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Solar Energy Uses and its Applications for Futuristic Energy Requirements

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Abstract: Renewable energy is a solution of current and futuristic energy requirement for environment friendly development. The aim of this article is to aware people from solar energy in various felid like solar fuel, solar building, solar electricity, solar cooking, solar agriculture, solar architecture etc so reduces dependency from fossil fuel. It is alternative power source due to continuous reduction in fossil fuels like petrol, diesel, CNG, LPG etc. Today solar energy is the main inspiration for socio-economic and environment friendly development in the world. The electricity is generated from solar energy as is used in various sectors like industrial, commercial and residential with pollution free environment. Earth receives sufficient solar energy for socioeconomic and environment friendly development.
Keywords: Sun, Solar Energy, Solar Agriculture, Solar Building, Solar Electicity.

I. INTRODUCTION

A. Solar energy

Energy resources can categorize as renewable energy resources and non-renewable energy resources. Due to some harmful environmental impacts such as air pollution, climate change and natural resources decay, people are focused on using renewable energy resources to generate energy. Solar energy is one of the widely discussing renewable energy resources. Recently with the rising human population and energy demand, new technologies and improvements should be made in the solar energy field to fulfill the global energy demands and increase energy efficiency.[1]

Solar energy is radiant light and heat from the Sun that is using as solar heating, photovoltaic's, solar thermal energy, solar architecture etc. It is an important source of renewable energy. The large amount of solar energy makes it a highly appealing source of electricity. The International Energy Agency said that "the development of affordable, inexhaustible and clean solar energy technologies will have huge longer-term benefits. It will increase countries' energy security through reliance on an indigenous, inexhaustible and mostly import-independent resource, enhance sustainability, reduce pollution, lower the costs of mitigating global warming, and keep fossil fuel prices lower than otherwise. These advantages are global. Hence the additional costs of the incentives for early deployment should be considered learning investments; they must be wisely spent and need to be widely shared"

The Earth receives 174 petawatts (PW) of incoming solar radiation at the upper atmosphere. Approximately 30% is reflected back to space while the rest is absorbed by clouds, oceans and land masses. The spectrum of solar light at the Earth's surface is mostly spread across the visible and near-infrared ranges with a small part in the near-ultraviolet. Most of the world's population live in areas with insolation levels of 150–300 watts/m², or 3.5–7.0 kWh/m² per day.[1A-2]

II. VARIOUS APPLICATION OF SOLAR ENERGY

A. Solar Heating of Water

Solar hot water systems use sunlight to heat water. The most common types of solar water heaters are evacuated tube collectors (44%) and glazed flat plate collectors (34%) generally used for domestic hot water; and unglazed plastic collectors (21%) used mainly to heat swimming pools.[3]

Solar Water Heating System Solar water heating system is a device that helps in heating water by using the energy from the Sun. The Sun's rays fall on the collector panel (a component of solar water heating system). A black absorbing surface (absorber) inside the collectors absorbs solar radiation and transfers the heat energy to water flowing through it. Heated water is collected in a tank which is insulated to prevent heat loss. Circulation of water from the tank through the collectors and back to the tank continues automatically due to thermo siphon system. Based on the collector system, solar water heaters can be of two types: A solar water heater consists of a collector to collect solar energy and an insulated storage tank to store hot water. The stored hot water can be used later any time.[3A]

B. Solar Building

In passive solar building design, windows, walls, and floors are made to collect, store, reflect, and distribute solar energy, in the form of heat in the winter and reject solar heat in the summer. Thermal mass is any material that can be used to store heat—heat from the Sun in the case of solar energy. Common thermal mass materials include stone, cement and water. Historically they have been used in arid climates or warm temperate regions to keep buildings cool by absorbing solar energy during the day and radiating stored heat to the cooler atmosphere at night. However, they can be used in cold temperate areas to maintain warmth as well. The size and placement of thermal mass depend on several factors such as climate, day lighting and shading conditions. When properly incorporated, thermal mass maintains space temperatures in a comfortable range and reduces the need for auxiliary heating and cooling equipment.[4]

