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THE JOURNEY TO SUSTAINABLE DEVELOPMENT VIA SOLAR ENERGY: A RECAP

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ABSTRACT

In addition to being a fantastic source of energy and environmentally friendly technology, solar energy is one of the most significant types of green and renewable energy. It greatly facilitates the achievement of sustainable development energy results. Because sunlight has such a large daily energy quantum available,It is an incredibly useful resource for producing electricity. To completely fulfill our energy needs, efforts are being made to improve both solar photovoltaics and concentrated solar power operations. In other words, the energy sector benefits and job needs are met when there is a installed capacity of solar energy operations in the same location internationally. This research looks at the application of solar energy, how it fits into the framework of sustainable development, and how employment is generally impacted by renewable energy sources. It offers understanding and analysis of solar energy sustainability, covering both environmentally friendly and financially successful development. Likewise, It has established a link between the advantages of solar energy operations and sustainable development by enhancing environmental conservation, creating jobs, and satisfying energy needs. Lastly, solar energy technology serves as a backdrop for the energy sector's operations and provides an early look at future advancements in this area.

Keywords: Sustainable Development; Solar Energy Applications; Perspective of Solar Energy

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1. INTRODUCTION

We can leave the future generation with a priceless gift: long-term sustainability. The development of diverse renewable energy sources, including hydropower, geothermal, biomass, solar, and wind power, is essential for meeting a country's energy needs for sustainable development. Of them, solar energy is one of the most promising since it can help developing nations like Sri Lanka satisfy their unmet energy needs. It can be accomplished directly by using solar radiation to generate heat through the solar thermal effect or indirectly by using solar photovoltaic, or PV, panels to produce electricity.

The utilization of solar energy is a viable option for developing nations, as it falls well within the realm of science and technology. In addition to being ecologically benign, solar energy will gradually replace more conventional, but ecologically risky, methods of producing electricity through reactive energy burning. PV panels are growing in popularity and cost-effectiveness due to the extensive research being conducted to produce inexpensive solar cells. Tiny-film and silicon solar panels are less expensive than 1.0 and 0.5 bones per watt, respectively.—are another result of the producers' intense competition. Depending on the needs of a developing nation, solar electricity can be used for anything from private residences to massive solar farms with hundreds of solar PV units, as well as for everything from electrical cars to public utilities. The world's recurring power consumption (1.5 TW) is exceeded by 66,000 times the amount of solar energy (100 000 TW) that the planet receives. Performing a fast calculation shows that ten highly efficient solar panels covering 0.3 of the Sahara Desert's total land area could supply all of the world's electricity needs! Numerous developing countries benefit from being situated near a region that receives adequate sunlight virtually year-round. As a result, it makes sense to deploy solar photovoltaic (PV) systems in these countries to harness solar energy.[1]

2. WHY SOLAR ENERGY

One of the least carbon-intensive energy sources is solar power. For every kWh of electricity generated, concentrated solar energy releases 38 grams of CO_2 equivalent, PV roof solar releases 41 grams, and PV utility solar releases 48 grams. In addition to having several environmental advantages, solar helps fight climate change.[2]

Solar plants do a great deal in silently removing the carbon emission from the environment, the fuels used by the solar plant is renewable solar energy, which is available in abundance. Also, this source of energy is nonpolluting and does not emit any carbon. A small plant of size 10 kilowatt can reduce carbon emissions of 250 metric ton on an average one kilowatt of solar plant reduces26 metric ton of carbon emission from the environment. An average life of a solar plant is 25 years so 1kWp solar plant produces approximately 29000 units in 25 years. 1 unit of electricity from coal creates 0.9 kg of carbon emission. So, to produce 29000 units of electricity it would lead to carbon emission of 26100kg or 26MT. 1kWp solar plant contributes equivalent to 70 trees. From the above fig we came to know that 70 trees would be required to absorb the carbon emission.

