Energy Resources:
Where Are They and How Do We Get Them?

SPN LESSON #5

TEACHER INFORMATION

LEARNING OUTCOME: Students describe some of the many ways solar energy is converted into other forms of energy; the patterns of distribution of energy resources in the United States; and how these patterns of distribution are represented through maps.

LESSON OVERVIEW: In this lesson, emphasis is on the development of interpretive skills and the use of models to reveal scientific processes. Students learn the nature of various energy resources, how they form, and the science that allows them to be discovered and extracted. Through short laboratory tasks at a series of stations, and through pencil-and-paper activities, solar, wind, water, and fossil fuel (coal) energy sources are explored. The lesson includes study of:

- field maps and isolines and the information they convey;
- energy conversions of sunlight into other forms of energy;
- subsurface rock structures; and
- why energy resources are unevenly distributed.

GRADE-LEVEL APPROPRIATENESS: This Level II general energy lesson, intended for younger students, is most appropriate for grades 5–8.

MATERIALS **(materials needed at each station)**

Station 1: Coal Power
Hand lenses (4)
Rock specimens:

- Silty shale with marine fossils [label "A"]
- Limestone with marine fossils [label "D"]
- Coal – bituminous with land plant fossils [label "B"]
- Sandy shale with land plant fossils [label "A"]
- Sandstone with land plant fossils [label "E"]

Colored pencils

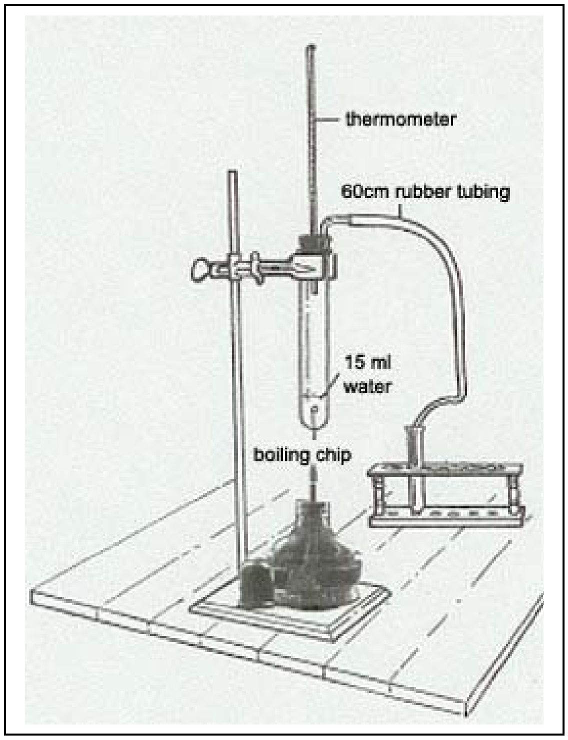
Station 2: Wind Power
Safety goggles
Alcohol burner
Lighter
400 mL Pyrex beaker
Burner tripod ring stand
5” x 5” wire gauze
Crystals of copper (II) nitrate (or other water-soluble crystal that will color water)
Colored pencils: yellow, light blue

Station 3: Solar Power

- Colored pencils: red, yellow, green, blue
- Computer terminal

Station 4: Water Power

- Safety goggles
- Alcohol burner
- Ring stand with utility clamp
- Test-tube rack
- Large test tube
- Small test tube
- Boiling chip
- 2-hole stopper
- 10-cm glass tubing
- Thermometer
- 15 mL of water
- Graduated cylinder
- 60-cm rubber tubing



SAFETY
The wind power and waterpower worksheets (stations 2 and 4) involve using alcohol burners to heat liquids. Safety goggles are required. Caution students on the handling of hot laboratory equipment and materials.

TEACHING THE LESSON
This lesson includes a series of five worksheets. The first worksheet provides an introduction to the lesson. The last four worksheets are designed for use at independent “stations” to which students will move at the teacher’s direction. Each station, 1–4, involves some sort of map work as well as a simple laboratory task. You may choose to approach the lessons in a variety of ways, depending on your classroom management style. The worksheets might also stand alone as independent lessons. Students should be expected to develop initial responses for the questions posed on worksheets for each

station. Clarification during post-lab discussions should lead to each student's improving and elaborating on original thoughts.

Introduction

This worksheet is an introductory homework or class work activity to encourage students to think about the various aspects of solar energy. You might want to hold off on discussing students' responses until after the completion of the station worksheets. Or, you might want to conduct a brief discussion now and then come back to this worksheet after discussing the other worksheets to see if students' original responses have changed. A general review of **isolines** and **timelines** would be helpful before students proceed to the individual stations.

Station 1: Coal Power

You may add samples of igneous, metamorphic, and sedimentary rocks for students to look at and contrast during the introductory section of this activity. A geologic timeline is provided in the Background Information for Teachers section to share with students to enhance their understanding of the surface bedrock map. Encourage students to use their logic skills while completing the laboratory portion of the worksheets. Feel free to provide descriptive sedimentary rock information as additional scaffolding.

Station 2: Wind Power

Make sure students are wearing eye protection before they begin the lab portion for this station.

Station 3: Solar Power

Station 4: Water Power

Make sure students are wearing eye protection before they begin the lab portion for this station.

ACCEPTABLE RESPONSES FOR DEVELOP YOUR UNDERSTANDING SECTION

Introduction

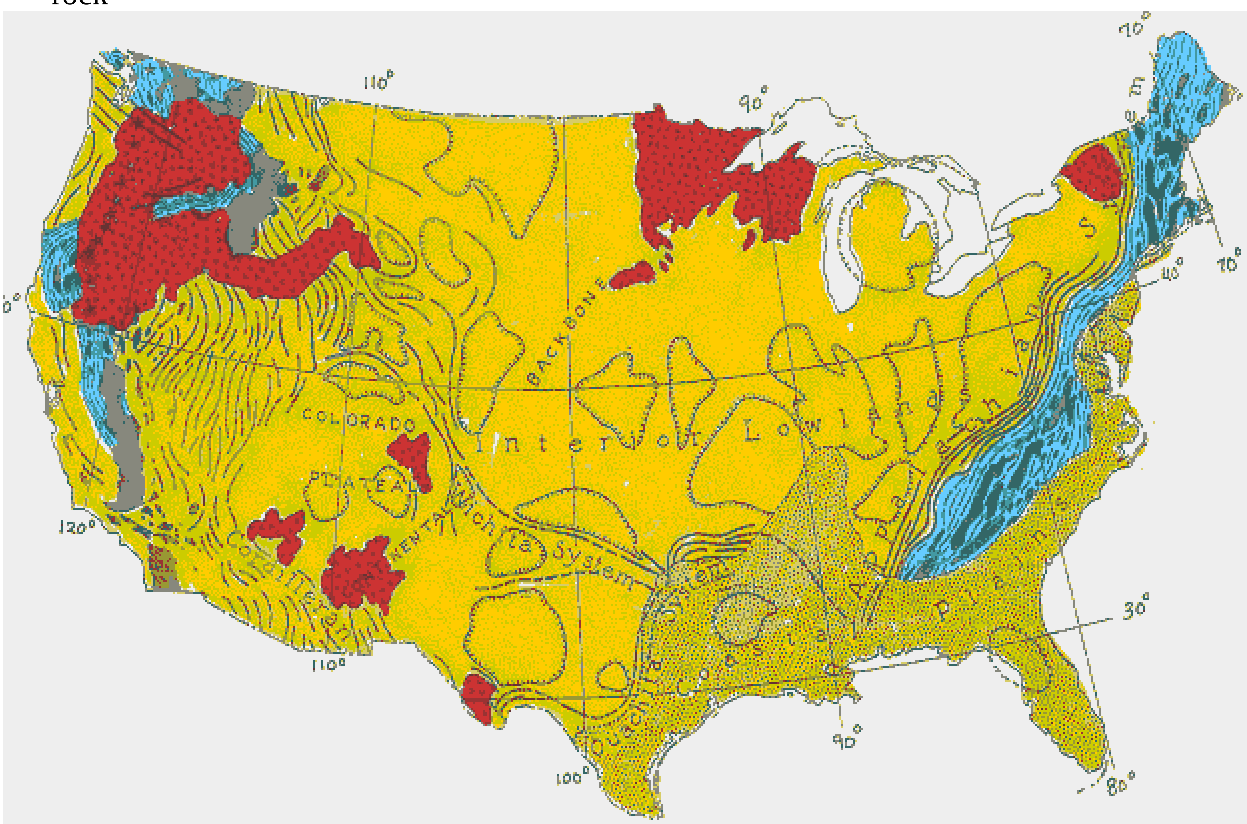
1. The Sun
2. It is a large natural nuclear reactor.
3. Objects around us, our clothes, and our bodies absorb the light and convert it into heat.
4. Directly using photovoltaic cells; or by burning fuels that contain energy from the Sun converted into chemical bonding energy and using the released heat energy to drive generators
5. By heating Earth's surface differing amounts in adjacent areas , setting up convection and winds
6. A process occurring in green plants and other producers; this process uses sunlight to excite chlorophyll and convert carbon dioxide and water into sugar
7. Fuels are made from former living things that contain converted sunlight energy.

8. Photosynthesis traps the Sun’s energy in carbon compounds that eventually become the fossil fuels.
9. It evaporates water into the air, and this evaporated water eventually returns to Earth as rain. The rain runs off into rivers, and as the rivers flow downhill, they power machines.
10. A gradient is a slope or rate of change of some value over time or distance.
11. Yes, nuclear power and geothermal power

Station 1: Coal Power

1. Anthracite is confined to limited areas of Pennsylvania and Washington.
2. In the western half of the country

Map coloring: Red – igneous rock; yellow – sedimentary rock; blue – metamorphic rock



3. Sedimentary rock covers most of the surface of the United States.
4. Sedimentary rock
5. Sedimentary rock that has been folded by mountain building
6. In sedimentary rock
7. a. and b. River erosion, glacial erosion, or faulting might lift rocks on one side of the fault and drop the other side down, exposing hidden rock layers.
8. Answers will vary, but students should come up with something like the drawings shown for question 12.

9. Fossils of land-dwelling organisms are present. [Some students might know that sometimes land-deposited sediments are red in color as a result of the oxidized iron in the rocks.]
10. Recognizing the sequence above or below the coal bed might lead them to discover the coal.
11. Weathering would chemically and physically weaken the rocks exposed on the cliff face. Erosion driven by the force of gravity would pull the broken cliff-face rocks down to the Earth's surface at the bottom of the cliff.
12. A. This is a normal horizontal layer formed during deposition of sediments. Mining is made easier by having a level work surface along the bottom of the coal.

    B. The coal layer has been folded, most probably by compressional forces associated with crustal plate collision (the top of the fold has been eroded away, but it probably used to loop over the area occupied by the deciduous tree). Mining is made more difficult by the curving nature of the coal layer, but access to the coal layer is available at several points.

    C. The coal layer has been broken by a fault. The stretching of the Earth's crust near divergent plate boundaries is usually the cause of this type of fault. Mining becomes more expensive because the seam exposed in the cliff face disappears at the fault and has to be relocated. The fact that the hidden part of the seam is close to the surface means that coal might be accessed by strip mining, which is usually cheaper.

