

Triangle Game

Student Objective

The student

- will explain in their own words the meaning of fundamental terms and concepts in electronics and solar energy
- will connect and apply electronic and solar energy terms or concepts to other related terms.

Materials:

- Triangle game board
- instructions
- playing pieces
- tape

Key Words:

(Key words depend on game vocabulary used. Below are the key words used in this solar energy version)

amperage	phase change
array	photon
azimuth	photovoltaic
capillary water	photovoltaic cell
conduction	pyranometer
convection	radiation
desalinization	STC (standard test conditions)
direct current	series circuit
efficiency	solar collector
electromagnetic spectrum	solar window
external costs	solar incidence
frequency	solar irradiance
galvanic cell	solar noon
hertz	solar still
I-V curve	speed of light
infrared waves	thermal conductivity
maximum power point	thermal energy
NO _x	transverse waves
Ohm's law	volatile organic compounds
parallel circuit	voltage
peak irradiance	watt
peak sun hours	

Time:

1 hour

Procedure (prior to class):

1. Cut out game pieces.
2. Print out Key Words/Definitions page.
3. The game board may be enlarged or laminated, if desired.

Procedure (in class)

1. Assign students to small groups.
2. Distribute a triangle game board and game pieces to each group.
3. Place the terms at the front of the class for the teams to refer to if there are disputed answers.
4. Discuss the rules of the game with the class and demonstrate a completed triangle using non-technical solar energy terms.
5. Allow 30-40 minutes for game time.

Key Words & Definitions

Key Words will vary depending on the vocabulary used. Below are the key words/definitions for the solar energy game pieces included in this unit.

- **ampere (amp)** – a unit of electrical current or rate of flow of electrons. One volt across one ohm of resistance causes a current flow of one ampere. One ampere is equal to 6.25×10^{18} electrons per second passing a given point in a circuit. The symbol for amps is I.
- **array** – a mechanically integrated assembly of modules or panels together with support structure to form a unit that produces DC power
- **azimuth** – the angular measure, which in the northern hemisphere is between due south and the point on the horizon directly below the Sun
- **capillary water** – the thin film of water that coats the soil particles even in the driest soil
- **conduction** – the movement of heat through materials by transferring kinetic energy directly from particle to particle
- **convection** – the circulatory movement or transfer of heat through fluids such as gasses or liquids due to differences in temperature (less dense, hotter fluids rise and cooler fluids, being more dense, sink)
- **desalinization** – process of removing salt and other chemicals and minerals from water
- **direct current (DC)** – a one way flow of electric current, from positive to negative.
- **efficiency** – the ratio of output compared to input of a device
- **electromagnetic spectrum** – the full range of frequencies, from radio waves to gamma rays, that characterizes light
- **external costs** – a cost or benefit other than those involved in the activity that produced it. For example, the pollution caused by using gasoline for transportation which isn't included in the price of gas.
- **frequency** – a property of a wave that describes how many wave patterns or cycles pass by in a period of time. Frequency is often measured in units called Hertz (Hz), where a wave with a frequency of 1 Hz will pass a point at 1 cycle per second.
- **galvanic cell** – a device that can change chemical energy into electrical energy
- **hertz** – the derived SI (international standard) unit of frequency, defined as a frequency of 1 cycle per second
- **I-V curve** – the plot of electrical output (voltage and current) characteristics of a photovoltaic cell or module at a particular temperature and irradiance
- **infrared waves** – electromagnetic radiation with wavelengths and frequencies between those of microwaves and visible light (wavelength ranges from 1 mm to 1000 μm). Some

of the Sun's infrared waves reach the Earth's surface but most are absorbed by the greenhouse gases in the atmosphere.

- **maximum power point (P_{mp})** – the point where the product of current and voltage is at maximum power
- **NO_x** – oxides of nitrogen, especially as atmospheric pollutants
- **Ohm's Law** – the current in a circuit is directly proportional to the voltage across the circuit, and inversely proportional to the total resistance of the circuit

$$I = V / R$$

$$V = I \times R$$

$$R = V / I$$

By substituting the equation for power ($P = V \times I$), variations in Ohm's law can also be expressed as follows:

