IJEECS
ISSN 2348-117X
Volume 6, Issue 8
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VII. Diesel Generator module:

Diesel generator set converts fuel energy (diesel or bio-diesel) into mechanical energy by means of an internal combustion engine, and then into electric energy by means of an electric machine working as generator.

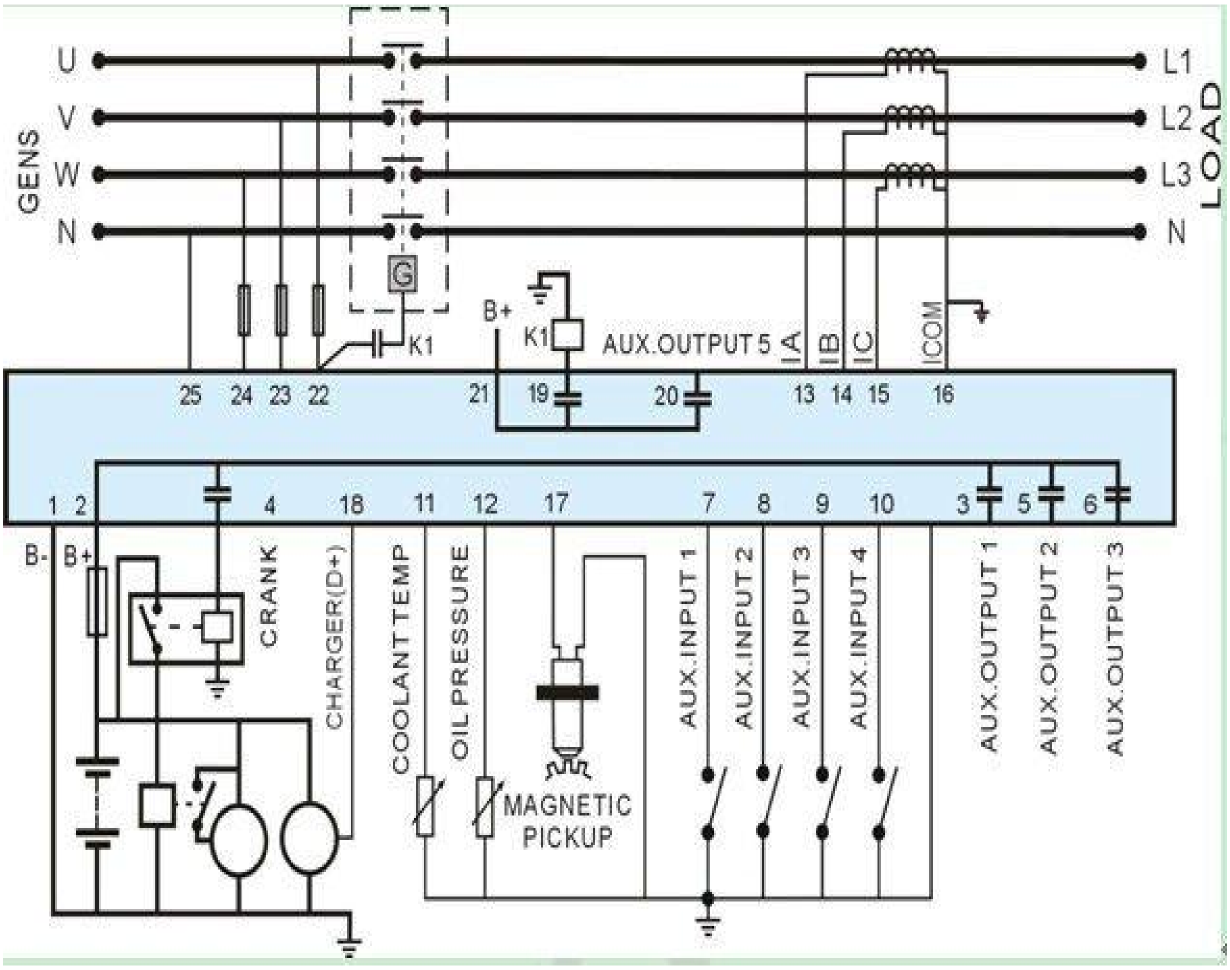

Fig.8 Diesel Generator Module

A diesel generator is the combination of a diesel engine with an electric generator (often an alternator) to generate electrical energy. This is a specific case of engine-generator. A diesel compression-ignition engine often is designed to run on fuel oil, but some types are adapted for other liquid fuels or natural gas.