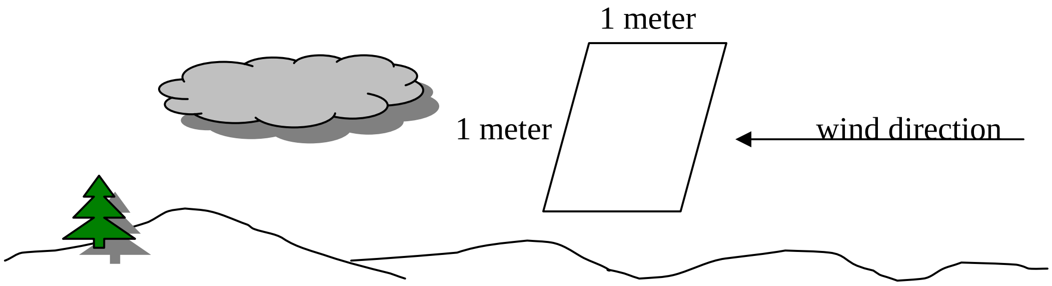
13. Provide students a rock identification guide if you can, but students should be able to use logic to make the identifications.

NAME OF ROCK	LETTER	EVIDENCE USED FOR ROCK IDENTIFICATION
Silty Shale (marine deposited)	C	Looks like A: dark with thin layers Contains marine fossils
Limestone (marine deposited)	D	Different from shale Contains marine fossils
Coal (land deposited)	B	Different from A or E Contains fossils of land plants
Sandy Shale (land deposited)	A	Looks like C Contains fossils of land plants/animals
Sandstone (land deposited)	E	Made up of SAND particles Contains fossils of land plants/animals

14. They had marine fossils in them.
15. Sandstone is made up of sand-sized particles.
16. Answers will vary. Two possible answers are "sedimentary rocks associated with coal deposits" and "characteristics of some sedimentary rocks found with coal."

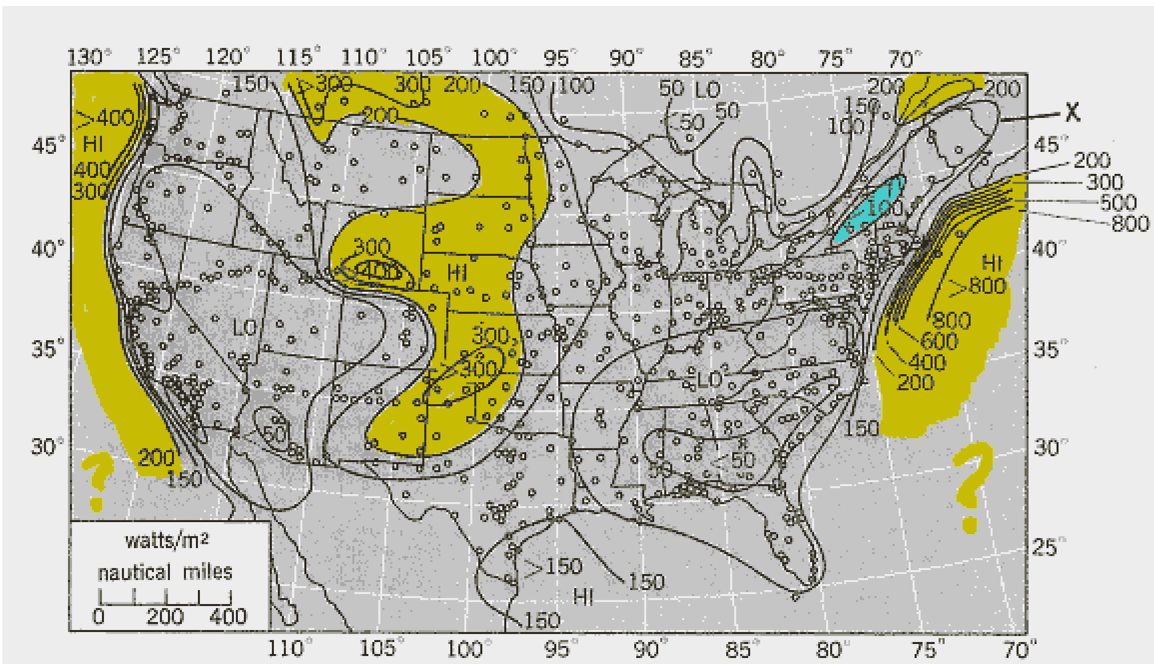
Station 2: Wind Power

1.



2. 150 watts / square meter

3. and 5.



4. a) Answers will vary according to location: values should be between 175 (on easternmost Long Island) to less than 100 in the blue-shaded area. b) Same answer as a).

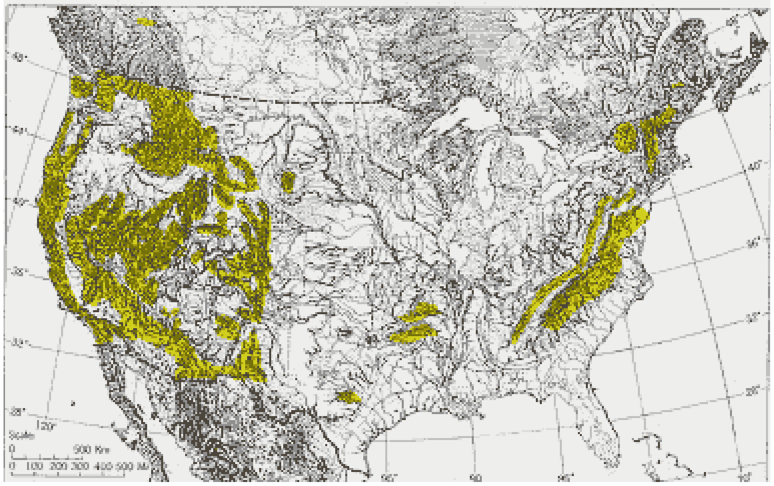
6. Answers will vary. Some correct assumptions include:

(1) In coastal areas and over the open ocean there are fewer objects like mountains and trees and buildings to block the wind.

(2) The central U.S. location is also flat and has few trees and buildings.

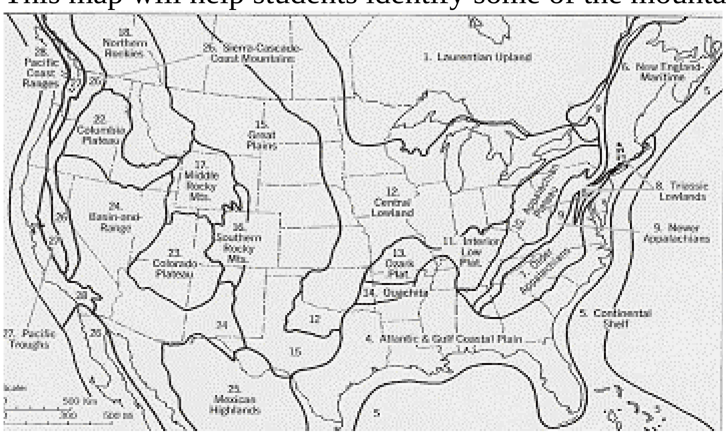
(3) The high wind area in southern Wyoming is a valley between surrounding mountains that funnel the wind into that valley.

7. Student answers will vary but should look something like this.

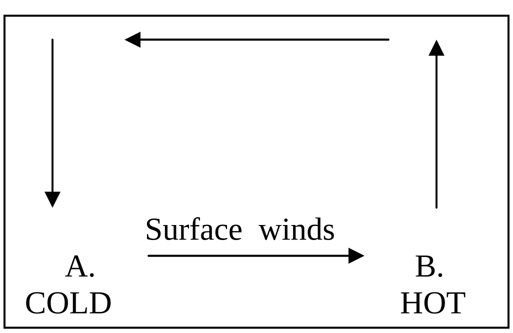


[above and below from Strahler, p. 676]

This map will help students identify some of the mountainous regions.



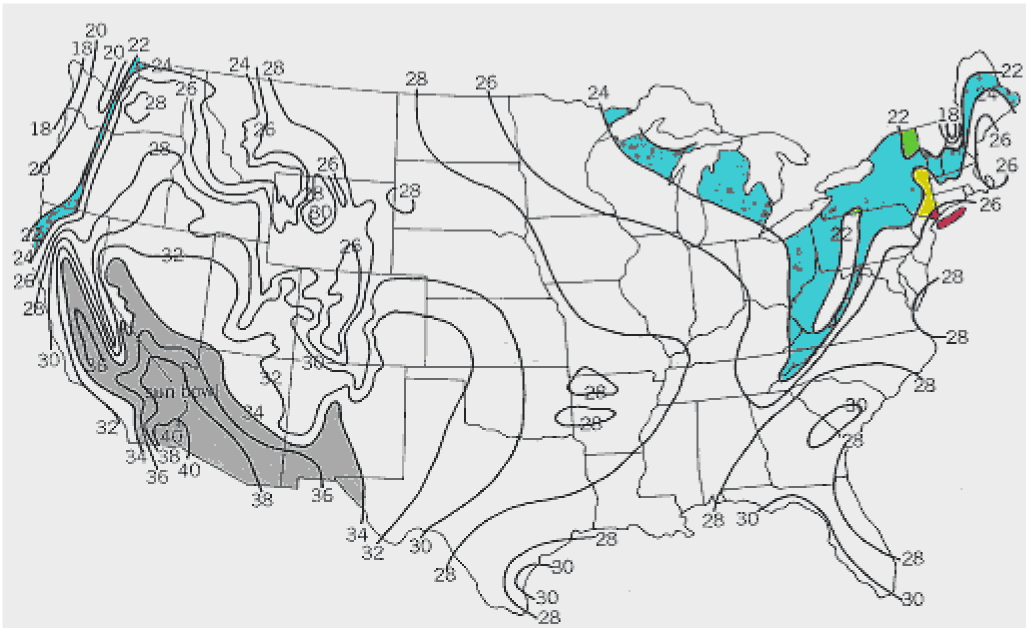
8. Open areas have higher winds closer to ground level.
9. It dissolves, and color streams into the water.
10. The color moves toward the heated area.
11. Student answers should be similar to that shown below.



12. *A* has high air pressure; *B* has low air pressure.

