A 3-part curriculum to educate grades 9-12 in the modern application of energy science.

PEIMS Code: N1300263
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This curriculum has been developed in collaboration with Texas Christian University’s Energy Institute; the Texas Natural Gas Foundation; the State Energy Conservation Office; the Texas Regional Collaboratives at the University of Texas; and Life:Powered, a nonprofit initiative to inform the public about energy resources.

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Unit 1

WHAT IS ENERGY?
TEACHER OVERVIEW

The three essential resources for any nation are food, water, and energy. As a matter of fact, it is energy that helps produce more food and cleaner water for our ever-growing global population. Securing and producing enough energy often becomes critical to economic and social stability throughout the world, so we need to know and understand as much as we can about our energy resources. Understanding where energy comes from and how we use it is more important now than at any time in our past as we want to provide a better and longer life for our global community. The energy concept is fundamentally scientific in nature, but it has tremendous personal and social significance. Energy is one of the most fundamental parts of our universe. We cannot see, hear, or touch energy, yet we use energy every day. Although energy isn’t visible, we can detect evidence of energy. Movement, sound, heat, and light provide evidence that energy is present and being used. Energy from the sun lights the earth during the day and is used by plants to produce food. Energy lights up our homes and towns; provides the power for our modes of transportation (planes, trains, vehicles, rockets, etc.); warms and cools our homes; cooks our meals; plays our music; powers our phones, computers, tablets and televisions; powers the machinery used by factories, farmers, and construction workers; and too many others to mention.

The sun provides the energy to produce food for nearly all organisms for their survival. Over time, we have developed an understanding of energy that has given us the means to harness it and use it. As far back as at least 400,000 years, we have used fire to cook food and heat our dwellings.\(^1\) Shortly after that, we learned to use the energy from the sun, water, wind, and animals for transportation, heating and cooling, and agriculture.

In the 19th century, the Industrial Revolution saw the invention of the steam engine, and the use of coal replaced the use of wood as our major fuel supply. The steam engine was used to transport coal, to drive the manufacturing of machinery, and to power locomotives, ships, and the first automobiles. Coal remained the major source of fuel until the middle of the 20th century when it was taken over by oil.

The ability to generate electricity and transmit it over large distances provided the next major energy revolution. After Nikola Tesla designed alternating current (AC) motors and transformers, we had the ability to generate electricity on a large scale and then transmit that electricity efficiently to many different locations. Also, hydroelectric dams were built on major waterways across the United States and served as a major source of electricity.

Wind energy has been used for centuries to power windmills that pump water, propel boats, and grind grain. Only recently we have begun harnessing wind energy to generate electricity. Currently, wind provides about 7 percent of the energy consumed in the United States.\(^2\)

Fossil fuels remain the major source of energy in the world because they are so abundant and relatively inexpensive for many energy needs. The three major fossil fuel sources are oil, coal, and natural gas. Oil provides more of the energy used by humans than any other source, and the U.S. Energy Information Administration predicts that fossil fuels will still provide 77 percent of the world’s energy in 2040.\(^3\)
An understanding of how energy is generated and measured is central to our decisions concerning the use and conservation of energy. Energy decisions are influenced by economic, political, environmental, and social factors. The quality of life for all individuals and societies is affected by our energy choices. The following chart shows U.S. energy consumption by energy source in 2017.

**World energy consumption increases for fuels other than coal**

Source: Energy Information Administration (https://www.eia.gov/pressroom/presentations/capuano_07242018.pdf)

**U.S. energy consumption by energy source, 2017**

Total = 97.7 quadrillion British thermal units (BTU)

Total = 11.0 quadrillion BTU

Because of rounding, total may not add up to 100%.

Source: Energy Information Administration
WHAT ARE THE TYPES OF ENERGY?

Whenever something moves, you can see the change in energy in that system. Energy can make things move or cause change in the position or state of an object. Energy can be defined as the capacity to cause a change or the ability to do work. Work is done when a force moves an object over a given distance. In scientific terms, energy is classified into two major types: kinetic and potential energy. Kinetic energy is defined as the energy of a moving object. A moving car, a waterfall, or a book falling off a table are examples of objects that have kinetic energy. Potential energy is defined as the energy in matter due to its position or the arrangement of its part.

**Forms of Potential Energy:**
- **Gravitational Potential Energy:** The kind of potential energy that results when something is separated from the earth.
- **Chemical Potential Energy:** The energy stored in the bonds of atoms and molecules. It is the energy that holds these particles together.
- **Elastic Potential Energy:** The energy stored in objects by the application of a force that results in the deformation of an elastic object.
- **Nuclear Energy:** The energy stored in the nucleus of an atom—the energy that binds the nucleus together.

**Forms of Kinetic Energy:**
- **Mechanical Energy:** The energy associated with the motion or position of an object.
- **Thermal Energy:** The internal energy of substances caused by vibration and movement of atoms and molecules within the substance.
- **Electrical Energy:** The energy of moving electrical charges.
- **Radiant Energy:** Electromagnetic energy that travels in waves which possess both electrical and magnetic properties.
- **Sound Energy:** The energy that is associated with the vibrations of matter and travels in longitudinal waves through an object (including air and water).

THE LAW OF CONSERVATION OF ENERGY

Within a closed system, the amount of energy must remain constant. Energy is neither created nor destroyed, but it can be transferred from one form to another. Thus when the water located at the top of a waterfall plunges over the edge, the potential energy of that water is converted to kinetic energy. The energy of an air molecule moving in the wind can be converted to mechanical energy when moving the rotor of a windmill, which then can be converted into electricity by a wind turbine generator. In almost all of these processes, some of the energy is also converted to heat energy.