Figure 2. Calculations

Average generation for a solar plant range's from 1100 to 1300 per kWp per year. Approximately 100 sq feet or 10 sq Mtrs Area is required for 1kWp. For a plant of, an area 0f 1000sq feet or 100 sq Mtrs would be required. Average period of Return on Investment (ROI) for the solar plant is approximately 4-5 years. It depends upon Electricity Tariff (higher the tariff, more the savings and lower would-be ROI period, could be 3 years also). If tariff is INR 10 then ROI goes to 4 years whereas if Tariff is INR-6 then ROI goes to 7 years.

A. SIZING OF THE SOLAR POWER PLANT

On an average the total consumption of a house goes to 14300 units. Thus, average generation per kWp goes to 1300 so, the size of plant equals total annual consumption/ average generation per kWp therefore, the size of the plant 14300/1300 = 11 kWp. Average area requirement per kWp = 10 sq Mtrs. Required Area size = plant size x Avg Area Requirement therefore, the required area = 11x10 = 110 sq Mtrs

B. BENEFITS AND RETURN ON INVESTMENT (ROI)

Reduction in Electricity Bills -- Since offsetting of generated solar power is against the highest tariff, energy bills are reduced significantly. As per present commercial tariff, electricity unit rate ranges from 8 Rupees to 11 Rupees.

Independence from increasing tariff -- Installed capacity of the Solar system would keep on producing the required power without any increase in cost for the next 25 years. However, discom tariffs would increase many times leading to very high tariff rates.

True Investment -- Investments made in Solar system are yielding far better returns than the average returns available with general saving means. Investment is always within your control too!

Net Metering -- Export of all the excess generated units to the Grid resulting in reduction in next bill. Therefore, no power will be wasted. Generated power will be used first & excessive power will be exported to grid and the same shall get credited into your account.
Accelerated Depreciation - Benefits of accelerated depreciation @ 40% results in 10% savings in the taxation amount.

Blue Dot - Earth protection -- Solar system helps in saving environment in significant way. Each1 kW of solar power system helps in reducing 26 ton of CO2 emissions which is equivalent of putting up 70 trees.

ROI CALCULATIONS (Self Capital) (Plant Size- 10 kWp)	
COST OF PLANT (in Rupees)	5,20,000
COST OF ELECTRICITY UNIT FROM DISCOM (In Rupees)	10
SIZE OF SOLAR POWER PLANT (in KW)	10
ANNUAL POWER GENERATION (in kWH) (1300 *10)	13,000
ANNUAL POWER SAVINGS (13,000*10)	1,30,000
ROI PERIOD (5,20,000/1,30,000) = 4 Years	4

Figure 3. Calculations

So, it is clear from the above that the initial cost of INR 5,20,000 in the Solar plant is recovered in a period of 4 years. After 4 years, the electricity from the solar plant is free.

C. ROIWITH EMI AND LOAN.

ROI CALCULATIONS WITH LOAN EMI (Plant Size- 10 kWp, Investment- 5.2 Lakh Rupees)	
ANNUAL GENERATION FROM 1 KW SOLAR PLANT(in kWH)	1,300
COST OF ELECTRICITY UNIT FROM DISCOM (In Rupees)	10
SIZE OF SOLAR POWER PLANT (in KW)	10
COST OF PLANT (in Rupees)	5,20,000
ANNUAL POWER GENERATION (in kWH) (1300 *10)	13,000
ANNUAL POWER SAVINGS (13,000*10)	1,30,000
MONTHLY SAVINGS (1,30,000/12)	10,833
LOAN PARTICULARS	
LOAN AVAILABLE FROM THE BANKS (75% of PROJECT COST)	3,90,000
LOAN DURATION (IN YEARS)	4
MONTHLY EMI (IN RUPEES)	10080

Figure 4. Calculations

$$\text{ROI Period} = \frac{\text{Initial Capital}}{\text{Saving of Each Year}}$$

$$\text{ROI Period} = \frac{5{,}20{,}000}{1{,}30{,}000}$$

$$\text{ROI Period} = \text{4 Years}$$

Thus, it is clear from the above that Solar plant itself pays for the EMI and after 4 years the electricity from the solar plant is free. Interesting to note here the power of Solar Energy (post the payback period, self-investment of 1,30,000 is getting a return of 10,833 which is approximately 9% per month).

