1.1 Current energy scenario

Current energy demand is fulfilled by following way:

- 75% of energy requirement is met by fossil fuels.
- Nuclear energy contributes to about 3%.
- 9% is met by hydro energy.
- 12% of energy consumption is met by biogas.
- Renewable sources like wind, tidal, wave, solar, contribute to about 1%
1.2 Alternate energy sources

We should look for alternative energy sources or renewable energy sources because of following reasons:

- Fossil fuels, which are the main source of energy, are getting depleted at a rapid rate. As a consequence the cost of fossil fuels is increasing.

- Fossil fuel based systems produce detrimental effects on the environments. This in turn will affect our health. This means that indirectly, the medical bills will be rising the world over.

- Green house effects: Green house gases make the Earth warmer by trapping energy in the atmosphere.

- Global warming: Global warming refers to an average increase in the Earth's temperature, which in turn causes changes in climate. A warmer Earth may lead to changes in rainfall patterns, a rise in sea level, and a wide range of impacts on plants, wildlife, and humans. When scientists talk about the issue of climate change, their concern is about global warming caused by human activities.

- Environmental hazards

- Health hazards

- Climate Change

- Depletion of stratospheric ozone layer
Different Renewable energy sources are listed here and shown in figure on next page:

- Solar Thermal
- Solar Photovoltaic
- Wind
- Small Hydro
- Geothermal
- Biomass
- Ocean Thermal
- Tidal
- Wave energy
Global Energy Scenario

- 75% fossil fuels
- 12% bioenergy
- 3% nuclear energy
- 8% hydro energy
- 1% renewables

Renewable Energy Sources:
- Solar
- Wind
- Geothermal
- Small hydro
- Biogas
- Ocean thermal/wave
2.1 Solar Energy

From discussion previous chapter it can be seen that there is a huge scope for development of renewable energy worldwide and also in India. Solar energy is the major renewable energy source and alone can fulfill need of country. Solar energy applications are broadly classified as

- Solar thermal
- Solar photovoltaics
2.1.1 Solar thermal energy

Solar thermal energy is a technology for harnessing solar energy for thermal energy (heat). Solar thermal collectors are defined as low-, medium-, or high-temperature collectors. Low temperature collectors are flat plates generally used to heat swimming pools. Medium-temperature collectors are also usually flat plates but are used for creating hot water for residential and commercial use. High temperature collectors concentrate sunlight using reflectors or lenses and are generally used for electric power production.

2.1.2 Solar photovoltaics

Solar photovoltaics, which convert solar energy directly into electricity. Cost of solar produced electricity is from Rs. 7 to Rs. 12, which is much greater than other sources. So there are limitations for Solar photovoltaics.
2.2 Solar thermal applications

Solar thermal applications is a promising option to fulfill the need of energy with effective cost. Various solar thermal applications are as follows:

1. Solar thermal power plants

   The two main types of solar thermal power plants are

   1.1 Concentrating Solar Power (CSP) plant

      a. Parabolic Trough Systems:

      b. Power Tower Systems

      c. Parabolic Dish Systems

   1.2 Solar Chimneys

2. Water heating

3. Solar Dryer

4. Solar Distillation/De-salination

5. Solar box cooker

6. Community Solar Cooker

7. Solar Air conditioning

Here, all above systems are described in brief
2.2.1. Solar thermal power plants

2.2.1.1 Concentrating Solar Power (CSP) plant

a. Parabolic Trough Systems

The sun's energy is concentrated by parabolic curved, trough-shaped reflectors onto a receiver pipe running along the inside of the curved surface. This energy heats oil flowing through the pipe and the heat energy is then used to generate electricity in a conventional steam generator.

A collector field comprises many troughs in parallel rows aligned on a north-south axis. This configuration enables the single-axis troughs to track the sun from east to west during the day to ensure that the sun is continuously focused on the receiver pipes. Individual trough systems currently can generate about 80 megawatts of electricity.

