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A Concentrated Solar Power Unit Collector's For Electrical Power Generation in Modern Age

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Abstract:- In present scenario, all over the world facing the challenge toward the crises of availability of natural resources like coal or fossil fuel , petroleum , natural gas etc in association with the environment protection , since human being fulfill all the desired from the nature directly or indirectly. But the increasing prices of fossil fuels and concerns about the environmental consequences of greenhouse gas emissions have renewed the interest in the development of alternative energy resources thus Renewable energy is more suitable & correct option due to no capital investment (availability free of cost) and absence of risk and disasters ,reducing carbon content in environment . all the conventional resources are popularly used in electricity generation in India , theses are going to lesser available because of large demand & supply , and hence all over the world was completely depended upon the renewable energy resources , for example solar energy , wind energy , wave energy ,tidal and ocean energy & also other form of natural form of energy availability . in this paper we were focus on the solar energy which is absorbs then converts into heat energy & finally then converted into electrical energy or power generation , to fulfill the desired purpose a concentrated solar power(csp) unit collector's was used for electrical power generation in modern age

Keyword :- Renewable energy , solar energy , electrical energy , Concentrated Solar Power (CSP) system

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I. INTRODUCTION

The basic principle of solar thermal collection is that when solar radiation is incident on a surface (such as black body) a part of this radiation is absorbed and causes to increase the temperature of the surface. The typical solar flux concentration ratio typically obtained is at the level of 30– 100, 100–1000, and 1000–10000 for trough tower and dish systems, respectively. The solar radiation incident on the Earth's surface is comprised of two types of radiation- beam and diffuse, ranging in the wavelengths from the ultraviolet to the infrared (300 to 200 nm), which is characterized by an average solar surface temperature of approximately 6000 degree Kelvin. The amount of this solar energy that is intercepted is 5000 times greater than the sum of all other inputs – terrestrial, nuclear, geothermal and gravitational energies and lunar gravitational energy. When dealing with solar energy, there are two basic choices. The first is photovoltaic's, which is direct energy conversion that converts solar radiation to electricity. The second is solar thermal, in which the solar radiation is used to provide heat to a thermodynamic system, thus creating mechanical energy that can be converted to electricity. In commercially available photovoltaic system, efficiencies are on the order of 10 to 15 percent, where in a solar thermal system, efficiencies as high as 30 percent are achievable. This work focuses on the electric power generation of a parabolic concentrating solar thermal system

II. PARABOLIC GEOMETRY

A parabola is the locus of points that moves equal distance from a fixed line and a fixed point. As shown in **Fig.1**, the fixed line is called the directrix and the fixed point is the focus **F**. The line perpendicular to the directrix and passing through the focus F is called the axis of the parabola. The parabola intersects its axis at a point **V** which called the vertex, which is exactly midway between the focus and the directory.

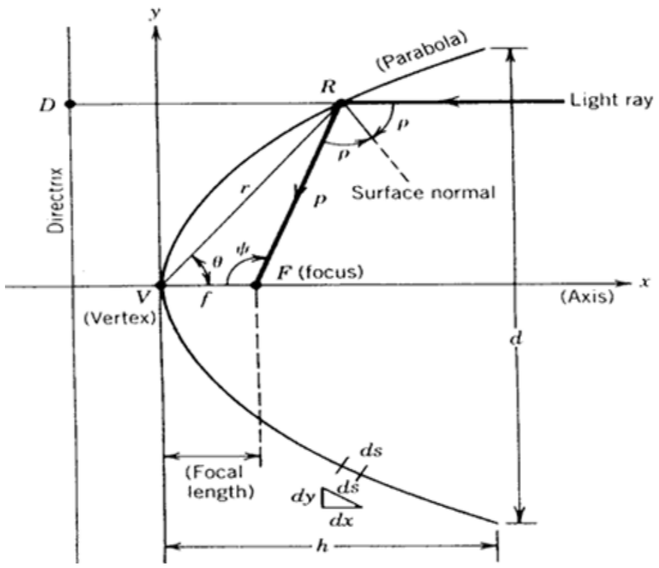


Figure -1 Parabolic Geometry of solar system

Some others type of solar collector is also generally used in power generation, now a days for domestic and commercially application Fig – 2 shows its diagrams

