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An analytical study of direct normal irradiaance for concentrated solar energy applications for the mechria region of Algeria

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Abstract – SUN FLUX calculates solar irradiance on Earth's surface quickly and accurately. Direct solar radiation is critical for concentrated solar power plants, which determine their opening surface size based on reference radiation values. To reduce investment costs, a statistical analysis was performed using direct radiation, meteorological data from NSDRB, and cloud cover statistics to identify optimum ranges for direct solar radiation. CSP plant performance is evaluated and power tower systems are simulated using the SAM software tool.

Keywords – Solar İrradiance , Meteorological Data, Direct Normal İrradiance (DNI) , CSP Plant Performance Evaluation, System Advisor Model (SAM).

I. INTRODUCTION

The investigation of direct normal radiation assumes an indispensable role in the efficient utilization of solar energy in concentrated solar power (CSP) plants. Direct solar radiation is harnessed to facilitate the conversion of solar energy into electricity, heat, or cold. The sizing of the aperture surface in CSP plants is predicated upon the reference radiation value, which is chosen in accordance with the solar deposit at the installation site. The complete investment expenditure of a CSP plant is directly proportional to the selected reference value of direct radiation. As such, the precise evaluation and selection of the design value are pivotal for optimizing the solar field and minimizing investment costs. This study is focused on the statistical analysis of direct radiation data, preceding irradiance values, meteorological information, Here are some relevant studies from this topic .Majid Hosseini et al suggest a new technique for predicting DNI by utilizing multivariate GRU and comparing it to LSTM using past irradiance data. The findings indicate that the proposed approach enhances DNI prediction accuracy, especially when incorporating wind direction and speed as observation states[1].In this paper, a novel aerosol parameterization is presented by Guoping Shi et al. The aim of this parameterization is to enhance the precision of direct normal irradiance (DNI) for the purpose of solar energy forecast. To evaluate the efficacy of this modified SUNFLUX scheme, observational datasets collected from the 14 Baseline Surface Radiation Network (BSRN) stations are utilized. The outcomes of this study are indicative of a

significant improvement in the accuracy of calculated DNI[2]. Francis M. Lopes and co-authors postulate a multivariate regression model aimed at advancing the precision of prognostications of direct normal irradiance. This improvement can be leveraged to refine daily tactics grounded in day-ahead predictions for concentrating solar power plants. The model's effectiveness is evident in its ability to significantly enhance hourly forecasts, with a skill score of approximately 0.84. Furthermore, it is estimated that this model has the potential to augment a power plant's profit by approximately 0.44 M€/year[3].Devon Kesseli and fellow authors unveil a comprehensive guide document for precise modeling of hazards, expenses, and electrical productivity in projects involving the concentration of solar energy. The guidelines were succinctly summarized in a spreadsheet-based checklist and subsequently executed on the System Advisor Model (SAM) software of the National Renewable Energy Laboratory (NREL), culminating in valuable feedback and recommended enhancements to SAM[4]Kelvin, Tsz Hei Choi, along with their co-authors, present in this paper four distinct methods for estimating spectrally resolved direct normal irradiance (DNI) for solar energy applications. These approaches vary from a straightforward climatological method to a more intricate approach that incorporates explicit aerosol typing and type-dependent circumsolar irradiance (CSI) contribution. The most sophisticated method demonstrates an average bias of +0.068% and an average spread of error of 2.5%[5]. Eleonora Riva Sanseverino and colleagues examine photovoltaic projects in Vietnam, discussing the challenges of institution, technique, economy, and finance. Although Vietnam has potential for solar energy, policies and infrastructure are lacking[6].

Materials and Method

In order to calculate solar irradiance on the Earth's surface, SUN FLUX offers a speedy methodology [2]. Concentrated solar power plants use direct solar radiation in order to convert solar energy into electricity or heat or cold, The dimensioning of the opening surface based essentially on the value of the reference radiation, this value is selected as a function of the solar deposit in the site of implantation, and the total investment cost of such a CSP plant is proportional to the reference value of the direct radiation chosen. The choice of the design value is based on a statistical study of direct radiation data, The analysis of previous irradiance values, meteorological information, and cloud cover statistics is imperative for anticipating solar irradiance[1]. We studied the radiation by filtering the intensity of direct radiation in ranges of 200 w /m2, we started with the values less than 200w /m2 and then the larger intervals up to greater than 1000w /m2, for each interval we calculated the number of hours or the direct radiation included in the interval We scan the whole year hour by hour, we find the interval where the direct solar radiation is the number of hours is maximum so the design value is selected from this interval. This method allows us to optimize the solar field is gained in the investment cost. To evaluate the performance of a CSP plant and simulate a power tower system, it is necessary to gather specific meteorological data along with DNI measurements The SAM software tool serves the purpose.[3].SAM utilizes meteorological data files to meet its weather data requirements, which includes the need for data height. SAM requires a full year's worth of data and is equipped with NSRDB weather files based on satellite modeling[5]The precise estimation of spectral irradiance is paramount for the accurate prediction of power output by upcoming CSP technologies[6]. To acquire unobstructed solar radiation within the confines of the Mecheria area, we undertook a diligent search on Google Maps to obtain the precise geographic coordinates consisting of latitude, longitude and elevation of a designated location within the area. Subsequently, these coordinates were efficiently inputted into the SAM software.

