Smart Interconnection technique by Hybrid Renewable Sources

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Abstract: Large population lives in remote areas that are geographically isolated where grid supply is sparely available. Also, consumer expects a mobile form of energy. These demands are provided by rural electrification. Due to limited reserve of conventional energy sources i.e. fossil fuels and global warming of environment, it is necessary to use Renewable Energy sources (RES). Hybrid Renewable Energy System (HRES) with conventional energy sources is the ideal system for rural electrification since it provides reliable energy supply to consumers. This paper discusses the HRES for rural electrification along with various connection topologies to integrate hybrid with the Grid.

***Index Terms* - Renewable Energy System, Hybrid Renewable Energy System (HRES), Rural Electrification, PV, Wind**

I. INTRODUCTION

There are many remote places, especially in developing countries, where grid supply has not reached yet but still with more availability of solar-wind hybrid systems. Over and above, the dependence of economy depleting fossil fuels and the adverse environmental effects of conventional power generation systems created renewed interest in renewable energy sources toward building a sustainable energy economy. Wind-solar-fuel cell hybrid energy is the world's fastest growing energy sources, expanding globally at a rate of 25–35% annually over the last decade. A combination of different renewable energy sources, like wind generator, fuel cell and PV-system, with conventional energy source, like a diesel generator, is known as hybrid power system. Hybrid systems can provide a steady community-level electricity service, such as village electrification, offering also the possibility to be upgraded through grid connection in the future. Also HRES having problem with power control, i.e. excess power can be fed to the load by the combination of HRES and grid. Which give rise to power loss? To avoid the power loss or extra charges due to power loss, power control I.e. if the load demand fulfilled by the HRES the grid automatically get cut-off and also at the peak load power required by the load con be fulfilled by the combination of HRE and grid. And if the power fed from the HRE system more than required demand then excess amount of power fed to the Storage system or to the grid as per the requirement. If the grid supply is not available then at the time of peak demand power requirement fulfilled by using HRE system and Storage system. This paper gives the best design layout to the different renewable component to design model for HRE system with the controlled environment to meet the required power demand or for rural electrification.

II. CONNECTION TOPOLOGIES

A typical hybrid system combines two or more energy sources, from renewable energy technologies such as PV-panels, wind or small hydro turbines; also it includes power electronic devices and electricity storage bank. A hybrid system of solar-wind with battery bank is considered. The different power generating units generate AC and also DC power. These generation systems have to be connected at some point and somewhere before the loads are supplied. Here, we study the different connection topologies.
The hybrid system is designed from the following different configurations to effectively use the locally available renewable energy sources and to maintain continuous power supply to all power appliances.

A. AC-COUPLED HYBRID POWER SYSTEMS

With this type of configuration, the different HPSs are connected at the AC-bus with the load. The AC coupled HPSs are further divided into two sub-topologies.
1. Centralized AC-coupled **HRES**
2. Distributed AC-coupled **HRES**
These two sub-topologies are explained below in detailed with schematic block diagrams

1. Centralized AC-coupled Hybrid Power Systems

An AC-coupled **HRES** is said to be centralized when all the energy conversion systems constituting it are connected to a main AC-bus before being connected to the load. This configuration can be depicted by the fig.1

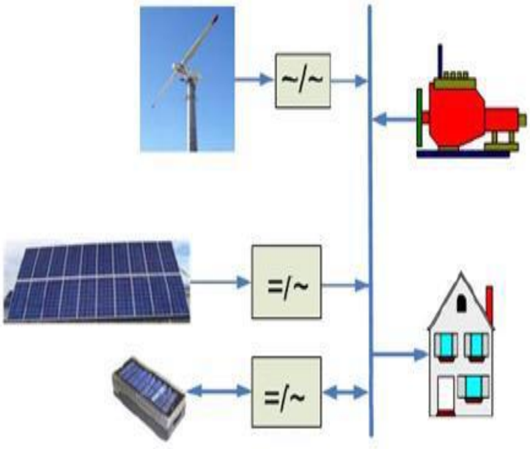

Figure- Centralized AC-coupled HRES

The wind turbine and diesel generator produce AC powers, thus they can be directly coupled onto the main AC-bus or with AC/AC converters. The PV-array produces DC power and an inverter must be used before it is coupled onto the main AC-bus. The charging or discharging of the battery bank with a DC current seeks for a bidirectional inverter must be used.

