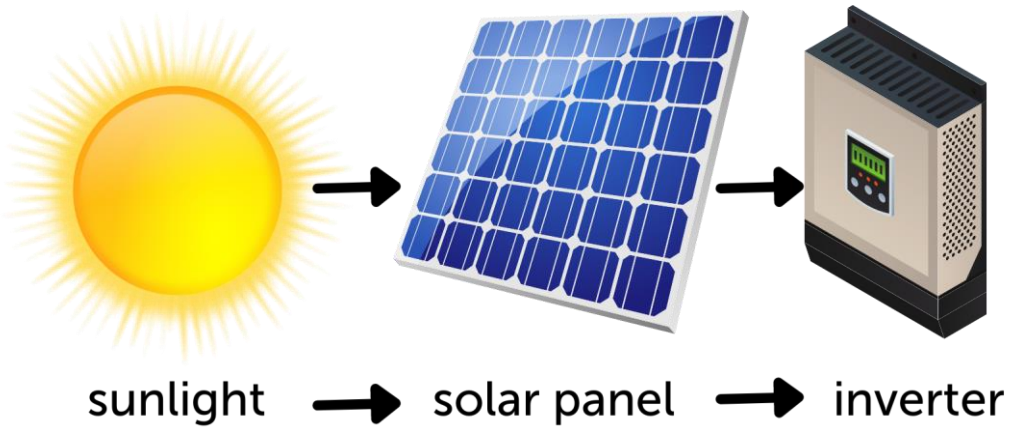
Solar Energy – Teacher Notes

Earth's resources are classified as renewable or non-renewable, according to the time they take to replenish. Resources are typically considered to be renewable if they replenish within a human lifespan. Some renewable resources are considered inexhaustible as they are perpetually being renewed. These resources can be used as renewable energies.

Solar energy is an example of a renewable energy resource. Solar energy is generated from nuclear fusion reactions within the Sun, emitted as electromagnetic radiation. This energy from the Sun can be collected by photovoltaic (PV) cells which then convert it to electricity. Household solar panels are comprised of many individual PV cells linked together.

ACTIVITY: The conversion of sunlight to electricity can be easily demonstrated via a flow diagram. Draw a diagram to show the steps in generating electricity from the Sun, including the following: inverter, sunlight, solar panel.

EXAMPLE



Complete the sentence:

The energy source is the SUN. When the SUNLIGHT falls onto the SOLAR PANEL it is converted to electricity. The INVERTER changes the low voltage electricity generated from the SOLAR PANEL into high voltage electricity used by appliances.

