K-W-L

Student Objectives
The student:
- will list what they have learned about solar energy
- will understand how knowledge of a subject creates further questions.

Materials:
- 4 sheets of large paper, flip chart size
- marker
- Science Journal

Key Words:
electromagnetic spectrum
photovoltaic
radiation
solar energy
solar thermal

Time:
½ hour each discussion (beginning and end of unit)

Background Information
Our Sun
- Our Sun is a medium-sized yellow star. It is a main sequence star sometimes referred to as a yellow dwarf.
- The Earth is 93,000,000 miles away from the Sun.
- If you were to drive a car from the Earth to the Sun at 70 miles per hour it would take you 151 years to reach the Sun.
- It would take about 109 Earths lined up end to end, to equal the diameter of the Sun.
- The Sun is expected to burn out in another 4.5 to 7 billion years.
- It takes approximately 8 minutes for sunlight to reach Earth.
- The Sun is the center of our solar system. All of the planets orbit the Sun. .
- Without the Sun, life would not exist on our planet.
- If you were to draw the Sun on the board one meter in diameter, the Earth you would draw would be approximately one centimeter in diameter.
- Sunlight intensity varies in different places around the world. It is affected by latitude, altitude, and seasons.
- Sun blockers can prevent the Sun's rays from reaching the Earth. They include clouds, wind, and pollution.
- The energy from sunlight can be transformed to electricity by photovoltaic cells and this energy can be stored in batteries.
- The Sun is a giant ball of gas, mostly hydrogen and helium.
- In a series of reactions in the Sun, atoms of hydrogen are fused into helium atoms. The loss of atomic matter (photons) is radiated into space and hits the Earth, providing light and heat.

Solar Energy

The Sun is the ultimate source of all energy on Earth. Even our fossil fuels were created by solar energy thousands of years ago. In general, solar energy can be grouped into eight types: photosynthesis, wind energy, hydroelectric power, ocean energy, passive solar heating, active solar heating, and photovoltaics.

Solar energy is using the energy radiated by the chemical reactions of our Sun for heat and electricity. During the nuclear fusion process in our Sun, four hydrogen atoms combine to form one helium atom with a release of matter that is emitted and travels outward from the Sun as radiant energy. The unit of measure for this energy is the *photon*. It takes these photons of energy a little under eight minutes to travel to Earth. There is so much energy radiating from our Sun that it produces more energy in one second than the Earth has used since time began.

Of the total energy from the Sun that reaches the Earth, about 30% is immediately bounced back into space by the atmosphere. 45% of the energy is absorbed in the form of heat by the atmosphere, land masses, and oceans. Almost 23% operates the water cycle, about 1% is used in air and ocean circulation, and less than 1% is used by plants.

Sunlight provides energy to plants through **photosynthesis**. This energy is recoverable through burning of wood and fossil fuels such as coal, petroleum, and natural gas which were created through the process of photosynthesis. Photosynthesis is also the basis of all food energy; our food chain on Earth begins with the Sun.

Sunlight heating the ground and the lower atmosphere produces wind which powers wind turbines. **Wind power** has the potential to become a very significant alternative fuel in many areas of the world.

Sunlight stored as the gravitational energy of water through the water cycle can be extracted with dams and electric generators. **Hydroelectric power** is renewable and considered a "clean" energy since no burning is required, but it is limited in quantity.

Ocean Energy - The use of the ocean tides has been harnessed to make electricity along with a variety of other methods which make use of the motions and thermal gradients in the ocean. A heat engine can derive useful energy through the use of the temperature difference between the sun-warmed surface layers of the ocean and the colder depths, in a process called ocean thermal energy conversion (OTEC). This technology is complex, therefore at this time the use of the tremendous amount of stored energy in the ocean thermal gradients is limited.

