Recent Research in Science and Technology 2014, 6(1): 141-145
ISSN: 2076-5061
Available Online: http://recent-science.com/

Present energy scenario and solar energy as an alternative option for environmental protection

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Abstract

In today's scenario utilization of energy in an effective manner is must and that is the need of the time. After industrial revolution we are using the classical energy sources which are dependent on fossil fuels. The rate of exploration ofthese resources are much higher along with the higher rate of pollution**.** With the advancement in technology more efficient alternative energy sources have been recognized for environmental protection and are now available for various applications. This paper focuses one of the alternativeused for energy generation i.e. the solar option. In this study comparison of flat plate solar collector and evacuated tube solar collector is carried out and feasibility is reported.

Keywords: Solar energy, solar water heating, Heat transfer

INTRODUCTION

Since 1973, the word "energy" has been continuously in the news and nearly 40 years since the first oil shock taken place. Then the words 'energy crisis' and 'energy security' continued in the news. Energy is one of the major inputs for the economic development of any country. Today every country draws their energy need from a variety of sources. In the case of the developing countries, the energy sector assumes a critical importance in view of the ever-increasing energy needs requiring huge investments to meet them.

Energy can be classified in to following types based on the sources-

- Renewable energy,
- Non-renewable energy,

Renewable energy

Renewable energy is energy obtained from sources that are essentially inexhaustible. Examples of renewable resources include wind power, solar power, geothermal energy, tidal power and hydroelectric power. The most important feature of renewable energy is that it can be harnessed without the release of harmful pollutants.

Non-renewable energy

Non-renewable energy is the energy drawn from conventional fossil fuels. Sources of non-renewable energy includes coal, oil, natural gas etc. which are likely to deplete with time. The energy generated through the use of fossil fuels is nearly 60-70% of the total energy generated in the world.

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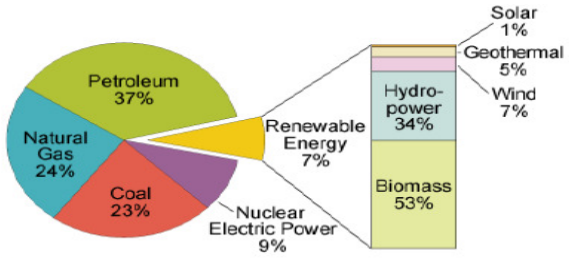

Fig 1. Energy consumption from various resources

Need of energy

The standard of life is normally measured by the use of energy consumed per person. The comfort and luxury are dependent on the amount of energy consumed. The energy consumption rate in India per capita is 400 KWh. Man has needed and used the energy at an increasing rate for his sustenance and well-being ever since he came on the earth. Primitive man required the energy in the form of food.

Need for alternatives

In the past few years it has become obvious that the fossil fuel resources are fast depleting and that the fossil fuel era is gradually coming to end. The proven reserves of fossil fuels will be lasting in coming few decades. Use of commercial energy on large scale has led to better quality of life, but also it created many problems. Perhaps most serious of these is the harmful effect on the environment. The magnitude of the problem and the key factors responsible for the present mess have been identified and it is needed to take corrective action.

The alternative energy source which hold potential for the future can be classified as following-

1. The solar Option,
2. The nuclear option,

3. Tar sands and oil shale,

This paper is focused exclusively on the solar option.

THE SOLAR OPTION

The usage of conventional energy resources of fossil fuels to fulfill our requirement leads to environmental damages by polluting the atmosphere. A variety of air pollutants have known and suspected harmful effects on human health and on the surrounding.

Also due to heavy use of these resources, an energy drought can occur in the near future. Thus the energy requirement can be balanced by providing alternative sources of energy subsequently.

The solar energy has now been identified as one of the best option of energy as it is renewable and inexhaustible. The sun is a gaseous sphere with diameter 1.39 x 10^9 m from the earth and it emits 63 MW/m^2 on the sun's surface. A fraction of the sun's global output energy is intercepted by the earth that is 1.7 x 10^{14} KW.

The greatest advantage of solar energy as compared with conventional energy source is that it is clean and can be supplied without any environmental pollution. One of the simplest and most direct applications of this energy is the conversion of solar radiation into heat, which can be used in water heating systems.

