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SOLAR ENERGY ANALYSIS AS THE DEFINITIVE RENEWABLE ENERGY SOURCE

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Abstract

Energy created from natural procedures and are constantly replenished is known as Renewable energy. These consist of water, geothermal, solar, heat, wind, tides, and various forms of biomass. The most ultimate and important source of renewable energy is the energy from the sun (Solar Energy). This is because it is independent of climatic changes is being utilized in many applications. This paper discusses from analysis solar energy as the ultimate energy source among other renewable energy.

Keywords: Solar, energy, Definitive, renewable energy, photovoltaics, Thermochemical

Introduction

Renewable energy is clean, non-polluting and occurs naturally. It is sustainable as it is obtained from sources that are inexhaustible which includes wind, solar, biomass, geothermal and hydro etc. [1]. It is cost-effective, efficient and can be relied upon for long-lasting applications. Most of this renewable energy does not produce any poisonous waste in the course of generating electricity.

Solar energy is the energy that is harnessed from the Sun using variety of technologies. These technologies include solar thermal energy, solar heating, molten salt power plants, photovoltaic, solar architecture, and artificial photosynthesis. These technologies are generally categorized into two (**passive solar** and **active solar technique**). This is dependent on how they capture and distribute solar energy or convert other renewable energy into solar power. Designing of spaces that naturally circulate air, positioning a building to the Sun and selecting materials with favorable thermal mass or light-dispersing properties belongs to Passive solar techniques while the use of photovoltaic systems, solar water heating and concentrated solar power to obtain solar energy is associated to active solar technique [2]. Availability of large magnitude of solar energy brands it a greatly attractive source of electricity. According to the United Nations Development Programme in its 2000 World Energy Assessment, the annual potential of solar energy was found to be 1,575–49,837 exa-joules (EJ), which is several times greater than the total world energy consumption(found to be 559.8 EJ in 2012). International Energy Agency (2011), said that the improvement of inexpensive, inexhaustible and spotless solar energy technologies will have global huge long lasting benefits. These benefits will include: 1) increase of countries' energy security through dependence on local, natural and inexhaustible source. 2) It is an import-independent resource. 3) It enhances sustainability. 4) It reduces pollution 5) It lowers the costs of mitigating global warming, and 6) it keep fossil fuel prices lower than otherwise.

Despite the great potential and advantages of solar energy, it has been ignored whenever fossil fuels were more affordable and available. However, an exploitation of an alternative renewable energy source (Solar energy) has emerged and has seriously globally grabbed attention due to the growing energy demands, increasing environmental problems and declining fossil fuel resources. US Department of Energy funded the installation and testing of over 3,000 PV systems during the 1973-1974 oil embargoes.

There is no longer an excuse not to consider solar power for homes as solar professional companies keep designing unique and specific solar power systems for individual homes use. Today, thermal and photovoltaic are the two forms of solar power in use. The thermal focuses and converts sunlight into heat, and then applies it to a steam generator or engine that converts it to electricity which is generated when the heated fluid drives the turbines or other machinery. The photovoltaic produces electricity directly without moving parts.

Photovoltaic system is composed of cells made of silicon. Power is produced when sunlight strikes the semiconductor material and creates an electric current. A cell is the smallest unit of the system. A module is cells wired together and modules wired together form a panel. A group of panels is called an array, and several arrays form an array field [4]. Photovoltaic solar power is one of the most promising renewable energy sources in the world. It is non-polluting and has no moving parts that could break down. It requires little maintenance and no supervision. It has a life of 20-30 years with low running costs and especially unique as no large-scale installation is required. Wind power, hydropower, and solar thermal power possess moving parts that are noisy and require maintenance [5].

Today in developing countries like Nigeria Solar energy is most sought, and is becoming the fastest growing segment of the photovoltaics market. People go without electricity as the sun beats down on the land, making solar power the obvious energy choice. With an inverter, which converts direct current (DC) power from the solar cells to alternating current (AC), which is what most home appliances run on, a solar home can look and operate very much like a home that is connected to a power line" [6].

