Solar PV Training Course

Solar Assessment for Commercial & Industrial (C & I) Customers

May 2019

COURSE OUTLINE

Section I:
Basic Knowledge to Solar Resources

Section II:
Orientation of PV Panels for Capturing Optimal Solar Resources

Section III:
Measurement for Shading Analysis and Estimation of Electricity Generation

Section IV:
Case Study

Section V:
Appendix

Section I:
Basic Knowledge to Solar Resources

BASIC FACTS OF THE SUN

Mass: 2×10^{30} kg (333,000 times of the Earth)

Surface temperature: 5800 K

Radius: 6.96×10^{8} m

Origin of Energy: Nuclear Fusion

The solar radiation incident on the Earth's atmosphere at relatively constant value.

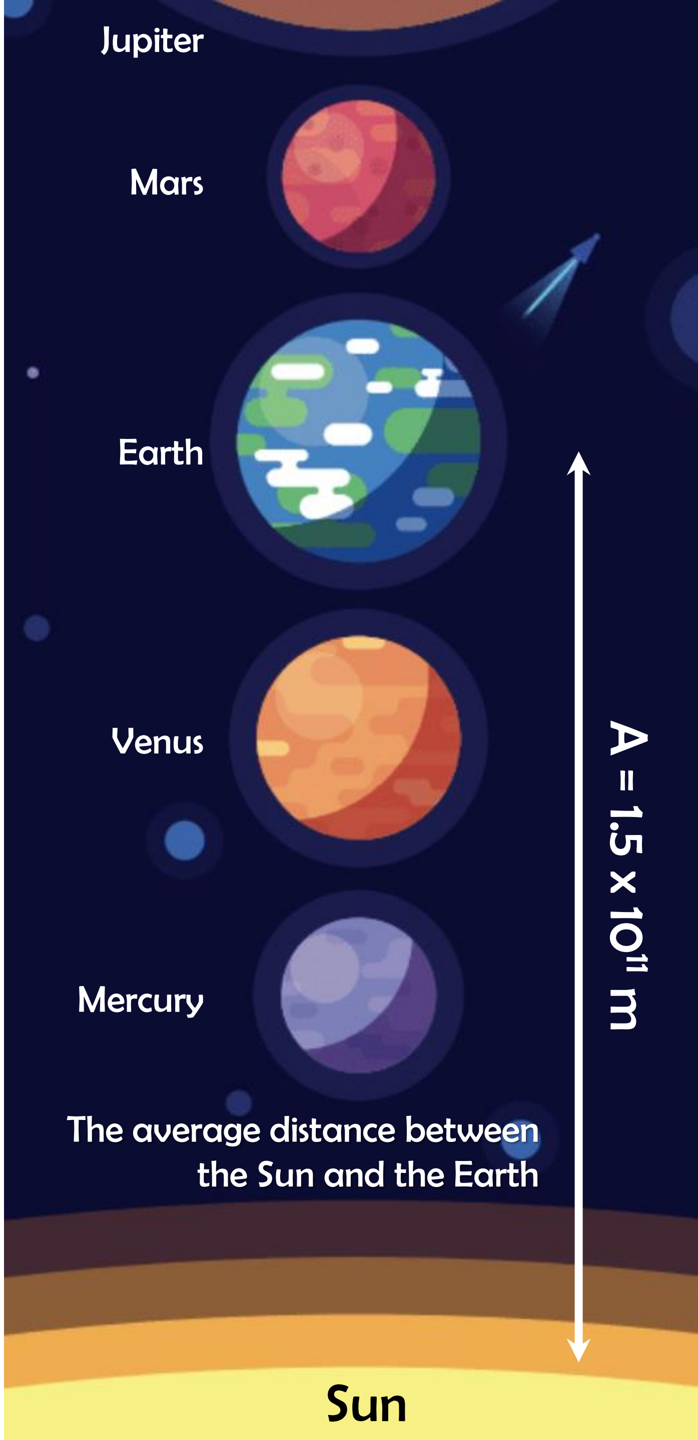
Solar Constant = 1,367 W/m²

However, the radiation measured at different parts on the Earth varies.

Factors that affect the radiation reaching the Earth's surface

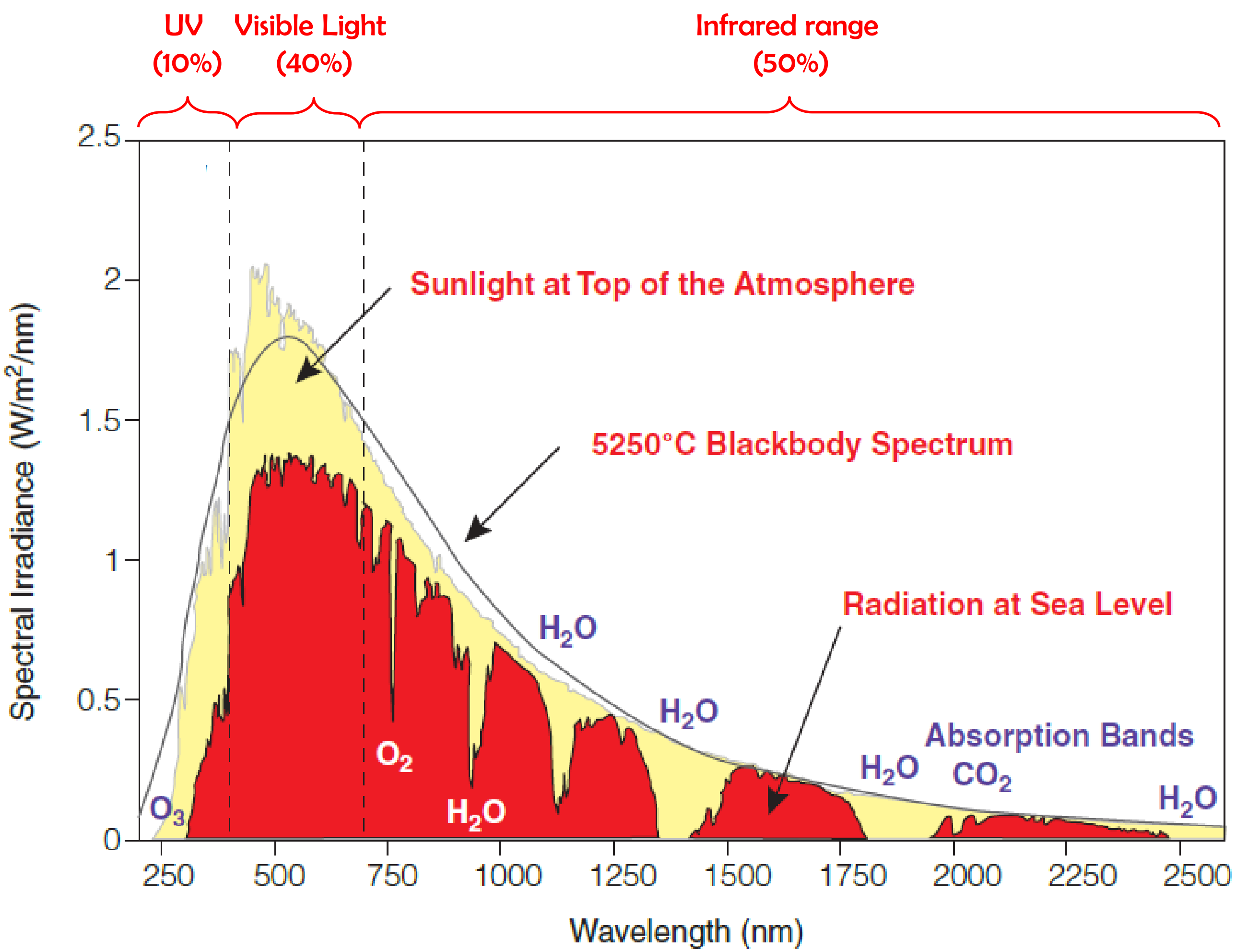
- Atmospheric effects, including absorption and scattering;
- Local variations in the atmosphere, such as water vapour, clouds, and pollution;
- Latitude of the location;
- The season of the year;
- The time of day

Most of the energy sources humans use to generate electricity come from the Sun.
E.g. fossil fuel, wind energy, solar energy etc.



SOLAR RADIATION SPECTRUM

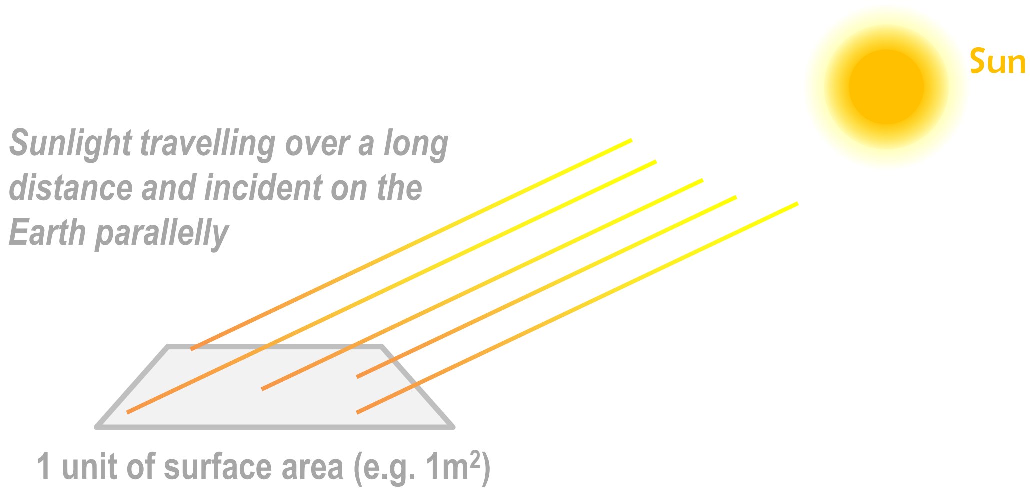
The Sun's radiation is made up of a range of wavelengths, which are affected differently as they pass through the atmosphere. PV panels can convert part of the radiation in the spectrum into electricity.



QUANTIFYING SOLAR ENERGY

The Sun's energy travels through outer space as electro-magnetic radiation. How to quantify energy carried by EM radiation in solar assessment?

Intensity = amount of energy falling on a unit area per unit time



Terminology used in Solar Assessment

Term	Definition	Unit
Irradiation (equivalent to intensity)	Total energy over a set period of time reaching a unit of surface area	Watts per square metre (W/m^2)
Irradiance	Rate of energy reaching a unit surface area	Watt hour per square metre (Wh/m^2)

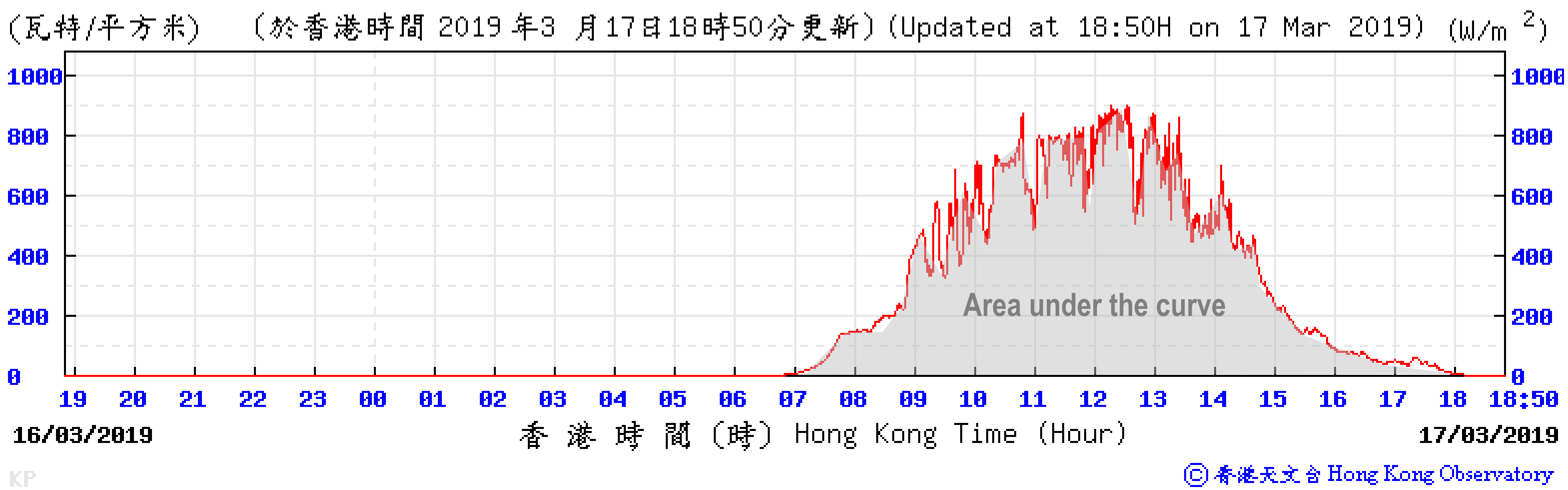
MEASUREMENT OF SOLAR IRRADIATION

Solar irradiation is either measured directly using pyranometer or photovoltaic reference sensor, or indirectly by analysing satellite image.

