Journal of The Gujarat Research Society

ISSN: 0374-8588
Volume 22 Issue 1, January 2020

A Look at How Solar Energy Is Used in Industry

Dr. Jayanta Kumar Mahato, Dr. Yogesh Kumar, Mr. Rajkishor Singh
Shobhit Institute of Engineering and Technology (Deemed to be University), Meerut
Email Id-Jayant.mahato@shobhituniversity.ac.in, yogesh.sharma@shobhituniversity.ac.in, rajkishore@shobhituniversity.ac.in

ABSTRACT: Solar energy conversion is now extensively utilized to create heat and power. According to a comparative analysis on global energy consumption published by the International Energy Agency (IEA), solar array installations will provide approximately 45 percent of global energy demand in 2050. Solar thermal has been discovered to be gaining a lot of traction in industrial applications. Solar thermal energy may be used to produce power, process chemicals, or even heat your home. Food, non-metallic, textile, construction, chemical, and even business-related sectors may all benefit from it. Solar energy, on the other hand, is widely used in the telecommunications, agricultural, water desalination, and construction industries to power lights, pumps, motors, fans, freezers, and water heaters. It is critical to use solar energy for a broad range of applications and to offer energy solutions by changing the energy percentage, increasing energy stability, boosting energy sustainability, reducing conversion, and therefore enhancing system efficiency. The goal of this research was to investigate into how solar energy systems are used in industrial applications and which industrial applications are more compatible with solar energy systems.

KEYWORDS: Industrial Applications., Photovoltaic Systems, Solar Energy, Solar Thermal, Solar in Industry.