Some of the major advantages of this form of energy that makes it the most important one from among all other natural sources of energy available are

- Solar energy is highly abundant and unanimous. There will never be the scarcity of this energy. In winter season also, a moderate amount of this energy is available. That means this is a renewable source of energy that is consistent and will never end.
- Solar energy is absolutely clean one. There is no production of any greenhouse gases.
- Besides many advantages there is a limitation of solar energy that it is not present during the night time.

The simplest and direct application of this energy is to convergence of solar radiation into heat. The solar radiation is directly used by means of photovoltaic modules and solar thermal collectors.

Solar thermal collectors

In conventional uses solar thermal collectors can provide energy for domestic hot water or space heating as well as a supporting energy sources for central heating installations.

Due to the nature of solar energy, two components are required to have a functional solar energy generator. These two components are a collector and a storage unit. The collector simply collects the radiation that falls on it and converts it in to another form of energy (heat or electricity). The storage unit is required because of the non-constant nature of solar energy.

Flat plate collector

In order to utilize the solar energy a commonly used solar collector device is flat plate collector. They consist of –

1. A dark flat-plate absorber of solar energy.
2. A transparent cover that allows solar energy to pass through.
3. A heat transport-fluid to remove heat from the absorber.
4. A heat insulating backing.

The absorber consist of a thin absorber sheet of thermally stable polymers, aluminum, copper to which selective coating is applied. The mechanism of heating involves initially sunlight passes through the glazing and falls on the absorber plate, which heats up, changing solar energy in to heat energy.

The heat is transferred to liquid passing through pipes attached to the absorber plate. Absorber plates are painted with selective coating, which absorb and retain heat better than ordinary black paint. Absorber plates are usually made of metal typically aluminum or copper.

In locations with average available solar energy, flat plate collectors are sized approximately one-half-to one-square foot per gallon of one day's hot water use.

With flat panels the solar rays strike the panels at an oblique angle during the early and late of the day and are only perpendicular at midday. The angle plays an important part in the flat panel's collection efficiency.

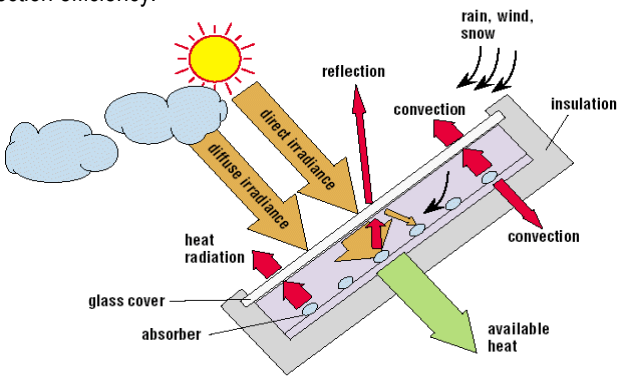

Fig 2. Schematic view of flat plate solar collector

Usually an iron-poor solar safety glass is used as a transparent cover, as it transmits a great amount of the short-wave light spectrum. Simultaneously, only very little of the heat emitted by the absorber escapes the cover (greenhouse effect).

In addition, the transparent cover prevents wind and breezes from carrying the collected heat away (convection). Together with the frame, the cover protects the absorber from adverse weather conditions. Typical frame materials include aluminum and galvanized steel; sometimes fiberglass-reinforced plastic is used.

The insulation on the back of the absorber and on the side walls lessens the heat loss through conduction. Insulation is usually of polyurethane foam or mineral wool, though sometimes mineral fiber insulating materials like glass wool, rock wool, glass fiber or fiberglass are used. Flat collectors demonstrate a good price-performance ratio, as well as a broad range of mounting possibilities.

In order to reduce heat loss within the frame by convection, the air can be pumped out of the collector tubes. Such collectors then can be called evacuated-tube collectors. They must be re-evacuated once every one to three years.

Evacuated tube collectors

Besides being the most efficient collector at absorbing the suns energy, solar vacuum tubes have other advantages. Solar angles (the angle at which the panel meets the sun) plays very little role with

solar vacuum tubes as the sun is always striking at an optimum angle.

Conventional simple flat-plate solar collectors were developed for use in sunny and warm climates. Their benefits however are greatly reduced when conditions become unfavorable during cold, cloudy and windy days. Furthermore, weathering influences such as condensation and moisture will cause early deterioration of internal materials resulting in reduced performance and system failure.

ETC have demonstrated that the combination of a selective surface and an effective convection suppressor can result in good performance at high temperatures. The vacuum envelope reduces convection and conduction losses, so the collectors can operate at higher temperatures than FPC. Like FPC, they collect both direct and diffuse radiation. However, their efficiency is higher at low incidence angles. This effect tends to give ETC an advantage over FPC in day-long performance.

