A Review Paper on Photovoltaic Solar Energy

Ashwini Kumar, Assistant Professor

Department of Engineering & IT, Arka Jain University, Jamshedpur, Jharkhand, India

Email Id- ashwini.kumar@arkajainuniversity.ac.in

ABSTRACT: ***The goal of this article is to gain a better understanding of the state of the art in photovoltaic solar energy through a systematic literature review that addresses the following topics: methods of obtaining energy, benefits and drawbacks, applications, current market, costs, and technologies, as well as what has been addressed in scientific researches published until 2016. We used a qualitative and quantitative method with a non-probabilistic sample size for this study, getting 142 articles with a slitting cut published between 1996 and 2016. According to the findings of this study, photovoltaic energy research is on the rise and may play a significant role in meeting global energy demand. To expand photovoltaic energy's involvement in the renewable energy market, it is necessary to first raise knowledge of its advantages; next increase research and development of new technologies; and last, adopt governmental policies and programs that promote solar energy production. Although crystal silicon solar cells were formerly the most common, new kinds of cells have since been created that may compete in terms of cost reduction and efficiency. Telecommunications, water pumping, public lighting, BIPV, agriculture, water heating, grain drying, water desalination, space vehicles, and satellites are the most common use.***

KEYWORDS: Cell, Energy, Environment, Photovoltaic, Solar.

1. INTRODUCTION

Human beings need more energy to produce a better living environment as their population grows and technological and economic progress accelerates. Traditional fossil fuels, on the other hand, are creating a slew of environmental issues, including climate change, global warming, air pollution, and acid rain.

As a result, the development of renewable energy technologies is critical in order to address the political, economic, and environmental problems that come with generating power. The emergence of such energies in recent years has piqued the attention of researchers, politicians, and business leaders in determining the new energy source's economic feasibility[1]–[5].

One of the most promising markets in the area of renewable energy is the capture of solar energy via photovoltaic panels in order to generate electricity. The photovoltaic market is increasingly highly contested throughout the globe, particularly in Europe, China, and the United States, due to its rapid development prospects and high levels of investment required. In Brazil, progress is beginning to be noticeable, particularly since the inclusion of solar energy in the country's energy matrix and the start of solar energy auctions at a time when the energy sector is struggling due to the reduction of hydroelectric energy, which is currently Brazil's main energy matrix, and the rise in electricity prices.

In recent years, both research and journal articles on photovoltaic solar energy have risen. This research attempts to address the following question based on what has been revealed: “How has photovoltaic solar energy been handled in scientific papers published between 1996 and 2016?” As a result, we conducted a comprehensive literature review and a structured analysis of the material published on photovoltaic solar energy[6]–[8].

Aside from the continuing introduction, the paper is divided into sections that illustrate the research technique used in the study. Following that, we will present the classification of the articles, followed by an analysis of the themes (definition, means of obtaining, advantages, disadvantages, applications, current state of the market, costs, and technologies) discussed in the analyzed pieces, and finally, we will present the theme's conclusion as well as suggestions for future research.

1.1 Classification of the papers examined:

The reading of 142 papers published between 1996 and 2016 was part of the study inquiry. The year with the most publications was 2014, which had 26 total. The year 2011 was in second place, with 15 publications.

Out of the 142 articles, the most significant was Renewable and Sustainable Energy Reviews, which accounted for approximately 22% of all publications, followed by Solar Energy, Solar Energy Materials & Solar Cells, Energy Policy, and Renewable Energy, which combined accounted for 35% of all publications.

The United States, with 26 articles, China, and Germany were the nations with the most publications on the key terms of this study. Other countries that have 87 published texts include Japan, Italy, Spain, Denmark, South Korea, Belgium, Croatia, Belgium, Lithuania, Scotland, Greece, UAE, Singapore, Spain, Australia, Australia, Brazil, India, Poland, Switzerland, Sweden, Thailand, Poland, Australia, Pakistan, Israel, Morocco, Mexico, Malaysia, Chile, Turkey, United Kingdom, and Taiwan.

According to the method, the bulk of the articles were categorized as qualitative, accounting for 59 percent of the total quantity, followed by qualitative and quantitative, and quantitative. With 75 and 58 texts, respectively, the exploratory and exploratory-descriptive categories were the most popular, followed by the explanatory classification, descriptive, and exploratory descriptive.

When we looked at the research's emphasis, we discovered that the theoretical focus received an 87 percent rating. The theoretical industrial emphasis, like the industrial focus, accounted for 6% of the texts, with the domestic focus, research center, and theoretical-domestic focus following closely behind.

In terms of the subject, 84 of the examined papers were labelled as literature research. Following that, we have laboratory research, field research, literature and field research, and literature and laboratory research texts.