	 Pyranometer	 Photovoltaic Reference Sensor
Working Principle	• Contain a black metal as an absorber surface, below which a thermopile will create a voltage proportional to the irradiance	• Contain a small PV cell that generate current proportional to irradiance by photovoltaic effect
Properties	• Wider spectrum of light can be measured • Slower in response	• Certain components of solar irradiation are measured (narrower light spectrum measured) • Faster in response
Accuracy	• Higher accuracy in measurement	• Lower accuracy in measurement
Cost		

MEASUREMENT OF SOLAR IRRADIATION BY THE OBSERVATORY

The Observatory keeps measuring the daily solar irradiation by pyranometer and hence it provides engineers a reference for the availability of local solar energy resource.



Area under the curve (Irradiation – time graph) (W/m²) = irradiance of the day (Wh/m²)

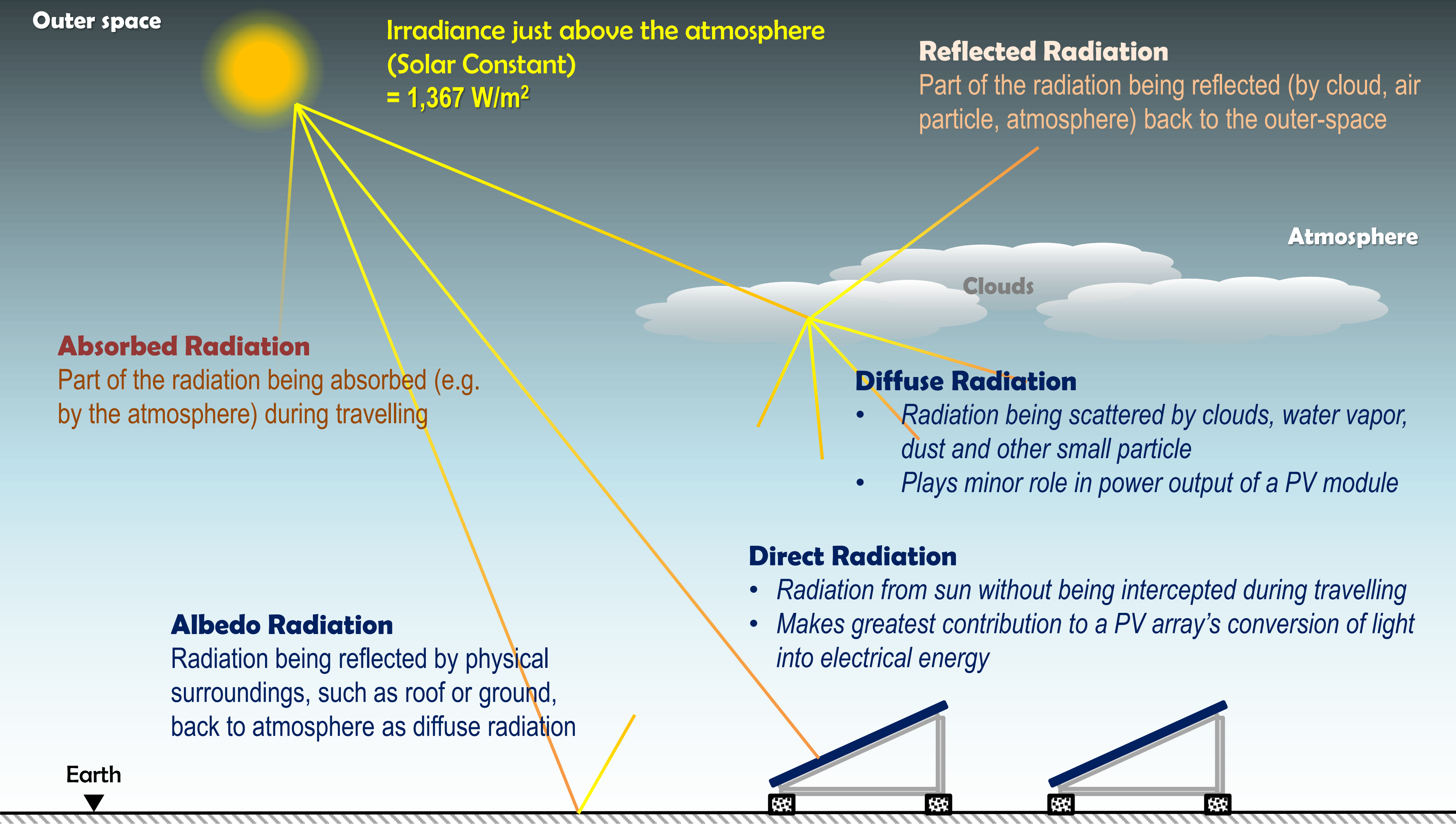
Advantages

- On site measurement provide an accurate solar irradiation record for a potential PV installation location
- The measurement will take weather into consideration

Disadvantages

- The measurement cannot tell the effect of shading
- The reading from the Observatory cannot tell the change in irradiance on a collection surface if there are changes in the azimuth and tilt angle

ATMOSPHERIC EFFECTS ON THE SOLAR RADIATION AT THE EARTH'S SURFACE



Remarks: *% of radiation being absorbed, reflected subject to status of the atmosphere*

AIR MASS

Since our planet is an oblate spheroid, and different location has different latitude, the sunlight incident on Earth should have different path length. What does it imply in solar assessment?

Definition

The Air Mass is the path length which light takes through the atmosphere normalized to the shortest possible path length (the condition under which the sun is directly overhead)

$$AM = \frac{y}{x} = \frac{1}{x / y} = \frac{1}{\cos \theta}$$

When the sun is directly overhead,

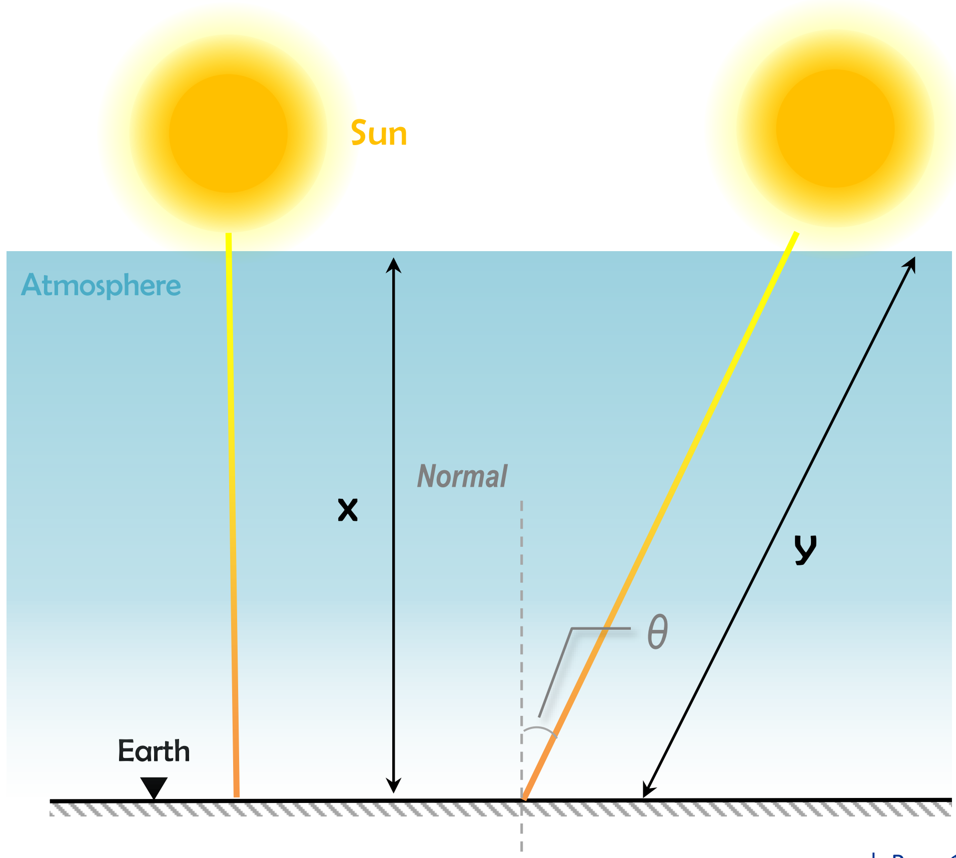
$$AM_{\text{Sun Overhead}} = \frac{x}{x} = \frac{1}{1} = 1 = AM1$$

For outer space, AM is defined as 0:

$$AM_{\text{outer space}} = 0 = AM0$$

The irradiance / intensity of the direct component of sunlight throughout each day can be determined experimentally as

$$I = 1367(0.7)^{AM^{\wedge}\,0.687}$$

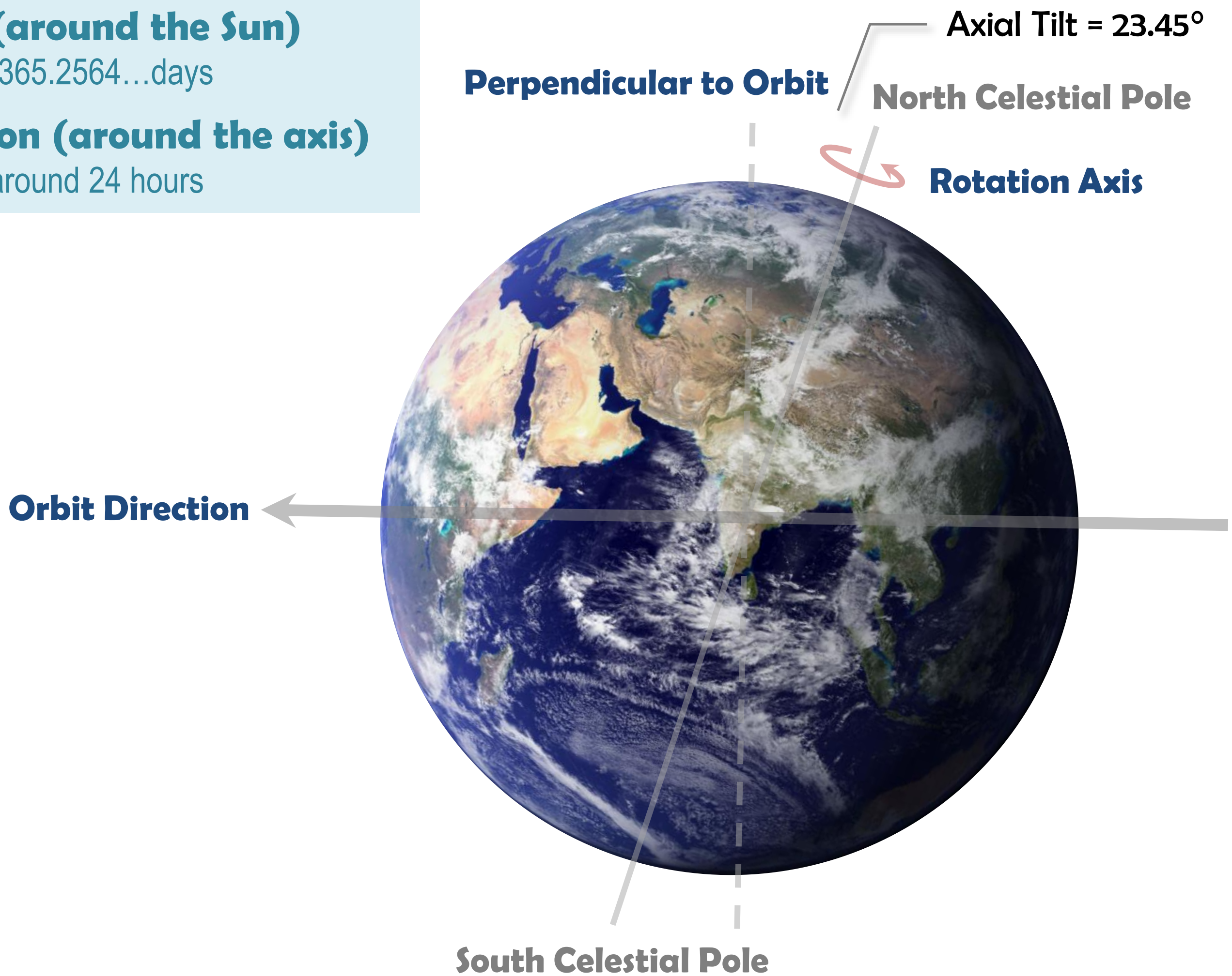


ORBIT AND ROTATION OF THE EARTH

The orbit and rotation of the Earth determine the solar resource that we can capture throughout the year.

