An Innovative Design of Solar based Building to Get Optimum Illumination and Create Better Living Environment with the Usage of Zero Electricity

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Abstract: The solar energy is one of the potential sources of energy which is clean, non-pollutant, inexhaustible and replenishable. At present, the conventional methods of illumination use electricity as a basic source. This paper discusses the new design of an efficient solar illumination system and solar based home appliances. This illumination system can be successfully used for illumination of single room as well as whole house/offices in a day time. At the same time solar based home appliances can be operated with the help of solar energy. It has been observed that new design of house is advantageous in following manner. (1) To take maximum advantages of solar energy, the concept of solar energy can be combined with civil engineering. (2) The home appliances and similar facilities can be designed and arranged in the building in a scientific manner. (3) The use of optical fibers, optical lenses, solar cells, solar energy storage devices, solar operated equipments etc. would be effective for the building design. (4) It is very economical against the conventional system which requires large amount of electricity. The estimation of total power required to run the electrical instruments was carried out very precisely. To fulfill the power requirement of the house an effort has been made by keeping in view the most favorable situation, arrangement and location of various solar driven home appliances.

I. INTRODUCTION

Today we are using electricity, most common and sophisticated form of energy, for lighting our houses, hospitals, factories, offices, community halls etc. We use mercury lamps, tube lights, Argon lamps, sodium vapor lamps, halogen tubes etc. during the day time. We use the same equipment and energy sources commonly in our living places. We know that during the daytime in India availability of sunrays is more than our need. We are very nearer to equator plan; our latitude angle is also 22.15. So geometrically we are on very sound place. Out of 12 months, we receive sunlight more than 9 months. Our working hours are from sunrise to sunset.

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The use of electrical energy in houses, class rooms, offices, industries is enormous. To date all the energy is produced by one or other kind of conventional methods and in near future, the conventional energy sources will be depleted. The use of non-conventional sources of energy such as solar energy etc. provides pollution free environment as well as to retain the existing conventional sources for a longer time. Hence, it is advisable to use solar energy at least for day time applications.

HISTORY

In older days the people wake up early in the morning and go to bed after sunset, most of the work was to be completed in the presence of sunlight. Construction of house and buildings are such that during the daytime there is no need of other source for lighting purpose. So they were utilizing sunlight as maximum as possible. After second world war the efforts have been started to develop electricity generation at faster rate. It is observed that the use of electrical energy is common for lighting purpose. It consumes a lot of electrical energy which is not advisable. Therefore for illumination so many techniques are used, like

- Middle portion of the houses are kept open.
- Kitchen is in the east south direction.
- Roofs are inclined.

There is scientific reason for it. It is convincing to follow the rules by which pyramids, sphinxes, tombs, mosques, churches, temples are constructed. The use of natural light is maximum there. Therefore this subject is not a new but it is very old. Only difference is that we try to apply a scientific rule for a better living environment in our living places and better lighting.

In Gujarat there is a one national sculpture which is known as “Surya Mandir” in Modhera near Mahesana district. This temple is 500 years old. In such older days this marvelous monument was constructed. In the morning at particular time sun rays enter in temple and striking on middle portion of the reflector. This reflector reflects sun rays on the diamond which is fixed on Taj of God Surya Narayana . Due to this diamond, reflection and refraction takes place and it lightened entire temple with sun light.

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II. SUITABILITY TO USE NATURAL LIGHT

1. The eye responds to a range of illumination level extending over a million orders of magnitude. From the days most common use of sunlight for illumination for 1 flux(full moon light) to 100000 flux(bright sunshine)
2. Fluctuation of brightness may not effect on our routine activity. So sudden change in environment lighting does not leave big impact on our routine activity.
3. Germs are destroyed.
4. In our room 100 flux to 900 flux is a normal requirement and nature gives us 1000 times more than our need.
5. Pleasant & natural environment.
6. Identification of the colours and activities will increase in the presence of sun light. Therefore the efficiency of the person will increase in natural light.
7. It is better to utilize solar light directly as compared to solar cell & solar based electricity production plant.
8. Electricity thus saved is utilized in some creative work. so economical growth of nation is achieved.