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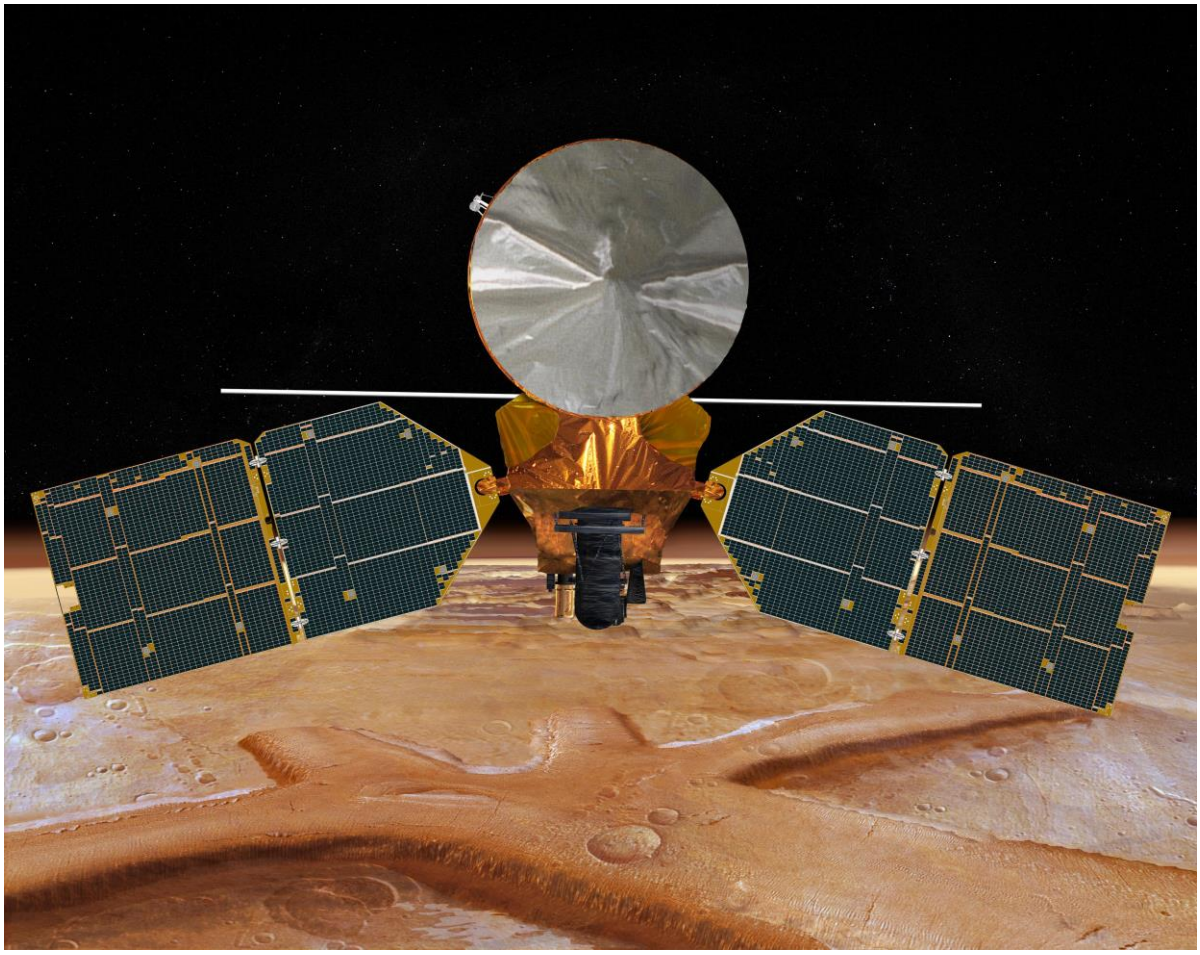
Powering Space Exploration

Solar energy is a readily accessible source of power and is used extensively by the National Aeronautics and Space Administration (NASA) in space exploration. The Mars Exploration Rovers (MER) Spirit and Opportunity, and the Mars Reconnaissance Orbiter were all powered by huge solar panels that were designed to capture as much energy from the Sun as possible on Mars.



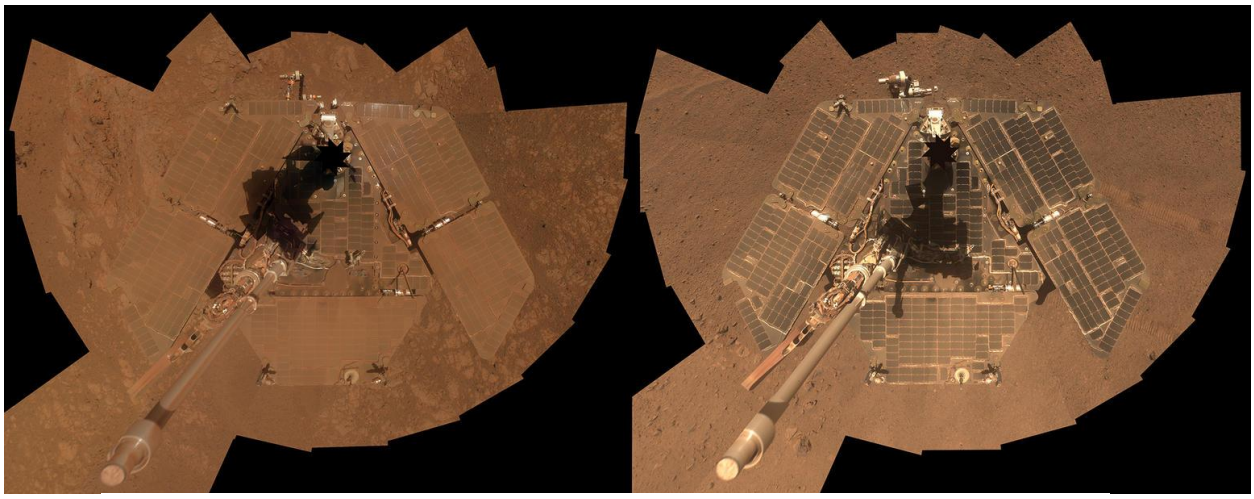
Sun-tracking solar panels on Mars Reconnaissance Orbiter
(Image credit. NASA/JPL-Caltech/Cornell Univ./Arizona State Univ.)