![Parabolic Trough Principle](image)

Trough designs can incorporate thermal storage—setting aside the heat transfer fluid in its hot phase—allowing for electricity generation several hours into the evening.
Currently, all parabolic trough plants are "hybrids," meaning they use fossil fuel to radiation.

b. **Power Tower Systems**

Power tower converts sun utilizes many large, sun-tracking mirrors (heliostats) to focus sunlight on a receiver at the top of a tower. A heat transfer fluid heated in the receiver is used to generate steam, which, in turn, is used in a conventional turbine-generator to produce electricity.

Early power tower (Solar One plant) utilized steam as the heat transfer fluid; current designs (including Solar Two, shown in fig) utilize molten nitrate salt because of its superior heat transfer and energy storage capabilities. Current European designs use air as heat transfer medium because of its high temperature and its good hand ability. Individual power plant can be sized to produce anywhere from 50 to 200 MW of electricity.
c. Parabolic Dish Systems:

Parabolic dish systems consist of a parabolic-shaped point focus concentrator in the form of a dish that reflects solar radiation onto a receiver mounted at the focal point. These concentrators are mounted on a structure with a two-axis tracking system to follow the sun. The collected heat is typically utilized directly by the heat engine mounted on the receiver moving with dish structure. Stirling and Brayton cycle engines are currently favored for power conversion. Projects of modular systems have been realized with total capacities up to 5 MW.

2.2.1.2 Solar chimney

A solar chimney is a solar thermal power plant where air passes under a very large agricultural glass house (between 2 and 30 kilometers in diameter); the air is heated by the sun and channeled upwards towards a convection tower. It then rises naturally and is used to drive turbines, which generate electricity.
A solar chimney is an apparatus for harnessing solar energy by convection of heated air. In its simplest form, it simply consists of a black-painted chimney. During the daytime, solar energy heats the chimney and thereby heats the air within it, resulting in an updraft of air within the chimney. The suction this creates at the chimney base can also be used to ventilate, and thereby cool, the building below. In most parts of the world, it is easier to harness wind power for such ventilation, but on hot windless days such a chimney can provide ventilation where there would otherwise be none. This principle has been proposed for electric power generation, using a large greenhouse at the base rather than relying on heating of the chimney itself. The main problem with this approach is the relatively small difference in temperature between the highest and lowest temperatures in the system. Carnot's theorem greatly restricts the efficiency of conversion in these circumstances.
2.2.2. Water heating

Water heating is required in most countries of the world for both domestic and commercial use. There are a wide variety of solar water heaters available. The simplest solar water heater is a piece of black plastic pipe, filled with water, and laid in the sun for the water to heat up. Simple solar water heaters usually comprise a series of pipes, which are painted black, sitting inside an insulated box fronted with a glass panel. This is known as a solar collector. The fluid to be heated passes through the collector and into a tank for storage. The fluid can be cycled through the tank several times to raise the heat of the fluid to the required temperature.

2.2.3 Dryer

Controlled drying is required for various crops and products, such as grain, coffee, tobacco, fruits vegetables and fish. Their quality can be enhanced if the drying is properly carried out. Solar thermal technology can be used to assist with the drying of
such products. Solar drying is in practice since the time imp-memorable for preservation of food and agriculture crops. This was done particularly by open sun drying under open the sky. In open air Solar drying the heat is supplied by direct absorption of solar radiation by material being dried. The vapor produced is carried away by air moving past the material, the air motion being due either to natural convection resulting from contact with the heated material or to winds.

Disadvantages of mechanical and artificial drying:

1. Spoilage of product due to adverse climatic condition like rain, wind etc
2. Loss of material due to birds and animals
3. Deterioration of the material by decomposition, insects and fungus growth
4. Highly energy intensive and expensive

Solar dryer make use of solar radiation, ambient temperature, relative humidity. Heated air is passed naturally or mechanically circulated to remove moisture from material placed in side the enclosure.

