CHAPTER 1

INTRODUCTION TO RENEWABLE ENERGY

1.1 Introduction

Electricity is the flow of electrons. Electricity is both a basic part of nature and one of the most commonly used forms of energy. Despite its great importance in routine life, few people maybe stop to think about what life would be like without electricity. Like air and water, people lean towards taking electricity from them. However, people use electricity to do many jobs every day for lighting, heating and cooling homes, powering televisions and computers. The electricity that we use is a secondary energy form because it is produced by converting main sources of energy such as coal, natural gas, nuclear energy, solar energy, and wind energy, into electrical power. Present most of the electricity production is done by using non-renewable resources like coal, gasoline, diesel, petrol, etc. in future non-renewable sources will exhaust. To overcome this problem production of electricity is done by renewable energy resources.

A renewable resource is a reserve that can be used repeatedly and substituted naturally. Renewable energy never runs out, for example, solar energy i.e. heat generates from the sun and never runs out. Examples include oxygen, water, solar energy, and biomass. Gasoline, diesel, natural gas, coal, plastics are other fossil fuels are not renewable. They take millions of years to be made, and cannot be renewed in a human's, or even a nation's generation. Renewable resources typically do not produce pollution or subsidize to global warming. The use of renewable resources and energy sources is increasing worldwide, with certain nations, such as Bhutan, and the US states, such as California, beginning to trust entirely on renewable energy. From 2008 to 2012, the U.S. doubled renewable generation from solar, wind, and geothermal bases. America and Britain are now home to some of the largest wind and solar farmhouses in the world. There are also things called human resources where human's waste is turned into energy. There are many other resources such as water power and Tidal power.

Renewable Energy Integration focuses on integrating renewable energy, distributed generation, energy-storing, thermally stimulated technologies, and demand response into the electric distribution and transmission system. A systems method is being used to conduct integration advancement and demonstrations to address practical, economic, governing, and institutional barriers for using renewable and distributed systems. In addition to fully addressing functioning issues, the integration also establishes feasible business models for integrating these technologies into bulk planning, grid operations, and demand-side supervision.

The goal of Renewable energy integration is to develop the system design, planning, and process of the electric grid to:

- Decrease carbon productions and releases of other air contaminants through increased use of renewable energy and other clean distributed generation.
- Increase the benefit of use through the integration of distributed systems and customer loads to condense peak load and thus reduced the costs of electricity.
- Support the accomplishment of renewable energy collection standards for renewable energy and energy efficiency.
- Increase consistency, safety, and resiliency from microgrid in dangerous infrastructure protection and highly controlled areas of the electric grid.

Renewable energy sources produce Direct Current (DC), but most of the appliances using Alternating Current (AC) to work. Replacing the AC devices with DC devices is very difficult and it is not economical. To overcome this challenge the DC produced by the renewable energy sources will be converted to AC by using inverters.

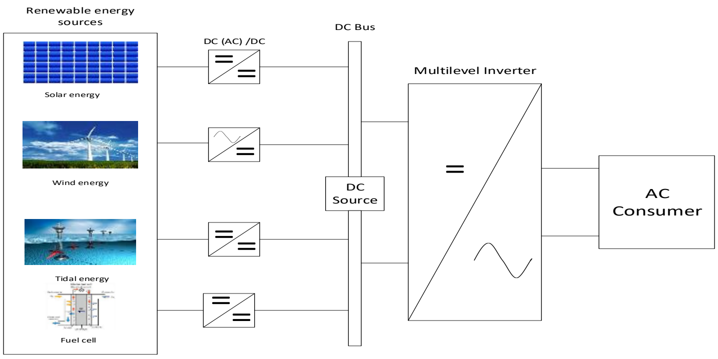

Fig.1.1 Renewable energy generation system with the multilevel inverter.

Basic inverters convert DC to AC (square waveform), but the required AC output is in pure/smooth sinusoidal. To get smooth sinusoidal output waveform multilevel inverters came into the picture, it can convert the fixed DC into multiple level output, if the levels of the inverter increase the output waveform is almost equal to sinusoidal.

Fig.1.1 shows the block diagram of a renewable energy generation system using a multilevel inverter. It integrates a variety of renewable sources, such as solar energy, wind energy, tide energy and so on and they are connected to a converter to generate DC power, which is stored in a capacitor or battery. After connected to a multilevel inverter, DC power is converted into AC power. The multilevel inverter capable of converting a single DC voltage source from a capacitor or battery into an AC voltage source is a key element of most stand-alone renewable energy generation systems. The multilevel inverter topologies, in general, can generate high-quality voltage waveforms, where power switches are operated at a very low frequency.

1.2 Solar energy

A number of different technologies and appliances are available for harnessing solar energy several of which are very relevant for meeting energy needs of developed and developing countries. Passive solar heating and cooling of buildings is being followed world over from time immemorial and interest in it has been revived in recent years. These techniques have been perfected over the years by applying modern scientific principles and computational aids.

Solar water heaters provide a very inexpensive way of meeting hot water needs of households, groups and the community at large. The technology is simple, proven and affordable. These systems are very appropriate for hotels, hostels, guesthouses and community centres. They make hot water available at zero operating costs. Efforts are however needed to reduce cost of equipment and organizing efficient installation and maintenance services.

