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Importance of Solar Energy Technologies for Development of Rural Area in India

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ABSTRACT

Solar energy is defined as the sun's radiation that reaches the earth. It is the most readily available source of energy. The sun is the earth's power station and the source of all energy on our planet. Solar energy is the energy force that sustains life on Earth for all plants, animals and people. It provides a compelling solution for all societies to meet their needs for clean, abundant sources of energy in the future. India is densely populated and has high solar insolation, an ideal combination for using solar power in India. Solar energy is widely used in India. This paper presents the solar energy current production in India from different stats and needs of solar energy for rural area development in India. The solar energy could supply all the present and future energy needs of the world. The most explored renewable energy technologies for power generation in India, namely, Solar pond, and Solar Photovoltaic systems need more sophistication for long-term benefits. This paper also summarizes the direct solar usage systems like Water heating system, Solar Drying, Solar Cooking and Solar Distillation. Solar energy can be tapped directly (e.g. PV); indirectly as with wind, biomass and hydropower; or as fossil Biomass fuels such as Coal and Natural Gas.

Keywords: Solar Energy, Solar PV, Solar Drying, Solar Cooking and Solar Pond

I. INTRODUCTION

The fossil fuels presently meet the all global energy needs to some extent. These Fossil Fuels should be slowly replaced by renewable energy sources in the view of their depletion rates and emission legislation. The usage of renewable energy sources can reduce the pollutant emissions into the atmosphere. Especially the exploration of solar energy can play vital role in developed and developing countries [1]. Solar energy is defined as the sun's radiation that reaches the earth. It is the most readily available source of energy.

The sun is the earth's power station and the source of all energy on our planet. The ways capturing of the solar energy for many applications have become an important research area in recent days. In developing countries like India where the energy problems is very serious, in spite of discoveries of oil and gas off the west coast, the important of crude oil continuous to increase and the price paid for all other expenditure. India being leader in wind power generation in the sector of solar energy few more developments is needed. One of them are 35000 km^2 area of Thar Desert has been set aside for solar power projects, sufficient to generate 700 GW to 21000 GW [2].

Solar energy is widely utilized in the form of Solar Lamps, Solar Water heater, Solar Cooker and also solar pumps and solar energy is used for heat buildings and to provide low temperature heat for Industry and Agriculture is a well-known technology [3-4]. India has large area in the form of a deserts, lakes and rivers for installation of solar plants. The amount of solar energy produced in India 2007 was less than 1% of total energy demand. The grid interactive solar powers as of December 2010 were 10 MW.

Solar energy is widely used in India. Solar energy is a exhaustible source of renewable energy. It is used in the form of solar water pumps, solar lamps, solar water heaters and cooking purpose [5]. Solar energy can be tapped directly (e.g., PV); indirectly as with wind, biomass, and hydropower; or as fossil biomass fuels such as coal, natural gas, and oil. Sunlight is by far the largest carbon-free energy source on the planet. More energy from sunlight strikes the Earth in 1 hour (4.3 × 1020 J) than all the energy consumed on the planet in a year (4.1 × 1020 J).

Although the Earth receives about 10 times as much energy from sunlight each year as that contained in all the known reserves of coal, oil, natural gas, and uranium combined, renewable energy has been given a dismally low priority by most political and business leaders.Even now a days, unelectrified villages are in India. These villages developed by using solar energy. With about 300 clear sunny days in a year, India's theoretical solar power reception, on only its land area. The daily average solar enegy incident over India varies 4 to 7 kWh/m^2, which is more than current total energy consumption.

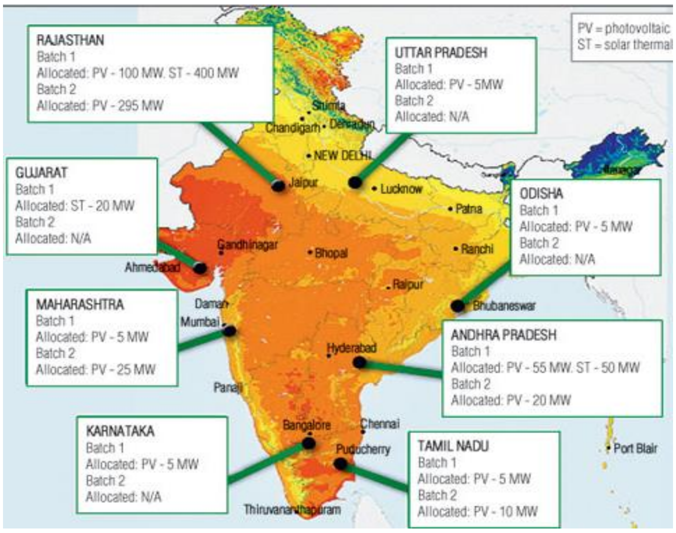

Figure 1: Figure shows the Solar Energy production in different states in India.

However, India is ranked number one in terms of solar energy production per watt installed. The state has commissioned Asia's biggest solar park at Chakra Village. The park is has generating capacity of 214 MW out of planned capacity of 500 MW. The state has also proposal for generation of power using solar panels on the Narmada canal branches. Rajasthan the India's sunniest state is next of Gujarat with proposals for many solar projects.

The need for power grows much faster for less developed nations than for those that already there is growing momentum for supplying electricity to developing regions using solar energy resource [6]. The solar energy technologies offer energy independence and sustainable development. Stand-alone solar and wind energy systems can provide cost effective, modest levels of power of lighting, communication, fans, refrigerators, water pumping etc. Installation of Photo Voltaic (PV) systems solely for remote site has expanded to include the promotion of rural economic development. PV system provides power for remote water pumping, refrigeration and water treatment of community water supplies.

In addition to PV systems the domestic solar hot water heating systems typically have better cost paybacks (5 to 7 years) than PV systems. The large-scale concentrating solar power (CSP) plants have better economics of scale than PV for utility power generation at almost half the kilo Watt-hour cost [7]. Solar energy often provides least-cost options for economic and community development in rural regions around the globe, while supplying electricity, creating local jobs. PV projects in developing nations have provided positive change in the lives of the rural people. The following sections will provide the major developments of many solar energy applications.

2. Solar Power plants installed in India

India is large country compared to all countries. India have a deserts, lakes and rivers for installation of solar plants and also having a lacks of acres of land available for installation of solar plants [8]. The amount of solar energy produced in India in 2007 was less than 1% of the the toal energy demand. The grid-interactive solar power as of December 2010 was 10MW.However,India is ranked number one in terms of solar energy production per watt installed. In India having a number of solar parks are installed in different states.

Table 1: The installed capacities of solar power plants across the states of India.

State	MWp	**State**	MWp
Andhra	21.8	Karnataka	9.0
Chhattisgarh	4.0	Maharashtra	20.0
Delhi	2.5	Orissa	13.0

Gujarat	654.8	Punjab	9.0
Haryana	7.8	Rajasthan	197.5
Jharkhand	4.0	Tamil Nadu	15.0

From the Table 1, conclude that Gujarat state has been producing high solar energy compared to all another states. This state is producing amount of 654.8 MWp. The state has commissioned Asia's biggest solar park at Charaka Village. The park is already generating 214MW solar power out of its planned capacity of 500MW.The states planes to generate solar power by putting solar panels on the Narmada canal branches. Next to Gujarat, Rajasthan is India's sunniest state, and many solar projects have been proposed.

