Solar and Wind Resource Assessment
Karan Gupta¹, Arjun Gupta², Ishaan Aziz³, Amit Sharma⁴, Ubaid Ul Khaliq⁵, Sahil Kumar⁶
Assistant Professor¹
Department of Electrical Engineering
GCET, Jammu, India

Abstract:
In 2010 to boost solar energy production, India launched Jawaharlal Nehru National Solar Mission (JNNSM), which aims at a target of 20,000 MW (20GW) of grid connected solar power by the year 2022. Later on this capacity of installation was increased to 100GW in the year 2015. The government of India has also proposed to launch a National Wind Energy Mission (NWM) on the track of the ongoing solar energy mission to add a part to renewable energy mission. Mission accounts for 60GW of wind power by the end of 2022. For achieving such big targets, there should be availability of reliable and ample solar radiation and wind flow data. India is a first country to set up a special body called Ministry of New and Renewable Energy (MNRE) for R&D of renewable energies in India. Some international groups like International Zusammenarbeit (GIZ) is working in cooperation with the MNRE for development of path toward Solar India. The paper is made to highlight the process of resource assessment and data analysis.

Keywords: Solar and wind resource assessment process, MNRE, NIWE contribution, components of resource measurement

I. INTRODUCTION
The resource assessment techniques and its analysis help in calculating the power output of plant in the area for which resource assessment is done. Resource assessment is the crucial part for site selection for power plants. India has setup MNRE for research and development on renewable energy sources. MNRE setup various centre for study and analysis of renewable energy sources. National Institute of wind Energy (NIWE) accounts for wind data and its analysis in terms of its availability and its variability whereas National Institute of Solar Energy (NISE) and Solar Energy Corporation of India (SECI) report the solar irradiance and its variation over the year. These data reports help the government to frame the path of development of solar and wind power plants on future prospects. In addition to this, the process of reverse bidding has made the market more competitive. Due to this, lower prices arrived in the market.

Some countries publish maps of estimated solar and wind resources, which serve in making policy and encourage solar and wind power development Like NIWE and NISE centre of India has provided. The combined solar and wind resource maps is shown above in the figure A. While designing the profitable solar power plants, the measurement of solar irradiance should be done in the assessment phase. Being a crucial parameter for plant design and site selection of plant, different ways and technologies are used for measurement of the irradiance phenomena that proves to be helpful for the future aspect. After the setting up the wind farm it is mandatory to ensure its best performance. Thus the process of wind measurement and assessment does not end with connecting it to the grid. The profitability of the wind turbines need to be monitored and controlled. Feasibility conditions and site assessment are the basis for the financial decision making.
to build a Solar/wind farm. Energy forecasts ensure the profitability of wind farm. To generate those studies, a campaign on wind measurement has to be performed and analysis of the site should be done in detail. Measurement campaigns generally last for at least a year, during which measurement data is continuously gathered. Afterwards the processing of measured data is done and then compared to long-term meteorological data, e.g. weather stations.

**Solar Resource Assessment:**
Irradiation is a crucial parameter for selecting a site and design and economics of plant. There are several ways and technologies for measurement of the solar irradiance. During the process of assessment, there are several factors that affect the measurement process and assessment of solar data.

II. PARAMETERS THAT INFLUENCE THE SOLAR ENERGY PRODUCTION:

1. Precipitation and soiling (sand storms): There are losses due to dust or soil over the solar panel. Thus, the measurement of soiling and precipitation can give important information regarding losses.

2. Temperature: Temperature has a great influence on the efficiency of solar module. Thus temperature measurement is crucial. To measure the solar module temperature, temperature sensors are used.

3. Wind speed and wind direction
Winds affect the solar panels. It is important to have data about the wind force to construct a robust module.

4. Insolation: Insolation has influence on the solar panel. So, forecasting it is the important part of the assessment. Certain measurements e.g., GHI, DHI, DNI are essential for solar resource assessment.

5. Air humidity and air pressure: Pressure and humidity has a great effect on the thermodynamic performance of Concentrated Solar power plants.

**Solar Measurements**

For solar site assessment certain measurements are crucial. The net insulation consists of Direct Normal Irradiation (DNI) and Diffuse Horizontal Irradiation (DHI). DNI and DHI are inter-related according to the formula for Global Horizontal Irradiation (GHI) as: 

\[ GHI = DHI + DNI \cdot \cos(\theta) \]

where \( \theta \) is the solar zenith angle.

On a normal sunny day, the insolation is 100% GHI or 20% DNI and 80% DNIcos(\( \theta \)). This is also been shown in the graph below figure b (NREL data).

![Graph representing the amount of DNI and GHI in NREL laboratory](image)

To measure solar irradiance, we have two devices namely pyranometer and pyrheliometer. The working principle of both the pyranometer and pyrheliometer is based on the working of a thermocouple.

**Pyrheliometer:**
A pyrheliometer is an instrument used for measurement of direct solar irradiance. The instrument is exposed to sun and sunlight enters through a window and is focussed on to a thermopile which converts heat into an electrical signal that can be recorded. It is installed with a solar tracking system to keep the instrument always aimed at the sun.

**Pyranometer:**
A pyranometer is a device used for measuring diffuse solar irradiance on a planar surface. A thermopile pyranometer is a sensor/device designed to measure the solar radiation flux density from a 180° field of view angle. A pyranometer usually measures around 300 to 2800 nm spectral sensitivity. The surface area of pyranometers exposed to sun is equally divided in black and white sectors of equal areas. The calibration of device is done in such a way that irradiation becomes equal to the differential measure of the temperature of the black sectors(exposed to the sun) and the temperature of the white sectors(sectors not exposed to the sun).
In this technology, the concept of thermocouple is used. The solar irradiation is proportional to the difference between the temperature of the sun exposed area and the temperature of the shadow area. In the figure tabular representation is done to show the measurement device required for particular quantity.