All energy sources impact the natural environment in different ways. As the world’s population continues to increase, there will be a greater demand for energy. The Energy Information Agency projects a 28 percent increase in the world’s energy consumption by 2040. To meet this tremendous growth, we need to understand energy better and learn about how we might produce a sustainable energy future.
EIA projects 28% increase in world energy use by 2040.

Engage: Cobra Weave
(See worksheet: Cobra Weave)

Materials
- Popsicle sticks
- Energy in Life handout

You will begin the Engage session by demonstrating a potential-to-kinetic energy transformation using a "cobra weave." It is called the cobra weave because when it is detonated in the right direction, the chain lifts itself off the ground like a rearing snake.

1. Before class, you will construct the cobra chain. To make the chain, start by placing one popsicle stick on the ground at a 45-degree angle. Then place a second stick on top of it so that the sticks are perpendicular and intersect at the top third of each stick. Then place a third stick on top of the second so that they intersect at the bottom third of the two sticks. To lock the left end in place, take a fourth stick and weave it under the top end of the first stick, over the middle of the third stick, and under the bottom end of the third. Now just continue the pattern out on the right side. The next stick should go over the bottom end of the third stick and under the first stick. Repeat this process until the chain reaches the desired length. The sticks should all intersect at the ends or the 1/3 point on the stick. To detonate the chain, simply pull out the last piece that you added. The chain should lift up off the ground and travel like a wave until all the pieces have flown apart.

2. When class starts, ask the students to predict what they think will happen when you remove the final stick.

3. Remove the stick and have the students observe what happens.

4. The key to the chain reaction comes from the transfer of potential energy to kinetic energy. When you wove the popsicle sticks together, you were continually building potential energy. Each popsicle stick is bent over the stick before it and pinned under the stick before that. This creates tension in the wood. When you let go, it releases the tension, and potential energy is transformed into a chain reaction of kinetic energy.
ENGAGE: Energy in Life
(See worksheet: Energy in Life Handout)

EXPLORE: Ball Bounce Lab
(See worksheet: Ball Bounce Lab)

Materials
+ Meter stick
+ 2 types of balls
+ Tape
+ Lab handout
+ Calculator
+ Balance scale

Part I: Potential and Kinetic Energy Ball Bounce Lab
Recall: Energy cannot be created nor destroyed (“conservation of energy”). Potential energy is stored energy, and kinetic energy is the energy of motion. Due to gravity, potential energy changes as the height of the object changes, and this is called gravitational potential energy.

Objective: Collect data to determine the relationship between height and gravitational potential energy.

Procedure:
1. Tape the meter stick to the side of the lab table with the 100-cm end at the top of the table and the 0-cm end of the floor. Make sure that the meter stick is resting flat on the floor and is standing straight up.
2. Choose a ball type and record the ball type in the data table.
3. Use the balance scale to determine the mass of the ball and record the ball’s mass in the data table. Be sure and convert the grams into kilograms. Example: 580 g /1000 = .580 kg
4. Calculate the gravitational potential energy (GPE) for the ball at each drop height. Record GPE in data table.
   a. \[ \text{GPE} = \text{ball mass (kg)} \times 9.8 \text{ m/s}^2 \times \text{drop height in meters} \]
   b. Example:
      \[ \text{Ball mass} = 8 \text{ kg} \]
      \[ \text{Drop height in meters} = .4 \text{ m} \]
      \[ \text{GPE} = 8 \text{ kg} \times 9.8 \text{ m/s}^2 \times .4 \text{ m} = 31.4 \text{ J} \]
      \[ J = \text{Joules} = \text{kg m}^2 \text{ s}^{-2} \]
5. For Trial 1, hold the ball at a height of 40 cm, drop the ball carefully and observe the bounce height. Record the bounce height in the data table.
6. Drop the ball 3 more times from 40 cm, recording the bounce height each time, for a total of 4 drops.
7. For Trial 2, repeat steps 5 and 6, but drop the ball from a height of 50 cm. Record the 4 bounce heights in the data table.
8. For Trial 3, repeat steps 5 and 6, but drop the ball from a height of 60 cm. Record the 4 bounce heights in the data table.
9. For Trial 4, repeat steps 5 and 6, but drop the ball from a height of 70 cm. Record the 4 bounce heights in the data table.

10. For Trial 5, repeat steps 5 and 6, but drop the ball from a height of 80 cm. Record the 4 bounce heights in the data table.

11. For Trial 6, repeat steps 5 and 6, but drop the ball from a height of 90 cm. Record the 4 bounce heights in the data table.

12. For Trial 7, repeat steps 5 and 6, but drop the ball from a height of 100 cm. Record the 4 bounce heights in the data table.

13. Repeat steps 2 through 12 for a different type of ball.

14. Calculate the average bounce height of the 4 drops for each drop height. Record the average bounce height in the data table. Calculate the average bounce height for all trials.

   a. To calculate average: Add the 4 bounce heights for a trial then divide the total by 4 drops.
      
      Example for Trial 1:
      
      Drop 1 + drop 2 + drop 3 + drop 4 = Total
      Total divided by 4 = average bounce height

   b. Sample:
      
      Trial 1: 5 cm + 6 cm + 5 cm + 7 cm = 23 cm
      23 cm/4 = 5.75 cm average bounce height

15. Plot the average bounce heights on a line graph. Place the independent variable of drop height on the x-axis and place the dependent variable of bounce height on the y-axis. Label the line with the ball type.

16. Answer the discussion questions

Part II: Energy Transformations
(See worksheet: Energy Transformations)

An energy transformation is the change of energy from one form to another. Energy transformations occur everywhere every second of the day. There are many different forms of energy such as electrical, thermal, nuclear, mechanical, electromagnetic, sound, and chemical. Because the law of conservation of energy states that energy is always conserved in the universe and simply changes from one form to another, many energy transformations are taking place constantly.

