Assessment and Design of Large Scale Solar Projects

Click to begin

TOPICS

Click on the ***Action Buttons*** *to directly jump to respective sections*

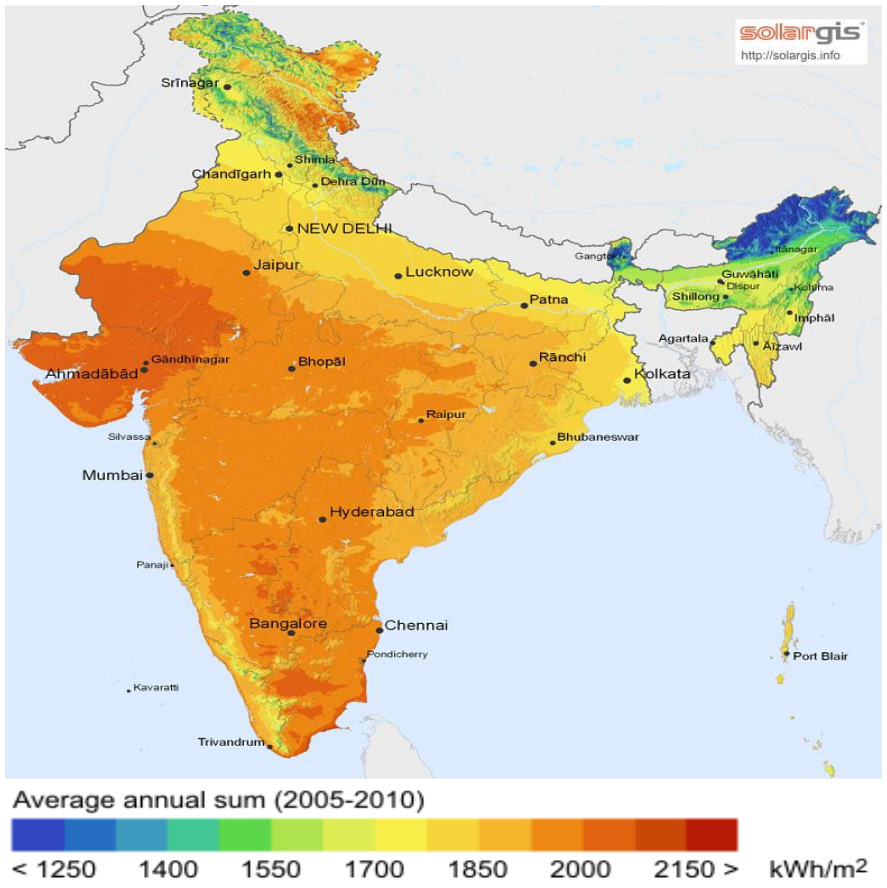
India Scenario

SOLAR POTENTIAL IN INDIA

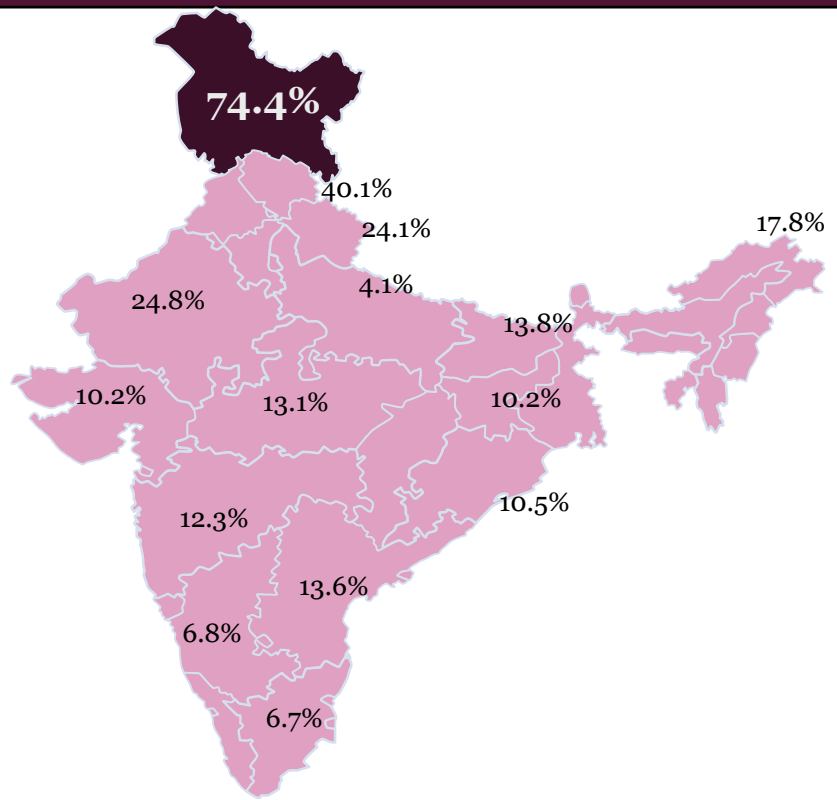
- India lies in the high solar insolation region, endowed with huge solar energy potential.
- Our country receives about 300 days of sunshine per year with annual mean daily global solar radiation in the range of 4.5-6.5 kWh/m2/day.
- MNRE is focused to develop Solar Parks and Solar power plants to tap this huge potential.
- To tap this huge potential, Solar Parks and Solar Power Plants of capacity 500 MW and above are planned under the Jawaharlal Nehru National Solar Mission to strengthen India's solar footprint, reduce GHG emissions and achieve the targets set by GoI for 2022.