INTRODUCTION

Because of the significant rise in energy consumption in recent decades, energy usage has become a major issue. Furthermore, malaria, starvation, and diarrhea are common across cultures. One of the catastrophes was recorded in 2003, when it struck European nations, killing 20,000 people and causing $10 billion in damages in the agriculture sector. Conventional energy sources now account for almost 80% of worldwide energy use. The urgent need to replace energy sources was postponed in tandem with the discovery of nuclear energy in the mid-twentieth century, which would outperform fossil fuels by ten to twenty times[1]. However, there are certain drawbacks to using nuclear power as a source of energy. Nuclear fusion, for example, exposes uranium and thorium ores, both of which are considered fossil fuels. Furthermore, nuclear power facilities are presently only accessible for large-scale electricity production. As a result, renewable energy remains the greatest option for cooking, heating, and small-scale applications. It is the source of energy that allows humanity to continue to exist on the planet without relying on fossil fuels. Solar, wind, biomass, hydropower, and tidal energy are all potential CO2-free options. Despite widespread knowledge of the benefits of renewable energy, renewable energy accounted for just approximately 1.5 percent of global energy consumption in 2006. In 2030, the trend is expected to increase to 1.8 percent. For the years 2006 to 2030, worldwide industrial energy consumption trends for different sources of energy[2]. Because a large portion of energy is utilized in industrial processes, the significance of energy in industrial growth is critical. It now accounts for more than half of all global energy use. The industrial sector's supplied energy is used in four main areas: construction, agriculture, mining, and manufacturing. Addressed industrial sector energy consumption, savings, and emission analyses for electrical motors, compressed air, and boilers, revealing that this sector consumes a significant amount of energy[3]. Illustrates the energy consumption of the industrial sector in a few chosen nations across the globe. Enterprises are no longer enticed to utilize fossil fuels in the industrial sector due to fast increases in conventional fuel costs and environmental concerns[4]. The adoption of renewable energy-based technologies in industry may substantially decrease greenhouse gas emissions. As a result, conventional energy sources should be replaced with renewable energy sources, and new technologies must be created and implemented in enterprises. Solar power, out of all the renewable energy sources, has gotten the most attention as the most promising choice for industrial use. Solar energy is abundant, free, and pure, and it produces no noise or pollution in the environment. Many efforts have been made thus far to harvest solar energy using solar collectors, sun trackers, and massive mirrors in order to use it for industrial uses[5]. In the industrial world, there are two types of solar energy applications: solar thermal and photovoltaic. Hot water, steam, drying and dehydration processes, preheating, concentration, pasteurization, sterilization, washing, cleaning, chemical reactions, industrial space heating, food, plastic, building, textile industry, and even business concerns are just a few of the most common applications. The percentage of yearly output and worldwide demand for various renewable energy sources for industrial applications (excluding hydropower and biomass in 2001.The use of solar energy has received a lot of interest in the engineering sciences due to the worldwide energy crisis and the need to prevent negative environmental effects. As a result, the pursuit of efficient and cost-effective ways to collect, store, and transform solar energy into usable energy should not be overlooked[6]. There is no thorough study of solar energy uses in industrial facilities in the literature. This report is anticipated to be very helpful to industrial energy users, policymakers, research and development organizations, and environmental groups. Power supply, manufacturing plant, energy recovery, and cooling systems are the four major components of a typical industrial energy system. The energy required for the system to function is provided by the power source, which is mostly made up of electrical energy, heat, gas, steam, or coal. The production plant is a component of the system that manages the manufacturing process. This section uses energy to power subsystems, pressure vacuum temperature solenoids, valves, and switches. Solar energy systems may be used as a power source or directly to power a process. The solar energy applications and technology used in industrial processes are listed. Sun thermal may be defined as the conversion of solar irradiance into heat[7]. Solar thermal is the most cost-effective option among renewable energy technologies. Solar collectors and concentrators are often used to collect solar radiation, store it, and utilize it to heat air or water in residential, commercial, or industrial facilities. A schematic representation of solar irradiation conversion to mechanical energy. Location, type of collector, working fluid to estimate necessary storage volume, system size and storage volume to determine heat exchanger size and load are all variables to consider for particular applications[8]. However, it should be remembered that solar energy is not accessible 24 hours a day for certain purposes. Additional measures should be given in such situations to collect solar irradiation on sunny days, store it in an embedded phase transition, and release it in a regulated way under severe conditions. Solar collectors are used to heat the air or water as the medium of heat transfer to improve the efficiency of solar thermal systems. Each collection, on the other hand, is devoted to a particular application[9]. Flat-plate collectors, for example, are well-suited to low-temperature applications, while concentrating and sun-tracking parabolic trough collectors (PTC) are well-suited to high-temperature applications in which the system can achieve temperatures of more than 250°C with high efficiency. In power generation, two-axes tracking collectors, stationary (non-tracking), and one-axis tracking collectors are used. Moveable collectors, in comparison to other collectors, have a greater maintenance cost. depicts the three major kinds and categories of solar collectors presently in use. A concentration ration is also provided, which is defined as the aperture area divided by the receiver absorber area of each kind of collection[10].

DISCUSSION ON USE OF SOLAR ENERGY IN DIFFERENT INDUSTRY

Solar thermal energy costs range from 0.015 to 0.028 C£/kWh, depending on the initial investment and the kind of solar collectors employed. Solar thermal systems with wide collecting fields are more cost effective on a big scale. When compared to many tiny plants, they need less initial investment; nevertheless, the collector cost is greater. To produce critical thermal energy, almost all industrial energy networks and systems are partly or completely reliant on the combustion of fossil fuels. According to the distribution of energy consumption, about 13% of thermal industrial applications require low temperatures thermal energy up to 100°C, 27% require high temperatures thermal energy up to 200°C, and the remaining applications require high temperatures in the steel, glass, and ceramic industries. A few examples of possible industrial processes as well as the temperatures needed for their operation.

