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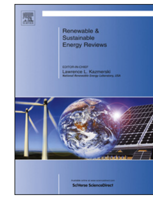

Inter-comparability of solar radiation databases in Indian context

Ishan Purohit [a,*], Pallav Purohit [b]

[a] Lahmeyer International (India) Pvt. Ltd., Gurgaon, India
[b] International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria

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ABSTRACT

Solar radiation resource assessment is one of the most important exercises towards implementation of large-scale solar power projects. The quality of resource makes significant impact on the selection of technology to be used at a specific location for solar electricity generation. In this study, inter-comparability of several solar radiation databases (i.e. ground, satellite and statistical) is assessed in Indian context. The long-term measured Global Horizontal Irradiance (GHI) over 23 representative locations is compared with the GHI obtained from satellite and weather databases. Direct Normal Irradiance (DNI) is estimated through long-term measured global horizontal and diffuse irradiance using basic sun–earth geometry and compared with the DNI obtained from different solar radiation and weather databases. It is observed that with respect to long-term measured data of GHI the average range of deviation varied from 0.20% to 22.53% whereas DNI varied from 0.64% to 35.12% across select locations. Impact of the variation due to solar radiation resource assessment on the annual electricity generation and levelized cost of electricity of grid-connected solar power projects is also underlined.

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* Corresponding author. Tel.: +91 9899113184.
E-mail address: drishanpurohit@gmail.com (I. Purohit).

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1. Introduction

Solar power, due to its abundant and sustained availability across the globe, has emerged as a promising long-term option for meeting growing global energy demand while addressing the adverse environmental impacts of conventional fuels. India is blessed with abundant solar insolation and energy generation potential. Recognizing its importance, the Government of India (GoI) launched the Jawaharlal Nehru National Solar Mission (JNNSM) in 2010 which targets 20 GW of grid-connected solar capacity by 2022, along with other solar targets for off-grid systems [1]. GoI significantly expanded its solar plans in January 2015, targeting US$100 billion of investment and 100 GW of solar capacity by 2022 [2]. As against India's ambition to set up 100 GW, the total solar power generation capacity in the world stands at 177 GW [3]. While the global capacity has been set up over 15 years, India has set out to achieve its target in a short span of seven years. Starting from a negligible base, the total installed grid-connected solar capacity at the end of March 2015 reached 3744 MW (mostly solar PV) contributing over 10% of the renewable installed capacity base of 35,777 MW (Fig. 1).

The idea in the first phase of the JNNSM (2010–2013) was to give equal emphasis to both solar photovoltaic (SPV) as well as concentrated solar power (CSP) technologies. Therefore, 500 MW each was allocated to SPV as well as CSP technologies in Phase-I. For CSP, 7 projects (470 MW) were awarded and further three projects of 10 MW capacities each were awarded through migration scheme of the Ministry of New and Renewable Energy (MNRE) out of which only 2.5 MW capacities is implemented. To date, only three CSP projects of 200 MW (out of 470 MW) capacity has been commissioned whereas other projects are under construction as the MNRE has extended the commercial date of operation. It may be noted that none of the above CSP projects are using thermal energy storage (TES) system. A CSP project of 25 MW capacities with 9 h thermal energy storage is under implementation in the state of Gujarat.

Limited availability of long-term ground data on solar irradiation levels and meteorological parameters, land availability and timely acquisition, water availability, grid loading and availability, etc. were bottlenecks experienced by solar projects across the country. The success of any solar energy installation depends largely on the availability of solar radiation at that location, making detailed knowledge of solar resource data critical for planning and siting. The intermittency associated with solar resource makes solar power projects more specific as compared to their conventional counterparts (viz. coal, oil, gas, etc.); as the magnitude of solar resource availability varies with location, season of the year and time of the day [5–8]. Availability of long-term solar radiation data over the potential locations across the country is one of the most important barriers towards financial closure of the solar power projects [9–11].

It becomes obvious that it is difficult to analyze the suitability of a site for solar systems with a short time-period of data. Lohmann et al. [12] observed that taking results from one year of measurements could be more than 15% above or below the long-term average whereas averaging five years still could lead to deviations larger than 10%. Therefore, at least 10 years of data should be taken into account to gather reliable information on solar resources [11,12]. The Indian CSP projects under JNNSM have been delayed mainly due to non-availability of ground level Direct Normal Irradiance (DNI) data [13]. In India, long-term measured global solar radiation is available for few select locations only. There are 23 locations across the country for which long-term global horizontal irradiance (GHI) and diffuse irradiance (DI) values along with climatic parameters are reported [14] by India Meteorological Department (IMD) whereas long-term ground DNI data over these 23 locations is not available. Recently, MNRE along with the Centre for Wind Energy Technology (C-WET) initiated steps to overcome the issue related to solar irradiation data by setting up Solar Radiation Resource Assessment (SRRA) stations. Under Phase-I of the SRRA programme 51 Automatic Weather Stations (AWS) have been implemented at different locations of India for which one year ground data is commercially available. Moreover, under Phase-II of the SRRA programme 60 new AWS are under implementation [15]. C-WET is commercially offering the short term measured solar and climatic data through SRRA programme to project developers.

In this study, inter-comparability of various solar radiation databases (i.e. ground, satellite and statistical) is assessed in India context. The impact of variation of solar radiation obtained from different databases on solar electricity through a MW scale solar PV and CSP project has also been carried out along with their levelized cost of electricity. The paper is set out as follows. Section 2 provides a brief literature review of solar resource assessment. The approach for conversion of all selected GHI and DNI databases into typical meteorological format and statistical tool used for inter-comparability are presented in Section 3. Section 4 presents results and highlights inter-comparability of various solar radiation databases. Impact of the variation due to solar radiation resource assessment on the levelized cost of electricity generation by the grid-connected solar PV and CSP projects is also analyzed in this study. Section 5 concludes.

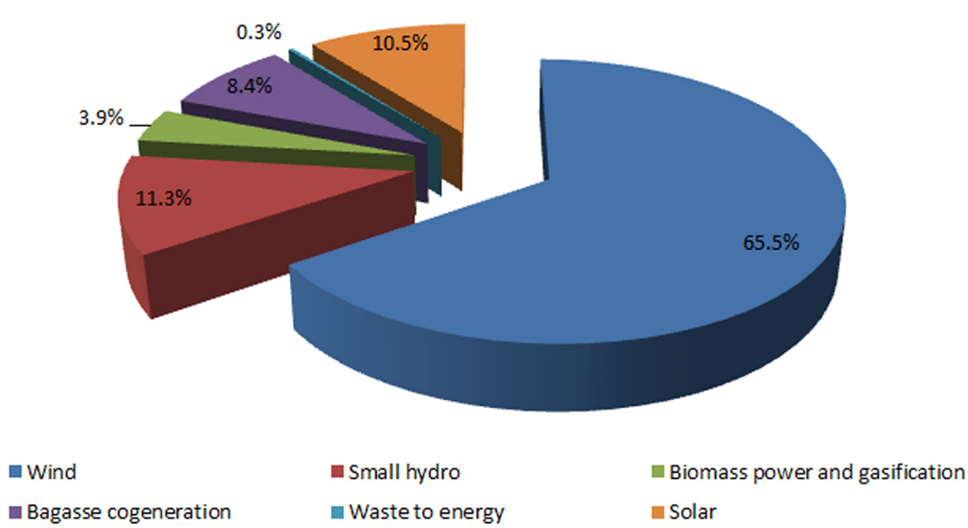

Fig. 1. Installed capacity of grid connected renewables in India as on 31st March 2015 [4].