Solar Energy: The Future

Sai Manoj Rompicherla[#1]

(Department Of Electrical And Electronics Engineering), K.L.University
Vaddeswaram, Vijayawada, Pin: 520001, Andhra Pradesh.

Abstract: Energy security has an important bearing on achieving national economic development goals and improving the quality of life of the people. World's dependence on crude oil will continue for most part of the 21st century but the continued dependence on crude oil is loaded against it with inherent price volatility linked to finite global reserves. In addition, global warming, caused largely by greenhouse gas emissions from fossil fuel energy generating systems, is also a major concern. So, there is a need to develop alternate fuels like non-conventional sources, considering the aforesaid two concerns. This paper describes about the solar energy, one of the non-conventional sources and different ways of using it to convert to electric energy.

Keywords: Energy, photovoltaic cells, power plant, electricity, solar tower

I. INTRODUCTION

As the power demand is going on increasing day-by-day, it is responsible for our engineers to make it available as per the demand. Many of the power generating plant are using non-renewable sources as their primary source. But these may become extinct at any time and before facing the situation we have to choose an alternative to avoid the power crisis. One of the best alternatives is choosing Non-conventional sources like Solar energy, Wind Energy, Tidal energy, Bio-mass energy etc as the primary sources for power generation in power stations. The power from these sources is several times greater than the one, which we are using at the present. Out of these energy sources, the best one which suits for our country is the Solar energy.

The power from the sun intercepted by the earth is approximately 1.8*1011 MW, which is many thousands of times larger than the present consumption rate on the earth of all commercial energy sources. Thus if we convert this to other forms of energy, it may be one of the most promising of the non-conventional energy resources.

As we know that the tropic of cancer passes midway through the earth, our country is one of hottest country in the world after the continent Africa. There are some places in the country where the mercury level raises upto 500c during summer. So, if we use this energy as the primary source for generation almost every house in our country can have power supply and is available at very reasonable cost.

II.SOURCE OF SOLAR ENERGY

2.1. Sun:

As far back as 5,000 years ago, people "worshipped" the sun. We know today, that the sun is simply our nearest star. Without it, life would not exist on our planet. We use the sun's energy every day in many different ways. Indirectly, the sun or other stars are responsible for ALL our energy. Even nuclear energy comes from a star because the uranium atoms used in nuclear energy were created in the fury of a nova - a star exploding.

Let's look at ways in which we can use the sun's energy which is also called Solar Energy.

What is solar energy?

Solar energy can be converted into other forms of energy, such as heat and electricity. In the 1830s, the British astronomer John Herschel used a solar thermal collector box (a device that absorbs sunlight to collect heat) to cook food during an expedition to Africa. Today, people use the sun's energy for lots of things.

How is solar energy collected?

Solar energy can be used to heat a fluid such as water in solar collector panels. Simple types use flat collector panels mounted on a south-facing roof or wall, each with transparent cover to admit sunlight. Water circulates through channels or pipes inside each panel. The inside is usually painted black, because black surfaces readily absorb heat. The water is heated, and then the hot water is pumped to a heat exchanger that extracts the heat for use within the house. Solar energy can also be used to generate electricity in photovoltaic (PV) cells. A PV cell may power your calculator. Photovoltaic cells are made of semiconductors, similar to those used to make computer chips. Until recently these cells were very costly to produce. However, they are still only about 10-15 per cent efficient.

III.Energy Derivations from Solar Energy

Solar energy can be converted to thermal (or heat) energy and used to:

- Heat water – for use in homes, buildings, or swimming pools.

- Heat spaces – inside greenhouses, homes, and other buildings.

Solar energy can be converted to electricity in two ways:

- **Photovoltaic (PV devices) or "solar cells"**

This change sunlight directly into electricity. PV systems are often used in remote locations that are not connected to the electric grid. They are also used to power watches, calculators, and lighted road signs.

- **Solar Power Plants -**

In this sunlight is converted to electricity indirectly. It is first converted to mechanic energy and later to electric energy. When the heat from solar thermal collectors is used to heat a fluid which produces steam that is used to power generator. Out of the 15 known solar electric generating units operating in the United States at the end of 2006, 10 of these are in California, and 5 in Arizona. No statistics are being collected on solar plants that produce less than 1 megawatt of electricity, so there may be smaller solar plants in a number of other states.

Let our discussion starts in detail that how solar energy is converted to electrical energy.

3.1. Photovoltaic Cell:

Photovoltaic is the direct conversion of light into electricity at the atomic level. Some materials exhibit a property known as the photoelectric effect that causes them to absorb photons of light and release electrons. When these free electrons are captured, an electric current results that can be used as electricity.

