

Site Assessment: **IS MY PLACE SUITABLE FOR SOLAR?**



FAIZATUL NOOR BINTI ABU BAKAR
NORASHIKIN BINTI AMIR
ZARULRIZAM BIN AB JALIL

SITE ASSESSMENT: IS MY PLACE SUITABLE FOR SOLAR?

FAIZATUL NOOR BINTI ABU BAKAR
NORASHIKIN BINTI AMIR
ZARULRIZAM BIN AB JALIL

KOLEJ KOMUNITI SEGAMAT 2

Copyright Declaration

e ISBN 978-967-18871-7-2

Copyright © 2024

All right reserved. No part of this publication can be reproduced, stored in retrieval system or transmitted in any forms or by any means, electronic or mechanical including photocopying, recording or otherwise without the prior permission of the copyright owner.

Perpustakaan Negara Malaysia

Published by:

Kolej Komuniti Segamat 2

KM4, Jalan Jementah

85100 Batu Anam,

Segamat, Johor

Tel: +6 07 949 8227

Fax : +6 07 949 8700

Email : [contact_us @kksegamat2.edu.my](mailto:contact_us@kksegamat2.edu.my)

Website : <https://kksegamat2.mypolycc.edu.my>

Preface

Assalammuallaikum w.b.t

We are delighted to present this interactive eBook on "Site Assessment: Is My Place Suitable For Solar?". This eBook is designed to serve as a valuable teaching aid for instructors and a comprehensive learning resource for students in Kolej Komuniti Segamat 2.

The aims of this eBook is to give teachers and students the information and tools they need to look at possible solar installation places. This resource gives a complete and useful way to learn about solar energy projects and make smart choices about them by going into important details like location, climate, and environmental concerns.

We hope this eBook will improve your teaching experience and boost your learning journey. Let's learn more about solar energy together and figure out how to use the sun's power to make the future more sustainable.

Sincerely,

Faizatul Noor Binti Abu Bakar

Norashikin Binti Amir

Zarulrizam Bin Ab Jalil

TABLE OF CONTENTS

TITLE	PAGE
PREFACE	i
TABLE OF CONTENTS	ii
TOPIC 1 INTRODUCTION TO SOLAR PV	1
TOPIC 2 GEOGRAPHIC COORDINATE SYSTEM	5
TOPIC 3 SOLAR PATH COORDINATE	10
TOPIC 4 BASIC QUANTITY SOLAR	20
TOPIC 5 ORIENTATION AND TILT ANGLE	26
TOPIC 6 SHADING	32
REFERENCE	47
BIOGRAPHY	48

Topic 1

Introduction to Solar PV



Solar energy has become a popular and practical option for many individuals and businesses as the demand for renewable energy sources grows. However, Not every site is suitable for solar panel installation; incorrect site assessments can lead to poor system performance and costly blunders.

In order to optimise energy output, the system is appropriately sized, positioned, and organised; precise site assessments are crucial.



Why is it Important?

A solar site assessment involves assessing a possible location to ascertain whether it is appropriate for setting up a solar energy system.

The evaluation usually involves a review of the site's solar resource, shading, availability of roof or ground space, orientation, and electrical infrastructure.

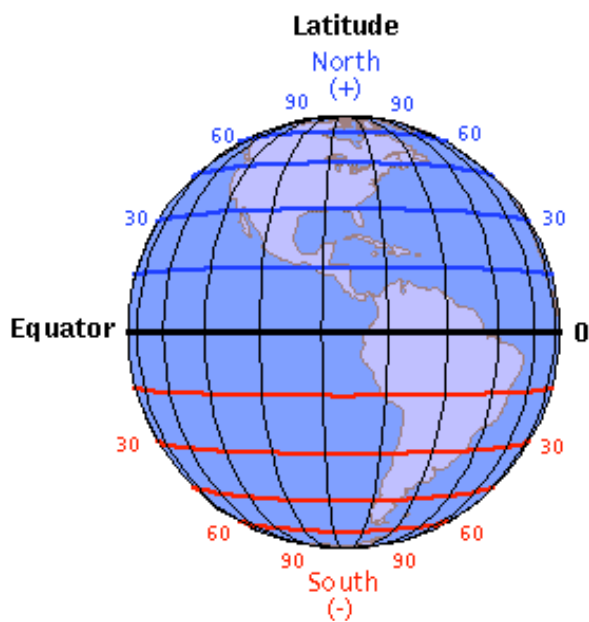
It is impossible to emphasize the significance of a solar site evaluation. Prior to installation, it is helpful to assess the viability and prospective performance of a solar energy system.



Topic 2

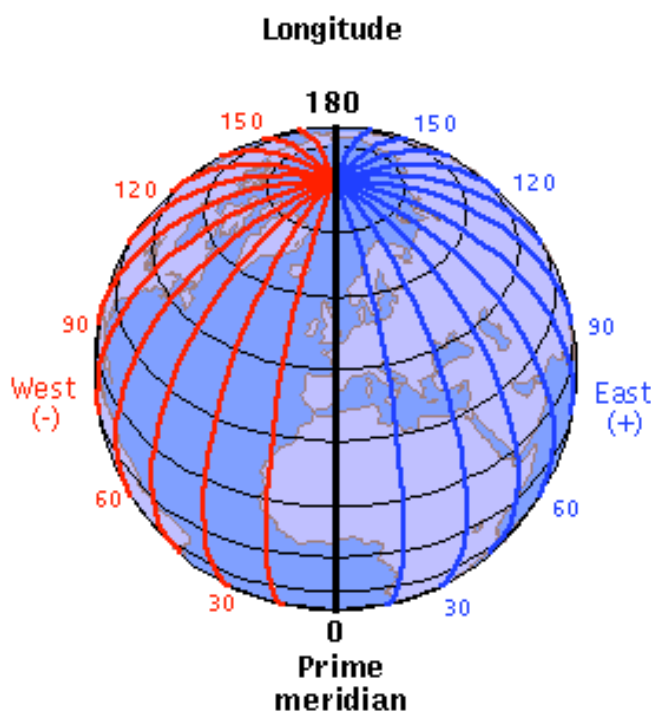
Geographic Coordinate System





Latitude of site on the Earth is the angular distance of a projected line from the centre of the Earth to a location on its surface, measured from **Equator**.

It is measure of how far **North or South** the site is from the Equator



Longitude is the angular distance of a projected line from the centre of the Earth to a location on its surface, measured from **Prime Meridian (PM)**.

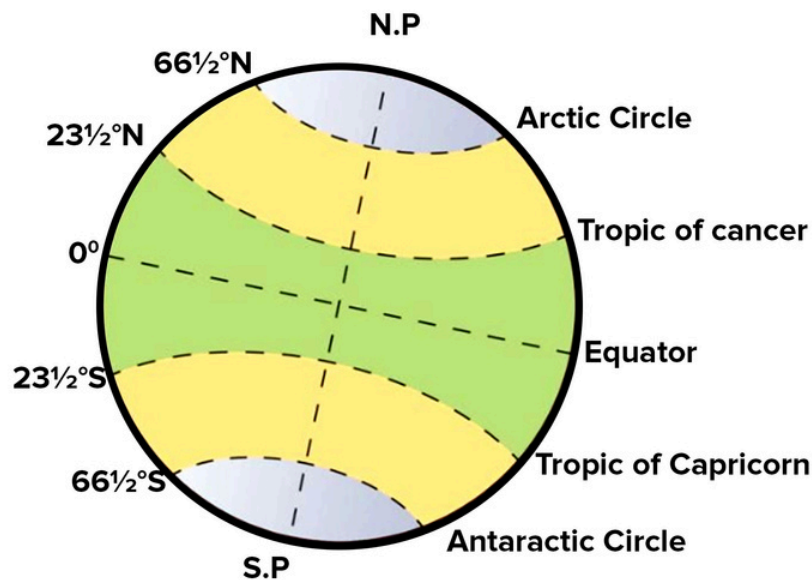
It is measure of how far **East or West** the site is from the PM.

Latitude Reference

These five main latitudes have significant meanings in their relationship with the position of the Sun.

EQUINOX - Dates when the Sun crosses the Equator.

It happens two times in a year and all locations on Earth have equal length of day and night [19-21 of March and 22-23 of September]



SOLSTICE- Dates when the Sun reaches the maximum declination angle.

It happens two times during the year when the Sun is farthest North & South of the Equator.

The dates are around 20-21 June (solar noon at Tropic of Cancer) and 21-22 December (solar noon at Tropic of Capricorn).



**WHAT MAKES SUMMER
AND WINTER HAPPEN?**

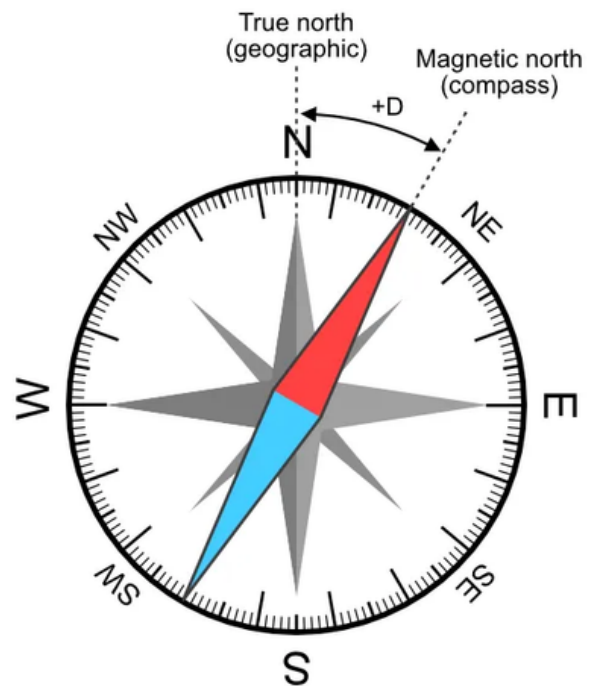
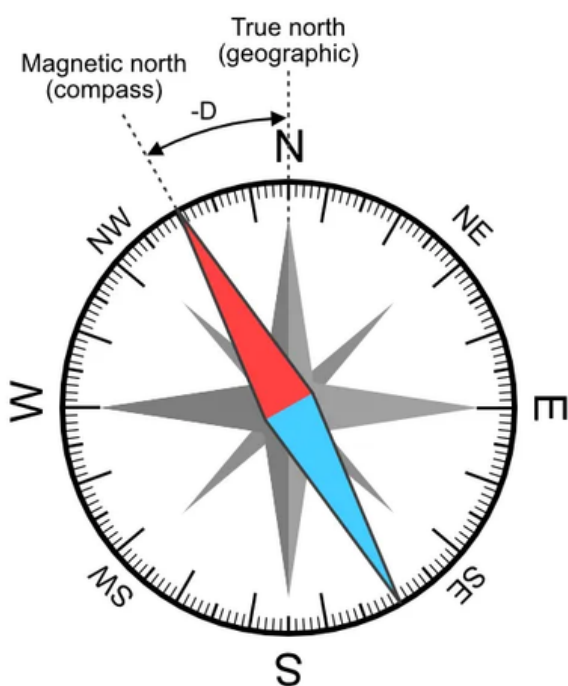


DID YOU

KNOW?