C. Solar Cooking

A solar cooker is a type of solar thermal collector. It "gathers" and traps the Sun's thermal (heat) energy. Heat is produced when high frequency light (visible and ultraviolet) is converted into low frequency infrared radiation. Solar cookers use sunlight for cooking, drying and pasteurization. They can be grouped into three broad categories: box cookers, panel cookers and reflector cookers. The simplest solar cooker is the box cooker first built by Horace de Saussure in 1767. A basic box cooker consists of an insulated container with a transparent lid. It can be used effectively with partially overcast skies and will typically reach temperatures of 90–150 °C.[5]

D. Solar Electricity

Solar power is the conversion of sunlight into electricity, either directly using photo voltaic (PV), or indirectly using concentrated solar power (CSP). CSP systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. PV converts light into electric current using the photoelectric effect. Solar power is anticipated to become the world's largest source of electricity by 2050, with solar photo voltaic and concentrated solar power contributing 16% and 11% to the global overall consumption, respectively.[6] But due to incremental rate of environmental concern renewable energy provide a significant interest. It is the energy comes from sun, wind, rain etc. Among the non-conventional, renewable energy sources, Solar energy affords great potential for conversion into electric power. Maximizing power output from a solar system is desirable to increase efficiency. In order to maximize power output, needs to keep the panels aligned with the sun. [6A] The Solar Energy is produced by the Sunlight is a non-vanishing renewable source of energy. Every hour enough sunlight energy reaches the earth to meet the world's energy demand for a whole year. It cans easily energy drawn from direct sunlight. So it is very efficiency & free environment pollution for surrounding.[6B]

E. Solar Photovoltaic

A photovoltaic (PV) cell, commonly called a solar cell, is a non mechanical device that converts sunlight directly into electricity. Some PV cells can convert artificial light into electricity. Sunlight is composed of photons, or particles of solar energy. These photons contain varying amounts of energy that correspond to the different wavelengths of the solar spectrum. A PV cell is made of semiconductor material. When photons strike a PV cell, they may reflect off the cell, pass through the cell, or be absorbed by the semiconductor material. Only the absorbed photons provide energy to generate electricity. When the semiconductor material absorbs enough sunlight (solar energy), electrons are dislodged from the material's atoms. Special treatment of the material surface during manufacturing makes the front surface of the cell more receptive to the dislodged, or *free*, electrons so that the electrons naturally migrate to the surface of the cell.[7]

F. Concentrated Solar Power

Concentrating solar power (CSP) plants use mirrors to concentrate the sun's energy to drive traditional steam turbines or engines that create electricity. The thermal energy concentrated in a CSP plant can be stored and used to produce electricity when it is needed, day or night. Concentrating Solar Power systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. The concentrated heat is then used as a heat source for a conventional power plant. A wide range of concentrating technologies exists; the most developed are the parabolic trough, the concentrating linear Fresnel reflector, the Stirling dish and the solar power tower. Various techniques are used to track the Sun and focus light. In all of these systems a working fluid is heated by the concentrated sunlight, and is then used for power generation or energy storage.[8] CSP technologies use mirrors to reflect and concentrate sunlight onto a receiver.

The energy from the concentrated sunlight heats a high temperature fluid in the receiver. This heat - also known as thermal energy - can be used to spin a turbine or power an engine to generate electricity. It can also be used in a variety of industrial applications, like water desalination, enhanced oil recovery, food processing, chemical production, and mineral processing. Concentrating solar-thermal power systems are generally used for utility-scale projects. These utility-scale CSP plants can be configured in different ways. Power tower systems arrange mirrors around a central tower that acts as the receiver. Linear systems have rows of mirrors that concentrate the sunlight onto parallel tube receivers positioned above them. Smaller CSP systems can be located directly where power is needed. For example, single dish/engine systems can produce 5 to 25 kilowatts of power per dish and be used in distributed applications.[8A]