13. Answers will vary by locale. Several applications have been made in western Massachusetts and Vermont.

Station 3: Solar Power

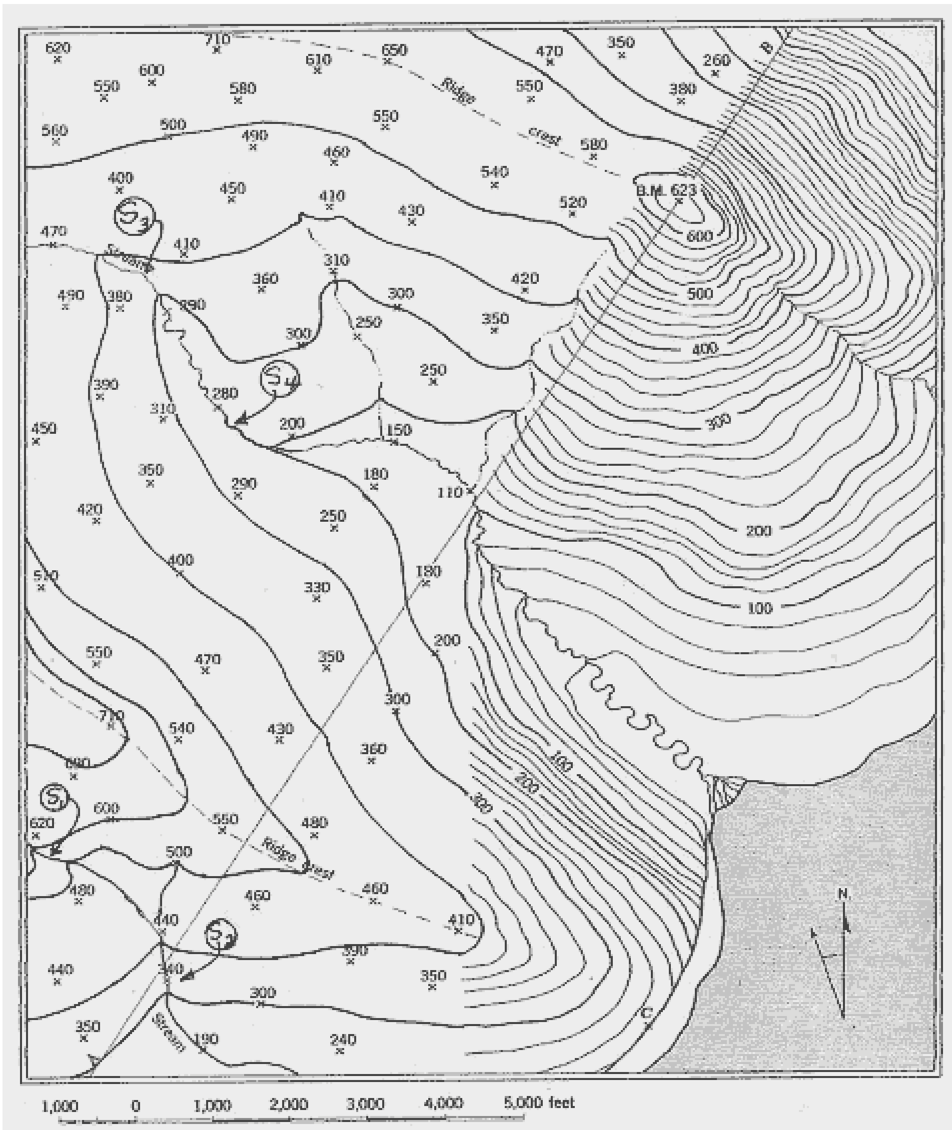


2. Answers will vary by location.
3. The average would be 12 hours if no blockage of sunlight occurred.
4. Clouds formed in air rising up the western slope of the Appalachians
5. Cloudless skies in air descending on the eastern slope of the Rockies
6. Sunnier skies
7. Sunlight is more intense in some places than in others; that's why you burn more easily and quickly when you go south, where the Sun is more directly overhead.
8. It costs nothing to receive it.
9. Very little environmental cost is involved unless you want to collect it with some device. Then the cost results from manufacturing the device.
10. Amounts will vary.
11. Variations were caused by variations in cloud cover and air clarity (dust and smog), both of which block sunlight.
12. Data will vary.
13. These map lines will vary even with the same data points: areas enclosed by lines should fall between the lines in value.
14. This will not always be the case as storms (and clouds) move through an area.
15. (a) Length of daylight—shorter days reduce the time of solar collection
    (b) Height of Sun in sky—lower Sun produces less intense sunlight
    (c) Amount of cloud cover—clouds prevent sunlight from getting to the Earth's surface
16. Light is converted to electricity.
17. Electromagnetic radiation travels through relatively empty space.

Station 4: Water Power

1. Student answers will vary: Troy; Hudson Falls; Glens Falls would be good responses.
2. Student answers will vary but expect "following a stream in a mountainous area" or "climbing to a hilltop to look for mountains with streams flowing down their side."

3. and 4.



5. The contour lines are close together in these sections.
6. Answers will vary depending on how the students drew their contour lines. For the key map above, the gradients are: S_1 = 100 ft / 500 ft = **.**2 feet/ horizontal foot distance

   S_2 = 100 ft / 700 ft = **.**14 feet/ horizontal foot distance

   S_3 = 100 ft / 1,000 ft = **.**1 feet/ horizontal foot distance

   S_4 = 80 ft / 900 ft = **.**09 feet/ horizontal foot distance
7. Answer will vary, but they should indicate rising temperatures until boiling starts, at which point the temperatures should level off to around 100^{o}C.

8. Water is accumulating.
9. It evaporated.
10. It transported water vapor.
11. Condensation
12. Lakes and streams in the mountains
13. Answers will vary.
14. The graph line should rise until the water starts boiling; it should level off after that time.

ADDITIONAL SUPPORT FOR TEACHERS

SOURCE FOR THIS ADAPTED ACTIVITY

This lesson was not adapted from a previous source.

BACKGROUND INFORMATION

Introduction

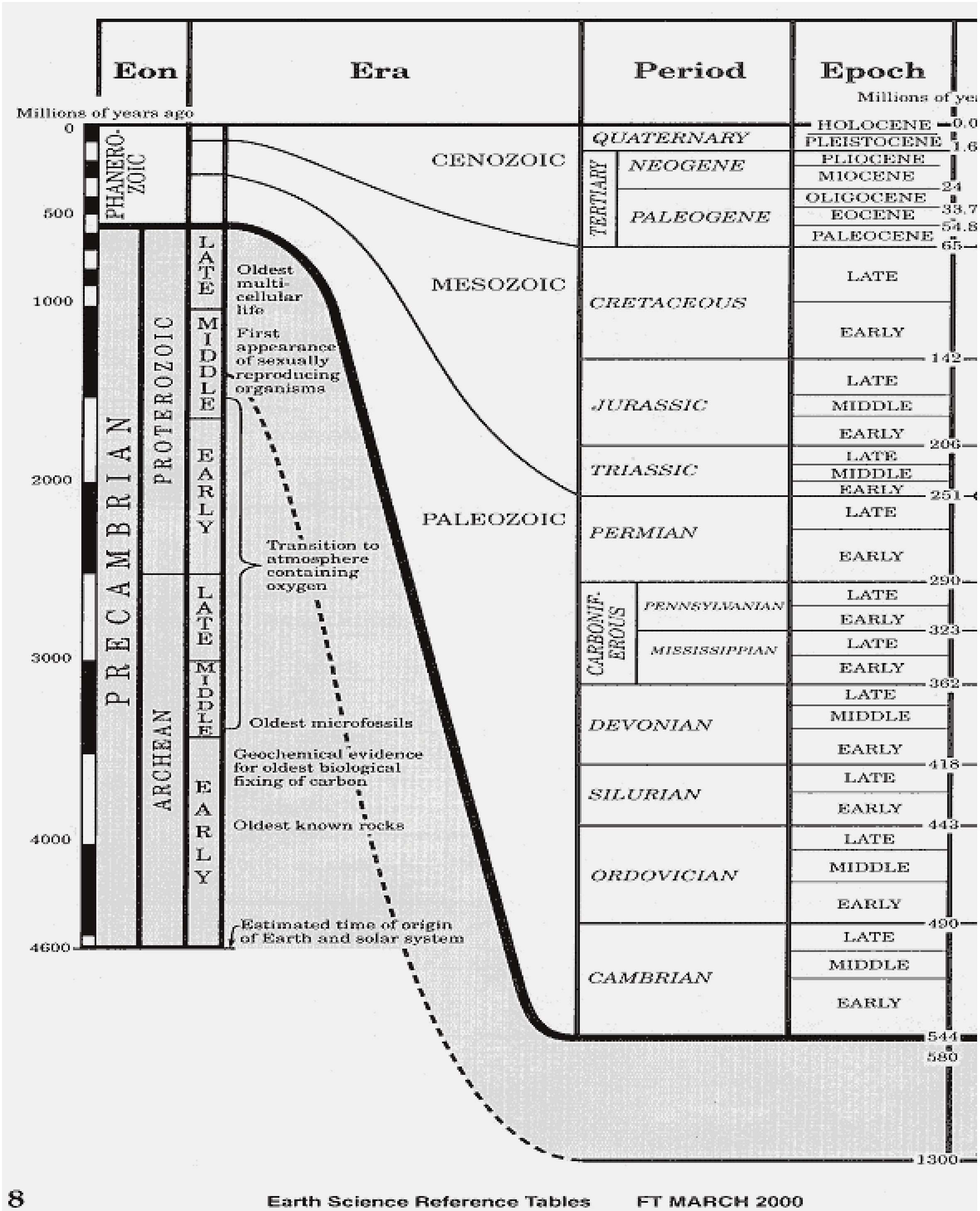
The Sun is the source of energy for most energy resources used on the Earth. The electromagnetic energy emitted from the Sun's photosphere is absorbed by atoms and molecules on Earth and converted to either heat or chemical bonding energy. While geothermal energy and nuclear energy seem independent from the Sun, they are not independent from other ancient stars. These ancient stars are believed to be the atomic manufacturing plants for the radioactive substances now found on Earth that provide the energy we use for nuclear and geothermal energy.

Station 1: Coal Power

Coal typically formed from land plant materials that accumulated in swamp conditions near sea level in tropical and semitropical environments. Burial and compaction by subsequent sediment accumulation compress these plant materials and gradually change them from peat to lignite to bituminous coal to anthracite coal. This relationship between coal type and pressure represents a hardening of coal with time so that younger coal beds are typically composed of softer coal. Normally, coal is associated with and found within sedimentary rocks. An exception is that some anthracite is found in highly folded and weakly metamorphosed rocks.

Most major rock structures such as folds and faults are associated with mountain-building activities known as orogenies. These result from collisions between the edges of the moving tectonic plates that are part of the Earth's lithosphere.

The timeline on the following page may help your students interpret the surface bedrock map at this station.


Eon
Era
Period
Epoch
Millions of years ago
0
500
1000
2000
3000
4000
4600
PHANERO-ZOIC
PRECAMBRIAN
PROTEROZOIC
ARCHEAN
LATE
MIDDLE
EARLY
LATE
MIDDLE
EARLY
CENOZOIC
MESOZOIC
PALEOZOIC
Oldest multi-cellular life
First appearance of sexually reproducing organisms
Transition to atmosphere containing oxygen
Oldest microfossils
Geochemical evidence for oldest biological fixing of carbon
Oldest known rocks
Estimated time of origin of Earth and solar system
QUATERNARY
TERTIARY
NEOGENE
PALEOGENE
CRETACEOUS
JURASSIC
TRIASSIC
PERMIAN
CARBONIFEROUS
PENNSYLVANIAN
MISSISSIPPIAN
DEVONIAN
SILURIAN
ORDOVICIAN
CAMBRIAN
HOLOCENE
PLEISTOCENE
PLIOCENE
MIOCENE
OLIGOCENE
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1.6
24
33.7
54.8
65
142
206
251
290
323
362
418
443
490
544
580
1300
8
Earth Science Reference Tables
FT MARCH 2000

Station 2: Wind Power

While discussing the limitations of the models, emphasize that the atmosphere behaves very much like the water in the beaker. Earth's gravitational field affects the air in the same way that it affects the water except that the gases of the air are more diffuse and the boundary between the atmosphere and outer space is more difficult to locate than the boundary between the water and the air that is above it.