Examples of Energy Transformations:

+ A toaster transforms electrical energy into thermal energy.
+ A blender transforms electrical energy into mechanical energy.
+ The sun transforms nuclear energy into ultraviolet, infrared, and gamma energy—all forms of electromagnetic energy.
+ Our bodies convert chemical energy from food into mechanical and electrical energy to allow us to move.
+ A natural gas stove converts chemical energy from burning into thermal energy used to cook food.

During this section of the Explore, students will use the PhET simulation called “Energy Forms and Changes.” Students often struggle to understand the interactions that underlie energy transformation. This simple simulation allows students to “see”
the flow of energy through a real-life system—from start to finish. They can choose sunlight, steam, flowing water, or mechanical energy to power their systems.

Use the included activity sheet for students to record their observations from the simulation.

Part III. (Optional) WATT Is Your Power?  
(See worksheet: WATT Is Your Power?)

Work and power are two important concepts that deal with energy. Work is done when a force \((F = m \times a\), where \(a\) is \(9.8 \text{ m/s}^2\)) that is applied to an object moves that object. Work (measured in Joules) is calculated by multiplying the force by the amount of movement of an object \((J = F \times d\)). Power is the rate of doing work. It is the amount of energy consumed per unit of time. In the SI system, the unit of power is the joule per second \((\text{J/s})\) known as the watt. Watt \((W)\) is calculated by taking work and dividing it by average time \((W = \text{work/average time})\).

In this activity, students will determine the amount of work done by lifting an object. They will then convert that work into power and determine how many of them it would take to light a 60-watt bulb.

Preparation:
You will need a 2L bottle filled with water for every group of 3-4 students. For each group, attach one end of the rope to the dowel rod and the other end to the bottle of water. This needs to be attached so that when you turn the dowel rod, the rope will wrap around the dowel and lift the bottle.

Activity:
Demo the activity first: Have one student hold the dowel horizontally in front of his/her body so that the bottle is not touching the floor. Have the student turn the dowel until the bottle is lifted all the way to the dowel rod.

Discuss what happened: This is a good time to review energy, work, and power and to go over the equations and units for force, work, and power. We are trying to determine power in this activity and power = work/time. \(W = \text{force \times distance}\) where \(\text{force} = \text{mass \times acceleration} \ (9.8 \text{ m/s}^2)\). Make sure the students know they need to measure the mass of the bottle in kg.

Put your students in groups of 3-4 students. Have them determine the mass of the bottle in kg. Then have each student hold the dowel rod horizontally so the bottle is not touching the floor. Measure the distance from the dowel rod to the bottle in meters. Put that value in the table on the lab handout. Then the student will twist the dowel so that the rope wraps around the dowel and lifts the bottle. Another student will time how long it takes for the person to wind the rope to bring the bottle all the way to the top of the pole. This time should be recorded in seconds and recorded on the lab handout. The student should repeat this so that three trials are recorded on the lab handout.

Repeat this process for each student in the group.

The students will then complete the table as they calculate work and power and answer the discussion questions.
EXPLAIN: Energy Transformation Matrix  
(See worksheet: Energy Transformation Matrix)

Materials:
+ Energy transformation matrix  
+ Energy transformation matrix student recording sheet  
+ Transformation cards

We have learned that there are many different forms of energy such as electrical, thermal, nuclear, mechanical, electromagnetic, sound, and chemical. Because the law of conservation of energy states that energy is always conserved in the universe and simply changes from one form to another, many energy transformations are taking place constantly. Students typically confuse energy forms and energy sources and think of “energy” as a fuel-like quantity that can be used up. Through the exploration activities we have tried to help students understand energy transfer, storage of energy, energy flow through systems, and the interactions that underlie energy transformation.

Explain session:  
Students will examine various types of energy transfer and determine the original form of energy and what form that energy is being transformed into.

Instructions:
1. Give each group (2-3 students) one matrix with arrows page and one set of Energy Transformation Cards.
2. Distribute the cards to the students as evenly as possible.
3. On their turn, each student is to place one card on the matrix and explain their reasoning. The direction of the arrows tells the student the direction of the energy transformation. Look at the example below, in the first box, the student would place an example of thermal energy transformed to mechanical energy. In the third box, the student would place an example of chemical energy transformed to thermal energy.
4. The goal is to place all of the cards on the matrix:

<table>
<thead>
<tr>
<th>Thermal (Heat)</th>
<th>Mechanical</th>
<th>Sound</th>
<th>Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal (Heat)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ELABORATE: Energy Source Project and Energy Choice Project  
(See worksheets: Energy Source Project and Energy Choice Project)

Materials:
+ Internet access  
+ Computer or tablet

It is well known that most of the energy used by the United States comes from fossil fuel sources. There are numerous other sources of energy that are available. But regardless of which energy source is used, there are benefits and hazards
associated with any use. When we try to harness those energy sources, often they are limited in availability, hazardous to the environment, and often require technology advances to make their use economically feasible. In this activity, students will research information about their assigned energy source and how that source is used to produce electrical energy. We will be able to use that information to examine the benefits and hazards of using that energy source.

**Development**

Group the students into teams of 2-3 students. Assign each group one of the following energy sources: fossil fuel, uranium, biomass, hydropower, geothermal, solar, or wind. Find the answers to the following questions:

1. What is your energy source, and where can it be found?
2. How do we capture this energy source and use it? How does it work?
3. What are the types of energy sources if there is more than one? Explain how these types are different.
4. What are the impacts that your energy source has on the environment?
5. What are the impacts that your energy source has on the economy?
6. What countries around the world are using this energy source? What percent of this energy is used by the United States?
7. What are the ways this energy source is currently used (e.g., for agriculture, for industry, etc.)? Would it be possible to use this source to provide energy for your home?
8. Have the groups create a presentation about their energy source. They will be able to choose the type of presentation from the included choice board.

