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Environmental Aspects of Sustainable Development

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Abstract

The utilization of sustainable energy sources is expanding globally. Photovoltaic (PV) energy systems have received the most attention during the past ten years out of all the sustainable energy sources. The solar industry adopts a proactive lifespan analysis in order to retain these benefits and prevent further environmental impact. Compared to alternative energy generation technologies, PV technology is clearly more environmentally friendly. Solar cell decommissioning at the end of the human generation life is a problem that could have an impact on the environment. Therefore, recycling of solar cells is a workable solution. By comparing solar energy systems to conventional energy sources, there are clear environmental advantages that can help promote human activity's sustainable development. Yet, their extensive use may have unfavorable effects on the ecosystem. These possible issues appear to be a significant roadblock for the continued adoption of these systems by some consumers. *To solve these issues, an outline of an environmental impact assessment is presented in this study. Future power systems should consider the potential environmental intrusions in order to decrease them through new technical developments and moral behaviours.*

Keywords: Sustainable energy sources, PV technology, PV industry, Solar energy, Solar cell

INTRODUCTION

Due to the production of CO_2, SO_2, and NO_2 by fossil fuel based generating stations, there are numerous environmental concerns today. Acid rain and global warming are both results of this environmental damage [1]. On the other hand, conventional synchronous machine-based power generation systems are regarded to be less economical and more polluting than renewable energy (RE) generation systems. Governments and various organizations are thus compelled to enhance the generation of RE in order to replace fossil fuel-based electricity generation. Figure 1 depicts, in accordance with the International Renewable Energy Agency's [2] strategy for global RE integration until 2030. By 2030, it is expected that sustainable energy sources could supply 36% of the world's total energy consumption. The primary energy sources for producing RE include the sun, wind, tide, waves, and geothermal heat. Solar and wind arrangements are the most favourable of these sources due to their reduced production costs and ability to maintain their peak power point despite a broad scope of wind and sunshine fluctuations [3]. According to Figure 2, more money was spent up until 2009 on the creation of electricity from solar and wind energy sources. According to [4] and [5], this scenario was really reversed. Figure 3 shows the gigawatts (GW) of power generated globally by wind and solar.

Due to the probabilistic characteristics of power generation, the maximum range of incorporation of RE into the usefulness grid may cause problems about the stable and dependable functioning of the system [6].

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Variable sunlight irradiance and consistent wind speed are the causes of this. The irregular and unforeseeable property of sustainable energy sources may be adequately represented in order to decrease the detrimental effects on the steady operation of the system. This literature presents numerous techniques for upcoming development of sustainable energy [7–9].

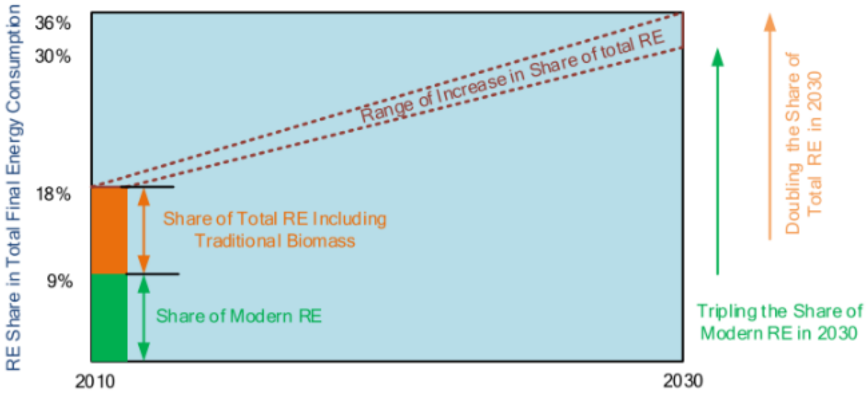

Figure 1. An estimation of the schedule for achieving renewable energy output by 2030.