3.Solar Energy for Development in India

The need for power grows much faster for less developed nations than for those that already industrialized. The three decades of major investments by less developed nations and multilaterals on electrification projects, nearly 2 billion people in developing regions around the globe still lack electricity [9,10]. Millions of people rely solely on kerosene lamps for lighting and disposable batteries for radios. For most of these people, there is little likelihood of ever receiving electricity from conventional grid sources. However, there is growing momentum is supplying electricity to developing regions using solar energy resource. The solar energy technologies offer energy independence and sustainable development by using renewable energy resources.

The cost of bringing utility power via transmission and distribution lines to non electrified villages is great [11]. This is largely due to small household electrical loads and the fact that many villages are located at great distances over difficult terrain from the existing grid. Stand-alone solar and wind energy systems can provide cost-effective, modest levels of power for lighting, communication, fans, refrigerators, water pumping, etc. Using a least-cost model, development tool for electrification planning as either centralized or distributed solutions. Two decades ago, PV technology was relatively unknown. Gradually throughout the developing world, small solar companies began to form as PV module manufacturers began to establish distributor networks to serve remote, non-electrified areas.

More total kilowatts of grid-tie PV systems are installed each year; however, numerically more small, off-gird systems are installed annually. Installation of PV systems solely for remote sites has expanded to include the promotion of rural economic development through Photovoltaic system. PV provides power for remote water pumping, refrigeration, and water treatment of community water supplies [12-13]. Solar thermal energy represents the most competitive but often overlooked solar technology option. Domestic solar hot water heating systems typically have cost paybacks from 5 to 7 years much better than grid-tied PV systems, where payback may take decades, if ever. Additionally, large-scale solar thermal concentrating solar power (CSP) plants have better economies of scale than PV for utility power generation at almost half the kilowatt-hour cost.

Figure 2: Remote areas PV power production.

Solar energy often provide least-cost options for economic and community development in rural regions around the globe, while supplying electricity, creating local jobs, and promoting economic development with clean energy resources. PV projects in developing nations have provided positive change in the lives of the rural people. Yet there is still much to do to educate, institutionalize, and integrate renewable technologies for maximum benefit for all. One of the greatest challenges is to work on reforming energy policies and legal frameworks to create a context that permits the sustainable development of renewable energy technologies [14].

4. Renewable Energy Solutions for day to day life

Approximately one-third of the world’s population lives in rural regions without access to the electric grid, and about half of these same people live without access to safe and clean water. Solar energy is unique in that it can easily provide electricity and purified water for these people today with minimal infrastructure requirements by using local energy resources that promote local economic development.

Unfortunately, traditional fossil fuel energy use has had serious and growing negative environmental impacts, such as CO_2 emissions, global warming, air pollution, deforestation, and overall global environmental degradation. Additionally, fossil fuel reserves are not infinite or renewable; the supply is limited [15]. Without a doubt, there will be significant changes in our society's modern energy infrastructure by the end of the twenty-first century.

The primary renewable energy sources are the Sun, wind, biomass, tides, waves, and the Earth's heat (geothermal). Solar energy is referred to as renewable and/or sustainable energy because it will be available as long as the Sun continues to shine. Estimates for the life of the main stage of the Sun are another 4 to 5 billion years. Another aspect of solar energy is the conversion of sunlight into biomass by photosynthesis. Animal products such as whale oil and biogas from manure are derived from this form of solar energy. Fossil fuels are stored solar energy from past geological ages (i.e., ancient sunlight).

Even though the quantities of oil, natural gas, and coal are large, they are finite and resources are sufficient to power the industrialized world anywhere from a few more decades to a few more centuries, depending on the resource [16]. There are also large environmental costs associated with fossil fuel exploitation from habitat loss and destruction due to strip mining and oil spills to global warming of the atmosphere largely caused by the combustion by-product of carbon dioxide.

The advantages of renewable energy are many: sustainability (cannot be depleted), ubiquity (found everywhere across the world in contrast to fossil fuels and minerals), and essentially non-polluting and carbon free. Energy solutions for the future depend on local, national, and world policies. Solutions also depend on individual choices and the policies that we implement as a society [12,14]. This does not mean that we have to live in caves to negate our energy inputs, but we do have to make wise energy choices and conserve by methods such as driving fuel-efficient vehicles and insulating our homes, to name a few. To overcome the twenty-first century perfect energy storm, we will all have to work together cooperatively while doing our individual parts.

5. Solar Thermal Power

Solar thermal energy is the technology used for harnessing solar energy for thermal energy (heat). A solar thermal collector captures the radiant energy from the Sun and converts it into heat. More recently, in a wide variety of thermal processes solar energy has been developed for power generation, water heating, mechanical crop drying, and water purification, among others [17]. A major benefit of solar thermal power is that it has little adverse environmental impact, with none of the polluting emissions or safety concerns associated with conventional generation technologies. There is hardly any pollution in the form of exhaust fumes or noise during operation. Decommissioning a system is not problematic.. Solar collectors are a cheap and effective means of converting sunlight into thermal heat. This module discusses these two types of solar thermal collectors since they are commonly used in India.

Heat is simply a form of energy associated with the motion of molecules. When the electromagnetic waves coming from the Sun hit an object, they excite the molecules of that object causing them to move [18]. This molecular movement is heat. Heat is always moving from higher to lower temperatures until the temperatures are equal. This is known as heat transfer. If you place two objects next to each other, the warmer object will cool down as its heat is transferred to the cooler object. The cooler object in turn will warm up. This heat transfer is driven by the difference in temperatures of the objects. The heat transfer rate is proportional to the difference in temperature. The larger the difference in temperature between the objects, the faster the heat moves.

5.1 Solar Collectors

Solar collectors are distinguished as low, medium, or high-temperature heat exchangers. There are basically three types of thermal solar collectors: flat plate, evacuated tube, and concentrating [19]. Although there are great geometric differences, their purpose remains the same: to convert the solar radiation into heat to satisfy some energy needs. The heat produced by solar collectors can supply energy demand directly or be stored. To match demand and production of energy, the thermal performance of the collector must be evaluated. The instantaneous useful energy collected the result of an energy balance on the solar collector.

To evaluate the amount of energy produced in a solar collector properly, it is necessary to consider the physical properties of the materials. Solar radiation, mostly short wavelength, passes through a translucent cover and strikes the energy receiver. Low-iron glass is commonly used as a glazing cover due to its high transmissivity; the cover also greatly reduces heat losses. The optical characteristics of the energy receiver must be as similar as possible to those of a blackbody, especially high absorbtivity.