**Solar dryer is a very useful device for**

1. Agriculture crop drying
2. Food processing industries for dehydration of fruits, potatoes, onions and other vegetables,
3. Dairy industries for production of milk powder, casein etc.
4. Seasoning of wood and timber.
5. Textile industries for drying of textile materials
2.2.4. Solar Distillation/De-salination:

Solar Stills

Solar still is a device to desalinate impure water like brackish or saline water. It is a simple device to get potable/fresh distilled water from impure water, using solar energy as fuel, for its various applications in domestic, industrial and academic sectors. A solar still consists of shallow triangular basin made up of Fiber Reinforced Plastic (FRP). Bottom of the basin is painted black so as to absorb solar heat effectively. Top of the basin is covered with transparent glass tilted fitted so that maximum solar radiation can be transmitted in to the still. Edges of the glass are sealed with the basin using tar tape so that the entire basin becomes airtight. Entire assembly is placed on a structure made of MS angle. Outlet is connected with a storage container. Provision has been made to fill water in the still basin. A window is provided in the basin to clean the basin from inside. Water is charged in to the basin in a thin layer.

Solar Stills have got major advantages over other conventional Distillation / water purification /de-mineralization systems as follows:

1. Produces pure water
2. No prime movers required
3. No conventional energy required
4. No skilled operator required
5. Local manufacturing/repairing
6. Low investment
7. Can purify highly saline water (even sea water)

2.2.5. Solar box cooker

2.2.6. Community Solar Cooker

Solar Cookers are described in next chapter.

2.2.7. Solar Air conditioning

The basic principle behind solar thermal driven cooling is the thermo-chemical process of absorption: a liquid or gaseous substance is either attached to a solid, porous material called Adsorption or is taken in by a liquid or solid material called Absorption.
The absorbent, silica gel, a substance with a large inner surface area is provided with heat from a solar heater and is dehumidified. After this "drying", the process can be repeated in the opposite direction. When providing water vapor or steam, it is stored in the porous storage medium (adsorption) and simultaneously heat is released. Processes are differentiated between closed refrigerant circulation systems, for producing cold water, and open systems according to the way in which the process is carried out. That is, whether or not the refrigerant comes into contact with the atmosphere. The latter is used for dehumidification and evaporative cooling.
Cooking is one of the important applications of solar thermal energy. The device which performs cooking by using solar energy is called as solar cooker. Solar cookers utilize the simple principles of reflection, concentration, glazing, absorption and the greenhouse effect to produce heat. Various types of solar cookers exist, harnessing one or more of these principles. The types are:

- Solar box cookers or solar ovens
- Parabolic reflector cookers
- Indirect types of solar cookers
3.1 Solar box cooker

A solar box cooker is an insulated transparent-topped box with a reflective lid. It is designed to capture solar power and keep its interior warm. The major parts of a solar cooker are enumerated below.

Important Parts of Solar Cooker:

1. Outer Box: The outer box of a solar cooker is generally made of G.I. or aluminum sheet or fiber reinforced plastic.

2. Inner Cooking Box (Tray): This is made from aluminum sheet. The inner cooking box is slightly smaller than the outer box. It is coated with black paint so as to easily absorb solar radiation and transfer the heat to the cooking pots.

3. Double Glass Lid: A double glass lid covers the inner box or tray. This cover is slightly larger than the inner box. The two glass sheets are fixed in an aluminum frame with a spacing of 2 centimeters between the two glasses. This space contains air which insulates and prevents heat escaping from inside. A rubber strip is affixed on the edges of the frame to prevent any heat leakage.

4. Thermal Insulator: The space between the outer box and inner tray including bottom of the tray is packed with insulating material such as glass wool pads to reduce heat losses from the cooker. This insulating material should be free from volatile materials.

5. Mirror: Mirror is used in a solar cooker to increase the radiation input on the absorbing space and is fixed on the inner side of the main cover of the box. Sunlight falling on the mirror gets reflected from it and enters into the tray through the double glass lid. This radiation is in addition to the radiation entering the box directly and helps to quicken the cooking process by raising the inside temperature of the cooker.
6. Containers: The cooking containers (with cover) are generally made of aluminum or stainless steel. These pots are also painted black on the outer surface so that they also absorb solar radiation directly.

The solar box cooker typically reaches a temperature of 90 °C; not as hot as a standard oven, but still enough to warm food over an hour. Because it doesn't reach too high a temperature, food can be safely left in it all day without burning. The cooker is often used to make a large pot of food in the morning, and then people eat servings or snack from it all day. The cooker is usually used to warm food and drinks but can also be used to pasteurize milk and sanitize water.