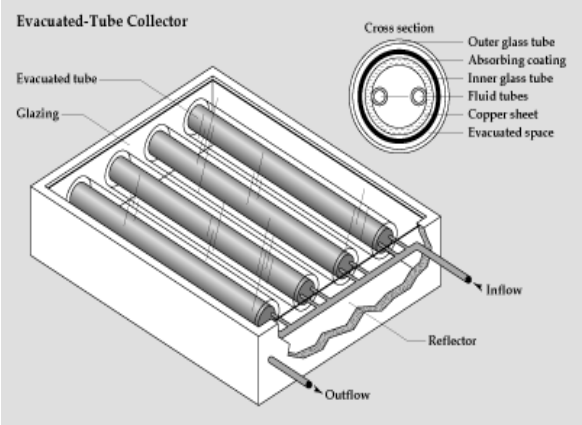

Fig 3. Evacuated tube solar collector

Significnce of vacuum in collector

As seen in conventional flat plate collectors, for heating purpose, there are thermal losses present in the form of convection losses and conduction losses due to presence of air between collector plates. Also the response time expands due to this losses. This deficiency can be overcome by removing the air from cavity.

The vacuum is created to recreate the thermos flask effect, as vacuum acts as perfect insulator and does not allow short wave radiations to escape through the glass tubes. Due to this fundamental property of vacuum trapping of solar radiation is much more effectively and hence an appreciable efficiency can be achieved.

Crating vacuum helps to keep the tubes from cooling down in colder weather conditions heat supply can be therefore continue even there is no sunlight striking the collector, due to trapped heat within the evacuated tube.

Because of the pure vacuum, there is virtually zero heat loss. This is evident by touching a glass vacuum tube which is cold while the liquid inside can be boiling. Almost 94% of the suns energy is directed to the inside of the tube and is captured. Flat panel collectors will always loose heat through the glass, and become very inefficient at higher temperatures.

Description of absorber surfaces

Absorbers are usually black, as dark surfaces demonstrate a particularly high degree of light absorption. The level of absorption indicates the amount of short-wave solar radiation being absorbed that means not being reflected. As the absorber warms up to a temperature higher than the ambient temperature, it gives off a great part of the accumulated solar energy in form of long-wave heat rays. The ratio of absorbed energy to emitted heat is indicated by the degree of emission.

In order to reduce energy loss through heat emission, the most efficient absorbers have a *selective surface coating*. This coating enables the conversion of a high proportion of the solar radiation into heat, simultaneously reducing the emission of heat.

The usual coatings provide a degree of absorption of over 90%. Solar paints which can be mechanically applied to the absorbers (with either brushes or sprays), are less or not at all selective, as they have a high level of emission. Galvanically applied selective coatings include black chrome, black nickel, and aluminum oxide with nickel. Relatively new is a titanium-nitride-oxide layer, which is applied via steam in a vacuum process. This type of coating stands out not only because of its quite low emission rates, but also because its production is emission-free and energy-efficient.

Evacuated-tube collector offer the advantage that they work efficiently with high absorber temperatures and with low radiation. Higher temperatures also may be obtained for applications such as hot water heating, steam production, and air conditioning.

Performance at higher temperatures

As the temperature differential between the ambient temperature (outside) and the operating temperature (inside vacuum tubes) increase vacuum tubes become the obvious choice. This can occur either in colder weather or for hotter applications such as space heating or process heating

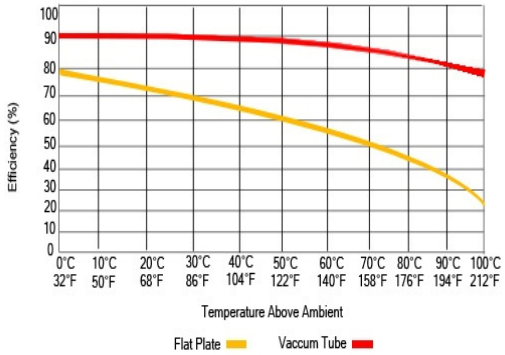

Fig 4. Eficiency comparision of flat plate collector

Comparison between evacuated tube and flat plate solar collector

In order to see the compatibilityof both collectors based on certain parameters comparison has been produced. Also the above plotted graph gives the clear information about the performance of solar collectors