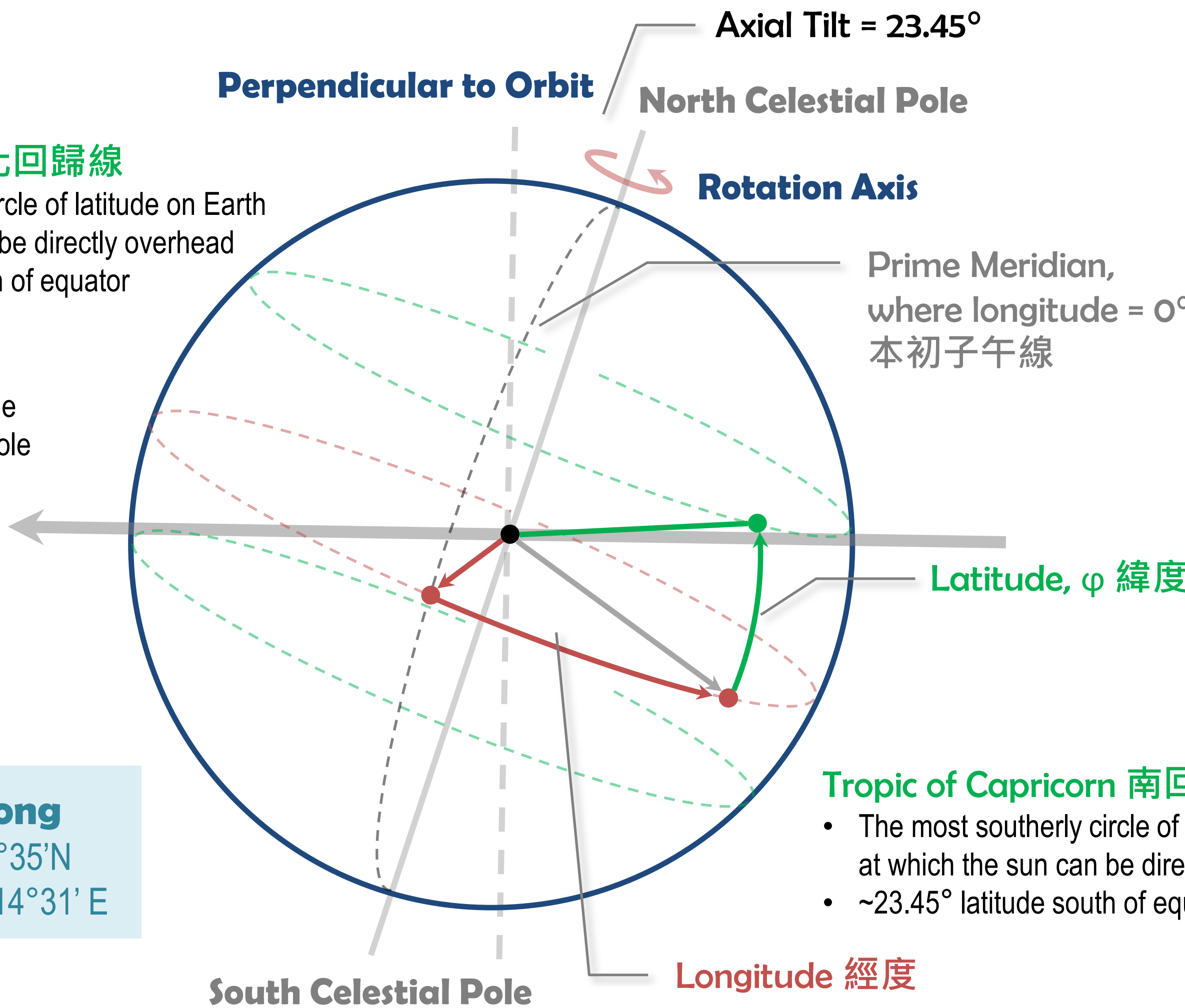
Orbit (around the Sun)
1 year = 365.2564…days

Rotation (around the axis)
1 day = around 24 hours



TERMINIOLOGY IN EARTH SCIENCE AND GEOGRAPHY

How to define a specific location on the Earth?



Tropic of Cancer 北回歸線

- The most northerly circle of latitude on Earth at which the sun can be directly overhead
- ~23.45° latitude north of equator

Equator 赤道

- Zeroth circle of latitude
- Equidistant from its pole

Tropic of Capricorn 南回歸線

- The most southerly circle of latitude on Earth at which the sun can be directly overhead
- ~23.45° latitude south of equator

Location of Hong Kong

Latitude: ~22°08' – 22°35'N

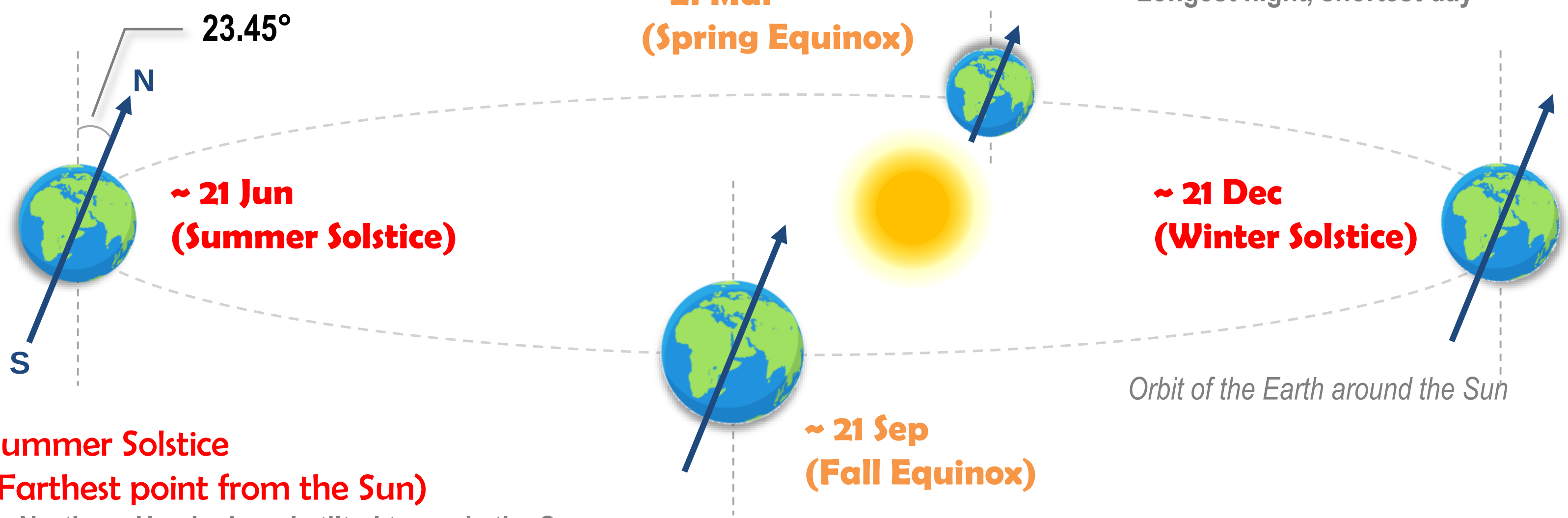
Longitude: ~113°49' – 114°31' E

ORBIT OF THE EARTH AROUND THE SUN

Knowing the motion of the Earth around the Sun not only helps us to set up the calendar, but also tells important information of the solar resources in different seasons.

Winter Solstice
(Closest point from the Sun)

- Southern Hemisphere is tilted towards the Sun
- Longest night, shortest day



Summer Solstice
(Farthest point from the Sun)

- Northern Hemisphere is tilted towards the Sun
- Longest day, shortest night

Spring & Fall Equinox
(The distances between the Earth and the Sun are equal)

- Neither Northern nor Southern Hemisphere is pointing towards the Sun
- Equal hours of day and night

DECLINATION ANGLE

Definition

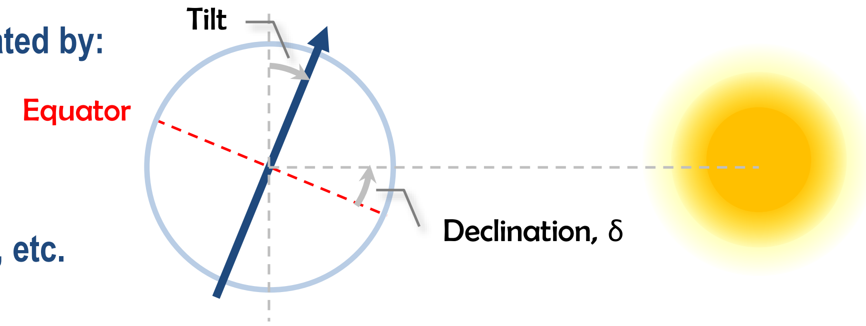
The declination angle, δ, is the angular distance of the sun north or south of the earth's equator, which is also equivalent to *the tilt of the Earth on its axis of rotation and the rotation of the Earth around the Sun*.

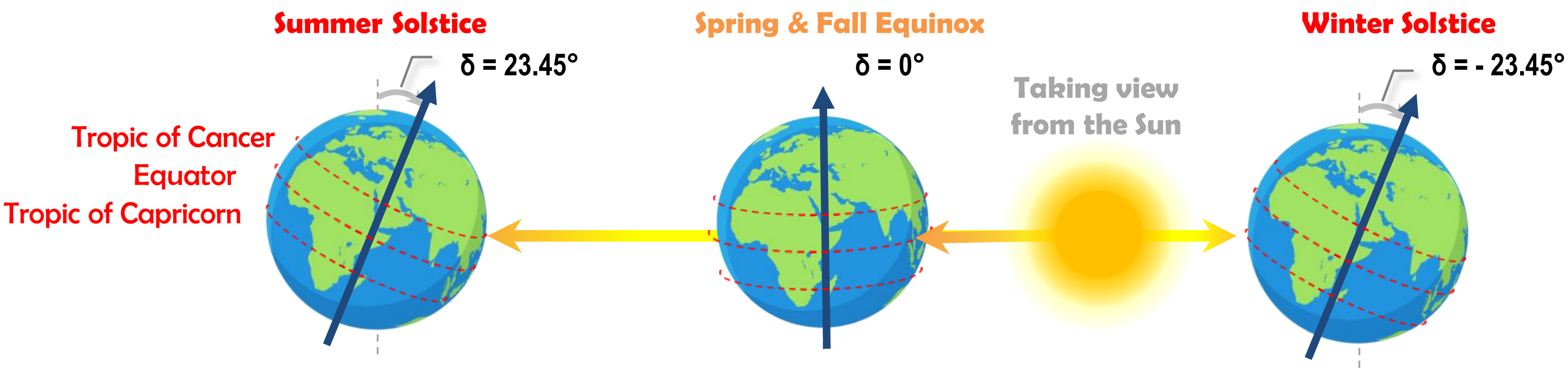
Remarks: Please note that declination does not necessarily be equal to tilt of the Earth, which is always 23.45°

By mathematical modelling, declination, δ, can be estimated by:

$$\delta = 23.45° \sin\left[\frac{360}{365} \times (d - 81)\right]$$

, where d = 1 for 1st Jan, 2 for 2nd Jan,… , 365 for 31st Dec, etc.





On the Summer Solstice, the Sun is directly over the Tropic of Cancer, where latitude = 23.5°; the condition reverses on the Winter Solstice. For Spring & Fall Equinox, the Sun is directly over the Equator

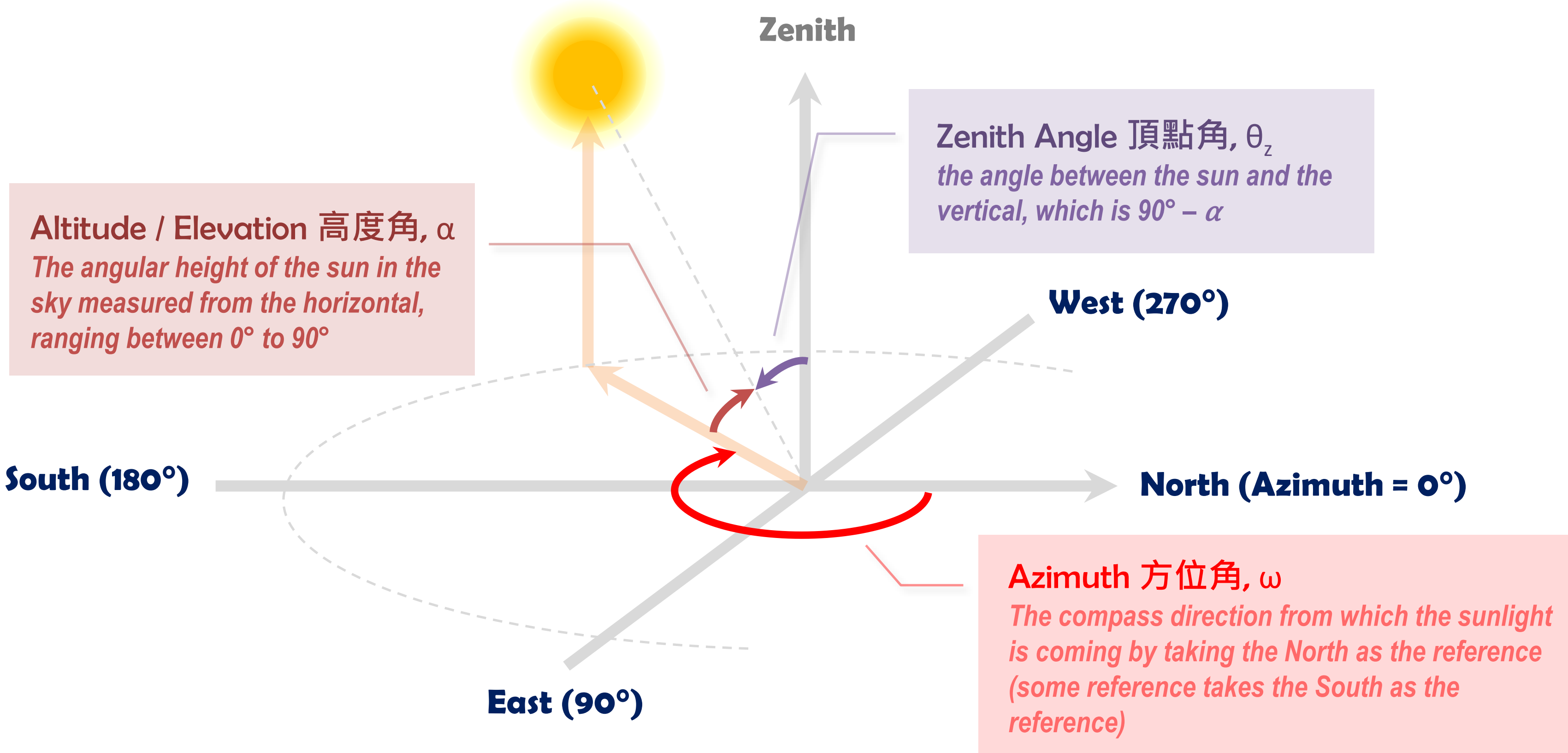
SOLAR GEOMETRY (FROM A FIXED POINT ON THE EARTH)

Knowing the sun path throughout the day and the year are important in solar assessment.
To define the position of the sun, at least two angles, known as azimuth and altitude are required.