A. Figures and Tables

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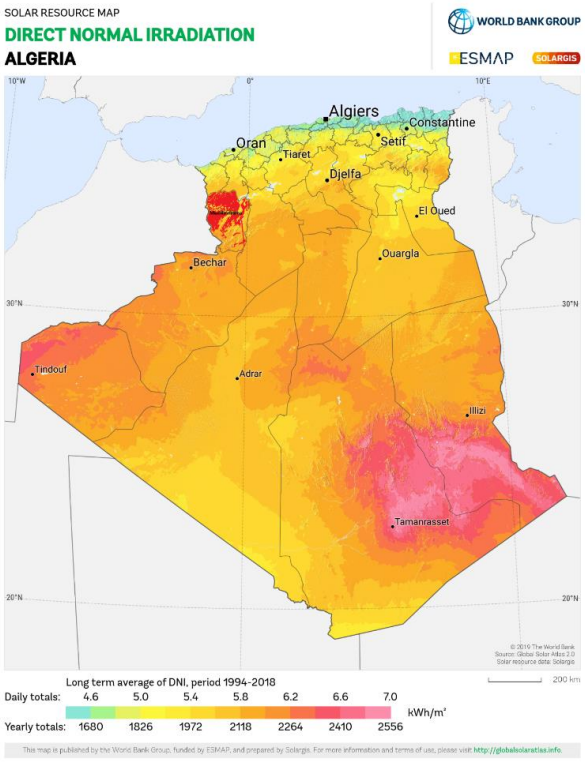


Fig. 1 . Solar map of the Direct normal radiation for the studied stations (Solar resource maps and G, 2019).

Fig. 2. Location of Mechria

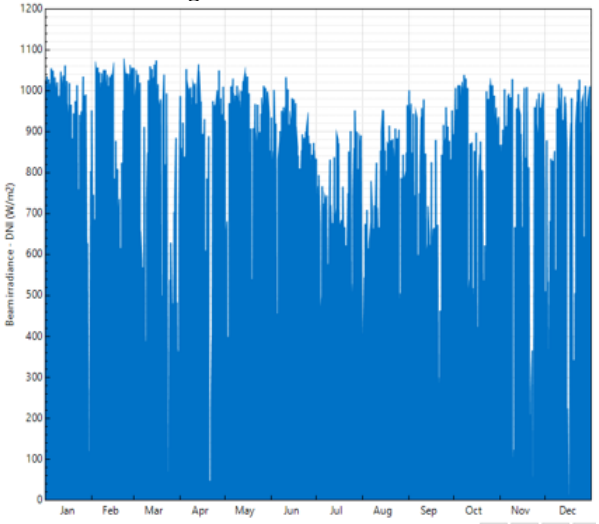


Fig. 3. hourly Direct normal radiation for the studied stations (SYSTEM ADVISOR MODEL from NSDRBb csv file 2019).

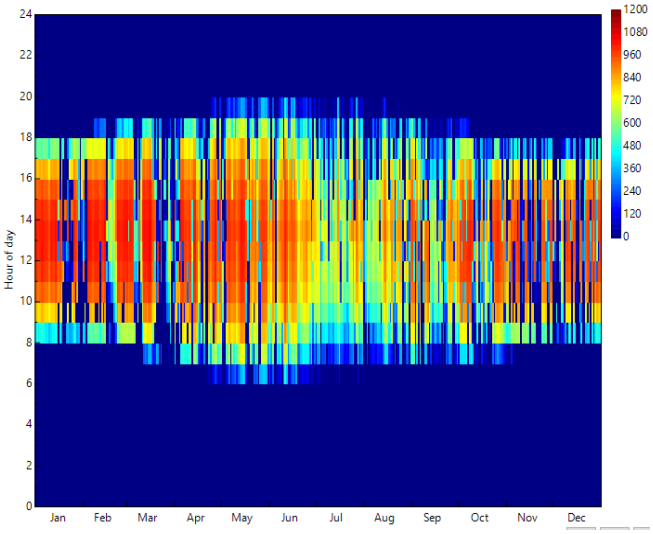


Fig.4. heat map Direct normal radiation for the studied stations (SYSTEM ADVISOR MODEL from NSDRBb csv file 2019).