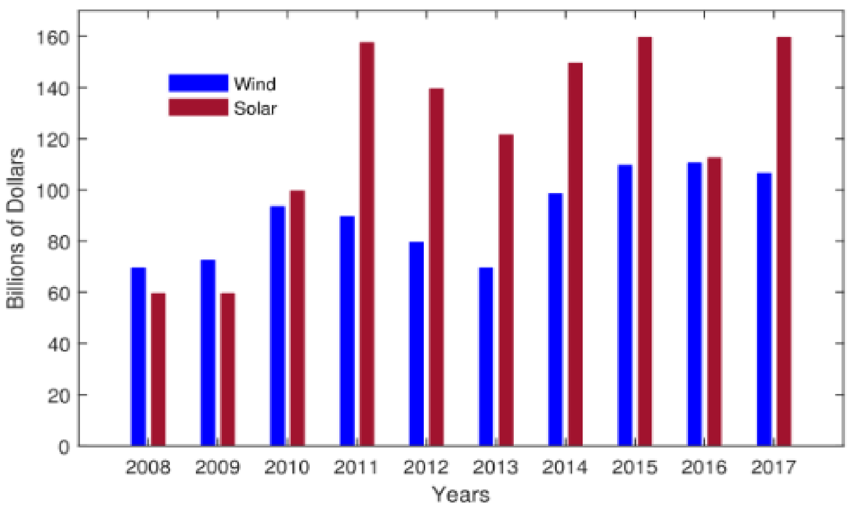

Figure 2. Worldwide financial support for renewable energy sources.

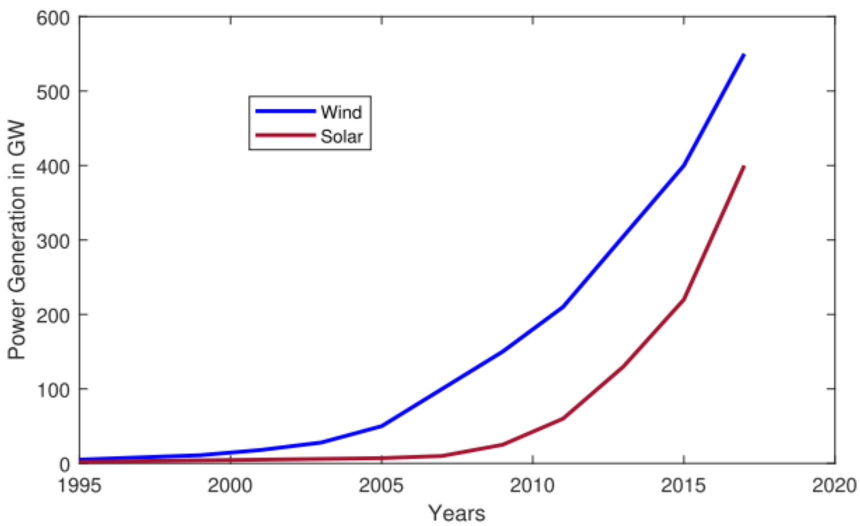

Figure 3. Global production of power from wind and solar.

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In the past 20 years, photovoltaic (PV) energy has been employed for remote applications at central power plants, making it a sustainable and adaptable energy source. The photovoltaic (PV) sector has developed a proactive and long-term approach to maintaining the industry's environmental friendliness. In order to better understand the health, safety, and environmental (HSE) concerns associated with the production of solar panels, the US Department of Energy's National Photovoltaic Programme performed various studies at Brookhaven National Laboratory [10]. The decommissioning of PV modules is one of the major issue after they have served their purpose. A module will need to be deactivated, disposed of, or used in other ways after its anticipated lifetime of 30 years.

SOLAR PHOTOVOLTAIC (PV) SYSTEMS

The atmosphere limits the direct solar energy received by the earth's surface, which on a clear day amount to 1366 W/m^2, to a peak normal surface radiation of roughly 1000 W/m^2. Due to its reliability and technological advantages over other renewable energy sources as well as its major environmental advantages over conventional sources, the sun is now a large and trustworthy source of energy generation in the area of focus. A solar-PV system typically includes arrays and combinations of PV panels, a charge controller (DC to DC), a converter from DC to AC, a power meter, a breaker, and, most crucially, a battery or arrangement of batteries, according to the volume of the mechanism. In several applications, notably those off the grid, PV showed encouraging results [11]. Figure 4 displays the general diagram of a PV network. The charge controller and battery work together to manage the DC output of the PV panel. A (DC/AC) inverter is used to convert the battery's energy to AC as necessary, or it can be used to directly power a DC load. The electricity flow feeding the load is measured and recorded using a power meter.

A survey of the literature on the development of converter-based microgrids is used to support the extensive list of difficulties and opportunities presented in this research. This paper's topic is aimed at building microgrids as an alternative to the current distribution networks.

A solar cell is a type of electronic device that turns sunlight directly into electricity. A current and a voltage are created by light striking the solar cell to create electricity. First, a substance in which light absorption lifts an electron to a higher energy state is needed, and then the higher energy electron needs to be moved from the solar cell onto an external circuit. After losing its energy in the external circuit, the electron returns to the solar cell. The requirements for photovoltaic energy conversion can be met by a variety of materials and methods, but, almost all photovoltaic energy conversion uses semiconductor materials in the form of a p-n junction.

PV systems are more cost-effective in the long run and produce fewer greenhouse gas (GHG) emissions when operating than other conventional and sustainable energy sources. The PV system is less environmentally friendly because some production procedures continue to use fossil fuels.