The photoelectric effect was first noted by a French physicist, Edmund Bequerel, in 1839, who found that certain materials would produce small amounts of electric current when exposed to light. In 1905, Albert Einstein described the nature of light and the photoelectric effect on which photovoltaic technology is based, for which he later won a Nobel Prize in physics. The first photovoltaic module was built by Bell Laboratories in 1954. It was billed as a solar battery and was mostly just a curiosity as it was too expensive to gain widespread use. In the 1960s, the space industry began to make the first serious use of the technology to provide power aboard spacecraft. Through the space programs, the technology advanced, its reliability was established, and the cost began to decline. During the energy crisis in the 1970s, photovoltaic technology gained recognition as a source of power for non-space applications.

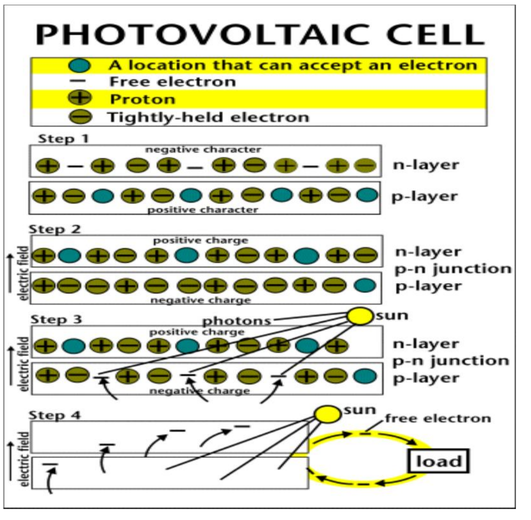

Fig.3.1

3.1.2. Working Principle:

Sunlight is composed of photons, or particles of solar energy. These photons contain various amounts of energy corresponding to the different wavelengths of the solar spectrum. When photons strike a photovoltaic cell, they may be reflected, pass right through, or be absorbed. Only the absorbed photons provide energy to generate electricity. When enough sunlight (energy) is absorbed by the material (a semiconductor), electrons are dislodged from the material's atoms. Special treatment of the material surface during manufacturing makes the front surface of the cell more receptive to free electrons, so the electrons naturally migrate to the surface.

When the electrons leave their position, holes are formed. When many electrons, each carrying a negative charge, travel toward the front surface of the cell, the resulting imbalance of charge between the cell's front and back surfaces creates a voltage potential like the negative and positive terminals of a battery. When the two surfaces are connected through an external load, electricity flows.

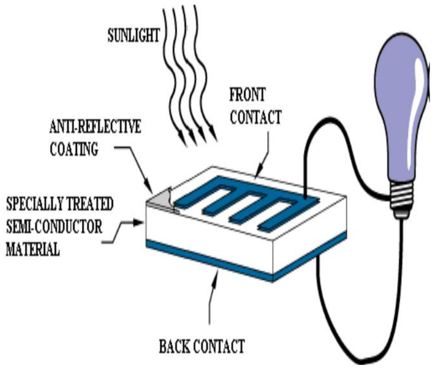

Fig.3.1.2(a)

The performance of a photovoltaic array is dependent upon sunlight. Climate conditions (e.g., clouds, fog) have a significant effect on the amount of solar energy received by a photovoltaic array and, in turn, its performance. Most current technology photovoltaic modules are about 10 per cent efficient in converting sunlight. Further research is being conducted to raise this efficiency to 20 per cent.

The photovoltaic cell was discovered in 1954 by Bell Telephone researchers examining the sensitivity of a properly prepared silicon wafer to sunlight. Beginning in the late 1950s, photovoltaic cells were used to power U.S. space satellites (learn more about the history of photovoltaic cells). The success of PV in space generated commercial applications for this technology. The simplest photovoltaic systems power many of the small calculators and wrist watches used everyday. More complicated systems provide electricity to pump water, power communications equipment, and even provide electricity to our homes.

Some **advantages** of photovoltaic systems are:

 Conversion from sunlight to electricity is direct, so that bulky mechanical generator systems are unnecessary.

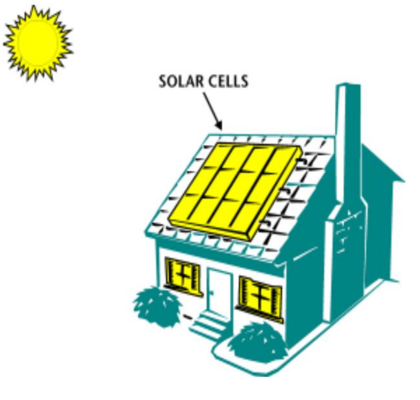

Fig.3.1.2(b)

1. PV arrays can be installed quickly and in any size required or allowed.

2. The environmental impact is minimal, requiring no water for system cooling and generating no by-products.

Photovoltaic cells, like batteries, generate direct current (DC), which is generally used for small loads (electronic equipment). When DC from photovoltaic cells is used for commercial applications or sold to electric utilities using the electric grid, it must be converted to alternating current (AC) using inverters, solid-state devices that convert DC power to AC.

