International Academic Institute for Science and Technology

International Academic Journal of Innovative Research
Vol. 12, No. 4, 2025, pp. 22-26.

ISSN 2454-390X

International Academic Journal of Innovative Research

www.iaiest.com

Harnessing the Infinite Potentials of Solar Energy

Ibragimov Ulmas Rakhmanovich [a], Azizov Azizbek Sabitkhanovich [b]

[a] *Turan International University, Namangan, Uzbekistan. E-mail: u.ibragimov@tiu-edu.uz, Orcid: https://orcid.org/0009-0007-2364-4625*
[b] *Turan International University, Namangan, Uzbekistan. E-mail: science@tiu-edu.uz,*

Abstract

In solar energy applications such as photovoltaic systems, solar thermal installations, and passive solar design, solar radiation data is essential. The design, optimization, and performance evaluation of solar technologies suited to particular regions depend on this data being current, reliable, and easily available. Solar energy is becoming more widely recognized as a crucial alternative energy source for the future and is being considered to supply a sizable amount of India's and the world's energy demands. In this regard, it is commonly acknowledged that solar radiation data is valuable for the design and effective operation of solar energy systems. Permanent atmospheric components, which stay relatively constant, reduce sun irradiance as it passes through a clean, dry atmosphere. As a result, only optical thickness may be used to characterize the amount of solar irradiation that reaches the Earth's surface. The typical composition of an ideal atmosphere completely describes the attenuation processes. Two other attenuation factors, known as atmospheric turbidity, are present in a real atmosphere, though: scattering by aerosol particles and absorption by water vapor. Understanding turbidity is vital for climate modelling, studying climate change, and examining pollution. Specific solar radiation data is necessary to estimate atmospheric turbidity, which measures the total amount of aerosol integrated through the vertical column of the atmosphere.

Keywords: Energy, Solar Radiation, Thermal Potential.

DOI:10.71086/IAJIR/V12I4/IAJIR1230
Received: 15 September, 2025/Revised: 22 October 2025/Accepted: 14 November 2025/Published: 30 December 2025

Introduction

The most widely utilized data points for forecasting daily global solar radiation and its many components at any location of interest are sunshine duration, latitude, and cloud cover. Accurate measurements of solar radiation have long been necessary for the production of sustainable solar energy in order to monitor solar systems, create or validate radiative models, and guide resource evaluations (Khodabakhshi et al., 2020). However, the quantity and quality of solar radiation data collected can vary significantly. Many current radiometers still utilize outdated technology, with only minor improvements over the years (Ponseca Jr et al., 2017). Unfortunately, the expensive cost, upkeep, and calibration requirements of the measuring equipment limit access to solar radiation measurements in many developing nations. Because of this, estimating solar radiation using easily accessible meteorological data is crucial. Such information can include the number of rainy days, altitude, latitude, total precipitation, cloudiness, evaporation, sunshine hours, mean temperature, soil temperature, relative humidity, and extraterrestrial radiation (Chen, 2011). Overall, global solar radiation was highest in winter and lowest in the post-monsoon season. SPM showed a significant correlation with global solar radiation, while relative humidity was significantly linked to wind speed during the pre-monsoon. In the post-monsoon season, both sunshine hours and temperature had a strong correlation with global solar radiation, with temperature explaining the most variation, followed by relative humidity in winter

Review of Literature

The author noted that the computer model is a solid choice for running modelling programs, serving as a valuable tool for assessing the potential of solar energy applications in Vietnam. M. Mohandas and colleagues (1998) brought forward the use of neural network techniques to model the spatial variation of global solar radiation. Their findings across various locations showed a fairly good match between the observed and predicted values (Zweibel, 2013).

Global solar radiation was estimated by Francisco Meza and Eduardo Vavas (2000) using empirical models, which might be a useful tool if the parameters are modified for various locations. The use of easily accessible meteorological data is advantageous for these models. Based on changes in air temperature, the models proposed by Allen and Bristow-Campbell are efficient and capable of estimating the average global solar radiation.

In 2002, Atsu, S.S. Dorulo, and associates demonstrated how neural network techniques can be used to model solar radiation. The data set yielded good results for both multilayer perceptron networks and the Radial Basis Function. However, because it requires less time and computer power, the RBF is frequently preferred. In areas of the Sultanate of Oman where sunshine hour measurements, latitude, longitude, and altitude data are available, these models can be used to forecast solar radiation (Sivaram, 2018).