Maximum Efficiency

The Mars Exploration Rovers (MER) work remotely and must have the best technologies to ensure a continuous and reliable energy source. The images below show Opportunity in January and March 2014, before and after the rover's self-cleaning mechanism was able to remove a large amount of dust that accumulated on its solar panels on the Martian planet.

In 2018, the MER Opportunity was impacted by a massive global dust storm on Mars which blocked the rover's photovoltaics for a long time. Opportunity was unable to recharge, and in 2019 NASA officially declared the rover dead.

Solar Energy – Teacher Notes



MER Opportunity on Mars before (left) and after (right) self-cleaning the solar panels (Image credit NASA/JPL-Caltech/Cornell Univ./Arizona State Univ.)

The death of Opportunity demonstrates that the amount of energy generated by the PV cell is dependent on the intensity of sunlight falling on the solar panels. The thick dust layer on the rover's solar panels blocked the sunlight, reducing the light intensity and the amount of energy that could be generated.

Three main factors that can impede the intensity of sunlight reaching a solar panel are:

1. ***Blocking*** – natural conditions can block light from reaching the solar panels, including Mars dust (for the MER Opportunity) or, on Earth, our atmosphere.

2. ***Angle*** – the angle between the Sun and the solar panel impacts the intensity of light reaching the panels. Maximum light intensity occurs when the PV is angled to be pointing directly at the Sun. On the International Space Station, the solar panels constantly rotate so that they are always facing the Sun and therefore can convert the maximum amount of solar energy into power for the Station.

3. ***Distance from the Sun*** - light intensity is inversely proportional to distance. That is, as the distance from the light source increases, the intensity of the light decreases. This is because the light spreads out as you move away from the source.

ACTIVITY: Work through the activity steps to demonstrate how the angle of a light source changes light intensity

1. Hold a torch directly above a sheet of graph paper so that it is at 90^0 to the paper
2. Trace around the area illuminated on the paper and count the number of squares that are lit up at this angle
3. Keeping the torch at the same distance from the paper, tilt it until it is at 45^0 to the paper
4. Trace around the area illuminated on the paper and count the number of squares that are lit up
5. Repeat Step 3, tilting the torch to approximately 10^0 to the paper. Measure the angle using a protractor for accuracy.

Solar Energy – Teacher Notes

Table 1. Effect on the area of illumination as the angle of the light source changes

Angle of torch	No. squares illuminated	Observations
90^0	41	Light is concentrated over a small area
45^0	110	Reduction in brightness of the light over the area
20^0	420	Low intensity light over a large area