D. CARBON FOOTPRINT

The entire amount of greenhouse gas emissions emitted into the atmosphere is known as the carbon footprint. The daily operations of a single person, business, or country are the source of these emissions. The unit of measurement is carbon dioxide emissions (CO2).

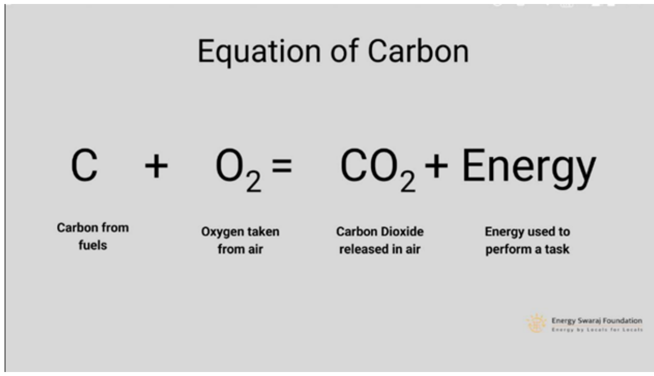

Figure 4. Equation of Carbon [15]

Given below are the carbon emissions done by different power generation methods.

- **CO2 emission due to power generation by coal for1 unit electricity is about 1 kg of CO2 equivalent**
- **CO2 emission due to petrol / diesel 1 liter is about 3 kg of CO2 equivalent**
- **CO2 emission due to LPG 1 kg of LPG is about 3 kg of CO2 equivalent**

Now let us calculate the carbon emission done by a person
Monthly CO2 Emission of a person
1 Liter Petrol = 3 kg of CO2 therefore 10 Liter Petrol is about 30 kg of CO2 equivalent
1 Unit Electricity = 1 kg of CO2 therefore 200 Unit Electricity is about 200 kg of CO2
1 kg LPG = 3 kg of CO2 14 kg therefore LPG is about 42 kg CO_2 equivalent.

Thus, total GHG emission is 30+200+42 which gives a total of 272 kg of CO2 equivalent. And calculating for 1 year it gives a total of 3,264 kg of CO2. So, if we shift to solar energy and reduce this value by half it will **give a good impact and will** be a good gift from us to our mother earth.

Figure 5. Solar

3. SOLAR ENERGY

The electromagnetic radiation that the sun emits is commonly referred to as solar radiation. While solar radiation reaches different parts of the Earth at different times, the majority of the planet experiences some solar radiation at any one moment. These sun beams are captured by solar cells, which then convert them to energy. The form of heat and radiation is one of the energy components called solar energy. displayed in Figure. Technologies that harness solar energy are continually expanding and evolving. Some examples of these technologies are artificial photosynthesis, solar armatures, solar thermal energy, molten swab power factories, and solar radiation and heat. Solar power is a very attractive source of electricity due to its vast amount of available power. The water, shadows, and land masses absorb the remaining solar radiation, sending the remaining thirty (about) watts back into space.

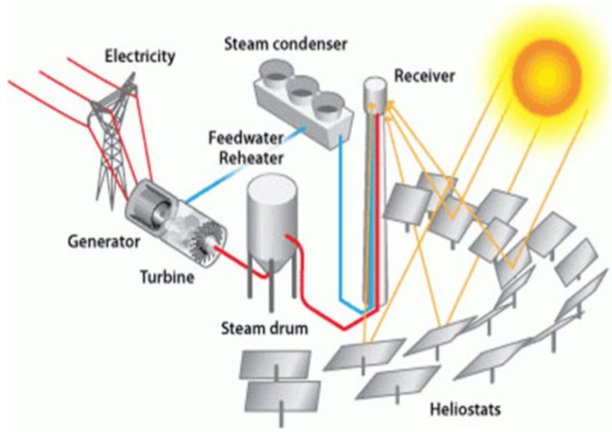

Figure 6. Internal Solar Energy Reaction [5]

A. TYPES OF SOLAR ENERGY TECHNOLOGIES

Currently, solar energy technologies can be broadly classified into two categories: photovoltaics (PV) and concentrating solar-thermal power (CSP).