Many industrial processes use heat at temperatures ranging from 80 to 240 degrees Celsius. Solar thermal energy has huge uses in low (i.e. 20–200 C), medium (i.e. 80–240 C), and medium-high (i.e. 80–240 C) temperature levels, according to industrial energy analysis. Almost every industrial operation necessitates the use of heat in some form. Heating accounts for almost 15% of the final energy consumption in the industrial sector in southern European nations. SWHs, solar dryers, space heating and cooling systems, and water desalination are the most frequent industrial uses for solar thermal energy. Many industrial applications utilize solar as an input power source for heat engines. Sterling engines may operate with any kind of external heat source. They are very dependable, have a basic design and construction, are simple to use, and are cost efficient. However, the efficiency of such mechanical devices is quite poor. When compared to external combustion engines, they are more efficient and emit less pollutants. Solar irradiation may be used to produce heat for Stirling engines, lowering their cost and complexity while improving their efficiency. Solar-powered Stirling engines would be cost-effective if they were mass-produced in large quantities. The most cost-effective option for industrial applications is to generate solar energy using Stirling engines in the 1–100kW range. On a Stirling cycle, compressed fluids such as air, hydrogen, helium, nitrogen, or steam are used. Stirling engines may be used in a variety of applications that demand quiet operation, such as systems with multiple fuel sources, a suitable cooling source, low speed, constant power output, and a slow rate of changing output power. Solar energy is used to produce thermal energy for industrial operations, which lowers reliance on fossil fuels while also lowering greenhouse gas emissions such as CO2, SO2, and NOx. In both the residential and industrial sectors, solar water heating accounts for the bulk of solar thermal applications. Among all the solar thermal systems presently available, they are thought to be the most cost-effective. SWH systems are currently marketed and well-established in a number of nations across the globe. SWH usage has grown at a 30 percent yearly growth rate since 1980.