1.2 Photovoltaic Solar Energy

Solar photovoltaic energy (PV) is a kind of renewable energy. Photovoltaic solar energy (PV) is one of the fastest-growing industries on the planet, and in order to keep up, new developments in material use, energy consumption to manufacture these materials, device design, manufacturing technologies, and new concepts to improve the overall efficiency of the cells have been emerging. The authors' perspectives on photovoltaic solar energy, which were consulted throughout the preliminary stages of this study.

It can be seen that the writers' definitions of photovoltaic solar energy contain words in common, such as "electricity," "solar radiation," "direct production," and "conversion." As a result, we may use the following definition of photovoltaic solar energy: electricity derived directly from the conversion of solar energy.

The photovoltaic effect, which was discovered for the first time by Becquerel in 1839, converts solar energy into electricity. This phenomenon happens in semiconductors, which have two energy bands, one of which allows the existence of electrons (valence bad) and the other of which does not, i.e., the band is entirely "empty" (conduction band). Its atoms are distinguished by the presence of four electrons that link to their neighbours to form a crystal network. Figure 1 shows the Photovoltaic cell.

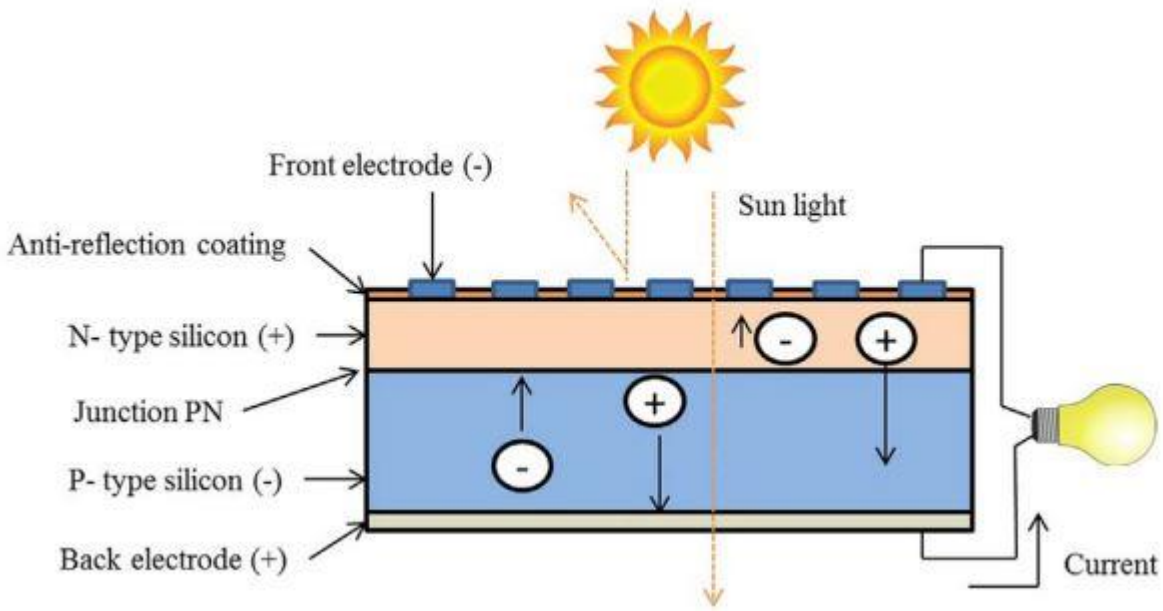

Figure 1: The above figure shows the Photovoltaic cell.

Sunlight's role in the photovoltaic effect is to provide enough energy to the outermost electron to allow him to migrate from the valence band to the conduction band in the material, resulting in the generation of electricity. In the case of silicon, 1.12 eV (electro volts) is required for electrons to surpass the GAP. Furthermore, the semiconductor material must be able to absorb a significant portion of the solar spectrum.

A PN junction in a semiconductor is present in almost all photovoltaic devices, and a photovoltaic voltage is generated by it. Solar cells or photovoltaic cells are other names for these technologies. The PN junction is the major section of the cell, where the light-receiving region is made of N-type material and the rest of the cell is made of P-type material.

Photovoltaic technology, in contrast to traditional power production sources such as those that utilize fossil fuels, does not create the severe environmental issues that these sources do during generation, such as climate change, global warming, air pollution, acid rain, and so on. Another benefit of solar energy over fossil fuels is that it does not need extraction, refinement, or transportation to the generating location, which is near to the load. However, it uses a significant amount of energy and produces greenhouse gases throughout certain phases of its life cycle (for example, the manufacture of solar cells, the assembling of photovoltaic modules, and material transportation)[9], [10].