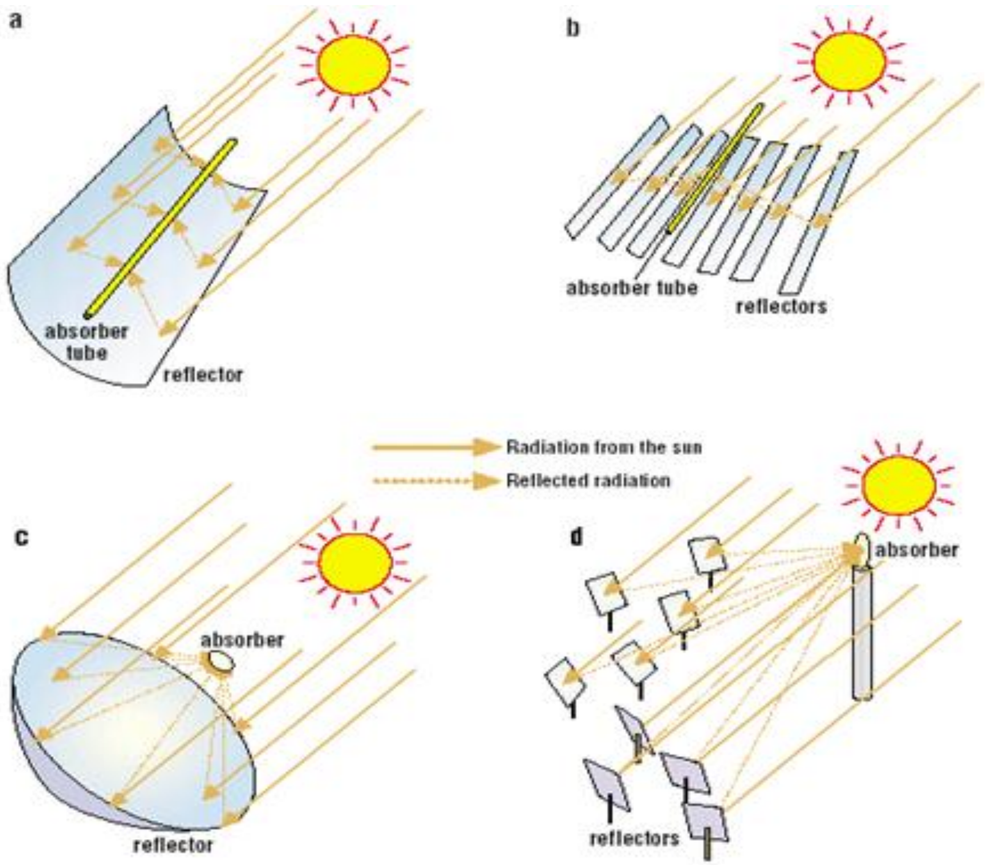


Fig- 2 some other type of solar collector

III. REQUIREMENT OF NECESSARY EXPERIMENTAL APPARATUS AND PROCEDURES

This work was focused on the development of a system for converting incoming solar radiation to electrical energy. The system concentrated the incoming solar radiation to power a thermal cycle in which the energy was converted to mechanical power, and subsequently to electrical power.

3.1 Solar Collector

To obtain the high temperatures necessary, a concentrating solar collector is needed due to solar radiation being a low entropy heat source. The type chosen was that of the parabolic „dish" type. The parabolic dish is a 3.99 meter diameter Channel Master Satellite dish, obtained from….The dish consists of six fiberglass, pie-shaped, sections which are assembled together to form the parabolic structure of the dish