<table>
<thead>
<tr>
<th>Irradiation</th>
<th>Description</th>
<th>Irradiation Measurement Device</th>
</tr>
</thead>
<tbody>
<tr>
<td>GHI Global Horizontal Irradiation</td>
<td>The total amount of radiation received from above by a horizontal surface. This value includes both Direct Normal Irradiation (DNI) and Diffuse Horizontal Irradiation (DHI).</td>
<td>Pyranometer (installed horizontally) to measure Global Horizontal Irradiation (GHI) and Solar reference cell</td>
</tr>
<tr>
<td>GTI Global Tilted Irradiation</td>
<td>The total amount of direct and diffuse irradiation received from above by a tilted surface. GTI can approximate value for the energy yield calculation of fixed installed tilted PV panels.</td>
<td>Pyranometer (installed tilted as solar panel) for irradiation on the solar panel surface and Solar reference cell</td>
</tr>
<tr>
<td>DNI Direct Normal Irradiation</td>
<td>Direct Normal Irradiation is the amount of solar radiation received per unit area by a surface that is always perpendicular (or normal) to the rays that come in a straight line from the direction of the sun at its current position in the sky.</td>
<td>Pyrheliometer installed on sun tracker and Rotating Shadowband Pyrheliometer</td>
</tr>
<tr>
<td>DHI Diffuse Horizontal Irradiation</td>
<td>Diffuse Horizontal Irradiation is the amount of radiation received per unit area by a surface (not subject to any shade or shadow) that does not arrive on a direct path from the sun, but has been scattered by molecules and particles in the atmosphere and comes equally from all directions.</td>
<td>Pyranometer with shadow ball or shadow ring installed on an spin tracker and Rotating Shadowband Pyrheliometer</td>
</tr>
</tbody>
</table>

**Wind measurement for site assessment**

A measuring system consists of several components. The specific components of a wind assessment system will vary depending primarily on climatic and regional variability, and the anticipated size of the wind farm. The surrounding terrain has also a very important role in the selection of measuring system components. The hub height is also critical one. The wind velocity increases with the increase in height. Masts and hence, wind turbines are becoming increasingly taller. The height of mast is approx. 100m. However, there are masts operating at 200m height. As a general rule of thumb: the x wind performance increases with the increase in the altitude.

**Components of wind measurement systems**

The accuracy of wind assessment results depend primarily on the quality of instruments used for the measurement purpose. An accurate wind site assessment ensures profitability of the wind farm which also helps in rapid return on investment (ROI). The measurement system, on a general basis, includes the following components:

- Met mast
- Data loggers
- Anemometers
- Wind vanes
- Temperature, Humidity and Barometric pressure sensors

**Data loggers**

Data logger forms the core of measurement system converting gathered electrical values by meteorological sensor into
meaningful data, e.g., wind speed in m/s instead of speed in rpm. It is available in three configurations - for every application the best suitable data logger. Data logger is designed for high end performance and accuracy working at a minimum amount of power consumption. It has many control option available like pressure control, temperature control etc.

Figure.5. Data logger used for analysis of gathered data

- Anemometer to measure wind speed: Anemometers are the devices used measure the horizontal wind speed (velocity), a very crucial parameter for any wind site assessment. Cup anemometers are the generally used.

Figure.6. typical anemometer used to determine wind speed
It consists of four hemispherical cups mounted on a vertical shaft with horizontal arms. The air flow turn the cups turning the shaft at a rate that is proportional to the wind speed. Therefore, by counting the number of turns of the shaft over a set period of time produces a value proportional to the average wind speed. Cup type anemometer have four cups symmetrically arranged on the end of the armband hence an effective measurement device.

- Wind vane to determine the wind direction: A wind vane or commonly known as weathercock, is an instrument used for getting the direction of the wind. Analyser collects many measurements in order to understand and predict the weather. A detailed data of the wind direction of a site ensures the best possible direction of positioning of wind turbines to have profitable wind farms.

Figure.7. typical Wind vanes used in meteorological stations

Temperature and humidity sensor
Temperature sensor is used to measure the air temperature, whereas humidity sensor senses the air humidity. They are generally applied in combination to reduce the costs. The calculation of air humidity does not have any direct influence on a wind site assessment, but having knowledge of this
parameter helps assessing the cases for ice build-up at the selected site.

**Barometric pressure sensors**

Barometric pressure sensors (barometers) are designed to measure the air pressure. Air pressure sensors are not an essential part of a measuring system. Its data is usually taken from nearby meteorological centers.

**Precipitation sensors**

Precipitation sensors are used to measure quantity and intensity of precipitation striking the earth’s surface. Its measurement is done with a tipping bucket device. Precipitation, collected over a surface of 200cm², is allowed to pass through an inflow sieve into a tipping bucket. When the bucket collects 2 square metres = 0.1mm of precipitation, it tips over. Precipitation sensors are typically applied for meteorological assessments. These devices are equipped with heating elements during colder climatic conditions. Precipitation sensors are not necessarily needed for wind site assessment.

**Figure 8.** Typical solar and wind resource assessment and measurement system

**III. CONCLUSION:**

Accurate wind resource assessments are crucial for the successful and profitable development of wind farms and solar parks. Data management software assists the user in gathering, analyzing, storing and validating resource data. Hence, resource assessment forms the basic part for site selection. Typically the data sets are gathered directly from a data logger, located at a meteorological weather station and are stored into a database. Once the data is set in the database, it can be analyzed and validated for future needs.

**IV. REFERENCES:**

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