1. PHOTOVOLTAICS BASICS

Because PV is used in solar panels, we are actually rather familiar with it. Solar panels absorb solar energy when it strikes them because they include photovoltaic cells. After solar energy is generated, electrical charges are created and move in reaction to the cell's internal electrical field, which is what generates electrical current.

Sunshine is made up of photons, or solar energy particles. varied photons have varied amounts of energy, and they react differently to different wavelengths in the solar spectrum.

Semiconductors are the parts that make up a PV cell. In a photovoltaic cell, photons from the sun can either absorb by the semiconductor material or travel through the cell and bounce back. The energy needed to generate electricity is only found in the absorbed photons. A semiconductor substance that receives enough solar light experiences electron loss in its atoms. Owing to specific surface treatment during manufacturing, the front face of the cell is more inert toward the extracted, or free, electrons, enabling them to flow toward the cell's surface on their own.

2. FOCUSING ON FUNDAMENTALS OF SOLAR-THERMAL POWER

In CSP systems, light is reflected from mirrors and focussed onto a receiver. The high-temperature fluid within the receiver is heated by the concentrated sunlight.

An engine or turbine that produces electricity can be powered by this heat, also referred to as thermal energy. Other industrial uses for it include food processing, chemical manufacturing, mineral processing, water desalination, and increased oil recovery.

Usually seen in utility-scale projects, hybrid power systems integrate solar and thermal energy. These CSP systems at utility scale have multiple configuration possibilities. Systems using power towers have a central tower serving as the receiver surrounded by a collection of mirrors. Solar radiation is directed by rows of mirrors above onto parallel tube receivers in linear systems.

In locations where electricity is required, smaller CSP

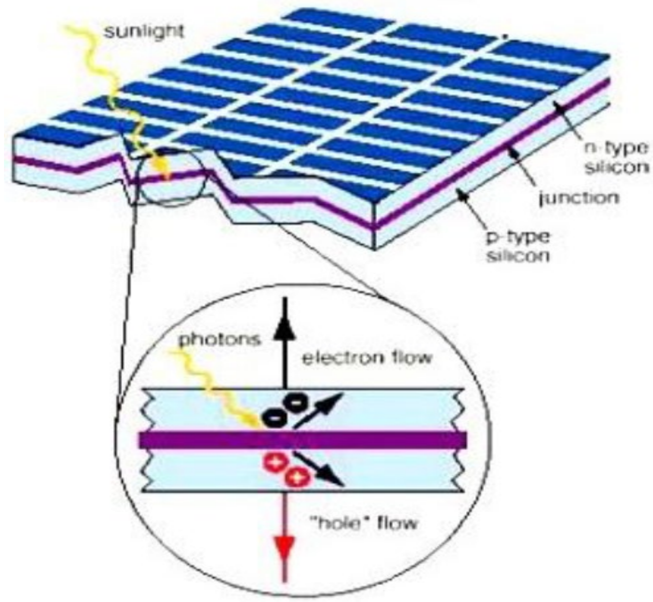

Figure 7. Photo Voltaic Cell [16]

systems can be built. To give an example, for distributed applications, single engine systems can generate 5 to 25 kW of power per dish.