The sides of the air model are represented by other convection cells located around the convection cell of the model.

Station 3: Solar Power

Nuclear fusion within the Sun converts hydrogen to helium. The loss of small amounts of mass during this process produces tremendous amounts of energy that radiates and convects its way to the Sun's photosphere (its visible surface) and is then released as radiation into space.

Station 4: Water Power

Closely spaced isolines represent a rapid change in value over a short distance. For running water, this means that rapids and/or waterfalls are present. This elevation change provides the "head" necessary for using water power to run machinery.

REFERENCES FOR BACKGROUND INFORMATION

Dunbar, Carl: *Historical Geology*, John Wiley, 1960.
Gilluly, Waters & Woodford: *Principles of Geology*, Freeman, 1959.
McGraw-Hill Encyclopedia of Science and Technology, Lapedes, Daniel, editor, 1976.
Strahler, Arthur: *The Earth Sciences*, Harper & Row, 1971.

LINKS TO MST LEARNING STANDARDS AND CORE CURRICULA

Standard 1—Analysis, Inquiry, and Design: Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

Key Idea 1: Abstraction and symbolic representation are used to communicate mathematically.

M1.1: Extend mathematical notation and symbolism to include variables and algebraic expressions in order to describe and compare quantities and express mathematical relationships.

M1.1a: Identify independent and dependent variables.

M1.1b: Identify relationships among variables including: direct, indirect, cyclic, constant; identify non-related material.

M1.1c: Apply mathematical equations to describe relationships among variables in the natural world.

Key Idea 2: Deductive and inductive reasoning are used to reach mathematical conclusions.

M2.1: Use inductive reasoning to construct, evaluate, and validate conjectures and arguments, recognizing that patterns and relationships can assist in explaining and extending mathematical phenomena.

M2.1a: Interpolate and extrapolate from data.

M2.1b: Quantify patterns and trends.

Key Idea 3: Critical thinking skills are used in the solution of mathematical problems.

M3.1: Apply mathematical knowledge to solve real-world problems and problems that arise from the investigation of mathematical ideas, using representations such as pictures, charts, and tables.

M3.1a: Use appropriate scientific tools to solve problems about the natural world.

Key Idea 1: The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing, creative process.

S1.1: Formulate questions independently with the aid of references appropriate for guiding the search for explanations of everyday observations.

S1.1a: Formulate questions about natural phenomena.

S1.1b: Identify appropriate references to investigate a question.

S1.1c: Refine and clarify questions so that they are subject to scientific investigation.

S1.2: Construct explanations independently for natural phenomena, especially by proposing preliminary visual models of phenomena.

S1.2a: Independently formulate a hypothesis.

S1.2b: Propose a model of a natural phenomenon.

S1.2c: Differentiate among observations, inferences, predictions, and explanations.

Key Idea 2: Beyond the use of reasoning and consensus, scientific inquiry involves the testing of proposed explanations involving the use of conventional techniques and procedures and usually requiring considerable ingenuity.

S2.1: Use conventional techniques and those of their own design to make further observations and refine their explanations, guided by a need for more information.

S2.1a: Demonstrate appropriate safety techniques.

S2.1b: Conduct an experiment designed by others.

S2.1c: Design and conduct an experiment to test a hypothesis.

S2.1d: Use appropriate tools and conventional techniques to solve problems about the natural world, including:

- measuring
- observing
- describing

Key Idea 3: The observations made while testing proposed explanations, when analyzed using conventional and invented methods, provide new insights into phenomena.

S3.1: Design charts, tables, graphs, and other representations of observations in conventional and creative ways to help them address their research question or hypothesis.

S3.1a: Organize results, using appropriate graphs, diagrams, data tables, and other models to show relationships.

S3.1b: Generate and use scales, create legends, and appropriately label axes.

Standard 2—Information Systems: Students will access, generate, process, and transfer information, using appropriate technologies.

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

1.1: Use a range of equipment and software to integrate several forms of information in order to create good-quality audio, video, graphic, and text-based presentations.

1.2: Use spreadsheets and database software to collect, process, display, and analyze information. Students access needed information from electronic databases and on-line telecommunication services.

Standard 6—Interconnectedness: Common Themes: Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.

Key Idea 2: Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

2.1: Select an appropriate model to begin the search for answers or solutions to a question or problem.

2.2: Use models to study processes that cannot be studied directly (e.g., when the real process is too slow, too fast, or too dangerous for direct observation).

2.3: Demonstrate the effectiveness of different models to represent the same thing and the same model to represent different things.

Key Idea 5: Identifying patterns of change is necessary for making predictions about future behavior and conditions.

5.1: Use simple linear equations to represent how a parameter changes with time.

5.2: Observe patterns of change in trends or cycles and make predictions on what might happen in the future.

Standard 7—Interdisciplinary Problem Solving: Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.

Key Idea 1: The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/technology/society, consumer decision making, design, and inquiry into phenomena.

1.1: Analyze science/technology/society problems and issues at the local level and plan and carry out a remedial course of action.

1.2: Make informed consumer decisions by seeking answers to appropriate questions about products, services, and systems; determining the cost/benefit and risk/benefit tradeoffs; and applying this knowledge to a potential purchase.

1.3: Design solutions to real-world problems of general social interest related to home, school, or community using scientific experimentation to inform the solution and applying mathematical concepts and reasoning to assist in developing a solution.

Standard 4—The Physical Setting: Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Key Idea 2: Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.

2.1: Explain how the atmosphere (air), hydrosphere (water), and lithosphere (land) interact, evolve, and change.

2.1a: Nearly all the atmosphere is confined to a thin shell surrounding Earth. The atmosphere is a mixture of gases, including nitrogen and oxygen with small amounts of water vapor, carbon dioxide, and other trace gases. The atmosphere is stratified into layers, each having distinct properties. Nearly all weather occurs in the lowest layer of the atmosphere.

2.1c: The rock at Earth's surface forms a nearly continuous shell around Earth called the lithosphere.

2.1d: The majority of the lithosphere is covered by a relatively thin layer of water called the hydrosphere.

2.1e: Rocks are composed of minerals. Only a few rock-forming minerals make up most of the rocks of Earth. Minerals are identified on the basis of physical properties such as streak, hardness, and reaction to acid.

2.1f: Fossils are usually found in sedimentary rocks. Fossils can be used to study past climates and environments.

2.1g: The dynamic processes that wear away Earth's surface include weathering and erosion.

2.1h: The process of weathering breaks down rocks to form sediment. Soil consists of sediment, organic material, water, and air.

2.1i: Erosion is the transport of sediment. Gravity is the driving force behind erosion. Gravity can act directly or through agents such as moving water, wind, and glaciers.

2.1j: Water circulates through the atmosphere, lithosphere, and hydrosphere in what is known as the water cycle.

2.2: Describe volcano and earthquake patterns, the rock cycle, and weather and climate changes.

2.2c: Folded, tilted, faulted, and displaced rock layers suggest past crustal movement.

2.2g: Rocks are classified according to their method of formation. The three classes of rocks are sedimentary, metamorphic, and igneous. Most rocks show characteristics that give clues to their formation conditions.

2.2h: The rock cycle model shows how types of rock or rock material may be transformed from one type of rock to another.

2.2i: Weather describes the conditions of the atmosphere at a given location for a short period of time.

2.2j: Climate is the characteristic weather that prevails from season to season and year to year.

2.2k: The uneven heating of Earth's surface is the cause of weather.

2.2o: Fronts are boundaries between air masses. Precipitation is likely to occur at these boundaries.

2.2r: Substances enter the atmosphere naturally and from human activity. Some of these substances include dust from volcanic eruptions and greenhouse gases such as carbon dioxide, methane, and water vapor. These substances can affect weather, climate, and living things.

Key Idea 3: Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

3.1: Observe and describe properties of materials, such as density, conductivity, and solubility.

3.1h: Density can be described as the amount of matter that is in a given amount of space. If two objects have equal volume, but one has more mass, the one with more mass is denser.

3.1i: Buoyancy is determined by comparative densities.

3.2: Distinguish between chemical and physical changes.

3.2a: During a physical change a substance keeps its chemical composition and properties. Examples of physical changes include freezing, melting, condensation, boiling, evaporation, tearing, and crushing.

Key Idea 4: Energy exists in many forms, and when these forms change energy is conserved.

4.1: Describe the sources and identify the transformations of energy observed in everyday life.

4.1a: The Sun is a major source of energy for Earth. Other sources of energy include nuclear and geothermal energy.

4.1b: Fossil fuels contain stored solar energy and are considered nonrenewable resources. They are a major source of energy in the United States. Solar energy, wind, moving water, and biomass are some examples of renewable energy resources.

4.1c: Most activities in everyday life involve one form of energy being transformed into another. For example, the chemical energy in gasoline is transformed into mechanical energy in an automobile engine. Energy, in the form of heat, is almost always one of the products of energy transformations.

4.1d: Different forms of energy include heat, light, electrical, mechanical, sound, nuclear, and chemical. Energy is transformed in many ways.

4.1e: Energy can be considered to be either kinetic energy, which is the energy of motion, or potential energy, which depends on relative position.

4.2: Observe and describe heating and cooling events.

4.2a: Heat moves in predictable ways, flowing from warmer objects to cooler ones, until both reach the same temperature.

4.2b: Heat can be transferred through matter by the collisions of atoms and/or molecules (conduction) or through space (radiation). In a liquid or gas, currents will facilitate the transfer of heat (convection).

4.2c: During a phase change, heat energy is absorbed or released. Energy is absorbed when a solid changes to a liquid and when a liquid changes to a gas. Energy is released when a gas changes to a liquid and when a liquid changes to a solid.

4.2d: Most substances expand when heated and contract when cooled. Water is an exception, expanding when changing to ice.

4.2e: Temperature affects the solubility of some substances in water.

4.3: Observe and describe energy changes as related to chemical reactions.

4.3a: In chemical reactions, energy is transferred into or out of a system. Light, electricity, or mechanical motion may be involved in such transfers in addition to heat.

4.5: Describe situations that support the principle of conservation of energy.

4.5a: Energy cannot be created or destroyed, but only changed from one form into another.

4.5b: Energy can change from one form to another, although in the process some energy is always converted to heat. Some systems transform energy with less loss of heat than others.

PROCESS SKILLS BASED ON STANDARD 4

General Skills

1. Follow safety procedures in the classroom and laboratory.
2. Safely and accurately use the following measurement tools:
    - metric ruler
    - graduated cylinder
    - thermometer
3. Use appropriate units for measured or calculated values.
4. Recognize and analyze patterns and trends.
8. Identify cause-and-effect relationships.

Physical Setting Skills

2. Using identification tests and a flow chart, identify mineral samples.
3. Use a diagram of the rock cycle to determine geological processes that led to the formation of a specific rock type.
7. Generate and interpret field maps including topographic and weather maps.