The Earth magnetic poles are not same as Earth's geographic poles.

The angular difference between the Geographic/True North and the Magnetic North on the horizontal plane is called **magnetic declination**.



By convention, the direction of magnetic declination is referred as **Zero (0); or East (+) or West (-) of the True North**.

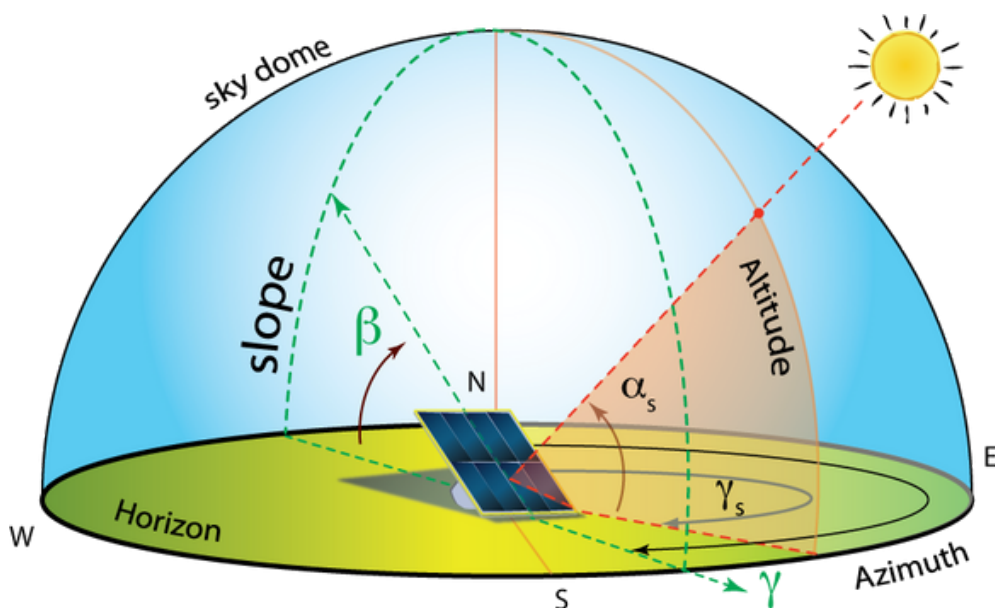
Topic 3

Solar Path Coordinate



Solar Altitude Angle, α

The angle between the Sun's incident ray and the horizontal plane of the observer. It specifies the **angular height the Sun appears** to the above the horizontal plane.



Credit: Jeffrey R. S. Brownson © Penn State University is licensed under CC BY-NC-SA 4.0

Solar Azimuth Angle, γ

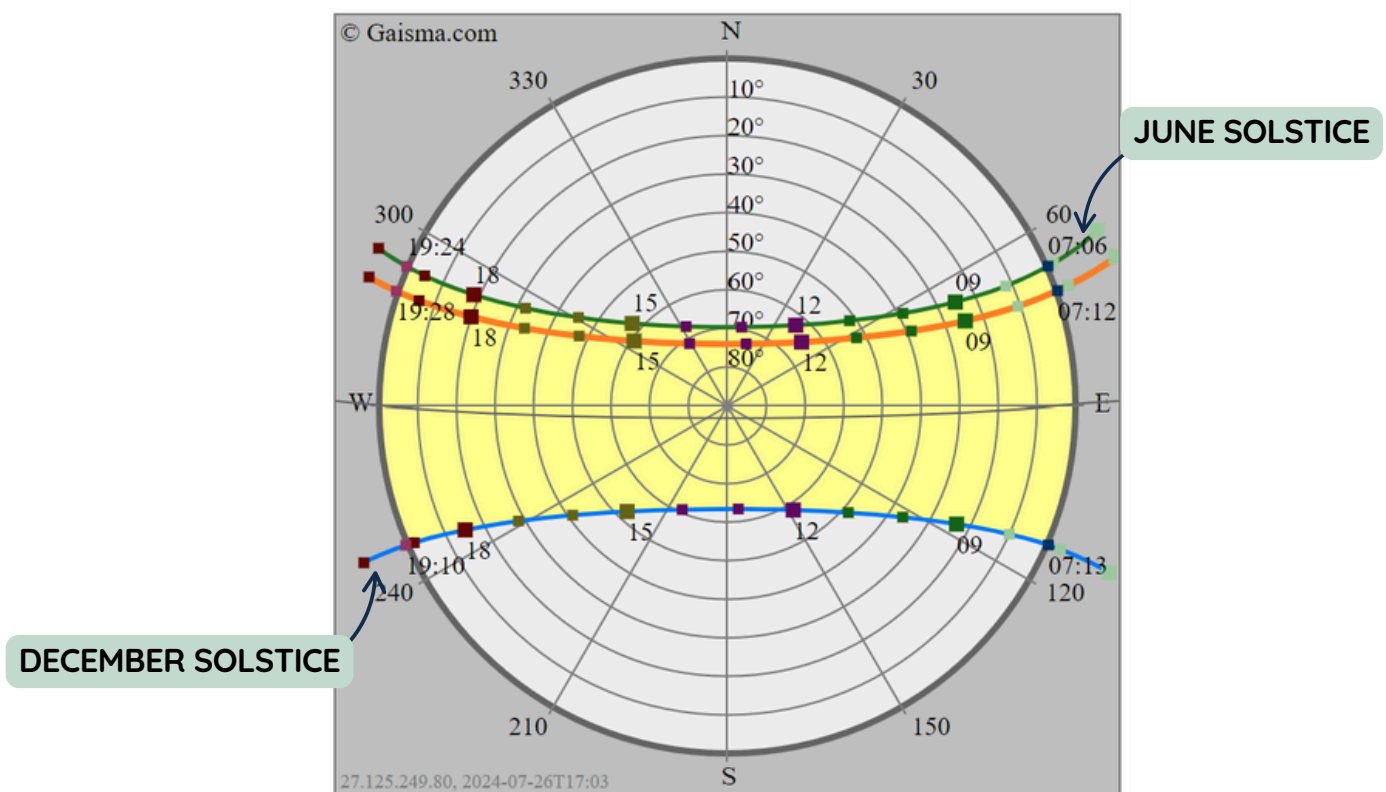
Angle between the vertical projection of the Sun's position in the sky onto horizontal plane and a reference direction of an observer. Any angle that swings towards **East is negative (-)** and **West as positive (+)**.

How to Calculate the Solar Altitude and Azimuth Angles



Sun Path Chart/Diagram

- The sun path chart can be traced using polar or Cartesian coordinates.
- Sun-path diagrams show the sun's location in the sky at any time of day and year.
- The sun-path diagram shows the sun's azimuth and tilt on a chart, allowing the sun's position to be calculated.



**EACH COUNTRY HAS A UNIQUE SUN
PATH DIAGRAM , LET'S EXPLORE!!!**

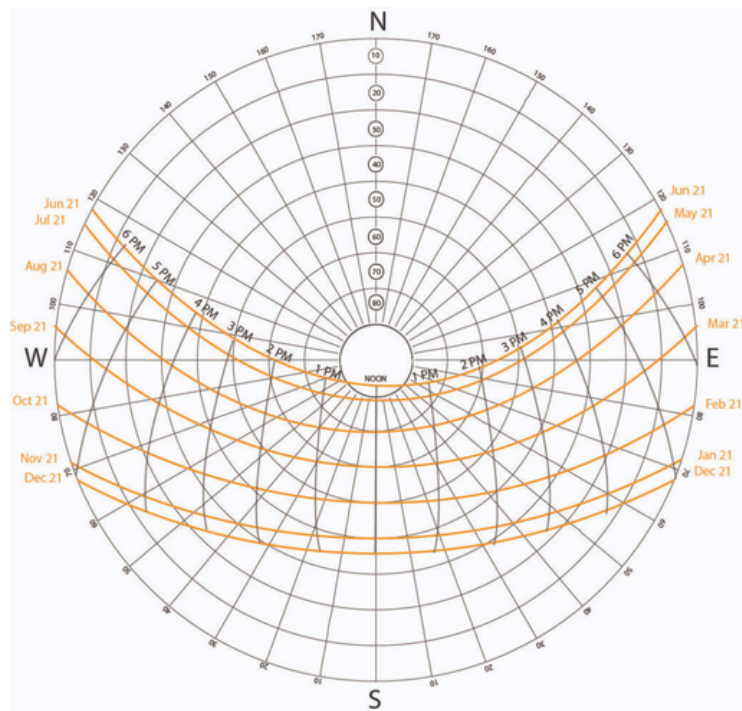
GAISMA 

www.gaisma.com

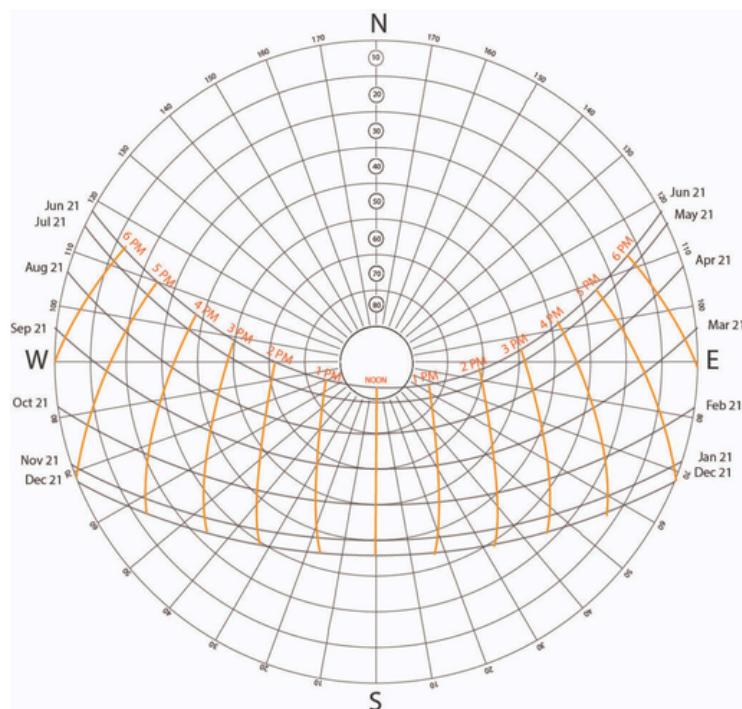
CLICK HERE

HOW TO READ SUN PATH CHART??