Terminology used in Solar Assessment

Relation between altitude, declination, latitude, and azimuth

$$\sin\alpha = \sin\delta \sin\varphi + \cos\delta \cos\varphi \cos\omega$$

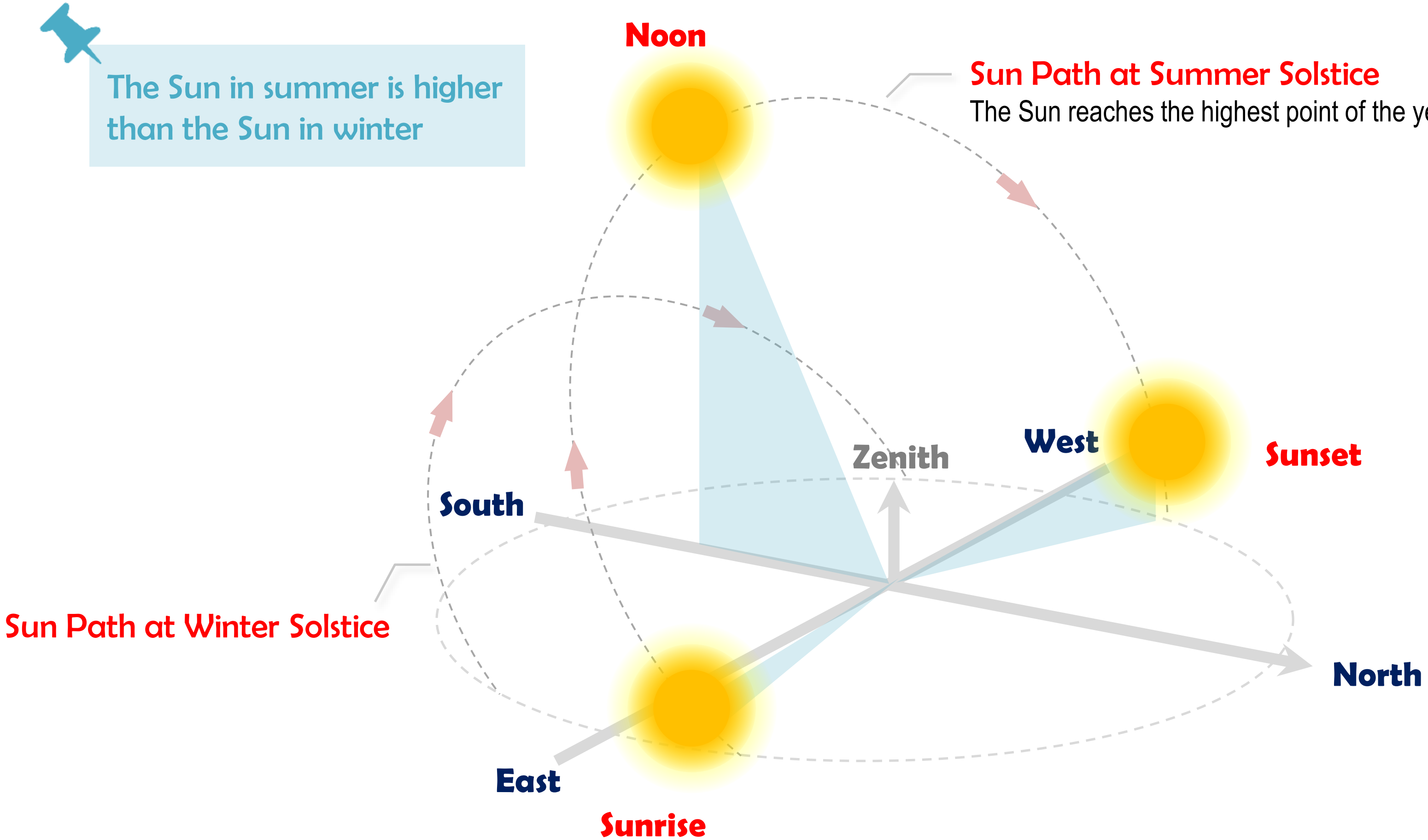


MOTION OF THE SUN (FROM A FIXED POINT ON THE EARTH)

The motion of the Sun in the sky throughout the year is different. What is the difference between the altitude of the Sun in summer and winter? What does it imply?

Taking Northern Hemisphere as an example

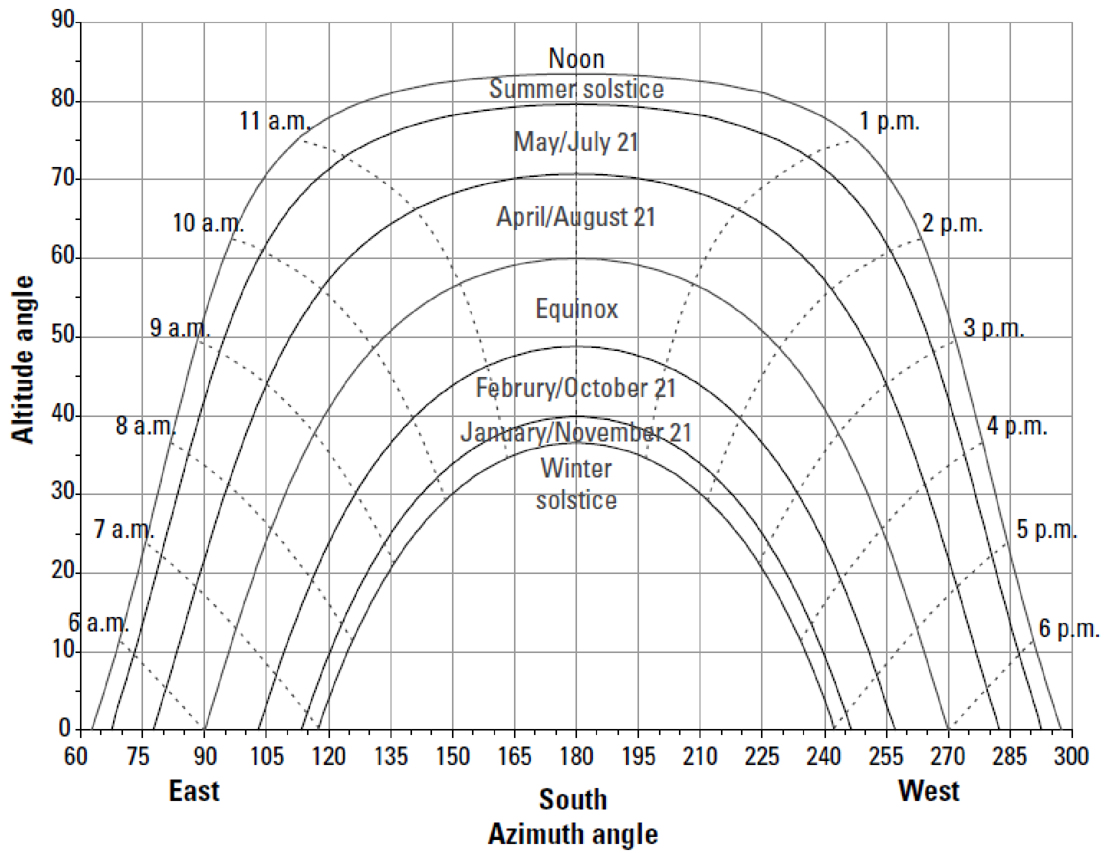
The Sun in summer is higher than the Sun in winter



SUN CHART AND SUN PATH

By measuring the azimuth and altitude of the sun throughout the year, a sun chart (graph of altitude vs azimuth) can be plotted. One can tell the position of the Sun at a given time and location without complicated calculation.

A sun chart shows a typical sun path across the sky for various times. One can determine the sun's altitude and azimuth quickly and accurately for a given time and location.

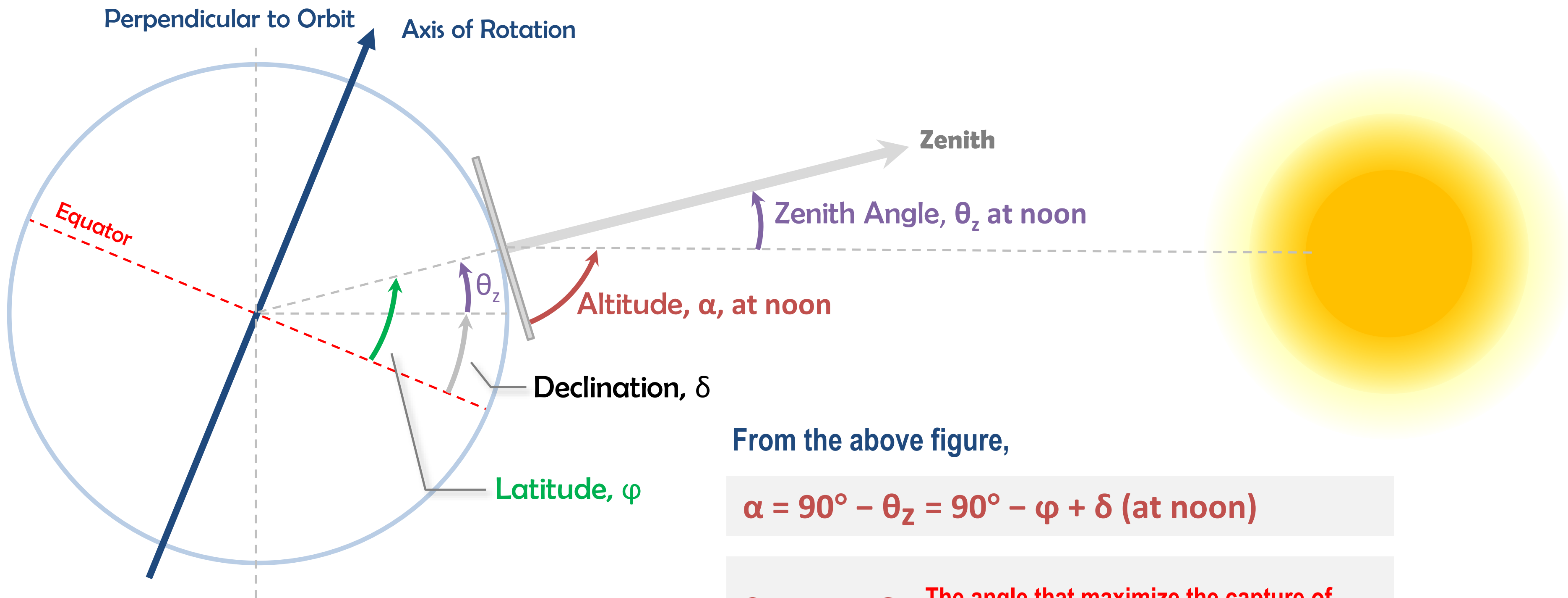


A Sun Chart for 30° North latitude

SOLAR GEOMETRY (FROM OUTERSPACE)

What is the relationship between the solar geometry and the tilt angle of solar PV? How do we make use of solar geometry to tilt the PV panel or solar collector on ground so as to maximize our solar radiation capture?

Consider the celestial body from the outer space and re-draw the angle, θ_z, α, δ and φ (time is taken at noon)



From the above figure,

$$\alpha = 90° - \theta_z = 90° - \varphi + \delta \text{ (at noon)}$$

$$\theta_z = \varphi - \delta$$

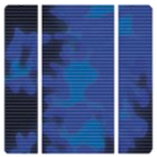
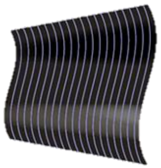
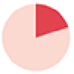
The angle that maximize the capture of solar radiation <u>at noon</u> for a fixed surface

<u>For a given location at noon</u>, a fixed solar PV panel or solar collector should have optimal angle of $\varphi - \delta$.
For annual optimal performance, the average δ should be computed.

Section II:
Orientation of PV Panels for Optimal Solar Resources

DIFFERENT TYPES OF SOLAR PV CELLS

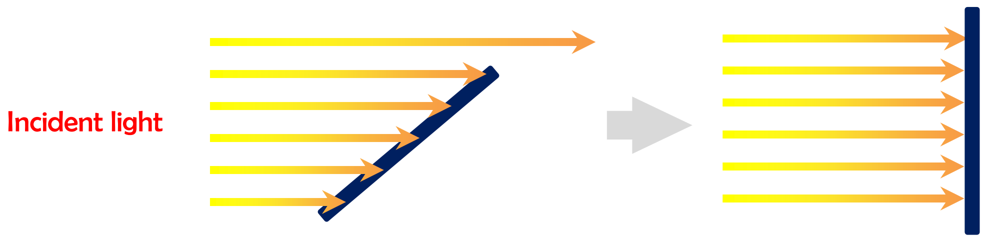
There are three major types of solar PV cells available in the market. Knowing their properties and economic benefit will help to design a cost effective system.