S.N.	Parameters	Evacuated Tube Solar Collector	Flat-plate Solar Collector
1.	Construction	The collector is hermetically sealed inside an evacuated glass tube, eliminating convection and conduction heat losses and isolating the collector from adverse ambient conditions. Therefore, no heat losses due to convection and conduction and no change of performance during the service life of the collector due to corrosion.	The collector is put in a casing with a glass shield to reduce heat losses. The air gap between absorber and cover pane allows heat losses to occur, especially during cold and windy days. Buildup of condensation will in due course influence the collector greatly due to corrosion, reducing performance and durability.
2.	Circulation of fluid	Used for super-efficient heat conduction. No water enters into the collector.	Circulates water inside insulated areas. Prone to leakage, corrosion and restriction of flow due to possible air lock.
3.	Principle of operation	Thermosyphon operation principle. The thermal flows one way only; form the collector to the water and never in the reverse.	Flat-plates can actually rob the water of built up heat if the collector becomes colder than the water temperature.
4.	Insulation	Corrosion and freeze free; there is nothing within the evacuated tube to freeze and the hermetic sealing of each tube eliminates corrosion. The insulated manifold header and can withstand subzero temperatures for a short period	Flat-plate collectors are vented and as such the copper piping is surrounded by colder air and lose contained water and unless well protected can burst upon freezing. Corrosion can become a major problem reducing performance!
5.	Maintenance	Easy installation and no maintenance. Lightweight individual collector tubes are assembled into the system at the point of installation. Each tube is an independently sealed unit requiring no maintenance.	Installation is difficult. Entire panels have to be hoisted onto the roof and installed. If one has a leak, the entire collector has to be shut down and removed.
6.	Orientation	Relatively insensitive to placement angle, allowing architectural and aesthetic freedom.	Requires accurate southern exposure and elevation placement.

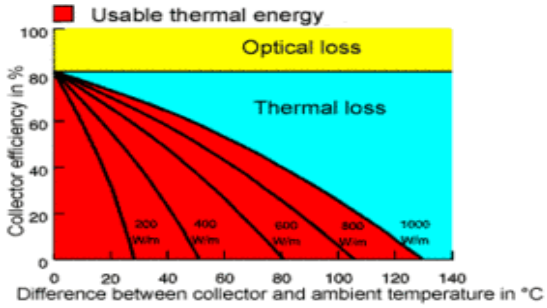

Fig 5. Collector efficiency curve and temperature ranges of both types of collectors (global radiation: 1000 W/m²)

The efficiency of a solar collector is the quotient of usable thermal energy versus received solar energy. Besides thermal loss there always is optical loss as well. The conversion factor or optical efficiency indicates the percentage of the solar rays penetrating the transparent cover of the collector (transmission) and the percentage being absorbed. Basically, it is the product of the rate of transmission of the cover and the absorption rate of the absorber.

Advantages of evacuated tube solar collector

Advantage of the sealed glass evacuated tube is that is acts as heat store, providing a stable supply of heat to the manifold even during intermittently overcast weather. The tube will continue to provide heat even after the sun has set.

An evacuated glass tube, eliminating convection and conduction heat losses and isolating the collector from adverse ambient conditions. Therefore, no heat losses due to convection and conduction and no change of performance during the service life of the collector due to corrosion.

During summer season it is observed that the solar system produces too much heat, and unplugging the tubes can simply be done to scale back the output. This also means that a broken vacuum tube will have little effect on the operation of the system.

Solar Vacuum tubes can operate at a much higher temperature and as such are the preferred choice for solar space heating applications, solar space heating, solar process heating, solar air conditioning, and commercial solar heating applications. The growth worldwide for solar vacuum tubes is growing exponentially and is expected to surpass flat plate collectors within the next 5-10 years. Currently Asia used 95% evacuated tubes in solar applications and Europe is quickly adopting vacuum tubes in areas such as home heat and even solar air conditioning.

CONCLUSION

There are many alternative energy sources which can be used instead of fossil fuels. The decision as to what type of energy source should be utilized must, in each case, be made on the basis of economic, environmental and safety considerations. Because of the desirable environmental and safety aspects it is widely believed that solar energy should be utilized instead of other alternative energy forms, even when the costs involved are slightly higher.

By using more and more solar energy as solar electrical or as solar thermal or direct utilization, the danger of increasing rate of combustion generated pollution shall certainly come within the control and shall greatly help for environmental protection.

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