STEP 1: IDENTIFY THE MONTH

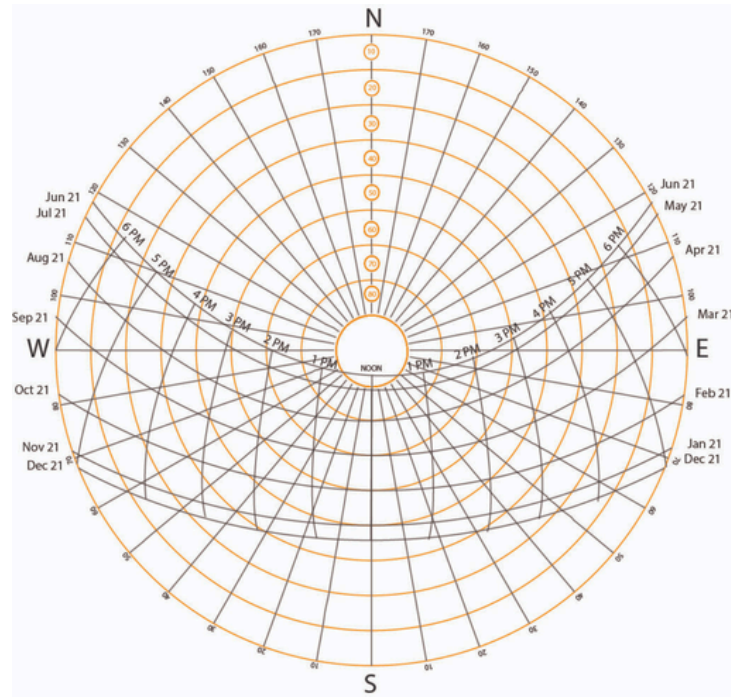


STEP 2: IDENTIFY THE TIME

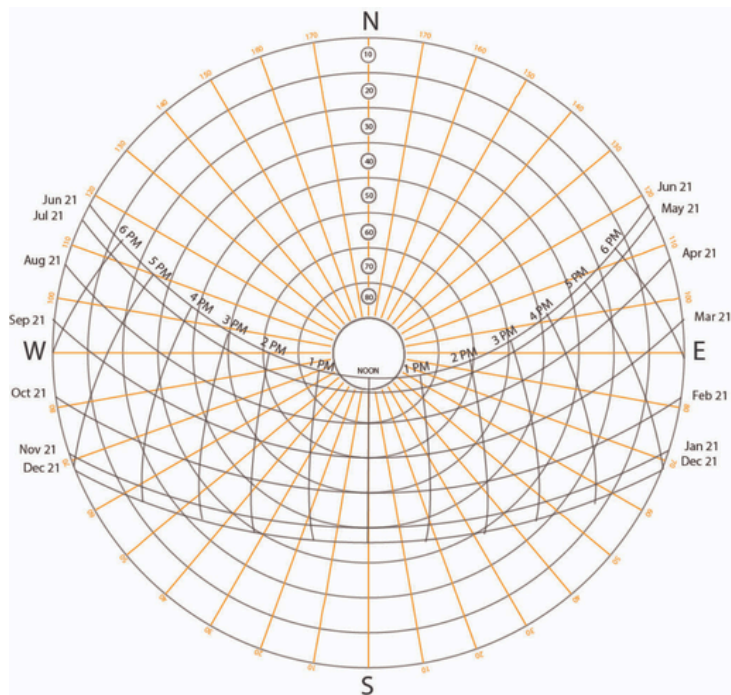


HOW TO READ SUN PATH CHART??

STEP 3: FIND THE ALTITUDE



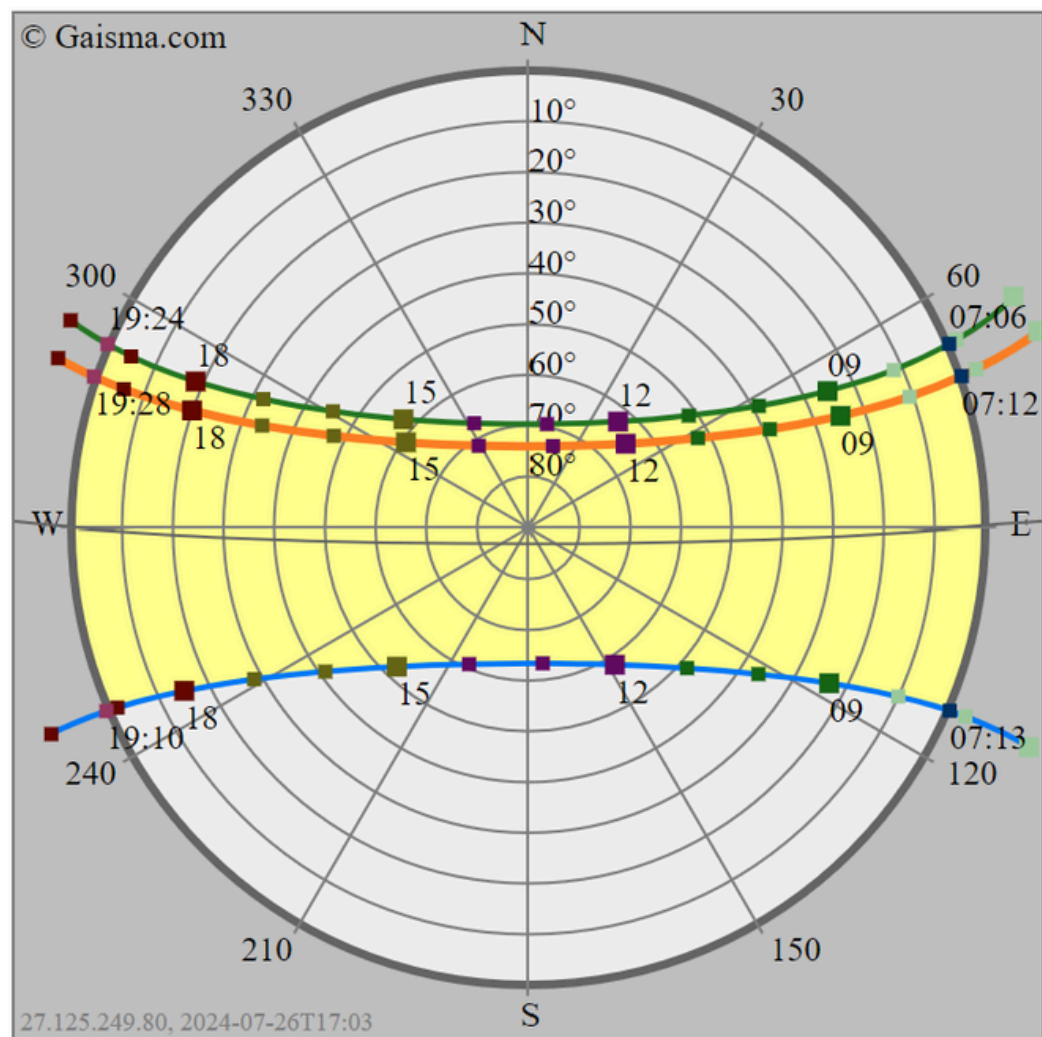
STEP 4: FIND THE AZIMUTH

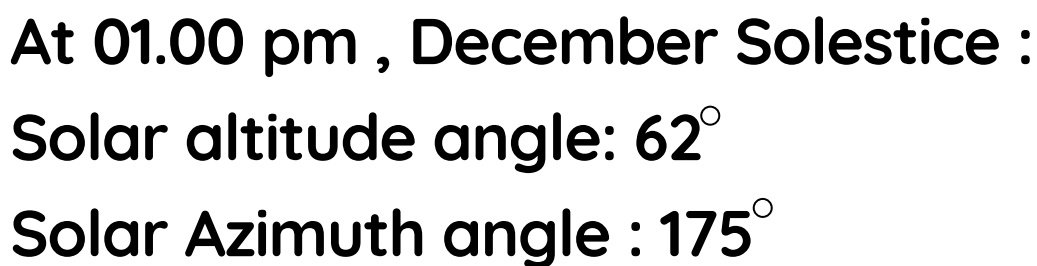




EXAMPLE

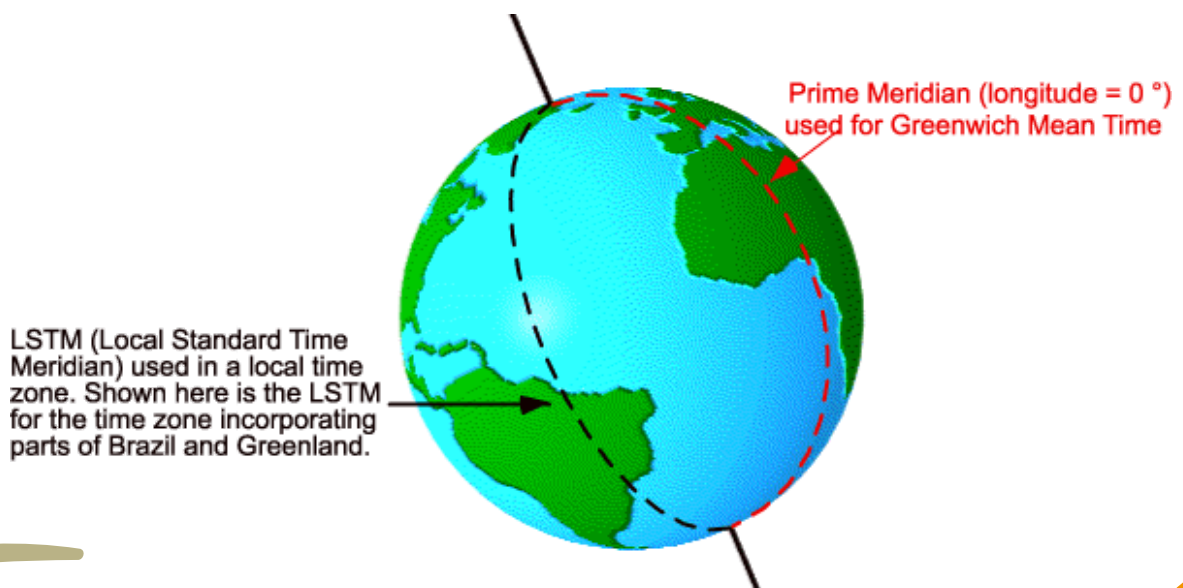
The path is at local time. Determine the solar altitude and solar Azimuth angle at 01.00 pm local time on December Solstice





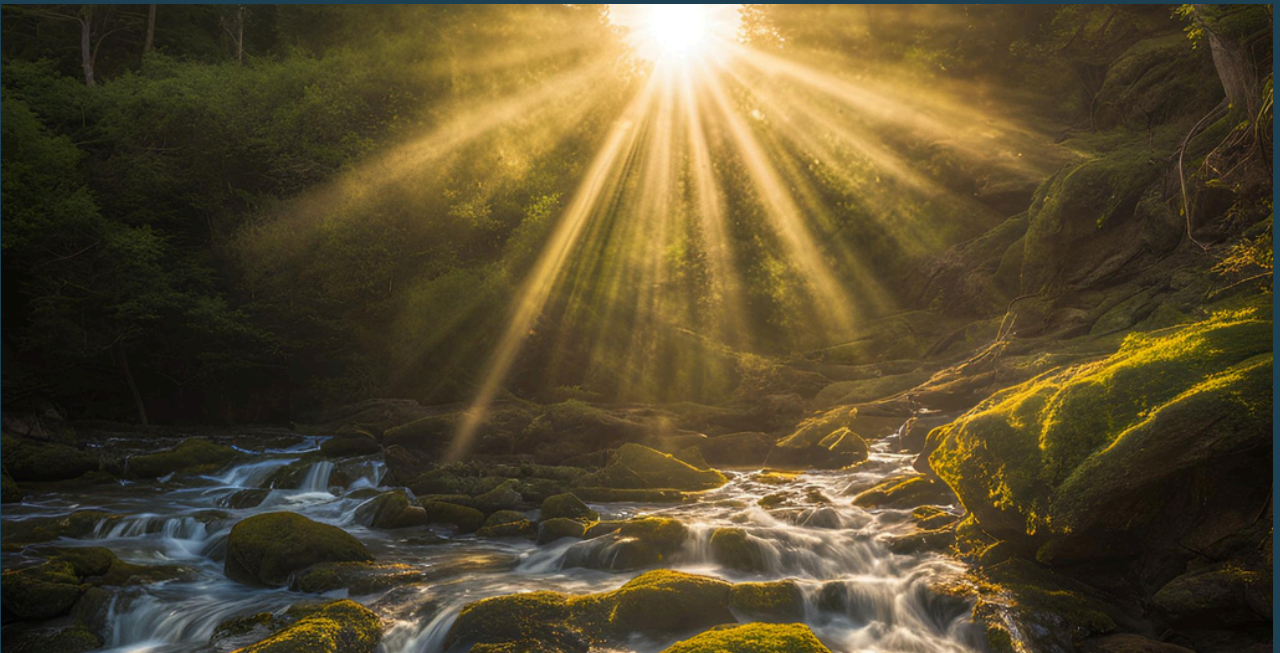
Solar Time (ST)

- **Local Time (LT)** is a concept of time based on rotation of the Earth relative to the Sun.
- **Local Solar Time (LST)**- to the time of the position of the Sun for a particular site on Earth's surface. LST can be calculated separately for the two hemispheres ; Eastern Hemisphere / Western Hemisphere.
- **Local Standard Time Meridian (LSTM)** is a reference meridian used for a particular time zone and is similar to the Prime Meridian, which is used for Greenwich Mean Time.