Before explaining various methods of utilization of solar energy, one must know the rules and laws of nature. The laws established for light, optics and geometry of sun path are very essential to understand to take optimum advantage of solar energy.

IMPORTANT DEFINITION

Day light factor**:** 100 flux is equal to a day light factor of value 1.25% based on 8000 flux as the external design illumination for India. 100x100/8000 = 1.25 is the daylight factor. For India we take a 8000 flux as the external design illumination level.

Location	Daylight factor
Kitchen	2.5
Living room	0.625
Bed room	0.313
Study room	1.9

Sol-air temperature**:** For building purpose it is useful to combine the heating effect at radiation incident on a building with the effect of warm air. This can be done by using the same thermal effect as the incident radiation in question and this value is added to the air temperature:

$$Ta = Ts + \frac{I \times a}{f}$$

Were,

Ta= Sol-air temperature, in ^{0}C
Ts= Outside air temperature, in ^{0}C
I = Radiant intensity, in w/m^2
a= absorbance of the surface.
f = surface conduction (outside), w/m^2 ^{0}C

DESIGN OF HOUSE

The most suitable designed to keep room cool or hot by using natural means instead of electrical or mechanical power. The art for passive cooling is much less developed than passive heating and it may not always be possible to use natural means to provide comfortable temperatures in the buildings. As a matter of fact passive solar cooling techniques are not strictly solar but the performance of these techniques depends directly or indirectly on solar energy and requires mechanical or electrical power. These natural cooling techniques can reduce at least to some extent the peak cooling load of a building thereby reducing the size of air-conditioning plants. The natural means which can be used for passive cooling are shading, ventilation, evaporation, radiation and dehumidification. The passive cooling system has many advantages such as

(1) The system is of low cost and requires less maintenance as compared to active system
(2) The system is simple and easily repairable and understandable
(3) The operation is natural and aesthetically attractive.
(4) The system remains operative and effective as and when required
(5) The system is more useful if incorporated at the design stage of to building but can be retrofitted also.

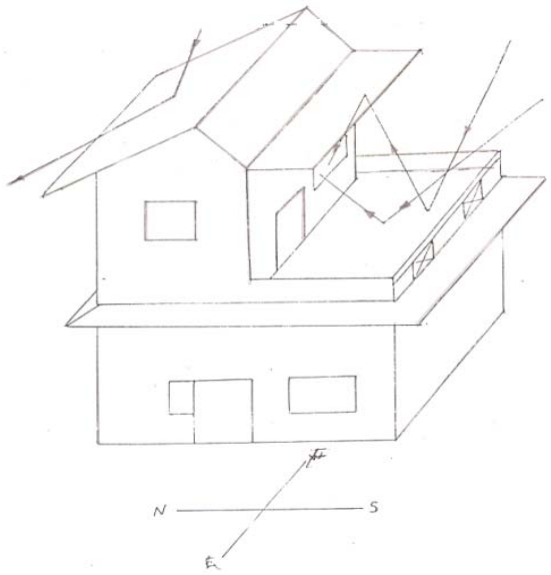

Fig 1 A house

For natural cooling the first and best approach is to reduce unnecessary thermal loads that are entering the building. These thermal loads may be due to direct sunlight entering the building, conduction of heat through building elements and infiltration of outside warm air.

The design of the house should be such that natural light enters into the house to save electrical energy during the day time. The selection of the direction of doors and windows and other things should be based on the sun's diurnal motion. As shown in Fig. 1, in a day time from gallery, sun rays are reflected. This reflected sunlight is useful for illumination. The middle portion of the house is kept open,

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so that during the day time sunlight will enter into the room from the middle portion. Thus, east and south facing rooms receive direct sunlight. The roof of the house should be constructed inclined to reflect the sun rays at its maximum so as to reduce the temperature inside the room. The Plantation of trees near the building helps to reduce green house effect since the solar rays will be absorbed by trees.