3.2 The Receiver

The receiver of the solar concentrator system serves as the boiler in the Rankine cycle, thus it needed to be able to handle high temperatures. This first generation receiver was designed with simplicity in mind for characterization of the system. An external type receiver was decided upon for use with the concentrator. The basis behind the design of the receiver was a standard D-type boiler, with a mud (water) drum, steam drum, and down-corners. Because of the extreme temperatures expected at the focal region, in excess of 900 K, the outer housing of the receiver was constructed of stainless steel. The receiver consists of a stainless steel cylindrical water drum and two sets of stainless steel coils housed within a stainless steel welded tube. The outer shell of the boiler is 250m long and 195m in diameter, with an internal volume of 3.245 liters. The water drum is 38.1 mm (1.5 in) tall and 133.5 mm (5.25in) in diameter, with a volume of 0.0402 liters. The inner coils consists of 25.4mm (1/4 inch) stainless steel tubing, one set coiled within the other, with the outer and inner coils consisting of fourteen windings with a diameter of 133.35 mm (5.25in) and six windings with a diameter of 63.5 mm (2.5in), respectively. The outer shell is filled with a molten salt into which the water drum and coils are submerged. The molten salt is known as Draw Salt, which consists of a 1:1 molar ratio of Potassium Nitrate (KNO_3 – 101.11 grams per mol) and Sodium Nitrate ($NaNO_3$ – 84.99 grams per mol). There is a total of 19.39 Mols of Draw Salt in the thermal bath, The Draw Salt serves as latent heat storage to allow for continuous heat transfer in the case of intermittent cloud cover and for equal thermal distribution over the water drum and the coils. The receiver is set up to record the inlet, outlet, and thermal bath temperatures, along with the outlet steam pressure. Three stainless steel sleeved K-type thermocouples, with ceramic connectors, are used for temperature measurements. The thermocouples are located at the inlet and exit of the receiver to measure the incoming water and exiting steam temperature. The third thermocouple is submerged halfway the thermal Draw Salt bath

3.3 Steam Turbine

It was decided that a single stage impulse turbine would best meet the system requirements of simplicity and use in developing areas.

3.4 Working Fluid of Solar Thermal System

Since the design of this system was to be kept as simple as possible, water was chosen as the working fluid. If the system were set up off-grid in a field, then a well could be used to supply water for the solar thermal system. In the event that a water-well is unavailable, as was the case here, a reservoir for the water is needed. A steel constructed tank, with a capacity of 13 liters (approx. 3.43 gallons) is used. Because of the conditions for which the system was designed, such as off-grid and emergency use, the water does not need filtered. However, if the water being used is full of debris, maintenance of the system will need to be performed more frequently, thus the use of a screen over the inlet supply line of the pump is suggested, but not necessary.

3.5 Pump

The water is supplied to the system from the tank by use of a Fluid-O-Tech pump located on the underside of the dish. The pump has a small foot print, with the motor having dimensions of 127mm * 114 mm * 109 mm, and the controller, 93 mm * 115 mm * 83mm. The pump has variable speed and power settings, ranging from speeds of 1000 rpm to 3500 rpm, and power settings from 30 percent to 85 percent. The pump runs off of 100 volt to 110 volt AC, with a maximum power usage of 250 Watts. The power setting on the pump has no affect on the flow rate; it affects the amount of pressure that the pump can overcome at a particular speed. The speeds of the pump, however, directly correspond to the flow rate, The pump is designed for longevity by having an absence of moving parts within the motor, with only a short single shaft inside the pump. The control unit of the pump utilizes a double protection system on the circuit board, with a thermal „cutout" to protect the pump and control unit from overheating and current protection for moments of high current peaks caused by overload or seizure of the pump. The original design of the pump was for espresso coffee machines, reverse osmosis system, cooling systems, circuit washing, and/or solar heating systems, thus it was deemed ideal for use in the solar thermal system discussed in this work.

3.6 Tracking

Tracking of the parabolic dish is done by a combination of satellite dish linear actuators and photo-sensing control units that are commercially available. Due to the need for two axis tracking, two heavy duty linear actuators were used. The actuator for altitude tracking was a Super Jack Pro Brand HARL3018, and the azimuth actuator is a Super Jack Pro Brand VBRL3024. The HARL3018 is a medium duty model, rated for a dynamic load of 600lbs, with an 18 inch stroke length equipped with limit switches. The VBRL3024, a heavy duty actuator, is rated at a dynamic load of 1500 lbs, with a 24inch stroke length and is also limit switch equipped. The heavy duty model was required for the azimuth tracking because of the East and West directional extremes required of the actuator. Each actuator requires 12 to 36 volts and up to 7.5 amps, depending on loading, for operation.

