# SOLAR PHOTOVOLTAIC CELLS: AN ENVIRONMENTAL IMPACT

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**Accepted**: 03.06.2022 **Published**: 01.07.2022

**Keywords**: Solar Panels, Carbon, Photovoltaic Cells, Renewable Energy, Technology Assessments.

## Abstract

*Carbon dioxide, nitrogen, sulphur, and other particles are released at high rates and end up in the atmosphere. Human activities are the source of these emissions. This research contributes to a reappraisal of the impact that solar panel installation can have on greenhouse gas emissions. Our research examined the different functions of solar panels. Generally speaking, photovoltaic cells are used to construct solar panels. The amount of carbon dioxide gas released into the atmosphere by your utility company in order to create one kilowatt-hour of energy is decreased by a solar photovoltaic (PV) system. A solar panel system may generate enough electricity to power a whole home, and it produces around 75 percent less carbon dioxide than conventional power plants do. In this article, I compared several solar panel systems and discussed how they use various technologies to reduce carbon emissions.*

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## 1. Introduction

In an increasingly carbon-constrained environment, solar energy sources stand out as among the least carbon-intensive ways to generate electricity. Energy needs around the world can only be met by burning fossil fuels. However, countries are moving their focus toward non-renewable energy sources in order to minimise their CO2 emissions and comply with the Kyoto pact. When compared to other RES, solar energy has the best combination of economic viability and environmental friendliness (J.G.J. Olivier et al., 2017). Therefore, solar photovoltaic (SPV) systems are suitable for meeting the rising need for energy and helping to keep the air clean (Tiwari, P., et al., 2009).

When compared to fossil fuels, solar energy has a lesser carbon impact from birth to death, according to life-cycle analyses. Urban solar power generation is an undeniable strategy for lessening our dependency on fossil fuels and cutting down on greenhouse gas emissions to slow the pace of climate change. But how do solar panels impact the natural world? Parameterizing their effects within the surface schemes of atmospheric models is required before studying how they affect the weather in urban areas (Valery M. et al., 2014).

*Solar Panels*

Photovoltaic solar cells are used in today's solar panel production. In order to harness the sun's rays directly, PV devices make use of an electronic process that occurs naturally in specific materials. Photovoltaic effect is the scientific name for this phenomenon. Modules and arrays of PV cells are constructed. These are capable of supplying energy to a wide range of electrical appliances. As a potential source of low-carbon energy, solar PV has yet to be fully realised. Thin film technologies have energy payback times of 1 to 1.5 years in South European locations, while crystalline silicon PV systems have payback times of 1.5 to 2 years in South European locations and 2.7 to 3.5 years in Middle European locations, as shown in a paper published by Brookhaven National Laboratory, Utrecht University, and the Netherlands Energy Research Center in 2006. (Rhone, R. 2007).

Using solar panels results in more greenhouse gases being released into the atmosphere, which speeds up global warming. Intensifying heat from greenhouse gas emissions has altered global precipitation patterns, increased ocean temperatures, and accelerated the melting of glaciers (Ibrahim 2000, Hughes 2000). Eighty percent of all emissions of greenhouse gases that contribute to global warming may be traced back to carbon (Lashof and Ahuja, 1990). And more than half of all projected climate change in the future will be caused by carbon dioxide (Vitousek, 1994). Since the beginning of the industrial era, carbon dioxide emissions have been on the rise due to various factors, the most significant of which are the rising need for power and the burning of fossil fuels to meet that demand (Lenton 2003). Carbon dioxide emissions are predicted to keep rising as the world's energy needs meet a 1.5–3 times rise by 2050. (Ibrahim 2000). Since rising carbon emissions have become such a major issue, the need to curb their production has grown. Many nations are passing legislation to facilitate this cutback.

Light is captured by a semiconductor, which subsequently generates an electric current in the process of photovoltaic solar energy conversion. This power can be used either directly, by feeding it into the grid, or indirectly, by charging a battery. A typical photovoltaic (PV) system includes PV modules ranging in size from 0.5 to 1 m2, as well as electronic components used to regulate output, mounting structures, power cables, and an inverter to convert DC from the panels to AC for usage in the home. In almost all cases, silicon is used to make semiconductor modules. All that's left are what we call "systems balancing" parts (BoS). The ability to operate without being connected to the grid necessitates the use of batteries. In some cases, an AC-to-DC converter could be superfluous. The peak wattage (Wp) rating of a PV panel or system is the amount of energy it produces when tested under standard laboratory conditions (1000 Wm-2). The peak watts of a PV system indicate its power output (Wp). These weather conditions are typical of a warm and pleasant summer day. Power output from a PV system is reported in yearly watt hours (Wh). Based on the system's capability and the amount of annual average irradiation at the site, this much electricity can be generated. As a result of daily and seasonal changes in available sunshine and the duration of periods of darkness, the actual average power output of any given system is typically far lower than the Wp rating. This occurs due to the fact that the amount of sunlight entering the system changes..