WINDOWS, DOORS AND LOUVERS DESIGN: Consider a sun path diagram by taking care of all important theory, season and incident angle. Also consider a latitude angle. Sunlight always entering in the room during the daytime in a controlled manner because heat and light both are the factors to be controlled. The louver can be designed to admit direct radiation in winter and exclude it in summer. The building facets can be shaded by using overhung and awning on the outside of the building. Reflective glasses or sun strips are also effective means to reduce the solar gain during summer months without loosing the visual contact. Operable shading devices are even more versatile. But, if provided outside the building are even more versatile but difficult to maintain and may deteriorate with time. These external shades can be of fixed type or adjustable type. The adjustable type is more versatile since one can control the amount of light more precisely. Painting of the walls and roof with light colors will help in the reduction of heat gain. White wash, which can cheaply be done on walls and roof, is effective way of reducing heat gain and increasing lighting. Shading can also be provided by growing suitable trees and vegetations adjacent to the building and by proper landscaping. In summer season we will get enough sun light and also control the temperature.
If window is south facing, in the winter, heat and light both are enough in room. If window is not south facing, it is to be placed in the direction of east-south or west-south. In this case, one can find out hour angle from the geometry of the house. During pre and post noon, sun rays are admitted into the room. Design louvers as per this hour angle are found by the difference between geometry and solar noon angle. Here, one consider a solar noon angle around a year average south facing or perpendicular line. So from, we can take hour angle and find Zenith angle considering previous hour angle to design louvers.

IMPORTANT CARES TO BE TAKEN

1. From morning to evening intensity of sunshine fluctuates. So some sunglasses to be found out which can pass light through them in regular manner.
2. Due to the movement of sun and earth we have a different seasons and incident angle is also changing. So we have to take care of this point.
3. We can't be totally dependent on sunlight during the day time also because of climatic changes. So during the daytime also we have some full proof stand by source.
4. Ultraviolet & infrared rays may be with the visible natural light. These rays should be eliminated. These rays are not suitable for pleasant environment.

ILLUMINATION USING OPTIC FIBRES
The optical fibers are prepared from the long and thin fiber of glass and quartz. Diameter of fiber is about 0.0001 cm the envelope of the substance having refractive index smaller than that of the material of fiber, is placed on the outer side of fiber. When ray of light is made to incident on one end of the fiber, the light enters the fibers. The angle of incidence is kept greater than the critical angle of material of fiber. Fiber is optically denser medium than the material of the envelope around the fiber. Hence, this ray suffers the total internal reflection for enumerable times and finally it emerged out from the outer end of the fiber. The light can pass through the curved or bend fiber. Hence fibers are used in our indirect method. (Fig 2)

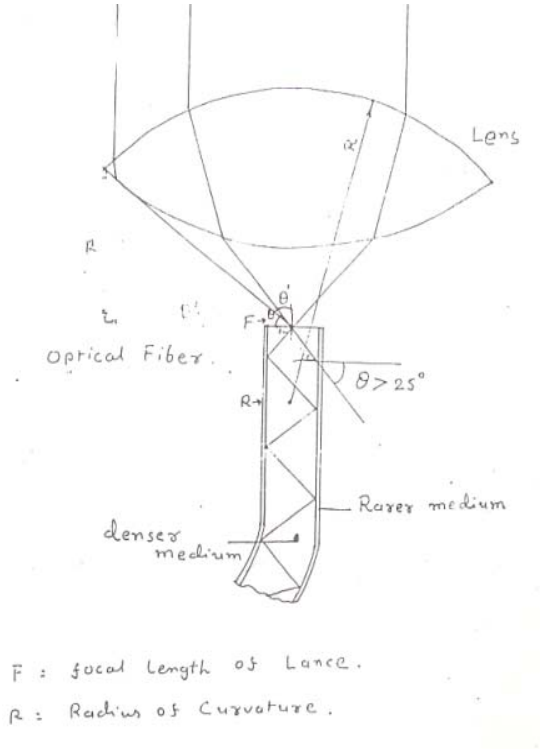

Fig. 2 The passing of light through the curved or bend fiber

Coherent bundles**:** If a large number of fibers are put together, it forms what is known as a bundle. If the fibers are not aligned properly, i.e. if the relative positions of the fibers in the input and output ends are the same, the bundle is said to form a coherent bundle. if a fiber is illuminate at one end, then there will be a bright spot at the other end of the fiber.