IV.**Solar Thermal Power Plant:**

There are two types of solar thermal power plants.

 Solar distributed collector power plants

 Solar central receiver power plants

In this type of power plants, collectors are used. A very large area is required. The collectors may be of following types.

 Parabolic through units with line focus.

 Paraboloidal dishes with central focus.

Parabolic through collectors are preferred because of low cost of manufacture and simple single plane sun-tracking. Where as in paraboloidal collectors use double plane sun-tracking and are expensive.

4.1.Basic structure:

Large parabolic collectors are employed for collecting solar energy, which is used to heat the fluid generally water which is stored in the storage tank. This heat energy is let to the boiler with a feedback, which is converted to high-pressure steam energy. This steam energy is sent to the turbine chamber with high speed leading to the rotation of prime-mover of the turbine. As turbine is internally coupled with the alternator, the incoming mechanical energy to the turbine is converted to electrical energy by the alternator. Steam is condensed in the condenser and feed water returns to the boiler for re-use. The heat of the cooling water of the condenser may be utilized for some other purposes.
There are two major solar power plants working on the above principle.

4.1.2. Solar distributed collector power plants:

Nevada Solar One is a new solar thermal plant with a 64 MW generating capacity, located near Boulder City, Nevada. Nevada Solar One uses parabolic troughs as thermal solar concentrators, heating tubes of liquid which act as solar receivers. These solar receivers are specially coated tubes made of glass and steel, and about 19,300 of these four meter long tubes are used in the newly built power plant. Nevada Solar One also uses a technology that collects extra heat by putting it into phase-changing molten salts. This energy can then be drawn at night. Solar thermal power plants designed for solar-only generation are ideally matched to summer noon peak loads. Using thermal energy storage systems, solar thermal operating periods can even be extended to meet base-load needs.

Fig.4.1

4.2.Solar central receiving power plant:

There are several **Solar power plants in the Mojave Desert** which supply power to the electricity grid. Solar Energy Generating Systems (SEGS) is the name given to nine solar power plants in the Mojave Desert, which were built in the 1980s. These plants have a combined capacity of 354 megawatts(MW) making them the largest solar power installation in the world. There are also plans to build other large solar plants in the Mojave Desert. The Mojave Solar Park will deliver 553 MW of solar thermal power when fully operational in 2011. Insolation (solar radiation) in the Mojave Desert is among the best available in the United States, and some significant population centers are located in the area.

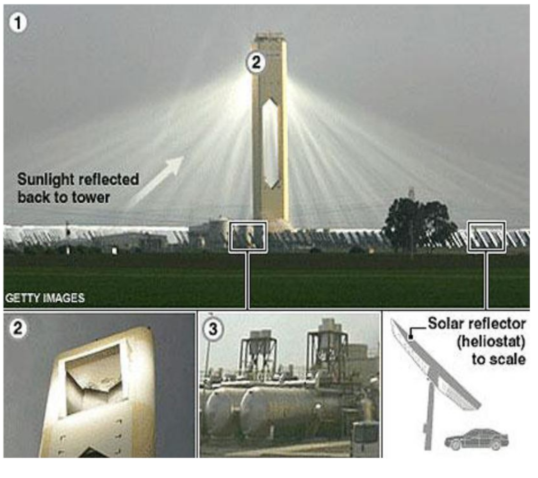

Fig.4.2(a)

This makes the Mojave Desert particularly suitable for solar power plants. These plants can generally be built in a few years because solar plants are built almost entirely with modular, readily available materials.

Fig.4.2(b)

The above shown is the photograph showing the components of the power plant in California, Mojave Desert. Component 2 is the central receiving tower, which receives the reflected radiation from the heliostats around it. The tower is installed with a boiler inside it. Component 3 is the power station, which is coupled to the solar collecting apparatus. The operation of the plant is as follows.