Solar thermal (active solar heating) uses the energy of the Sun to make heat; at the present time, solar thermal is mainly used to heat water for domestic and industrial use; however, it has also been used experimentally to create steam from a liquid that can then be turned into electricity with a turbine. **Photovoltaic** refers to the process of turning the energy of the Sun directly into electricity. Photovoltaic cells (commonly called solar cells) are made from silicon that undergoes a chemical process to add electrons and increase its instability, then the silicon mixture is allowed to form crystals from which the photovoltaic cells are made. Electricity is produced when a photon of light energy strikes the solar cell, causing the electrons to flow. The action of the electrons starts an electric current. This conversion of sunlight to electricity happens silently and instantly with no moving parts to wear out and no depletion of resources.

Documented use of passive solar thermal dates back at least to ancient Greek and Roman times, and recent research indicates that they also used glass as a passive solar thermal collector. However, photovoltaic technology is relatively new; as a viable energy source, it is only 65 years old.

Solar energy has great potential now and for the future. As a source of energy, sunlight is free, its supplies are unlimited and it is available in the majority of areas of the world. However, at this time having to pay for electricity "up front" instead of monthly (through monthly utility billing), and the public opinion that photovoltaic electricity is more expensive than traditional produced electricity, is limiting its use. This is expected to change as photovoltaics become more widespread, and new ways of financing are promoted.

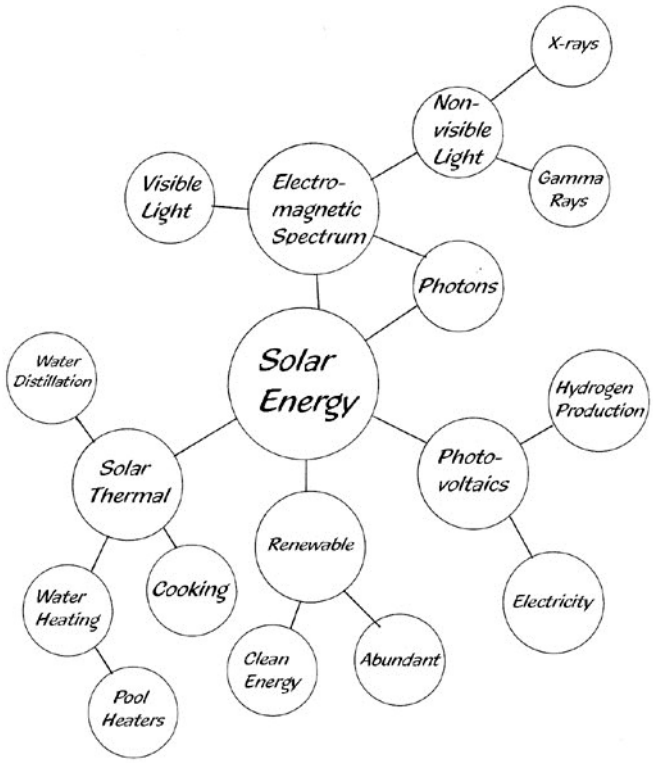
Procedure (Introductory Lesson)

1. Title two sheets of paper *Solar Energy* (the other two sheets will be used on the follow-up day).
2. Under the title, label one sheet, **K** - Things I know about solar energy, and the other sheet, **W** - Things I want to find out about solar energy.
3. Give the students a few minutes to answer questions 1 and 2 in their Science Journals.
4. Lead a brainstorming session with the class to fill in the first sheet. Write all of the information offered by the students. It is very important to use the words stated by the children or to ask permission to paraphrase. If they give false information, refrain from correcting them!
5. Then, ask the students what they would like to learn about solar energy. Use their questions to fill in the second sheet.
6. Save the K-W-L sheets for the follow-up lesson at the end of the unit.
7. Show the Ted Talks video, *A Guide to the Energy of the Earth* (by Joshua Sneideman), **https://www.youtube.com/watch?v=fHztd6k5ZXY** and explain to them that this video touchs on the concepts and ideas that they will be exploring during this unit on solar energy.
8. If time permits, ask the students if there are any items they would like to add to the **W**s that they previously listed.