The National Energy Education Development Project has a great energy information book that your students can access as one of their sources of information. It is a comprehensive classroom resource containing fact sheets that introduce students to energy and describe energy sources, electricity, consumption, efficiency, conservation, transportation, climate change, and emerging technologies. The information book can be used as a resource for many energy activities.

**EVALUATE: Energy Card Game Assessment**

(See worksheet: Types of Energy Card Game Assessment)

**Materials:**
- 1 set of picture cards for each group of 2-3 students
- 1 set of task cards

**Purpose:** This assessment is designed to determine if the student has a deeper understanding of the different types of energy. Students will examine the examples of objects (or actions) and decide which types of energy are related with that object (or action). For example, a picture of a campfire would be related to heat, light, and chemical energy. Students might also contend that sound energy is released as the wood burns and pops and crackles.

This activity encourages students to argue, justify, and defend their energy associations. Please note that as long as the student can defend and justify his/her association of an object or action, they should be given credit for a correct answer.
Assessment Card Game Procedure:

1. Make two stacks of cards face down in the middle of the group. One stack should be the picture cards, and the other stack should be the task cards.

2. Player 1 will draw 4 cards from the picture card stack and flip over one task card. Player 1 must use the cards in his or her hand to complete the task. For example, the task card might read, “Place 1 card on the table that shows something associated with both ELECTRICAL and HEAT energy.” The student must look for a card in his or her hand that meets that requirement—in that case it might be a picture of a toaster, for example.

3. After playing the card (or cards), player 1 MUST JUSTIFY to the group why the card (or cards) played is (or are) correct. Then the student will discard one picture card from the remaining cards in his or her hand and the turn will move to player 2.

4. If player 1 is unable to complete the task, he or she must discard one picture card and play moves to player 2.

5. Player 2 will then pick up the discarded picture card from player 1 as well as 3 more cards from the stack for a total of 4. If player 1 completed the task on the task card on his or her turn, then player 2 will flip another task card over from the stack. If player 1 was unable to complete the task, player 2 must try and complete it using the cards in player 2’s hand.

6. Play continues and as cards run low in the middle stacks, players can shuffle the already played cards and restack as needed.

7. A point or points can be given for each task card completed and justified successfully.

Note: Card game procedure was reprinted with permission from Marianne Dobrovolny.

As an alternate assessment, a star puzzle on energy conversions is included. The teacher cuts out the individual triangles and places them in a baggie. Each student or group of students then put the puzzle together so that adjacent sides match. The answer is shown below.
ENDNOTES

1 https://www.ancient.eu/article/991/prehistoric-hunter-gatherer-societies/

2 https://www.eia.gov/energyexplained/index.cfm?page=electricity_in_the_united_states


4 https://www.eia.gov/todayinenergy/detail.php?id=32912

WORKSHEETS
**ENGAGE: Cobra Weave Instructions**

**Materials**

- Lots of popsicle sticks

**Step 1:** Place two popsicle sticks so that they are in the shape of an X. Stick #1 will be on top and stick #2 will be on bottom.

**Step 2:** Place stick #3 so that one end goes under an end of stick #2 and the rest of it lies on top of stick #1.

**Step 3:** Place one end of stick #4 under the loose end of stick #2 so that the rest of it lies on top of stick #3.

**Step 4:** Place stick #5 under the loose end of stick #1 so that the rest of it lies on top of stick #4.

**Step 5:** Continue adding sticks in the pattern.

To end the cobra weave, add a stick under and over the last two sticks. For a handle, tie a string to the middle of the last stick before securing it to the cobra. To release the cobra weave, remove the final stick or pull on the string.
Have students complete the handout to demonstrate their understanding of potential versus kinetic energy forms.

List as many examples for each form of energy below as you can think of that are used in our lives.

**POTENTIAL ENERGY**

<table>
<thead>
<tr>
<th>Chemical Energy</th>
<th>Nuclear Energy</th>
<th>Gravitational Energy</th>
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</thead>
<tbody>
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</tbody>
</table>

**KINETIC ENERGY**

<table>
<thead>
<tr>
<th>Mechanical</th>
<th>Sound</th>
<th>Electrical</th>
<th>Thermal</th>
<th>Radiant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</table>
EXPLORE: Ball Bounce Lab Worksheet

Have students complete the handout to demonstrate their understanding of potential versus kinetic energy forms.

**Materials**
- Meter stick
- 2 types of balls
- Tape
- Lab handout
- Calculator
- Balance scale

**Procedure:**
1. Tape the meter stick to the side of the lab table with the 100-cm end at the top of the table and the 0-cm end at the floor. Make sure that the meter stick is resting flat on the floor and is standing straight up.
2. Choose a ball type and record the ball type in the data table.
3. Use the balance scale to determine the mass of the ball and record the ball's mass in the data table. Be sure and convert the grams into kilograms. (Example: 580 g/1000 = .580 kg)
4. Calculate the gravitational potential energy (GPE) for the ball at each drop height. Record GPE in data table.
   a. \( GPE = \text{ball mass (kg)} \times 9.8 \text{ m/s}^2 \times \text{drop height in meters} \)
   b. Example:
      