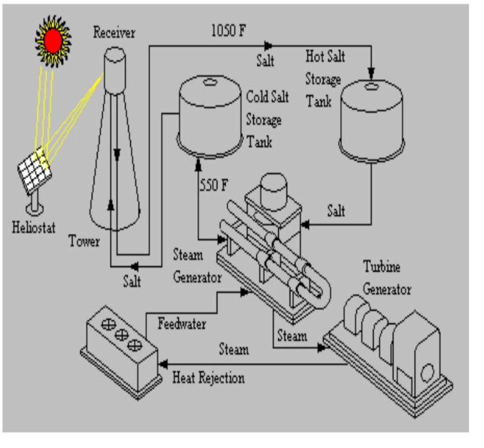

Fig.4.2(c)

The tower (boiler) is mounted on the top of the tower located near the center of the field of large mirrors called heliostats. The heliostats reflect sunlight on to the central tower. Sunrays after getting reflected some heliostats are focused on to the boiler. Thus boiler generates high temperature steam, which is used to drive a steam turbine, which is coupled to an alternator. From this alternator, electricity is generated.

V. Solar tower

This is the other type of conversion of solar to electrical energy with the help of a long tower.

The below shown is called solar power tower which is located in Spain built by Germans with German technology. The tower reaches upto a height of above 3000 feet

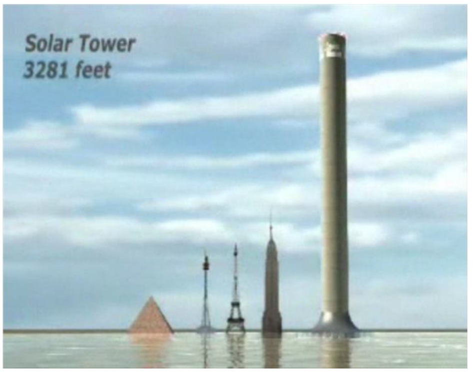

Fig.5

The base part of the tower is totally insulated with a polythene layer so as to avoid the loss of any radiation during cold and night conditions. The working of the plant is as follows.

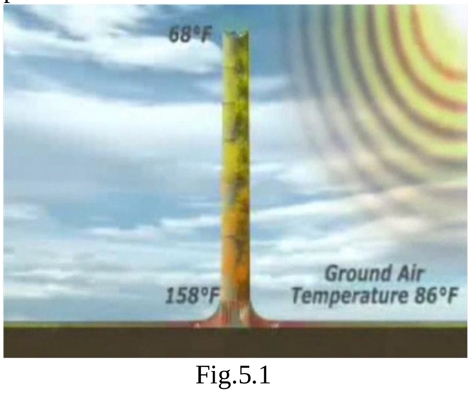

Fig.5.1

The upper part of the plant is equipped with high sensitive collectors, which collect sunlight directly. The top part of the tower is installed with a storage tank. The collected sunlight is used to heat up the water in the storage tank, which leads to generation of heat energy. This heat energy is transferred to the bottom of the tower without any transformational losses with the help of various heliostats fitted inside the tower. On the other hand the surface area under the insulated area gets exposed by the sun and develops heat energy. The steam energy, which is generated by the tower reaches down the tower, it tends to remain in low-pressure region. Therefore, it along with the heat energy of the bottom start moving upwards with high velocity which in turn rotates the prime-movers of the turbine.

The turbines are installed round the tower and all are rotated due to this velocity. As the turbines are internally coupled with the alternators, electricity is generated.

VI. Limitations of solar energy

Solar energy is available in most parts of the world but there are some limitations of solar energy.

- Low energy density 0.1 to 1 KW/m2.
- Large area is required to collect the solar energy.
- Direction of rays changes continuously.
- Energy is not uniform during cloudy weather and not available during the nights.
- Energy storage is essential.
- High initial cost.
- Low efficiency.

Advantages:

- This system of energy conversion is noise less and cheap.
- Maintenance cost is low.
- They have long life.
- Pollution free.
- Highly reliable.

VII.CONCLUSION

In the capital city of India, Delhi, citizens can face hours without electricity, but they are the lucky ones. In some parts of India it can be days. The basic weakness of the electric supply industry is non-viability of tariff. In 2001-02, the cost of supply was Rs.3.50 a unit while the realization was only Rs.2.40. Free or highly subsidized supply for agriculture and subsidies to domestic consumers have resulted in uneconomic charges for industrial consumers. This policy has driven many industries to depend more and more on self-generation. A second weakness of the Indian situation is under investment in transmission and distribution relative to generation. This is due to the lack of proper return in the investment of the power stations. This leads to the increase in price/unit and making the cost unreasonable for the common man.

The use of solar energy for the production of electricity reduces the price/unit as low as 50 paise. The only problem in this procedure is the high installation charges.

So, if our engineers work in such a way so as to reduce that cost and in further developments of the equipment, we can definitely meet the power demand in the future and this will be an ENERGY SOLUTION.

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