Site Feasibility Analysis for Large SPV Power Projects

Dr Sudhir Kumar
Jt. Director
Center for Solar Energy,
World Institute of Sustainable Energy
Email: drsk22@gmail.com

Solar Radiation

- **Global Horizontal Irradiation (GHI) –**is the total solar energy received on a unit area of horizontal surface.
  - GHI = Diffuse HI + Direct HI = DHI + DNI * Cos (Z), where Z is the solar zenith angle
  - GHI used in PV power plants
- **Global Radiation on Tilted Surface –**is the total solar energy received on a unit area of tilted surface. Tilt angle = latitude of location
- **Direct Normal Irradiation (DNI) –** is the total solar energy received on a unit area of surface directly facing the sun at all times: Used in concentrating solar technologies (CSP)
- **Diffuse Horizontal Irradiation (DHI) –**is the energy received on a unit area of horizontal surface from all directions when radiation is scattered off the atmosphere or surrounding area

Method of Radiation Measurement

- **Land-based measurement**
  - Radiation Measurement Stations
  - Global Horizontal radiation and Diffuse Horizontal Irradiation – Pyranometer
  - Direct Normal irradiance - Pyrheliometer
- **Satellite derived data**
  - Offer a wide geographical coverage
  - Historical periods where no ground-based measurements were taken
  - Provide long term averages
  - Data are not susceptible to maintenance and calibration discontinuities
  - Bias errors are consistent due to same sensor is used
  - Useful in comparing and ranking sites
  - Comparison of the GHI values obtained from satellite readings correspond well with ground-measured data
  - In the case of DNI values **NO** such relation observed

Data Sources for Solar Radiation

- India Meteorological Department
- NASA Solar Data
- SEC-NREL Database
- Centre for Wind Energy Technology
- METEONORM Software

India Meteorological Department

- Head office at Pune, 45 Weather stations, 23 measure radiation
  - Period 1986 to 2000 (Book entitled ‘Solar Radiant Energy over India’)
  - Objective is to have an understanding of basic physical processes involved in the conversion of the Sun's radiant energy into atmospheric motions as also into chemical and biochemical energy
  - There are only few stations
  - Do not provide meteorological data for exact location apart from 45 sites

SRA by NIWE

- worldâ€™s largest net work of solar radiation resource assessment stations
- National Institute of Wind Energy (NIWE), formerly Centre for Wind Energy Technology (C-WET), Chennai
- first phase, 51 SRRA stations were set up by October, 2011, in 11 States 1 Union Territory and in the second phase, 60 SRRA stations (in 28 states and 3 UTs) and 4 Advanced Measurement Stations (AMS) by June,2014. NIWE, Chennai has also established 6 SRRA stations in Maharashtra for Maharashtra Energy Development Agency (MEDA), Government of Maharashtra under consultancy mode.
- SRRA station consists of two towers of 1.5 m and 6 m tall each for measuring solar and meteorological parameters respectively. The 1.5 m tall tower houses a solar tracker equipped with Pyranometer, Pyranometer with shading disc and Pyrheliometer to measure global, diffuse and direct irradiance respectively. The 6 m tall tower houses instruments for measuring ambient temperature, relative humidity, atmospheric pressure, wind speed & direction, rain fall and a state of-the-art data acquisition system. The solar sensors are traceable to the World Radiometric Reference (WRR) and the meteorological sensors are traceable to World Meteorological Organization (WMO).
- Data is sampled every second and averaged over a minute and transmitted to the Central Receiving Station (CRS) established at NIWE through GPRS mode.
- NIWE has launched the Indian Solar Radiation Atlas, with 3 km X 3 km spatial resolution, on 03.06.2015, providing details of solar resources at any location. At present annual average values of GHI, DNI and DHI are provided along with the administrative details pertaining to the 3 km X 3 km grid. 1 to 3 years quality ground measured solar data has been used for geographical adjustment and validation of the long term (1999-2014) data from Meteosat-5 and Meteosat-7.

Centre for Wind Energy Technology

- C-WET implementing the Solar Radiation Resource Assessment stations across the country in phase-wise manner
  - 51 SRRA Stations was completed and commissioned
  - 10 States and 1 Union Territory
  - Data is monitored at an interval of one second and averaged over a period of 1 minute
  - Data is available for short period
  - Quality checking process of the data is on
  - Paid Data Source http://www.cwet.tn.nic.in/html/departments_srra.html

State wise SRRA stations Phase I & II

Sl.No	State/UT	Phase I	Phase II	Total
1	Andhra Pradesh	6	3	9
2	Bihar	-	3	3
3	Chhattisgarh	1	1	2
4	Gujarat	11	2	13
5	Haryana	1	1	2
6	Himachal Pradesh	-	2	2
7	Jammu & Kashmir	1	1	2
8	Jharkhand	-	2	2
9	Karnataka	5	1	6
10	Kerala	-	2	2
11	Madhya Pradesh	3	5	8
12	Maharashtra	3	6	9