Crop drying is an important operation in the agricultural economies of both developing and developed countries. Solar crop driers are an effective answer to meet these needs. A number of designs of solar driers have been developed in India, China, Philippines, Thailand and several other countries. They can be built using simple schemes and local materials. They can easily replace electricity-operated or oil-fired crop driers dispensing with open air-drying which is best with post -harvest losses. Seasoning of timber can be inexpensively carried out in solar kilns, a number of designs of which have been developed by the Forest Research Institute, Dehradun. Central Building Research Institute, Roorkee and Allahabad Polytechnic, Allahabad. Hundreds of such solar Kilns designed and installed by these institutions are satisfactorily functioning in different parts of the country, saving electricity or precious fossil-fuels, and ensuring favourable returns on investment. Having these ideas in our mind, we tried to convert a solar box cooker in to a passive solar drier and its performance was quite appreciable. This dryer can be used for a family to dry their vegetables fruits and can preserve it.

The sun is a sphere of intensely hot gaseous matter with a diameter of 1.39 x 109 m and is on the average, 1.5 x 1011 m from earth. The sun is a continuous fusion reactor with its constituent gases as the "containing vessel" retained by gravitational forces. Several fusion reactions have been suggested to supply the energy radiated by the sun. The one considered the most important is a process in which hydrogen (i.e. four protons) combines to form helium (i.e. one helium nucleus); The mass of the helium nucleus is less than that of the four protons, mass having been lost in the reaction and converted to energy. The sun produces heat by nuclear fusion reactions. The thermal energy radiated by sun is inexhaustible hence the solar energy is called renewable source of energy. The energy produced in the interior of the solar sphere at temperature of millions of degrees must be transferred out to the surface and then be radiated into space. A succession of radiative and convective processes occurs successive emission, absorption, and reradiation; the radiation in the sun’s core is in the x-ray and gamma-ray parts of the spectrum, with the wavelength of the radiation increasing as the temperature drops at large radial distances

1.3 Fuel cell

Fuel cells generate electricity by an electrochemical reaction in which oxygen and a hydrogen-rich fuel combine to form water. Unlike internal combustion engines, the fuel is not combusted, the energy instead being released electrocatalytically. This allows fuel cells to be highly energy efficient, especially if the heat produced by the reaction is also harnessed for space heating, hot water or to drive refrigeration cycles.

A fuel cell is like a battery in that it generates electricity from an electrochemical reaction. Both batteries and fuel cells convert chemical potential energy into electrical energy and also, as a by-product of this process, into heat energy. However, a battery holds a closed store of energy within it and once this is depleted the battery must be discarded, or recharged by using an external supply of electricity to drive the electrochemical reaction in the reverse direction. A fuel cell, on the other hand, uses an external supply of chemical energy and can run indefinitely, as long as it is supplied with a source of hydrogen and a source of oxygen (usually air).

There are several different types of fuel cell but they are all based around a central design. A fuel cell unit consists of a stack, which is composed of a number of individual cells. Each cell within the stack has two electrodes, one positive and one negative, called the cathode and the anode. The reactions that produce electricity take place at the electrodes. Every fuel cell also has either a solid or a liquid electrolyte, which carries ions from one electrode to the other, and a catalyst, which accelerates the reactions at the electrodes. The electrolyte plays a key role it must permit only the appropriate ions to pass between the electrodes. If free electrons or other substances travel through the electrolyte, they disrupt the chemical reaction and lower the efficiency of the cell.

Fuel cells are generally classified according to the nature of the electrolyte (except for direct methanol fuel cells which are named for their ability to use methanol as a fuel), each type requiring particular materials and fuel. Each fuel cell type also has its own operational characteristics, offering advantages to particular applications. This makes fuel cells a very versatile technology.

As a result, fuel cells have a broader range of application than any other currently available power source - from toys to large power plants, from vehicles to mobile chargers, and from household power to battlefield power.

1.4 Wind energy

In recent years, wind energy has become one of the most economical renewable energy technologies. Today, electricity generating wind turbines employ proven and tested technology, and provide a secure and sustainable energy supply. At good, windy sites, wind energy can already successfully compete with conventional energy production. Many countries have considerable wind resources, which are still untapped.

The technological development of recent years, bringing more efficient and more reliable wind turbines, is making wind power more cost-effective. In general, the specific energy costs per annual kWh decrease with the size of the turbine notwithstanding existing supply difficulties.

Many African countries expect to see electricity demand expand rapidly in coming decades. At the same time, finite natural resources are becoming depleted, and the environmental impact of energy use and energy conversion have been generally accepted as a threat to our natural habitat. Indeed these have become major issues for international policy.

Many developing countries and emerging economies have substantial unexploited wind energy potential. In many locations, generating electricity from wind energy offers a cost-effective alternative to thermal power stations. It has a lower impact on the environment and climate, reduces dependence on fossil fuel imports and increases security of energy supply.