2. Distributed AC-coupled Hybrid Power Systems

AC-coupled **HRES** is said to be distributed or decentralized when the different ECSs constituting it are not connected to a main AC-bus; otherwise, some or all of them are individually connected to the load.

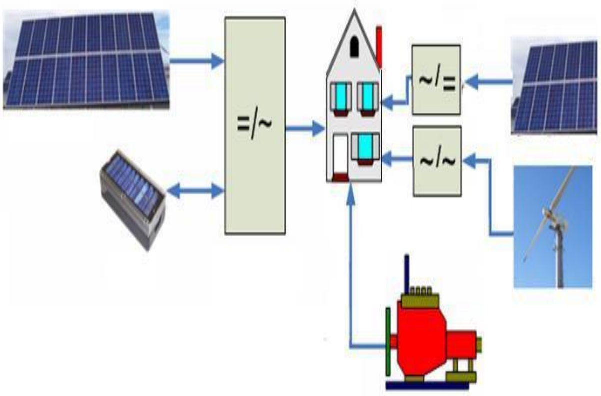

Figure- Decentralized AC-coupled HRES

In this topology, the power sources do not need to be connected to one common bus as in the previous cases. These sources may not also be installed close to each other i.e. the sources are distributed in different geographical locations and each source is connected to the load separately

B.DC-COUPLED HYBRID POWER SYSTEMS

In DC-coupled HPSs configuration, all the ECSs, unlike AC-coupled HPSs, are connected to a DC main bus before being connected to the load. Connection with the AC loads done through a main inverter. This configuration is also termed as centralized DC-bus topology.

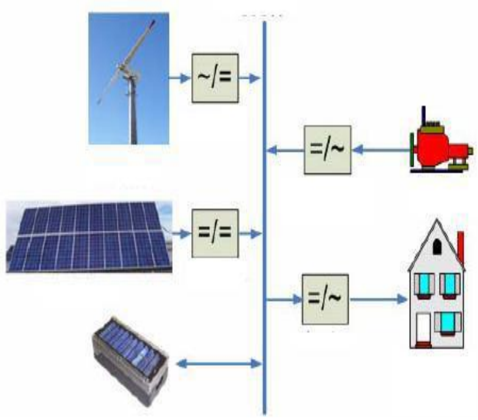

Figure - Centralized DC-coupled HRES

Since the energy sources are connected at the DC-bus bus, the wind turbine and the diesel Genset need AC-DC converters before they are connected at the main bus. The AC load is connected to the main bus via the main inverter

C.MIXED-COUPLED HYBRID POWER SYSTEMS

It is also possible to combine AC-coupled and DC coupled HPS systems and form mixed HPSs. With this type of configuration, some of the RESs (PV-array, in this case) are connected with the battery bank at the DC-bus and other RESs (wind turbine, in this case) are connected with the Gen set at the AC-bus.

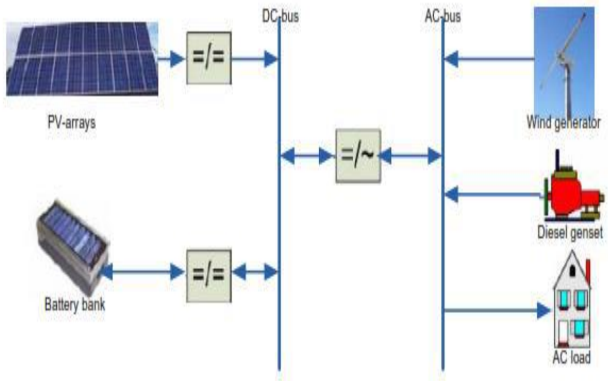

Figure-AC-coupled sources connected with DC-coupled sources or mixed HRES

A comparison of mixed, AC- and DC-coupled systems show that AC-coupled systems have numerous advantages, such as standardized coupling of different components, off-the shelf grid components can be used, simplified design and operation of island grids, compatibility with existing grids, reduction of system costs, increased reliability of electrical power supply as well as expandability.

