International Journal of Education, Modern Management, Applied Science & Social Science (IJEMMASSS)
ISSN : 2581-9925, Impact Factor: 6.882, Volume 04, No. 04(II), October - December, 2022, pp. 284-289

CONCENTRATED SOLAR POWER AS RENEWABLE ENERGY AND PERCEPTION OF RISKS: AN ANALYTICAL STUDY

Dr. Govind Ram Yadav*
Dr. Shailesh Yadav**

ABSTRACT

The use of fossil fuels has gradually replaced traditional sources of energy like wood and biomass since the industrial revolution, leading to an increase in energy consumption. Solar technology emerged in the 1860s as a possible solution to coal depletion, but lost popularity with the emergence of accessible, cost-effective coal and petroleum in the early 1900s. Concentrated solar power technologies, such as parabolic dish, trough, and Scheffler reflectors, offer a promising option for providing process heat in commercial and industrial settings. However, a significant issue with both photovoltaic and concentrated solar power generation is the potential harm to endangered, rare, or endemic bird species that inhabit specific habitats necessary for their survival. Additionally, there are hazards associated with the reflection of sunlight from reflective objects. This study explores these concerns and suggests potential solutions to mitigate the ecological risks involved.

Keywords: *Photo Voltaic, Concentrated Solar Power, Energy Consumption, Solar Technologies, Scheffler Reflectors.*

Introduction

Solar power has become an increasingly popular source of renewable energy, but concerns have been raised about its impact on wildlife, particularly avian species. Avian fatalities at solar energy facilities are a complex issue that requires careful consideration of various factors. To minimize avian mortality, a variety of measures can be implemented, including enhanced monitoring using trained canines and video surveillance, modifying solar panels and mirrors, suspending operations during migration periods, and implementing measures to deter birds from roosting at solar facilities [1]. The Centre for Biological Diversity recommends restoring habitats in alternative locations to redirect avian populations away from solar installations. Despite these concerns, solar energy is a promising source of process heat for commercial and industrial purposes [1]. The Solar Total Energy Project in Georgia, USA, utilized parabolic dishes to provide heating, air conditioning, and electrical power to a clothing factory [2]. Additionally, solar power can be used in evaporation ponds, for ventilation air preheating, and in UTC systems to elevate air temperature. While it is important to consider the impact of solar power on wildlife, these technologies offer great potential as a renewable energy source.

CSP Projects and the Technology Involved

The use of Concentrated Solar Power (CSP) farms can have a more significant impact on avian species than Photovoltaic (PV) farms due to the presence of central receiver towers, standby focal points, and heliostats. CSP technology uses solar radiation to create concentrated energy, which generates heat that can be used to power a steam turbine or external heat engine for the production of electricity. A heat transfer fluid (HTF), typically made of oils or gas, is used to generate steam that powers a turbine generator. The heat focal points are directed at a central receiver tower and standby focal points, and linear concentrators, including parabolic troughs and linear Fresnel types, redirect solar

* Professor, Geography, BND Government Arts College, Chimanpura, Shahpura, Jaipur, Rajasthan, India.
** Assistant Professor, Geography, Seth RL Saharia Government PG College, Kaladera, Jaipur, Rajasthan, India.

radiation onto a tube filled with fluid to generate steam. Figure 1 illustrates a standard photovoltaic panel arrangement, while Figure 2(a) demonstrates a CSP facility using parabolic troughs to focus solar radiation on the central receiver tower. The second figure also shows a layout of CSP technology and a CSP facility. Once used for heat generation, the HTF medium undergoes a cooling and condensation process for reuse [3].

Fig.1: Photo-voltaic (PV) Solar farm Showing typical Arrangement of Photovoltaic Panels

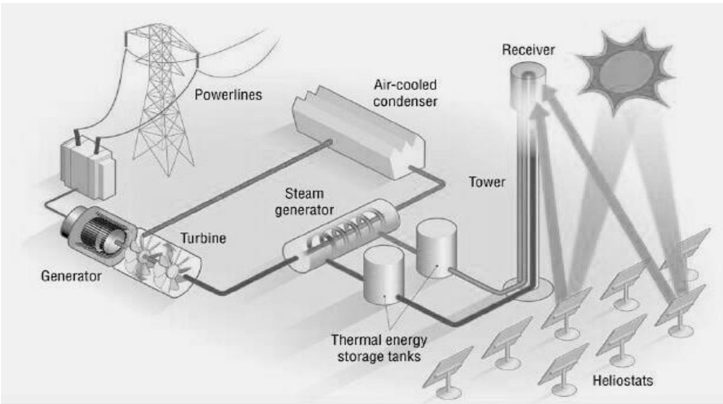

Figure 2 illustrates a Concentrated Solar Power (CSP) Facility that uses parabolic troughs to concentrate solar radiation onto a central receiver tower. The figure also presents a schematic representation of CSP technology and a layout of a CSP facility. CSP technology generates thermal energy from solar radiation and utilizes it to generate electricity through a steam turbine or an external heat engine. The heated fluid or gaseous medium is then cooled and recycled.