5.2 Working principle of a solar collector

A solar collector works on the principle of converting solar energy into heat by taking advantage of a process known as the greenhouse effect. The basic idea is that the solar energy passes through a layer of glazed glass where it is absorbed by the underlying material [20]. The solar energy excites the molecules in the underlying material resulting in heat. The glazing of the glass prevents the heat from escaping, thereby effectively capturing the heat. Once that heat is captured we can put it to good use. But in order to use it, we first need to understand some of the basic principles of heat.

Types of Solar Collectors

5.2.1 Flat-Plate Collectors

A flat-plate solar collector consists of a waterproof, metal or fiberglass insulated box containing a dark-colored absorber plate, the energy receiver, with one or more translucent glazings. Absorber plates are typically made out of metal due to its high thermal conductivity and painted with special selective surface coatings in order to absorb and transfer heat better than regular black paint can. The glazing covers reduce the convection and radiation heat losses to the environment.. These systems are always mounted in a fixed position optimizing the energy gain for the specific application and particular location. Flat collectors can be mounted on a roof, in the roof itself, or be freestanding.

5.2.2 Evacuated -Tube Solar Collectors

Evacuated-tube solar collectors have better performance than flat plate for high-temperature operation in the range of 77–170°C. They are well suited to commercial and industrial heating applications and also for cooling applications by regenerating refrigeration cycles [21-23]. They can also be an effective alternative to flat-plate collectors for domestic space heating, especially in regions where it is often cloudy. An evacuated-tube solar collector consists of rows of parallel glass tubes connected to a header pipe. The air within each tube is removed reaching vacuum pressures around 10^{-3} mbar. This creates high insulation conditions to eliminate heat loss through convection and radiation, for which higher temperatures than those for flat-plate collectors can be attained. Depending on the mechanism for extracting heat from the absorber, evacuated-tube solar collectors are classified.

5.2.3 Concentrating Collectors

There are two ways of classifying solar thermal collectors according to their concentration ratio (C). In the most general terms, solar collectors are classified as flat-plate collectors with a concentration ratio C = 1 and as concentrating collectors with C > 1. The existing types of concentrating collectors are parabolic-compound, parabolic-trough, parabolic-dish, Fresnel, and central tower concentrators, among others [24]. Two definitions of concentration ratio for these systems are used. In the first, the concentration ratio depends on geometric characteristics, and it is given by

$$C = \frac{A_a}{A_r}$$

Where, A_a is the area of the collector aperture, and A_r is the energy absorber or receiver area.

5.3 Parabolic Concentrators

The parabola is found in numerous situations in the physical world. In three dimensions, a parabola traces out a shape known as a paraboloid of revolution when it is rotated about its axis and as a parabolic cylinder, when it moves along the axis normal to its plane. Solar collectors whose reflecting surfaces follow such geometrics are called parabolic dish concentrators and parabolic troughs, respectively. If a receiver is mounted at the focus of a parabolic reflector, the reflected light will be absorbed and converted into a useful form of energy. The reflection to a point or a line and subsequent absorption by a receiver constitute the basic functions of a parabolic concentrating collector.

5.4 Applications of Solar Thermal energy in developing Countries

5.4.1 Water heating

The most common use for solar thermal technology is for domestic water heating. Hundreds of thousands of domestic hot water systems are in use throughout the world. The main components of a solar water heater are the solar collector, storage, and heat distribution. Several configurations differ on the heat transport between the solar collector and the storage tank, as well as on the type of freeze protection [25]. The most successful solar heaters are the integrated collector and storage (ICS), thermosiphon, drain-back, and drain-down systems . These are habitually assisted in backup by a conventional system. In some countries, the installation of solar equipment must comply with local, state, and national building codes, roofing codes, plumbing codes, and national electrical codes.

The ICS and thermosiphon are passive solar water heaters where fluid circulation occurs by natural convection, as shown in the diagram of Figure 3. The absorber's energy gained by solar radiation is transferred to the copper pipes. The inlet fluid is located at the bottom of the collector; as heat is captured, the water inside the pipes warms up. The hotter the water is, the less dense and better it is for circulation. When hot water travels toward the top, the cooler and denser water within the storage tank falls to replace the water in the collector. Under no or low insolation, circulation stops; the warm and less dense fluid stagnates within the tank. The ICS is a self-contained integration of a solar collector and solar heated water storage, usually holding 30–40 gallons in a tank. Both the ICS and the thermosphon heaters are a low-cost alternative to an active-open-loop solar water system for milder climates. These systems have 40- to 120-gal storage tanks installed vertically or horizontally above the collector.

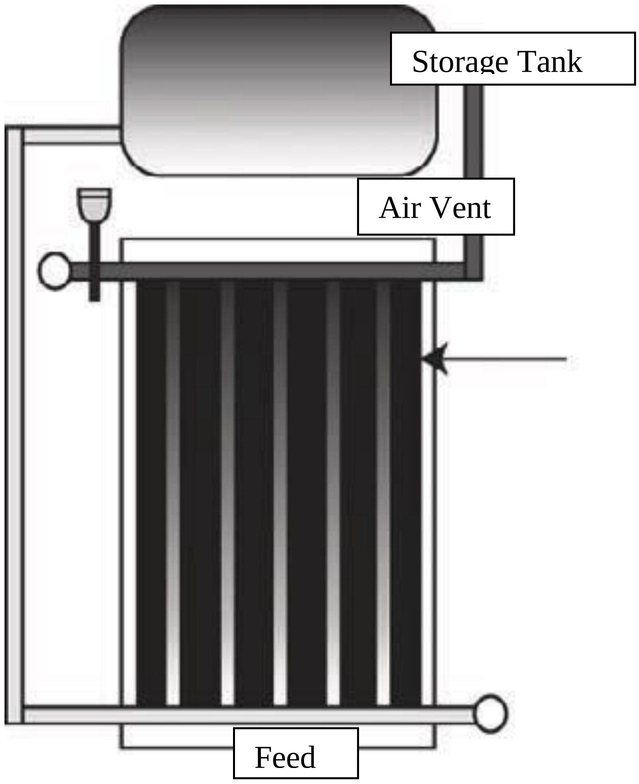

Figure 3: Thermosiphon water heater.

5.4.2 Solar cooking

Over 80% of rural households use biofuels and animal dung for cooking. A vast majority of such homes burn firewood in traditional cook stoves (chulhas). This emits smoke and also has adverse environmental and health effects. Additionally, the process of collecting firewood is often an exhausting and time-consuming task [26]. While small-scale solar cooking will benefit individual families in terms of health, large-scale solar cooking has the potential to save considerable fossil fuel. Solar cooking has several advantages since it requires very little maintenance, and saves cooking time and fuel cost.

The focus of this case study is on large-scale solar cooking applications with the solar steam cooker. There are many large installations of solar cookers in India where several thousand meals are prepared daily [27]. Solar cookers fall into two main categories – solar box and direct solar concentrators. The basic design for a solar box is that of a box with a glass cover. The box is lined with insulation and a reflective surface is applied to concentrate the heat onto the pots. The other approach is to reflect the sun's rays onto a pot, often with a parabolic dish. The pots can be painted black to help with heat absorption. The main advantage to solar cookers is that wood does not need to be purchased or collected, which is often a very time consuming activity for women. Many variations of solar cooker have been developed from the very basic reflective cardboard sheet box to the very sophisticated large-scale institutional and commercial solar cookers now being used in India.