Findings

The possible solar energy that could be used by human being varies from the quantity of solar energy existing nigh the surface of the sphere. This is because of some factors like geography, time disparity, cloud cover, and the land available to humans, these factors limit the amount of solar energy that can be obtained [7].

For the case of time disparity, during nighttime there is little or no solar radiation on the surface of the Earth to be absorbed by the solar panels; this reduces the extent of sun energy that solar panels can absorb in a day. On the other hand, cloud cover blocks radiation from the sun on solar panel and hence reduce the light available for solar cells. This also affects the potential of solar panels. Moreover land availability has an enormous effect on the available solar energy as solar panels are set upon unused land that is suitable for solar panels. It has been discovered that roofs can be a suitable place for solar cells, this way solar energy can be directly obtained from various homes. Solar plants can also be established in lands that are not being used for businesses.

Table 1 below displays the yearly solar fluxes and human consumption while figure 1 shows its diagrammatic representation in bar chart.

Table 1: Yearly solar fluxes & human consumption (Exa-joule (EJ) = 1018 J = 278 TWh)

Solar	3,850,000
Wind	2,250
Biomass potential	~200
Primary energy use	539
Electricity	~67

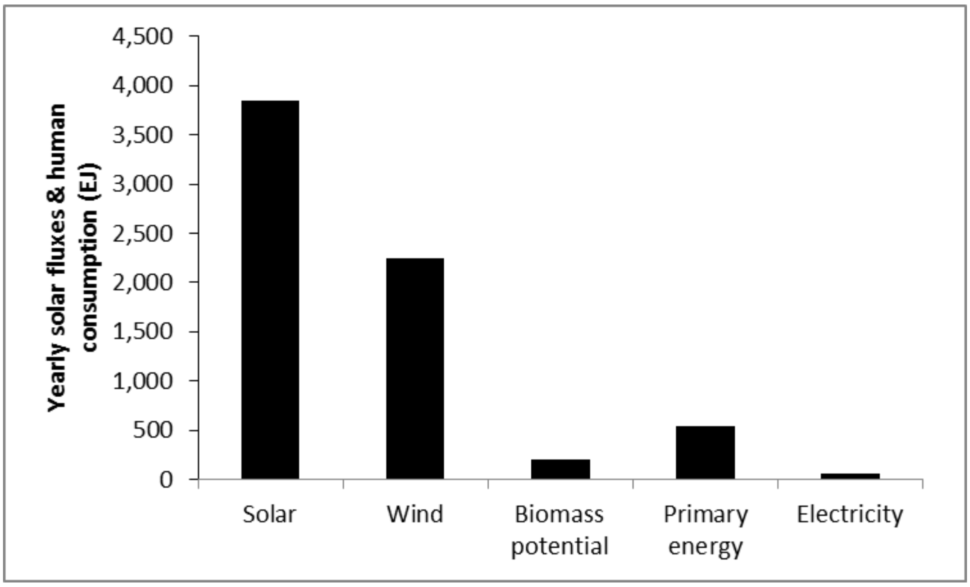

Figure 1: Bar chart of yearly solar fluxes & human consumption.

Table 2 shows the estimate found that solar energy has a global potential of 1,575–49,837 EJ per year given in (Exajoules) while figure 2 shows its graphical representation

Table 2: Annual estimate of solar energy by region in Exajoules.

Region	*North America*	*Latin America and Caribbean*	*Western Europe*	*Central and Eastern Europe*	*Former Soviet Union*	*Middle East and North Africa*	*Sub-Saharan Africa*	*Pacific Asia*	*South Asia*	*Centrally planned Asia*	*Pacific OECD*
Minimum	181.1	112.6	25.1	4.5	199.3	412.4	371.9	41.0	38.8	115.5	72.6
Maximum	7,410	3,385	914	154	8,655	11,060	9,528	994	1,339	4,135	2,263