      \[
      \begin{align*}
      \text{Ball mass} &= 8 \text{ kg} \\
      \text{Drop height in meters} &= .4 \text{ m} \\
      GPE &= 8 \text{ kg} \times 9.8 \text{ m/s}^2 \times .4 \text{ m} = 31.4 \text{ J} \\
      J &= \text{Joules} = \text{kg m}^2 \text{s}^{-2}
      \end{align*}
      \]
5. For Trial 1, hold the ball at a height of 40 cm, drop the ball carefully and observe the bounce height. Record the bounce height in the data table.
6. Drop the ball 3 more times from 40 cm, recording the bounce height each time, for a total of 4 drops.
7. For Trial 2, repeat steps 5 and 6, but drop the ball from a height of 50 cm. Record the 4 bounce heights in the data table.
8. For Trial 3, repeat steps 5 and 6, but drop the ball from a height of 60 cm. Record the 4 bounce heights in the data table.
9. For Trial 4, repeat steps 5 and 6, but drop the ball from a height of 70 cm. Record the 4 bounce heights in the data table.
10. For Trial 5, repeat steps 5 and 6, but drop the ball from a height of 80 cm. Record the 4 bounce heights in the data table.
11. For Trial 6, repeat steps 5 and 6, but drop the ball from a height of 90 cm. Record the 4 bounce heights in the data table.
12. For Trial 7, repeat steps 5 and 6, but drop the ball from a height of 100 cm. Record the 4 bounce heights in the data table.
13. Repeat steps 2 through 12 for a different type of ball.
14. Calculate the average bounce height of the 4 drops for each drop height. Record the average bounce height in the data table. Calculate the average bounce height for all trials.
   a. To calculate average: Add the 4 bounce heights for a trial then divide the total by 4 drops.
      
      Example for Trial 1:
      
      \[
      \begin{align*}
      \text{Drop 1} + \text{drop 2} + \text{drop 3} + \text{drop 4} &= \text{Total} \\
      \text{Total divided by 4} &= \text{average bounce height}
      \end{align*}
      \]
   b. Sample:
      
      Trial 1: \( 5 \text{ cm} + 6 \text{ cm} + 5 \text{ cm} + 7 \text{ cm} = 23 \text{ cm} \)
      
      \( 23 \text{ cm}/4 = 5.75 \text{ cm} \) average bounce height
Ball Bounce Lab Worksheet cont’d

Ball 1 Mass [grams] = ____________________

<table>
<thead>
<tr>
<th>Drop Height (cm)</th>
<th>Mass (kg) x 9.8 m/s² x Height (m)</th>
<th>Gravitational Potential Energy (GPE)</th>
<th>Bounce Height (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Drop 1</td>
<td>Drop 2</td>
<td>Drop 3</td>
</tr>
<tr>
<td>40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>60</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>70</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>90</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Ball Bounce Lab Worksheet cont’d

**Ball 2 Mass (grams) = __________________________**

<table>
<thead>
<tr>
<th>Gravitational Potential Energy (GPE)</th>
<th>Bounce Height (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drop Height (cm)</td>
<td>Mass (kg) x 9.8 m/s² x Height (m)</td>
</tr>
<tr>
<td>-----------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>40</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td></td>
</tr>
<tr>
<td>80</td>
<td></td>
</tr>
<tr>
<td>90</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>
Plot the average bounce heights on a line graph. Place the independent variable of drop height on the x-axis and place the dependent variable of bounce height on the y-axis. Label the line with the ball type.

**AVERAGE BOUNCE HEIGHT**

**X axis:** Drop Height

**Y axis:** Bounce Height
Discussion Questions

1. Where was the potential energy coming from in this lab?
   ___________________________________________________________________________________
   ___________________________________________________________________________________
   ___________________________________________________________________________________

2. Where was the kinetic energy coming from in this lab?
   ___________________________________________________________________________________
   ___________________________________________________________________________________
   ___________________________________________________________________________________

3. Describe the relationship between drop height and the bounce height.
   ___________________________________________________________________________________
   ___________________________________________________________________________________
   ___________________________________________________________________________________

   Was the relationship the same for both ball types that you tested? ________________

4. Compare your gravitational potential energy to your bounce height for each trial. Describe the relationship between GPE and bounce height.
   ___________________________________________________________________________________
   ___________________________________________________________________________________
   ___________________________________________________________________________________

5. Look at the results of both ball types you tested.
   a. Which ball type had the most gravitational potential energy? _______________________
   b. Which ball type had the most mass? _____________________________________________

6. Describe the relationship between mass and GPE.
   ___________________________________________________________________________________
   ___________________________________________________________________________________
   ___________________________________________________________________________________

7. What are the variables that affect the gravitational potential energy of an object?
   ___________________________________________________________________________________

8. When did ball 1 have the most kinetic energy in this investigation?
   ___________________________________________________________________________________
   ___________________________________________________________________________________

9. Describe a real-world situation, other than bouncing a ball, to explain how energy is transferred.
   ___________________________________________________________________________________
   ___________________________________________________________________________________
10. Given the following graph of the bounce of a super ball’s height vs. time, label each box on the graph where for that particular bounce:

a. The potential energy is the greatest with PE = MAX.

b. The kinetic energy is the greatest with KE = MAX.

c. The potential energy equals the kinetic energy PE = KE.

Superball Height vs. Time

11. Each time the ball bounced up, the height that it reached was less than the previous bounce (the bounces got smaller). This tells you that you lost some energy on each bounce. Where did that energy go? 

___________________________________________________________________________________

___________________________________________________________________________________

___________________________________________________________________________________
Go to the PhET site and download the “Energy Forms and Changes” simulation:

http://phet.colorado.edu/en/simulation/energy-forms-and-changes

(Note: You can run the simulation online or you can download it to your computer.)