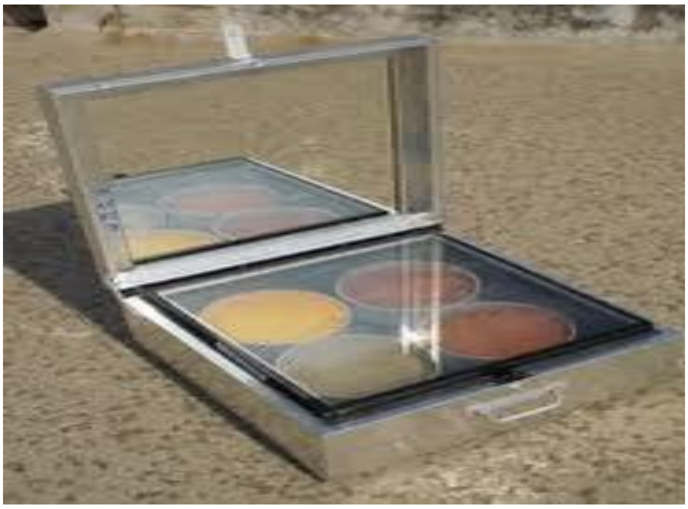

Figure 4: Schematic view of Box type solar cooker.

5.4.3 Solar drying

Annually in India, about 35% of all agricultural produce worth roughly `500,000 million goes to waste during the post-harvest period [28]. The loss is anywhere from 10% for durables (cereals and pulses) to about 40% for perishables (fruits and vegetables). Proper drying techniques for grains, cereals and pulses can ensure effective storage and reduce losses. Controlled drying is required for various crops and products, such as grain, coffee, tobacco, fruits vegetables and fish. Solar thermal technology can be used for this purpose.

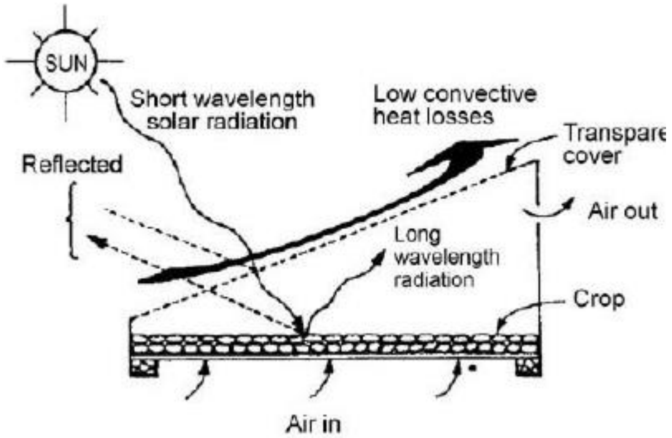

Figure 5: Figure shows working of Solar Dryer.

The main principle of operation is to raise the heat of the product, which is usually held within a compartment or box, while at the same time passing air through the compartment to remove moisture. The flow of air is often promoted using the 'stack' effect which takes advantage of the fact that hot air rises and can therefore be drawn upwards through a chimney, while drawing in cooler air from below [29]. Alternatively a fan can be used. Solar crop drying technologies can help reduce environmental degradation caused by the use of fuel wood or fossil fuels for crop drying and can also help to reduce the costs associated with these fuels and hence the cost of the product.

5.4.4 Solar thermal energy in architecture

Providing comfortable buildings, while reducing the use of conventional fuels and electricity, can be obtained through solar passive architecture. Solar Passive Architecture involves blending architectural principles and solar energy to design interiors which remain warm in winter and cool in summer, thus providing year-round comfortable indoor environment. Solar designs can save up to 90% of the energy required to cool or heat a building [30]. The benefit of solar energy is utilized through designing energy efficient buildings. Here specific attention is directed to the site and location of the dwelling, the prevailing climate, design and construction, solar orientation, placement of glazing-and-shading elements, and incorporation of thermal mass. As mentioned earlier we shall discuss two applications of solar energy which are solar cooker and solar water heater [31].

5.4.5 Solar Distillation

Distillation is a process that allows purifying some components of a solution based on differences of volatilities. In general terms, when solutes have much smaller volatilities than the solvent, distillation is carried out by evaporating the solvent in a particular region of the device and then condensing the vapor in a different region to obtain as pure a solvent as possible. When conventional energy supply is replaced by solar radiation, the process is called solar distillation [32-34]. For the conventional process, the production rate remains constant under stable conditions of pressure, temperature, energy consumption, composition, and flow rate of the inlet stream. For the solar process, although predictable, it varies during the course of a day, showing a maximum during the hours with the highest irradiance. The variation is not only hourly but also daily over the whole year.

The most widely used application for solar water distillation has been for water purification. The advantage of solar over conventional systems in the purification of simple substances, such as brine or well waters, is that operation and maintenance are minimal because no moving parts are involved [66-67]. Also, there is no consumption of fossil fuels in solar distillation, leading to zero greenhouse- gas emissions. Most importantly, these types of systems can be installed in remote sites to satisfy freshwater needs of small communities that do not have conventional electric service.

Solar distillation represents one of the simplest yet most effective solar thermal technologies. Currently, several solar still prototypes exist; differences lie in their geometries and construction materials. All designs are distinguished by the same operation principles and three particular elements: solar collector, evaporator, and condenser [35,36].

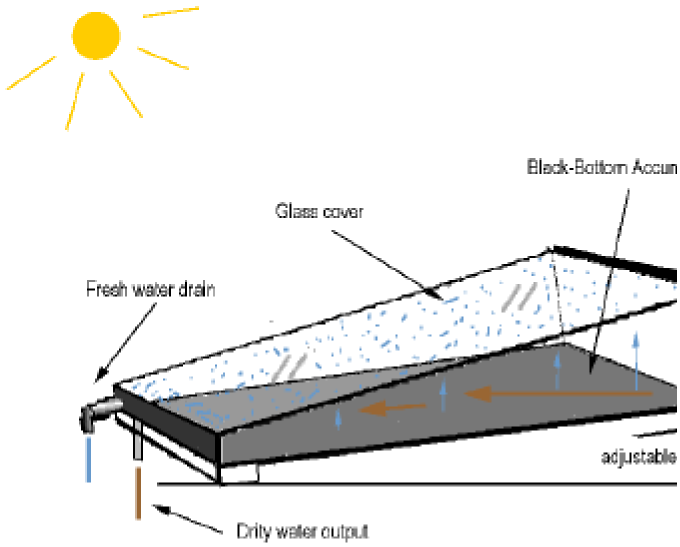

Figure 6: Schematic view of solar still for Solar Distillation.

6. Solar Photovoltaics

Photovoltaic systems (PV system) use solar panels to convert sunlight into electricity. Photovoltaics provide practical solutions to many power supply problems in both space and remote terrestrial applications. In addition to larger power applications, portable electronic devices may charge their batteries using solar cells or get their power directly from solar cells.