$$P = I^2 \times R$$

$$P = V^2/R$$

- **parallel circuit** – a type of electrical circuit in which each device provides two or more separate paths or connections for the current to travel
- **peak irradiance** – standard peak sunlight condition, $1kW/m^2$
- **peak sun hours** – the equivalent number of hours at peak sun conditions ($1kW/m^2$) that produces the same total insolation as actual sun conditions
- **photon** – a tiny particle or bundle of radiant energy
- **photovoltaic** – a device that generates electricity when exposed to light
- **photovoltaic cell** – the smallest, basic photovoltaic device that generates electricity when exposed to light. Cells can range in size from microscopic to 8 inches square.
- **pyranometer** – a device to measure the amount of solar irradiance
- **radiation** – the way we receive heat from the Sun each day. The energy is emitted in the form of waves or photons (electromagnetic waves) and can be transferred through the vacuum of space.
- **STC (standard test conditions)** – the standard reference environment for photovoltaic cell operation is an environment of $1000W/m^2$ irradiance, 1.5 air mass, and cell temperature of $20^\circ C$
- **series circuit** – a type of electrical circuit in which all the current travels on a single line or path through each device or resistor in the circuit
- **solar collector** – a device used to collect energy from the Sun
- **solar window** – the critical area of the Sun's path that should be free of obstructions for any solar collector. This area is defined on top and bottom by the Sun's path in the summer and in the winter, and in the east and west by the Sun's position three hours before solar noon and three hours after solar noon.
- **solar incidence** – the angle that the Sun's rays strike the Earth in relation to surface normal at a given longitude and latitude
- **solar irradiance** – the measure of the power density of sunlight. Expressed in watts per square meter. The solar constant for Earth is the irradiance received by the earth from the sun, $1367 W/m^2$ at the top of the atmosphere, and $\approx 1000 w/m^2$ after passing perpendicularly through the atmosphere.
- **solar noon** – the time of day when the Sun is at its highest point in the sky. At this time

- in the northern hemisphere, the Sun's shadow will point directly north.
- **solar still** – a device that uses solar energy to evaporate a liquid
 - **speed of light** – 299,792,458 meters per second or 3.0×10^8 m/s
 - **thermal conductivity** – the measure of a substance's ability to conduct heat. The higher the value, the more conductive the substance.
 - **thermal energy** – internal energy; sum of kinetic and potential energy of random motion of particles making up the object. Commonly known as "heat"; its symbol is Q.
 - **transverse waves** – waves such as light waves that can transfer energy at the speed of light in a vacuum without a medium
 - **volatile organic compounds (VOC)** – a compound of carbon which participates in atmospheric photochemical reactions, and can create photochemical smog under certain conditions
 - **voltage** – a measure of the force or "push" given the electrons in an electrical circuit; a measure of electric potential. One volt produces one amp of current when acting against a resistance of one ohm. The symbol for voltage is V.
 - **watt** – a measure of electrical power or amount of work done in a unit of time. One amp of current flowing at a potential of one volt produces one watt of power.

Internet Sites

<http://www.wordcentral.com/>

Merriam Webster, Word Central student dictionary

Understanding Solar Energy Florida and National Standards Next Generation Science & Common Core

Triangle Game

The Sunshine State Standards will vary according to vocabulary used. Below are the benchmarks covered by using the solar energy key words included with this activity.

Florida NGSS Standards & Related Subject Common Core

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Earth and Space																						
Standard 5	SC.912.E.5.				X				X													
Standard 6	SC.912.E.6.						X															
Physical Science																						
Standard 10	SC.912.P.10.	X			X										X	X						
Language Arts Standards		Grades 9 & 10: LAFS.910.L.3.6 Grades 11 & 12: LAFS.1112.L.3.6																				

Science–Standard 5: Earth in Space and Time

- SC.912.E.5.4 - Explain the physical properties of the Sun and its dynamic nature and connect them to conditions and events on Earth.
- SC.912.E.5.8 - Connect the concepts of radiation and the electromagnetic spectrum to the use of historical and newly-developed observational tools.

Science–Standard 6: Earth Structures

- SC.912.E.6.6 - Analyze past, present, and potential future consequences to the environment resulting from various energy production technologies.

Science–Standard 10: Energy

- SC.912.P.10.1 - Differentiate among the various forms of energy and recognize that they can be transformed from one form to others.
- SC.912.P.10.4 - Describe heat as the energy transferred by convection, conduction, and radiation, and explain the connection of heat to change in temperature or state of matter.
- SC912.P.10.14 - Differentiate among conductors, semiconductors, and insulators.
- SC912.P.10.15 - Investigate and explain the relationships among current, voltage, resistance and power.

Language Arts–Language Standards

- LAFS.910.L.3.6 & LAFS.1112.L.3.6 - Acquire and use accurately general academic and domain-specific words and phrases, sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or

Triangle Game

Individual Player Version

The Object: To be the player with the most points at the end of the game.

The Set Up: Vocabulary playing pieces are turned face down on the playing surface. Each player writes their name on the back of the triangle game board.

The Play:

1. The first player randomly chooses a term, defines that term, and uses it in a sentence.
2. The player then attaches (with glue or tape) the term to any triangle segment on the game board.
3. The next player randomly chooses a term, defines the term and uses it in a sentence. If the player is able to explain the relationship between his/her term and another term already on the board, the playing piece is placed on another segment of that same triangle. If the player cannot demonstrate a relationship with any of the other terms on the game board they must attach their term to a segment on an open triangle.
4. Play continues with terms being attached to the game board.
5. When a player is able to complete a triangle by explaining a relationship between their term and the other two terms on the other segments of a triangle, they initial the completed triangle and receive a game point.

Challenges:

1. If a player believes that the definition or the relationship that was just stated by another player is incorrect, they call “challenge”, and state what they believe to be the correct definition and/or relationship between terms.
2. The game play stops, while the players verify the definition and/or relationship.
3. If the original player is correct, the original player receives the point or play as usual, and the challenger loses their next turn.
4. If the challenger is correct, they get the play or point, and an additional turn when the gameplay comes around to them for their next turn.
5. If necessary, the instructor will settle any disagreements over definitions and/or relationships.

