Ministry of New and Renewable Energy
Government of India

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

C-WET

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

IRENA
International Renewable Energy Agency

IRENA CASE STUDY 2013
SOLAR RADIATION RESOURCE ASSESSMENT IN INDIA

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RESOURCE ASSESSMENT IN INDIA

CONTEXT

India receives good annual radiation despite having several climatic zones. However, the Indian economy is heavily dependent on fossil fuels that are largely imported; with this background India began its exploration towards renewable energy over three decades ago. In order to maintain momentum, a separate Ministry was also set up, which is now called the Ministry of New and Renewable Energy (MNRE). In January 2010, the Indian Government launched Jawaharlal Nehru National Solar Mission (JNNSM), with an overall aim to develop and promote solar energy applications in the country, with an aim of reaching grid parity for solar power by 2022. For this, a target of 20,000 megawatt (MW) of grid connected solar power has been envisaged, which is in addition to an off-grid target of 2,000 MW equivalent and cumulative growth of solar thermal collector area to 20 million square metres (m^2) by 2022. To achieve this target, the importance of accurate, reliable and available solar data was realised and the Government took the decision to expand the data measurement network to fulfil this requirement. The India Meteorological Department (IMD) is the statutory body responsible for measurements and monitoring of weather parameters. Solar radiation data, as a part of the overall monitoring of weather data, has been available in the country for many decades. The data has been analysed and made available in the form of handbooks; the first version was published in 1981 and an updated version in 2010. In 2009 the MNRE also published "Solar Radiant Energy over India".

To achieve the large solar capacity additions detailed in the JNNSM targets required an enlargement of the monitoring network and a focus on high potential sites for solar applications. There are 45 IMD stations that undertake regular measurements of some kind or other, but many of these stations are to be found either in metropolitan cities or at airports, etc. The Government of India decided to expand the monitoring network by setting up an additional 51 Solar Radiation Resource Assessment (SRRA) stations in order to produce the best quality radiation data, these new stations were situated in high potential areas throughout the country and are state-of-art to produce the best quality data.

The limited monitoring of solar radiation data through the existing IMD stations were used to map the availability of solar. Out of the original 45 stations, 18 have been designated as principal stations where global and diffuse components of solar radiation are also measured. Based on simulation models, availability of solar radiation data at other locations in the country were estimated and the radiation maps prepared. In addition, worldwide data sets in coarse resolution, like NASA-SSE, have been made available and provide solar radiation data with quite large offsets. Additionally, time-series and ground-based measurements have been mapped, and model-derived solar radiation values of Global Horizontal Irradiance (GHI) and Direct Normal Irradiance (DNI) are also available from the Meteonorm software. In 2009 the US National Renewable Energy Laboratory (NREL) released its first version of a satellite-based solar radiation map, which included both GHI and DNI and covered the North West of India. In 2010 an updated version of the map was released by NREL that covered the entire country. Meanwhile several commercial satellite-derived data sets became available for example, 3TIER, the Solemi data set of DLR (Deutsches Zentrum für Luft- und Raumfahrt – German Aerospace Centre), the iMaps data of GeoModel