State wise SRRA stations Phase I & II

Sl.No	State/UT	Phase I	Phase II	Total
13	Orissa	-	4	4
14	Punjab	-	2	2
15	Rajasthan	12	-	12
16	Tamil Nadu	7	-	7
17	Uttar Pradesh	-	5	5
17	Uttarakhand	-	2	2
18	West Bengal	-	3	3
19	North-East	-	10	10
20	Union Territories	1	5	6
	Total	51	60	111

Charges for C-WET data

Sr. No.	Data Product per Station	Amount in Rs	
		Commercial Entities	Non-profit Organizations including academic and research institutions
1	Per day report	200	100
2	Per month	5,000	2,500
3	Per year	50,000	25,000
4	Monthly and daily average data (PDF file)	2,000	2,000

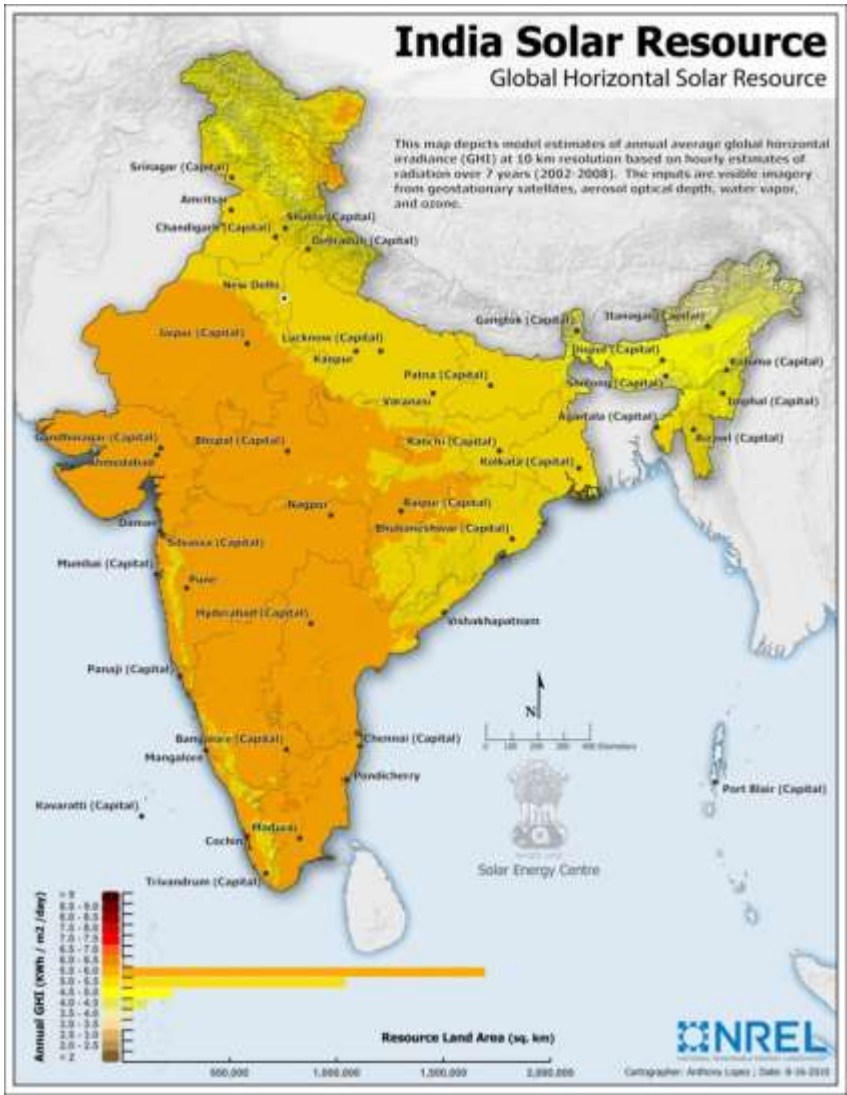
NASA Surface Meteorology and Solar Energy

- Developed by NASA' Langley Research Centre
- Data Period: 22 yrs data (July 1983-June 2005)
- Resolution: 1 degree x 1 degree =111km x 111km
- Global solar energy data for 1195 ground sites worldwide
- Data tables for a particular location
- Used for an approximate cross validation of data available from other sources

http://eosweb.larc.nasa.gov/cgi-bin/sse/register.cgi

SEC-NREL Database

- Products developed by the U.S. National Renewable Energy Laboratory(NREL)
- Solar Resource Assessment based on satellite imagery
- 8 yrs data January 2002 to December 2008
- Spatial Resolution: 10 km x 10 km
  http://mnre.gov.in/sec/solar-assmnt.htm