G. Solar Architecture

Solar architecture is an approach to design with an emphasis on harnessing the sun's power (usually through solar panels) to create energy-efficient buildings. By incorporating these green practices in design, architects can help address the climate crisis head-on. Sunlight has influenced building design since the beginning of architectural history. Advanced solar architecture and urban planning methods were first employed by the Greeks and Chinese, who oriented their buildings toward the south to provide light and warmth. The common features of passive solar architecture are orientation relative to the Sun, compact proportion (a low surface area to volume ratio), selective shading (overhangs) and thermal mass.[9]

H. Solar Agriculture

Agriculture seek to optimize the capture of solar energy in order to optimize the productivity of plants. Techniques such as timed planting cycles, tailored row orientation, staggered heights between rows and the mixing of plant varieties can improve crop yields.[10] Most large, ground-mounted solar photovoltaic (PV) systems are installed on land used only for solar energy production. It's possible to co-locate solar and agriculture on the same land, which could provide benefits to both the solar and agricultural industries. Co-location, also known as agrivoltaics, is defined as agricultural production, such as crop or livestock production or pollinator habitats, underneath solar panels or adjacent to solar panels. Pollinator habitats and grazing are currently co-located at some solar facilities, though solar co-location sites with crops are primarily limited to research sites. Exploring alternate solar system designs and agricultural practices that optimize both energy and agricultural production at co-located sites may offer opportunities to increase overall value and lower soft costs, or non-hardware costs, of solar energy. [9A]

I. Solar Vehicle

A solar vehicle or solar electric vehicle is an electric vehicle powered completely or significantly by direct solar energy. Usually, photovoltaic (PV) cells contained in solar panels convert the sun's energy directly into electric energy. The term "solar vehicle" usually implies that solar energy is used to power all or part of a vehicle's propulsion. Solar power may also be used to provide power for communications or controls or other auxiliary functions. Solar vehicles are not sold as practical day-to-day transportation devices at present, but are primarily demonstration vehicles and engineering exercises, often sponsored by government agencies. However, indirectly solar-charged vehicles are widespread and solar boats are available commercially. [11A] Development of a solar-powered car has been an engineering goal since the 1980s. Some vehicles use solar panels for auxiliary power, such as for air conditioning, to keep the interior cool, thus reducing fuel consumption.[11]

J. Solar Fuel

Solar fuels are synthetic fuels produced from solar energy. They are the most economically viable, efficient, scalable, and environmentally friendly solution for clean, long-distance transportation. A cutting-edge technology that offers a sustainable alternative to fossil fuels.[12A] Solar chemical processes use solar energy to drive chemical reactions. These processes offset energy that would otherwise come from a fossil fuel source and can also convert solar energy into storable and transportable fuels. Solar induced chemical reactions can be divided into thermo chemical or photochemical.[12]

K. Solar Energy Storage

Thermal mass systems can store solar energy in the form of heat at domestically useful temperatures for daily or inter seasonal durations. Thermal storage systems generally use readily available materials with high specific heat capacities such as water, earth and stone. Well-designed systems can lower peak demand, shift time-of-use to off-peak hours and reduce overall heating and cooling requirements.[13]

Some times two is better than one. Coupling solar energy and storage technologies is one such case. The reason: Solar energy is not always produced at the time energy is needed most. Peak power usage often occurs on summer afternoons and evenings, when solar energy generation is falling. Temperatures can be hottest during these times, and people who work daytime hours get home and begin using electricity to cool their homes, cook, and run appliances. Storage helps solar contribute to the electricity supply even when the sun isn't shining. It can also help smooth out variations in how solar energy flows on the grid. These variations are attributable to changes in the amount of sunlight that shines onto photovoltaic (PV) panels or concentrating solar-thermal power (CSP) systems. Solar energy production can be affected by season, time of day, clouds, dust, haze, or obstructions like shadows, rain, snow, and dirt. Sometimes energy storage is co-located with, or placed next to, a solar energy system, and sometimes the storage system stands alone, but in either configuration, it can help more effectively integrate solar into the energy landscape.[13A]