Schffler Reflectors

The Scheffler reflector is a solar concentrator created for the purpose of focusing solar radiation and has numerous potential applications, including solar-powered cooking. The reflector was invented by Wolfgang Scheffler, a German physician, to provide a more efficient and convenient way of cooking using solar energy. It is designed to keep a fixed cooking point while adjusting to the sun's movement throughout the day and allows indoor cooking. Incoming sunlight is redirected by a secondary reflector towards a black surface of a cooking pot, where the energy is converted into thermal energy. The reflector's cooking efficiency, measured by its ability to heat water from 25°C to 100°C, can reach up to 57%, depending on factors such as reflector cleanliness and pot insulation. The focal point's optical efficiency can be up to 75% using 2mm ordinary glass mirrors. The standard dimensions of a Scheffler reflector can vary but are generally around 2.8m x 3.8m, resulting in an 8m² total area. The reflector's cooking power is affected by its aperture, which determines the area perpendicular to the incident light from which sunlight can be collected, ranging from 4.3m² to 6.4m² depending on the season. Using an 8m² reflector under 700W/m² of direct solar radiation, it is possible to boil 22 liters of cold water in one hour [4].

Figure 3 a: Scheffler Reflector being used as a Solar Cooker to Cook Food by Concentrating the Sunlight

The Scheffler mirror's ability to generate power varies with the season, with a range of 2.2 kW in the summer to 3.3 kW in the winter, given a solar radiation of 700 watts per square meter. In certain latitudes, the mirror produces more power in the winter than in the summer due to the sun's position at a lower angle in the sky, allowing for more effective use of the mirror's surface area. However, despite this advantage, the total energy collected during a day is greater in the summer months due to the longer duration of solar radiation, even though the efficacy of the mirror is reduced [5].

Green Job Hazards: Solar Energy

The solar energy industry is rapidly expanding, providing both environmentally-friendly energy and job opportunities that promote sustainability. However, the production, installation, and maintenance of solar energy systems come with various potential health and safety risks. Employers in the solar energy industry must take measures to protect their workers from workplace hazards, and it is essential for employees to have a thorough understanding of the necessary safety measures to protect themselves from potential dangers. Recent studies indicate that the solar electric and solar thermal sectors are currently the most financially viable options among the two primary commercial solar energy sectors [6].

- **Solar Electric**

Two primary methods for converting solar energy into electrical energy are photovoltaics (PV) and concentrating solar power (CSP). PV systems are commonly used to generate electricity by capturing sunlight with semiconductors. The amount of electrical output of a PV system is directly proportional to the number of solar modules within the array. PV technology utilizes a variety of materials such as monocrystalline silicon, polycrystalline silicon, microcrystalline silicon, cadmium telluride, copper indium selenide/sulfide, and others. [7]

- **Solar Thermal or Solar Water Heaters**

Solar water heating systems are classified into two main types: direct and indirect (Glycol) systems, and the decision regarding which type to use is often influenced by the prevailing weather conditions in the area. It is particularly important to carefully select the type of solar water heating system in areas where temperatures regularly fall below freezing, as certain types of systems may become damaged under such conditions. [8]

Hazards and Controls

The solar energy industry has various hazards that can cause serious harm or death to its workers, including arc flashes, electric shock, falls, and thermal burn hazards. Employers in the solar energy sector are required to comply with the Electric Power Generation, Transmission, and Distribution Standard, 29 CFR 1910.269, and establish secure work practices and worker training to reduce such risks. OSHA has set up several regulations to address such risks. Workers in the solar panel installation and maintenance field usually work on rooftops, climb ladders and scaffolds, and are vulnerable to fall-related risks. As the number of solar panels installed on a roof increases, there may be less walking space, and workers may be required to work near skylights and roof hatches. Employers must provide adequate guarding for skylights or require workers to use personal fall protection measures. Electrical hazards are also present when using solar energy equipment, which can produce electrical energy and expose workers to electrical circuits. Employers should ensure that workers are trained to protect solar panels and themselves from electrical circuits. Maintenance workers may also be at risk of injuries due to unforeseen energization or the discharge of stored energy [9].