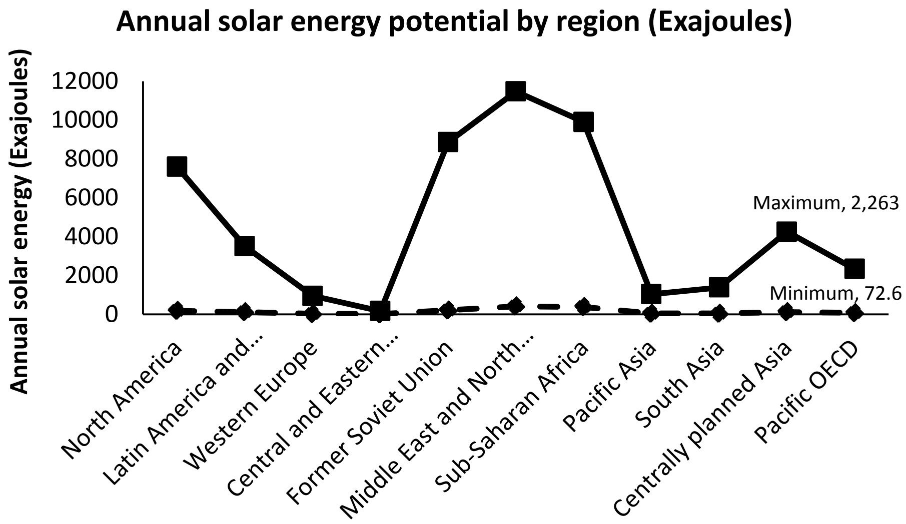

Figure 2: Graph of annual estimate of solar energy by region in Exajoules Source: United Nations Development Programme – World Energy Assessment (2000)

Analysis of the Applications of Solar Energy as the Ultimate Renewable Energy Source

Solar energy, the ultimate renewable energy source can be applied in the followings:

a) Solar Water heating

Solar hot water systems like evacuated tube collectors, unglazed plastic collectors and glazed flat plate collectors use sunlight to heat water. It is also mainly used to heat swimming pools In low geographical latitudes (below 40 degrees), 60 to 70% of the domestic hot water use of up to 60 °C temperatures can be provided by solar heating systems.

b) Heating, cooling and ventilation

Thermal mass is any material that can be used to store heat from the solar energy. These materials include stone, cement and water. In arid climates or warm temperate regions, they have been used to keep buildings cool. This is done by their absorbing and storing solar energy during the day time, and then radiating the stored heat to the cooler atmosphere at night. In cold temperate areas they are used to maintain warmth as well. Factors such as climate, day lighting and shading conditions affect the size and placement of thermal mass. When these factors are properly considered, thermal mass maintains space temperatures in a comfortable range and reduces the need for supplementary heating and cooling equipment. Solar cookers like box cookers, panel cookers and reflector cookers use sunlight for cooking, drying and pasteurization. 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 (194–302 °F). Panel cookers use a reflective panel to direct sunlight onto an insulated container and reach temperatures comparable to box cookers. Reflector cookers use various concentrating geometries (dish, trough, Fresnel mirrors) to focus light on a cooking container. These cookers reach temperatures of 315 °C (599 °F) and above but require direct light to function properly and must be repositioned to track the Sun.

c) Process heat

Solar concentrating technologies such as parabolic dish, trough and Scheffler reflectors can provide process heat for commercial and industrial applications. The first commercial system was the Solar Total Energy Project (STEP) in Shenandoah, Georgia, USA where a field of 114 parabolic dishes provided 50% of the process heating, air conditioning and electrical requirements for a clothing factory. This grid-connected cogeneration system provided

400 kW of electricity plus thermal energy in the form of 401 kW steam and 468 kW chilled water, and had a one-hour peak load thermal storage. Evaporation ponds are shallow pools that concentrate dissolved solids through evaporation. The use of evaporation ponds to obtain salt from seawater is one of the oldest applications of solar energy. Modern uses include concentrating brine solutions used in leach mining and removing dissolved solids from waste streams. Clotheslines, clotheshorses, and clothes racks dry clothes through evaporation by wind and sunlight without consuming electricity or gas. Unglazed transpired collectors (UTC) are perforated sun-facing walls used for preheating ventilation air. UTCs can raise the incoming air temperature up to 22 °C (40 °F) and deliver outlet temperatures of 45–60 °C (113–140 °F).