Mirror Bricks and Transparent Roofs**:**
The mirror bricks and transparent roof are available as per sun path geometry we can fix the mirror in the wall or a transparent roof. Best place for the mirror on the wall is above the window or middle portion of the wall and below the ceiling. So sun rays are allowed in the room in the distributed form.
Bricks are always placed in the south direction then we will get best advantage.

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Shade should be such designed so that east-west direction roof is inclined so during the day hour we receive sunlight for the illumination.
An appropriate home design places most-used rooms and outdoor activity areas on the south to take advantage of useful heat from winter sunlight during the day.

Location of Solar House**:**
Longer seasonal use of patios and other outdoor activity areas can also be assured by locating these areas on the south and west sides of the home.
The north, east, and west sides of the home should have the minimum amount of glass area necessary for light and ventilation.
Garages, utility rooms, and storage areas should be located to the north, because these rooms are used less frequently than the home's living areas, they do not need continual heating. These rooms can act as buffers against cold winter winds.
Heat can be collected from sunlight by a variety of methods, including large expanses of windows, a solarium, a sun space, or a thermal storage wall on the south side of the house.

Air Tightness**:**
Energy-efficient homes are designed and built to minimize air leakage. Special attention is paid to all potential leaks. Air leakage can occur through the walls, where window and doors are framed; where brick or siding laps the foundation wall; inside the basement, where the sill rests on the foundation; around any penetrations of the outside wall such as water faucets, electrical outlets, and water pipes; and where outside chimney or other masonry joints the house wall. Air leakage can also occur through the attic where insulation is inadequate or not installed properly. These areas must be sealed to reduce infiltration or exfiltration.

Windows:
Windows play a major role in energy efficiency. Non-energy efficient windows can increase costs of heating and conditioning by as much as 10 percent because of conduction and air leakage. Heat can be lost through the glass, the frame, and through the spaces between the frame and the rough opening. Purchasing of windows should be based on the windows infiltration rating, R-value, and U-value. Consider low "E" glazing (low emissivity) of window construction for energy efficiency.
Low "E" glazing is window glass that has had a thin, transparent, heat-reflective coating applied during manufacturing. Low "E" glazing allows light through the glazing but reduces ultraviolet light (Fig).
With low "E" glazing, when the long-wave heat energy inside the home, which stays warmer .An added benefit is the reduction of ultraviolet light transmitted through the windows, which fades interior furnishings, such as carpets, curtains, and furniture.

Doors**:**
Pre-huge, foam core, entry doors generally provide better thermal performance than wooden solid-core doors. These pre-huge doors are usually better insulated, and the weather stripping is made to fit the door properly. The weather stripping provides a good seal and the air infiltration is reduced. Look for weather stripping that has a durable, air seal that makes a continuous and complete seal around the door.

APPLICATION OF SOLAR ENERGY
There must be some perfect and sound solar base devices to carry out daily domestic activities and function in presents as well as absence of the son. The same has been enumerated as below**,**

- Solar water heater,
- Solar cooker,
- Solar dryers,
- Solar heating & cooling systems,
- Solar cell,
- Solar lantern,
- Solar distillation system,
- Solar refrigeration and air conditioning,
- Solar photo voltaic refrigerator,
- Solar photo voltaic panel,
- Storage tanks etc….

Above stated devices should be attached with home then only it can recognized as a complete solar house.