Run the “Energy Forms and Changes” simulation. Select the Systems button.

Click on the Energy Symbols box.

The three panels at the bottom allow you to create your own system.

The panel on the bottom left allows you to select the source of energy for your system (water flowing, sunlight, steam from a kettle, or a bicycle rider).

The bottom middle panel allows you to select either a wheel or a solar panel.

The third panel allows you to select either a beaker of water to heat, or an incandescent light bulb to light, or a fluorescent light bulb to light.

After setting up a simulation, you can use the reset button to clear your choices so that you can do a different simulation.
Use the panels at the bottom to choose devices and construct a working system that includes the wheel. As you run the simulation, please pay close attention to the energy symbols in the simulation. This will help you determine how energy is being transformed. (Remember to click on the reset button between each simulation run and make sure the energy symbols box is checked.)

For each of the energy sources that causes the wheel to spin, create an explanation of the energy transformations from start to finish. Record each of those energy chains in the space below:

1)_____________________________________________________
   ______________________________________________________
   ______________________________________________________

2)_____________________________________________________
   ______________________________________________________
   ______________________________________________________

3)_____________________________________________________
   ______________________________________________________
   ______________________________________________________

4)_____________________________________________________
   ______________________________________________________
   ______________________________________________________

Why does the bicyclist need to be fed in order for the wheel to turn?
_____________________________________________________
   ______________________________________________________
   ______________________________________________________

Now reset all and change the wheel to the solar panel. Explore with the four energy sources to see which ones will create energy transformations on the solar panel.

Which is the only source of energy that heats the water using the solar panel? ___________________

Create an energy chain that describes all the energy transformations from start to finish that occurred with the solar panel.
   ______________________________________________________
   ______________________________________________________
   ______________________________________________________
   ______________________________________________________

Now click on the reset all button and change the beaker of water to the incandescent light bulb.

What types of energy are created when the electrical current runs to the incandescent bulb? ___________________
   ______________________________________________________
   ______________________________________________________
   ______________________________________________________

Reset all and change to the fluorescent bulb. What types of energy are created when the electrical current runs through this bulb and how is it different from the incandescent bulb? ___________________
   ______________________________________________________
   ______________________________________________________
   ______________________________________________________
Materials

- Balance scale
- 2-liter bottle filled with water and connected to dowel rod
- Rope
- Timing device
- Meter stick
- Calculator

Work and power are two important concepts that deal with energy. Work is done when a force \( F = m \times a \), where \( a \) is \( 9.8 \text{ m/s}^2 \) that is applied to an object moves that object. Work (measured in Joules) is calculated by multiplying the force by the amount of movement of an object \( J = F \times d \). Power is the rate of doing work. It is the amount of energy consumed per unit of time. In the SI system, the unit of power is the joule per second \( (\text{J/s}) \) known as the Watt. The watt \( (W) \) is calculated by taking work and dividing it by average time \( (W = \text{work/average time}) \). In this activity, you will determine the amount of work done by lifting an object, you will then convert that work into power and determine how many of “you” it would take to light a 60-watt bulb.

Steps:
1. Measure the mass of the bottle in kg and record that mass in Table 2.
2. Measure the distance from the dowel rod to the bottle in meters. Put that value in Table 2.
3. Each student in your group will hold the dowel rod horizontally so the bottle is not touching the floor. The student will twist the dowel so that the rope wraps around the dowel and lifts the bottle.
4. Another student will time how long it takes for the person to wind the rope to bring the bottle all the way to the top of the pole. This time should be recorded in seconds in Table 1.
5. This should be repeated so that three trials are recorded in Table 1.
6. Calculate the average speed and record it in Table 1.
7. Repeat this process for each student in the group.

Table 1. Calculate the average time for each person

<table>
<thead>
<tr>
<th>Person</th>
<th>Time (seconds)</th>
<th>Average Time (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Discussion:
1. What is power?
2. What does it mean if one person has a higher value for power?
3. Based on your power in the chart, how many of you would it take to light a 60-watt bulb?

Table 2. Calculate the work and power in watts for each person

<table>
<thead>
<tr>
<th>Person</th>
<th>Mass (m) in kg</th>
<th>Force (N) ( f = m \times 9.8 \text{ m/s}^2 )</th>
<th>Distance (m)</th>
<th>Average time from Table 1 (sec)</th>
<th>Work (J) ( J = \text{Force} \times \text{distance} )</th>
<th>Power (Watts, ( w = \text{work/average time} )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
Material Preparation:
1. Print one matrix with arrows per group of 2 to 3 students.
2. Print and cut out one set of the Energy Transformation cards per group and place in a Ziplock bag.
3. Print one blank matrix for each student.

Instructions:
1. Give each group one matrix with arrows page and one set of Energy Transformation cards.
2. Distribute the cards to the students as evenly as possible.
3. On their turn, each student is to place one card on the matrix and explain their reasoning. The direction of the arrows tells the student the direction of the energy transformation. Look at the example below: in the first box, the student would place an example of thermal energy transformed to mechanical energy. In the third box, the student would place an example of chemical energy transformed to thermal energy.
4. The goal is to place all the cards on the matrix.
<table>
<thead>
<tr>
<th></th>
<th>Thermal (Heat)</th>
<th>Mechanical</th>
<th>Sound</th>
<th>Chemical</th>
<th>Electrical</th>
<th>Radiant (Light)</th>
<th>Nuclear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal (Heat)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sound</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Electrical</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radiant (Light)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nuclear</td>
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<td></td>
</tr>
</tbody>
</table>
## Energy Transfer Matrix Guide