METEONORM Software

- Data Period - 20 yrs 1981-2000
- Fixed database contains 6200 cities , 8000 weather stations and 1162 Design Reference Year (DRY) sites
- Resolution = 1.85 km x 1.85 km
- Site within 50 km – Data from Meteonorm Meteorological Station
- Site more than 50 km but near than 300 km - a mixture of ground and satellite information
- Site more than 300 km - Satellite data
- Data at every location of the globe
- Files can be used in most of the solar power plant designing software
- Paid Data Source

Conclusion

Sr No	Data Source	Remark
1	IMD	Data available only for selected sites
2	C-WET SRRA	Data available only for selected sites for very short duration
3	NASA	Useful for an approximate cross validation of data
4	SEC-NREL	Data for exact latitude, longitude is not available
5	Meteonorm	For most of the sites data is interpolated
	NIWE	

Meteonorm is preferred due to high resolution, global applications and conservative approach

Site Analysis

- Solar resource
- Local climate
- Available area
- Land use
- Topography
- Geotechnical
- Geopolitical
- Accessibility
- Grid connection
- Module soiling
- Water availability

Site Selection Considerations

- **Solar resource**
  - higher the resource, the greater the energy yield per kWp installed
  - More than 1500 kWh/sq m /year

Contd…

Site Selection Considerations

- **Area**
  - Depending on the type of PV module selected (efficiency) and the site location (latitude)
  - Sufficient area to avoid significant inter-row shading
  - Crystalline SPV Plant - 5 acres/MWp
  - Thin film SPV Plant – 8 acres/MWp

Contd…

Site Selection Considerations

- **Climate**
  - **Temperature** : Efficiency reduces with increasing temperature
    - Thin Film PV module (-0.25%/oC)
    - Crystalline PV module (-0.45%/oC)
  - **Flooding** : the risk of erosion of support structure and foundations
  - **High wind speeds:** Locations with a high risk of damaging wind speeds should be avoided
  - **Snow :** Snow settling on modules reduce annual energy yield
  - A site that has regular coverings of snow for a long period of time may **not** be suitable for developing a solar PV plant

Contd…

Site Selection Considerations

- **Topography –**
  - the site should be flat
  - on a slight south facing slope (in the northern hemisphere)
  - Slope < 3-5%

Contd…

Site Selection Considerations

- **Geotechnical**
  - Groundwater level
  - Load-bearing capacity of the soil
  - Presence of rocks or other obstructions
  - Soil pH (6.5 – 8.5) and chemical constituents
  - Resistivity of the soil
  - Seismic zone
    - Zone-V: highest risks zone;
    - Zone-II: Low Damage Risk Zone

Contd…

Site Selection Considerations

- **Geopolitical**
  - Directly affected groups (economically and physically displaced people) living within the project footprint
  - Rehabilitation and resettlement issues
  - Local political issues

Contd…

Site Selection Considerations

- **Access**
  - to carry material during construction and commissioning
  - Good road take care of susceptibility to damage in transport
  - Existing road network can enhance project viability

Contd…

Site Selection Considerations

- **Grid Connection**
  - **Capacity**
    - Enough capacity to feed generated power into grid
    - Upgrade the network to allow the desired export capacity
  - **Proximity**
    - distance from the site to the grid connection point
    - not adversely affect project economics
  - **Availability**
    - It is the percentage of time that the network is able to export power from the solar PV plant

Contd…

Site Selection Considerations

- **Land Use**
  - Solar PV power plants will ideally be built on low value land or waste land
  - Developer must purchase the land or rights for the duration of the project
  - Future land use of the area must also be taken into account
  - Locating the plant in an environmentally sensitive area should be avoided

Contd…

Site Selection Considerations

- **Module Soiling**
  - Efficiency of the solar plant could be significantly reduced
  - Dust particles from traffic, building activity, agricultural activity or dust storms
  - Module soiling from bird excreta
  - Areas close to nature reserves, bird breeding areas and lakes should be carefully assessed
  - Typically 2-3 % losses

Contd…

Site Selection Considerations

- **Water Availability**
  - Clean, low mineral content water for cleaning modules
  - A mains water supply, ground water, stored water required
  - Water requirement is depends upon
    - Level of module-soiling
    - Extent of natural cleaning due to rainfall
    - Required cleaning frequency
    - Typically for 1 MWp SPV plant requires 12000-15000 liters water per cleaning

Contd…

Conclusion:

Sr No	Parameters	Remark
1	Solar resource	Should have sufficient GHI
2	Local climate	Site with extreme weather condition may be avoided
3	Available area	Should have sufficient area
4	Land use	Mostly waste land may be preferred
5	Topography	Site with minimum slope and South facing may be preferred
6	Geotechnical	Site may be select on the basis of geotechnical survey
7	Geopolitical	Site with political conflict may be avoided
8	Accessibility	Site with connectivity may be selected
9	Grid connection	Distance of substation should be minimum
10	Module soiling	Avoid site with high level of soiling
11	Water availability	Site with sufficient water may be selected

Thank You