LAND AVAILABILITY: UTILIZING WASTELANDS

Solar Resource



Wastelands in a few states (% of total area)



Jammu & Kashmir has the highest % of Land as **wastelands**

Solar PV System

SOLAR ENERGY – TERMINOLOGIES (1/2)

- **Irradiance:** Intensity of solar energy received per unit area i.e. instantaneous solar power falling on a unit perpendicular area. Unit is KW/square meter

- **Insolation:** Quantity of solar energy received per unit area i.e. solar irradiance integrated over time is called solar insolation. Unit is KWh/square meter. Solar Insolation is depended on location and needs to be evaluated specific to the site.

- **Peak Sun hours:** Number of hours during which the intensity of sunlight is 1,000 watts per square meter.

- **Tilt Angle:** Solar panels are most efficient, when they are perpendicular to the sun's rays. It is the angle that the panel should be tilted to derive the best incidence of solar energy. The Tilt Angle is the angle that forms between the horizontal and the long axis of the PV Module. The default value is a tilt angle equal to the station's latitude.

- **Azimuth Angle:** Azimuth Angle is the angle between the surface of the panel and exact south direction. For maximum performance, the azimuth angle in Indian context should be 180 degrees.

SOLAR ENERGY – TERMINOLOGIES (2/2)

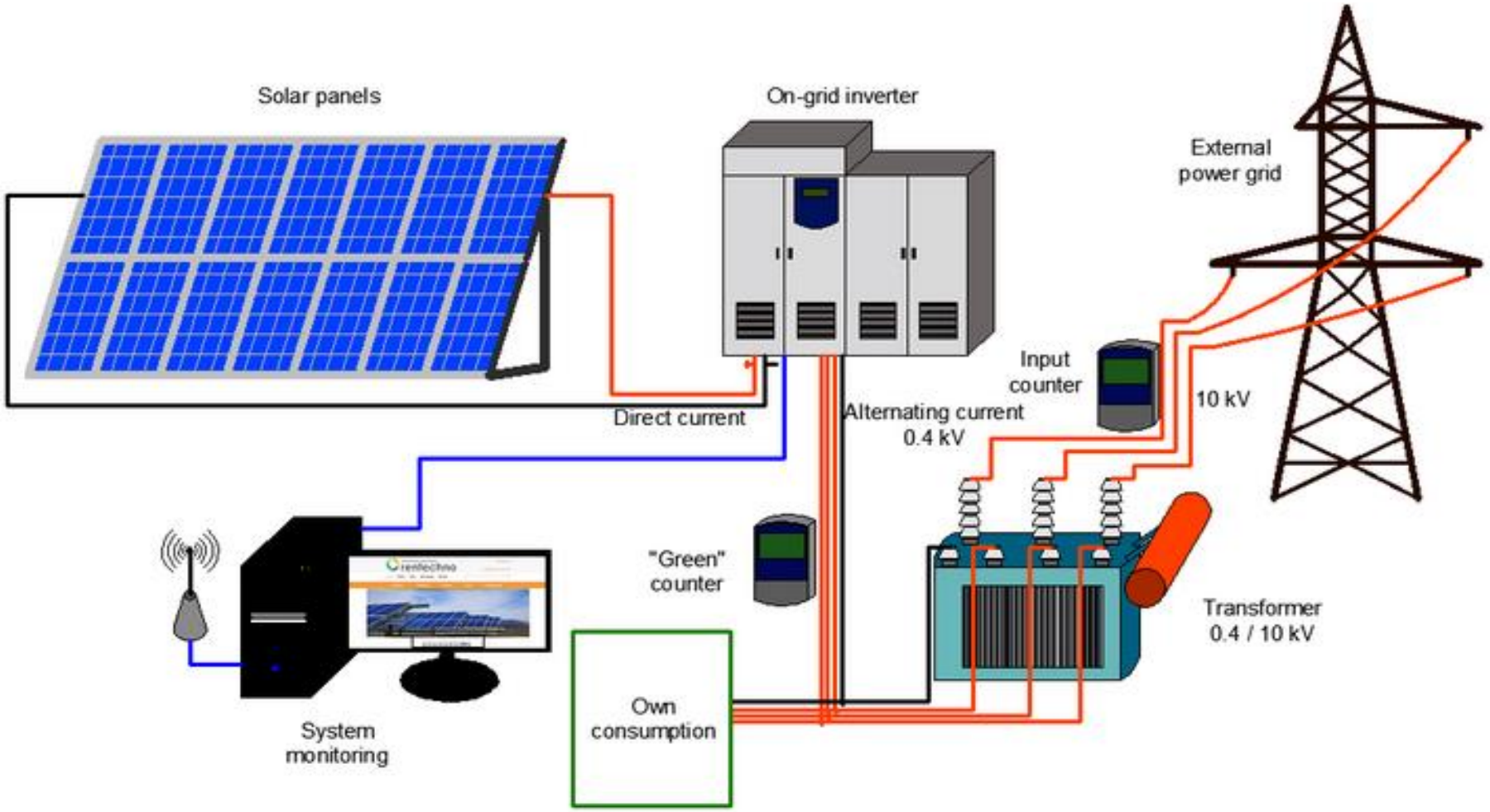
- **Direct Normal Irradiance (DNI):** It is the amount of solar radiation received per unit area by a surface that is always held perpendicular (or normal) to the rays that come in a straight line from the direction of the sun at its current position in the sky.

- **Diffuse Horizontal Irradiance (DHI):** It 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.

- **Global Horizontal Irradiance (GHI):** It is the total amount of shortwave radiation received from sun by a surface horizontal to the ground. This value is of particular interest to photovoltaic installations and includes both Direct Normal Irradiance (DNI) and Diffuse Horizontal Irradiance (DHI).