Produced by the Research Foundation of the State University of New York with funding from the New York State Energy Research and Development Authority (NYSERDA)

Should you have questions about this activity or suggestions for improvement, please contact Bill Peruzzi at billperuz@aol.com

(STUDENT HANDOUT SECTION FOLLOWS)

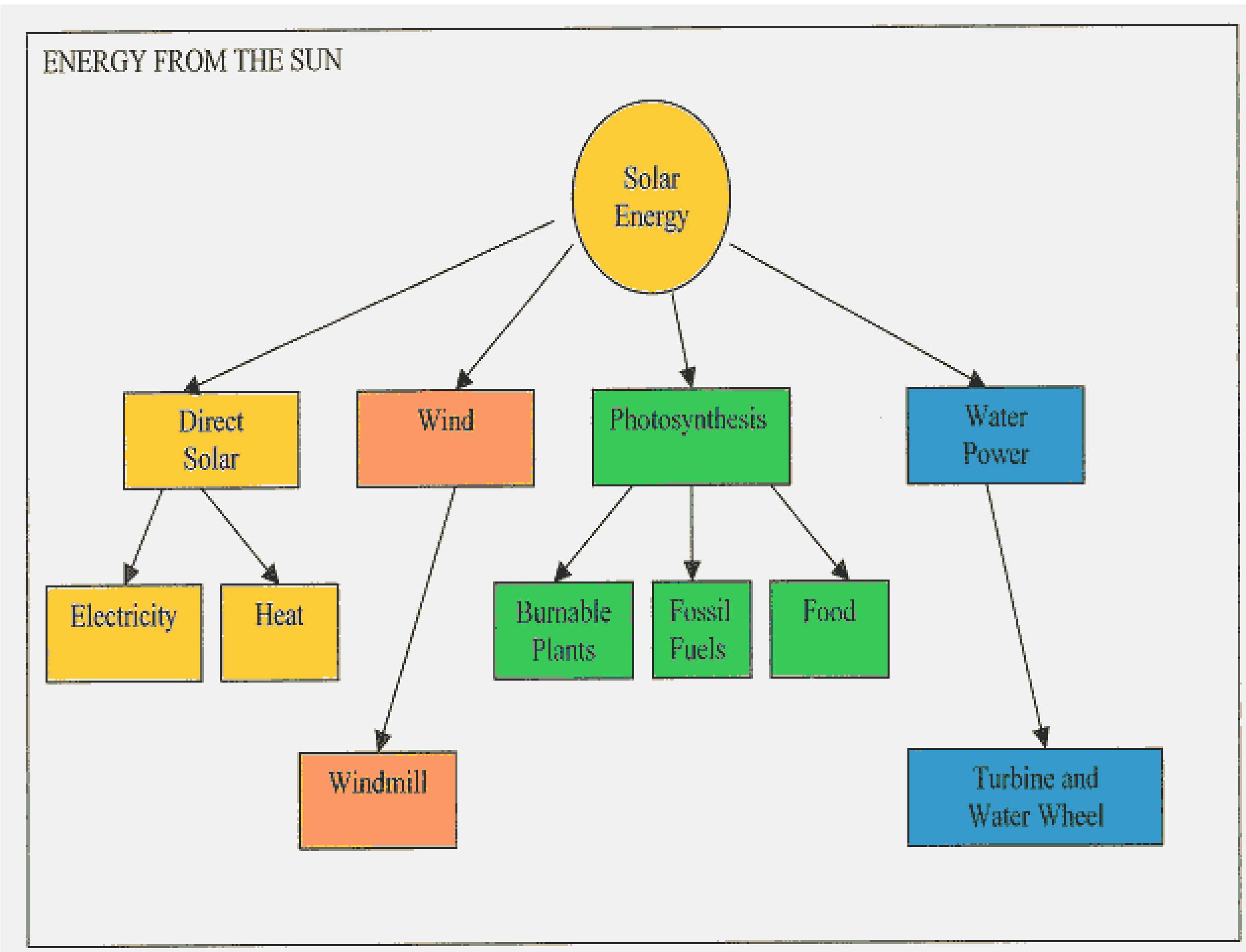
Name______________________________

Date_______________________________

Energy Resources: Where Are They and How Do We Get Them?
SPN LESSON #5

INTRODUCTORY WORKSHEET

Introduction: Energy resources used across Earth take many forms. Energy and its uses are constantly in the news; we hear about the energy crisis, oil spills, the price of gasoline, pollution from burning fossil fuels, acid rain. The list goes on and on. But what is the source of all this energy? Where does energy come from? The information shown on the flowchart diagram below may surprise you. Look at this diagram and respond to the questions that follow. The arrows indicate the flow of energy from one place to another.



DEVELOP YOUR UNDERSTANDING

1. What does the diagram indicate as the source of all energy?

2. Why does the Sun have so much energy?

3. Why does the light energy from the Sun make us warm?

4. How do we turn sunlight into electricity?

5. How does the Sun cause the wind to blow?

6. What is photosynthesis?

7. What are fossil fuels?

8. How does photosynthesis lead to fossil fuels?

9. How does Sun energy create waterpower?

10. What is a gradient?

11. Are there any energy sources that are not powered by the Sun?

Name_______________________________

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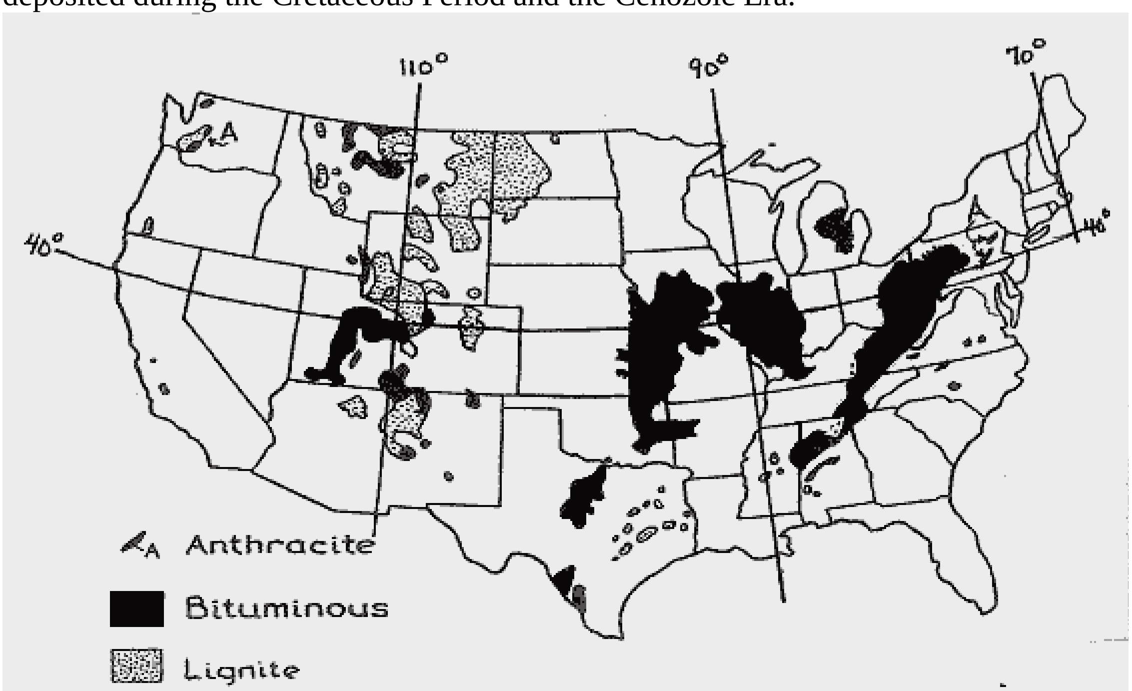
Energy Resources: Where Are They and How Do We Get Them?
SPN LESSON #5

STATION 1 WORKSHEET: COAL POWER

Introduction: Energy resources found on Earth are typically converted to mechanical energy or electrical energy to power modern industrial nations. During the development of the industrial age, coal was the dominant energy source for England, Germany, and France, and also for world powers such as Russia and the United States. How do we locate this important resource? As is the case with many natural resources, we have to explore the rocks of Earth's **lithosphere**, using our knowledge of the rocks and rock structures found there.

The map below shows those portions of the United States where coal has been discovered in the lithosphere. Much of the coal in the eastern half of the country was formed during a period of geologic time called the Pennsylvanian Period. Coals in the western half were deposited during the Cretaceous Period and the Cenozoic Era.



[modified from Gilluly, p. 460 and Dunbar, p. 225]

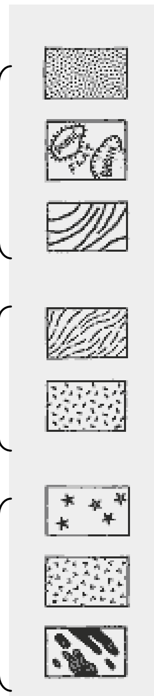
1. Which type of coal seems least abundant and where is it found?

2. Lignite is the poorest grade of coal. Where is most of the lignite found?

The map below shows where the three rock types—igneous, metamorphic, and sedimentary—are found at the surface of the lithosphere. Using a different color of pencil for each rock type, lightly color the areas of the United States where these rock types are found.

Generalized Map of the Surface Bedrock of the United States

Key to Map Symbols



Sedimentary Rocks	Cretaceous to Quaternary Coastal Deposits: Older sediments inland; younger sediments along present coast
	Cambrian to Tertiary Rocks: Deposited in shallow seas on continent and on interior lowlands
	Cambrian to Tertiary Rocks: Folded and thrust faulted during mountain building episodes after deposition
Metamorphic Rocks	Late Precambrian to Tertiary Sedimentary and Volcanic Rocks: Weakly to Intensely metamorphosed during mountain building episodes
	Late Precambrian and Older Rocks of Continental Core: Mostly intensely metamorphosed
Igneous Rocks	Recently Erupted Volcanoes: Neogene to Quaternary
	Cenozoic Lava Flows
	Phanerozoic Granites: Intrusions usually during mountain building episodes

3. Which type of rock covers most of the United States?

4. Coal deposits are found mainly in which type of rock?

5. In which type of rock are the anthracite coal deposits in Pennsylvania found?

6. If you were going to look for coal deposits in another part of the world—for example, in Antarctica—where would you look?

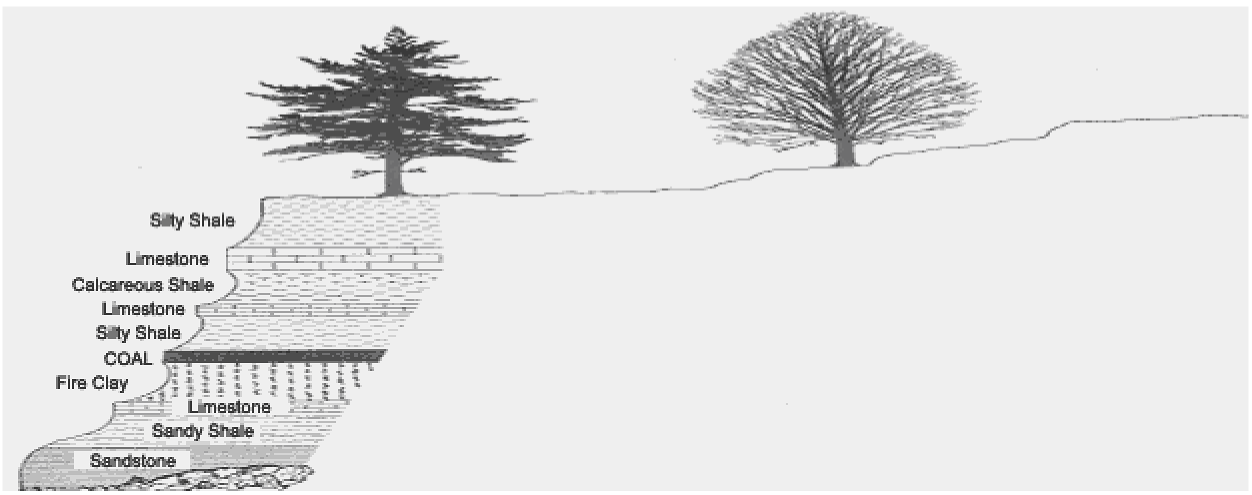
Actually, coal is first discovered where it outcrops at the surface. Oftentimes, natural processes cut down into the rocks of the lithosphere and expose the rocks that were buried beneath the surface rocks.