Diesel generating sets are used in places without connection to a power grid, or as emergency power-supply if the grid fails, as well as for more complex applications such as peak-lopping, grid support and export to the power grid.

Proper sizing of diesel generators is critical to avoid low-load or a shortage of power. Sizing is complicated by the characteristics of modern electronics, specifically non-linear loads. In size ranges around 50 MW and above, an open cycle gas turbine is more efficient at full load than an array of diesel engines, and far more compact, with comparable capital costs; but for regular part-loading, even at these power levels, diesel arrays are sometimes preferred to open cycle gas turbines, due to their superior efficiencies.

The packaged combination of a diesel engine, a generator and various ancillary devices (such as base, canopy, sound attenuation, control systems, circuit breakers, jacket water heaters and starting system) is referred to as a "generating set" or a "genset" for short.

VIII. Geothermal Source:

Most power plants need steam to generate electricity. The steam rotates a turbine that activates a generator, which produces electricity. Many power plants still use fossil fuels to boil water for steam. Geothermal power plants, however, use steam produced from reservoirs of hot water found a couple of miles or more below the Earth's surface. There are three types of geothermal power plants: dry steam, flash steam, and binary cycle.

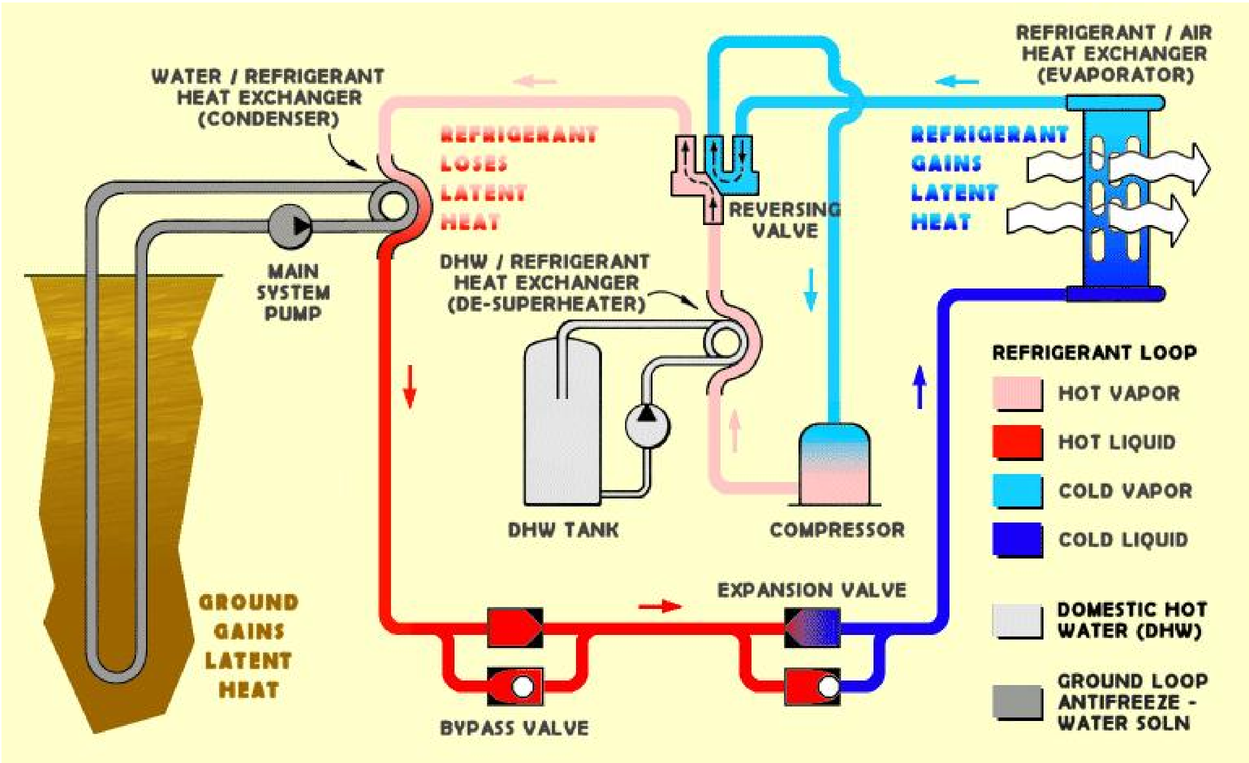

Fig.9 Structure of Geothermal source

1. Dry steam power plants:

Dry steam power plants draw from underground resources of steam. The steam is piped directly from underground wells to the power plant, where it is directed into a turbine/generator unit.

2. Flash steam power plants:

Flash steam power plants are the most common. They use geothermal reservoirs of water with temperatures greater than 360°F (182°C). This very hot water flows up through wells in the ground under its own pressure. As it flows upward, the pressure decreases and some of the hot water boils into steam. The steam is then separated from the water and used to power a turbine/generator. Any leftover water and condensed steam are injected back into the reservoir, making this a sustainable resource.

3. Binary cycle power plants:

Binary cycle power plants operate on water at lower temperatures of about 225°-360°F (107°-182°C). These plants use the heat from the hot water to boil a working fluid, usually an organic compound with a low boiling point. The working fluid is vaporized in a heat exchanger and used to turn a turbine. The water is then injected back into the ground to be reheated. The water and the working fluid are kept separated during the whole process, so there are little or no air emissions. Small-scale geothermal power plants (under 5 megawatts) have the potential for widespread application in rural areas, possibly even as distributed energy resources. Distributed energy resources refer to a variety of small, modular power-generating technologies that can be combined to improve the operation of the electricity delivery system.

Academic Science

International Journal of Electronics, Electrical and Computational System
IJEECS
ISSN 2348-117X
Volume 6, Issue 8
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Table .4 Important global indicators for renewable energy

S.No	Challenges	Solutions
1	Voltage fluctuation due to variations in wind speed and irregular solar radiation	➢ Series and shunt active power filters. ➢ Power compensators such as fixed/switched capacitor or static compensator. ➢ Less sensitive customer's equipment to power disturbance/voltage distortions and utilities line conditioning systems
2	Frequency fluctuation for sudden changes in active power by loads	➢ PWM inverter controller for regulating three- ➢ phase local AC bus voltage and ➢ frequency in a microgrid
3	Harmonics by power electronics devices and non-linear appliances.	➢ PWM switching converter and appropriate filters.
4	Intermittent energy's impacts on network security	➢ Accurate statistical forecasting and scheduling systems. ➢ Regression analysis approaches and algorithms for forecasting weather pattern, solar radiation and wind speed. ➢ Increase or decrease dispatchable generation by system operator to deal with any deficit/surplus in renewable power generation. ➢ Advanced fast response control facilities such as Automatic Generation Control and Flexible AC Transmission System.
5	Synchronization	➢ The most popular grid synchronization technique is based on phase-locked loop. Other techniques for synchronization include detecting the zero crossing of the grid voltages ➢ or using combinations of filters coupled with a non-linear transformation.

IX. Conclusion:

This paper presents an overview of the various Renewable energy sources. This overview will help power electronics researchers and engineers to understand and identify the pros and cons of each renewable energy resources and choose the most suitable one for their application.

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