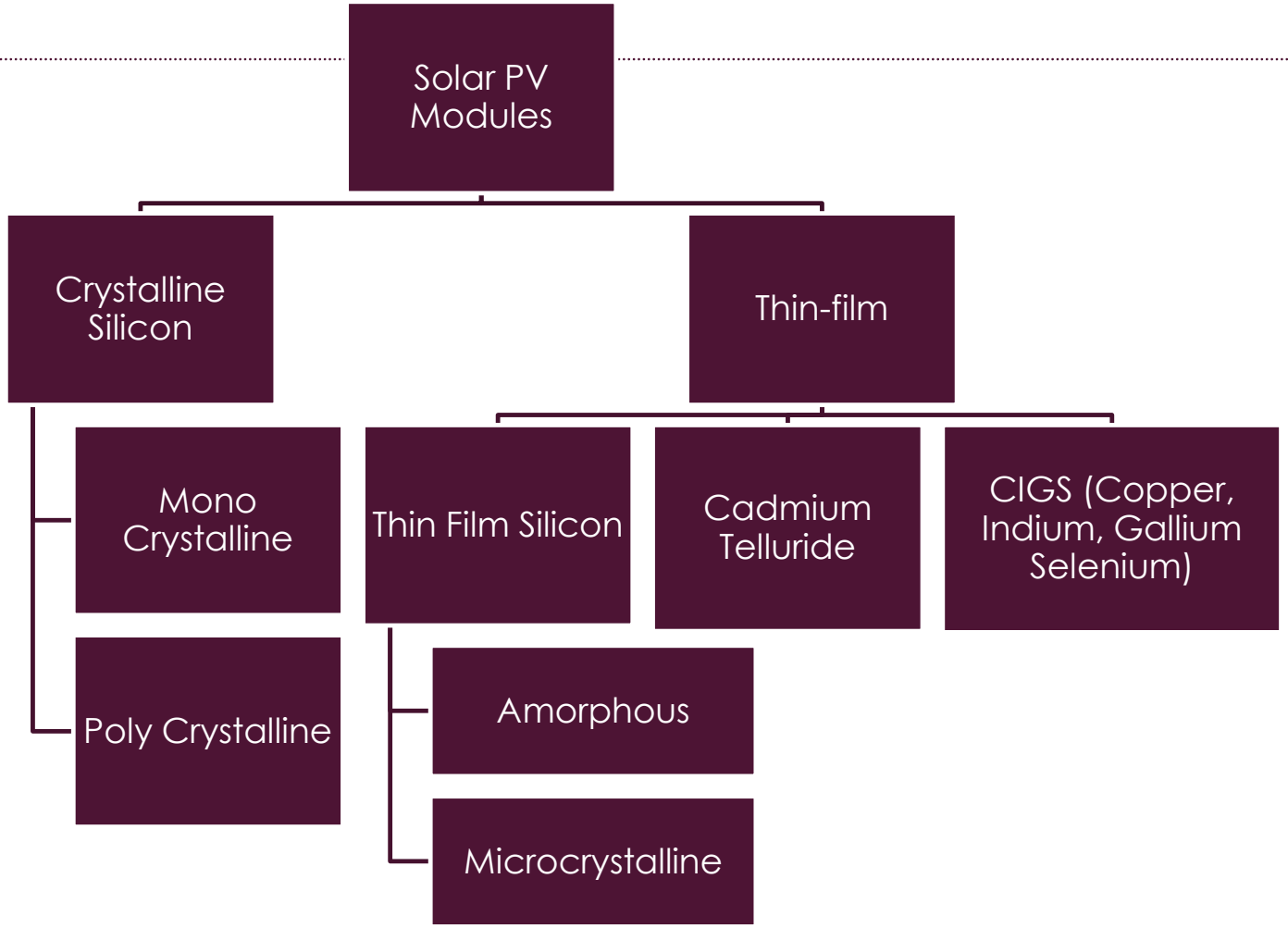
- **Capacity Utilization Factor (CUF):** It is used to define a solar PV plant's performance. It is the ratio of the actual energy produced over a period of a year and its output if it had operated at nominal power the entire year (including night times i.e. 365 X 24)

SOLAR PV – SYSTEM COMPONENTS (1/5)



SOLAR PV MODULES (2/5)

- Most basic and important component of the solar PV system
- Component that converts sunlight to electricity
- More the number of panels, more the amount of electricity generated
- Life of panels can be upto 20 years



SOLAR PV MODULES (3/5)

Parameter	Crystalline	Thin film
Method of Preparation	Monocrystalline cells cut from a single crystal while polycrystalline cut from multi-faceted crystal	Manufactured by depositing one or more thin layers of PV material on a substrate
Efficiency	Higher Efficiency compared to Thin-Film. Range 12-22 %	Efficiency Range 6 – 16%
Temperature Tolerance	Higher temperature coefficient and decreased efficiencies as temperature increases	Less temperature coefficient and largely unaffected under higher temperatures
Shade Tolerance	Low	High
Power Output	High power per given area	Low power per given area
Land requirement	Lower area requirement compared to thin-film; 5 – 12 m^2 / KWp	Area requirement is high 8 – 22 m^2 / KWp
Maturity at large scale	Proven	Low
Environmental Issues	No	Moderate
Balance of System (mounting structure, cabling, etc.)	Not flexible and heavier compared to thin films	Thin Film, flexible and light weight compared to crystalline cells
Accessories & additional materials	Less requirement	High requirement
Inverter flexibility	High	Low
Cost	$ 0.6 – 0.9 / Watt	$ 0.5 – 0.7 / Watt
Status of commercialization	High	High

