SI Environmental Science - Full Discipline Demo

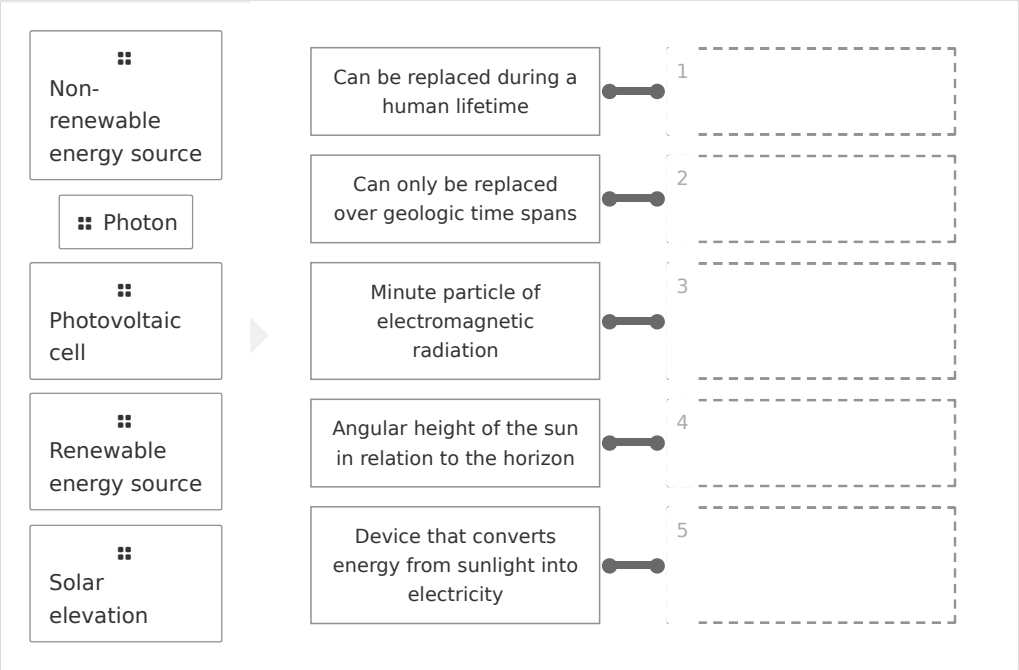
Renewable Solar Energy

Final Report - Answer Guide

Institution	Science Interactive University
Session	SI Environmental Science - Full Discipline Demo
Course	SI Environmental Science - Full Discipline Demo
Instructor	Sales SI Demo

Test Your Knowledge

Match each term with the best description.



Correct answers:

1 Renewable energy source 2 Non-renewable energy source 3 Photon

4 Solar elevation 5 Photovoltaic cell

Identify each statement as true or false.

Maximum power is generated when solar panels are pointed directly at the sun such that the panel surface is perpendicular to incoming light rays.

Solar elevation is at its maximum during the summer because the tilt of earth is facing the sun.

Solar panels should be tilted toward the south in the Southern Hemisphere and tilted toward the north in the Northern Hemisphere.

Stationary solar panels should be tilted toward the sun at the angle matching the location's longitude to maximize annual efficiency.

True	False
1	2

Correct answers:

1

Maximum power is generated when solar panels are pointed directly at the sun such that the panel surface is perpendicular to incoming light rays.

Solar elevation is at its maximum during the summer because the tilt of earth is facing the sun.

2

Stationary solar panels should be tilted toward the sun at the angle matching the location's longitude to maximize annual efficiency.

Solar panels should be tilted toward the south in the Southern Hemisphere and tilted toward the north in the Northern Hemisphere.

Exploration

Renewable energy sources can be replaced during a human lifespan and include _____ energy.

- hydropower
- solar
- wind
- All of the above ✔

The solar energy that the earth receives in a single year is in excess of the global reserves of coal, oil, and natural gas.

- True ✔
- False

When the sun is directly overhead, the solar elevation is _____ at latitudes near the equator.

- 0°
- 45°
- 90° ✔
- 23.5°

Electrons flow from the n-layer up to the p-layer in a photovoltaic cell.

- True ✔
- False

The angle of movable solar panels should be decreased in relation to the ground during winter.

- True
- False ✔

Exercise 1

How does a photovoltaic cell like the one used in this exercise generate electricity?

When the photovoltaic cell is placed in sunlight, photons are absorbed by the p-layer. Once absorbed in sufficient quantities, photons provide energy to free electrons in the conducting material, causing them to become excited. The excited electrons then move through the conducting layers and into the circuit, creating electric current.