3.7 Power Supply

Although the system is designed to produce power, some power must be consumed in order to do so. Power was needed for the linear actuators for positioning of the dish, as well as for operation of the pump. This power was being provided by two 12-volt, valve regulated, deep cycle, and AGM type Delco brand batteries, The batteries were wired in series to increase the voltage to 24 volts for control of the tracking.

3.8 Generator/Alternator

In order to produce electrical power from the system, a generator has to be coupled with the output shaft of the steam turbine. The generator used was a 443541-10Amp Permanent Magnet DC Generator from Wind stream Power LLC. The generator is capable of producing power at speeds ranging from 0 to 5000 rpm at voltages between 12 and 48volts. Maximum power production for this particular generator, for 12, 24 and 48 volts is 120,240 and 480 watts, respectively.

IV. HEAT TRANSFER FLUIDS

The development of new heat transfer fluids (HTFs) is crucial for increasing the operating temperature of a solar thermal plant, and hence the efficiency of the steam cycle. Stability at high temperature, low flammability, low vapor pressure at high temperature, low corrosivity in standard materials, low freezing point, high boiling point, and low cost are the main required characteristics. Various thermal storage options are currently being considered for parabolic troughs and power towers. Some of them have already been demonstrated but many need further research, particularly concerning the optimization of the HTF materials. Here are some among the most significant technologies

4.1 Concrete – This system would use a HTF in the solar field and pass it through an array of pipes imbedded in concrete. The highest uncertainty is the long-term stability of the concrete material itself after thousands of charging cycles.

4.2 Indirect two-tank molten-salt – In current applications, a synthetic oil (e.g. biphenyl-diphenyl oxide) is used as HTF in the solar field and for heating molten salt through a heat exchanger in the thermal storage system. Two separate tanks are used for this system. The excess heat of the solar collector field heats up the molten salt, which is pumped from the cold to the hot tank. If the solar collector field cannot produce enough heat to drive the turbine, the molten salt is pumped back from the hot to the cold tank, and heats up the heat transfer fluid. The molten salt, as it was used in the Solar-Two solar tower pilot demonstration plant [102], is a binary mixture of 60% sodium nitrate (NaNO3) and 40% potassium nitrate (KNO3) salt. The feasibility of this system was proven and the concept seems to have low technological risk despite the relatively high freezing point (~225oC) of the salt

4.3 Thermo-cline storage – Thermo-clines use a single storage tank. A low-cost filler material (e.g. quartzite and silica sand) acts as the primary thermal storage medium and replaces approximately two-thirds of the molten salt that would be needed in a two-tank system. With the hot and cold fluid in a single tank, the thermo line storage system relies on thermal buoyancy to maintain thermal stratification. The thermo line is the region of the tank between the two temperature resources, with a temperature difference of about 60oC [103]. Thermo lines can maintain their integrity over a three-day no-operation period.

4.4 Molten-salt HTF – Using a lower temperature molten salt as the HTF in the solar field allows the same fluid to be used in both the solar field and the thermal storage field, leading to significant cost reduction for the thermal storage, especially when used in the thermo line configuration. This also allows the solar field to be operated at higher outlet temperatures, increasing the power cycle efficiency and further reducing the cost of thermal storage. Major technical barriers to this option include the challenges of high freezing temperature salts (of the order of 120^{o} C) and with higher operating temperatures leading to higher heat losses and requiring new materials and components.

4.5 Organic molten-salt HTF – Organic salts, or ionic liquids, have the advantage of being liquid at room temperature. Additionally they can be synthesized to have specific properties desirable for solar applications, namely low freezing point, high thermal stability, low corrosivity, good heat transfer and thermal properties, and low cost. The development of organic salts is relatively new and more research is required to optimize all these characteristics, particularly to lower the materials cost .