Solar collectors and a storage area are typically seen in SWHs. It is based on the density difference between hot and cold water, or thermos syphon. Because of their simple and compact construction, combined collector/storage SWHs are more popular in colder regions. Batch solar collectors are better at adjusting for sun radiation restrictions in the afternoon and evening. The block architecture of SWH systems widely employed in industrial applications in which the water never returns to the storage tank. Solar collectors, a circulation pump, a load pump, a storage area or tank, a differential thermostat, and a thermal relief valve are all part of the system. The controller components are needed for the system's functioning to regulate temperature. If the tank temperature rises over a pre-determined level, the valves will release energy by mixing hot water with the main water supply system to achieve the desired temperature. In the event that the tank's temperature is insufficient, an auxiliary heater is considered. The once-through systems and the recirculating water heaters are the two major types of SWHs. Cleaning processes in the food sector often use once-through technology. As a result of the pollutants present in the used water, it is not permitted to circulate again in the system. Recirculating water heaters are identical to residential SWHs. Hot water (low-pressure steam) or pressured steam are often used in industrial heat demand applications to provide the heat needed for system functioning. Because of its availability, thermal capacity, storage ease, and cheap cost, water is often used as the flowing fluid in thermal applications. Nonetheless, when greater pressure is needed, the cost of the storage system skyrockets. The system must be pressurized at temperatures over 100°C. Mineral oils are utilized in medium temperature (over 100°C) applications. However, increased prices, cracking, and oxidation are only a few of the problems that come with such systems. Because of the nature of solar systems, which has a somewhat lower input temperature, processes that need water preheating have achieved greater efficiency. The primary reason for this is because simple collectors in such systems catch sunlight at the temperature needed by the load. Solar thermal energy is also utilized in the textile sector to heat water to temperatures around 100 degrees Celsius for bleaching, dyeing, and washing. In the textile business, fossil fuels are now utilized as a source of energy. As a result, SWHs may make a major contribution to reducing the environmental issues connected with the textile sector. In Pakistan's textile sector, built-in storage water heaters have been used to enhance system performance and stability. The construction sector is another growing SWH business that has already gained traction and is in the early stages of growth. According to statistics, SWHs and space heating and cooling will become more mainstream, with 20–30% of full commercialization. Because the majority of developing nations have warm climates, hot water is not as essential as it is in developed countries with colder climates. However, over 10 million SWHs are now deployed in underdeveloped nations, according to. Solar collector systems in India reached a total area of 500,000m2 by the year 2000. SWH was installed in millions of Chinese homes by 2001. Hundreds of thousands of homes in Egypt and Turkey utilize SWHs. Botswana and Zimbabwe, respectively, have installed 15,000 and 4000 SWHs. Thailand has a 15% share of the global SWH market. SWH is also accessible in Zimbabwe, Namibia, South Africa, Botswana, Morocco, Tunisia, Papua New Guinea, Kenya, Tanzania, Lesotho, and Mauritius, among other countries. In Africa, a small-scale SWH may pay for itself in as little as 3–5 years. Large-scale SWHs, on the other hand, provide substantial cost savings. For example, by installing SWHs at a school with 850 pupils in Nepal, the monthly energy cost was lowered by 1200 Euro. Even after 20 years, 75% of collectors are still in good working order. Another benefit of implementing such a project is that it encourages the home sector to utilize modern technology in the kitchen, bath, and swimming pool with temperatures ranging from 45 to 50 degrees Celsius. Designers, engineers, architects, service engineers, and material suppliers may all play important roles in large-scale production's long-term sustainability. Furthermore, different government and community policies may have a significant impact on encouraging the household and industrial sectors to adopt new technologies. In sterilizing and desalination evaporator supplies, low-temperature steam is often utilized. PTCs (parabolic trough collectors) are high-efficiency collectors that are frequently used to produce steam in high-temperature applications. The steam-flash, the direct or in situ, and the unfired-boiler are the three principles used by PTCs to produce steam. The steam-flash method generates steam by flashing pressurized hot water in a separate vessel. To generate steam in an in situ method, there is a two-phase flow in the collector receiver. Steam is generated in an unfired-boiler system through heat exchange in an unfired boiler. A heat medium fluid passes through the collector in this design. A steam-flash system is depicted schematically. To keep the water from boiling, the system applied pressure to it. The pressurized water passes through the solar collector before being discharged into a flash vessel. The feed water supply keeps the water level in the flash vessel at a consistent level. The direct or in situ boiling idea is the only difference is that in this arrangement, the flash-valve is not used. To produce steam in the receiver, make-up water is immediately heated. This system is much simpler than the previous ones. The pressure is quite modest, and the control system is simple. Both flash-steam and direct-steam systems have a similar starting cost. In situ systems, on the other hand, suffer from receiver scalability and stability issues. The right steam generating system with the right crucial elements should be selected to develop an acceptable industrial application. Solar drying and dehydration systems utilize solar irradiance to heat the air either as the primary source of energy or as a complement. Solar dryers take use of sun irradiation for drying and dehydration operations in industries such as bricks, plants, fruits, coffee, wood, textiles, leather, green malt, and sewage sludge. They are divided into two groups: high temperature dryers and low temperature dryers. Almost all high-temperature dryers require fossil fuels or electricity to heat them, while low-temperature dryers may utilize either fossil fuels or solar energy. Solar thermal energy with low temperatures is also suitable for preheating procedures. Solar dryers, on the other hand, are divided into two categories depending on the technique of air flow generation: natural circulation (passive) and forced-convection (active) solar dryers. Passive solar dryers, in general, rely on solar energy, which is plentiful in the environment. As a result, in the agricultural sector in underdeveloped nations, this approach is often referred to as the only commercially accessible method. They are divided into two categories: exposed to the sun and natural-circulation solar-energy crop drying. Open-to-sun passive drying methods are extensively used in developing nations, particularly those with tropical climates. They dry the crops in two ways: in the field or in situ, and by spreading them on the ground or on any vertical or horizontal plate exposed to sunlight.