III.PROPOSED SYSTEM

The proposed system consists of RES connected to the dc link of a grid-interfacing inverter as shown in Figure. This configuration is fit for the stand-alone hybrid power system used in remote area. Before reaching towards load centres, the conversion of electricity from wind and solar are carried out. The two energy sources are connected in parallel to a common DC bus line through their individual converters. Then such a DC power is converted back to AC power at fundamental grid frequency of 50 Hz by using multi-level inverter

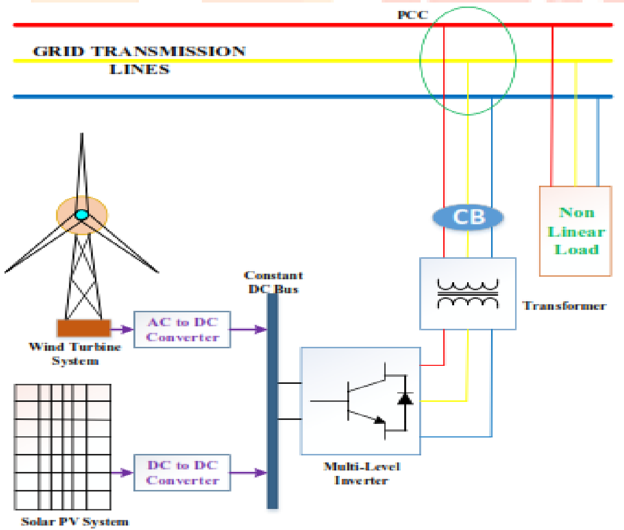

Figure - Grid interconnection of HRES

IV.COMPONENT OF HYBRID POWER SYSTEM

A PV–Wind power system, which is a combination of a photovoltaic array integrated with a wind generator. The system consists different component such as, PV array, wind generator, a battery bank, a charge controller and a DC/AC or AC/DC converter. Depending upon requirement it can be used.

A. PV System

Sizing of PV system can be depending on different factors these are;

1. Solar radiation of the site.
2. The daily power consumption (WH) and types of the electric loads
3. The storage system to contribute to the system's energy independence for a certain period of time. The PV generator is oversized it will have a big impact in the final cost and the price of the power produced and in the other hand, the PV-generator is undersized, problems might occur in meeting the power demand at any time.

B. Wind Energy

Wind energy sources have the potential to significantly reduce fuel costs, greenhouse gas emissions, and natural habitat disturbances associated with conventional energy generation. Wind turbine generators are an ideal choice in developing countries where the most urgent need is to supply basic electricity in rural or isolated areas without any power infrastructure.

Wind energy has become competitive with conventional forms of energy. Wind energy is a potential choice for smaller energy producers due to relatively short installation times, easy operating procedures, and different available incentives for investment in wind energy.

C. Storage Bank

Batteries are the basic component of an energy storage system. Which is used as a back for the power supply for the system?

D. Power Electronic Devices

Different power electronic devices are used in this system as per the requirement such as AC-DC or DDC-AC converter, DC-DC converter

E. The controller plays an important role in controlling and maintaining the proper functioning of the whole system by limiting the system parameter in specified ranges. With the advancement of power electronics and emergence of new multi-level converter topologies [13], it is possible to work at voltage levels beyond the classic semiconductor limits, so multi-level inverters have been widely used for high-power high-voltage DG applications. Due to higher number of sources, lower EMI, lower % THD in output voltage and less stress on insulation, they are widely used. A converters or regulators are used to step up the PV-array voltage close to the specified dc-link voltage, as shown in Fig.1.

V.COMPONENT DESCRIPTION

The Grid tie power system, described here, basically includes the following main elements.
1. Renewable energy sources: PV-system
2. Wind generator
3. Power electronic devices
i. Chopper
ii. 3 phase Inverter
4. Transformer
5. Circuit Breaker
6. Electrical Grid
1. Solar Cell (PV System)

A solar cell, or photovoltaic cell, is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect. It is a form of photoelectric cell, defined as a device whose electrical characteristics, such as current, voltage, or resistance, vary when exposed to light. Solar cells are the building blocks of photovoltaic modules, otherwise known as solar panels. Solar cells are described as being photovoltaic irrespective of whether the source is sunlight or an artificial light. They are used as a photo detector (for example infrared detectors), detecting light or other electromagnetic radiation near the visible range, or measuring light intensity.