<table>
<thead>
<tr>
<th></th>
<th>Thermal (Heat)</th>
<th>Mechanical</th>
<th>Sound</th>
<th>Chemical</th>
<th>Electrical</th>
<th>Radiant (Light)</th>
<th>Nuclear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal (Heat)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sound</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radiant (Light)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nuclear</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Energy Transformation Matrix Key

<table>
<thead>
<tr>
<th>Thermal (Heat)</th>
<th>Mechanical</th>
<th>Sound</th>
<th>Chemical</th>
<th>Electrical</th>
<th>Radiant (Light)</th>
<th>Nuclear</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thermal (Heat)</strong></td>
<td>Steam Turbine</td>
<td>Lightning Bolt (heats air causing it to expand resulting in thunder)</td>
<td>Burning Coal</td>
<td>Clothes Iron</td>
<td>Microwave Oven</td>
<td>Sun</td>
</tr>
<tr>
<td><strong>Mechanical</strong></td>
<td>Heat Pump</td>
<td>Vibration of Ear Drum</td>
<td>Person Running</td>
<td>Hydro-electric Dam</td>
<td>Radiometer or Toy that Dances in Sunlight</td>
<td></td>
</tr>
<tr>
<td><strong>Sound</strong></td>
<td>Playing a Violin</td>
<td></td>
<td>Talking on a Telephone</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Chemical</strong></td>
<td>Hand Warmers</td>
<td>Chewing, then Digesting</td>
<td>Fireworks</td>
<td>Battery Charger</td>
<td>Flashlight</td>
<td></td>
</tr>
<tr>
<td><strong>Electrical</strong></td>
<td>Toaster</td>
<td>Blender</td>
<td>Electric Guitar</td>
<td>Solar Calculator</td>
<td>Nuclear Power Plant</td>
<td></td>
</tr>
<tr>
<td><strong>Radiant (Light)</strong></td>
<td>Fire</td>
<td>Hand Crank Flashlight</td>
<td>Tree Growing Fruit</td>
<td>Tanning Bed</td>
<td></td>
<td>Stars</td>
</tr>
<tr>
<td><strong>Nuclear</strong></td>
<td>Heat from Radioactive Decay Used to Heat Water into Steam that Turns a Turbine</td>
<td></td>
<td></td>
<td>Nuclear Bomb</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Energy Transformation Matrix Worksheet cont’d

**Energy Transformation Cards (one set per student group)**

<table>
<thead>
<tr>
<th>Steam Turbine</th>
<th>Lightning Bolt (heats air causing it to expand resulting in thunder)</th>
<th>Burning Coal</th>
<th>Clothes Iron</th>
<th>Microwave Oven</th>
<th>Sun</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Pump</td>
<td>Vibration of Ear Drum</td>
<td>Person Running</td>
<td>Hydro-electric Dam</td>
<td>Radiometer or Toy that Dances in Sunlight</td>
<td>Playing a Violin</td>
</tr>
<tr>
<td>Hand Warmers</td>
<td>Chewing, then Digesting</td>
<td>Fireworks</td>
<td>Talking on a Telephone</td>
<td>Battery Charger</td>
<td>Flashlight</td>
</tr>
<tr>
<td>Fire</td>
<td>Hand Crank Flashlight</td>
<td>Tree Growing Fruit</td>
<td>Tanning Bed</td>
<td>Nuclear Power Plant</td>
<td>Stars</td>
</tr>
<tr>
<td>Toaster</td>
<td>Blender</td>
<td>Electric Guitar</td>
<td>Heat from Radioactive Decay Used to Heat Water into Steam that Turns a Turbine</td>
<td>Nuclear Bomb</td>
<td>Solar Calculator</td>
</tr>
</tbody>
</table>
1. What is your energy source and where can it be found?
2. How do we capture this energy source and use it? How does it work?
3. What are the types of the energy source if there is more than one? Explain how these types are different.
4. What are the effects that your energy source has on the environment?
5. What are the effects that your energy source has on the economy?
6. What countries around the world are using this energy source? What percent of this energy is used by the United States?
7. What are the ways this energy source is currently used (i.e., for agriculture, for industry, etc.)? Would it be possible to use this source to provide energy for your home?
8. Have the groups create a presentation about their energy source. They will be able to choose the type of presentation from the included choice board (see below).

Energy Project Choice Board Worksheet:
A. Create an Information Booklet
   The booklet should include at least 15 facts about the energy source you researched and definitions for any important words. The booklet should be neat and organized.
B. Create a Poster
   The poster should include at least 15 facts about the energy source you researched and definitions for any important words. The poster should be neat and organized.
C. Create a Newscast
   The newscast should include at least 15 facts about the energy source you researched. The newscast can be presented live or recorded.
D. Create a Slideshow
   The slideshow should include at least 15 facts about the energy source you researched.
Card Game Procedure:

1. Make two stacks of cards face down in the middle of the group. One stack should be the picture cards and the other stack should be the task cards.

2. Player 1 will draw 4 cards from the picture card stack and flip over one task card. Player 1 must use the cards in his or her hand to complete the task. For example, the task card might read, “Place 1 card on the table that shows something associated with both ELECTRICAL and HEAT energy.” The student must look for a card in his or her hand that meets that requirement—in that case it might be a picture of a toaster, for example.

3. After playing the card (or cards), player 1 MUST JUSTIFY to the group why the card (or cards) played is (or are) correct. Then the student will discard one picture card from the remaining cards in his or her hand and the turn will move to player 2.

4. If player 1 is unable to complete the task, he or she must discard one picture card and play moves to player 2.

5. Player 2 will then pick up the discarded picture card from player 1 as well as 3 more cards from the stack for a total of 4. If player 1 completed the task on the task card on his or her turn, then player 2 will flip another task card over from the stack. If player 1 was unable to complete the task, player 2 must try and complete it using the cards in player 2’s hand.