7. Describe two examples of what those natural processes are:

a.

b.

8. The picture below shows a cliff exposed by erosion. This cliff is an outcrop of bedrock containing several layers of sedimentary rocks normally associated with the coal layers in Illinois. The coal layer is shown in black and is easily seen where exposed in the cliff face. But what happens to the coal seam where it's hidden from view at the right? This is the challenge geologists face as they try to locate mineable coal resources: where do the coal seams go underground? What do you predict? Show your opinion by drawing a location for the coal seam to the right side of the diagram.



[modified from Strahler, p. 522]

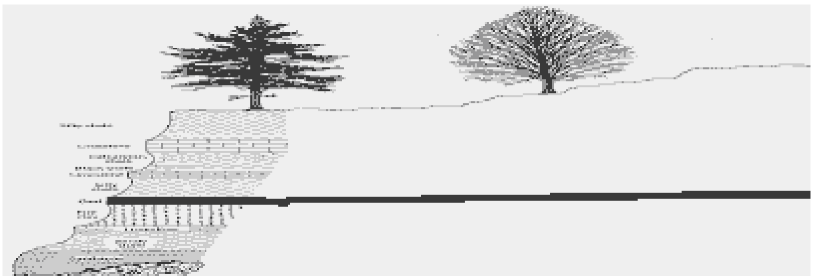
9. While studying this outcrop, geologists determined that the rock layers above the coal seam were made up of sediments deposited under the sea (in a marine environment). The rock layers from the coal layer down were deposited in a land environment. Describe the evidence they found in these rocks that likely led them to these conclusions.

10. How might the information available at this outcrop help geologists find coal elsewhere in Illinois?

11. There is a pile of boulders and cobbles at the base of the cliff. Explain how these boulders are likely to have accumulated at this location (hint: two natural processes are involved).

12. Identify each type of geologic structure shown in each of the coal-seam cross sections below. Explain how each structure formed. What impact might the structure have on mining the coal seam?

A.

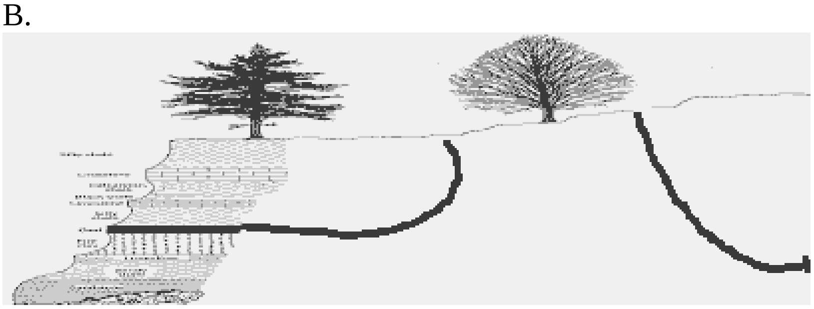


Structure:

How Formed:

Impact on Mining:

B.

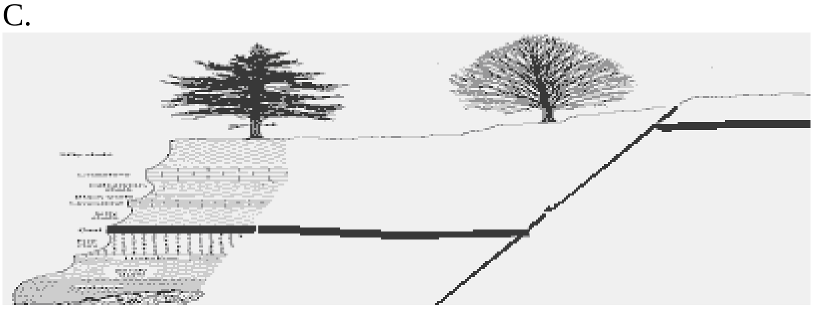


Structure:

How Formed:

Impact on Mining:

C.



Structure:

How Formed:

Impact on Mining:

Lab Task

13. At this station, use a hand lens to look at the five rock samples taken from the outcrop above. Identify each of these samples and place the letter of the sample next to its name in the chart below. Describe the evidence you used to identify the sample.

NAME OF ROCK	LETTER	EVIDENCE USED FOR ROCK IDENTIFICATION
Silty Shale (marine deposited)		
Limestone (marine deposited)		
Coal (land deposited)		
Sandy Shale (land deposited)		
Sandstone (land deposited)		

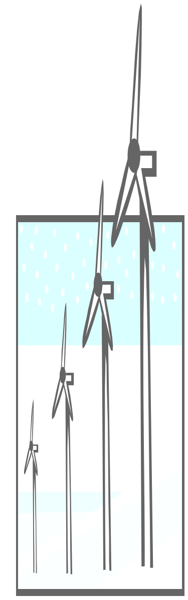
14. How could you tell which rocks were deposited in the ocean (marine) environment?

15. How could you tell the difference between the sandstone and the shales?

16. What might be a good title for this chart?

Name______________________________

Date________________________________



Energy Resources: Where Are They and How Do We Get Them?
SPN LESSON #5

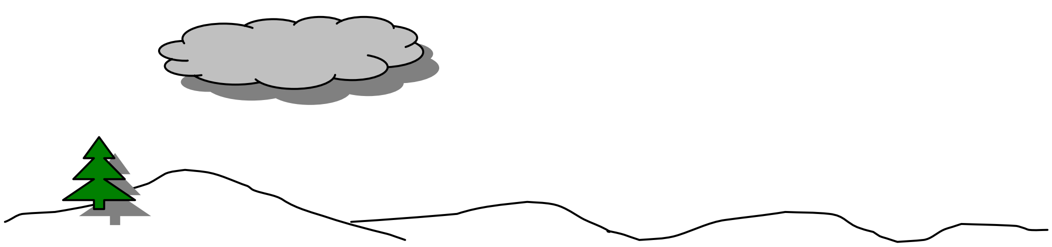
STATION 2 WORKSHEET: WIND POWER

Introduction: For centuries, wind energy has been used in simple technologies to grind grains, power ships, and pump water. In rural areas of the United States during the first half of the 1900s, thousands of small wind-powered water pumps and electric generators were in use. As rural electric power lines became popular in the mid-1900s, wind devices became obsolete and fell into disuse. If you look carefully, you may see the remnants of these small windmills still standing in farming areas. Recently, interest in wind energy has been renewed as the need for energy increases along with the cost of the remaining fossil fuels.

Part 1:

Find the two maps of the United States region on the following pages. The first map is an isolines map showing estimates of the wind **power** available around mainland United States. The numbers indicate the number of watts of energy available each hour for each vertical square meter of surface area exposed to the wind.

1. Show this by making a sketch in the space below. Draw an arrow to show the wind direction. Draw a square that represents one meter on a side.



2. As you can tell, average wind speeds vary quite a bit from place to place. Find New York State on this map. Find the isoline labeled "X" that cuts through New York twice: once through the eastern edge of Long Island and again across the western Adirondacks, Tug Hill, and the southern tier. Carefully study the pattern of isolines around this line. What is the value for this isoline?

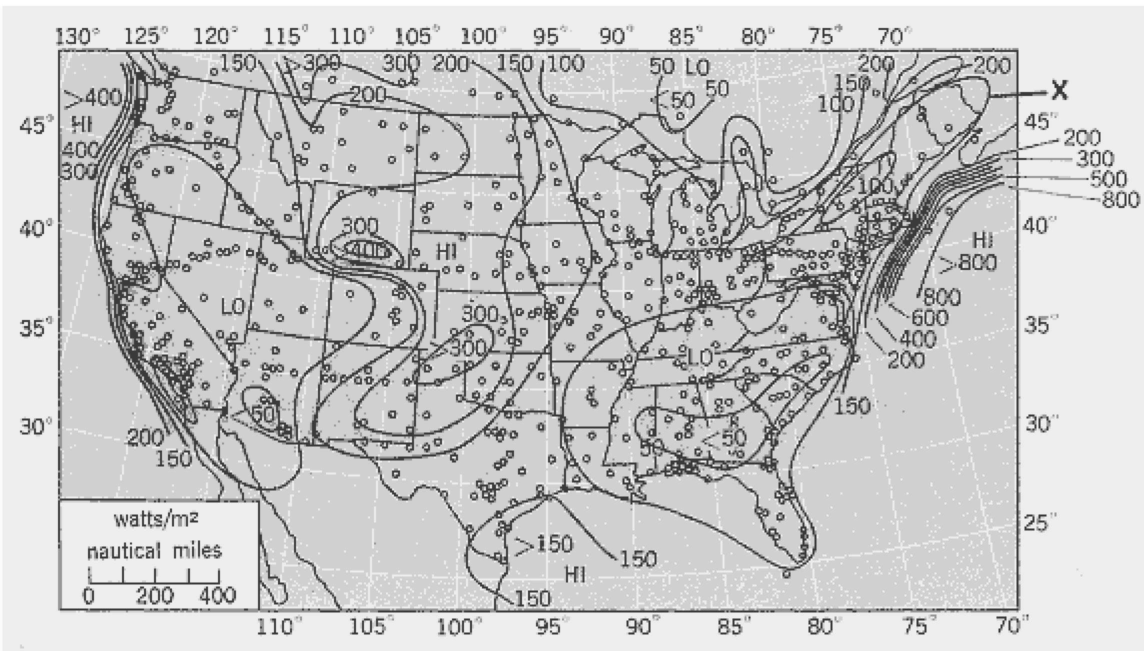
3. Using a light-blue colored pencil, shade the region of New York that is incorrectly labeled as having wind power greater than 100 (it should be labeled "less than 100").

4. a) How much wind power potential exists around your home or school?

b) What size light bulb might a 1 square meter windmill (generator) light at your house for a year?