The operation of a photovoltaic (PV) cell requires 3 basic attributes
a. The absorption of light, generating either electron-hole pairs or exactions.
b. The separation of charge carriers of opposite types.
c. The separate extraction of those carriers to an external circuit

In contrast, a solar thermal collector supplies heat by absorbing sunlight, for the purpose of either direct heating or indirect electrical power generation from heat. A "photo electrolytic cell" (photo electrochemical), on the other hand, refers either to a type of photovoltaic cell (like that developed by Edmond Becquerel and modern dye-sensitized solar cells), or to a device that splits water directly into hydrogen and oxygen using only solar illumination.

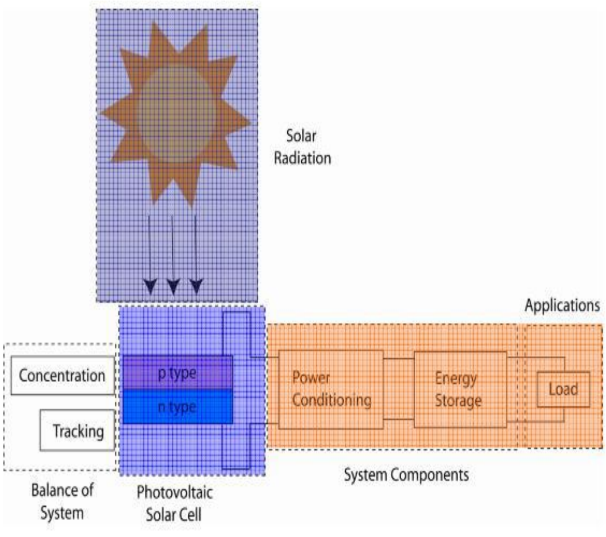

Figure - Energy Generation from Solar Array

The solar irradiation varies daily with time and seasonally. These in turn results to the reliability problems from such sources of energy seeking energy conversion, energy storage and load control etc. when compared with conventional sources of energy

2. Wind Turbines

Wind turbines are used to generate electricity from kinetic power of the wind i.e. the generation of wind energy primarily depends on the wind speed. To enhance the energy capture, the turbine is mounted on a tall tower. Wind is an intermittent resource; however, wind turbines are not unreliable technology.
Modern wind turbines capture more than 90% of available energy from wind, compared with fuel efficiency between 30- 40% for a conventional coal fired station, which typically loses a significant portion of energy through heat loss and pollution.

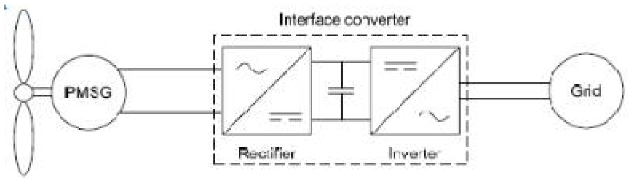

Figure - Block diagram of wind energy system

The main components of a wind turbine are the rotor of the turbine, which is the prime mover, and the induction generator. The rotor is connected to the generator via a gearbox which matches and enhances the rotational speed.
As the wind does not blow all the time nor does the sun shine all the time, solar and wind power alone are poor power sources. Hybridizing solar and wind power sources together with storage batteries to cover the periods of time without sun or wind provides a realistic form of power generation.

3. Power Electronic Devices
i. Chopper
ii. Three phase Multilevel Inverter

3.1 Chopper**:-**
There are three different types of chopper such as,
1. Buck converter
2. Boost converter
3. Buck-boost converter

1. Buck Converter:-
Step-down (buck) switching converters are integral to modern electronics. They can convert a voltage source into a lower regulated voltage. Step-down converters transfer small packets of energy using a switch, a diode, an inductor and several capacitors. Though substantially larger and noisier than their linear-regulator counterparts, buck converters offer higher efficiency in most cases.
Figure shows the basic circuit diagram of buck converter

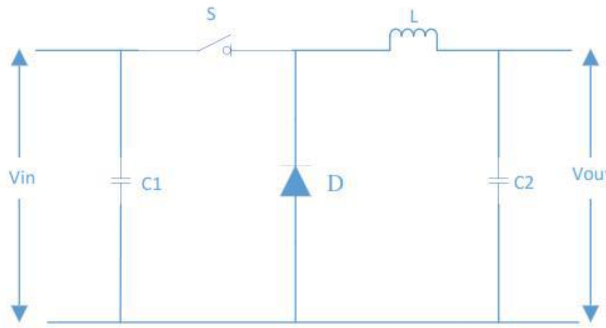

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Figure – Buck converter Basic diagram

2. Boost Converter**:-**
Power for the boost converter can come from any suitable DC sources, such as batteries, solar panels, rectifiers and DC generators. A process that changes one DC voltage to a different DC voltage is called DC to DC conversion. A boost converter is a DC to DC converter with an output voltage greater than the source voltage.