Topic 4

Basic Quantity Solar



2

CHARACTERIZE SOLAR RADIATION

Solar Irradiance, (G)

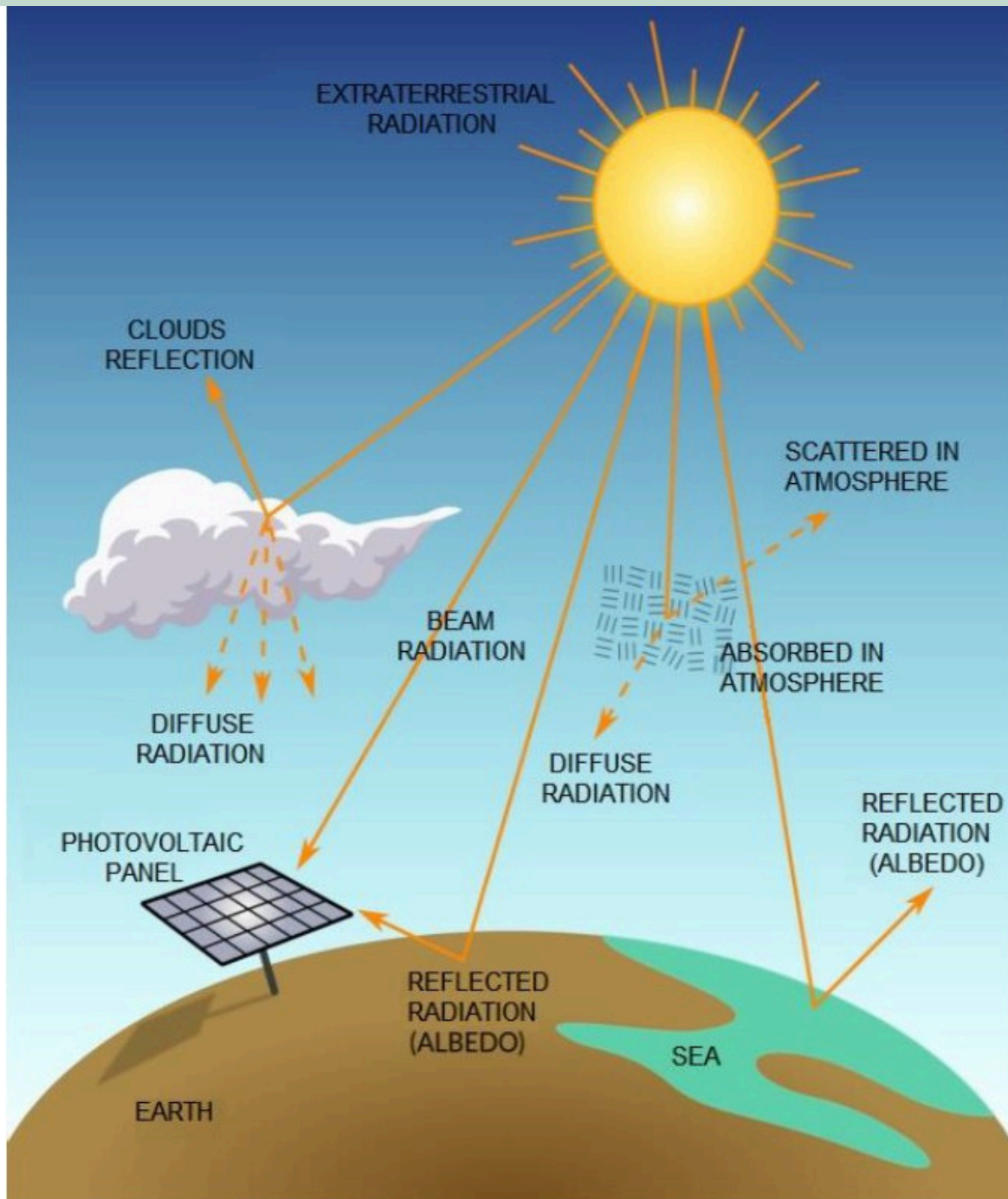
The intensity of solar power at a point of observation.

Solar Irradiation, (H)

The intensity of solar energy at a point of observation.

PARAMETER	SIMBOL	UNIT
Irradiance (Kesinaran)	G	Wm^{-2}
Irradiation (Penyinaran)	H	Whm^{-2}
Solar constant (Pemalar solar)	G_{SC}	$1,367 \text{ Wm}^{-2}$
Peak value at sea level (Nilai puncak pada aras laut)	G_{O}	$1,000 \text{ Wm}^{-2}$

SOLAR RADIATION COMPONENTS



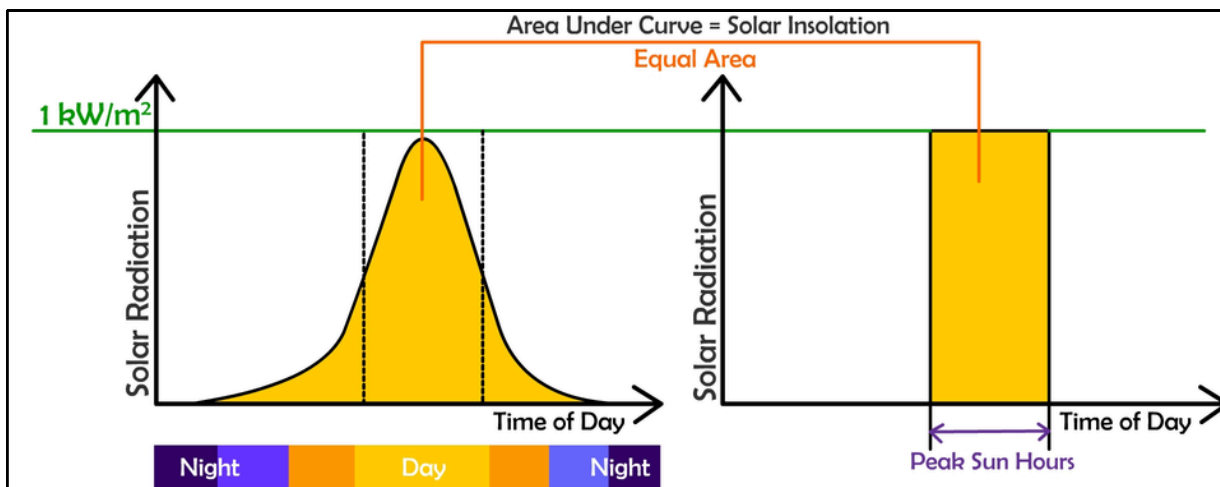
<https://www.scielo.br/j/babt/a/VSQdPY4VyZ6CJLKqyzmN78G/#ModalFiggf01>

PEAK SUN HOUR (PSH)

PSH is the **number of hours** that the solar radiation of **1000 Wm^{-2}** gives the equivalent amount of solar radiation for the day.

The PSH can be calculated for **a day, a month or a year**.

The unit for PSH is **hour (h)**.



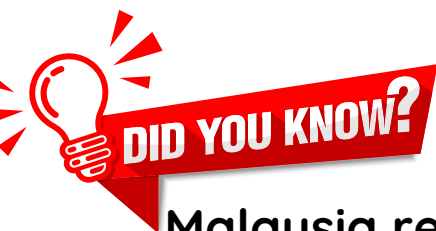
source of: <https://greensarawak.com>

"Peak sun hours" refers to the amount of solar radiation that a specific location can receive when the sun is at its **highest intensity** for a duration of time.

For example, a location that receives **9 kWhm²** per day can be said to have received **9 hours** of sun per day at **1 kWm⁻²**

HIGHER
Sun Hours

MORE
solar Energy



Malaysia receives an average **4 - 4.5 kWhm⁻²** per day , resulting they received average of **4 - 4.5 hours** of sun per day.



EXAMPLE

The monthly solar irradiation at a site is given in the table below. Determine:

- a) Annual solar irradiation, H in kWh/m^2
- b) Annual Peaks Sun Hour, PSH.

MONTH	H (kWh/m^2)
January	136
February	124
March	139
April	138
May	145
June	135

MONTH	H (kWh/m^2)
July	136
August	136
September	129
October	133
November	123
December	124



ANSWER

- a) Sum up the solar irradiation for each month

$$136 + 124 + 139 + 138 + 145 + 135 + 136 + 129 + 133 + 123 + 124 = \underline{1,598 \text{ kWh/m}^2}$$

- b) Annual Peak Sun Hour, PSH

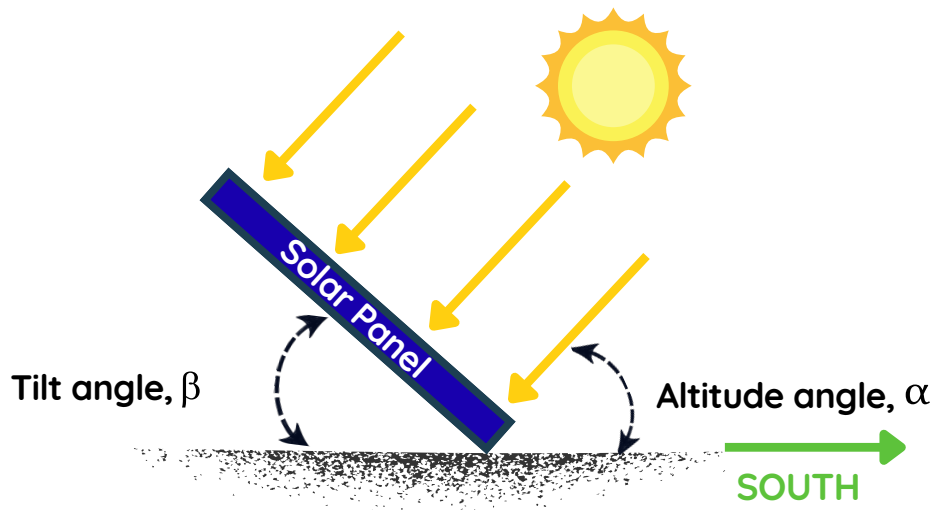
$$= \frac{1,598 \text{ kWh/m}^2}{1 \text{ kWh/m}^2} = \underline{1,598 \text{ h}}$$

So, the average daily is
 $1598 \text{ h} / 365 \text{ days} = \underline{4.37 \text{ h}}$

Topic 5

Orientation and Tilt Angle





The power incident on a PV module depends not only on the power contained in the sunlight, but also on the angle between the module and the sun.