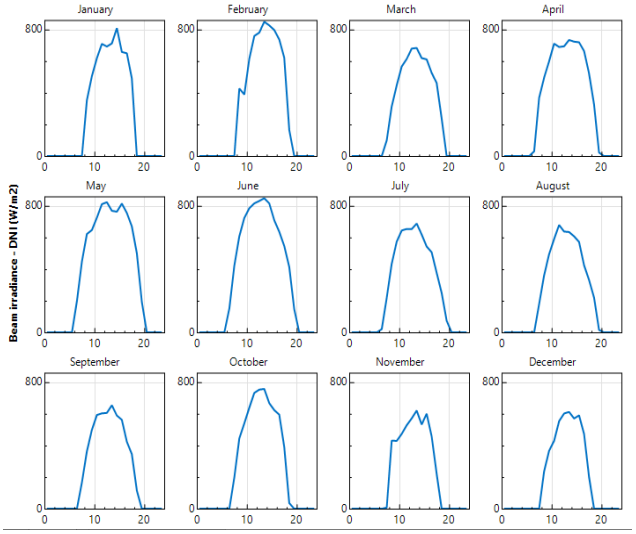


Fig.5. monthly Direct normal radiation for the studied stations (SYSTEM ADVISOR MODEL from NSDRBb csv file 2019).

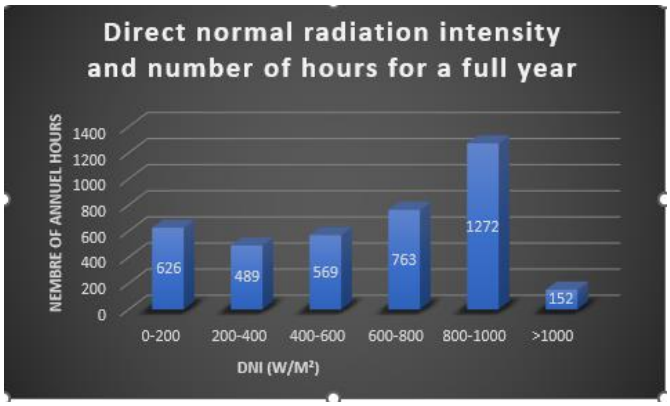
Table 1. General Information About Region Of Mechria

Desaign parameter	Regions : mechria
contry	algeria
Latitude(°)	33.53
Longitude(°)	-0.22
Elevation(m)	1099

Results:

In this paper, we studied the mishriya area, where we took the latitude and longitude lines next to the airport through google maps, and then thanks to the SAM program, we were able to download the weather file in TMY 60 min or CSV format for the year 2019, and thanks to the NSDRB website, we

were able to download the weather file, and then through the exel program, these results appeared to us :



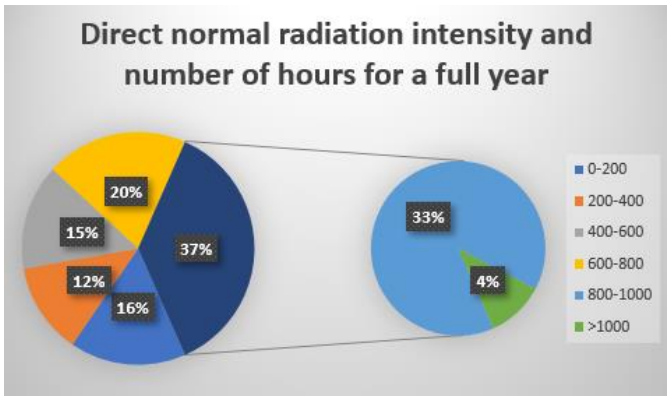


Fig.6 and 7. An illustration showing the annual hours of direct solar radiation in Mecheria.

Table 2. Direct normal radiation intensity and number of hours for a full year

dni(w/m2)	0-200	200-400	400-600	600-800	800-1000	>1000
Nember of hours	626	489	569	763	1272	152

DISCUSSION

Figure 6 &7and table 2 shows the annual hours of direct solar radiation in Mecheria. By analyzing all the annual data, the interval presenting the greatest number of hours of direct solar radiation was identified on the DNI domain [800-1000] w/m2, Then, by means of an exel calculation, we obtain dni=918 (w / m2)

CONCLUSION

In conclusion, this paper presents a methodological approach for gathering weather data in the Mechria area using Google Maps, the SAM program, and the NSDRB website. The utilization of these tools allowed for the successful acquisition of detailed weather files in TMY 60 min or CSV format for the year 2019, The availability of accurate and reliable weather data is of paramount importance for various applications, including climate studies, renewable energy planning, and urban development. The obtained weather files enable from ours to analyze and interpret the meteorological conditions specific to the Mishriya area, However, without specific details on the research objectives and analysis conducted, it is not possible to draw definitive conclusions about the findings or implications of the study. The conclusion would depend on the specific research goals, hypotheses, and the results derived from the analysis of the collected weather data, Overall, this methodological approach serves as a valuable foundation for future studies in the CSP technologies, providing a framework for accessing and utilizing weather data to enhance understanding and decision-making in relevant fields.

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