The Winner: When the time allotted for play is complete, the player with the most game points (completed triangles) wins.

Team Version

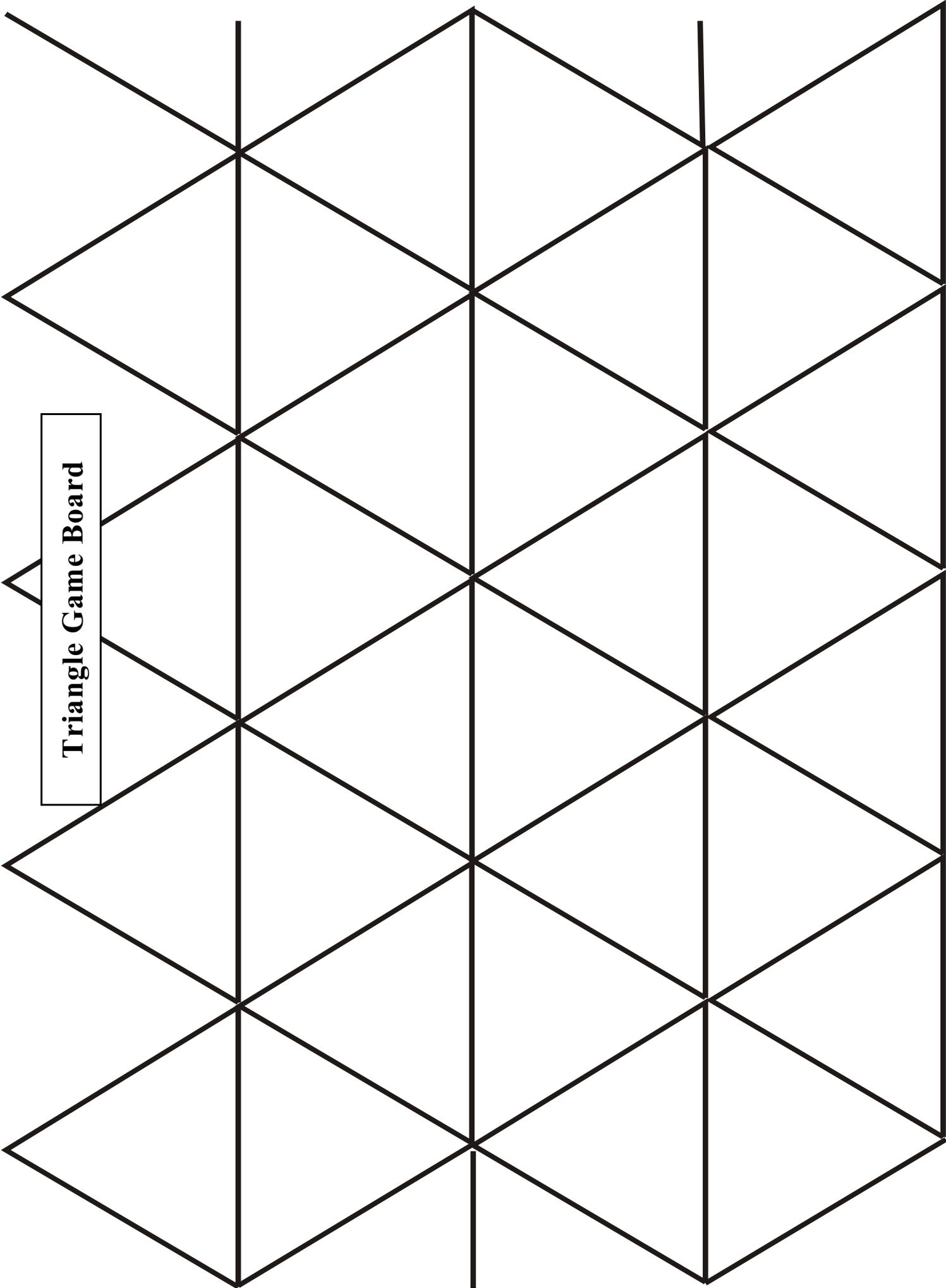
The Object: To be the team with the most completed triangles at the end of the game.

The Set Up: Same as Individual Player Version

The Play: The same as Individual Player Version, except that cooperation between team members is encouraged and players do not put their initials in completed triangles.

The Winner: When the time allotted for play is complete, the team with the most completed triangles wins.

Triangle Game Board



Triangle Game

electromagnetic spectrum

watt

frequency

amperage

photon

direct current

transverse waves

I-V curve

speed of light

azimuth

thermal energy

solar incidence

radiation

peak irradiance

convection

photovoltaic

conduction

parallel circuit

solar irradiance

series circuit

voltage

external costs

NO_x

maximum power point

solar collector

solar noon

thermal conductivity

Ohm's law

hertz

insolation meter

infrared waves

array

ultraviolet light

peak sun hours

desalinization

STC (standard test conditions)

solar still

solar window

phase change

volatile organic compound

capillary water

galvanic cell

efficiency

photovoltaic cell