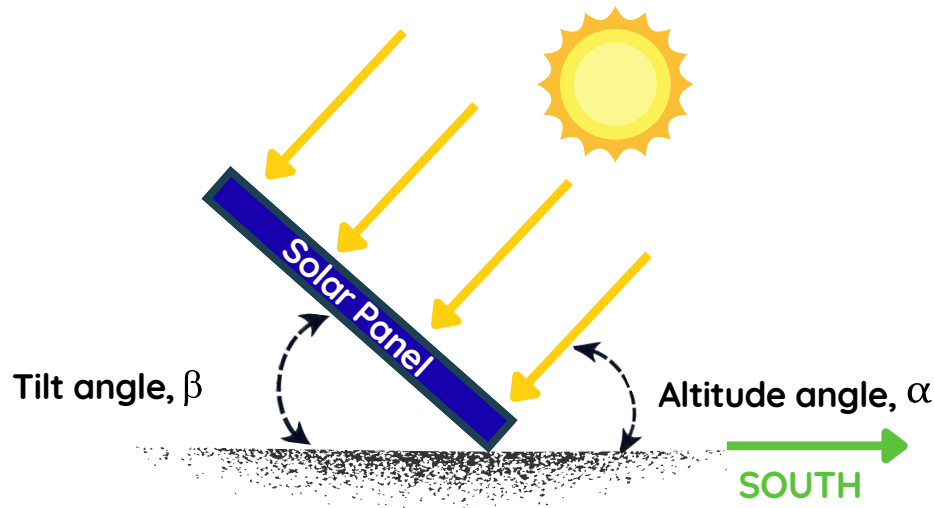
When the absorbing surface and the sunlight are perpendicular to each other, the power density on the surface is equal to that of the sunlight .

However, as the angle between the sun and a fixed surface is continually changing, the power density on a fixed PV module is less than that of the incident sunlight.

The power density will always be at its maximum when the PV module is perpendicular to the sun

METHODS TO DETERMINE THE SOLAR ALTITUDE AND THE TILT ANGLE OF A SOLAR PV PANEL

i) Analytical Method



The Tilt angle can be calculated as,

$$\beta = 180^{\circ} - 90^{\circ} - \alpha$$

The solar altitude angle can be calculated,

- when the Sun is over the Equator

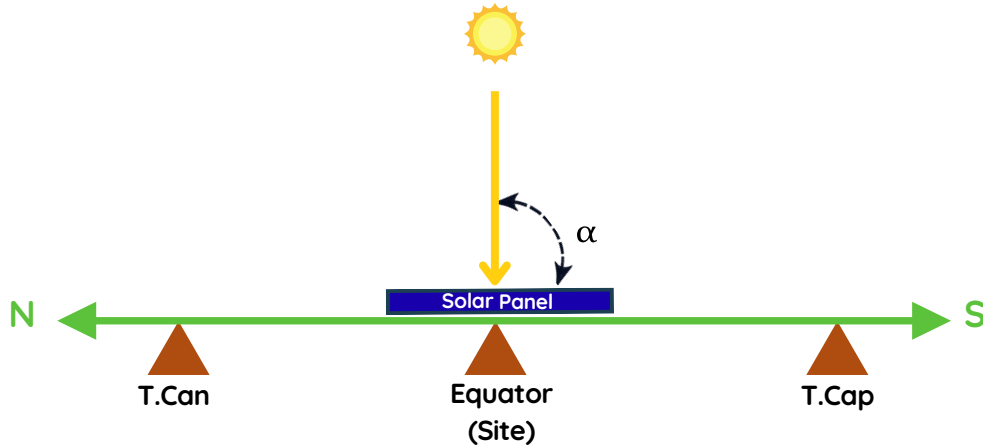
$$\alpha = 90^{\circ} - \theta$$

- when the Sun is over the Tropic of Cancer or Capricorn

$$\alpha = 90^{\circ} - \theta \pm 23.45^{\circ}$$

ii) Geometrical Method

a) Site and Sun at the Equator

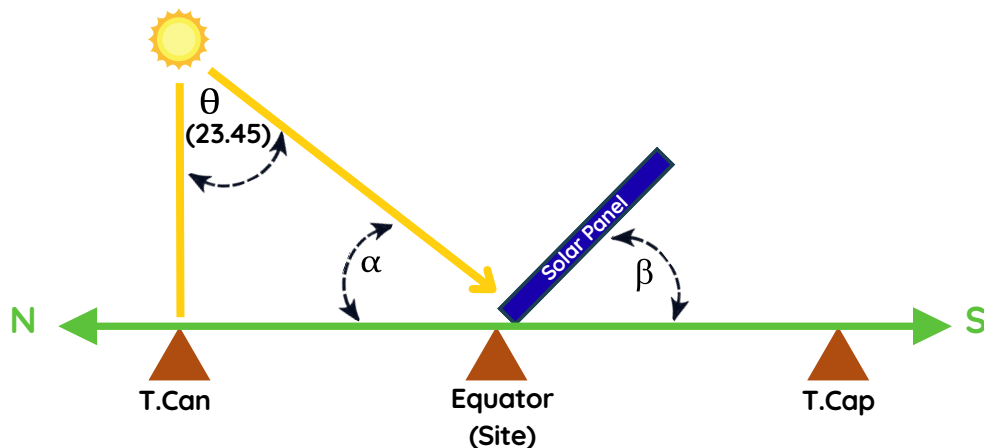


Altitude angle, $\alpha = 180 - 90 = 90$

Tilt angle, $\beta = 0$

Face of solar panel is looking the sky

b) Site at the Equator and Sun is over Tropic of Cancer

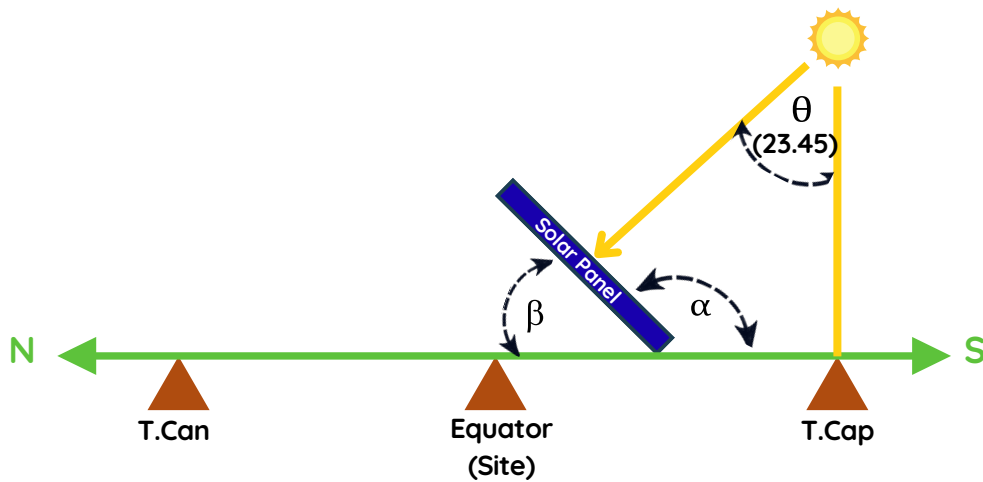


Altitude angle, $\alpha = 180 - 90 - 23.45 = 66.55$ looking N

Tilt angle, $\beta = 180 - 90 - 66.55 = 23.45$ looking to N

Face of solar panel is looking North

c) Site at the Equator and Sun is over Tropic of Capricorn



Altitude angle, $\alpha = 180 - 90 - 23.45 = 66.55$ looking S

Tilt angle , $\beta = 180 - 90 - 66.55 = 23.45$ looking to S

• Face of solar panel is looking South



EXERCISE

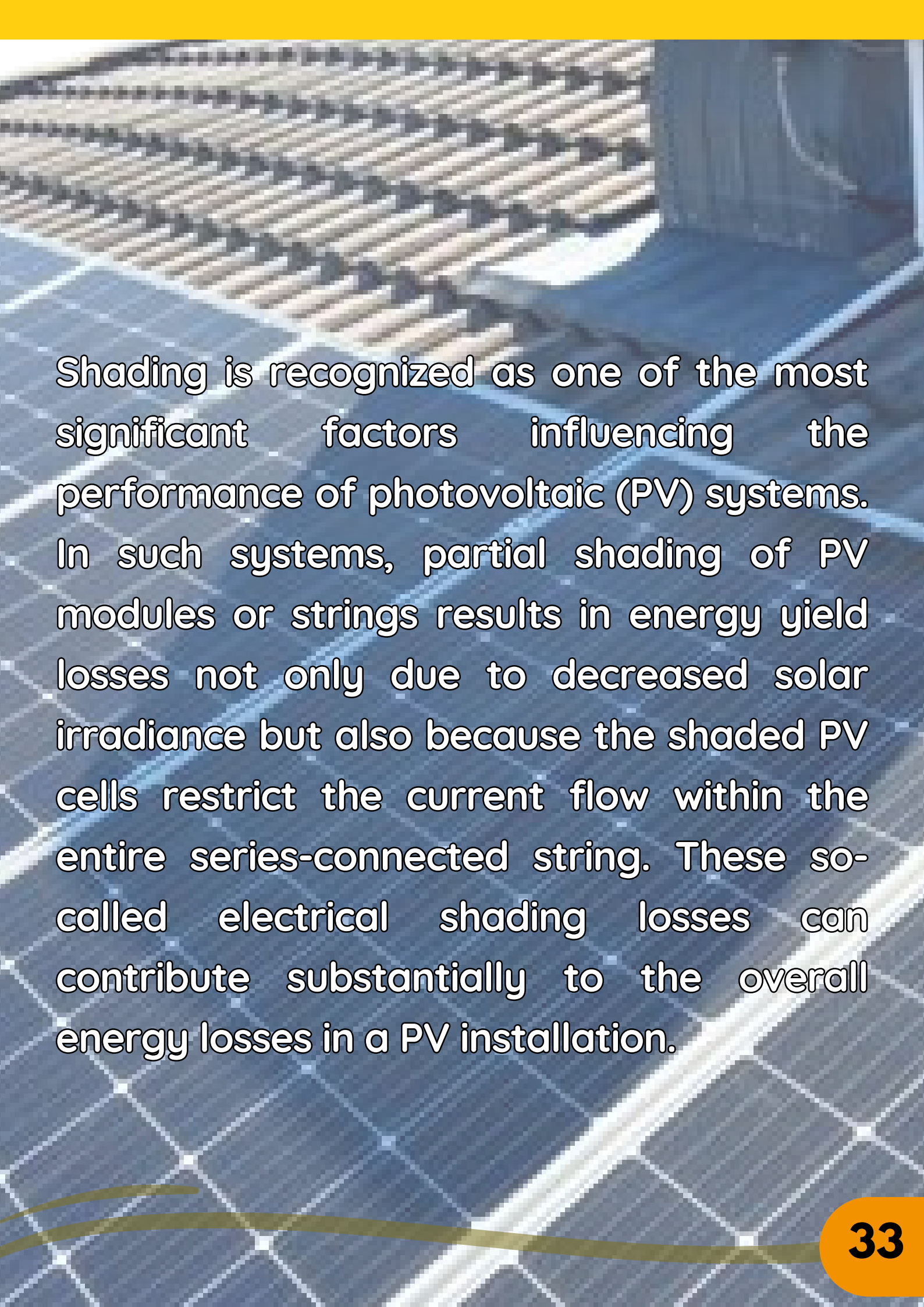
Location A has coordinates 27°N , 112°E . Determine the solar altitude angle and the tilt angle for a PV array at solar noon using the calculation and geometrical method when The Sun is :