Passive dryers that are exposed to the sun are extremely popular since they have a cheap initial and ongoing cost and need little maintenance. However, owing to insufficient drying, fungal and insect infestation, and bird and rat encroachment, open-to-sun drying causes significant waste and crop losses. Furthermore, weather and climatic variations like as rain and even cloudiness have an impact on the effectiveness of such systems. Another kind of passive solar drier is natural-circulation dryers, which are ideal for rural and remote locations. The hot air is directed toward the drying crops using buoyancy forces, wind pressure, or a mix of both in this kind of drier. They have a number of benefits over open-air drying methods. Sun energy is used with electricity or fossil fuels to produce power for pumps and motors that circulate air in active solar drying systems. Solar energy is the sole source of heat in this kind of solar dryer. This technique is utilized in commercial drying applications on a big scale. This kind of technology may decrease energy usage while also regulating drying conditions. The fossil-fuel fueled dehydrator, on the other hand, is used to raise the air flow temperature to the required level in medium and low temperature systems. The latter is referred to as a "hybrid solar dryer." It eliminates the impacts of the solar collector's variable energy production at night or when the sun's irradiation is low.

CONCLUSION AND IMPLICATION

This study discussed the applications, advancements, and predictions of solar energy in industry. It was addressed how using solar energy may enhance product quality and quantity while lowering greenhouse gas emissions. Both solar thermal and photovoltaic systems have been shown to be appropriate for a variety of industrial process applications. The total efficiency of the system, however, is dependent on correct system integration and solar collector design. Solar energy systems may be used as a source of electricity or directly applied to a process. Because stationary collectors are used, large-scale solar thermal systems with huge collector fields are economically feasible. Furthermore, as compared to tiny plants, they need a lower initial investment. The feasibility of integrating solar energy systems into conventional applications is determined by the energy systems used by businesses, as well as a study of heating and cooling demand and benefits over current technologies. Solar PV systems are dependable alternatives that should be regarded as a cutting-edge power source in construction, industrial industries, and water desalination systems. When these systems are used in distant areas where there is no connection to a public grid, they have a better economic future. Other technical and economic factors like as wear and tear, initial and ongoing expenses, economic incentives, PV module price declines, and oil price increases should not be overlooked. Solar energy systems must be considered by designers, engineers, architects, service engineers, and material suppliers as a sustainable energy development. Furthermore, government and community policies may play an important role in encouraging the household and industrial sectors to adopt new technology.

REFERENCES

[1] R. K. Luna, R. K. Manhas, S. Banyal, and S. K. Kamboj, “Effect of Lantana camara Linn. on Biomass Production and Carrying Capacity of Forest Areas of Shiwalik Hills of Punjab,” *Indian For.*, 2009.

[2] V. S. Prabhin, K. Jeyasubramanian, N. R. Romulus, and N. N. Singh, “Fabrication of dye sensitized solar cell using chemically tuned CuO nanoparticles prepared by sol-gel method,” *Arch. Mater. Sci. Eng.*, 2017, doi: 10.5604/01.3001.0009.7535.

[3] K. K. Chittibabu and N. K. Alphonse, “Analysis of conducted EMI with a standalone solar-powered DC motor,” *Turkish J. Electr. Eng. Comput. Sci.*, 2013, doi: 10.3906/elk-1110-7.

[4] M. A. Azhari, F. Arith, F. Ali, S. Rodzi, and K. Karim, “Fabrication of low cost sensitized solar cell using natural plant pigment dyes,” *ARPN J. Eng. Appl. Sci.*, 2015.

[5] A. M. Omer, “Development of sustainable energy research and applications,” in *Handbook of Sustainable Energy*, 2011.

[6] P. R. Newswire, “Nanogrids,” *UK-Reportbuyer*. 2014.

[7] A. Chirapart, J. Praiboon, R. Ruangchuay, and M. Notoya, “Sources of marine biomass,” in *Marine Bioenergy: Trends and Developments*, 2015.

[8] M. Murali and R. Arulmozhiyal, “Design of topology for maximum energy efficient charge pumps as storage device for renewable energy applications,” *J. Chem. Pharm. Sci.*, 2014.

[9] J. G. García Clúa, H. De Battista, and R. J. Mantz, “Application of photovoltaics to hydrogen production: Dynamics, modeling and control,” in *Photovoltaics: Developments, Applications, and Impact*, 2010.

[10] A. M. Omer, “The green revolution: Development of sustainable energy research and applications,” in *Advances in Environmental Research*, 2014.