d) Water treatment

Solar distillation can be used to make saline or brackish water potable. Solar water disinfection (SODIS) involves exposing water-filled plastic polyethylene terephthalate (PET) bottles to sunlight for several hours. Exposure times vary depending on weather and climate from a minimum of six hours to two days during fully overcast conditions. It is suggested by the World Health Organization as a viable method for household water treatment and safe storage. Over two million people in developing countries use this method for their daily drinking water [9]. Solar energy can be applied in a water stabilization pond to treat waste water without the use chemicals or electricity. An extra ecological benefit is that algae grow in such ponds and consume carbon dioxide in photosynthesis, though algae may produce toxic chemicals that make the water useless.

e) Molten salt technology

Molten salt can be used as a thermal energy storage technique to hold thermal energy collected by a solar tower or solar trough of a concentrated solar power plant, which can be used to produce electricity in bad weather or at night [10]. In 1995–1999, this was demonstrated in the Solar Two project. The system is projected to have an annual efficiency of 99%, a reference to the energy retained by storing heat before transforming it into electricity, against converting heat directly into electricity. The molten salt mixtures vary. The most extended mixture contains sodium nitrate, potassium nitrate and calcium nitrate. It is non-flammable and nontoxic, and has already been used in the chemical and metals industries as a heat-transport fluid, so experience with such systems exists in non-solar applications. The salt melts at 131 °C (268 °F). It is kept liquid at 288 °C (550 °F) in an insulated "cold" storage tank. The liquid salt is pumped through panels in a solar collector where the focused sun heats it to 566 °C (1,051 °F). It is then sent to a hot storage tank. This is so well insulated that the thermal energy can be usefully stored for up to a week. When electricity is needed, the hot salt is pumped to a conventional steam-generator to produce superheated steam for a turbine/generator as used in any conventional coal, oil, or nuclear power plant. A 100-megawatt turbine would need a tank about 9.1 metres (30 ft) tall and 24 metres (79 ft) in diameter to drive it for four hours by this design.

Solar power is the conversion of sunlight into electricity, either directly using photovoltaics (PV), or

f) Concentrated solar power

In Concentrated Solar Power (CSP) system, a working fluid is heated by the concentrated sunlight, and is then used for power generation or energy storage. Concentrating Solar Power (CSP) 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 Various techniques are used to track the Sun and focus light; the most developed are the parabolic trough, the concentrating linear fresnel reflector, the Stirling dish and the solar power tower. [11].

g) *Agriculture and horticulture*

Agriculture and horticulture seek to increase the capture of solar energy in order to improve 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. While sunlight is generally considered a plentiful resource, the exceptions highlight the importance of solar energy to agriculture. During the short growing seasons of the Little Ice Age, French and English farmers employed fruit walls to maximize the collection of solar energy. These walls acted as thermal masses and accelerated ripening by keeping plants warm. Early fruit walls were built perpendicular to the ground and facing south, but over time, sloping walls were developed to make better use of sunlight. In 1699, Nicolas Fatio de Duillier even suggested using a tracking mechanism which could pivot to follow the Sun. Applications of solar energy in agriculture aside from growing crops include pumping water, drying crops, brooding chicks and drying chicken manure. More recently the technology has been embraced by vintners, who use the energy generated by solar panels to power grape presses.

Greenhouses convert solar light to heat, enabling year-round production and the growth (in enclosed environments) of specialty crops and other plants not naturally suited to the local climate. [12].

h) *Transport*

Since the 1980s, the development of a solar-powered car has been an engineering goal. The World Solar Challenge is a biannual solar-powered car race, where teams from universities and enterprises compete over 3,021 kilometres (1,877 mi) across central Australia from Darwin to Adelaide. In 1987, when it was founded, the winner's average speed was 67 kilometres per hour (42 mph) and by 2007 the winner's average speed had improved to 90.87 kilometres per hour (56.46 mph). The North American Solar Challenge and the planned South African Solar Challenge are comparable competitions that reflect an international interest in the engineering and development of solar powered vehicles.