			
	Monocrystalline Cell	**Polycrystalline Cell**	**Thin Film Cell**
Efficiency	 ~20%	 ~18%	 8 – 13 %
Cost			
Application	• Large scale generation	• Commercial • Residential	• Commercial • Residential
Advantages	• High efficiency	• Cost effective	• Easy to install • Not limited by space
Disadvantages	• Relatively expensive • High spatial and structural requirements for installation	• Low efficiency • High spatial and structural requirements for installation	• Low efficiency

The choice of PV panel product greatly affects the electricity output of your proposed system in preliminary solar assessment

SOLAR RADIATION ON A TILTED SURFACE

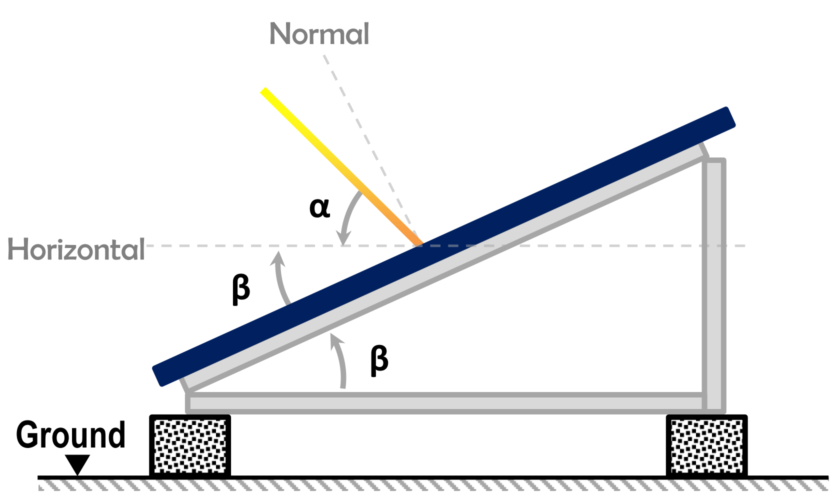
The power incident on a PV panel depends not only on the power contained in the sunlight, but also the angle between the panel and the incident light. How the tilt angle of the panel affect the amount of sunlight captured?



1 By tiling the angle between the incident light and the panel (from narrow angle to right angle) with size of collector remain unchanged, more radiation can be captured

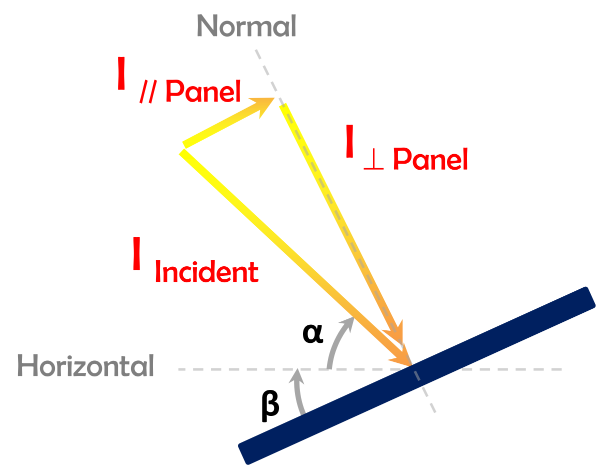
2 Assume solar radiation incidents on a panel at the following condition:

α = the elevation angle of the Sun
β = the tilt angle of the panel measured from the horizontal



3 Solar irradiance can be resolved into two component, only the normal component $I_{\perp \text{Panel}}$ is captured. By trigonometry, the solar irradiance I_{captured} by the panel is given by

$$I_{\text{Captured}} = I_{\perp\text{Panel}} = I_{\text{Incident}} \sin(\alpha + \beta)$$



SOLAR RADIATION ON A TILTED SURFACE

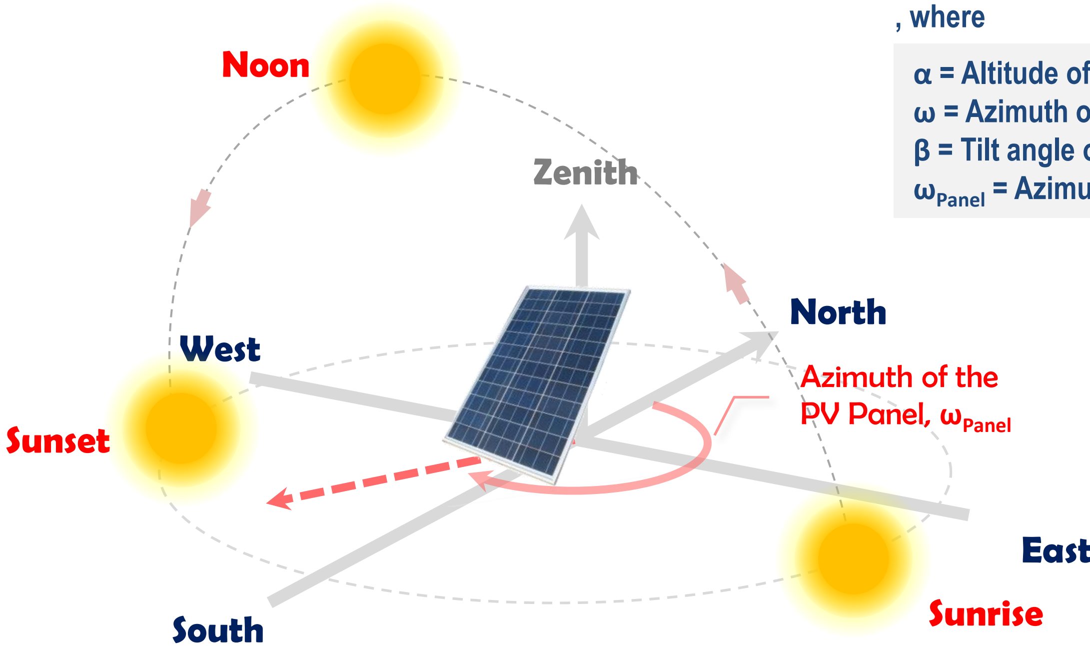
In previous case, only the altitude of the Sun is considered. In real case, the azimuth angle of the Sun throughout the day keep changing and the installation of the solar collector or PV panel does not necessarily facing the right direction (true south / north).

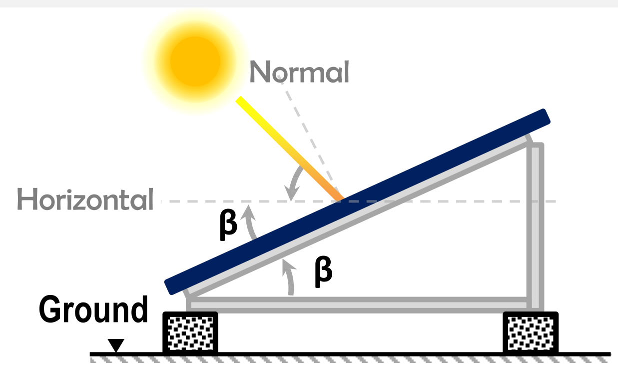
For arbitrary orientation and tilt angle of the panel (at the right cardinal direction), the solar radiation casting on the panel can be estimated as

$$I_{Captured} = IIncident\ [\cos(\alpha)\sin(\beta)\cos(\omega_{Panel} - \omega) + \sin(\alpha)\cos(\beta)]$$

, where

- α = Altitude of the Sun (from Sun Chart)
- ω = Azimuth of the Sun (from Sun Chart)
- β = Tilt angle of the Panel (known from the proposed design)
- ω_{Panel} = Azimuth of the Panel (known from the proposed design)

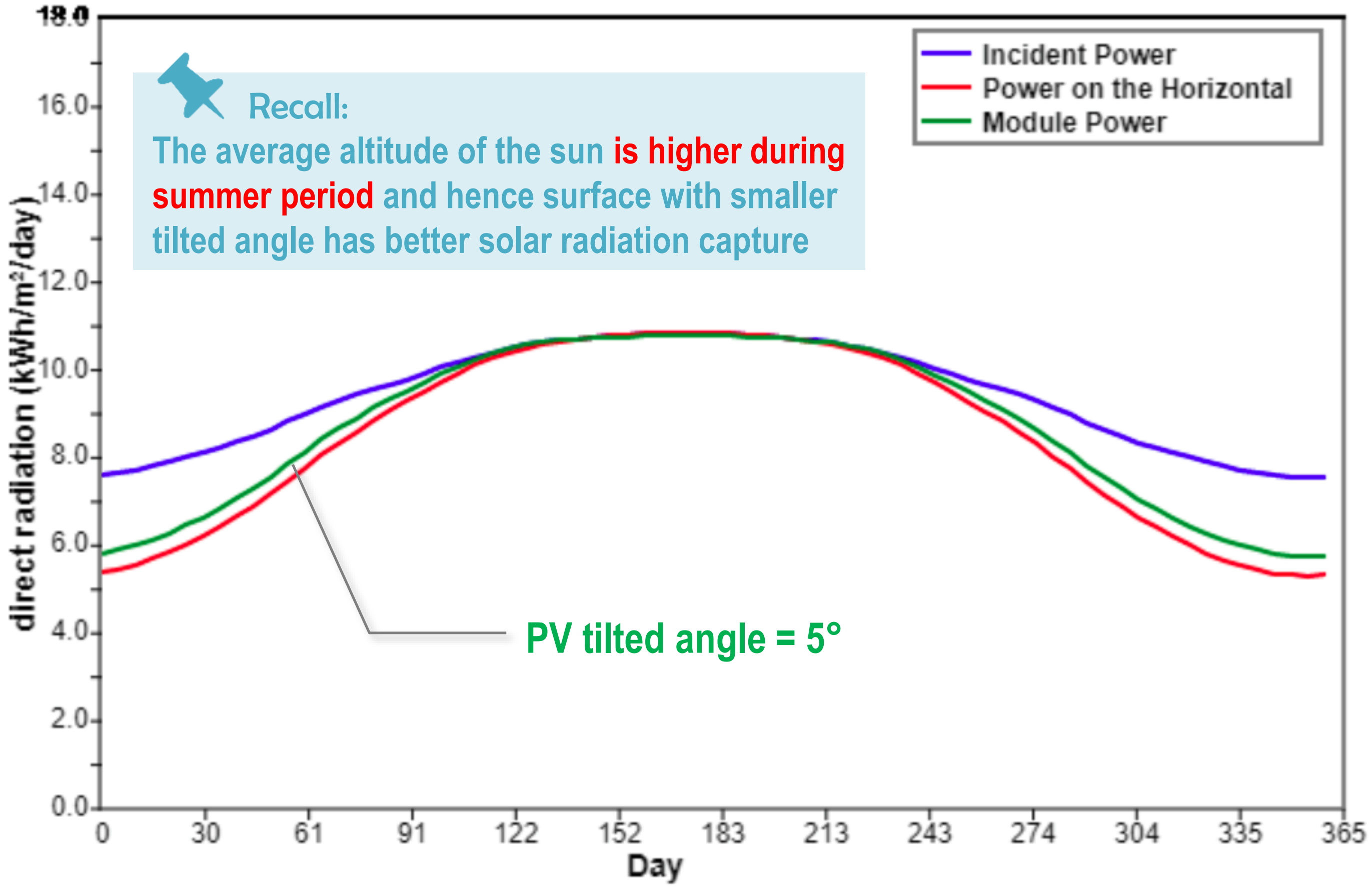




Since the computation of solar irradiation throughout the year is complicated and redundant, Engineers usually seek computer simulation (which basically apply the above mathematical relationship) for estimation of solar energy potential.