A boost converter is sometimes called a step-up converter since it “steps up” the source voltage. Since power (P = VI) must be conserved, the output current is lower than the source current. Battery power systems often stack cells in series to achieve higher voltage. However, sufficient stacking of cells is not possible in many high voltage applications due to lack of space.

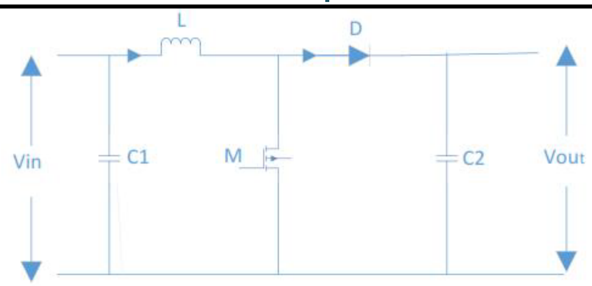

Figure – Boost converter Basic diagram

3. Buck-boost Converter:-

The buck–boost converter is a type of DC to DC converter that has an output voltage magnitude that is either greater than or less than the input voltage magnitude. It is equivalent to a Fly back converter using a single inductor instead of a transformer.

Two different topologies are called *buck–boost converter*. Both of them can produce a range of output voltages, from an output voltage much larger than the input voltage, down to almost zero. While in the On-state, the input voltage source is directly connected to the inductor (L). This results in accumulating energy in L. In this stage, the capacitor supplies energy to the output load. While in the Off-state, the inductor is connected to the output load and capacitor, so energy is transferred from L to C and R

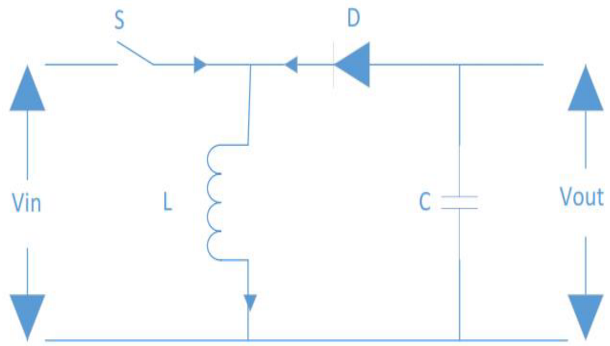

Figure – Buck-Boost converter Basic diagram

ii. Three phase Inverter

Power inverter, or inverter, is an electronic device or circuitry that changes direct current (DC) to alternating current (AC).The input voltage, output voltage and frequency, and overall power handling depend on the design of the specific device or circuitry. The inverter does not produce any power; the power is provided by the DC source. An inverter converts the DC electricity from sources such as batteries or fuel cells to AC electricity. The electricity can be at any required voltage; in particular it can operate equipment designed for mains operation, or rectified to produce DC at any desired voltage.

In one simple inverter circuit, DC power is connected to a transformer through the Centre tap of the primary winding. A switch is rapidly switched back and forth to allow current to flow back to the DC source following two alternate paths through one end of the primary winding and then the other. The alternation of the direction of current in the primary winding of the transformer produces alternating current (AC) in the secondary circuit

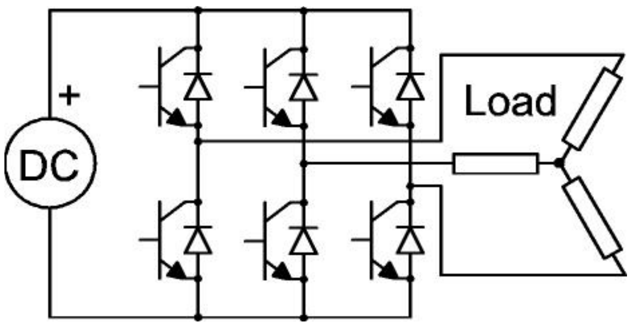

Figure - Basic circuit diagram of 3 phase Inverter

4. TRANSFORMER:-

A transformer is an electrical device that transfers energy between two or more circuits through electromagnetic induction. A varying current in the transformer's primary winding creates a varying magnetic flux in the core and a varying magnetic field impinging on the secondary winding. This varying magnetic field at the secondary induces a varying electromotive force (EMF) or voltage in the secondary winding. Making use of Faraday's Lawin conjunction with high magnetic permeability core properties, transformers can thus be designed to efficiently change AC voltages from one voltage level to another within power networks.