Solar Water Heater**:**
Solar energy to heat water has been in use for many years, and the design requirements of solar water heating equipment has been studied for more than 100 years. Solar water heater were not widely used, not due to lack of under standing, but because the other sources of energy were more economical. Interest in solar water heating in the past was limited to those having the understanding and enthusiasm necessary to build their own equipment.

Highlights**:**
Solar water heaters can provide half or more of the hot water needs in the average home Simple or complex, solar water heater systems save money.

Summary**:**
Solar water heaters can be as simple as a garden hose left in the sun or as complex as multiple glass-plated solar collectors filled with propylene glycol. Simple or complex solar water heaters are an economical option for home and business owners wishing to reduce their water heating costs.

Low Cost Solar Water Heater
Feature
This is a low cost flat plate solar water heater utilizing; natural convection process for the movement of hot water. It has a tube-in-fin absorber coated with blackboard paint and made of GI sheets and tubes. Ordinary windowpane glass has been used for glazing and the storage tank is also made of GI sheets. The plate type heat exchanger used in the storage tank of this SWH is simpler and cheaper than pipe heat exchanger used in the commercial SWH. 20 cm thick composite insulation consisting of glass wool and

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polystyrene foam (thermo Cole) has been used in the covered with aluminum sheets to improve the performance of the solar water heater.

Specifications

Solar collector

- Numbers: Two
- Aperture area (m^2): 1, for each collector
- Type: tube-in-fin absorber
- Material: tube-GI pipe(37 mm)
  Fin – GI sheet (26 gauges)

Storage tank

- Capacity (L): 100
- Material: GI sheet (24 gauges)
- Heat exchanger: plate type

Uses

Water heating for domestic and industrial applications.

Storage Tanks

Whether the design used is direct or indirect, a large storage tank will be required. The most commonly used size is 80 gallons. Similar in shape to a water heater, solar water storage tanks must be highly insulated to preserve the heat gained by the collectors. From the storage tank, the water is usually routed to a standard water heater. Tempering or mixing valves are recommended for residential water heating because solar systems typically heat water to 180 degrees, which can be a safety hazard especially with small children. The tempering valve can be set to 120 degrees and allows cold water to mix with the hot water before it reaches the faucet.

Solar Water Heater

Specifications

Solar collector

- Numbers: one
- Aperture area (m^2): 1.5 for each collector
- Type: tube-in-fin absorber
- Material: tube-copper pipe(15 mm)
  Fin – copper sheet (26 gauges)

Storage tank

- Capacity (L): 100-200
- Material: copper sheet (24 gauges)
- Heat exchanger: plate type

Uses

Water heating for domestic and industrial applications

Solar Basin Still (Solar Distillation System)

Solar basin still consists of a simple blackened box for storing and heating water. The box is provided with a glazed top, which serves the purposes of both insulator and condensing surface. The glazed top is kept at an angle to allow the condensed water to flow to one side and into a small gutter. The bottom of the unit is insulated with glass wool to improve the efficiency. Solar energy is allowed into the collector to heat the water. The water when heated to a certain temperature evaporates and condenses on the underside of the glass. When water evaporates , only the water vapor rises, leaving contaminants behind, thus purifying the water. The gentle slope of the glass directs the condensate to a collection through, which in turn delivers the water to the collection bottle. The still is filled each day with double quantity of impure water as one requires. The still is also fitted with overflow outlets, which allows the excess water to flush the still every day. A major advantage of the basin still is that it does not require a pressurized water supply.

Specifications

Distillation capacity (I/m^2): 2.5-3.0
Capacity of raw water tank (I/m^2): 5-6
Capacity of distilled water (I): 2

Uses

Solar still is an useful device to get fresh/ distillation water which is required in industries, hospitals and dispensaries for sterilization, garages and automobile workshop for radiator and battery maintenance telephone exchanges for battery maintenance, laboratory use for analytic work and marshy and costal area to get fresh potable water.