Present view of solar energy in India:-

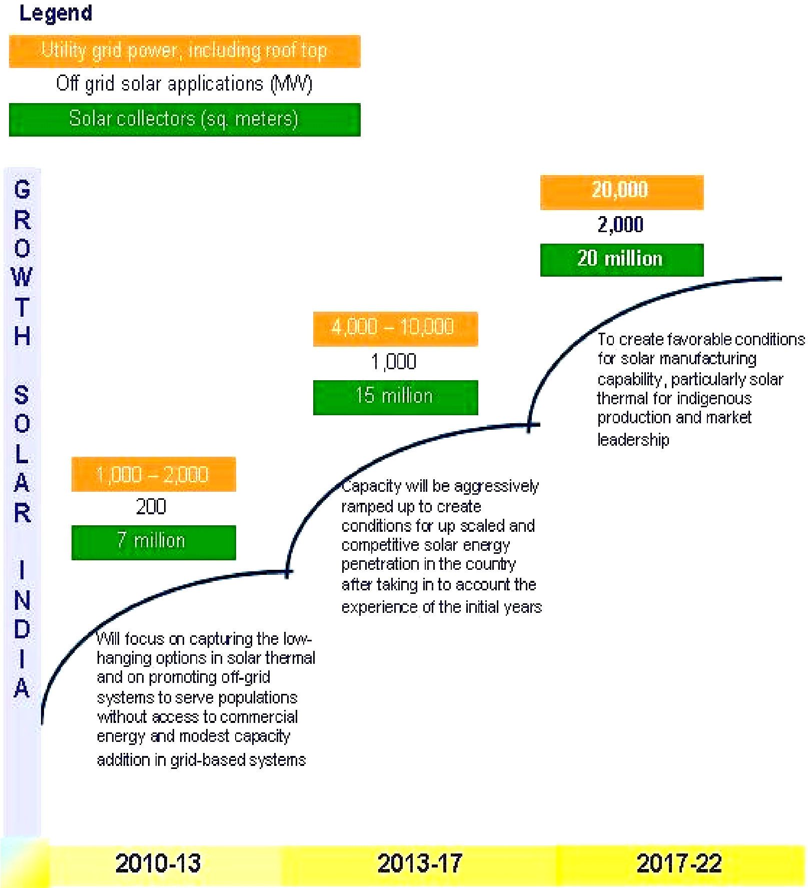
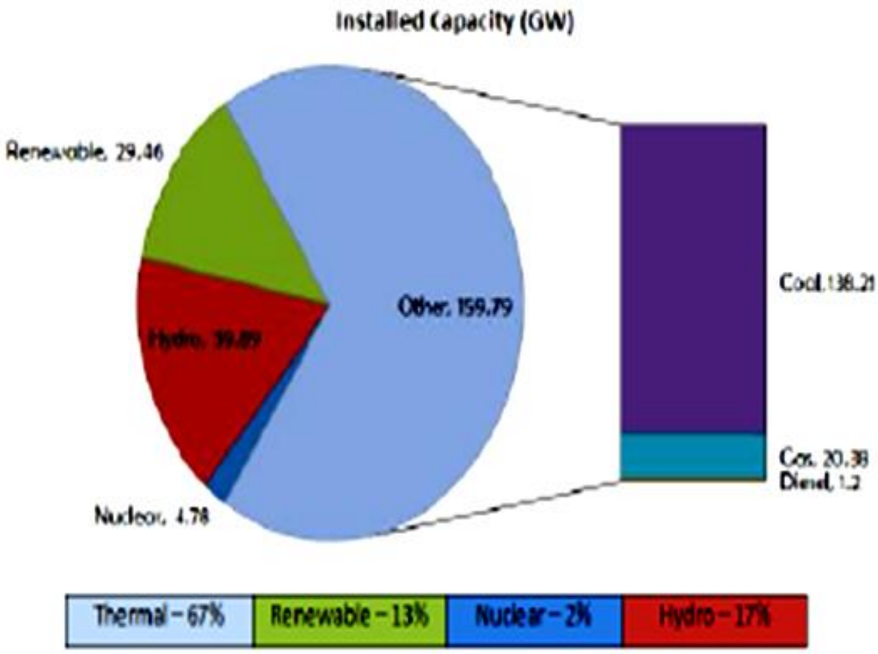
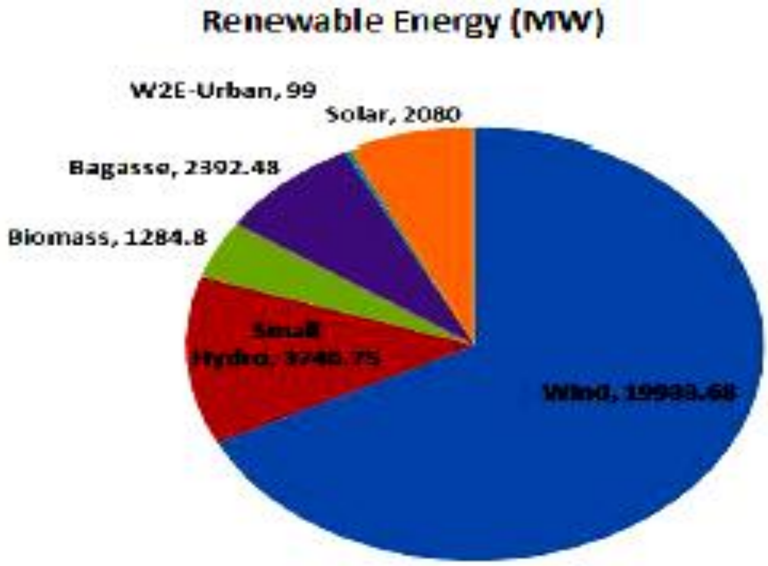