SOLAR PANEL SPECIFICATIONS (4/5)

- **Peak Power (W_p):** It is the maximum power that a solar panel can give when it is being operated in full sunlight. Higher the peak power, higher the energy output of panel.
- **Open Voltage (V_{oc}):** It is the voltage measured when panel is connected only to voltmeter and pointed to sun. The open voltage value helps to position the panel in right direction. Higher the Voc, higher the energy output of panel.
- **Short Circuit Current (I_{sc}):** It is the current measured when the panel is connected only to ammeter to measure the short circuit current. Higher the $I_{sc,}$ higher the energy output of the panel.
- **Standard Test Conditions (STC):** All the solar modules are rated under the STC i.e. maximum power output is given at standard conditions of temperature (25 degrees), irradiance (1 KW/m2), well controlled laboratory losses.
- **Peak Power (W_p) = Max. power voltage (V_{mp}) X Max, power current (I_{mp})**

Temperature ⇧	Output Voltage ⇩	Output Power ⇩
Irradiance ⇧	Output Current ⇧	Output Power ⇧

OTHER COMPONENTS (5/5)

- **Inverter**
  - Converts DC output of PV panels to AC for supply to appliances or feed to grid
  - Inverter selection should be done critically considering starting current requirements of motors and compressors
  - Responsible for matching the panel output voltage to reference voltage, ensuring steady supply to equipments
- **Step-up Transformer**
  - Distribution transformer steps up the voltage to match the distribution system
  - Grid transformer steps up the voltage to match the voltage of transmission systems
- **Mounting / Tracking system**
  - Allows PV modules to remain fixed to ground at a defined tilt angle or on sun tracking frame

Solar Resource Assessment

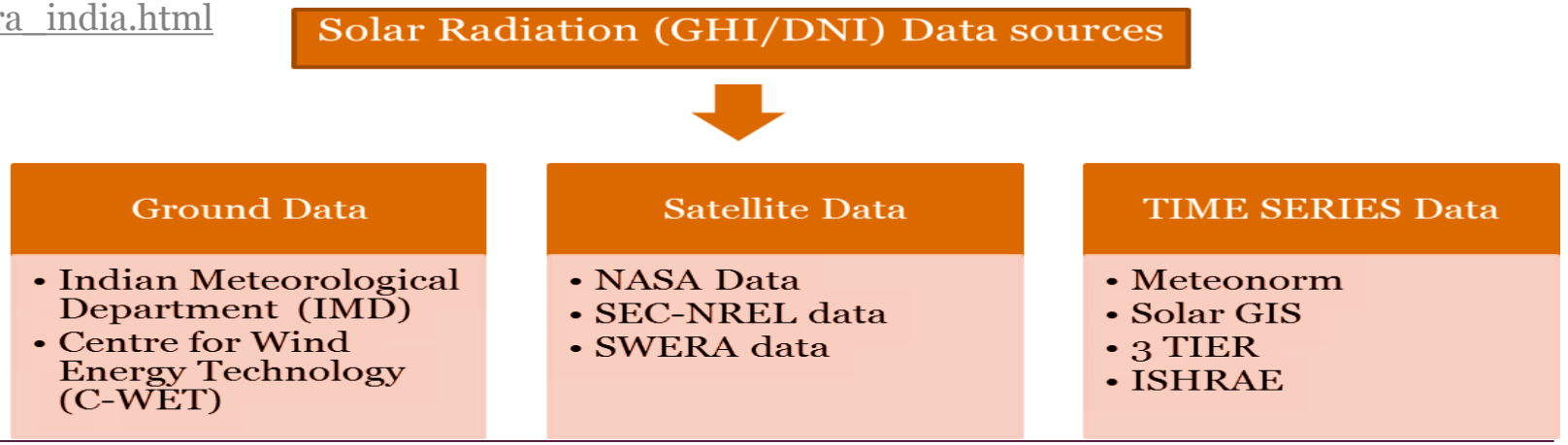
SOLAR RADIATION RESOURCE ASSESSMENT

- Solar resource assessment provides the means to accurately determine the availability of solar radiation resources for developing, deploying, and operating cost-effective solar energy technologies

- Accurate solar radiation data sets are the foundation of a successful performance model and are critical in reducing the expense associated with mitigating the performance risk. It is thus an important aspect before taking up any site for a project implementation.