**2. Renewable Energy Technology with Solar Resources**

Renewable energy is a technique that generates electricity using renewable resources like wind, sun, and biomass. This type of energy generation is an option that can be considered for producing clean electricity in order to meet energy needs (De Vries et al. 2007). Reduced carbon emissions are one way that switching to renewable energy sources can help slow the rate at which the planet is warming. One way to use renewable technology is to place solar panels on homes and flats; a standard solar system can provide enough energy for a single family (Pearce 2002).

Developing nations are looking at alternatives due of climate change, emissions of greenhouse gases, fluctuating oil prices, and rising electricity needs (O. Peter, and C. Mbohwa, 2019). Therefore, the current energy structure and the direction that energy development is heading have an effect on renewable energy, which is an important component. "Limitations in the ability to transport energy have led to widespread use of solar power as a renewable energy source (Thomas B., 1993). Lower carbon emissions, better air, and the possibility to manufacture power again during our lifetimes are just a few of the many advantages solar energy offers over fossil fuels like coal and oil (H. Soonmin, 2018). The current global situation has resulted in a surge in the consumption of power. Consequently, a lot of work has gone into developing solar energy technologies in the hopes of reaching a high level of efficiency with a low investment cost and a low environmental impact (H. Soonmin, 2018).

For remote places, such as those in the mountains, where it can take days to travel to the nearest power plant, solar hybrid power systems are often the most viable solution. The unpredictable and unstable nature of solar energy means that it can't be relied on for reliable 24/7 power generation (Thomas B., 1993). Because each community's culture dictates how its members should divide up the world's limited natural resources, this form of solar power can't be used everywhere (J. Mohtasham, 2015). Solar power plants may not be able to compete with the potential output of fossil fuel-based thermal oil and coal power plants. Solar power generation has substantial upfront expenditures that society as a whole must shoulder. When these factors are considered together, it's obvious that new ideas in the field of solar energy are needed to assist it overcome its issues and shortcomings in order to fulfil the growing need for energy around the world.

Global primary energy consumption was estimated to be around 160310 million MWh in 2014, with projections showing that this figure will climb to 240318 million MWh by 2040. For example: (Thomas T.D. Tran, 2017). In 2010, renewable energy accounted for around 20% of total power generation; by 2035, that number is predicted to rise to about 31% of total electricity generation. The source is (M. A. Islam, 2014). 57% of the world's electricity will be generated by renewables by 2025, according to the International Energy Agency's scenario for a sustainable future (M. A. Islam, 2014). Achieving the objective calls for meticulous preparation and study over a long time frame (D. NchelatebeNkwetta et al., 2012). Across the globe, the usage of solar energy to generate power is on the rise (F.R. Pazheri., 2014). Technology for the provision of solar energy should be supported and improved because the production of conventional energy is linked to a variety of unfavourable and irreversible externalities (S. Abolhosseini, 2014). Massive investments and technological advancements in recent years have allowed countries to produce solar energy at cheaper cost (S. Abolhosseini, 2014).

Using organic materials for solar photovoltaic cells has a number of benefits, including lower production costs and less environmental damage, as stated by Thomas T.D. Tran (2017). By definition, typical solar cell models cannot produce power when there is no sunlight. On the other hand, Ronald J.'s (2000) anti-solar cell concept will soon make it possible to generate power at night without the use of solar panels. As such, this article's primary objective is to provide a succinct overview of the development of solar energy technology.