Electricity can be produced from sunlight through a process called the PV effect, where "photo" refers to light and "voltaic" to voltage [38-41]. The term describes a process that produces direct electrical current from the radiant energy of the Sun. The PV effect can take place in solid, liquid, or gaseous material; however, it is in solids, especially semiconductor materials, that acceptable conversion efficiencies have been found. Solar cells are made from a variety of semiconductor materials and coated with special additives. The most widely used material for the various types of fabrication is crystalline silicon, representing over 90% of global commercial PV module production in its various forms.

A typical silicon cell, with a diameter of 4 in., can produce more than 1 W of direct current (DC) electrical power in full sun. Individual solar cells can be connected in series and parallel to obtain desired voltages and currents. These groups of cells are packaged into standard modules that protect the cells from the environment while providing useful voltages and currents.

PV modules are extremely reliable because they are solid state and have no moving parts. Silicon PV cells manufactured today can provide over 40 years of useful service life. A system is made up of one or more solar photovoltaic (PV) panels, a DC/AC power converter (also known as an inverter), a tracking system that holds the solar panels, electrical interconnections, and mounting for other components [42]. Optionally it may include a maximum power point tracker (MPPT), battery system and charger, solar tracker, energy management software, solar concentrators or other equipment.

6.2 Applications

PV systems can be used for a wide variety of applications, from small stand-alone systems to large utility grid-tied installations of a few Mega Watts. Due to its modular and small-scale nature, PV is ideal for decentralized applications. At the start of the twenty-first century, over one-quarter of the world's population did not have access to electricity, and this is where PV can have its greatest impact.

PV power is already beginning to help fill this gap in remote regions, with literally millions of small residential PV systems installed on homes around the world, most commonly as small stand-alone PV systems, but also increasingly as larger on-grid systems in some industrialized regions (notably Japan, Germany, and California). Ironically, the wealthy, who want to demonstrate that they are “green,” or often impoverished remote power users, who need electricity and have limited options, form the majority of PV users.

6.2.1 Standalone systems

A standalone system does not have a connection to the electricity "mains" (aka "grid"). Standalone systems vary widely in size and application from wristwatches or calculators to remote buildings or spacecraft [43]. If the load is to be supplied independently of solar insolation, the generated power is stored and buffered with a battery. In non-portable applications where weight is not an issue, such as in buildings, lead acid batteries are most commonly used for their low cost and tolerance for abuse.

A charge controller may be incorporated in the system to: a) avoid battery damage by excessive charging or discharging and, b) optimizing the production of the cells or modules by maximum power point tracking (MPPT). However, in simple PV systems where the PV module voltage is matched to the battery voltage, the use of MPPT electronics is generally considered unnecessary, since the battery voltage is stable enough to provide near-maximum power collection from the PV module [44]. In small devices (e.g. calculators, parking meters) only direct current (DC) is consumed. In larger systems (e.g. buildings, remote water pumps) AC is usually required. To convert the DC from the modules or batteries into AC, an inverter is used. Solar photovoltaic

6.2.2 Rural Electrification

Simple effective solutions, including solar lanterns and SHLS are discussed, along with solar-based micro grids. Prevailing financial, policy and institutional mechanisms and barriers to wide-scale adoption are also taken up. The techno economics of a solar-based micro grid is compared with grid extension [45, 46]. The current capital subsidy is compared with a generation-based tariff structure. Based on the analysis, a generation-based tariff is recommended for rural micro grids solely consisting of solar energy or hybridized with other renewable energy sources in order to ensure sustainable operation.

6.2.3 Solar-PV-based irrigation pump sets

These pumps are found to be competitive at today’s cost relative to diesel-based pumps based on cost per unit of electricity or work done [47]. Economic analysis is provided for pumps of two sizes – 1 HP and 2 HP – needed to draw water from up to 230 ft (70.1 m) and up to 530 ft (161.5 m) respectively.

1) 6.2.4 Small scale DIY solar systems

With a growing DIY-community and an increasing interest in environmentally friendly "green energy", some hobbyists have endeavored to build their own PV solar systems from kits or partly diy. Usually, the DIY-community uses inexpensive or high efficiency systems(such as those with solar tracking) to generate their own power [48]. As a result, the DIY-systems often end up cheaper than their commercial counterparts. Often, the system is also hooked up into the regular power grid, using net metering instead of a battery for backup.

These systems usually generate power amount of ~2 kW or less. Through the internet, the community is now able to obtain plans to construct the system (at least partly DIY) and there is a growing trend toward building them for domestic requirements. Small scale solar systems are now also being used both in developed countries and in developing countries, for residences and small businesses [49-51]. One of the most cost effective solar applications is a solar powered pump, as it is far cheaper to purchase a solar panel than it is to run power lines.

6.3 PV System Safety

Finally, when working with PV systems, please be careful. Never work on a PV system alone [52]. Have proper knowledge of the PV system. Be careful accessing roofs and ladders. Be careful with batteries and be sure to have bicarbonate, etc., to neutralize battery acid. Dress appropriately. Have an alert mind, a skeptic instinct, and a slow hand. The goal is to avoid accidents and injuries. This requires the following:

- good work habits;
- awareness of potential hazards;
- proper tools and hardware;
- safe PV systems; and
- working in pairs (buddy system).

6.4 PV System Testing Rules

- Remove all jewelry.
- Visually inspect the system and take notes of risks and problems.
- Be aware of telephone and first-aid equipment locations.
- Be careful climbing up and down ladders and roofs.
- Identify and locate disconnects.
- Measure the open-circuit voltage.
- Measure the voltage of each conductor.

7. The Solar Pond

Solar pond is an artificially constructed pond in which significant temperature rises are caused to occur in the lower regions by preventing convection. To prevent convection, salt water is used in the pond [22,12]. Those ponds are called “salt gradient solar pond”. In the last 15 years, many salt gradient solar ponds varying in size from a few hundred to a few thousand square meters of surface area have been built in a number of countries. Nowadays, mini solar ponds are also being constructed for various thermal applications.

A Salinity Gradient Solar Pond (SGSP) is a simple and low cost mean to collect and store solar energy in the high-density salt water. Therefore, in practice, a typical solar pond consists of three distinct zones. Two convective zones where the first is at the top (Upper Convective Zone, UCZ) and the second is at the bottom (Lower Convective Zone, LCZ). These two layers are separated by a salinity gradient (Non Convective Zone, NCZ). Although the diffusion flux tends to homogenize the system, the maintenance of the salinity profile in the solar pond can be obtained by addition of brine at the LCZ and fresh water in the UCZ.