Commercial Deployment of CSP around the World

Concentrated Solar Power (CSP) plants were first deployed in the United States in 1984 with the SEGS plants, but no new plants were built globally from 1991 to 2005. However, since 2004, there has been a significant increase in installed CSP capacity, with an average annual growth rate of 50% over the last five years. In 2013, global installed capacity grew by 36% to almost 0.9 GW, surpassing 3.4 GW. While Spain and the United States are the primary players in the CSP market, developing nations with abundant solar radiation are increasingly adopting the technology. Despite competition from more cost-effective photovoltaic and concentrator photovoltaics (CPV) technology, CSP remains a feasible alternative, and a new hybrid system combining CPV and CSP has been introduced. As of 2022, the global installed CSP capacity has increased to over 6 GW, with Spain, the United States, and China leading the expansion. Additionally, South Africa, Morocco, and Saudi Arabia have begun investing in this technology [10].

Effect on Wildlife

Concentrated solar technology may attract insects due to its luminous intensity, which can subsequently attract predatory birds. This can lead to unintended harm to birds if they approach the focal point of the light, as well as to birds of prey that hunt these species. Federal wildlife officials have referred to power towers as "mega traps" for wildlife. However, reports suggest that only 133 avian specimens were marked with a signature over a six-month period. The implementation of a restriction on the concentration of mirrors in the air to four during standby mode resulted in the complete cessation of fatalities at the Crescent Dunes Solar Energy Project within three months. [11].

Figure 4: Dead Warbler burned in Mid-Air by Solar Thermal Power Plant Credit

Solar Farms Threaten Birds

The use of large-scale solar power installations may pose a danger to bird populations, causing them to suffer fatal injuries or thermal burns due to the concentration of solar radiation. The Yuma Ridgway's rail, a bird species with a population of fewer than 1,000, is particularly at risk of collision in marshlands with cattails across Mexico, Utah, and California. Despite their comical appearance, the decline in their population is a significant concern. According to the National Fish and Wildlife Forensics Laboratory, 233 birds, including endangered species such as the southwestern willow flycatcher and yellow-billed cuckoo, were discovered dead or fatally injured at three solar power plants in California. Although wind turbines also pose a threat to birds, they are believed to cause fewer bird fatalities per unit of energy produced than conventional power plants that rely on non-renewable sources. The increase in the number of concentrated solar farms has raised concerns among environmentalists about their potential negative impact on wildlife, leading to opposition to their further expansion [12].

Figure 5: Yuma Clapper Rail. Credit: Fish & Wildlife Services

Threats to the Environment

There have been reports of a significant number of avian deaths at a solar energy plant in the southwestern United States. Between June 2012 and December 2013, 141 bird carcasses were found at Ivanpah, with about a third of them attributed to the effects of exposure to solar flux. House finches and yellow-color warblers were the species most affected by this event as they rely heavily on insects for their survival. It is crucial to develop methods to prevent birds from colliding with solar radiation and minimize the ecological impact on the surrounding habitats. This responsibility is not limited to energy producers but also extends to manufacturers, builders, infrastructure, and consumers. The use of photovoltaic and concentrated solar power generation methods may pose risks such as the displacement or exclusion of rare or threatened bird species and collisions with reflective surfaces [13].

Role of Environmental Regulatory Bodies on Death of Birds

The Ivanpah power plant is a solar thermal facility in the desert of Southern California. It uses concentrated solar flux, produced by mirrors that focus the sun's rays onto water-filled boilers atop three 459-foot towers, to generate electricity without producing carbon emissions. However, this concentrated solar flux poses a threat to avian, chiropteran, and lepidopteran species, and there have been documented accounts of bird fatalities at Ivanpah. Between June 2012 and December 2013, 141 bird carcasses were discovered, and roughly one-third of these birds are believed to have died due to the solar flux [14]. The facility's design, including its blue panels and luminous towers, could attract insectivorous birds, leading to a food chain that is vulnerable to harm and mortality, and the National Fish and Wildlife Forensics Laboratory warns that Ivanpah could function as a "mega-trap" for avian wildlife. To mitigate the impact on avian, insect, or chiropteran populations, measures such as shutting down the plant during peak migration periods or installing video cameras to monitor birds' movements are suggested [15]. However, Jeff Holland, a representative of NRG, the facility's operator, disagrees with some of these recommendations, citing a lack of established protocols and scientific literature. As with other solar technologies, Ivanpah may displace or exclude avian species that are rare, endemic, globally or nationally threatened, or have a restricted range. While Ivanpah is an advancement in environmentally friendly energy sources, its full effects on wildlife are not yet known, and further research is needed to evaluate the ecological effects of solar power plants [16].