- Evaluation of DNI, DHI, GHI is important so that the PV modules generate maximum output throughout their lifecycle.

- Click on following links to gain further insight on the solar radiation assessment: http://niwe.res.in/department_srra.php, http://www.nrel.gov/international/ra_india.html



Solar Site Assessment

SITE ASSESSMENT – CRITERIA

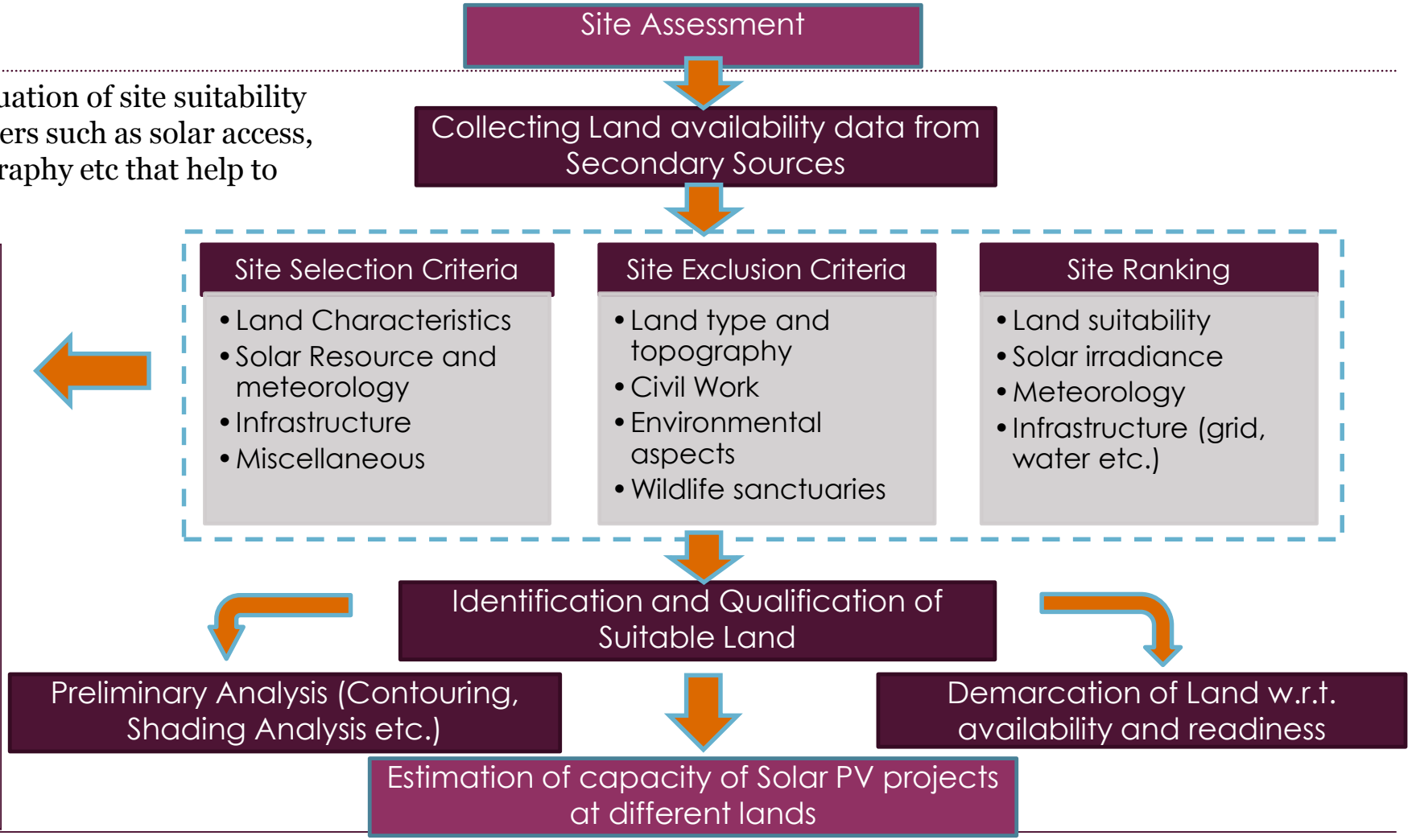
- Site assessment involves evaluation of site suitability in relation to several parameters such as solar access, shadowing, geography, topography etc that help to optimize the plant's output.