Gayathri Vijayakumar and associates (2004) discovered that increased usefulness can result from short-term radiation being distributed within an hour. On clear days, the error margin tends to decrease if the short-term data exhibits substantial variance but the hourly variations are small. Hourly assessments, however, may understate a system's actual performance on partially overcast days with significant hourly changes (Eros, 2019). Users can reliably create short-term data from widely accessible hourly averages by creating diffuse fraction correlations and frequency distributions of short-term data based on air mass. Solar energy system simulations and performance evaluations can then make use of this short-term data.

In 2005, F.S. Tymvios and his colleagues presented an ANN methodology as a viable substitute for conventional approaches in the estimation of global solar radiation, especially when radiation measurements are scarce. This analysis emphasizes that other scholars who have studied comparable meteorological difficulties have reached similar results.

Rani Gupta and G.N. Tiwari (2005) found that having a reflective surface on the north side significantly boosts the available solar radiation for heating greenhouses. Their review notes that even an inclined reflective surface can't completely eliminate solar radiation loss; some losses will always occur.

Materials and Methods

The parabolic trough, the compact linear Fresnel reflector, the Stirling dish, and the solar power tower are some of the most well-known concentrating methods available. To track the sun and focus the light, various methods are used. In each of these systems, focused sunlight heats a fluid, which is subsequently utilized to generate electricity or store energy (Zafar & Rashid, 2023).

Now, regarding the challenges faced by the Tamil Nadu government and TANGEDCO in the power sector, they are grappling with several issues. One major problem is the shortage of fuel. Tamil Nadu is facing a severe shortage of fossil fuels despite having large reserves since the government isn't producing enough to satisfy its power plants. Some facilities are running dangerously low, lacking even a day's worth of reserve fuel. The situation is further complicated by India's state-run coal producer, which is hindered by outdated mining practices and plagued by theft and corruption. As a result, coal producers have consistently fallen short of their production and growth targets, and the poor infrastructure for coal transport has only exacerbated these challenges (Fig. 1).