Discussions

Solar panel farms and concentrated solar power are rapidly expanding in California, which helps utilities meet the state's renewable energy target of 20% electricity sold by 2017. However, the growth of concentrated solar power could face legal challenges and opposition from environmentalists concerned about its impact on wildlife. The problem is that solar installations can create a "lake effect," where birds and insects mistake the panels or water basins for actual bodies of water. Federal investigators have described solar farms as "mega-traps" for avian species, which can suffer from collisions with structures or predation by natural predators. While the full impact on avian species remains unclear, the high numbers of bird fatalities are concerning to conservation groups. Different types of solar power plants, such as trough systems and solar power towers, like the Genesis Solar Energy Project and Ivanpah Solar Electric Generating System, are at risk for these potential hazards.

Conclusion

The idea of Space-based solar power (SBSP) involves capturing solar energy in outer space and transmitting it back to Earth. This method offers advantages such as increased efficiency due to the lack of atmospheric interference and the ability to collect energy continuously in areas with no night. Sodium bicarbonate (SBSP) has been identified as a viable and sustainable source of energy that could help combat climate change and reduce reliance on fossil fuels. Despite research dating back to the 1970s, none of the proposals for SBSP have been economically feasible with current space launch infrastructure. To launch a microwave system with the power output of a commercial power plant would require launching 80,000 tonnes of material into orbit, making the cost of energy much higher than nuclear power. Some technologists believe that an industrial base off the planet could produce solar power satellites using resources from asteroids or the moon in the future. However, SBSP faces several technological challenges, such as transmitting energy efficiently to Earth and the durability of space-based collectors in harsh conditions. The proposed method involves using solar energy to generate electricity, which would be transmitted to a collector on Earth's surface through a microwave rectenna. While the beam energy densities are safe, acquiring large plots of land for receiving antennas would be necessary. Countries like Japan, China, and Russia are pursuing SBSP, with Japan enacting the Basic Space Law and developing a roadmap for commercialization. China's plan includes developing a 1 GW commercial system by 2050.

References

1. John Upton (2014). “Solar Farms Threaten Birds” Scientific American 27 August 2014.
2. Brandon Robertson “Zeus and RA Digital Space Bible” Edition 4 part 2, https://books.google.co.in/books?id=rcxp BQAAQBAJ. Accessed on March 3, 2023.
3. "Solare Termodinamico, una ricchezza per il paese, p.21" (PDF). Associazione Nazionale Energia Solare Termodinamica (in Italian). Retrieved 2023-04-07.
4. S S Junare, S V Zamre ,M M Aware,”Scheffler Dish & its Application”ICEMESM-2017
5. https://www.tamera.org/pt/projetos/autono mia- tecnologia/espelho-scheffler
6. https://www.osha.gov/dep/greenjobs/solar. Html. Accessed on March 3, 2023.
7. http://www.gosolarcalifornia.ca.gov/solar _basics/how.p hp. Accessed on March 3, 2023.
8. http://www.folkecenter.net/mediafiles/folk ecenter/pdf/S olar-Water-Heaters.pdf. Accessed on March 3, 2023.
9. Mustapha Hatti (2014) “Operation and Maintenance Methods in Solar Power Plants”, Springer M. Yadav, A. Yadav “Development of Solar Power Electricity Plants in India” IJATES Vol 5, Issue 5 2017
10. Sebastian Anthony, (2014) “California’s new solar power plant is actually a death ray that’s incinerating birds mid flight, EXTREMETECH
11. https://www.scientificamerican.com/articl e/solar-farms- threaten-birds’ . Accessed on March 3, 2023.
12. https://www.eenews.net/stories/10600118 53. Accessed on March 3, 2023.
13. https://www.theatlantic.com/technology/ar chive/2014/0 4/how-to-stop-solar-powerplants-from-incinerating- birds/361318/. Accessed on March 3, 2023.
14. "Linear-focusing Concentrator Facilities: DCS, DISS, Eurotrough and LS3". Plataforma Solar de Almería. Archived from the original on 2007-09-28. retrieved 2007-9-29.
15. Deloitte Touche Tohmatsu Ltd, (2011) "Energy & Resources Predictions 2012", 2 November 2020.
16. Goossens, Ehren, (2011) "Chevron Uses Solar-Thermal Steam to Extract Oil in California", "Bloomberg", Accessed on March 3, 2023.

❖◆❖