Energy generation from the sun is less efficient than that from nonrenewable sources. This is one of solar energy's biggest drawbacks. Solar power plants are less likely to be built than nuclear or fossil fuel-based power plants, which means they will be used to generate more electricity. To overcome this challenge, maximise efficiency, and meet the increasing demand for energy in the future, innovations and research projects should be conducted in the field of solar energy. As you can see, this is not a simple solution. Researchers must invest a sizable sum up front and spend time learning about cutting-edge technologies in order to perform their researches. We can make the world a better place to live by minimising the environmental challenges caused by nonrenewable technology, but only if we invest in solar energy research and development. Second and third-generation improvements to the technology behind solar electricity are currently being developed. Additional studies have been conducted on the possibility of using nanomaterials in solar technology. Because silicon is the principal component, traditional solar panels can only absorb a small fraction of the sun's whole spectrum. However, the efficiency of a solar cell can be improved by using a multi-junction solar cell, which can extract the entire visible light spectrum. Hybrid solar power systems, like those that combine solar panels with wind turbines or solar panels with biomass generators, can produce electricity even on cloudy days and at night.

## 3. Benefits for Solar Panels with Technology Assessment

The United States military might benefit greatly from the use of solar panels. When used in place of fossil fuels in combustion processes, solar energy can help reduce emissions of greenhouse gases and other air pollutants caused by human activities. Sunlight is a completely cost-free resource that we may take advantage of. Therefore, once installed, solar systems have low ongoing expenses and little if any additional materials or maintenance needs. This hedges against the risks associated with conventional fuel supply outages and price fluctuations. Additionally, expanding the domestic solar energy sector has the potential to make the United States a global leader in the advancement of solar technology, hence increasing the number of available solar-related employment.

Despite these benefits, solar panels now meet only a fraction of energy needs in the United States. Historically, the cost of solar energy has been higher than that of other forms of energy, which is a major factor in its underutilization. The cost of solar power is beginning to rival that of more conventional energy sources in many regions of the United States and the world. In addition, the knowledge gathered by solar power system manufacturers and developers, utility companies, and regulatory authorities has decreased the time and cost required to construct a fully functional solar power system. Research and development (R&D) has played a role, and the growth of the solar industry in the United States and around the world has also contributed to these developments (DOE, 2012). With increased and well-coordinated effort, solar energy technologies may become competitive with traditional electricity generation methods in the United States within the next decade. By some estimates, the price of installing a solar energy system has dropped by as much as half since 2010. The average price of a solar module has dropped dramatically since then, from $2.08/W to just $0.66/W. (2015) Several researchers (D. Feldman et al. Due to improvements in photovoltaics (PV), concentrating solar power (CSP), systems integration, technology to market, and soft costs, the installation of solar panels will become more affordable, allowing for a greater penetration of solar energy into the grid. Besides improving the ecology and the climate, solar panels also reduce carbon emissions.

Big satellite dishes are used as a model for the curved mirrors that cover the engines in a Dish-Stirling propulsion system. A Stirling engine's pistons are driven by liquid hydrogen heated by the curved reflectors. Straight mirror rows run conventional steam turbines. Among the most important technologies for concentrated solar power are dish-stirring engine systems. Concentrated solar power (CSP) systems can look like anything from a trough to a mirror array (CSP). CSP systems are suitable for reducing greenhouse gases (GHG) and other pollutants without posing any new environmental concerns or pollution, as shown by a lifecycle analysis of their emissions and impacts on the land surface. In particular, their suitability for lowering emissions of greenhouse gases (GHGs) and other pollutants demonstrates its value. Combining a study of the impacts on the land surface with a life-cycle analysis of the ensuing emissions led to this conclusion. For every megawatt hour of solar thermal power capacity, carbon dioxide emissions are reduced by 600 kilogrammes, as reported by the European Solar Thermal Industry Association. That's a yearly weight loss prevention of 600 kilogrammes. The estimated payback period for CSP systems is five months, which is quite favourable when compared to their 25-30 year lifespan (Rhone R., 2007).

**4. Carbon Reduction due to Solar Panels**

Recent growth in photovoltaic (PV) usage (about 40% annually) and PV cost (about 20% for every doubling of capacity) have shown that solar power can provide on a large scale. Carbon dioxide (CO2) emissions from the burning of fossil fuels around the world would be greatly diminished if this were to occur. This goal is not only realistic but also ambitious because the rate of installed capacity development needed to attain it is far lower than the actual average growth rate observed over the past two decades. In a society striving for minimal carbon emissions, the ability of energy networks to manage the resulting supply uncertainty will be the key barrier to achieving such high penetration levels, especially if balancing power from fossil fuels is limited. With the right amount of flexibility built into large-scale power networks, solar photovoltaics can provide a substantial amount of the world's energy needs. Therefore, energy storage and extensive power distribution networks have emerged as necessary complements to solar power (Kopp, G., and Lean, J.L.A., 2011).