Some vehicles use solar panels for auxiliary power, such as for air conditioning, to keep the interior cool, thus reducing fuel consumption.

In 1975, the first practical solar boat was constructed in England. By 1995, passenger boats incorporating PV panels began appearing and are now used extensively. In 1996, Kenichi Horie made the first solar-powered crossing of the Pacific Ocean, and the Sun21 catamaran made the first solar-powered crossing of the Atlantic Ocean in the winter of 2006–2007. There were plans to circumnavigate the globe in 2010. In 1974, the unmanned AstroFlight Sunrise airplane made the first solar flight. On 29 April 1979, the Solar Riser made the first flight in a solar-powered, fully controlled, man-carrying flying machine, reaching an altitude of 40 feet (12 m). In 1980, the Gossamer Penguin made the first piloted flights powered solely by photovoltaics. This was quickly followed by the Solar Challenger which crossed the English Channel in July 1981. In 1990 Eric Scott Raymond in 21 hops flew from California to North Carolina using solar power. Developments then turned back to unmanned aerial vehicles (UAV) with the Pathfinder (1997) and subsequent designs, culminating in the Helios which set the altitude record for a non-rocket-propelled aircraft at 29,524 metres (96,864 ft) in 2001. The Zephyr, developed by BAE Systems, is the latest in a line of record-breaking solar aircraft, making a 54-hour flight in 2007, and month-long flights were envisioned by 2010. As of 2016, Solar Impulse, an electric aircraft, is currently circumnavigating the globe. It is a single-seat plane powered by solar cells and capable of taking off under its own power. The design allows the aircraft to remain airborne for several days.

A solar balloon is a black balloon that is filled with ordinary air. As sunlight shines on the balloon, the air inside is heated and expands causing an upward buoyancy force, much like an artificially heated hot air balloon. Some solar balloons are large enough for human flight, but usage is generally limited to the toy market as the surface-area to payload-weight ratio is relatively high.

i) ***Fuel production***

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 thermochemical or photochemical. A variety of fuels can be produced by artificial photosynthesis. The multielectron catalytic chemistry involved in making carbon-based fuels (such as methanol) from reduction of carbon dioxide is challenging; a feasible alternative is hydrogen production from protons, though use of water as the source of electrons (as plants do) requires mastering the multielectron oxidation of two water molecules to molecular oxygen. Some have envisaged working solar fuel plants in coastal metropolitan areas by 2050 – the splitting of sea water providing hydrogen to be run through adjacent fuel-cell electric power plants and the pure water by-product going directly into the municipal water system. Another vision involves all human structures covering the earth's surface (i.e., roads, vehicles and buildings) doing photosynthesis more efficiently than plants.

Hydrogen production technologies have been a significant area of solar chemical research since the 1970s. Aside from electrolysis driven by photovoltaic or photochemical cells, several thermochemical processes have also been explored. One such route uses concentrators to split water into oxygen and hydrogen at high temperatures (2,300–2,600 °C or 4,200–4,700 °F). Another approach uses the heat from solar concentrators to drive the steam reformation of natural gas thereby increasing the overall hydrogen yield compared to conventional reforming methods. Thermochemical cycles characterized by the decomposition and regeneration of reactants present another avenue for hydrogen production. The Solzinc process under development at the Weizmann Institute of Science uses a 1 MW solar furnace to decompose zinc oxide (ZnO) at temperatures above 1,200 °C (2,200 °F). This initial reaction produces pure zinc, which can subsequently be reacted with water to produce hydrogen.

Conclusion

Solar energy is the ultimate renewable energy source since all energies come from the sun, and it is replaceable. The earth receives an incredible supply of solar energy, it is a free and inexhaustible resource, yet harnessing it is a relatively new idea. It is anticipated to become the world's largest source of electricity by 2050, with solar photovoltaic and concentrated solar power contributing 16 and 11 percent to the global overall consumption, respectively.

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