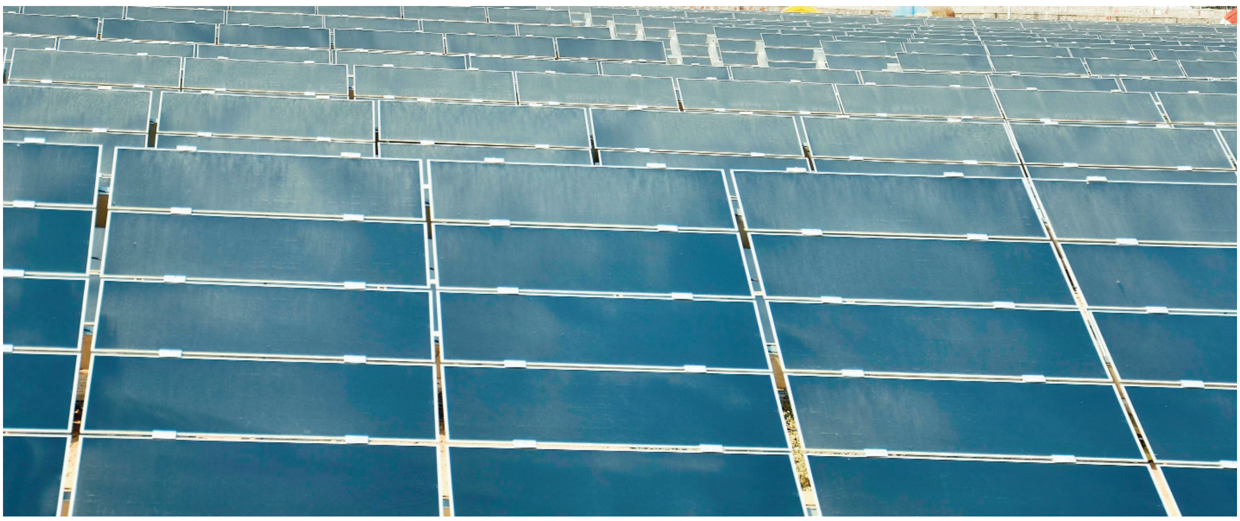


Figure 1: Locations of SRRA stations

TABLE 1: INSTRUMENTS AT SRRA STATIONS

Instrument	Manufacturer	Parameter
A. SOLAR MEASURING INSTRUMENTS		
01. Pyranometer	Eppley Laboratory, USA	Global Radiation (watt/square metre (W/m^2); Instantaneous, Average
02. Shaded Pyranometer	-do-	Diffuse Radiation (W/m^2); Instantaneous, Average
03. Pyrheliometer	-do-	Direct Irradiance (W/m^2); Instantaneous, Average
04. Solar Tracker	Geonica, Spain	Mounted with Shaded Pyranometers and Pyrheliometer
B. METEOROLOGICAL MEASURING INSTRUMENTS		
05. Ultrasonic Wind Sensor	R M Young, USA	Wind Speed and Wind Direction; Standard deviation, Maximum and Average
06. Rain Gauge	-do-	Rain Accumulation
07. Pressure sensor	-do-	Atmospheric Pressure
08. Temperature and Relative Humidity sensor	-do-	Temperature and Humidity; Average, Maximum and Minimum
C. GENERAL INSTRUMENTS		
09. GPS	Garmin, USA	To synchronise Sun Tracker with Sun movement
10. Data logger and Modem	Geonica,Spain	Collecting data from sensors and transferring it to Central Receiving Station at CWET, Chennai
11. GPRS	Garmin, USA	To transfer data through mobile SIM cards to Central Receiving Station at CWET, Chennai
12. Solar PV Panel	Moserbaer, India	To charge batteries that are used to power ASRMS
13. External Battery	Exide, India	For electrical storage

Solar and the data from IrSOLaV. Despite these efforts the reliability of solar radiation data for India is still poor. Ground verification of the satellite-derived data sets is still widely missing and this has coincided with the demand for high quality solar resource data for India.

The SRRA project is fully funded by the Indian MNRE. The project is implemented by the Centre for Wind Energy Technology (CWET), Chennai. During Phase-1 of the project, a network of 51 solar radiation measurement stations were set-up with the data processing and storage facilities located centrally at CWET, Chennai. The cost of this Phase of the project was INR 250 million (approximately USD 4.5 million). The Second Phase of the project envisages a further addition of 60 stations in parts of India that currently have no monitoring stations. This will augment the existing network of monitoring stations

The SRRA project is being supported by the SolMap project, an initiative under the Indo-German Bilateral Cooperation and funded by the German Ministry for Environment, Nature Conservation and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit; BMU). In SolMap the Deutsche Gesellschaft für Internationale

Figure 2: A typical SRRA station

Zusammenarbeit (GIZ), together with its contractors Suntrace GmbH and PSE AG are cooperating with CWET. The funding for SolMap from BMU is about EUR 1.6 million. SolMap provides the SRRA data quality control, data processing, data product generation and aims to create a solar radiation atlas of India.

MEASUREMENT CAMPAIGN

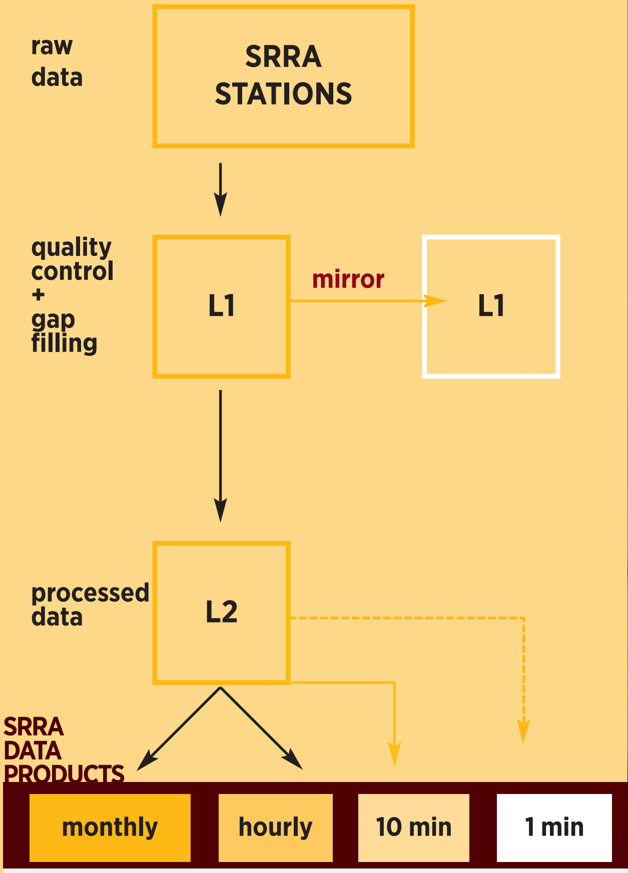
CWET is an autonomous institution under MNRE engaged in activities pertaining to wind resource assessment and monitoring in India and making the results available to various stakeholders including industry, project developers and the policy makers. The task of solar radiation monitoring was assigned to CWET to take advantage of their experience in handling large scale data. To enable them to perform this task effectively, a technical group, which comprised of solar experts from various institutions, including IMD, Solar Energy Centre, Indian Institute of Technologies, the State Agencies, World Bank, GIZ and MNRE, was established. To implement the project, new staff (trained engineers) were recruited and further trained at existing facilities of IMD and other institutions. The 51 sites were chosen to cover 11 States and 1 Union Territory, and all the stations were commissioned through a vendor who was selected by an international competitive bidding process between March to October, 2011, quite possibly one of the biggest global initiatives of its kind. The locations have been depicted in Figure 1 for the 51 stations for Phase-1 and an additional 60 stations proposed for Phase-2. Data from all SRRA stations are transmitted through General packet radio service (GPRS) to a Central Receiving Station established at CWET.