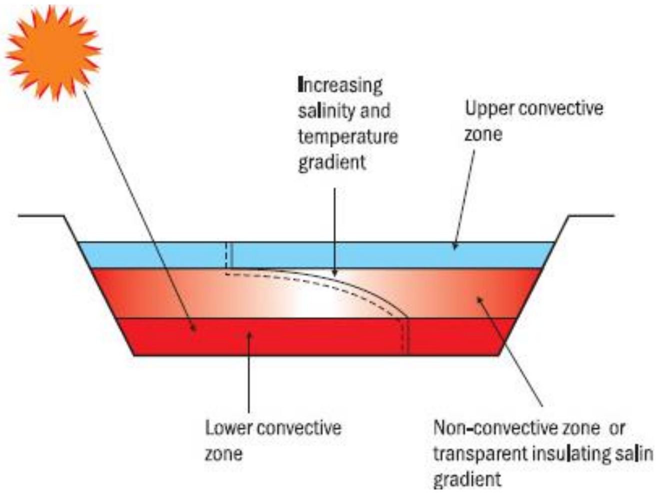

Figure 7: Diagram Shows the Operation of Solar Pond.

The solar pond (SP) is a shallow water body being virtually a trap for solar radiation. The trapped solar radiation is converted into thermal energy which is accumulated in the deep water layers of the SP. The thermal energy can be accumulated due to the stabilizing salinity gradients existing in the SP, which prevent thermal convection in the water body. Proper operation of the SP depends on the ability to withdraw hot water by a selective withdrawal while preserving the density profile of the pond.

7.1 Management of Solar Pond

7.1.1 Typical Construction

Size of Salinity Gradient Solar Pond ranges from hundreds to thousands square meters in surface area [53]. These are 1-5 m deep. Typically these are lined with a layer of sand insulation and then a dark plastic or rubber impermeable liner material.

7.1.2 Salt used

Sodium chloride is used normally, Manesium chloride, sodium nitrate, Sodium carbonate, Sodium sulfate, Ammonium nitrate, fertilizer salts such as urea satisfy the stability criterion and thus considered suitable for a solar pond.

7.1.3 Site selection

Since solar ponds are horizontal collectors, sites should be at low to moderate northern latitudes, that is latitudes between -40 to +40 degree.

7.2 Applications of Solar Pond

The following applications are:

- Salt Production
- Aqua Culture
- Dairy Industry
- Fruit and Vegetable canning industry
- Grain industry
- Power generation
- Hot water production
- Water supply (for Desalination).

8. Solar Energy Storage

Solar energy is a nondispatchable energy technology that only captures energy during daylight hours. Some type of energy storage is thus required to make the energy available during nonsunny periods [54-56]. Energy storage can take a number of forms, most commonly electrochemical energy storage through batteries. But energy also can be stored in the form of compressed air, Pumped hydrostorage, hydrogen, or thermal mass. Many types of batteries and charge controllers are used in standalone Photo Voltaic systems to provide energy, when sun is not shining.

A storage battery is an electrochemical device. It stores chemical energy that can be released as electrical energy. When the battery is connected to an external load, the chemical energy is converted into electrical energy and current flows through the circuit (Harrington 1992, Lasiner and Ganang 1990).

8.1 Lead-Acid Battery operation

When two unlike metals such as the positive and the negative plates are immersed in Sulfuric acid (the electrolyte), the battery is created and a voltage is dependent on the types of metals and the electrolyte used [57]. It is approximately 2.1 V per cell in a typical lead-acid battery. Electrical energy is produced by the chemical action between the metals and the electrolyte.

The chemical actions start and electrical energy flows from the battery as soon a there is a circuit between the positive and negative terminals (whenever a load such as the head lamps is connected to the battery). The electrical current flows as electrons through the outside circuit and as charged portions of acid (ions) between the plates inside the battery (Lasnier and Ganang 1990 & Vinal 1951).

The action of the lead-acid storage battery is characterized by the following equation:

$$PbO_2 + Pb + 2H_2SO_4 * 2PbSO_4 + 2H_2O$$

Where;

Lead dioxide (PbO2) = Material on the positive plate

Sponge lead (Pb) = Material on the negative plate

Dilute Sulphuric acid =Electrolyte

9. Thermal Vs Photovoltaic

It is important to understand that solar thermal technology is not the same as solar panel, or photovoltaic, technology. Solar thermal electric energy generation concentrates the light from the sun to create heat, and that heat is used to run a heat engine, which turns a generator to make electricity [58-62]. The working fluid that is heated by the concentrated sunlight can be a liquid or a gas. Different working fluids include water, oil, salts, air, nitrogen, helium, etc. Different engine types include steam engines, gas turbines, Stirling engines, etc.

All of these engines can be quite efficient, often between 30% and 40%, and are capable of producing 10’s to 100’s of megawatts of power. Photovoltaic, or PV energy conversion, on the other hand, directly converts the sun’s light into electricity [28-32]. This means that solar panels are only effective during daylight hours because storing electricity is not a particularly efficient process [63-65]. Heat storage is a far easier and efficient method, which is what makes solar thermal so attractive for large-scale energy production. Heat can be stored during the day and then converted into electricity at night. Solar thermal plants that have storage capacities can drastically improve both the economics and the dispatchability of solar electricity.

10. Challenges and Oppotunuties

Land is a scarce resource in India and per capita land availability is low. Dedication of land area for exclusive installation of solar arrays might have to compete with other necessities that require land. The amount of land required for utility-scale solar power plants currently approximately 1 km^2 for every 20–60 megawatts (MW) generated could pose a strain on India's available land resource. The architecture more suitable for most of India would be a highly distributed set of individual rooftop power generation systems, all connected via a local grid.

However, erecting such an infrastructure, which does not enjoy the economies of scale possible in mass, utility-scale, solar panel deployment, needs the market price of solar technology deployment to substantially decline, so that it attracts the individual and average family size household consumer. That might be possible in the future, because PV is projected to continue its current cost reductions for the next decades and be able to compete with fossil fuel.

India should adopt a policy of developing solar power as a dominant component of the renewable energy mix, since being a densely populated region in the sunny tropical belt, the subcontinent has the ideal combination of both high solar insolation and therefore a big potential consumer base density. In one of the analyzed scenarios, India can make renewable resources such as solar the backbone of its economy by 2050, reining in its long-term carbon emissions without compromising its economic growth potential.

According to a 2011 report by BRIDGE TO INDIA and GTM Research, India is facing a perfect storm of factors that will drive solar photovoltaic (PV) adoption at a "furious pace over the next five years and beyond". India, "as a growing economy with a surging middle class, is now facing a severe electricity deficit that often runs between 10 and 13 percent of daily need".

II. CONCLUSION

The fossil fuels presently meet the all global energy needs to some extent. These Fossil Fuels need replacement by renewable energy sources in the view of their depletion rates and emission legislation. The usage of renewable energy sources can cut the pollutant emissions into the atmosphere. The sun is about 1.4 million km in diameter and 150 million km from the earth. It is close to 5500°C at its surface and emits radiation at a rate of 3.8 × 1023kW. This power is due to nuclear fusion reactions near its core going to continue for several billion years. Exploration of solar energy plays a vital role in developed and developing countries like India where the energy problem is very serious, despite of discoveries of oil and gas off the west coast. Importance of crude oil continuous to increase and the price paid for all other expenditure. India being a master in wind power generation and the sector of solar energy needs more development.