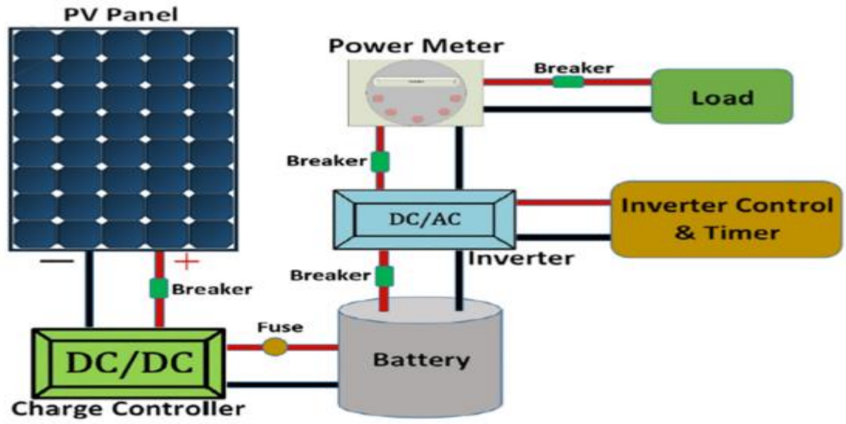

Figure 4. Solar-PV system's basic diagram.

Different solar photovoltaic (PV) technologies use different materials, have different production processes, and have different electrical requirements. The effectiveness of the system can also be altered by the use of one of the various installation strategies that vary with the present condition of the site. They can be found in great quantities and serve multiple purposes. As seen in Figure 5, the capacity of installed PV solar systems in different countries has also increased at an exponential rate.

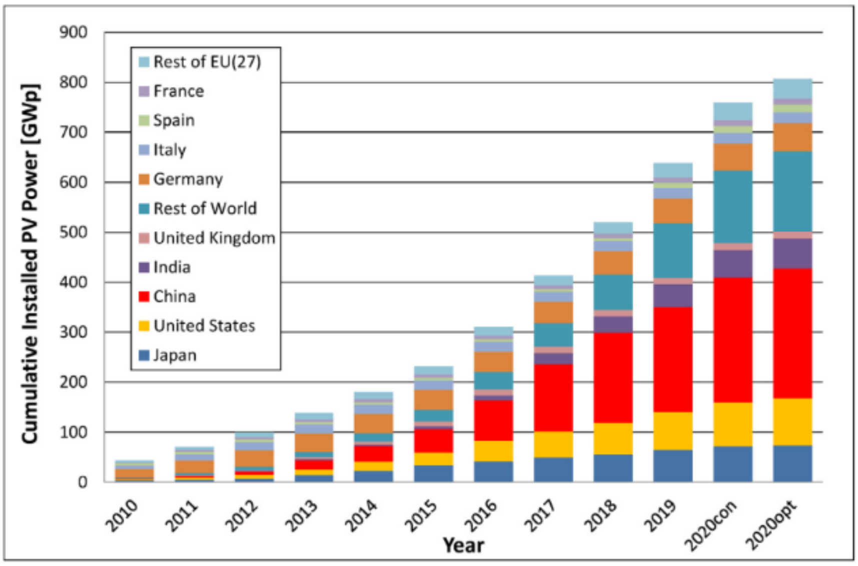

Figure 5. Gigawatts of global solar power expansion.

TYPES OF PHOTOVOLTAIC CELLS

An improved manufacturing process and higher cell efficiencies will help bring down the price of solar photovoltaics as a whole. The materials used to create solar cells can have one or more layers, and are designed to absorb light at various wavelengths. The different solar cell technologies and the materials utilized are used to classify PV systems. There are three primary generations used to categorize solar cells. They are the first, second, and third generations [12]. The advantages and disadvantages of the different solar cell types subject to the different generation kinds are listed in Table 1.

Table 1. The advantages and disadvantages of different types of solar cells.