L. Solar Heat Process

Solar concentrating technologies such as parabolic dish, trough and Scheffler reflectors can provide process heat for commercial and industrial applications.[14] Solar water-heating systems are designed to provide large quantities of hot water for nonresidential buildings. A typical system includes solar collectors that work along with a pump, heat exchanger, and/or one or more large storage tanks. The two main types of solar collectors used for nonresidential buildings—an *evacuated-tube collector* and a *linear concentrator*—can operate at high temperatures with high efficiency. An evacuated-tube collector is a set of many double-walled, glass tubes and reflectors to heat the fluid inside the tubes. A vacuum between the two walls insulates the inner tube, retaining the heat. Linear concentrators use long, rectangular, curved (U-shaped) mirrors tilted to focus sunlight on tubes that run along the length of the mirrors. The concentrated sunlight heats the fluid within the tubes.[14A]

M. Solar Treatment of Water

Solar distillation can be used to make saline or brackish water potable. The first recorded instance of this was by 16th-century Arab alchemists.[15] Solar water purification involves purifying water for drinking and household purposes through the usage of solar energy in many different ways. Using solar energy for water treatment has become more common as it is a usually low-technology solution that works to capture the heat and energy from the sun to make water cleaner and healthier for human use and consumption. Solar water treatment is particularly beneficial for rural communities, as they do not have other forms of water purification infrastructure and more importantly, electricity to run such structures. The most positive feature about solar water purification is that there is no requirement of fuel. It's precisely due to the lack of fuel that makes solar applications relatively superior than conventional sources of energy as it does not cause pollution (global warming, acid rain, ozone depletion) or health hazards associated with pollution. There are four main types of solar water treatment: solar water disinfection (SODIS), solar distillation, solar water pasteurization, and solar water treatment systems. Some of these technologies have been around for a very long time, but most are new adaptations to the concept of solar energy. These technologies are quite simple and easy to understand, usually require low financial input, and are proven effective.[15A]

N. Solar Molten Salt

Molten salt can be employed as a thermal energy storage method to retain thermal energy collected by a solar tower or solar trough of a concentrated solar power plant, so that it can be used to generate electricity in bad weather or at night. The system is predicted to have an annual efficiency of 99%, a reference to the energy retained by storing heat before turning it into electricity, versus converting heat directly into electricity.[16] Molten salt is used as a heat transfer fluid (HTF) and thermal energy storage (TES) in solar power plants. Operators can take advantage of a new ternary mixture of molten salts based on Calcium-Potassium-Sodium-Nitrate introduced by Yara. This low melting (131°C) ternary mixture of molten salts can be used both as a heat transfer fluid and thermal energy storage, for concentrated solar power plants. It is also designed to be used in all other thermodynamic power units, where medium to high temperatures have to be transported and / or stored.[16A]

III. CONVERSION OF SOLAR ENERGY INTO CHEMICAL ENERGY

Solar chemical conversion involves processes that ultimately convert solar radiant energy into stored chemical potential energy in the form of fuels or chemical products. This is in contrast to photovoltaic and thermal energy conversion where the final form of the converted solar energy is electricity and heat, respectively. Solar chemical conversion is distinguished from biomass conversion, which also yields fuels and chemicals as the final product, by the fact that the former is a two-step process, the first step involving biological photo-synthesis whereby carbon dioxide and water are converted into higher energy, complex carbohydrates and organic polymers by green plants and algae. The second step in the biomass process is the refinement of the complex chemical products of biological photosynthesis into useful fuels and chemical feed stocks such as methane, methanol, ethanol, and carbon monoxide/hydrogen. In contrast, solar chemical conversion is a one-step process by which sunlight acting upon simple reactants, such as water, carbon dioxide, and nitrogen in the presence of a photo catalyst drives a direct conversion to fuels and chemicals, such as hydrogen, hydrocarbons, alcohols, and fixed nitrogen compounds.[17]