Which tilt angle for the photovoltaic cell used in this exercise produced the most power? How does that angle correspond to the solar elevation recorded for the date, time, and location where you conducted the procedures? Reference Data Table 1 and Data Table 2 in your answer.

The tilt angle of 15^{o} resulted in 0.07 W of power from the photovoltaic cell as recorded in Data Table 2. This relates favorably to the solar elevation of 73^{o} for the time and location of the measurements as recorded in Data Table 1, since the ideal tilt angle to maximize output should be 90^{o} - 73^{o} =17^{o}.

Describe the orientation and tilt angle you would use when installing a fixed position (non-movable) solar array at the location where you performed this exercise. Reference Data Table 1 in your answer.

The solar array should be oriented toward the south since the recorded location in Data Table 1 is in the Northern Hemisphere. The stationary solar panels that make up the solar array should be tilted toward the sun at the angle matching the location's latitude to maximize annual efficiency. This angle would be 39.6^{o} as recorded in Data Table 1.

Data Table 1: Measurement Time, Date, Latitude, and Solar Elevation
(SAMPLE ANSWER BELOW)

Time (24hr)	Date	Latitude (°)	Solar Elevation (°)

Instructor note: Student answers will vary based on their location. Answers in data tables are reported for Denver, CO.11:50	6-14-2019	39.6467	73

Data Table 2: Photovoltaic Cell Output by Tilt Angle
(SAMPLE ANSWER BELOW)

	Cell angle 0°	Cell angle 15°	Cell angle 30°	Cell angle 45°	Cell angle 60°	Cell angle 75°	Cell angle 90°
Voltage	0.57	0.55	0.54	0.54	0.53	0.52	0.50
Amperage	0.105	0.127	0.0995	0.0715	0.0494	0.0485	0.0257
Wattage	0.059	0.070	0.054	0.039	0.026	0.025	0.013

Competency Review

_____ energy is the most prevalent renewable resource on earth.

- Coal
- Nuclear
- Solar ✔
- Natural gas

Solar energy arrives on earth in the form of light waves consisting of _____, minute particles of electromagnetic radiation.

- electrons
- photons ✔
- silicon
- helium

Solar elevation is determined by _____.

- latitude
- season
- time of day
- All of the above ✔

Conventional photovoltaic cells consist of two thin layers of silicon connected to a circuit.

- [x] True
- [ ] False

To increase power output above 1-2 watts, photovoltaic cells are combined in a weather-tight package called a solar _____.

- [ ] array
- [ ] cell
- [x] panel
- [ ] eclipse

Stationary solar panels should be tilted toward the sun at the angle matching the location's _____ to maximize annual efficiency.

- [ ] elevation
- [x] latitude
- [ ] longitude
- [ ] altitude

Movable solar panels should be adjusted 40^{o} between seasons to maximize efficiency.

- [ ] True
- [x] False

A digital multimeter can be used to measure the output of a photovoltaic cell.

- [x] True
- [ ] False

The power output of a photovoltaic cell generating 0.50 volts and 0.10 amps is _____ watts.

$$\text{Wattage} = \text{Voltage} \times \text{Amperage}$$

- [x] 0.05
- [ ] 0.1
- [ ] 5
- [ ] 10

A photovoltaic cell exposed to sunlight at a solar elevation of 70º in the Northern Hemisphere should be tilted to _____ to maximize power output.

Tilt angle = 90º - Solar elevation

- [x] 20° South
- [ ] 30° North
- [ ] 70° South
- [ ] 70° North

Extension Questions

The city of Quito, Ecuador, which sits at 0° latitude on the equator, has contracted an engineering firm to develop a municipal solar installation for providing power to the city. Describe the type (stationary or movable) of panels and positioning of the panels that the engineering firm should recommend to generate maximum power output.

(SAMPLE ANSWER BELOW)

Movable solar panels should be used to maximize power output. The panels should be mounted horizontally at 0^{O} to match the latitude of the installation site. The panels should be tilted towards the north during the summer months for the Northern Hemisphere to a maximum of 23.5° on the summer solstice. The panels should then be returned to 0° coinciding with the fall equinox. Similarly, the panels should be tilted towards the south for the summer months for the Southern Hemisphere to a maximum of 23.5° for the summer solstice. Again, the panels should be returned to 0° coinciding with the spring equinox.