- a) over the Equator
- b) over the Tropic of Cancer
- c) over the Tropic of Capricorn

Topic 6

Shading





Shading is recognized as one of the most significant factors influencing the performance of photovoltaic (PV) systems. In such systems, partial shading of PV modules or strings results in energy yield losses not only due to decreased solar irradiance but also because the shaded PV cells restrict the current flow within the entire series-connected string. These so-called electrical shading losses can contribute substantially to the overall energy losses in a PV installation.



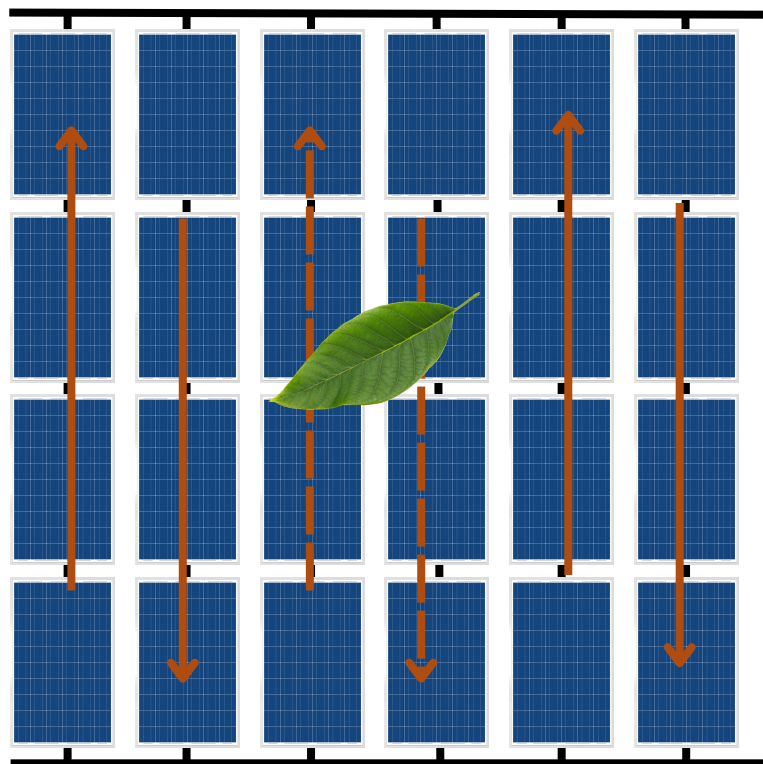
Shading occurs when an object obstructs solar radiation from reaching all or part of a PV module. Potential sources of shading include, but are not limited to:

- Nearby obstructions such as buildings, trees, antennas, or utility poles;
- Self-shading caused by adjacent rows of PV modules;
- Horizon shading due to surrounding topography;
- Additional contributing factors include suboptimal panel orientation, surface soiling, and non-uniform aging of modules.



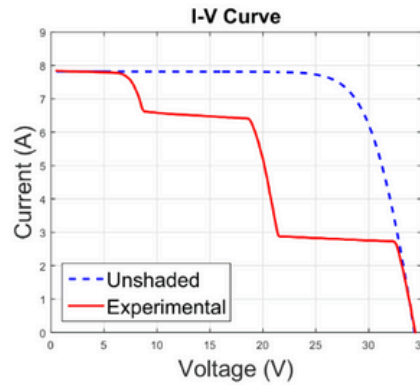
Standard PV modules typically comprise between 32 and 72 solar cells connected in series, a configuration that renders the module highly susceptible to partial shading. Even minimal shading can lead to significant reductions in overall system output. This performance degradation occurs due to two primary reasons:

- Since the cells are connected in series, shading a single cell constrains the current through the entire string.
- In systems utilizing string inverters, shading of one panel within the string adversely affects the output of all connected panels.

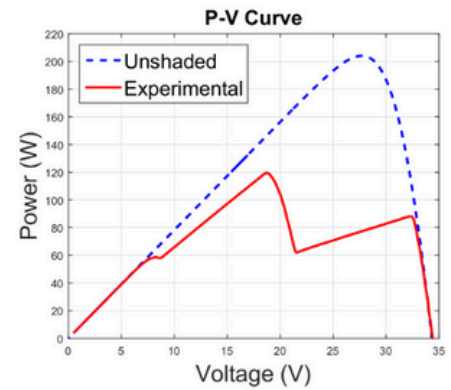




(a) Shaded PV module



(b) Experimental I-V curve

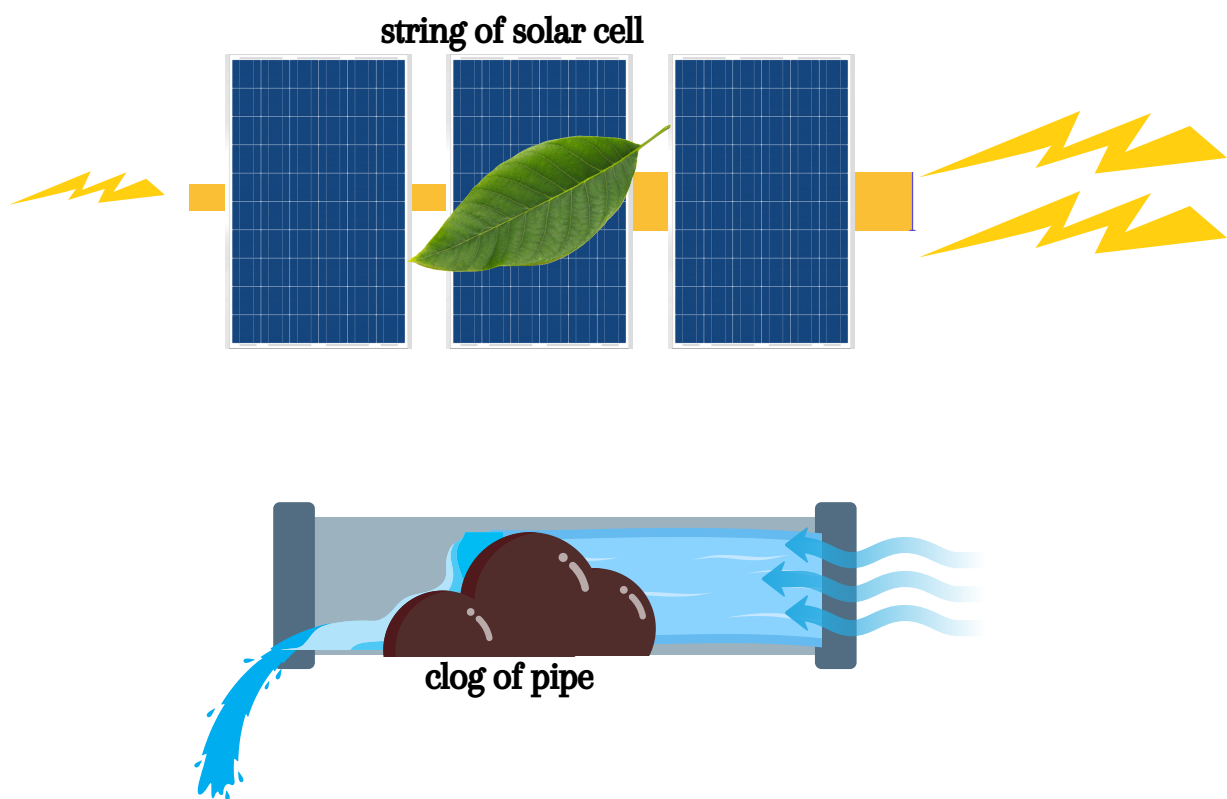


(c) Experimental P-V curve

From the above, the shading experiment was conducted under clear, sunny conditions. At 1:00 p.m., the ambient temperature was recorded at 15°C, and the global solar irradiance on the horizontal plane measured approximately 910 W/m².

The experimental results presented demonstrate the pronounced effect of partial shading on the current-voltage (I-V) and power-voltage (P-V) characteristics of the PV system. Furthermore, previous research has indicated that such shading conditions can contribute to localized overheating, potentially leading to hot-spot formation and long-term degradation of PV modules.

To better understand the substantial impact of shading on PV system performance, it is helpful to use the analogy of water flowing in pipes. The flow rate of water through the pipe is constant, much like the current through a cell string is constant for a given irradiance level.



Shading to a solar cell is analogous to placing a blockage within the pipe, which constrains water flow throughout the entire system. Similarly, when a solar cell is shaded, it impedes the current flow across the entire series-connected string.

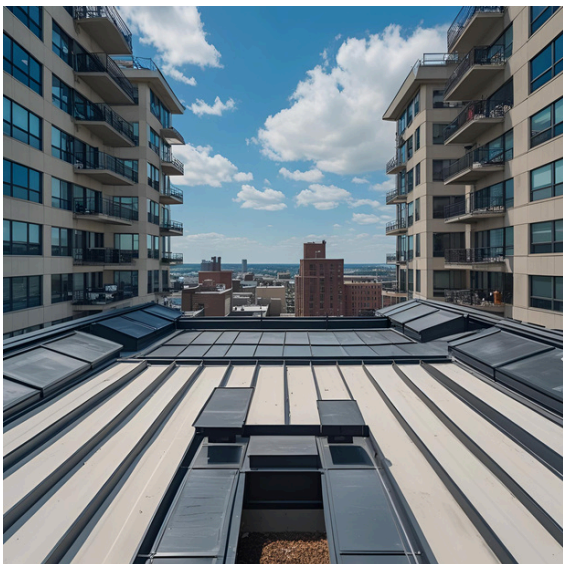
This phenomenon is particularly critical because all PV cells within the string are required to operate at the current level dictated by the shaded cell.

Consequently, unshaded cells are unable to function at their optimal performance levels. This can be likened to a chain in which each solar cell represents a link; the shaded cell becomes the “weakest link,” thereby limiting the effectiveness of the entire chain. Hence, even minimal shading can result in a significant decrease in the total energy output of a PV system.

The same principle extends to modules connected in series. The overall current in a string of modules can be significantly reduced if even a single module experiences shading.