First-generation photovoltaic cells				
S.N.	**Solar cells' category**	**Efficiency**	**Advantages**	**Disadvantages**
1	Single crystalline silicon (sc – Si)	- On a lab scale, 25% to 27% - Business effectiveness, 16–22% - Bandwidth among 1.11 and 1.15 eV	High efficiency	Production needs time and uses limited, expensive materials.
2	Multi – crystalline silicon (mc-Si)	- On a lab scale, 15% to 18%. - Bandwidth is 1.11 eV	Perfect for lowering the market price for a solar panel	In comparison to sc-Si cells, efficiency is lesser
Second generation photovoltaic cells				
3	Amorphous silicon (a – Si)	- Business effectiveness, 8% - On a lab scale, effectiveness can reach 12%	Low cost on the marketplace	Thinner cells absorb less solar light
4	Gallium arsenide (GaAs)	- On a lab scale, efficiency is 29% - Bandgap is 1.43 eV	Compared to silicone ones, they are less thick and have a high efficiency	Costly

Third generation photovoltaic cells				
5	Perovskite solar cells (PSC)	19–22%	Superior effectiveness. Less expensive to produce than silicone varieties	When exposed to temperature, snowfall, dampness, etc., can readily degrade
6	A dye-sensitized solar cell (DSSC)	Nearly 10%	Functional even under small light, can be recycled.	Frozen electrolytes cause power outages.

ECOLOGICAL EFFECTS OF A PV SCHEME'S ELEMENTS

Currently, solar power accounts for 1.7% of global energy production. Both the production methods and the materials employed have seen significant advances. But there are still some environmental issues that need to be resolved before solar energy can be used as a totally clean energy source. Manufacturing solar panels is where the majority of the environmental impact occurs. As a first step, quartz is mined and refined into metallurgical-grade silicon, a process that requires a great deal of fossil fuel. Polysilicon and liquid silicon tetrachloride are the ultimate products after further processing with hydrochloric acid. About three to four tonnes of these toxic waste products are produced for every tonne of polysilicon that is produced.

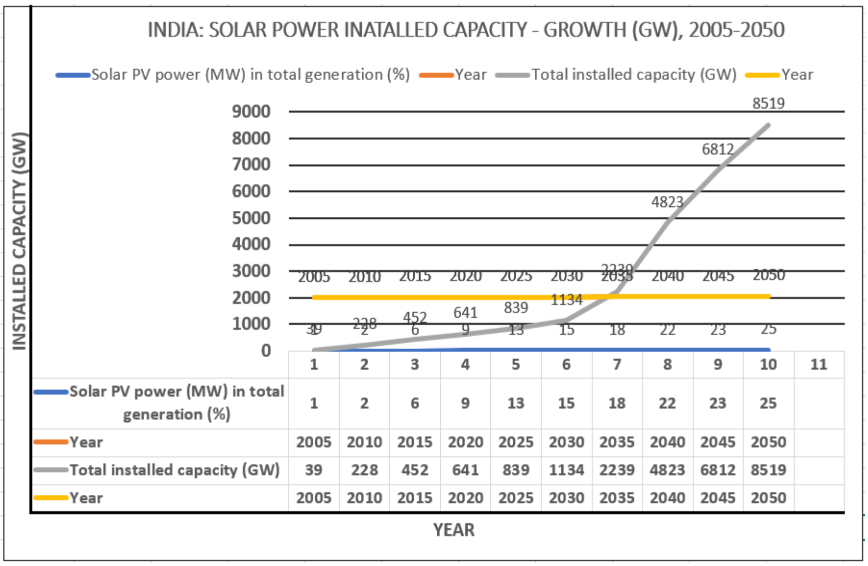

Figure 6. Present and future solar power generation in India.

The ambitious target set by the Indian government is to produce 175 GW of clean energy by 2022. A variety of sources contribute to India's estimated 900 GW renewable energy potential, including solar energy (750 GW), wind energy (mast height of eighty meters), bio energy (25 GW), and small hydropower (20 GW), when the nation's 3% wasteland is taken into consideration. Due to the above-mentioned reasons, solar energy has emerged as a significant source of green energy between sustainable energy sources. This progress will change the course of history for the country's growth and take the Indian power industry to new heights. Figure 6 depicts the generation of solar energy in India in both the existing and the future. India's power generating capacity is anticipated to rise by 1134 GW by 2030 and by 8519 GW by 2050. With an estimated installed solar power capacity of 750 GW, India has significant solar energy potential according to Ministry of New and Renewable Energy (MNRE), 2017. This is due to the nation's demographics. For that reason, solar energy will supply all of the country's energy requirements.

CONCLUSIONS

In order to keep solar cells environmentally friendly, the PV industry employs a proactive, long-term environmental approach. This method is being applied as researchers look at recycling possibilities for manufacturing waste and used solar cells. According to the current study, such recycling is technically and financially possible with cautious preparation. In order to create a recycling programme, new recycling technology was combined with the collection and reprocessing infrastructure that is already in place. Metal smelting and refining firms may be able to recover the majority of the metals from outdated solar panels by integrating them into their production streams. The glass is used in these facilities as a fluxing agent, and they are able to recover the metals from massive centralised applications. The financial aspects of product reprocessing and garbage disposal, logistics, and ecological disposition and garbage management rules all have an impact on the justification for and viability of recycling.

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