The climate impact of a certain energy technology can be described in terms of the magnitude of its carbon emissions. Emissions of carbon dioxide (or carbon dioxide equivalent) per unit of energy generated are used to characterise emissions intensity. CO2eq stands for "comparable greenhouse gases," which in this case means gases besides CO2. Some of the most important include methane and nitrous oxide. A number of human activities, such as farming and the mining of fossil fuels, contribute to the emission of these gases into the atmosphere. Since they require the burning of carbon-rich fuels, the existing technologies that rely on fossil fuels produce a lot of carbon dioxide. Renewable energy sources, such as solar panels, emit virtually no harmful gases while operation but may do so during production (Figure 1). Substituting solar energy for carbon-intensive heat and power sources helps reduce emissions. Reduced emissions are directly proportional to the carbon intensity of the conventional heat or electricity that is replaced by solar energy, as well as the amount and type of energy consumed in the production, installation, and operation of solar energy systems (World Energy Outlook, 2012).

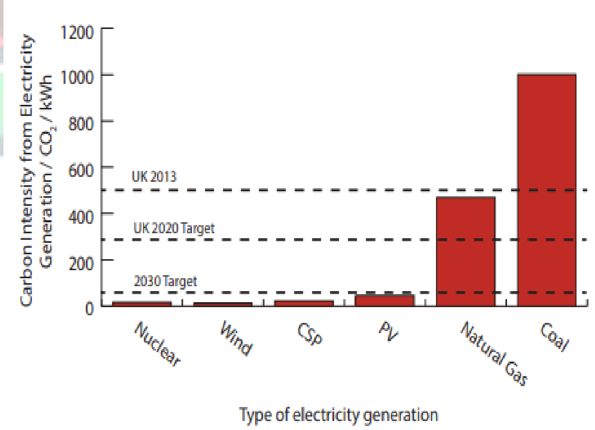


**Figure 1: Key electricity-generation technologies' carbon intensity**

Several factors contribute to the current low level of solar energy use. Historically, the high cost of solar photovoltaic technologies was a major barrier to their widespread adoption. However, thanks to significant price reductions, this technology is now quite affordable; the cost of the system is now primarily determined by the cost of the other parts of the solar panel system. Compared to alternatives with fewer carbon emissions, the private cost of fossil fuels is relatively low. This helps explain why fossil fuels are so widely used today. [Citations required] As cited in (S.R. Allen, 2010). Scaling up their use and getting the investments needed to drive down costs and encourage innovation is challenging in the absence of strong policy incentives or rules because there aren't many large-scale commercial experiences with low-carbon alternatives, and because these alternatives are all different. It has been difficult because of this to increase the usage of low-carbon options". If solar energy is to supply a large fraction of the electricity demand, further energy storage or power management techniques will be needed, even if these requirements are adhered to.

*Mitigation Potential for Carbon Emission*

It is common practise to pair a solar hot water system with a traditional backup boiler in true home solar hot water installations. Because of this, the combined system has a carbon intensity that is 100 to 200 gCO2/kWh higher than other renewable energy sources (I. Pineda, 2010). Carbon intensity of these heat sources is fairly low, ranging from 200 to 300 gCO2/kWh, thanks to the high efficiency of modern condensing gas boilers, which may convert over 90% of the calorific value of the fuel into useful heat (F. Ardente, 2005). The installation of household solar water heating systems as an alternative to more energy-efficient modern boilers is an expensive endeavour undertaken in an effort to reduce carbon emissions. Abatement costs for the solar hot water system are lower than those for an electric immersion heater powered by carbon intensive production. To reduce the expense of pollution control, solar energy systems should be used in newly constructed buildings. Also, by implementing an absorption/refrigeration cycle or a desiccant system, solar heating of water and other fluids can be used for industrial applications like food processing and desalination and, in theory, for space cooling. Some of these shows include (G. Grossman, 2002). In the summer when cooling is needed and solar heat is abundant, heat-driven refrigeration cycles may be a good compromise between the efficiency of mechanically driven systems and the need for cooling. To calculate the amount of carbon dioxide gas released into the atmosphere due to the SPV system in India, Chauray and Kandpal (2009) conducted a study. The study's authors concluded that carbon credits reduce users' financial burden by 19% and lead to decreased pollution-causing gas emissions. The CO2 mitigation potential of SPV systems suitable for usage in the home has also been calculated by Purohit (2009). This work was done in India as part of the CDM, and the maximum number of SPVs that could have been created is 97 million..