Procedure (Follow-up Lesson–to be used at the end of the unit)

1. Hang the K and W sheets from the first lesson.
2. Hang the third sheet and title it *Solar Energy* and under the title, label it **L** - Things I learned about solar energy.
3. Lead a brainstorming session with the class to fill in the last sheet. Refer back to the first two sheets and make sure the items listed in the second column have either been answered, or the students know where they could go to find their answers. At this time they should also revise any misconceptions that they had at the beginning of the unit.
4. Have the students help you create a concept map on the board. Write Solar Energy in the center circle. If the students are unfamiliar with concept mapping, you may want to write a few more concepts and their connections to get them started. Invite students to come up to the board, a few at a time to add to the concept map. For each concept that a student adds, they should draw arrows to any of the other concepts that form a cause and effect relationship. The object is for the class to create a large and interconnected web.

Concept Map example:



Encourage students to use large concepts/classifications (photovoltaics, renewable energy), specific uses (pool heaters, electricity generation), drawbacks/benefits (high cost, no pollution), as well as scientific concepts (radiation, convection, conduction, electromagnetic spectrum etc.).

5. On the fourth sheet of paper write the title *Further Study*
6. Explain to students how scientific study spawns new questions of inquiry. Brainstorm with the students what new questions they now have about solar energy. Write these on the *Further Study* sheet.
7. If time permits, show the Ted Talks video from the beginning lesson again. This time they should be familiar with the concepts and connections discussed.
8. Students should complete questions 3 and 4 in their Science Journal.

Key Words & Definitions

- **electromagnetic spectrum –** the radiant energy that is emitted from the sun which is made up of varying wavelengths. From longest to shortest, these are: radio waves, radar/microwave, infrared, visible light, ultraviolet, x-rays and gamma rays**.**
- **photovoltaic (PV)** – the effect of producing electric current using light
  "photo": light
  "voltaic": relating to electricity (volt)
- **radiation** – the way we receive heat from the sun each day. The energy is emitted in the form of waves/particles, and can move from one object to another without heating the area in between.
- **solar energy** – energy derived from the Sun

- **solar thermal** – using the Sun's energy to heat something. Common uses include water heaters and pool heaters**.**

Related Research

1. Divide class into groups of 2 - 4 students per group. Give each group a piece of poster board or a large sheet of paper divided into quarters. On the top of each section the team writes one of the "W" questions (these could either be assigned or chosen by the groups). The group's job is to investigate this question throughout the unit and record the answers they discover. These could be written, drawn, or made in a collage format. At the end of the unit have the groups present their answers to the rest of the class.
2. After the follow-up, assign Further Study questions to groups of students to research and report to the class.

Related Reading

- ***A Look at the Sun*** by Ray Spangenburg & Kit Moser (Franklin Watts, 2002)
  This detailed yet accessible book unravels the scientific wonders of the Sun—including nuclear fusion, fiery solar prominences shooting into space and the sprinkling of dark spots on its surface.
- ***The Sun*** by Steele Hill (Abrams, 2006)
  Awe inspiring images taken from satellites, observatories and photographers.

Internet Sites

https://www.youtube.com/watch?v=fHztd6k5ZXY
Ted Ed video, *A Guide to the Energy of the Earth* by Joshua Sneideman, is a good introduction to the different energy systems on the Earth that come from the Sun.

http://sunearthday.nasa.gov/spaceweather/#
NASA daily Sun image

https://video.nationalgeographic.com/video/101-videos/sun-101
National Geographic video, Sun 101

http://www.neok12.com/Sun.htm
Neo K-12 Education. A good site for teachers that has quizzes, games, presentations, links to videos and lessons about the Sun.

http://solar-center.stanford.EDU/FAQ
Stanford University's Solar Center answers frequently asked questions about the sun and solar energy. Included are facts on myths and history, facts about the gravitational sun, magnetic sun, and solar evolution.