That is why it is important to do a shading analysis during the site survey to find out if there are any trees or buildings that might **block the sunlight**.

- Avoid installing PV systems in areas that experience a lot of shading.
- If the installation needs to be done in an area that experiences shading, then the amount of shading needs to be determined.



SHADING ASSESMENT: HOW IT WORK?

- Calculate the total energy intensity that can be obtained at the location. This information is important for calculating the size of the PV system and calculating energy yield.
- The amount of shading at a location can be determined using this equipment:

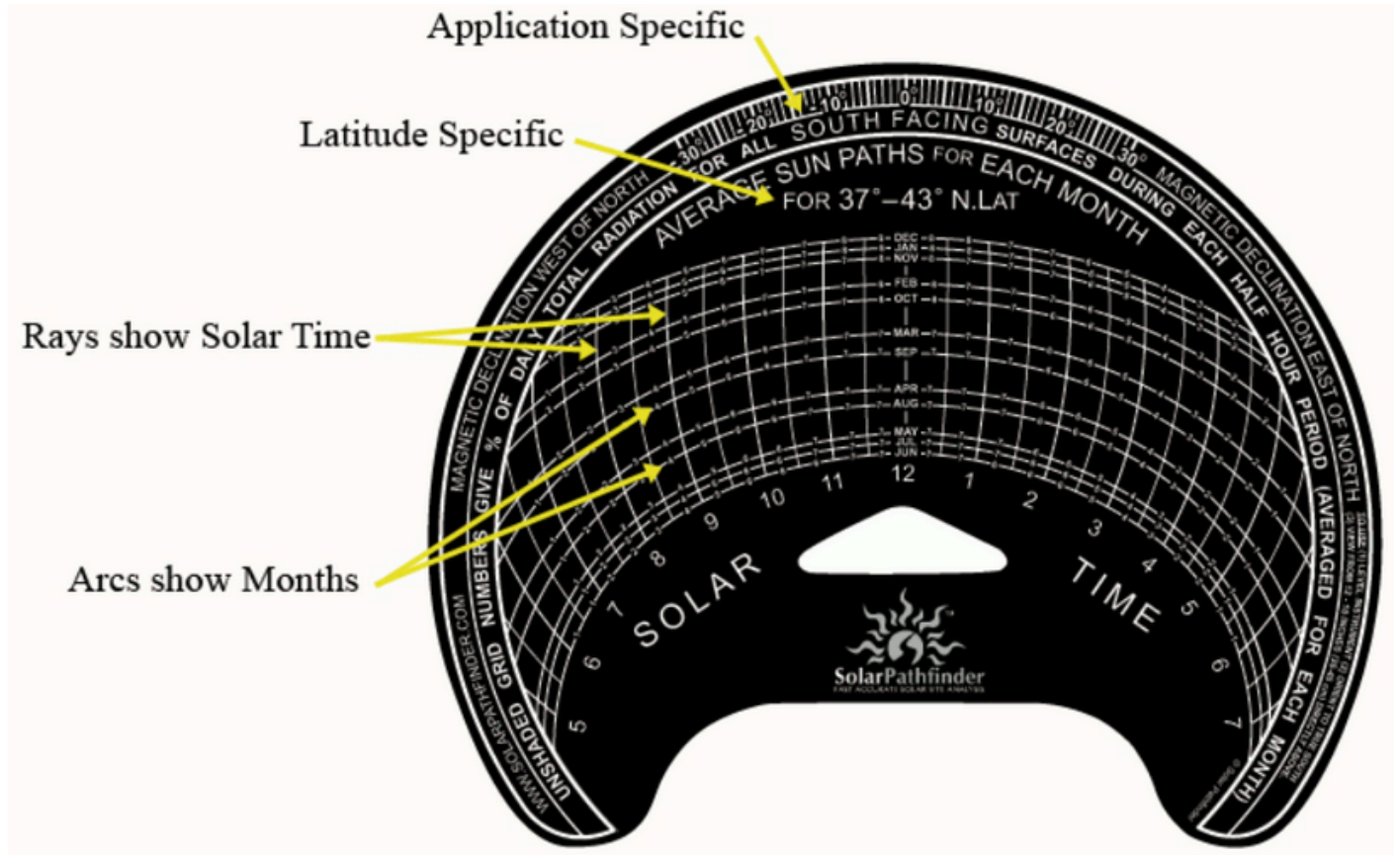
1 **Solar Pathfinder** is a non-electronic tool that performs an accurate shading assessment of solar site analysis.

2 **Solmetric PV Analyzer** is a professional diagnostic tool that plays an important role in assessing shading impacts, especially when used alongside the Solmetric SunEye device.



SHADING ANALYSIS

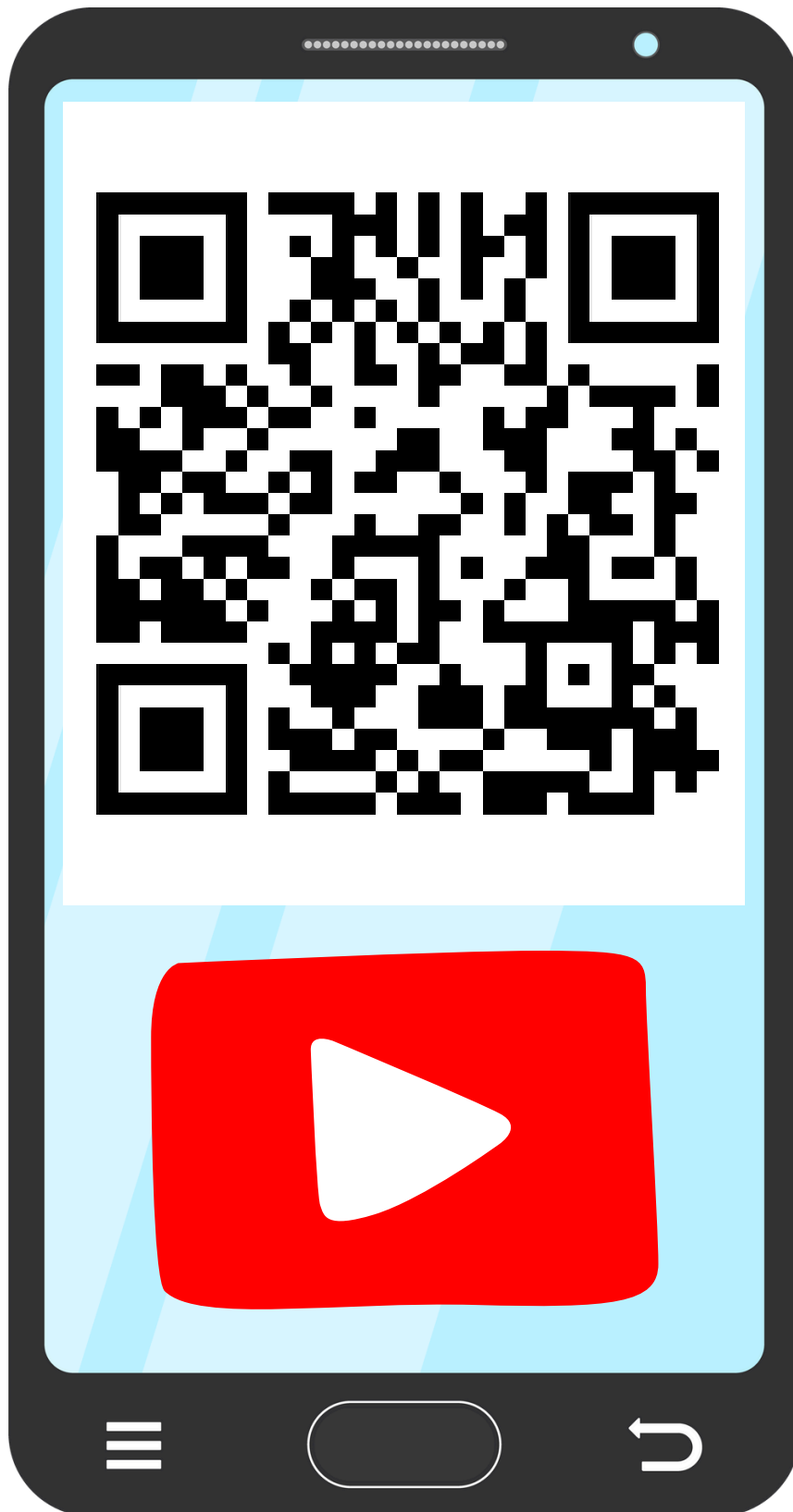
SOLAR PATHFINDER : HOW TO READ?



percent of shading



SHADING ASSESMENT SOLAR PATHFINDER : HOW IT WORK?



SHADING SITE ASSESSMENT USING SOLAR PATHFINDER

PROCEDURES:

a) Assembly of solar pathfinder set

b) Orientation of chart - turn the direction of the chart so that it is oriented in the correct compass direction

c) Magnetic declination of chart - set the chart according to the correct magnetic declination angle of the site

d) Direction of magnetic compass -

i. Ensure the direction of the compass aligns correctly (ie: red arrow points to the North)

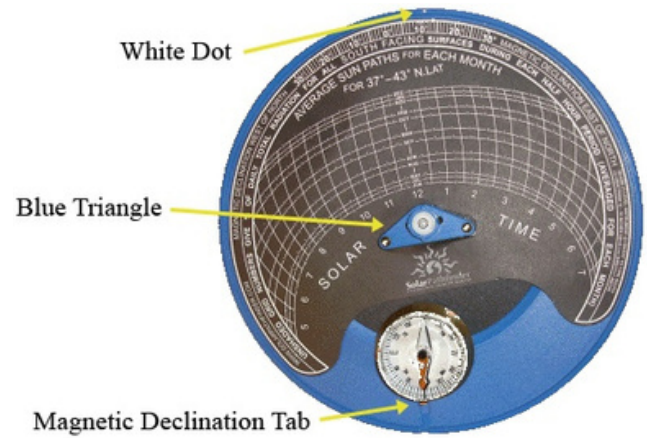
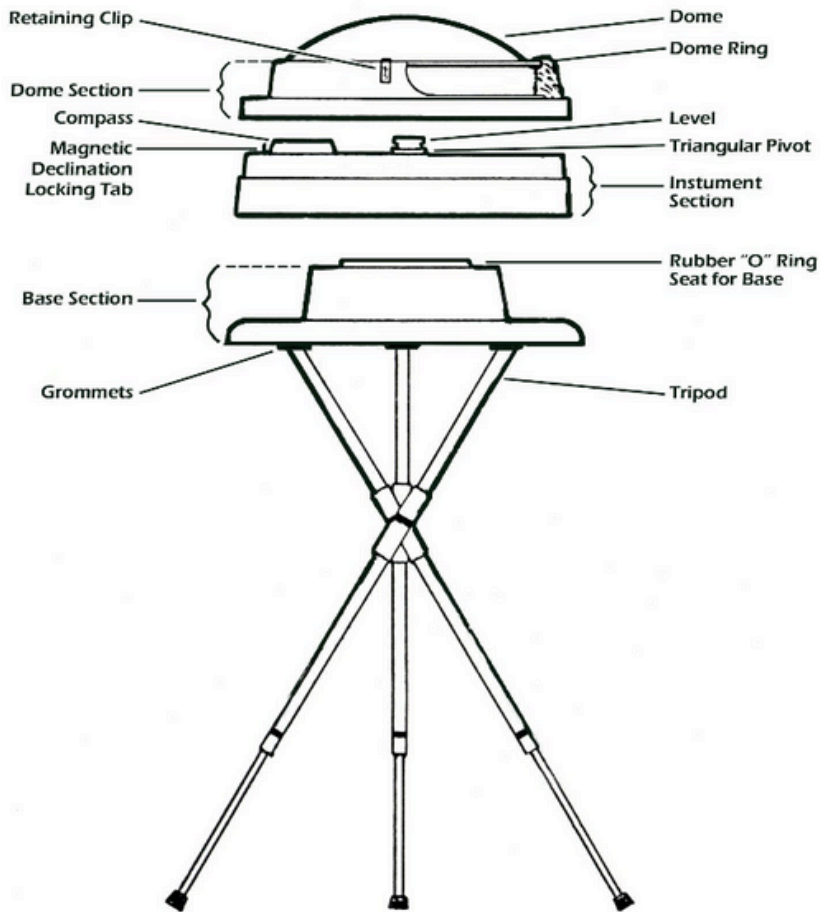
ii. You may need to move the equipment to a suitable spot

e) Position of bubble - adjust the level until the bubble set in the center.