The state Gujarat has better contribution in developing solar energy. The state has commissioned Asia's biggest solar park at Charaka Village. The park is has generating capacity of 214 MW out of a planned capacity of 500MW.The state has also proposal for generation of power using solar panels on the Narmada canal branches. Rajasthan the India's sunniest state is next to Gujarat with proposals for many solar projects.

Installation of Photo Voltaic (PV) systems solely for remote sites has expanded to include rural economic development. PV system provides power for remote water pumping, refrigeration and water treatment of community water supplies. In addition to PV systems the domestic solar hot water heating systems typically have better cost paybacks (5 to 7 years) than PV systems.

A major benefit of solar thermal power is that it has little adversative environmental impact, with none of the polluting emissions or safety concerns associated with conventional generation technologies.

III. REFERENCES

[1]. A.Giostri, M.Binotti, P.Silva, E.Machhi and G.Manzolini, 2013, “Comparison of Two Linear Collectors in Solar Thermal Plants: Parabolic Trough Versus Fresnel” ASME J Sol. Energy Eng., 135, p.0110011.

[2]. A.Renuka Prasad and D.Jagadish., “Developments in Solar Pond Technology: A Literature Review”, 2013, Proceedings of National Conference on Frontiers in Mechanical Engineering (FIME-2013), Department of Mechanical Engineering., National Institute of Technology Bhopal (MANIT), Bhopal, Madhya Pradesh, pp. 154-156.

[3]. Hui Hong, Hongguang Jin, Jun Sui, Jun Ji, 2008, “Mechanism of upgrading Low-Grade Solar Thermal Energy and Experimental

Validation" ASME J Sol. Energy Eng.,130,p.0210141.
[4]. Christoph Trinkl,Wilfried Zoner,Vic Hanby,2009, "Simulation Study on a Domestic Solar/Heat Pump Heating System Incorporating Latent and Stratified Thermal Storage" ASME J Sol. Energy Eng.,131,p.0410081.
[5]. A.Renuka Prasad and D.Jagadish., "Current Status of Solar Energy Technologies in Perception towards Energy needs of India", 2013, National Conference on Innovations in Mechanical Engineering, Department of Mechanical Engineering., Madanapalle Institute of Technology, Madanapalli, Andhra Pradesh, pp. 103-109.
[6]. SP Sukhatme "Text Book of Solar Energy Engineering" McGraw-Hill; 1978.p.xii.
[7]. Jane H.Davidson., 2005, "Low-Temperature Solar Thermal Systems: An Untrapped Energy Resource in the United States" ASME J Sol. Energy Eng.,127, p.305.
[8]. Amnon Einav., 2004, "Solar Energy Research and Development Achievements in Israel and Their Pracical Significance" ASME J Sol. Energy Eng., 126, p.921.
[9]. K.Mahkamov, E.P.Orda., 2005, "Solar Thermal Water Pumps:A Preliminary Analysis of the Working Process" ASME J Sol. Energy Eng.,127,p.29.
[10]. E.Orda, K.Mahakamov., 2004, "Development of ''Low-tech'' Solar Thermal Water Pumps for Use in Developing Countries" ASME J Sol. Energy Eng.,126,p.768.
[11]. Robert Foster, Majid Ghassemi and Alma Cota, "Text Book of Solar Energy Engineering". p.002.
[12]. A.Renuka Prasad, " Efficiency and Thermal Analysis of a Salinity Gradient Solar Pond", International Journal of a Scientific Research in Science, Engineering and Technology, Vol.2, no.4, pp.865-871.
[13]. Hongguang Jin,Jun Sui,Hui Hong,Zhifeng Wang,Danxing Zheng and Zhi Hou.,2007, "Prototype of Middle-Temperature Solar Receiver/Reactor with Parabolic Trough Concentrator" ASME J Sol. Energy Eng.,129,p.378.
[14]. M.Eck.W, D.Steinmann., 2005, "Modeling and Design of Direct Solar Steam Generating Collector Fields" ASME J Sol. Energy Eng.,127,p.371.
[15]. Soteris A. Kalogirou., 2004, "Solar thermal collectors and applications" Progress in Energy and Combustion Science 30 (2004) 231–295.
[16]. Robert Foster, Majid Ghassemi and Alma Cota, "Text Book of Solar Energy Engineering"p.073.
[17]. Rainer Tamme,Doerte Laing and Wolf-Dieter Steinmann,2004, "Advanced Thermal Energy Storage Technology for Parabolic Trough" ASME J Sol. Energy Eng.,126,p.794.
[18]. J.Glembin,D.Eggert,G.Rockendorf and J.Scheuren.,2011, "Evaporation in Solar Thermal Collectors During Operation-Reasons and Effects of Partial Stagnation" ASME J Sol. Energy Eng.,133,p.0410031.
[19]. Robert Foster, Majid Ghassemi and Alma Cota, "Text Book of Solar Energy Engineering"p.074.
[20]. Wolf-Dieter Steinmann,Doerte Laing and Rainer Tamme,2010, "Latent Heat StoragebSystems for Solar Thermal Power Plants and Process Heat Applications" ASME J Sol. Energy Eng.,132,p.0210031.
[21]. Wolf-Dieter Steinmann,Rainer Tamme.,2008, "Latent Heat Storage for Solar Steam Systwms" ASME J Sol. Energy Eng.,130,p.0110041.
[22]. A.Renuka Prasad, "Thermal Behaviour and Exergy Analysis of a Salinity Gradient Solar Pond", International Journal of a Scientific Research in Science, Engineering and Technology, Vol.2, no.5, pp.524-532.
[23]. Robert Foster, Majid Ghassemi and Alma Cota, "Text Book of Solar Energy Engineering"p.099.
[24]. Robert Foster, Majid Ghassemi and Alma Cota, "Text Book of Solar Energy Engineering"p.104.
[25]. T.T.Chow, J.Ji and W.He.,2007, "Photovoltaic-Thermal Collector System for Domestic Application" ASME J Sol. Energy Eng.,129,p.205.
[26]. Abraham Kribus and Gur Mittelman.,2008, "Potential of Polygene ration With Solar Thermal and Photovoltaic Systems" ASME J Sol. Energy Eng.,130,p.0110011.
[27]. Robert Pitz-Paal, Jurgen Dersch,Barbara Milow, Felix Téllez, Alain Ferriere, Ulrich Langnickel,

Aldo Steinfeld, Jacob Karni, Eduardo Zarza, Oleg Popel.,2007, “Development Steps for Parabolic Trough Solar Power Technologies With Maximum Impact on Cost Reduction” ASME J Sol. Energy Eng.,129,p.371.

[28]. Amin Ghobeity, Alexander Mitsos.,2012, “Optimal Design and Operation of a Solar Energy Receiver and Storage” ASME J Sol. Energy Eng.,134,p.0310051.

[29]. Tripanagnostopoulos Y, Souliotis M, Nousia Th. “Solar collectors with colored absorbers”.Solar Energy, 2000, vol.68, p.343–56.