INCLINATION OF PV PANEL FACING TRUE SOUTH AT 5° INCLINED ANGLE

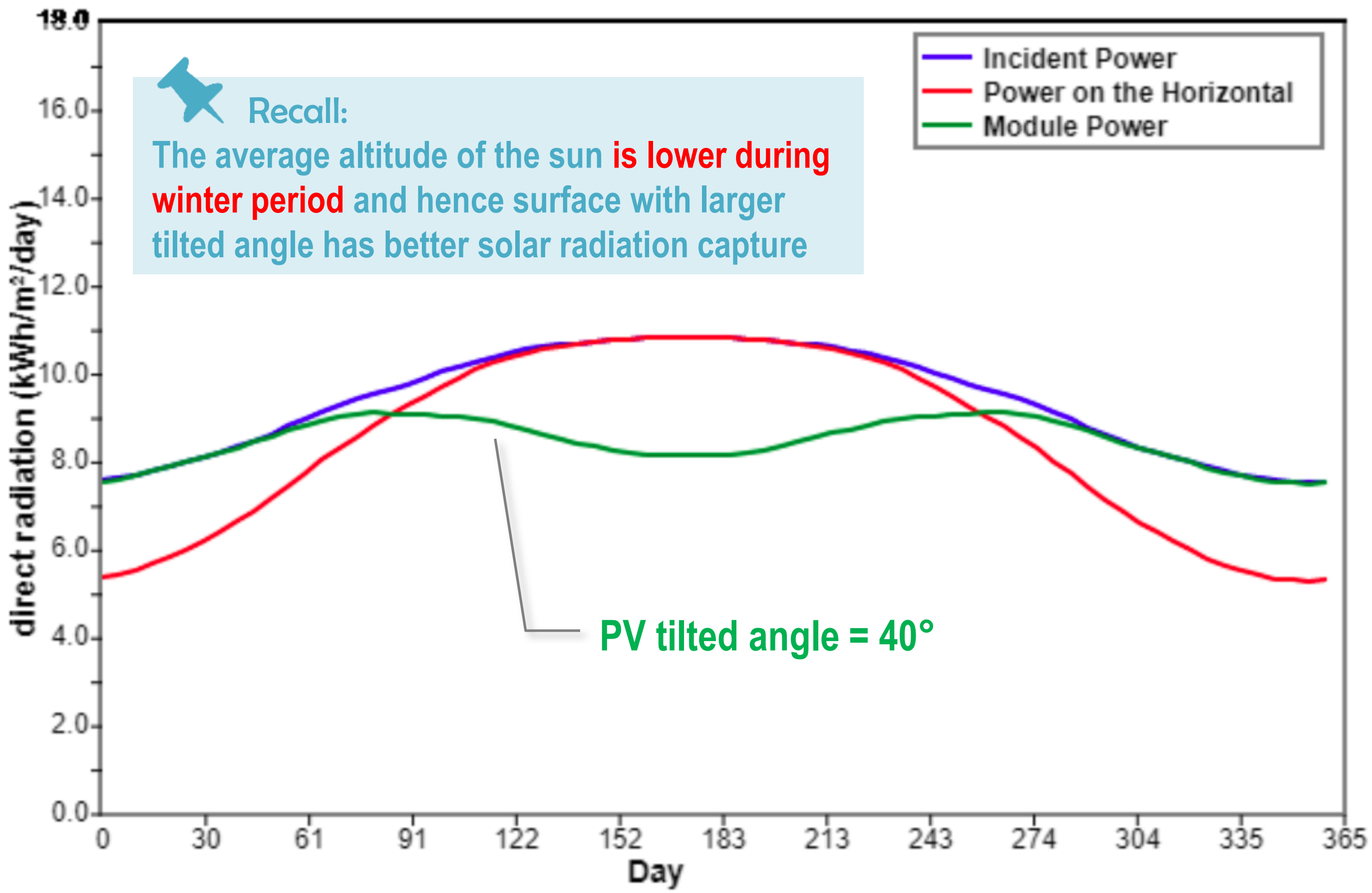
Setting: latitude φ = 22˚, azimuth of PV Panel = 180˚, PV tilt angle β = 5˚



The simulation indicated that smaller tilted angle have better solar radiation access rate during summer. For better performance in winter, the tilt angle should be ~φ - 15°

INCLINATION OF PV PANEL FACING TRUE SOUTH AT 40° INCLINED ANGLE

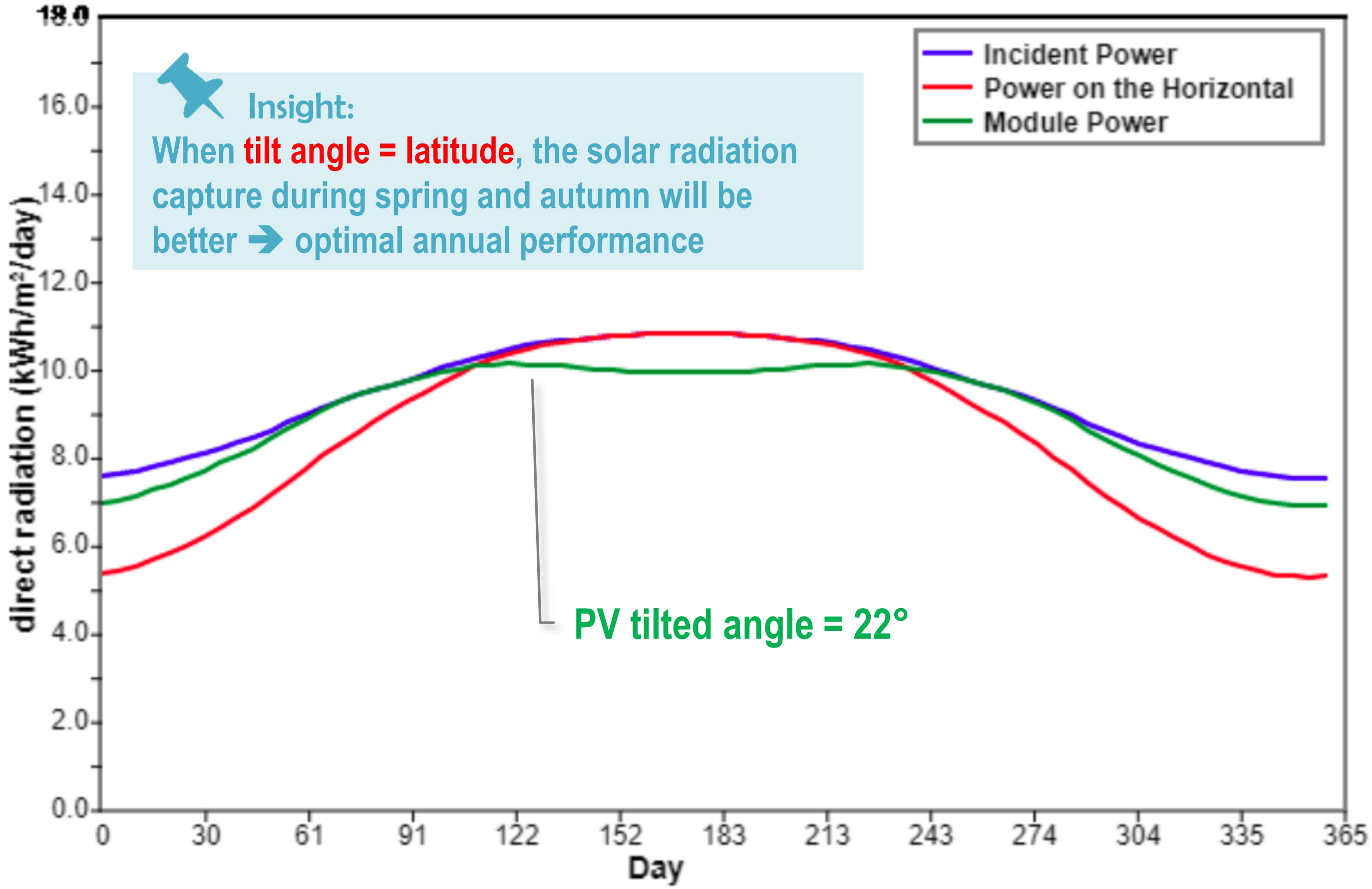
Setting: latitude φ = 22°, azimuth of PV Panel = 180°, PV tilt angle β = 40°



The simulation indicated that larger tilted angle have better solar radiation access rate during winter.
For better performance in winter, the tilt angle should be ~φ + 15°

INCLINATION OF PV PANEL FACING TRUE SOUTH AT 22° INCLINED ANGLE

Setting: latitude φ = 22°, azimuth of PV Panel = 180°, PV tilt angle β = 22°



From annual performance perspective, the optimal tilt angle β = latitude φ

SPACING BETWEEN ROWS OF PV PANEL IN SITE

In solar assessment, the spacing between the rows of proposed panels and obstacle needed to be found out for estimation of the panels no. that can be installed at site. Below provide a quick and rough estimation for spacing.

Consider the Sun on Winter Solstice (21 Dec) latitude = 30°N. (why winter solstice?)

Quick and Rough Estimation

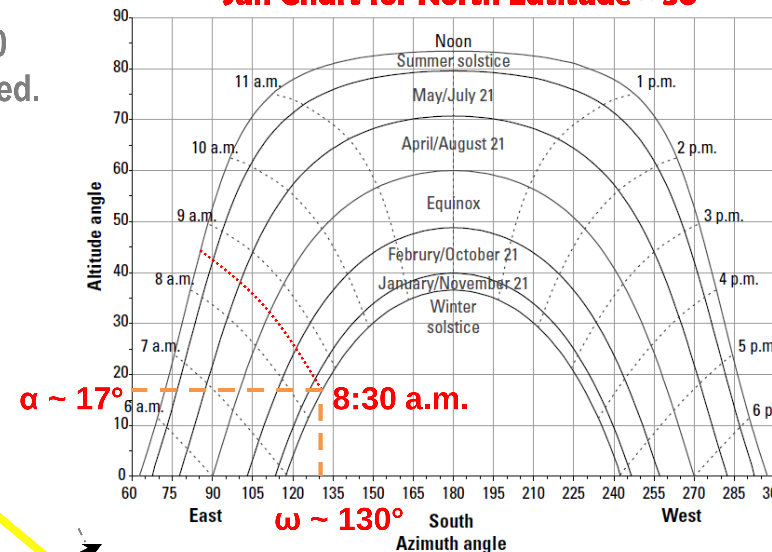
Consider shading between rows of Panels / obstacle from 8:30 a.m. to 3:30 (why 3:30 p.m.) for latitude = 30°N are to be avoided. From the Sun Chart,

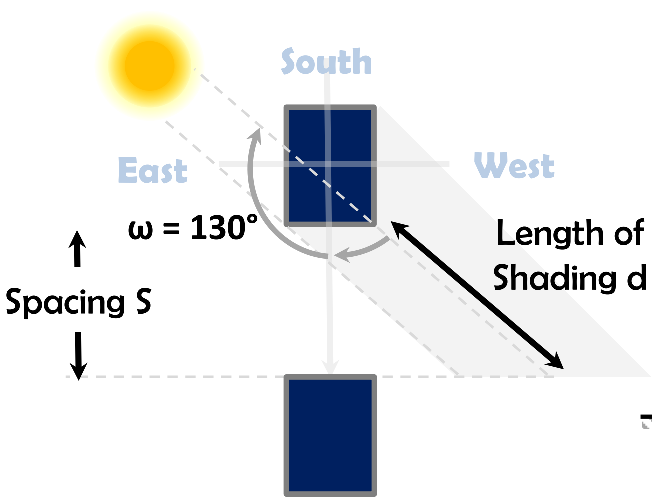
$\alpha = 17°$ if $\beta = \varphi = 30°$

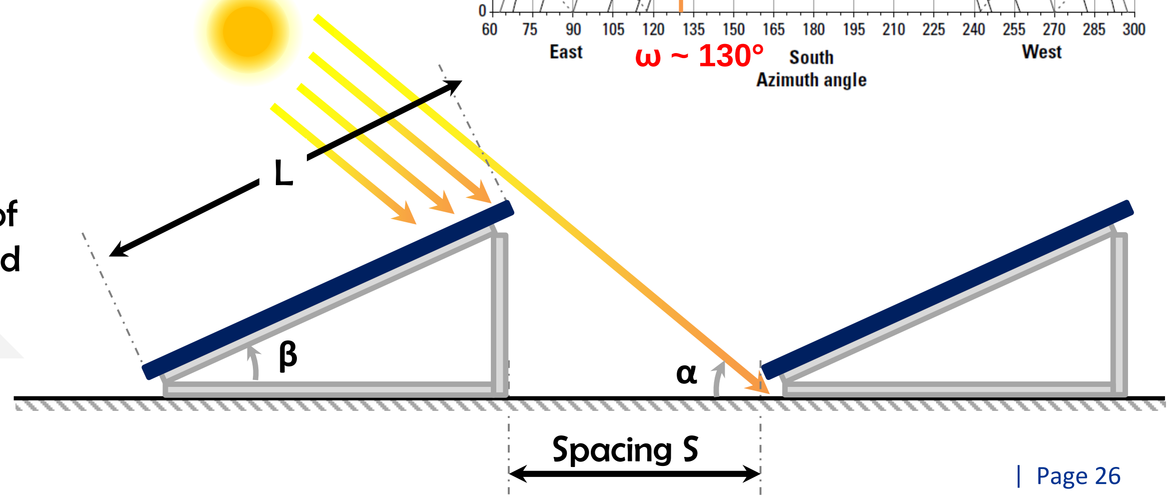
$$\text{Length of Shading } d = \frac{L \sin\beta}{\tan\alpha} = \frac{1.5 \sin 30°}{\tan 17°} = 2.45 \text{ m}$$