Built in Storage Type Solar Water Heater**:**

In which all the three function i.e. collector, storage, and control are combined into a single unit. Hot water (unto 60^0c only) from such water heater has to be used during the day; otherwise the heat stored would be lost during the night.

Solar Cooker

Solar cooker are required since firewood used for cooking causes deforestation, commercial fuels are not available, dried cow dung and agriculture wasted used for cooking is a good fertilizer, and human resources used for collecting fuel can be diverted and cookers have been developed, but these are not in use as expected.

Solar Cooker

Several basic types of solar cookers have been developed to date. These cookers are broadly divided into three types:

1. Directed or focusing type
2. Indirect or box type
3. Advanced type

Box Type Solar Cooker

Feature

The important parts of a solar cooker include the outer box with thermal insulation, inner cooking box or tray, the double glass lid, mirror and cooking containers. The outer box is generally made of GI or aluminum sheet or fiber reinforced plastic. The inner cooking box or tray is made from aluminum sheet and coated with black paint to absorb solar radiation and transfer the heat to the cooking pots. The cooking tray is covered with a double glass lid in which the two glass sheets are spaced at about 20 mm to entrap air which acts a insulator and prevent escape of heat from the inside. 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 issue from the cooker. In addition to the above, the cooker is fitted with a mirror to increase the radiation input on the

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absorbing space. This radiation is addition to the radiation entering the box directly and helps to quicken the cooking process by raising the inside temperature of the cooker. The cooking containers (with cover) are generally made of aluminum and painted black on the outer surface so that they also absorb solar radiation directly. A large number of items such as pulses, rice, kheer, khichri, vegetables, meat, and fish etc.can are cooked in the solar cooker. The time taken to cook will depend upon the type of food, time of the day and solar intensity.

Specifications

Overall Dimensions	
Length x breadth x height (mm)	500x500x200
Weight (kg)	12
Time taken in cooking (min)	rice- 45-60, vegetable 60-100
Conversion efficiency (%)	35-40

Uses

It is used for cooking purposes where sunshine is available in plenty.

Double Reflector Box Type Solar Cooker Specifications

Overall Dimensions	
Length x width x height (mm)	600x500x250
Weight (kg)	19
Time taken in cooking (hrs)	2.0-2.5
Cooking capacity	4-5 persons

Uses

It is used to cook foods and for backing purposes especially during winter in the northern latitude of India.

Solar Dryers: Drying or dehydration of material means removal of moisture from the interior of the material to the surface and then to remove this moisture from the surface of the drying material.

SOLAR HEATING AND COOLING SYSTEM

In passive solar heating and cooling of houses, the natural on site energy sources (for heating) used are solar radiation, outside air and internal metabolism while sinks (for cooling) used are sky, space, outside air and wet surfaces.

Space heating**:** In one of the schemes based on functional or generic classification, the passive solar buildings are classified as:

1. direct gain
2. indirect gain
3. isolated

in the second class classification which is more widely used and is based on physical classification these are classified as:

1. direct gain
2. thermal storage wall
3. attached sunspace
4. thermal storage roof and
5. convective loop

Packed bed (Solar Air Preheater)

Specifications

Aperture area (m^2): 1.25 for one collector
Type: Packed bed (air duct packed with iron turnings)
Material of body: GI sheet
Glazing: windowpane glass, 4 mm thick
Insulation: Glass wool, 7.5cm thick at back and 2.5cm on side

Uses

For hot air application e.g. drying of agricultural produce, desiccant seed drying, etc.

Space Cooling

Building is suitably designed can be cooled by natural means without the use of a mechanical or electrical power. The state of the art for passive cooling is much less developed then for passive space hitting and it may not always be possible to use natural means to provide comfortable temperature in the buildings. The natural means which can be used for passive cooling are: shading, ventilation, evaporation, radiation cooling, ground coupling and dehumidification. The passive cooling systems have many advantages such as

1. The system is of low cost, and requires less maintenance as active system.
2. The system is simple and easily repairable and understood,
3. The operation is natural and aesthetically attractive also.