Fig – 3 Present & Expected View Of Solar Energy Generation In India

Contribution of various non-conventional energy resources in power generation clearly Shown in pie- chart

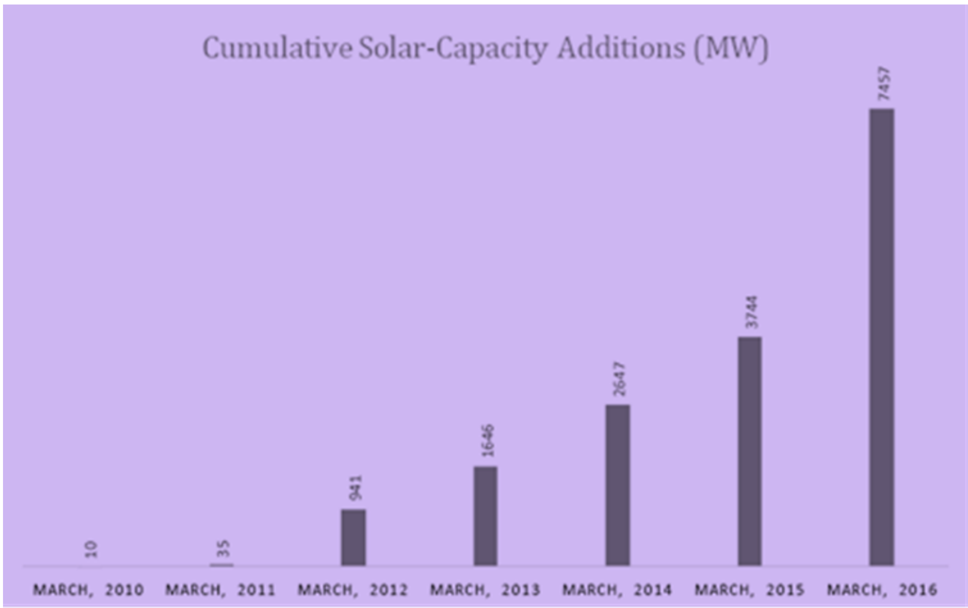




Source: MNRE achievements

Pie- chart

Renewable Energy: India Solar Energy Scenario



V. CONCLUSION

India was the first country in the world to set up a ministry of non-conventional energy resources, in early 1980s.because in modern age there is a necessity of such kind of resources which is available of free of cost , no harmful to our environment , and minimum capital investment for their installation , the correct & suitable answer is renewable energy resources or non- conventional energy utilization for power generation . there are various percentage sharing in power generation by using non- conventional energy resources that is available free of cost in huge amount. All the non- conventional resources contribute differently among them the contribution of **solar energy is about 19%** of total power generation in India. it is not to much depends upon weather condition, the basic influence is speed of wind which deflected the intensity of incoming path of solar energy. I want to also indicated some other renewable resources and their contribution, about **63.2 %** of the renewable power came from **wind** , About **12%** of **Bio-Power**, About **0.3%** waste of power and remaining from other non- conventional resources.

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