Horace de Assure, a Swiss naturalist, invented solar cookers as early as 1767.

We can cook a large number of items, like pulses, rice, cheer etc. The time taken to cook will depend upon the type of the food, time of the day and solar intensity. However, the time taken to cook some of the dishes in a solar cooker is as follows:

1. Rice (one to two hour),
2. Vegetables (about one to two hours),
3. Black gram and Rajama (about two hours),
4. Cake (one to one and half hour).
3.2 Parabolic reflector cookers (Community Solar Cooker)

Numerous households all over the country are using ‘Surry’ Cooker to cook their meals. This family-sized cooker can cook meals for 4-5 persons. A larger version of the family size box-type cooker was also developed and used for canteen application. The canteen size solar cookers are just larger in size and can cook for 10-15 persons. For meeting still larger demands a large Community Solar Cooker has been developed with Solar Concentrator technology. It is an ideal cooking device for hostels, guesthouses etc.

Firewood is the most commonly used cooking fuel in community kitchens and traditional woodstove - a “Chula” are the most commonly used cooking device. These chelas have an efficiency of 5-10 % only. The implications of utilizing such inefficient devices are higher fuel consumption & environment pollution. As a result more trees are felled each year for meeting the ever-increasing energy demands. This leads to rapid deforestation and environment degradation. In addition, the smoke from chelas causes serious health hazard to kitchen workers. The Community Solar Cooker, in contrast, poses no such health hazards as it utilizes ‘the freely available eco-friendly solar energy from nature.

This Community Solar Cooker employs a parabolic reflecting concentrator that can cook large quantities of food at much faster rate. The best part is that the cooking can take place within an enclosed kitchen. It can replace LPG, kerosene and firewood which are either cumbersome to use, very expensive or which are in short supply. This Cooker is technologically far superior to the box-type community cooker, having overcome a number of shortcomings of the box type cooker.
This cooker is capable of achieving higher temperature unto 250°C as against 100-125 °C in box type cooker. This helps cooking much faster. The conventional cooking arrangement within the kitchen does not require to be changed and the cooking can be done inside the kitchen. Additionally roasting & frying can be done with this cooker, which is not possible in the old box type solar cooker.

The Market cost of Cooker, inclusive of all attachments and installation charges is about Re. 55,000.

The manufacturing of Parabolic solar cooker is with tracking arrangement is a complex task. Its high cost is not affordable to common man.

3.3 **Indirect solar cookers**

In indirect solar cookers the pot is physically displaced from the collector and a heat transferring medium (Steam) is required to convey the heat to the cooking pot.
3.4 Analysis of Solar Cookers

We studied various available high temperature solar cookers for construction, design, life, cost, user, etc. For this we refer different books, websites and took help of people which are working in this field. The available solar cookers in the above said respect are described here in brief.

3.4.1 Analysis of Solar box cooker

A solar box cooker is an insulated container with a multiple or single glass (or other transparent material) cover. Advantages include simplicity of construction and operation with minimal attendance required during the cooking process. The cookers are also more stable, can keep food warm for a long time, produce no glare and present no risk of fires and burns. The speed of cooking depends on the cooker design and thermal efficiency. Disadvantages of solar box cookers include a slow cooking process due to low temperatures.

Solar box cookers are ideally suited to preparing dishes, which require a long, slow cooking time. They are normally used flat on the ground but if preferred, can be placed on a table or a chair to make it easier to use.

Solar box ovens can cost between Rs. 5,000 and Rs.10,000 depending on the type and quality of material used. The life span of solar box cookers depends on the type and quality of material used. Home-made cookers, utilizing recycled material will obviously not last as long as cookers made of more expensive materials and manufactured in a workshop utilizing proper tools.
3.4.2 Analysis of Solar oven

A solar oven is somewhat similar to a hot-box cooker in that it is an insulated container with a multiple or single glass cover. Oven cooking chambers are generally smaller than hot box interiors and the glazed cover is also considerably smaller. The major difference is in the mechanism for directing solar radiation to the cooking area.