Solar Photovoltaic Refrigerator

Features

A solar photovoltaic refrigerator has developed to keep vaccines, medicines and other perishables. A solar photovoltaic (SPV) panel of 180 watt peak power along with battery pack supplied the powers to the compressor unit. The unit is operated on direct current power supply and hence special compressor unit has been adopted. The unit has an opening on the top the so that cold air does not escape when it is opened for removing/replacing the product.

Specifications

Refrigeration:	top opening
Capacity (I):	100
Compressor:	12/24 V DC
SPV panel capacity (W):	180
Battery pack:	lead acid 130 Ah, 24 V
Charged controller:	24 V, 10 A

Uses

To store vaccines, medicines and other perishables at a low temperature in areas not connected to utility electricity supply.

Solar cell (Photovoltaic cell)

In a Photovoltaic cell or a solar cell, solar radiation is transformed directly into electricity.

The solar cell consists of a disc or surface with two thin layer of differently doped semiconductor material, often silicon, forming a junction in between Metal strips runs

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along the front of the surface and along the back is a metal plate. When solar radiation hits the top of the upper layer, the disc is polarized. The upper layer becomes negatively charged and the lower layer in a closed circuit, an electrical current will flow through the circuit. Thus electrical power is accessible.

The voltage obtained from a single disc is rather low in the range of 0.5V. To obtained higher voltage, several discs are connected in series. To increase the current rows of serially connected solar cells can be connected in parallel. Thus solar cell panels, also called modules, are constructed. The cells are encapsulated in a transparent material (often plastic and low-iron glass) to protect them from the environment (but not to heat insulate them). Several solar cell panels can be combined into a solar cell array.

This is illustrated in figure. Commonly the output voltage from solar cell panels seems to be in the range of 12-24 V. Imaging concentrators have a sharp focus point and thus create an "image" of the solar radiation that hits the larger reflector or lens area onto the smaller solar cell area (fig). Non-imaging concentrators create a more diffuse "image" of the solar radiation.

APPLICATION

- Social Application Solar powered telephones
- Van mounted PV system for defense application
- Isolated house powered by PV system

Consumer Application

- Solar powered fencing
- PV water pump for irrigation
- PV powered refrigeration for vaccine preservation
- A recreational boat solar power system

Solar Lantern

Features

The solar lantern consists of a small photovoltaic panel to capture and convert sunlight into direct current (DC). The DC is used to charge a sealed maintenance free led acid battery using a charge controller. Whenever Light is required the DC is inverted and fed to a compact florescent lamp of 7 or 9 Watt rating.

Specifications

- Spy rating (W): 8
- Dimensions, Panel
  Length (mm): 560
  Width (mm): 260
  Height (mm): 60
- Dimension, Lantern
  Diameter (mm): 240
  Height (mm): 450
- CFL rating (W): 7 and 9
- SMF battery: 12V,7 Ah

III. CONCLUSION

The solar energy is one of the potential sources of energy which is clean, non pollution, inexhaustible and replenishable.

At present the conventional method of illumination using electricity as basic source, can be eliminated by designing efficient solar house.

In the day time various demands can be fulfilled by constructing and designing various components of the house i.e. location of house, size of doors and windows, optical fibers, design of roofs, terrace, design of louvers, it also include the use of optical fibers , glass panel, reflector, E glazing.

This illumination system can be successfully used for illumination of single room as well as whole house/offices in daytime. If we use stand by sources such as solar cell, solar storage devices, solar photo voltaic panel, solar storage tank, the same solar source can be utilized during night time also.

It can be concluded that our system is advantageous in the following way.

1. Solar illumination system is an excellent and efficient system for daytime illumination purpose.
2. It is very economical against the conventional system, which requires large amount of electricity.
3. It has almost negligible maintenance cost.
4. It may prove an ideal system in remote areas where electricity is major problem and also the cost and maintenance.
5. Also the system is long lasting.

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