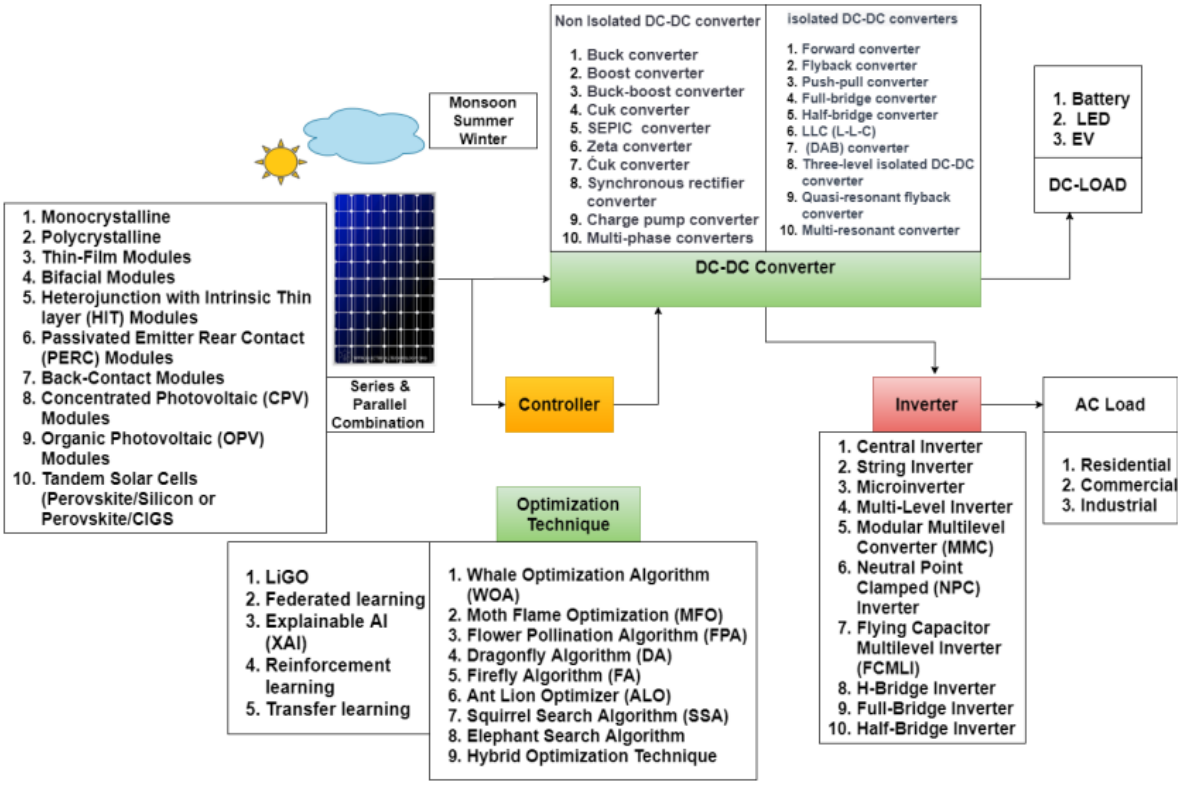


Fig. 1: Design Framework

The receiver is just a functioning fluid-filled tube that is positioned along the focus points of a linear parabolic mirror. The reflector is made to follow the sun on a single axis throughout the day in order to maximize sunlight. Among solar technologies, parabolic trough systems are renowned for having the highest land-use efficiency. The SEGS facilities in California and Action's Nevada Solar One, which is situated close to Boulder City, Nevada, are notable instances of this technology. Conversely, Compact Linear Fresnel Reflectors are a kind of CSP plant that directs sunlight onto two tubes holding the working fluid by using a large number of thin mirror strips rather than conventional parabolic mirrors. This design maximizes the amount of accessible sunlight by allowing more reflectors to fit in the same space and allowing the use of flat mirrors, which are far less expensive than parabolic ones. Both large-scale and smaller plants can use concentrating linear Fresnel reflectors.

Results and Discussion

To boost its coal production capacity, the Government of Tamil Nadu needs to tap into new deposits. Nonetheless, a sizable amount of India's coal is found beneath designated tribal territories or protected forests. Because of this, any mining operations or property purchases in these coal-rich areas have provoked a surge of social activism, political demonstrations, and public interest litigation (Fig. 2).

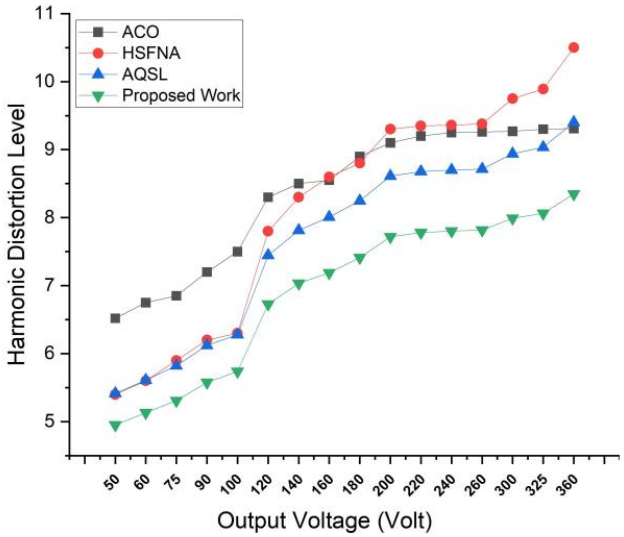


Fig. 2: Total Harmonic Distortion

In an effort to gain support from voters, the government has taken steps like giving farmers free electricity, although this has depleted the state-run electricity distribution system's cash reserves (Zafar & Rashid, 2023). Because of this, Tamil Nadu's economy has been under financial hardship, which has affected the distribution network's ability to pay for the electricity required to meet demand (Fig. 3).

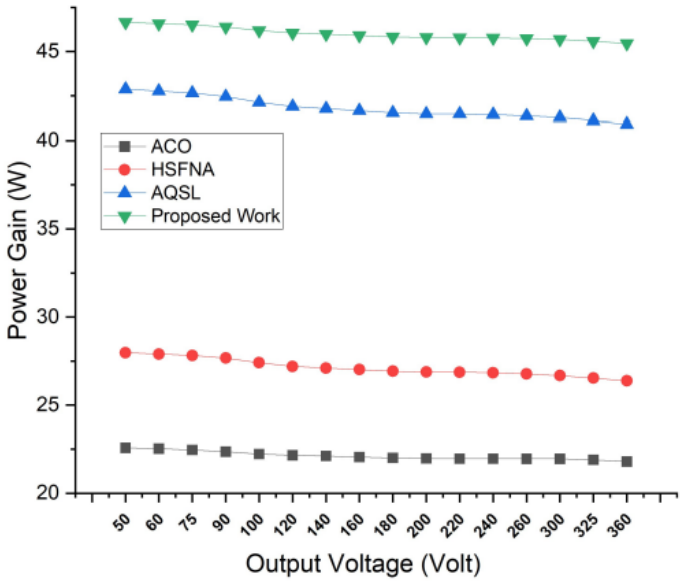


Fig. 3: Gain for Separate Loads

This issue has been made even worse by government departments that are slow to settle their bills. When it comes to the quality of coal, Indian coal doesn't quite measure up. Typically, Indian power plants need around 0.7 kg of coal to produce just one kilowatt-hour (kWh) of energy, while their counterparts in the United States only require about 0.45 kg per kWh. The high ash content in Indian coal also plays a significant role in increasing the emissions from thermal power plants (Fig. 4).