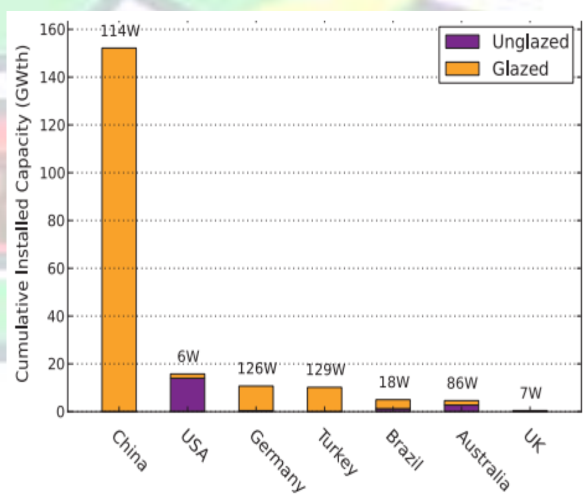


**Figure 2: Solar Power for CO2 Mitigation**

PV energy's carbon intensity varies from system to system based on the used materials and techniques and the module's performance. M. de Wild Schotten found that the CO2 emissions from c-Si, multi-crystalline silicon, and CdTe photovoltaic (PV) systems in southern Europe were 38 gCO2/kWh, 27 gCO2/kWh, and 15 gCO2/kWh, respectively (2013). These systems are manufactured all around Europe. About 5 gCO2/kWh of this is absorbed by the BoS. Concentrating photovoltaic systems, which utilise a lot of steel to construct the collectors and have a limited device surface, have a carbon intensity of 20-40 g CO2/kWh, which is comparable to that of silicon for deployment at optimal sites, as discovered by V. M. Fthenakis and H. C. Kim (2013). In every case, the renewable energy source has a carbon intensity that is significantly lower than the carbon intensity of the grid electricity it is replacing. The carbon intensity of the replaced plant will be affected by both supply and demand changes in the affected region. The regularity of power generation and the built-in thermal storage of thermodynamics lessen the demand for extra storage or flexible capacity, as well as the necessity for curtailment, in comparison to photovoltaics. Thus, the carbon intensity of power generated by CSP is between 20 and 50 gCO2/kWh (John J. et al., 2012). PV and other kinds of variable capacity may be integrated more smoothly into existing power grids if CSP were used.

Renewable energy sources, such as solar power, have the potential to reduce carbon dioxide emissions over a set period of time (often one year), but the exact amount that this can be reduced by varies widely depending on a variety of factors. One of these factors is the amount of energy that can be saved because to technological advancements. The quantity of emissions avoided depends on how much energy can be harvested from the sun during that time frame. The quantity of carbon dioxide emissions avoided may be calculated by multiplying this figure by the gap between the carbon intensity per kilowatt-hour of the power source being replaced by solar energy and the carbon intensity of the solar technology being used to make the switch. It's trickier than it seems to figure out how much carbon a certain solar technology emits. The reason for this is that the carbon intensity is not only technology and region dependant, but also generation technique. To maximise solar power's ability to cut down on greenhouse gas emissions, it's best to maximise solar power capacity, minimise carbon dioxide emissions per unit of electricity generated, and substitute solar power with higher-emitting technologies like coal or diesel power plants.

## 5. Conclusion

A major focus these days is on cutting down on carbon output. The most recent technological breakthroughs in solar panels have a considerable effect on greenhouse gas emissions. There are only a few decades left for the world to switch to a cleaner energy system. This is essential if the target of limiting the rise in Earth's average surface temperature to 2 degrees Celsius above pre-industrial levels is to be met. It is generally agreed that conventional solar-based power generation cannot be maintained over the long term due to the inefficiency and inability to store energy. That's why there are brand-new innovations appearing in every part of the globe. One of the most critical and cutting-edge answers is the production of power throughout the night. With the current state of the art in technology, solar energy technologies can provide enough energy to meet the rising demand for energy, especially when compared to nonrenewable energy technologies. Clearly, we need to keep funding R&D into the most promising new solar technologies that could lead to significant reductions in production costs or increases in overall system efficiency. Meanwhile, we must keep working to bring down prices and increase adoption of currently available solar technologies.

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