Photovoltaic methods use 64 times more material resources, 7 times more human resources, and 10 times more capital per unit of energy generated than nuclear technologies. Although the data is skewed, it shows the severe inefficiency of PV technologies in areas with moderate sunlight in terms of achieving the objective of creating a resource-effective and efficient power delivery system. Parallel energy delivery infrastructure is required in these areas due to the intermittent nature of electricity generation.

In comparison to other renewable energy sources, photovoltaic solar energy does less harm to the environment where it is created, which is not the case with hydroelectric energy, which involves changing the flow of a river and flooding vast areas of agricultural and forest output. Another significant consideration is the cost of operation, which is higher for hydraulic power production than for solar power generation. Despite the fact that production drops on overcast days, the sun's energy is plentiful, and the amount of water in the dams is restricted during droughts. Photovoltaic solar energy is quieter than wind energy and can be produced in urban settings since panels may be placed on the roof.

Despite its limitations, photovoltaic power generating technologies may be used to build a short-term power plant that can produce many megawatts in less than a year. Photovoltaic systems, unlike highly polluting systems, do not need preliminary studies that require long-term evaluation since their environmental effects are low.

Solar plants built on both water and land are used for large-scale photovoltaic applications. Installing solar photovoltaic systems in water bodies such as seas, lakes, reservoirs, irrigation ponds, wastewater treatment facilities, vineyards, fish farms, dams, and canals may be an appealing alternative for conserving precious land and water. Floating photovoltaic solar panels offer a number of benefits over grounded solar panels, including less impediments to block sunlight, easier energy efficiency, and better power production efficiency owing to lower panel temperatures. Furthermore, the solar system helps the aquatic environment by preventing excessive evaporation of water, limiting algal development, and possibly improving water quality.

Due to the high amounts of solar radiation, installing photovoltaic plants in the desert may be one of the best locations to utilize photovoltaic solar energy. It is a feasible alternative in Chile's Atacama desert, for example, capable of contributing to the ongoing supply of sustainable energy in the country's north, as well as the stability of electricity costs, benefitting the Chilean mining sector.

1.2.1 Photovoltaic solar energy system components:

A conventional photovoltaic solar system has four fundamental components: a photovoltaic module, a charge controller, an inverter, and, if required, a battery. The photovoltaic module is made up of photovoltaic cells, or electricity-generating surfaces, that convert solar energy into electricity directly. These surfaces have no

moving components that may wear out or break down, and they operate without the need of fuel, vibrations, noise, or damage to the environment.

The charge controller's job is to keep the batteries from being fully drained or overcharged, thereby extending their usable life. The inverter is in charge of transforming the power produced by solar panels (DC – DC) to alternating current – AC voltage levels and network frequency. Batteries are used in solar systems to store the excess energy generated by the modules so that it may be utilised at night or on cloudy days. Figure 2 shows the Typical System of photovoltaic solar energy.

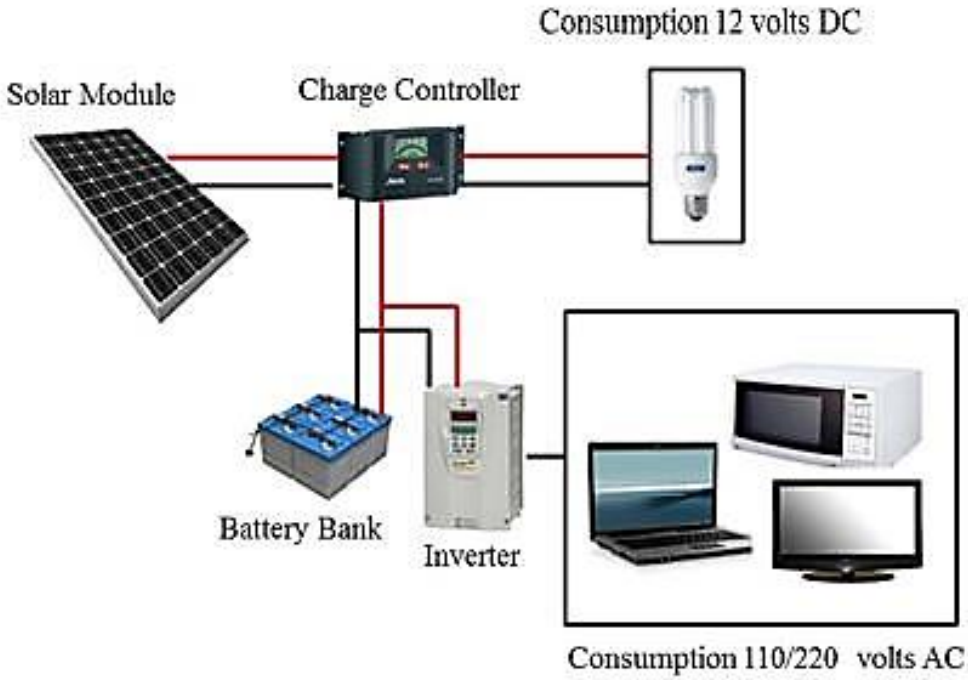

Figure 2: The above figure shows the Typical System of photovoltaic solar energy.