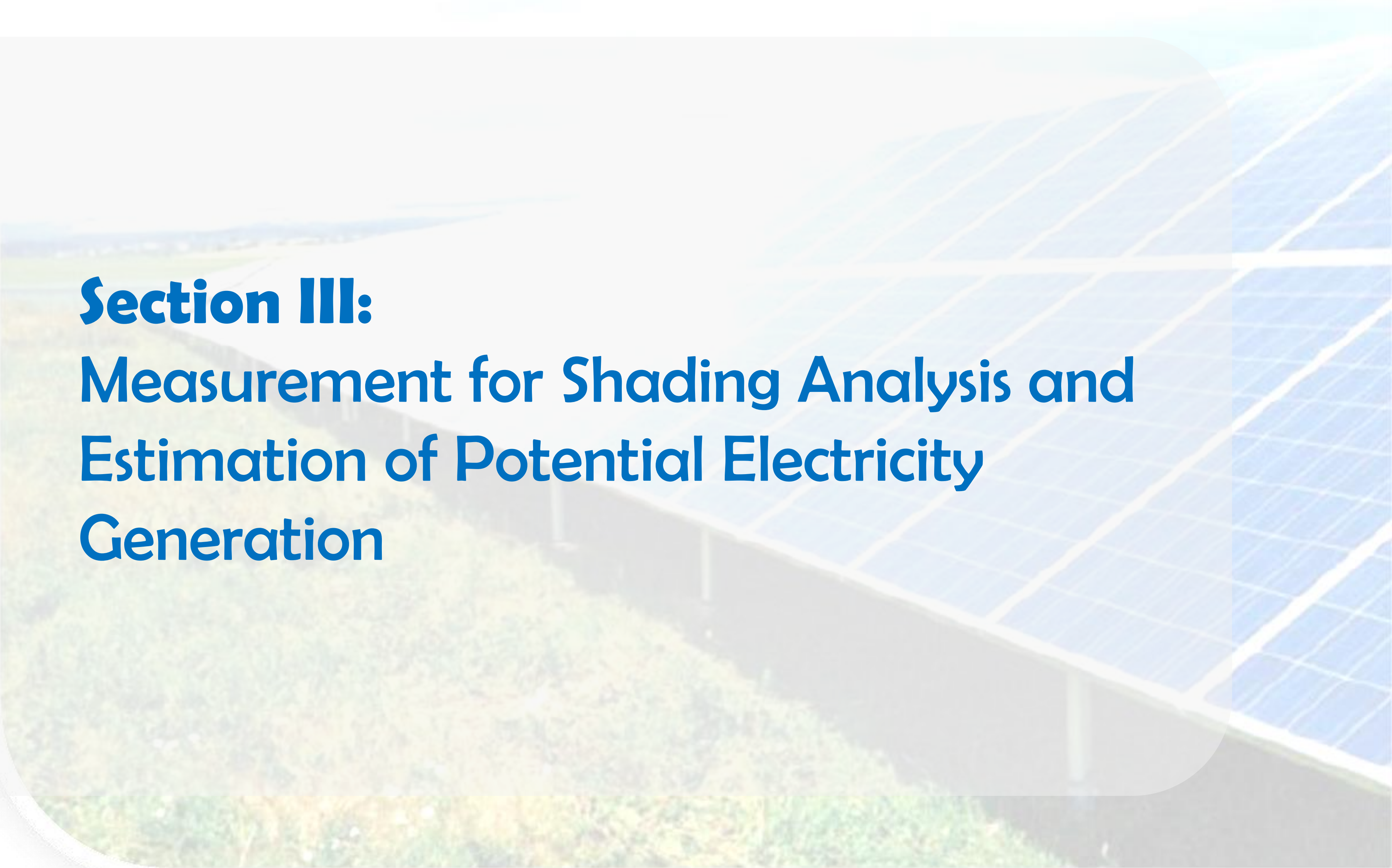
$$\text{Spacing } S = d \times \cos(180° - \omega) = 2.45 \times \cos 50° = 1.57 \text{ m}$$

Sun Chart for North Latitude = 30°





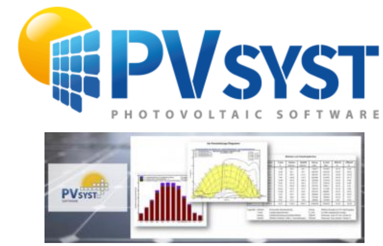




Section III:
Measurement for Shading Analysis and Estimation of Potential Electricity Generation

SHADING ANALYSIS TOOLS

From previous discussion, the results from measurement of solar irradiance tells the solar energy resources at site. Shading at site is another important factor to be considered. There are some tools for shading analysis.

			
Name of Tool	**Solar Pathfinder**	**Solmetric SunEye**	**PVSYST Software**
Output	Manually drawn horizon shading mask diagram	Digital fisheye image & horizon shading mask diagram	Computer simulates the shading from the input
Ease of Use	Easy	Easy - Medium	Hard
GPS	Basic compass	Full GPS (optional)	N/A
Cost			

Solmetric SunEye is easy to use and provides fast results of shading effect and monthly solar access rate.

SOLMETRIC SUNEYE 210

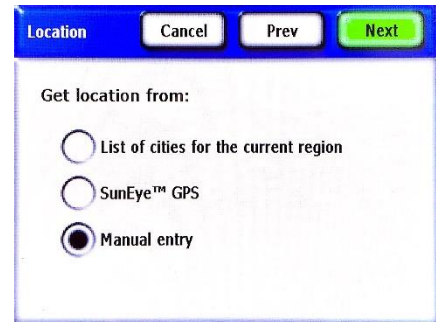
How to use SunEye 210 to perform a solar assessment?

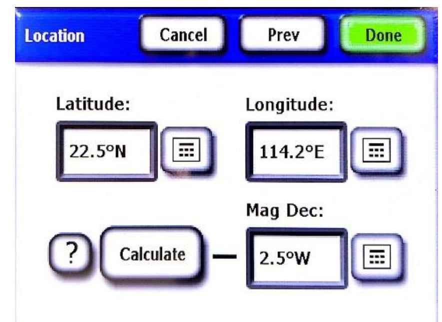
SOLMETRIC SUNEYE210 – WORKING PRINCIPLE

How to use SunEye 210 to perform a solar assessment?

1

- User should set the built-in GPS function, or manually input the location, e.g. latitude and longitude before measurement





2

- The digital fisheyes lens will capture the image of the surrounding (obstacle)
- The image captured will be cast on Sun path throughout the year at the location

Photo taken by the Fisheyes Cam

Shading

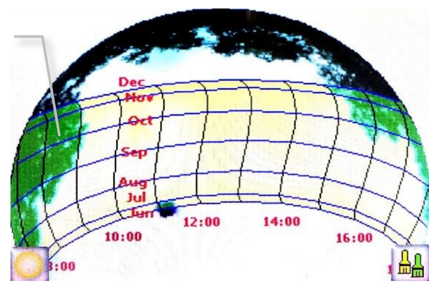
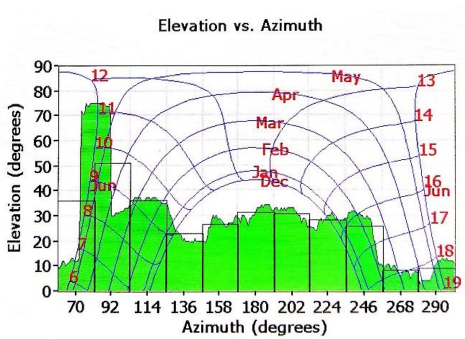
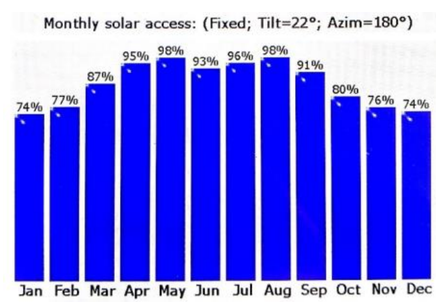


Image on the Sun Path





3

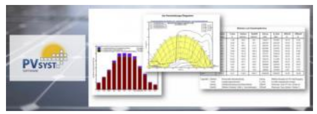
- The built-in software simulates the shading effect (by providing the average monthly solar access %) and the graph of elevation vs azimuth

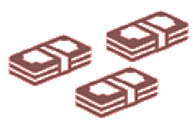
4

- User can also use its software for PV design and reporting

ESTIMATION OF SOLAR GENERATION BY ONLINE PLATFORM

There are plenty of software present in the market to assist estimation of annual electricity generation of PV system before investment. What kinds of software can we use for solar assessment?



	PV SYST	**PVWatts' Calculator**
Output	• One-stop design (shading effect, estimation of annual generation, system configuration, payback)	• High level estimation of monthly and annual generation with basic system configuration input
Ease of Use	Hard	Easy
Cost		Free of charge
Disadvantage	• Plenty of information (e.g. building information) needed to be collected • Time consuming	• No information towards the shading effect of the obstacle on the proposed location

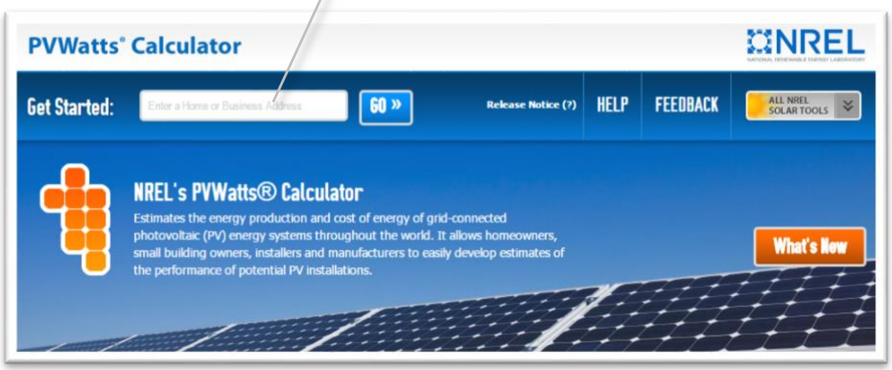
**There is no preference for adopting which software for solar assessment / system design.
From experience, PVWatts' Calculator provides us cost effectiveness, convenience and accurate results.**

PVWATTS CALCULATOR BY NATIONAL RENEWABLE ENERGY LABORATORY

PVWatts Calculation is developed by National Renewable Energy Laboratory (NREL), Department of Energy, USA. This online platforms provide a user-friendly interface for customers / planner to have a quick estimation of electricity generation for a given system and location.

Link: https://pvwatts.nrel.gov/ **(Please give a trial!)**

1 Entry of your location



SOLAR RESOURCE DATA

The latitude and longitude of the solar resource data site is shown below, along with the distance between your location and the center of the site grid cell. Use this data unless you have a reason to change it.

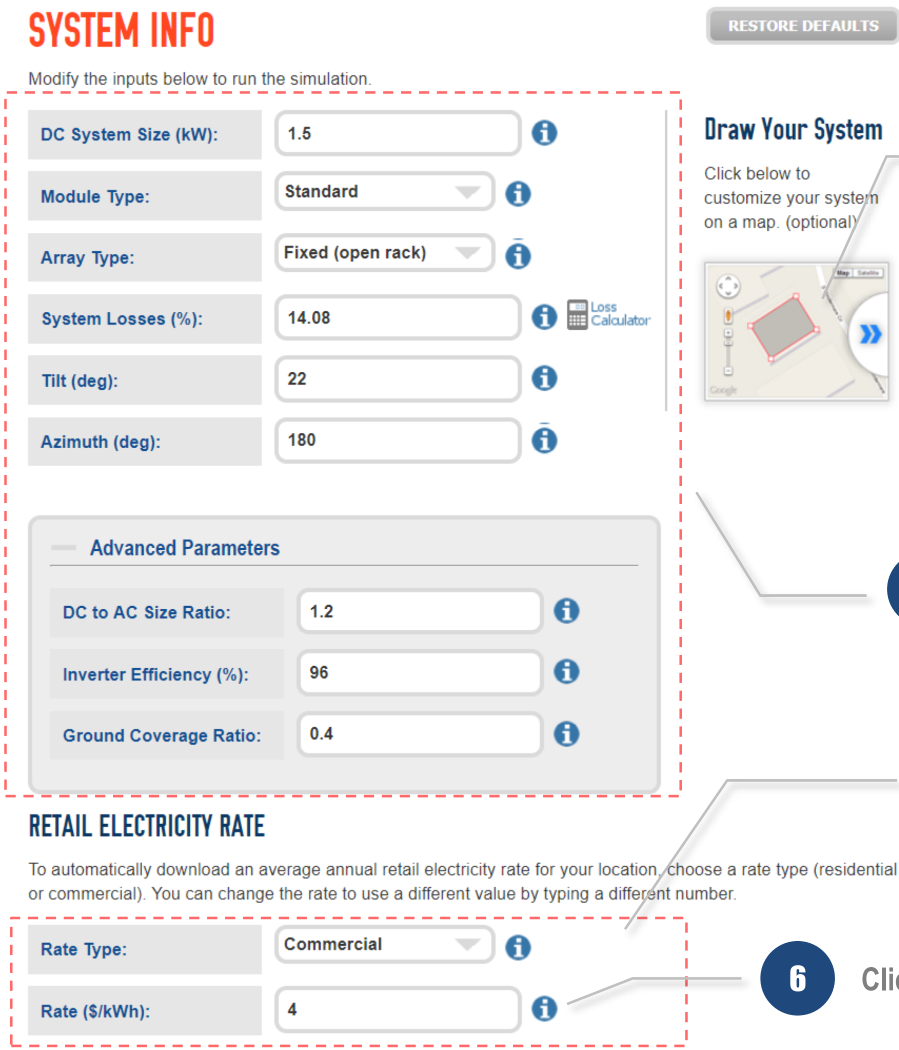
Solar resource data site	(INTL) HONG KONG, CHINA, PEOPLE'S REPUBLIC OF	8.5 mi

2 It will retrieve the solar data of your input location

Resource Data Map

The blue rectangle on the map indicates the NREL NSRDB grid cell for your location. If your location is outside the NSRDB area, the map shows a pin for the nearest avaliable NREL international data site instead of a rectangle. If you want to use data for a different NSRDB grid cell, double-click the map to move the rectangle. *Dragging the rectangle will not move it.* Use the Legacy Data Options check boxes to show pins for legacy data sites. Click a legacy data pin to use legacy data instead of the recommended NSRDB data. See Help for details.