K-W-L

Florida NGSS Standards & Related Subject Common Core

			.1	.2	.3	.4	.5	.6	.7	.8	.9	.10	.11	.12
Grade 6														
Earth Systems & Patterns	**# 7**	**SC.6.E.7**					**X**			**X**				
Grade 7														
Forms of Energy	**# 10**	**SC.7.P.10**	**X**											
Grade 8														
Characteristics of Science Knowledge	**# 2**	**SC.8.N.2**	**X**											
Earth in Space & Time	**# 5**	**SC.8.E.5**	**X**				**X**	**X**	**X**		**X**		**X**	
Language Arts Standards	**Sixth Grade:** LAFS.6.SL.1.1 **Seventh Grade:** LAFS.7.SL.1.1 **Eighth Grade:** LAFS.8.SL.1.1													

Sixth Grade Benchmarks

Science–Big Idea 7: Earth Systems and Patterns

- SC.6.E.7.5 - Explain how energy provided by the Sun influences global patterns of atmospheric movement and the temperature differences between air, water, and land.
- SC.6.E.7.8 - Describe ways human beings protect themselves from hazardous weather and sun exposure.

Language Arts–Standards for Speaking & Listening

- LAFS.6.SL.1.1 - Engage effectively in a range of collaborative discussions with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly.

Seventh Grade Benchmarks

Science–Big Idea 10: Forms of Energy

- SC.7.P.10.1 - Illustrate that the Sun's energy arrives as radiation with a wide range of wavelengths, including infrared, visible, and ultraviolet, and that white light is made up of a spectrum of many different colors.

Language Arts–Standards for Speaking & Listening

- LAFS.7.SL.1.1 - Engage effectively in a range of collaborative discussions with diverse partners on grade 7 topics, texts, and issues, building on others' ideas and expressing their

own clearly.

Eighth Grade Benchmarks

Science–Big Idea 2: The Characteristics of Scientific Knowledge

- Distinguish between scientific and pseudoscientific ideas.

Science–Big Idea 5: Earth in Space and Time

- SC.8.E.5.1 - Recognize that there are enormous distances between objects in space and apply our knowledge of light and space travel to understand this distance.
- SC.8.E.5.5 - Describe and classify specific physical properties of stars: apparent magnitude (brightness), temperature (color), size, and luminosity (absolute brightness)
- SC.8.E.5.6 - Create models of solar properties including: rotation, structure of the Sun, convection, sunspots, solar flares, and prominences.
- SC.8.E.5.7 - Compare and contrast the properties of objects in the Solar System including the Sun, planets, and moons to those of Earth, such as gravitational force, distance from the Sun, speed, movement, temperature, and atmospheric conditions.
- SC.8.E.5.9 - Explain the impact of objects in space on each other including: 1) the Sun on the Earth including seasons and gravitational attraction, 2) the Moon on the Earth, including phases, tides, and eclipses, and the relative position of each body.
- SC.8.E.5.11 - Identify and compare characteristics of the electromagnetic spectrum such as wavelength, frequency, use, and hazards and recognize its application to an understanding of planetary images and satellite photographs.

Language Arts–Standards for Speaking & Listening

- LAFS.8.SL.1.1 - Engage effectively in a range of collaborative discussions with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly.

National Next Generation Science Standards - Sixth to Eighth Grade Standards

Science–Earth and Human Activity

- MS-ESS3-4 - Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.
- MS-ESS3-5 - Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

Note: Related Common Core Language Arts Standards are listed in the Florida section above.

K-W-L

1. List below the things you know about solar energy.

2. List below the things you would like to find out about solar energy.

Follow-up K-W-L

3. List below some of the things you learned about solar energy.

4. List below some of the new questions you have about solar energy.