[30]. Md. Irfan Ali, Bijo Joseph, R. Karthikeyan, and R. Yuvaraj “Performance Investigation of Solar Still Integrated to Solar Pond” International Journal of Power Systems and Integrated Circuits, Vol. 2, No. 1, March 2012.

[31]. Rajamohan Ganesan and Chua Han Bing, “Theoretical Analysis of Closed Rankine Cycle Solar Pond Power Generator” Modern Applied science, Vol.2, No.2, March 2008.

[32]. 32) A.Z.A. Saifullah, A.M. Shahed Iqubal and Anirban Saha, “Solar pond application and

[33]. desalination”, Asian Transactions on Science & Technology (ATST ISSN: 2221-4283) Volume 02 Issue 03.

[34]. Serhadoglu, A. C., O. Buyukukidik, 2004: Solar Ponds, Phys. 471 Solar Energy Fall 2004.

[35]. Kurt H., M. Ozkaymak and A.K. Bin ark, 2006: Experimental and numerical analysis of sodium-carbonate salt gradient solar-pond performance under simulated solar radiation, Applied Energy, 83, 324-342.

[36]. Vanderhulst.P, Lanser.H,Bergymer.p, Foeth.F,Alber.S,:Solar energy-small scale applications in developing countries, Amsterdam(1990).

[37]. Rabl, A. and C.E. Neilsen.1975. solar ponds for space heating. Solar energy. 17:1-12.

[38]. Tobor, H. and R.Matz.1965. solar pond project. Solar energy. 9(4):177-182.

[39]. Ahmed, S.F. and P.W. Scanlan.1980. Large scale space heating and DHW system using shallow solar pond with heat pump assistance. American section of the solar Internationa Solar Energy Society, Inc. pp.359-363.

[40]. Funn,R.P. and T.H. Short.1983. solar ponds. A basic manual. Ohio Agricultural Research and Development Centre special circular 106.40p.

[41]. Hull, J.R.1980b. Membrane Stratified Solar Ponds. Solar energy 25:317:323.

[42]. Dickinson,W.C.,A.F. Clark, J.A. Day.1976. The Shallow solar pond energy conversion system Solar energy.18:3-10.

[43]. A Report in Ministry New and Renewable Energy, Government of India.

[44]. Pragya Sharma and T.Harinarayana.,2013 “Solar Energy generation potential along national Highways” International Journal of Energy and Environmental Engineering 2013, **4**:16.

[45]. Husseini,I.,T.H. Short, and P.C. Badger.1979. Radiation on a solar pond with green house covers and reflectors. Transactions of the ASAE.22(6):1385-1389.

[46]. Nitin Sethi, TNN, 18 November 2009, 12.42am IST (18 November 2009). "1gw solar power in 2013". Timesofindia.indiatimes.com. Retrieved 2010-11-27.

[47]. Steve Leone (9 December 2011). "Report Projects Massive Solar Growth in India". Renewable Energy World.

[48]. Muneer, T.; Asif, M.; Munawwar, S. (2005). "Sustainable production of solar electricity with particular reference to the Indian economy". Renewable and Sustainable Energy Reviews **9** (5): 444. doi:10.1016/j.rser.2004.03.004. edit (publication archived in ScienceDirect, needs subscription or access via university)]

[49]. Roul, Avilash (15 May 2007). "India's Solar Power: Greening India's Future Energy Demand". Ecoworld.com. Retrieved 2012-02-28.

[50]. Chittaranjan Tembhekar (26 October 2009). "India tops with US in solar power". Economic Times.

[51]. "Adani Group commissions largest solar power project". Economic Times (New Delhi, India). 2102-1-5.

[52]. "Tata BP Completes Solar Photovoltaic Plant in Eastern India". Bloomberg. 29 August 2011.

[53]. Marcu, C., Luminosu, I., Lupea, F., On the Efficiency of Solar Energy Storage in the Pebble

Beds, Scientific Bul le tin of the “Politehnica” University of Timisoara, Math.-Phys. Series, 47 (61) (2002), 1, pp. 10-108

[54]. Pedersen, P. V., Experience with a Large Solar DHW System in Den mark – The Nordic Solar Heating Demonstration Project, Solar Energy, 50 (1993), 30, pp. 259-266

[55]. Savulescu, T. D., Ventilation and Heating Installations, (in Romanian) Tehnical, Bu cha rest, 1984

[56]. Leonachescu, N. P., Heat Transfer between Buildings and Ground, (in Romanian) Tehnica, Bu cha rest,1989

[57]. Duffie, J. A., Beckman, W. A., Solar Engineering of Thermal Processes, 2nd ed., John Wiley and Sons,New York, USA, 1991

[58]. Duman, R., Solar Energy and Energy Storage, Masson Pub., Paris, 1979

[59]. Swanson, R. M., Pho to voltaic Concentrators, in: Luque, A., Hegedus, S., Hand book of Photovoltaic Science and Engineering, John Wileyand Sons, New York, USA, 2003, pp. 449-504

[60]. Luminosu, I., Lamellar Non-Imaging Concentra tor with Dihedral Angle, Scientific Bulletin of the “Politehnica” University of Timisoara, Math.-Phys. Se ries, 52 (66) (2007), 1, pp. 82-86

[61]. Em ery, K., Measurement and Characterization of Solar Cells and Modules, in Luque, A., Hegedus, S.,Hand book of Photovoltaic Science and Engineering, John Wiley and Sons, New York, USA, 2003, pp.701-752

[62]. Brogren, M., Optical Efficiency of Low-Concentrating Solar Energy Systems with Parabolic Reflectors, Uppsala University, Comprehensive Summaries of Uppsala Dissertations from the Faculty of Science and Technology, 934, Acta Universitatis Upsaliensis, Uppsala, Sweden, 2004

[63]. Bowden, S. B. E., A High Efficiency Photovoltaic Roof Tile”, Ph. D. the sis University of New SouthWales, Sydney, Australia, 1996

[64]. Luminosu, I. V., et al.: Solar Energy Based Industrial Applications at the “Politehnica” THERMAL SCIENCE: Year 2011, Vol. 15, No. 3, pp. 587-598 597

[65]. Zaharie,I., Luminosu, I., Ignea, D., The Study of a Paraboloidal Optical Concenrator by Ray-Tracing Method: Results”, CFM, Conference of Phys i cists from Moldova, Chisinau, Abstracts, 2007, p. 114.

[66]. Luminosu, I., Zaharie, I., Negrea, R., Ignea, D., The study of a Static Paraboloidal Concentra tor through the Ray-Tracing Method, Incorporated in the Southern Wall of a Building, National Forum of Energy FOREN 2008, Neptun-Olimp, Ro mania, in electronic for mat

[67]. De Sabata, C., et al., Building of a Sports Facility on the Sacalaz lake, Eco log i cal Considerations, Proceedings, National Conference in Solar Energy, “Politehnica” University of Timisoara, 1989, pp. 66-6

[68]. Cocheci, V., Gitye, V., Bio-Solar Cleaning of Ur ban Waste Water by Means of Tropical Plants, Proceedings, National Conference in Solar Energy, “Politehnica” University of Timisoara, 1989, pp. 74-76.