PVWATTS CALCULATOR BY NATIONAL RENEWABLE ENERGY LABORATORY



3 The website also provide a satellite map for customizing your system on a map (which is optional)

4 Entry of basic parameter of your proposed system. You have high feasibility to adjust your input and view the corresponding results

5 Define your trade and input the Feed-in tariff rate

6 Click this button if user is not clear towards the input item

PVWATTS CALCULATOR BY NATIONAL RENEWABLE ENERGY LABORATORY

RESULTS

Print Results

1,577 kWh/Year*

Month	Solar Radiation (kWh / m² / day)	AC Energy (kWh)	Value ($)
January	2.97	110	551
February	2.96	100	498
March	3.04	112	558
April	3.34	116	582
May	3.51	124	619
June	3.60	122	611
July	4.65	161	805
August	4.28	149	744
September	4.16	141	706
October	4.57	161	807
November	4.11	144	719
December	3.72	137	685
Annual	3.74	1,577	$ 7,885

Location and Station Identification	
Requested Location	Sai Kung, Hong Kong
Weather Data Source	(INTL) HONG KONG, CHINA, PEOPLE'S REPUBLIC OF 8.5 mi
Latitude	22.32° N
Longitude	114.17° E
PV System Specifications *(Commercial)*	
DC System Size	1.5 kW
Module Type	Standard
Array Type	Fixed (open rack)
Array Tilt	20°
Array Azimuth	180°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2
Economics	
Average Retail Electricity Rate	5.000 $/kWh
Performance Metrics	
Capacity Factor	12.0%

7 From the input, the PVWATTS calculator will simulate and propose the potential monthly electricity generation

PVWATTS is one of the most cost-effective, user friendly software for customers / beginners for quick estimation. The simulation result provide a quick but reliable reference for planning a project.

STUDYING THE POTENTIAL OF A SITE FOR PV SYSTEM

What is the preparation work before solar assessment?

A Standard Site-survey Preparation Work

- Customer basic information (contact, emails, name, business nature etc.)
- The type of system desired (grid-connected, standalone etc.)
- Layout plan of the site (area for PV panel installation)
- A list of pictures to be taken
- Roof tilt and azimuth of the proposed array
- Remarks for customers' requests / special site considerations

Some other items (only for detailed design)

- Space proposed for inverter location (optional)
- Options for wiring the array to the inverter (optional)
- Information related to the roof / ground material and its conditions (optional)

Survey Equipment

- Suneye210 or any related measuring equipment
- Camera / pen / notebook / compass / calculator / tape

SunEye 210

Camera

Notebook

Tape

You may prepare a standard checklist before the site visit to avoid missing any important items during the inspection.

PROCEDURE OF SOLAR ASSESSMENT

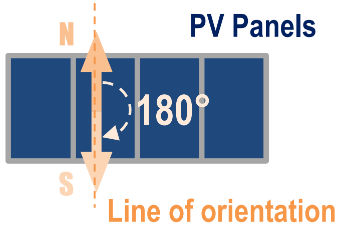
The following summarize what has been learnt previously to perform a solar assessment.

	Key Steps in Solar Assessment	Knowledge Required
1	**Preparation Work** • Perform desktop research on website • Asking for building configuration / layout plan from customer	
2	**Site Visit** • Check target installation area, e.g. shading factor by SunEye 210 • Measure obstacle and useful distance at site for estimation of no. of PV to be installed (Remarks: floor loading is ignored in our assessment)	• How to use SunEye210?
3	**Proposal Preparation (Rough Estimation)** • Determine the no. PV panels from the layout plan • Determine the corresponding cable routing / inverter location to the connection point • Determine the size and capacity of the inverter (require to input into PVWatts Calculator)	• Types of PV Panels • Tilt angle, spacing between row & obstacle • Basic knowledge, such as voltage drop, power loss
4	**PVWatts Estimation** • Input the no. of PV panels, orientation and tilt angle • Input parameter, such as DC to AC ratio, system loss as requested by the Calculator	• How to use PVWatts Calculator?
5	**Combination of the PVWatts Estimation with SunEye210's results to obtain the estimated annual PV electricity output**	

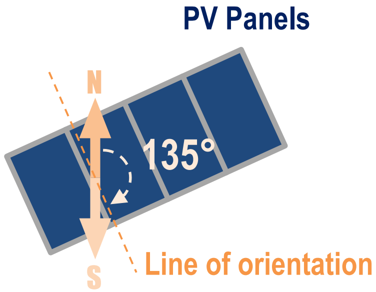
ORIENTATION OF PV ARRAYS SIMULATED BY PVWATTS

It is recommended that the PV modules should be directed to true South / North (depends on locations, with inclination of latitude as the best orientation. However the building orientation does not always align with our expected degree.

- Aligning the PV arrays with the building / floor implies simpler installation work and hence lower installation cost
- For example, aligning the orientation of the PV panels with the building makes azimuth of the PV panel as 135° (not 180°)
- The following study demonstrates the drop of average solar radiation when PV panels are rotated from azimuth = 180° to azimuth = 135° (and tilt angle from 22° to 15°).



Azimuth of the PV Arrays	180° (South)	180° (South)	135° (S45°E)	135° (S45°E)	135° (S45°E)
Tilt angle of the PV Panel	22°	15°	22°	15°	5°
Average Solar Radiation under Different Azimuth and Tilt Angle [1] (kWh/m²/day) [1] Data from (PVWatts)	3.74	3.73 (-1%)	3.66 (-2.14%)	3.65 (-2.41%)	3.62 (-3.21%)



User can try different tilt angle and azimuth of the panel for simulation by using PVWatts.
From the results above, a reasonable change in tilt angle and azimuth is allowed with minor loss in solar radiation capture.

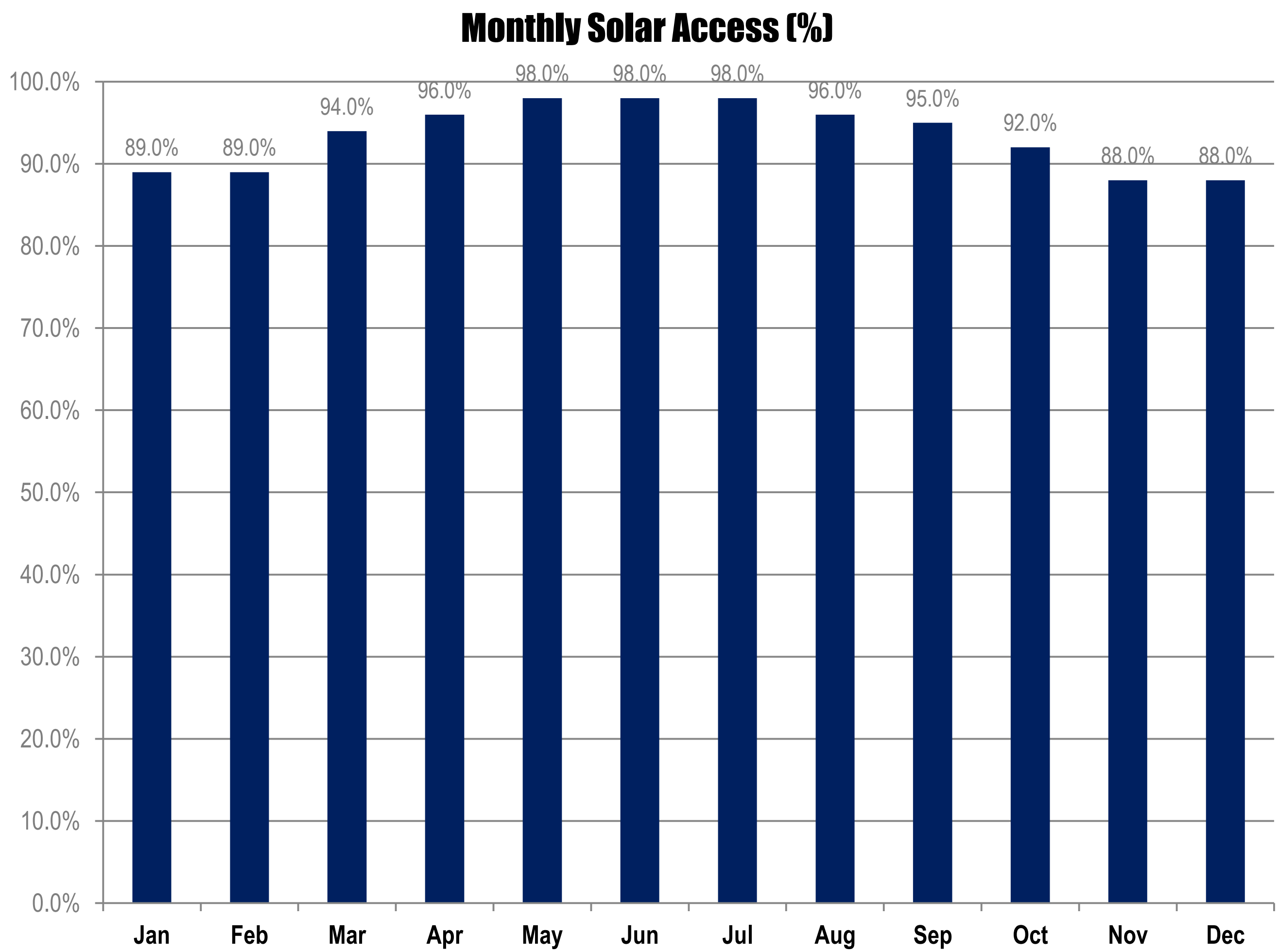
Section IV:
Case Study

MEASUREMENT OF MONTHLY SOLAR ACCESS RATE / SHADING EFFECT

One of our site for solar assessment at Sai Kung.

MEASUREMENT OF MONTHLY SOLAR ACCESS RATE / SHADING EFFECT

By taking the fisheye picture of the site at direction of true south while setting tilt angle as 22-23˚, the monthly solar access percentage can be calculated (with shading factor considered).



Month	Monthly Solar Access Percentage
Jan	89.0%
Feb	89.0%
Mar	94.0%
Apr	96.0%
May	98.0%
Jun	98.0%
Jul	98.0%
Aug	96.0%
Sep	95.0%
Oct	92.0%
Nov	88.0%
Dec	88.0%

ESTIMATION OF ANNUAL ELECTRICITY GENERATION BY PVWATTS

By considering the solar access rate from SunEye, the estimated generation by the proposed design (6 x 250 W/panel, inclination 22°, azimuth 180°) and other simple input parameter, monthly electricity generation can be simulated.

Month	PVWatts Clear Sky Solar Radiation (kWh / m^2 / day)	PVWatts Clear Sky AC Energy (kWh)	SunEye 210 Monthly Solar Access Percentage (From previous Chart) (%)	Estimated Monthly Generation by PV (kWh/month)
January	3.00	115	89.0%	102
February	2.97	103	89.0%	92
March	3.04	115	94.0%	108
April	3.32	119	96.0%	114
May	3.48	127	98.0%	124
June	3.56	125	98.0%	123
July	4.60	164	98.0%	161
August	4.25	152	96.0%	146
September	4.15	145	95.0%	138
October	4.60	167	92.0%	154
November	4.16	150	88.0%	132
December	3.76	143	88.0%	126
Annual	3.74 (Average)	1,625 kWh/annum		1,519 kWh/annum

The estimated annual electricity generation by the proposed PV system is 1,519 kWh/annum.

COMPARISON OF ESTIMATED GENEARATION AND ACTUAL GENERATION

After the commissioning of the system, the actual monthly generation of the PV system is measured regularly. The following demonstrates the difference between actual generation and the estimated generation for reference.

Month / 2018	Monthly Electricity Generation by Actual Measurement (kWh)	Estimated Monthly Electricity Generation by Solar Assessment (kWh)	Difference (%)
January	111	102	-8%
February	105	92	-13%
March	157	108	-31%
April	139	114	-18%
May	177	124	-30%
June	141	123	-13%
July	172	161	-7%
August	131	146	11%
September	159	138	-13%
October	151	154	2%
November	115	132	15%
December	111	126	13%
Annual	1,669	1,519	-9%

The annual generation (kWh) by the captioned simulation method is close to the actual annual generation. The difference is subject to the weather and the final rating of the equipment adopted.

Section V:
Appendix

SOLMETRIC SUNEYE 210 – HOW TO USE

Site Survey Mode

- **Before the site survey, you can pre-set the proposed inclination of the panel**

Compass

Horizontal Level

Photo Taking Button

1

When you press the snap button, the machine will take some time (10 sec) to do graphic processing.

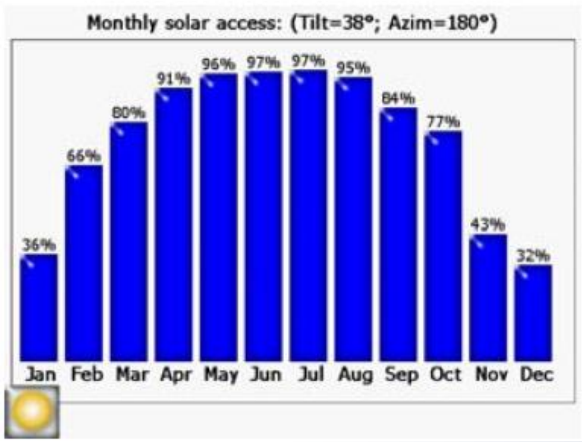
2

- SunEye will capture the a full range 360 degree photo on which the annual sun path will be plotted
- The shading on the sun path provide basis for built-in programme in the device to calculation the monthly solar access percentages

SOLMETRIC SUNEYE 210 – HOW TO USE

Monthly Sola Access

- **By choosing the Monthly Solar Access Button, you will see the bar chart of the monthly solar access for the location where you captured data.**



3

This report generate a graphic presentation on the nearest objects which will block the solar energy gain according to annual sun-path

Obstruction Elevation View

- **By choosing the Obstruction Elevation View, a graph showing elevation angle of the highest obstruction at each azimuth**

4

This report generate a graphic presentation on the nearest objects which will block the solar energy gain according to annual sun-path