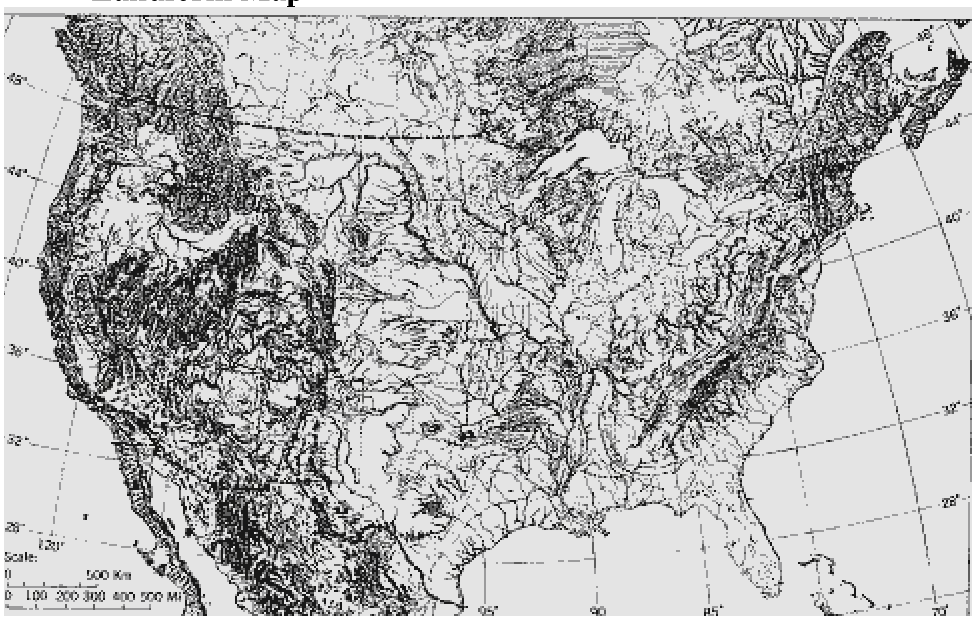
5. With a yellow colored pencil, shade the regions of the map that have the greatest potential for the use of wind power as an energy source. [Shade those areas with estimated power greater than 200 watts/meter^2.]

Wind Power Map



[from Lapedes, p. 733]

Landform Map



[from Strahler, p. 676]

6. Why might the wind power be greater in the areas shaded yellow? Write out at least two possibilities.

   (1)

   (2)

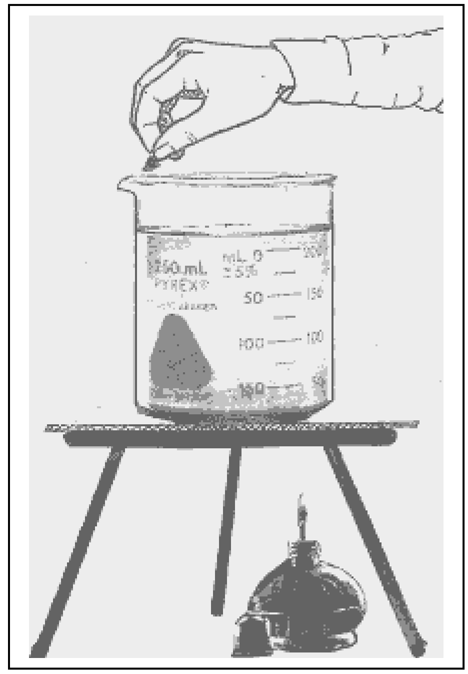
The second map shows the topography (landforms and relief) of southern Canada, the United States, and northern Mexico. Mountainous areas generally appear darker and “busier” because of the many changes in elevation. Flatter land areas appear lighter except where rivers cut across them.

7. With your yellow pencil, shade in the mountainous areas of the United States. Label a mountain range that you recognize.
8. What is the relationship between the topography of the Earth’s surface and those places having the greatest wind power potential? Describe that relationship.

Lab Task: How does energy from the Sun make wind power? The shape of the Earth's surface may affect the local strength of the wind, but where does the wind come from? Why does it blow?

In this task, you make a model of the wind system and the energy system that cause air currents to move. Although winds are much more complex than shown by this model, the model **does** demonstrate the overall cause of winds.

The laboratory equipment has been set up for you at this station as shown at the right.



The beaker has been filled with fresh water.

Make sure you are wearing safety goggles.

Light the alcohol burner.

Let the burner heat the water for two minutes.

Drop the copper nitrate crystal into the side of the beaker opposite the burner as shown.

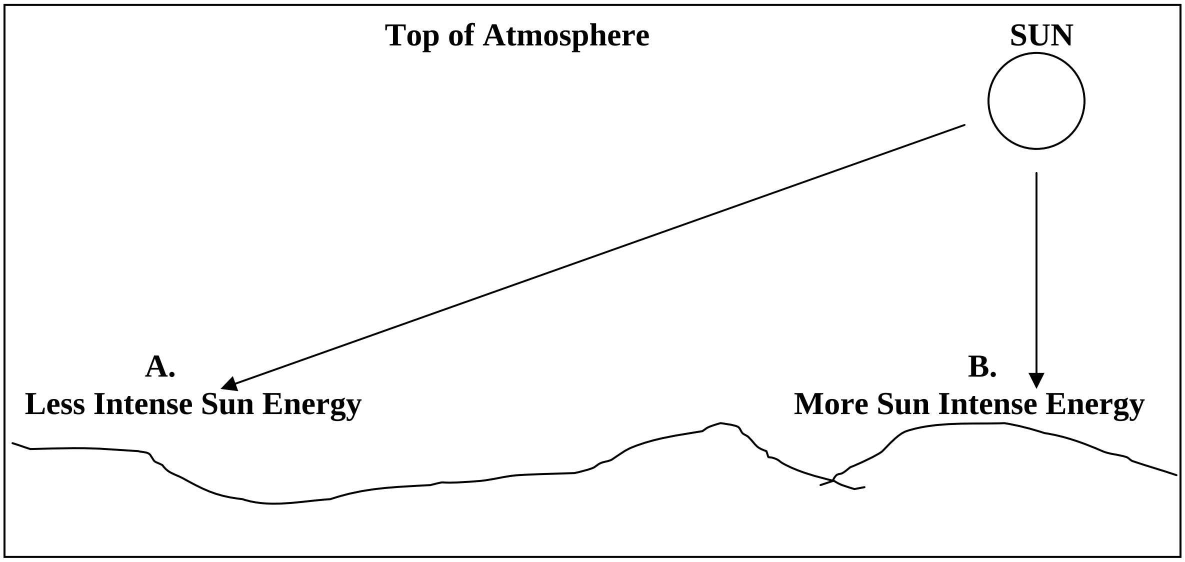
9. What happens around the crystal after you drop it into the beaker?

10. What direction of movement do you detect along the bottom of the beaker?

11. While this model may not look anything like the Sun and the surface of Earth, think in terms of energy and the movement of a fluid.
    - Let the energy from the alcohol lamp represent the energy present in sunshine.
    - Let the bottom of the beaker represent the surface of Earth receiving more energy in one place than it does in another.
    - Let the water (a fluid) represent the atmosphere (another fluid).
    - The sides of the beaker are a little trickier, so let's put our air model below in a box for now.

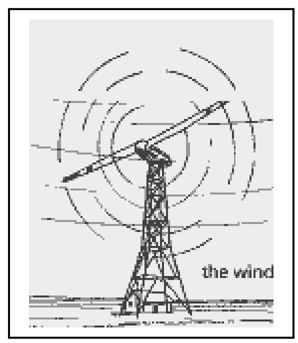
Apply the original water-heating model above to the diagram on the next page, using the ideas in the bullets.

- Label the land surface "Hot" or "Cold" under each Sun ray arrow.
- Draw arrows to show the overall air movement pattern.
- Label the surface winds.



12. These temperature differences actually cause a difference in air pressure at each of these locations. Indicate which side of the air model—A or B—has high air pressure at the Earth's surface and which has low air pressure.

13. Recently many locations around New York State have applied for licenses to build modern wind generators such as the one shown to the right.
    Where is the one nearest your house or school?



Name_____________________________

Date______________________________

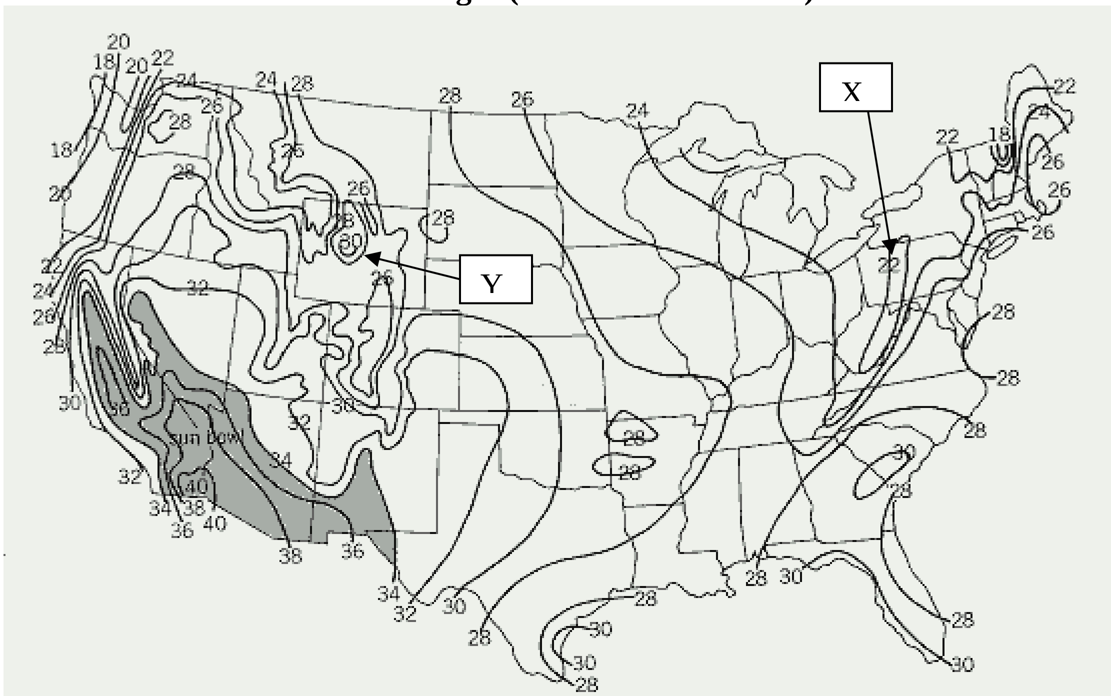
Energy Resources: Where Are They and How Do We Get Them?
SPN LESSON #5

STATION 3 WORKSHEET: SOLAR POWER

Introduction: Solar energy, as the introductory worksheet revealed, is the source of nearly all energy resources used on Earth. There are a few exceptions, such as geothermal energy and atomic energy, but most energy can be traced back through various transformations to the electromagnetic radiation from the Sun. But why go through all those transformations? Could we harness the Sun's energy directly? Would it be difficult to do so? At certain times of year and in certain locations, sunlight does seem scarce. But for most of us, locating the Sun as a resource is no problem at all. Look at the map below: it shows the hundreds of hours of sunlight received in the continental United States.

1. Using various colored pencils, lightly color parts of the map following these directions.
    a) Color **blue** those parts of the United States that receive between 2,200 and 2,400 hours of sunlight each year.
    b) Color **red** those parts of New York State that receive more than 2,600 hours of sunlight each year.
    c) Color **yellow** those parts of New York State that receive between 2,400 and 2,600 hours of sunlight each year.
    d) Color **green** those parts of New York State that receive less than 2,200 hours of sunlight each year.