Transformers range in size from RF transformers less than a cubic centimeter in volume to units interconnecting the power grid weighing hundreds of tons. A wide range of transformer designs is encountered in electronic and electric power applications. Since the invention in 1885of the first constant potential transformer, transformers have become essential for the AC transmission, distribution, and utilization of electrical energy

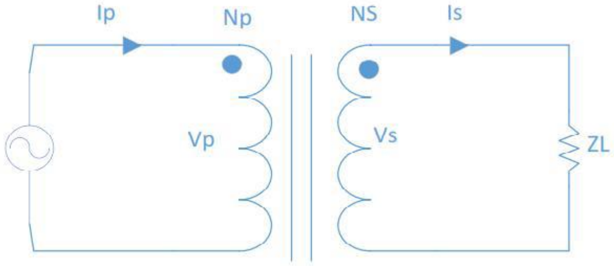

Figure - Basic Circuit diagram of Transformer

5. CIRCUIT BREAKER

A circuit breaker is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit. Its basic function is to detect fault condition and interrupts current flow. Unlike a fuse, which operates once and then must be replaced, a circuit breaker can be reset (either manually or automatically) to resume normal operation. Circuit breakers are made in varying sizes, from small devices that protect an individual household appliance up to large switchgear designed to protect high voltage circuits feeding an entire city.

6. ELECTRICAL GRID

An electrical grid is an interconnected network for delivering electricity from suppliers to consumers. It consists of generating stations that produce electrical power, high-voltage transmission lines that carry power from distant sources to demand centres, and distribution lines that connect individual customers. Power stations may be located near a fuel source, at a dam site, or to take advantage of renewable energy sources, and are often located away from heavily populated areas.

They are usually quite large to take advantage of the economies of scale. The electric power which is generated is stepped up to a higher voltage at which it connects to the bulk power transmission network. The bulk power transmission network will move the power long distances, sometimes across international boundaries, until it reaches its wholesale customer (usually the company that owns the local electric power distribution network

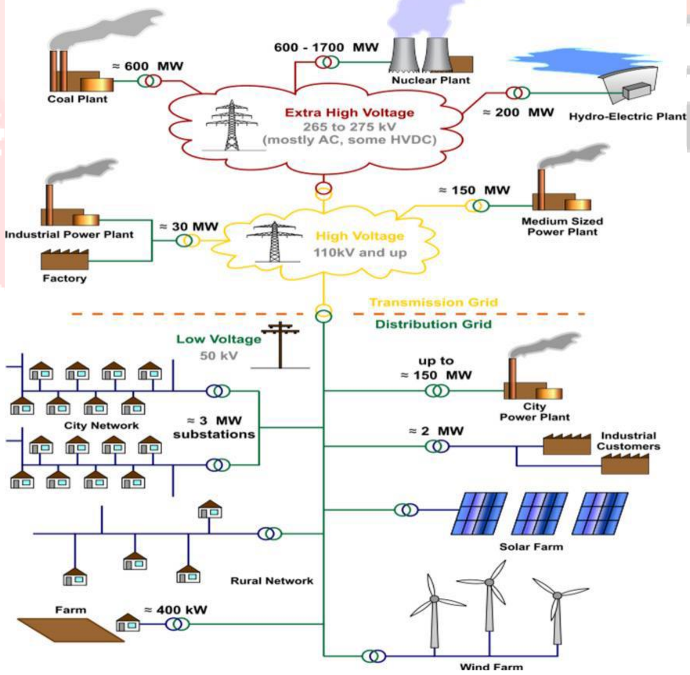

Figure - Electrical Grid

VI. CONCLUSION

The renewable resources potential available in the country confers to achieve some strategic aims such as to help in the deficiency of energy sector and to protect the environment. In order to achieve the economic benefits reaped through renewable resources in competitive conditions on the energy market, it is necessary to adopt and implement some energy policies and specific resources as per the various topologies discussed in this paper. The promotion of energy production from renewable resources represents an imperative objective in present times justified by environment protection, the increase of energetic independence by supplying power to meet the diversity of demand and to satisfy social needs.

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