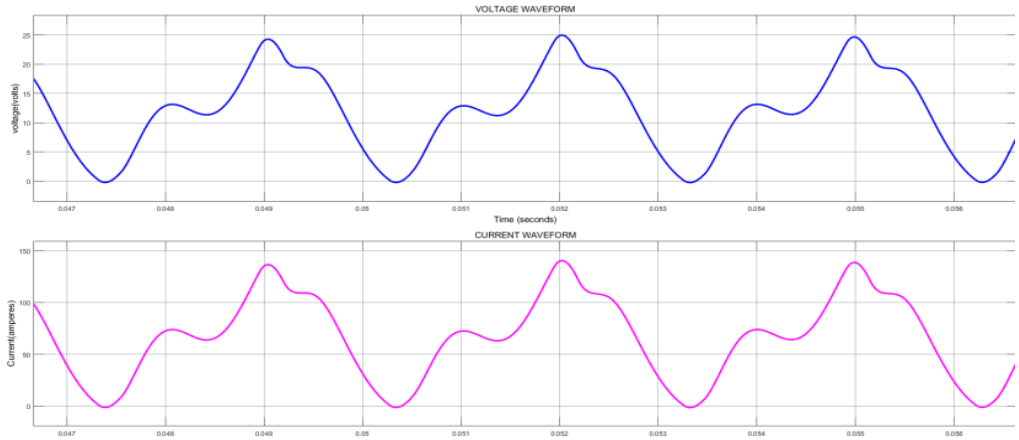


Fig. 4: Output Current and Voltage

Power stations in ecologically sensitive or severely polluted metropolitan areas are required by India's Ministry of Environment & Forests to use beneficiated coals, which have an ash level lowered to 34% or less. India's coal benefaction sector has grown significantly, and it now has a capacity of over 90 million tons (MT). However, the new offshore natural gas field has not provided as much fuel as initially expected.

Conclusion

Let's take a closer look at global solar radiation trends over the years. Between 1980 and 1990, we noticed that solar radiation was pretty stable during the pre-monsoon season. Then, from 1990 to 2000, it remained consistent in the post-monsoon season, and from 2000 to 2010, it was steady during the monsoon season. Significant variations in temperature, relative humidity, wind speed, sunshine hours, and global solar radiation were observed throughout the 1980–2010 study period in all seasons. However, atmospheric pressure and suspended particulate matter didn't show significant differences during this time. Interestingly, Suspended Particulate Matter (SPM) had a strong correlation with global solar radiation, while relative humidity was closely linked to wind speed during the pre-monsoon season. In the post-monsoon season, sunshine hours were significantly correlated with global solar radiation, and temperature had a notable relationship with wind speed. For the other variables, the correlations were generally insignificant across all seasons. When we look at winter, the temperature variation was quite striking, reaching nearly 89.8%, with relative humidity contributing 10.2% to global solar radiation. In the pre-monsoon season, relative humidity played a major role, accounting for 59.3%, followed by temperature at 32.8%. During the monsoon, relative humidity surged to 86%, with wind speed contributing 9.3%. In the post-monsoon season, relative humidity again took the lead at 63.2%, with temperature following at 36.8%.

References

Khodabakhshi, S., Fulvio, P. F., & Andreoli, E. (2020). Carbon black reborn: Structure and chemistry for renewable energy harnessing. *Carbon*, *162*, 604-649. https://doi.org/10.1016/j.carbon.2020.02.058

Ponseca Jr, C. S., Chábera, P., Uhlig, J., Persson, P., & Sundstrom, V. (2017). Ultrafast electron dynamics in solar energy conversion. *Chemical reviews*, *117*(16), 10940-11024.https://doi.org/10.1021/acs.chemrev.6b00807

Chen, C. J. (2011). *Physics of solar energy*. John Wiley & Sons. https://doi.org/10.1002/9781118172841

Zweibel, K. (2013). *Harnessing solar power: The photovoltaics challenge*. Springer. https://doi.org/10.1007/978-1-4899-6110-5

Sivaram, V. (2018). *Taming the sun: Innovations to harness solar energy and power the planet*. MIT Press. http://dx.doi.org/10.1057/s41312-018-0066-4

Eros, T. (2019). Harnessing the sun: A critical look at the feasibility of solar energy. *University of Delaware (USA)*.

Zafar, S., & Rashid, U. (2023). Harnessing Solar Power: The Physics Behind Photovoltaic Cell. *WORLDWIDE JOURNAL OF PHYSICS*, *4*(02), 40-48. https://doi.org/10.3390/en16186456