Meteorology
- Micro-Climate

Solar Resource Assessment

Land Characteristics
- Size, shape, orientation
- Shading, land use
- Seismic activities, flooding etc.
- Ownership

Infrastructure
- Grid availability
- Accessibility
- Connectivity (Road, Rail, air)
- Water availability
- Electrical situation



Design of Large Scale Solar PV plants

PLANT DESIGN REQUIREMENTS (1/2)

- **PV Module Selection**
  - Technology selection in accordance with local conditions of temperature, topography, irradiation etc.
  - Warranties by the manufacturer
  - Certifications obtained from the manufacturer
- **Inverter Selection**
  - Adequate capacity
  - Compliance with all standards and regulations
  - Good conversion efficiency
- **Transformer Selection**
  - Capacity is adequate
  - Compliance with all standards and regulations
  - Efficiency and losses as per market standards

PLANT DESIGN REQUIREMENTS (2/2)

- **Solar Resource Assessment**
  - Appropriate assessment of solar resource at site by referring to various sources such as satellite data, site measurements etc
- **Site Selection**
  - Identification of suitable land area
  - Complete assessment of site – solar resource assessment, topography, soiling, access routes, grid connection proximity etc.
- **General**
  - Designing row spacing of modules to reduce inter-row shading and associated shading losses.
  - Designing the layout to minimize cable runs and associated electrical losses
  - Creating access routes and sufficient space between rows to allow movement for maintenance purposes
  - Appropriate selection of tilt angle to ensure maximum irradiation on panel surface

QUIZ TIME

Lets check what you have learnt till now.

Answer the questions correctly OR

Consider revising this module … All the Best !!

NOTE: Click on the suitable option for answering the question

Q 1. Solar Insolation is defined as

1. Instantaneous solar power falling on a unit perpendicular area (KW/m2)
2. Quantity of solar energy received per unit area (KWh/m2)
3. Number of hours during which the intensity of sunlight is 1,000 watts per square meter
4. Angle that forms between the horizontal and the long axis of the PV Module

QUIZ TIME

Q 2. Global Horizontal Irradiance GHI) is defined as total amount of radiation received from sun by a surface horizontal to the ground. This important parameter takes into account which other two (2) parameters?

1. Direct Normal Irradiance (DNI) and Capacity Utilization Factor (CUF)
2. Tilt Angle and Direct Horizontal Irradiance (DHI)
3. Direct Normal Irradiance (DNI) and Direct Horizontal Irradiance (DHI)
4. Direct Normal Irradiance (DNI) and Azimuth Angle

QUIZ TIME

Q 3. Crystalline type solar PV modules **are better than** Thin Film type solar PV modules in which of the following parameters?

1. Efficiency and Power Output
2. Temperature Coefficient
3. Land Requirement
4. Environmental Issues
5. All of the above

QUIZ TIME

Q 4. The **Output Power** of the solar panel is related to **Temperature and Irradiance** in which of the following manner

1. Directly to Temperature and Inversely to Irradiance
2. Directly to both Temperature and Irradiance
3. Inversely to both Temperature and Irradiance
4. Inversely to Temperature and Directly to Irradiance

QUIZ TIME

Q 5. Which of the following is **not** important while designing a large scale solar PV plant?

1. Selection of solar PV module
2. Selection of Inverter and Transformer of appropriate capacity
3. Consent of consumers who will get the power from the plant setup
4. Solar Radiation assessment and Land identification for the plant

End of Training Module

THANK YOU

Congratulations !!

That's a correct response...

Next Question

Sorry !!

That's incorrect…

Try again

Next Question

Congratulations !!

That's a correct response…

Next question

Sorry !!

That's incorrect…

Try again

Next question

Congratulations !!

That's a correct response…

Next question

Sorry !!

That's incorrect…

Try again

Next question

Congratulations !!

That's a correct response…

Next question

Sorry !!

That's incorrect…

Try again

Next question

Congratulations !!

That's a correct response...

Exit

Sorry !!

That's incorrect…

Try again

Go to the beginning of the section

Exit