Number of Hours of Sunlight (in hundreds of hours)



[after Lapedes, p. 629]

2. How many hundreds of hours of sunlight are received where you live?

3. Using 365 ¼ days in the year, calculate how many sunlight hours/day you receive.

4. Why does area X receive less sunlight than the area that surrounds it?

5. Why does area Y receive so much more sunlight than its surrounding area?

6. Why does Florida receive more sunlight than your home or school area?

4. In addition to number of hours, what are the other important sunlight variables that affect the amount of sunlight received in the map area?

5. How much does it cost to receive this solar energy?

6. What is the environmental cost of using this solar energy?

Lab Task:

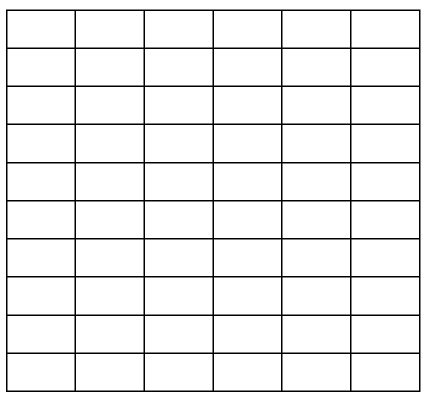
The number of hours of sunlight is important, but more important is the energy content of that sunlight. Use your classroom computer to access information about your school's solar panel power output.

7. In the chart below, record how much energy was received by your school's solar panels during the last week.

Day of Week							
Energy Amount	kW	kW	kW	kW	kW	kW	kW

Plot this data on the grid below. Be sure to include appropriate scales on both the horizontal and vertical axes.

Amount of Energy (kW)



Day of the Week

8. Describe why the daily energy from your school's solar collectors varied during the week. Write your explanation in the space below.

9. Compare your school's solar panel energy output for the week to that of other participating schools in New York State. Place dots to record at least 15 weekly totals as close as you can to those schools' locations on the map of New York State on the next page.

10. Using a pencil, draw isolines on this map every 100 kW to show the pattern of energy collection across New York during the time of your analysis. This may be difficult because real data is typically not as clear-cut as data used for teaching examples.

11. Did the schools that received more hours of daylight according to the map at the beginning of this activity also produce the greatest amount of electricity?

DEVELOP YOUR UNDERSTANDING

12. Explain the day-to-day variations in electrical output from the solar collector by listing three factors that affect the amounts of sunlight and then describing how they affect sunlight.

    (a)

    (b)

    (c)

13. Describe the energy conversion that takes place in your school's solar collectors.

14. Describe how the Sun's energy gets from the Sun to Earth.

Name_____________________________

Date______________________________

Energy Resources: Where Are They and How Do We Get Them?
SPN LESSON #5

STATION 4 WORKSHEET: WATERPOWER

Introduction: Waterpower was an early source of energy for heavy industry. Mills were located at sites where waterfalls were available. Settlements for the original colonies clustered around the sites of earlier mill towns. There are probably several towns in your vicinity of New York State that owe their early development and population growth to waterpower resources.

1. Name at least two towns that you know of that developed into population centers because jobs were available in industries that were directly powered by water.

(1) (2)

Locating sources of waterpower is a straightforward procedure: look for rapids and waterfalls along rivers and streams.

2. If you were an early pioneer looking for a site to build a mill, how might you go about finding a site as you rode your horse or hiked through the wilderness? Mention two strategies.
(1)

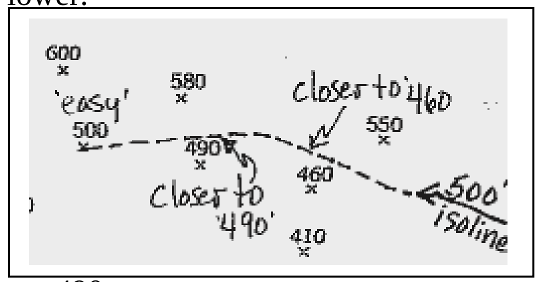
(2)

Part 1: Topographic Maps

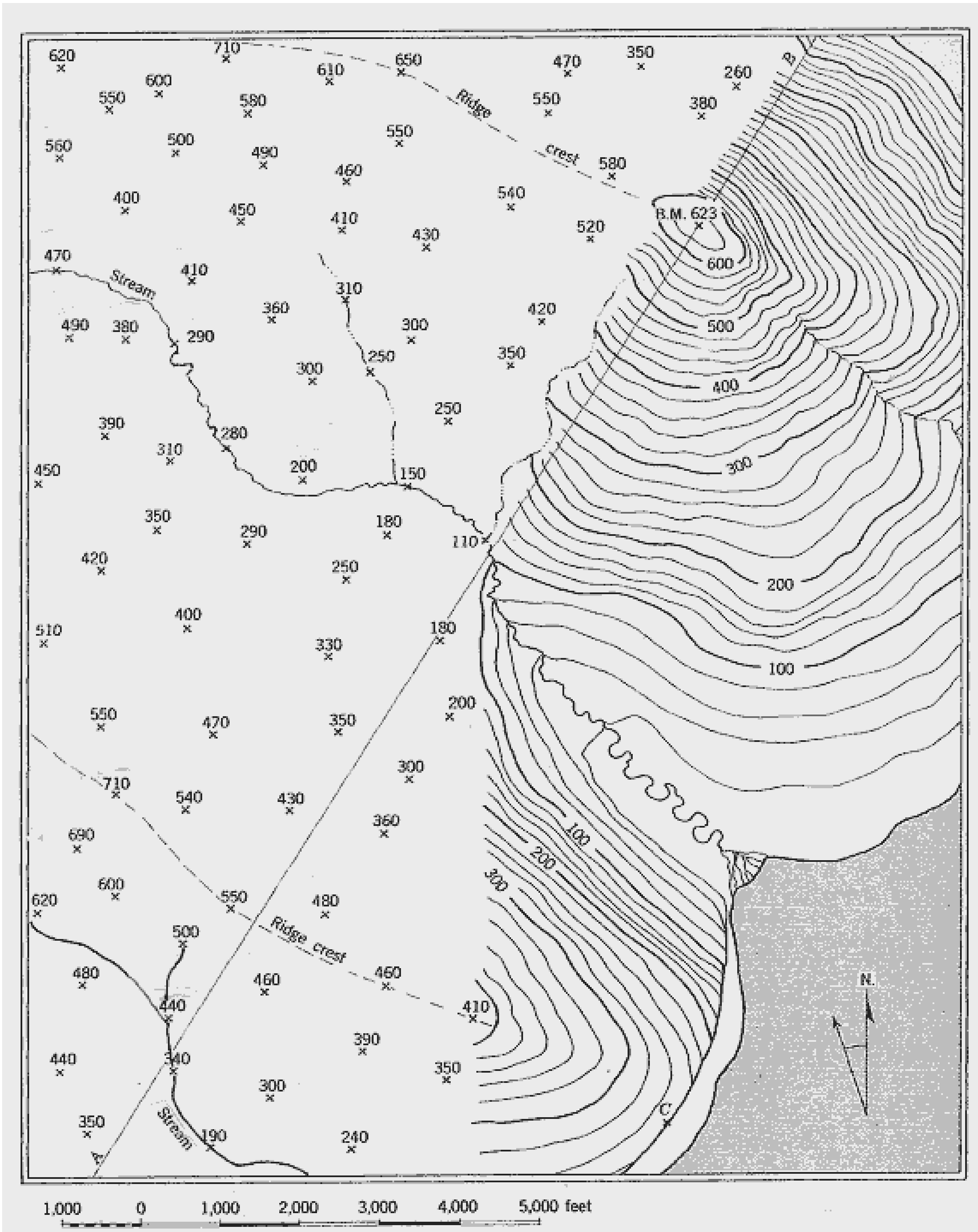
3. If you were looking for a potential water-powered mill site today, you would probably start with a map that shows changes in elevation and locations of streams. This kind of map is called a topographic map. On such maps, the **lines connect points of equal elevation, and these points are called contour lines or isolines.** The map on page 5.3 is a half-completed topographic map. Using a pencil, complete the unfinished isolines with values of 200, 300, 400, 500, 600, and 700 feet

above sea level. If you have never done this type of task before, or have forgotten how, keep in mind that:

- Every point on an isoline should have the value of the isoline.
- The numbers shown are the values at the point indicated by the small *x*'s.
- The elevation points shown on the map are samples of all the millions of points of elevation actually present in the mapped area.
- By drawing the isolines, you will be making the pattern of elevation changes easier to see. As you draw an isoline, the values on one side of the line will be higher than the line; the values on the other side will be lower.
- As you draw a line through the number field, you should determine where your line value "fits" within the value points ahead of you as shown in the example to the right. Since 500 is slightly closer in value to 460 than it is to 550, the isoline should be drawn slightly closer to 460. Then, it is much closer in value to 490 than it is to 580, so in this case the isoline is drawn much closer to 490.



Topographic Map



[modified from Strahler, p. 646]

4. Identify two sites that show the best potential as waterpower sites by placing the letter *S* on the map at each of those sites.
5. Describe the map evidence that led you to choose these two sites.

6. Determine how steep the slope of the riverbed is in the vicinity of your two chosen sites. [Divide the change in elevation at the site by the horizontal distance between the contour lines whose value you used to determine the change in elevation.] Show your math work and label your answers.
   Site 1: Site 2:

Lab Task: How the Sun Affects Waterpower

What role does the energy of sunlight play in waterpower? The laboratory equipment at this station is a model of the processes that occur in the real world. The model will help you understand the role played by the energy of sunlight. Some of the energy from the Sun at Earth's surface is absorbed by water molecules located there. In the apparatus at this station, the heat from the alcohol lamp represents sunlight energy, the water in the test tube represents the water at Earth's surface, and the rubber tubing represents the atmosphere that surrounds Earth.

Measure 15 milliliters of water in the graduated cylinder. Pour the water into the test tube. Carefully seal the top of the test tube with the stopper.

Put on your safety goggles. Light the alcohol burner and move it under the test tube. Make sure the end of the rubber tubing is inside the test tube in the test tube rack. Record the temperature of the air in the test tube under "0" time on the chart below.

7. As you heat the water, continue to record the temperature of the air on the chart below every minute until the water has boiled for ten minutes. Turn off the alcohol burner.

Time	0	1	2	3	4	5	6	7	8	9	10
Temp.											

Time	11	12	13	14	15	16	17	18	19	20
Temp.										

Time	21	22	23	24	25	26	27	28	29	30
Temp.										

8. As the water in the heated test tube boils, what do you notice happening in the test tube in the test tube rack?

9. What happened to some of the water in the heated test tube?

10. What did the "atmosphere" in the rubber tubing do with the evaporated water?

11. What process occurred in the atmosphere to change the evaporated water back into liquid water?

12. What does the water-collecting test tube represent in our waterpower model?

13. Measure the amount of water collected in the water-collecting test tube. Write down the amount and multiply that number by 540.

Sunlight causes bodies of water at their surfaces to change from liquid water to water vapor. 540 calories of energy are required to evaporate each milliliter of water that passes into the atmosphere. This water vapor is transported by the winds of the atmosphere over land areas, where clouds form and rain falls on Earth's surface. Here it collects in streams and flows downhill to provide waterpower.

14. Plot the temperature changes over time that you recorded in the chart in step 4 of the procedure. Fill in a temperature scale for the vertical axis and give the graph a title.

Title: ____