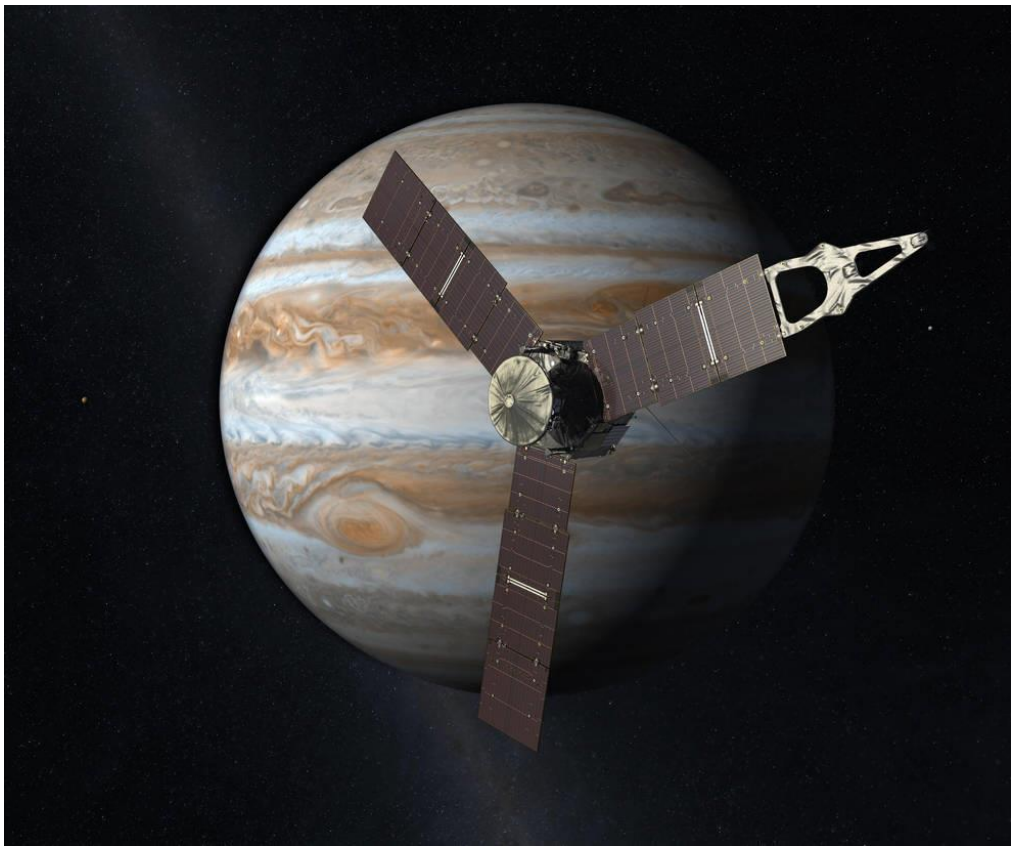
What do you observe about the number of squares that are illuminated as the torch angle changes?

The number of squares illuminated increases as the torch angle decreases.

What do you observe about the intensity of the light as the torch angle reduces?

The amount of light coming out of the torch does not change, however, when the same amount of illumination is spread over a large area, the light intensity decreases

Distance from the Sun places limitations on exploration by solar-powered spacecraft. NASA's Juno spacecraft is currently the most distant solar-powered craft, breaking records in 2017 when it reached 793 million kilometers from the Sun. As Juno uses the Sun as its energy source, the maximum distance it can travel is 832 million kilometres away. As a comparison, Earth is 149.6 million kilometres from the Sun.



The Juno spacecraft and Jupiter
(Image Credit: NASA/JPL-Caltech)

Solar Energy – Teacher Notes

ACTIVITY: Research the different ways you can measure the relationship between light intensity and distance. Design a simple experiment to compare these. Suggestions include using a light meter, light intensity app, digital camera, or to calculate using a light bulb of known wattage.

Students own work

Large scale solar power projects

The use of solar power as a renewable energy resource on Earth is a growing trend. With advances in the use of sun-tracking and adjustable tilt angles for solar panels, to gain maximum exposure to the Sun, the use of solar energy in large scale projects is rapidly increasing. One example is the Woodside Power Project being proposed at the Maitland Strategic Industrial Area, about 15km south west of Karratha. Woodside is looking to generate electricity from a large-scale Solar PV Farm, complemented by battery storage facilities. Electricity would be delivered to customers in the region through an electricity grid called the North-West Interconnected System (NWIS).

Small scale solar energy systems

Many of us are familiar with household roof top solar panels and hot water systems for the collection of solar energy. This is known as small scale solar energy. The panels are usually fixed and therefore do not track the Sun, unlike the large-scale solar energy projects. As a result, the amount of sunlight falling on the panels will change over the year, as the angle of incoming sunlight changes (incident angle or angle of incidence).

ACTIVITY: Complete the activity steps to explore how the angle of the Sun relative to a fixed solar panel changes throughout the year.