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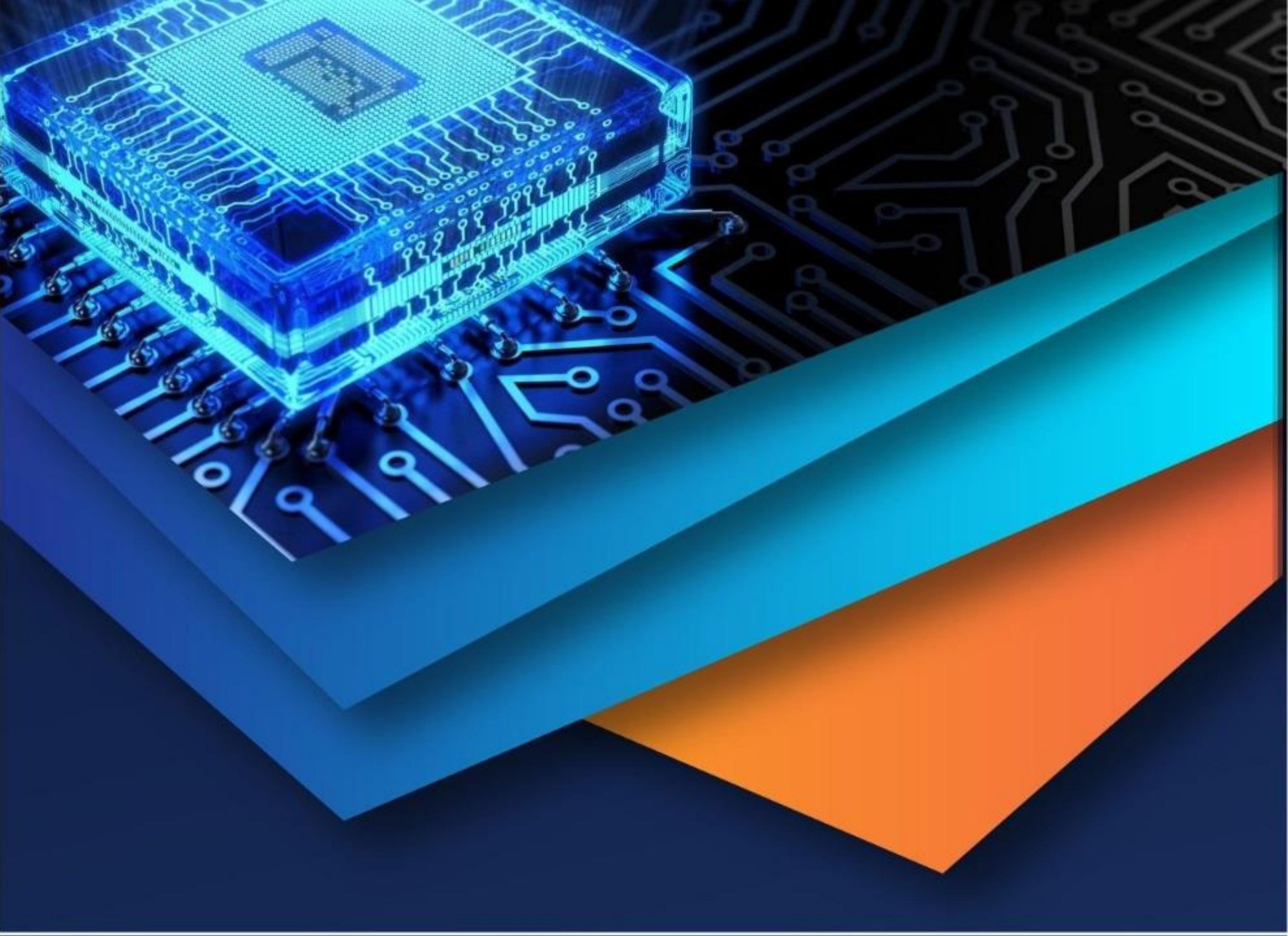

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