For many years now, developing countries and emerging economies have been faced with the challenge of meeting additional energy needs for their social and economic development with obsolete energy supply structures. Overcoming supply bottlenecks through the use of fossil fuels in the form of coal, oil and gas increases dependency on volatile markets and eats into valuable foreign currency reserves. At the same time there is growing pressure on emerging newly industrialised countries in particular to make a contribution to combating climate change and limit their pollutant emissions.

In the scenario of alternatives, more and more developing countries and emerging economies are placing their faith in greater use of renewable energy and are formulating specific expansion targets for a ‘green energy mix’. Wind power, after having been tested for years in industrialised countries and achieving market maturity, has a prominent role to play here. In many locations excellent wind conditions promise inexpensive power generation when compared with costly imported energy sources such as diesel. Despite political will and considerable potential, however, market development in these countries has been relatively slow to take off. There is a shortage of qualified personnel to establish the foundations for the exploitation of wind energy and to develop projects on their own initiative. The absence of reliable data on wind potential combined with unattractive energy policy framework conditions deters experienced international investors, who instead focus their attention on the expanding markets in Western countries.

It is only in recent years that appreciable development of the market potential in developing countries and emerging economies has taken place. The share of global wind generating capacity accounted for by Africa, Asia and Latin America reached about 20% at the end of 2008, with an installed capacity of 26 GW. This is attributable above all to breath taking growth in India and China: these two countries alone are responsible for 22 GW. This proves that economic use of wind energy in developing countries and emerging economies is possible, and also indicates that there is immense potential that is still unexploited

1.5 Tidal energy

Tidal energy is produced by the surge of ocean waters during the rise and fall of tides. Tidal energy is a renewable source of energy.

During the 20th century, engineers developed ways to use tidal movement to generate electricity in areas where there is a significant tidal range the difference in area between high tide and low tide. All methods use special generators to convert tidal energy into electricity.

Tidal energy production is still in its infancy. The amount of power produced so far has been small. There are very few commercial-sized tidal power plants operating in the world. The first was located in La Rance, France. The largest facility is the Sihwa Lake Tidal Power Station in South Korea. The United States has no tidal plants and only a few sites where tidal energy could be produced at a reasonable price. China, France, England, Canada, and Russia have much more potential to use this type of energy.

In the United States, there are legal concerns about underwater land ownership and environmental impact. Investors are not enthusiastic about tidal energy because there is not a strong guarantee that it will make money or benefit consumers. Engineers are working to improve the technology of tidal energy generators to increase the amount of energy they produce, to decrease their impact on the environment, and to find a way to earn a profit for energy companies.

There are currently three different ways to get tidal energy: tidal streams, barrages, and tidal lagoons.

For most tidal energy generators, turbines are placed in tidal streams. A tidal stream is a fast-flowing body of water created by tides. A turbine is a machine that takes energy from a flow of fluid. That fluid can be air (wind) or liquid (water). Because water is much more dense than air, tidal energy is more powerful than wind energy. Unlike wind, tides are predictable and stable. Where tidal generators are used, they produce a steady, reliable

stream of electricity. Placing turbines in tidal streams is complex, because the machines are large and disrupt the tide they are trying to harness. The environmental impact could be severe, depending on the size of the turbine and the site of the tidal stream. Turbines are most effective in shallow water. This produces more energy and allows ships to navigate around the turbines. A tidal generator's turbine blades also turn slowly, which helps marine life avoid getting caught in the system.

The world's first tidal power station was constructed in 2007 at Strangford Lough in Northern Ireland. The turbines are placed in a narrow strait between the Strangford Lough inlet and the Irish Sea. The tide can move at 4 meters (13 feet) per second across the strait.

Another type of tidal energy generator uses a large dam called a barrage. With a barrage, water can spill over the top or through turbines in the dam because the dam is low. Barrages can be constructed across tidal rivers, bays, and estuaries.

Turbines inside the barrage harness the power of tides the same way a river dam harnesses the power of a river. The barrage gates are open as the tide rises. At high tide, the barrage gates close, creating a pool, or tidal lagoon. The water is then released through the barrage's turbines, creating energy at a rate that can be controlled by engineers.

The environmental impact of a barrage system can be quite significant. The land in the tidal range is completely disrupted. The change in water level in the tidal lagoon might harm plant and animal life. The salinity inside the tidal lagoon lowers, which changes the organisms that are able to live there. As with dams across rivers, fish are blocked into or out of the tidal lagoon. Turbines move quickly in barrages, and marine animals can be caught in the blades. With their food source limited, birds might find different places to migrate.

A barrage is a much more expensive tidal energy generator than a single turbine. Although there are no fuel costs, barrages involve more construction and more machines. Unlike single turbines, barrages also require constant supervision to adjust power output.

The tidal power plant at the Rance River estuary in Brittany, France, uses a barrage. It was built in 1966 and is still functioning. The plant uses two sources of energy: tidal energy from the English Channel and river current energy from the Rance River. The barrage has led to an increased level of silt in the habitat. Native aquatic plants suffocate in silt, and a flatfish called plaice is now extinct in the area. Other organisms, such as cuttlefish, a relative of squids, now thrive in the Rance estuary. Cuttlefish prefer cloudy, silty ecosystems.