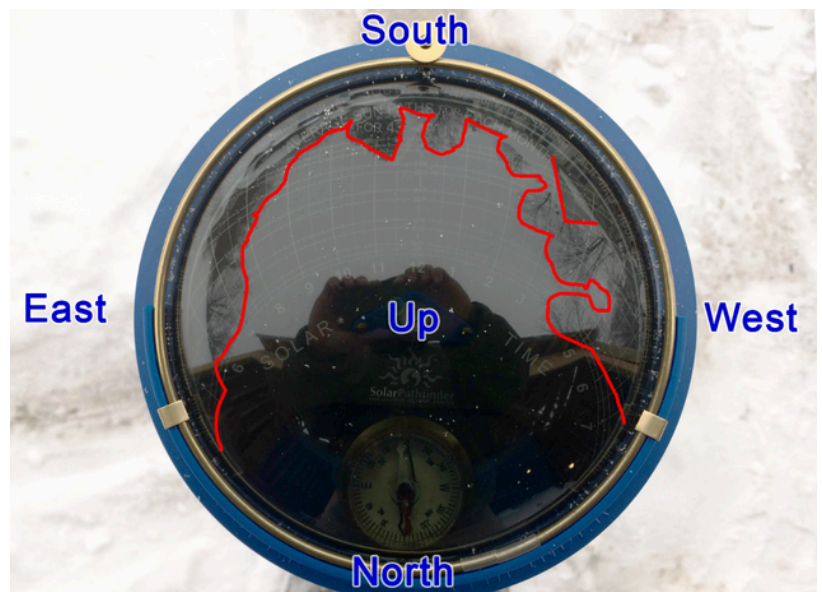
f) Position of Solar Disk - solar disk should fall at about correct solar time and the relative position of the month

g) Overall Set up- recheck and confirm the accuracy of all the steps.

SHADING ASSESMENT SETUP SOLAR PATHFINDER



TAKE PICTURE OF SHADING PROFILE

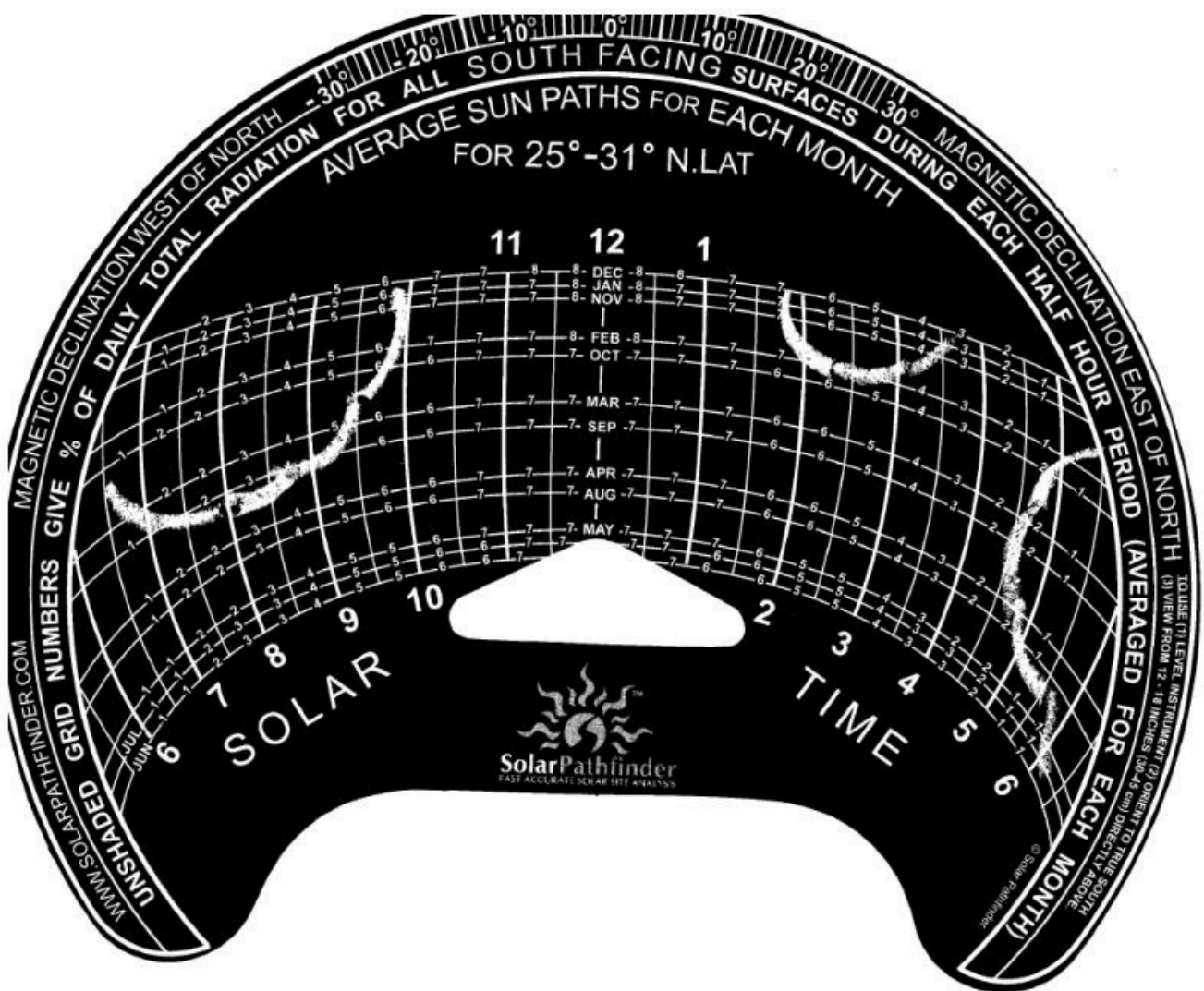


SKETCH SHADING PROFILE

SOLAR SITE SHADING ANALYSIS



EXAMPLE





ANSWER

Month	H (kWhm ²) unshaded	Percentage shading (%)	F unshade	H available (kWhm ²)
Jan	130	$1+2+3+4+5+6+7+6+5+4+3 = 46$	$(100-46)/100 = 0.54$	$0.54 \times 130 = 70.20$
Feb	135	$1+2+3+4+5+6+6+5 = 32$	$(100-32)/100 = 0.68$	$0.68 \times 135 = 91.80$
Mar	155	18	0.82	127.10
Apr	145	3	0.97	140.65
May	135	1	0.99	133.65
Jun	137	0	1.00	137.00
Jul	145	1	0.99	143.55
Aug	138	3	0.97	133.86
Sep	150	18	0.82	123.00
Oct	151	24	0.76	114.76
Nov	129	43	0.57	73.53
Dec	124	46	0.54	66.96
TOTAL	1674	-	-	1356.06

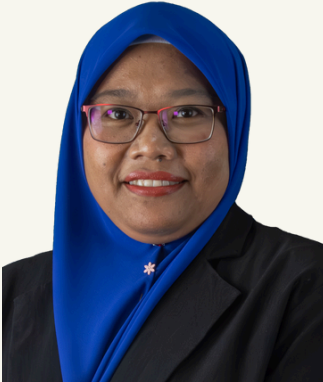
Reference

1. Namrata, K., Saini, R. P., & Kothari, D. P. (2024). *Introduction to Photovoltaic Solar Energy. In Wind and Solar Energy Systems* (pp. 101-134). Singapore: Springer Nature Singapore.
2. Duffie, J.A. and Beckman, W.A. (2013) *Solar Engineering of Thermal Processes*. 2nd Edition, Madison, New York; John Wiley & Sons, Hoboken.
3. Gaisma, See <https://www.gaisma.com>
4. Solar pathfinder, 2021. See <http://www.solarpathfinder.com>
5. Sustainable Energy Development Authority (SEDA) Malaysia, 2022. SEDA Malaysian Grid Connected Systems Design course.
6. Sulaiman Shaari, Ahmad Maliki Omar, Ahmad Hadri Haris and Shahril Irwan Sulaiman (2010). *Solar Photovoltaic Power: Fundamentals*. REM/MBIPV National Project Team, Ministry of Energy, Green Technology and Water Malaysia, 2010. Putrajaya, Malaysia

Biography



FAIZATUL NOOR BINTI ABU BAKAR is a lecturer for the Diploma in Photovoltaic Solar Technology at Kolej Komuniti Segamat 2. She graduated with Bachelor of Engineering (Hons) Electrical Engineering from Universiti Teknologi Mara in 2008 and Master's in Science Space Science from Universiti Kebangsaan Malaysia in 2012.



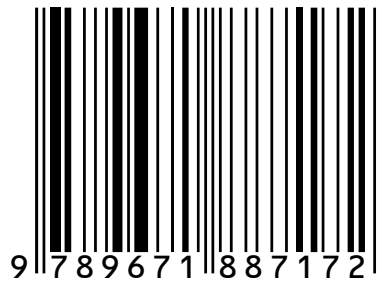
NORASHIKIN BINTI AMIR is a lecturer for the Diploma in Photovoltaic Solar Technology at Kolej Komuniti Segamat 2. She graduated with Bachelor of Engineering (Hons) Electrical Engineering from Universiti Teknologi Mara in 2009. She was a lecturer in Electrical Technology department at Kolej Komuniti Masjid Tanah.



Ts. ZARULRIZAM BIN AB JALIL is a senior lecturer for the Diploma in Photovoltaic Solar Technology at Kolej Komuniti Segamat 2. He graduated with Bachelor of Technical and Vocational Education (2005) and Master of Technical Education in Instructional Design & Technology (2015) from Universiti Tun Hussein Onn (formerly known as the Tun Hussein Onn Institute of Technology)

SITE ASSESSMENT IS MY PLACE IS SUITABLE FOR SOLAR?

e ISBN 978-967-18871-7-2



KOLEJ KOMUNITI SEGAMAT 2
(online)