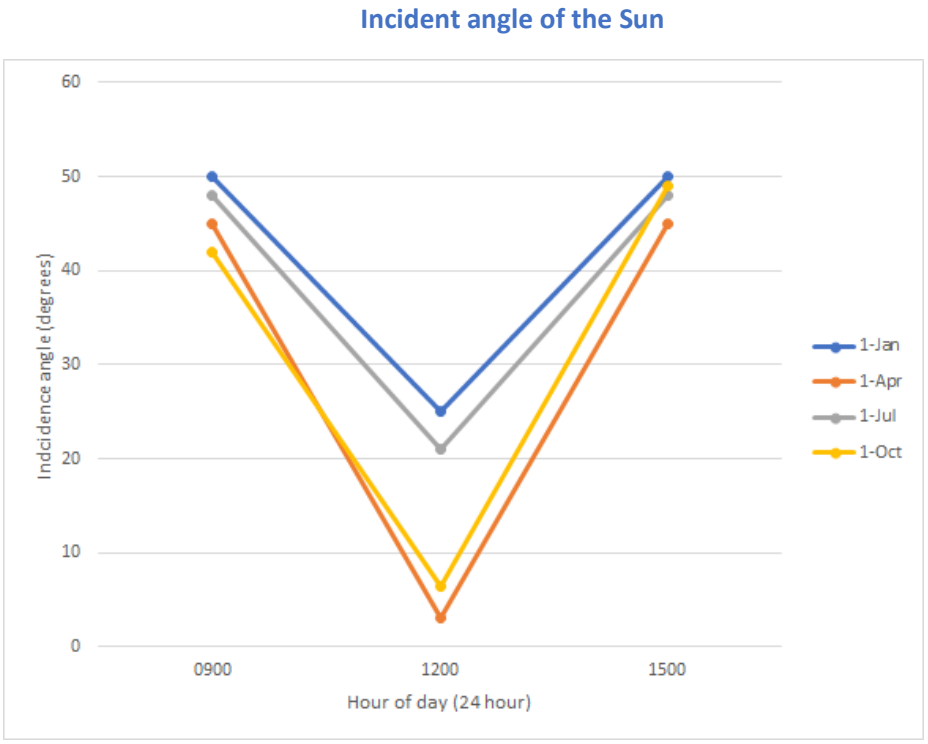
Table 2. Sun incident angle relative to the fixed solar panel and sunlight hours per day in PERTH, WESTERN AUSTRALIA

	1 Jan			1 Apr			1 Jul			1 Oct		
	9am	**12**	**3pm**	**9am**	**12**	**3pm**	**9am**	**12**	**3pm**	**9am**	**12**	**3pm**
Incident angle	50	25	50	45	3	45	48	21	48	42	6.5	49
Sunlight hours/day	14:03			11:35			9:57			12:17		

NOTE: these angles were calculated by placing the latitude and longitude of Perth (-31.9523, 115.8613) to the inputs in the solar path calculator. To make the exercise more meaningful for the students, add in the latitude and longitude of your location. For example, inputs for Karratha would be -20.7337, 116.8447. This will enable you to construct a table relevant to your own location.

1. Table 2. shows the angle of the Sun at 9am, 12pm and 3pm in Perth, Western Australia on four different dates. Plot these points on the grid below using a different colour for each date. Remember to include a title and key on your graph. Note that the solar panels are tilted at an angle of 33^0 for maximum sunlight exposure, therefore a low incident angle means that the Sun is directly overhead the panels.

2. Interpret a curve for each date by joining up the points, using a different colour for each date. This will provide you with an indication of the path of the Sun and the angle of the sunlight through the year.



From your graph, in which months does the incident angle reach its lowest point over the panels? These are the months when the maximum solar energy is captured by the fixed solar panels.

April and October

Describe one factor that could affect the amount of sunlight reaching the panels during these months

1. Blocking e.g. April - dust on the solar panels from summer dust storms and lack of rainfall (to remove the dust)
   October - Cloud cover as the seasons change from winter to spring
2. Angle – as the angle of the Sun changes through the year, the amount of sunlight falling on a fixed solar panel will change

Based on your graph and on the number of sunlight hours recorded at different times of the year (Table 2), discuss the advantage of sun-tracking to maximise solar energy production.

Student response, with reference to their previous answers and readings

Extension

Research the advantages and disadvantages of using solar power as the sole source of electricity generation.

Solar Energy – Teacher Notes

Explore ways in which issues can be overcome to enable solar power to become a viable option for large scale power initiatives.

References

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Curriculum links

Year 7 Science: Earth and space sciences

Some of Earth's resources are renewable, including water that cycles through the environment, but others are non-renewable (ACSSU116)