2. DISCUSSION

The author has discussed about the photovoltaic solar energy, in photovoltaic solar energy via a systematic literature analysis that covers the following topics: energy sources, advantages and drawbacks, applications, present market, prices, and technologies, as well as what has been covered in scientific studies published until 2016. We obtained 142 articles with a slitting cut published between 1996 and 2016 using a qualitative and quantitative approach with a non-probabilistic sample size. Photovoltaic energy research is on the increase, according to the results of this study, and may play a major part in fulfilling global energy demand. To enhance photovoltaic energy's participation in the renewable energy market, first raise awareness of its benefits, next increase research and development of new technologies, and finally implement government policies and programs that encourage solar energy production. Although crystal silicon solar cells were formerly the most prevalent, other types of cells have since been developed that can compete with them in terms of cost and efficiency.

3. CONCLUSION

The author has discussed about the photovoltaic solar energy, Photovoltaic solar energy is a renewable energy source that has been proposed as a solution to the problems of energy scarcity caused by conventional sources. The academic community showed minimal interest in this issue until the mid-2000s, based on the number of papers published on the subject. With a substantial rise in the number of published papers in the second part of the 2000s, this scenario of scientific interest began to shift. When it comes to the definition of solar photovoltaic energy, it is worth noting that the writers utilize similar words, such as "electricity," "sunlight," "direct production," and "conversion." In this paper, we propose a common understanding of these words, stating that photovoltaic solar energy is energy acquired directly from solar radiation conversion.

It has been argued in several articles, including, that global power consumption is increasing every year, and that among the various technologies competing for power generation, renewable energies, particularly photovoltaic solar technology, which has grown rapidly in recent decades and can play an important role in meeting the high demand for energy worldwide, should be highlighted. A large number of yearly solar systems built demonstrates each country's commitment and duty in saving the Earth by utilizing renewable energy. According to some articles, the author need to raise awareness about the benefits (social, economic, and environmental); increase research and development of new technologies that are cheaper and more efficient cells; implement policies and programs that encourage PV generation; and train more qualified professionals in order to increase PV participation in the renewable energy market.

REFERENCES

[1] E. Kabir, P. Kumar, S. Kumar, A. A. Adelodun, and K. H. Kim, "Solar energy: Potential and future prospects," *Renewable and Sustainable Energy Reviews*. 2018.

[2] P. G. V. Sampaio and M. O. A. González, "Photovoltaic solar energy: Conceptual framework," *Renewable and Sustainable Energy Reviews*. 2017, doi: 10.1016/j.rser.2017.02.081.

[3] N. Kannan and D. Vakeesan, "Solar energy for future world: - A review," *Renewable and Sustainable Energy Reviews*. 2016, doi: 10.1016/j.rser.2016.05.022.

[4] G. Alva, L. Liu, X. Huang, and G. Fang, "Thermal energy storage materials and systems for solar energy applications," *Renewable and Sustainable Energy Reviews*. 2017, doi: 10.1016/j.rser.2016.10.021.

[5] K. H. Solangi, M. R. Islam, R. Saidur, N. A. Rahim, and H. Fayaz, "A review on global solar energy policy," *Renewable and Sustainable Energy Reviews*. 2011, doi: 10.1016/j.rser.2011.01.007.

[6] A. Shahsavari and M. Akbari, "Potential of solar energy in developing countries for reducing energy-related emissions," *Renewable and Sustainable Energy Reviews*. 2018, doi: 10.1016/j.rser.2018.03.065.

[7] S. K. Sansaniwal, V. Sharma, and J. Mathur, "Energy and exergy analyses of various typical solar energy applications: A comprehensive review," *Renewable and Sustainable Energy Reviews*. 2018, doi: 10.1016/j.rser.2017.07.003.

[8] G. R. Timilsina, L. Kurdgelashvili, and P. A. Narbel, "Solar energy: Markets, economics and policies," *Renewable and Sustainable Energy Reviews*. 2012, doi: 10.1016/j.rser.2011.08.009.

[9] L. Phillips, "Solar energy," in *Managing Global Warming: An Interface of Technology and Human Issues*, 2018.

[10] Q. Li, Y. Liu, S. Guo, and H. Zhou, "Solar energy storage in the rechargeable batteries," *Nano Today*. 2017, doi: 10.1016/j.nantod.2017.08.007.