Solar ovens use several mirrors to reflect additional radiation into the cooking cavity. Due to increased radiation penetration and decreased cooker area for heat losses, very high temperatures can be achieved. The ovens generally have to be moved periodically throughout the day and therefore, require more attention than solar box cookers. They require more sophisticated materials and are more expensive than solar box cookers.

3.4.3 Analysis of Parabolic reflector cookers

Spherical parabolic cookers are direct concentrating cookers with a dish-type reflector directing most of the intercepted solar radiation to a point of focus. The cooking vessel is supported at this focus point, thus creating a heating situation very similar to traditional open fire cooking. The concentrators can vary in form from shallow to deep dish shapes and they can have a continuous reflecting surface or be made out of concentric rings, which are supported to focus the radiation. Dish-type concentrators require direct sunlight to function and must be frequently orientated towards the sun.

Advantages include high cooking temperatures, virtually any type of food can be cooked and short heat-up times are possible.
Limitations are their size, cost, the risk of fires and burns and the inconvenience to adjust the cooker. Most direct-focusing cookers are also unstable at wind speeds exceeding 10km/h and are sometimes considered inconvenient to use because the glare can be uncomfortable to the cook.

Parabolic solar cookers are suitable for households and small institutions and can typically cook for 6-20 people.

Parabolic solar cookers are generally more expensive than box cookers because more expensive materials and tracking arrangements are used. A cost estimate would be between Rs. 25,000 to Rs. 50,000.

Parabolic solar cookers have a long life span, since materials such as aluminum, steel and stainless steel are usually used.

Many other solar kitchen in India use another unique concentrating technology known as the Scheffler reflector. This technology was first developed by Wolfgang Scheffler in 1986. A Scheffler reflector is a parabolic dish that uses single axis tracking to follow the Sun's daily course. These reflectors have a flexible reflective surface that is able to change its curvature to adjust to seasonal variations in the incident angle of sunlight. Scheffler reflectors have the advantage of having a fixed focal point which improves the ease of cooking and are able to reach temperatures of 450-650 °C built in 1999, the world's largest Scheffler reflector system in Abu Road, Rajasthan India is capable of cooking up to 35,000 meals a day. By early 2008, over 2000 large cookers of the Scheffler design had been built worldwide.
3.4.4 Analysis of Indirect solar cookers

In indirect solar cookers the pot is physically displaced from the collector and a heat transferring medium (Steam) is required to convey the heat to the cooking pot. Saibaba Sansthan uses same type of cooker for daily food cooking in Maharashtra.

Generally, indirect cookers are more expensive due to more expensive materials being used as well as increased component requirements. A cost estimate would be between Rs. 2, 50,000 to Rs. 5, 00,000.

Indirect cookers have a long lifetime expectation due to expensive materials used. The solar cooker can be incorporated into the kitchen design, which would enable the cooking process to take place inside the kitchen.

3.4.1 Analysis of Other Reflector type solar cookers
3.5 Conclusion

Parabolic solar cooker are useful to cook wide range of food. It also attains temperature range from 400-600 degree Celsius. This cooker is easy to manufacture without tracking arrangement and also easy to transport. Its cost can be sustainable by common Indian after research. By considering all these advantages we decide to make a parabolic solar cooker.

3.6 Objectives of the Present work:

Objectives of the present work are as follows:

1. To manufacture a parabolic solar cooker to fulfill the need of a family with 5-10 persons
2. To make economical solar cooking system affordable to medium class family
3. To make a single piece reflector by using sheet metal
4. To use simple arrangement instead of complex and costly tracking arrangement
5. In addition to these to achieve following technical educational objectives as listed below:

To get practical knowledge of following subjects:

- Energy engineering: To study various solar thermal application systems
- Manufacturing Processes: To learn about manufacturing processes
  - Sheet metal work,
  - Metal joining processes-welding, etc
  - Various fabrication processes
  - Surface finishing processes
• Materials and their properties

• Application of Design Data Handbook

• Application of Different manufacturers catalogue

6. To interact with industries and market for various manufacturing processes and purchasing respectively.