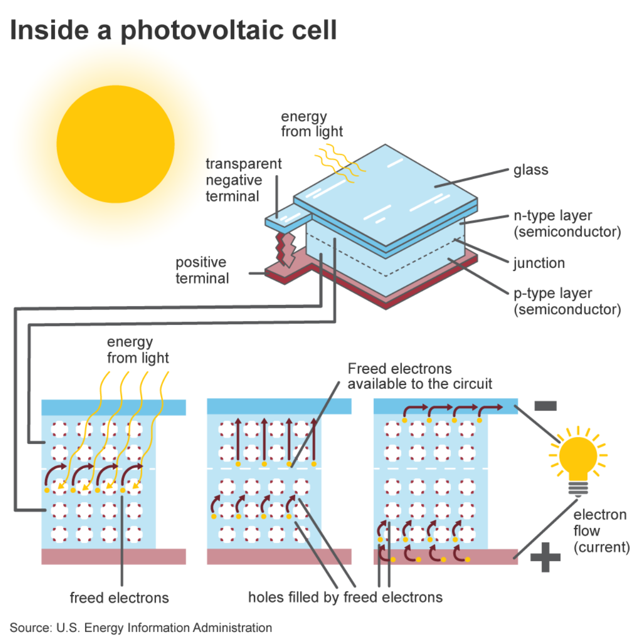

Figure 8. System of Power generation from solar energy [9]

B. INSTALLED SOLAR ENERGY CAPACITY.

Mirrors driven by solar energy have been around since the dawn of time, roughly speaking, in the seventh century. Years later, once the photovoltaic (PV) effect was discovered in 1893, scientists created this energy-producing technique. Solar thermal and solar photovoltaic energy technology are the two main applications of solar energy technology, which have been the subject of years of research and development by experts all over the world. [6]

Solar power is converted into electrical power by PV systems using solar panels. These photovoltaic systems have become because to their extensive deployment, the most economical method of producing fresh electricity in numerous locations across the globe. Since then, solar photovoltaics (PV) has become a vital component of the low-carbon sustainable energy system required to provide predictable and reasonably priced electricity. thereby assisting in the achievement of the 2030 Sustainable Development Goals and the Paris Climate Agreement.

The substantial volume additions in 2020 and 2021 were mostly responsible for China's 38% share of the growth in solar PV power in 2021. Within the generation growth, the United States accounted for the second-highest percentage (17%), followed by the European Union (10%). In 2021, solar photovoltaics (PV) demonstrated resilience amidst Covid-19 problems, supply chain delays, and product price increases, achieving yet another record-breaking year capacity increase of about 190 GW. This should therefore cause the growth in power generation to pick up even more speed in 2022. [7]

However, from the current 1 000 TWh, As per the Net Zero Scenario, solar PV generation should decrease to approximately 7,400 TWh by 2030, requiring an average annual generation rise of about 25% between 2022 and 2030. As the PV market expands, it will require more effort to maintain this push even though the rate of growth is comparable to the average annual growth observed during the preceding five years.

Resulting nstallations for solar PV technology are more structured than those for CSP. Thus, large-scale grid-connected photovoltaic facilities and unbiased solar PV are widely utilized in astronomy applications and around the world. The installation of solar energy across the globe is represented in Fig.

Cumulative solar PV capacity is predicted to double by 2030 compared to 2018 levels, growing at a CAGR of about 9% until 2050 [7].

4. OBSTACLES TO SOLAR ENERGY DEVELOPMENT

Since solar energy technology is still in its infancy abroad, there are significant obstacles to overcome. The challenges are organized into three categories: financial, technical, and institutional, which are listed in the table. The difficulties are:

a. The expensive expense of producing solar energy. In these situations, If India is to reach its energy ambitions, the higher efficiency devices may be essential. While thermal electricity costs have grown to 4.5/kWh with subsidies, the cost of solar energy has dropped from 18/kWh in 2011 to 7/kWh in the Indian market.
b. An insufficient infrastructure for financing solar projects will hinder the sector's growth because they require a lot of finance.
c. The variation in solar potential between states.
d. b) A poor understanding of consumers
e. Ineffective communication between government and industry cooperative efforts.
f. The absence of standards, which causes the producer and supplier to lose their market share.

CONFLICT OF INTERESTS

None.

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