The technical configuration of the SRRA stations consist of measurements of GHI, Diffuse Horizontal Irradiation (DHI) by pyranometers and direct normal (DNI) solar irradiances with pyrheliometers mounted on solar trackers, in addition to measurements of associated meteorological parameters, like air temperature, relative humidity, wind speed and wind direction, atmospheric pressure and precipitation. The SRRA stations (Figure 2) have been configured and equipped to a very high standard using good equipment and sensors that are powered by photovoltaic (PV) with battery banks, thus making them independent of grid electricity. High temporal resolution with data streams having 10 seconds sampling and 10 minute averaging rate in the initial phase were upgraded to 1 second sampling and 1 minute averaging in August 2012. As a part of the project, comprehensive facilities are being developed for on-site calibration of solar radiation sensors, with traceability to national/international standards. A calibration laboratory is also being established at CWET, Chennai and is to be equipped with two Absolute Cavity Radiometers, four Standard Precision Pyranometers and a Solar Tracker. The various instruments being used in each SRRA station are listed in Table 1.

DATA PRODUCTS AND ANALYSIS

One of the objectives of undertaking the SRRA project is to develop a solar radiation resource map for India, with a reasonable spatial resolution. The SRRA network is still being established and currently focusing on safe data storage and putting in place a quality control system to ensure integrity and reliability of the data. For this, Suntrace GmbH, a consultant under SolMap project that is supported by GIZ, is assisting in setting up a quality control system, the analysis of data as per international protocols and producing data reports for use by various stakeholders. At present the data measured by the stations are received and stored in a Central Receiving Station located at CWET headquarter in Chennai. The receiving server system is named as Level 1 (L1) and stores all data received from all 51 stations. In the L1 server system only basic quality tests are implemented. To avoid data losses and reach high availability, a RAID-5 back-up system with two hot-swappable servers are used. Once the data is stored in L1 server, it is checked for its quality, i.e. missing data, plausibility of data measured, etc. Level 1 data receives an automatic check with quality test algorithms following internationally established tests as developed by the World Meteorological Organization's highest precision solar radiation network, Baseline Surface Radiation Network (BSRN). This includes checking physical limits, limits of clean and dry clear sky conditions, coherence between measurements, tracking error, etc. and assigning appropriate flags. This is done in another server system, which is called Level 2 (L2) system. The L2 system consists of data processing and processed data storage. Once data has passed through quality control, various reports and data products are created at different temporal resolutions, for example hourly, daily, monthly, yearly, etc. A chart for flow of information from SRRA stations to the preparation of data products is shown in Figure-3.

Figure 3: Data flow from SRRA measurement to data products



IMPACT

Previously, IMD measured various weather parameters, including solar radiation and based on these measurements published various products in the form of data books that provided average hourly values, maps showing solar radiation profile in various parts of the country and statistical information on the frequency and values of solar irradiance. This information was available to stakeholders, as well as the data being available in a soft form from National Data Centre of IMD. This knowledge provided a macroscopic view of potential areas with good availability of solar irradiance. The availability of this information, together with data from other sources (viz. simulation models, satellite derived values, etc.) was generally used by the project developers in project designs at the beginning of the missions. It was envisaged that the SRRA project would make available reliable and accurate data based on ground surface measurements and that subsequently this data could then be used to ground truth for other data sources. The information provided from SRRA stations has already initiated some fine policy adjustments of various State Governments in terms of predicting solar park developments and as an incentive to structure for solar power projects.

With solar power being expensive at the current stage of development, tariffs in India are based on a cost plus tariff and set by the Central Electricity Regulatory Commission (CERC). The information generated so far from the SRRA initiative has already been used by regulatory and policy making bodies such as the introduction of a “solar data policy” in 2012 by MNRE, which makes available quality controlled solar data products and corresponding reports to various stakeholders.To publicise the SRRA facility at CWET, Chennai, Dr. Farooq Abdullah, the Honourable Union Minister for New and Renewable Energy inaugurated the venue on 28th November, 2012.

Already, a natural interest in this initiative has been observed from various sectors. The commercial solar project developers are keen to access the data and to take advantage of the accurate solar resources data to plan and design projects more effectively. Similarly, several national and international banks involved in financing solar projects in India have shown an interest in using the data.

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