6. Play continues and as cards run low in the middle stacks, players can shuffle the already played cards and restack as needed.

7. A point or points can be given for each task card completed and justified successfully.

* Game card procedure reprinted with permission from Marianne Dobrovolny.
<table>
<thead>
<tr>
<th>Task Cards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Place 2 cards</strong> on the table that both show something associated with HEAT energy.</td>
</tr>
<tr>
<td><strong>Place 1 card</strong> on the table that shows something associated with 3 different forms of energy.</td>
</tr>
<tr>
<td><strong>Place 2 cards</strong> on the table that both show something associated with both MECHANICAL and SOUND energy.</td>
</tr>
<tr>
<td><strong>Place 2 cards</strong> on the table that both show something associated with CHEMICAL energy.</td>
</tr>
<tr>
<td><strong>Place 2 cards</strong> on the table that both show something associated with both MECHANICAL and SOLAR energy.</td>
</tr>
<tr>
<td><strong>Place 2 cards</strong> on the table that both show something associated with both MECHANICAL and CHEMICAL energy.</td>
</tr>
<tr>
<td><strong>Place 3 cards</strong> on the table that all show an association with SOUND energy.</td>
</tr>
<tr>
<td><strong>Place 3 cards</strong> on the table that all show something associated with both HEAT and LIGHT energy.</td>
</tr>
<tr>
<td><strong>Place 2 cards</strong> on the table that both show something associated with both ELECTRICAL and LIGHT energy.</td>
</tr>
<tr>
<td><strong>Place 1 card</strong> on the table that shows something associated with both ELECTRICAL and HEAT energy.</td>
</tr>
<tr>
<td><strong>Place 1 card</strong> on the table that shows something associated with both ELECTRICAL and CHEMICAL energy.</td>
</tr>
<tr>
<td>Task Cards</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Place 1 <strong>card</strong> on the table that shows something associated with both</td>
</tr>
<tr>
<td>ELECTRICAL and SOUND energy.</td>
</tr>
<tr>
<td>Place 2 <strong>cards</strong> on the table that shows something associated with both</td>
</tr>
<tr>
<td>MECHANICAL and ELECTRICAL energy.</td>
</tr>
<tr>
<td>Place 1 <strong>card</strong> on the table that shows something associated with both</td>
</tr>
<tr>
<td>MECHANICAL and HEAT energy.</td>
</tr>
<tr>
<td>Place <strong>2 cards</strong> on the table that both show something associated with</td>
</tr>
<tr>
<td>MECHANICAL energy.</td>
</tr>
<tr>
<td>Place 1 <strong>card</strong> on the table that shows something associated with SOLAR</td>
</tr>
<tr>
<td>energy.</td>
</tr>
<tr>
<td>Place 2 <strong>cards</strong> on the table that show NO relationship to one type of</td>
</tr>
<tr>
<td>energy (that you identify) in any way.</td>
</tr>
<tr>
<td>Place 2 <strong>cards</strong> on the table that show something associated with</td>
</tr>
<tr>
<td>MECHANICAL, SOUND, and ELECTRICAL energy.</td>
</tr>
</tbody>
</table>
### Types of Energy Card Game Assessment Worksheet cont’d

<table>
<thead>
<tr>
<th>Picture Cards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gas Grill</strong></td>
</tr>
<tr>
<td><img src="image" alt="Gas Grill" /></td>
</tr>
<tr>
<td><strong>Electric Clothes Dryer</strong></td>
</tr>
<tr>
<td><img src="image" alt="Electric Clothes Dryer" /></td>
</tr>
<tr>
<td><strong>Sunburn</strong></td>
</tr>
<tr>
<td><img src="image" alt="Sunburn" /></td>
</tr>
<tr>
<td><strong>Grill</strong></td>
</tr>
<tr>
<td><img src="image" alt="Grill" /></td>
</tr>
<tr>
<td><strong>LaserJet Printer</strong></td>
</tr>
<tr>
<td><img src="image" alt="LaserJet Printer" /></td>
</tr>
<tr>
<td><strong>Solar Panels</strong></td>
</tr>
<tr>
<td><img src="image" alt="Solar Panels" /></td>
</tr>
<tr>
<td><strong>Forest Fire</strong></td>
</tr>
<tr>
<td><img src="image" alt="Forest Fire" /></td>
</tr>
<tr>
<td><strong>Plants Growing</strong></td>
</tr>
<tr>
<td><img src="image" alt="Plants Growing" /></td>
</tr>
<tr>
<td><strong>Sun</strong></td>
</tr>
<tr>
<td><img src="image" alt="Sun" /></td>
</tr>
<tr>
<td><strong>Refrigerator</strong></td>
</tr>
<tr>
<td><img src="image" alt="Refrigerator" /></td>
</tr>
<tr>
<td><strong>Old Faithful Geyser</strong></td>
</tr>
<tr>
<td><img src="image" alt="Old Faithful Geyser" /></td>
</tr>
<tr>
<td><strong>Energy Drinks</strong></td>
</tr>
<tr>
<td><img src="image" alt="Energy Drinks" /></td>
</tr>
</tbody>
</table>
### Types of Energy Card Game Assessment Worksheet cont’d

<table>
<thead>
<tr>
<th>Picture Cards</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Playing the Drums</td>
<td>Flashlight</td>
<td>Yelling</td>
</tr>
<tr>
<td><img src="image1" alt="Drums" /></td>
<td><img src="image2" alt="Flashlight" /></td>
<td><img src="image3" alt="Yelling" /></td>
</tr>
<tr>
<td>Computer</td>
<td>Putting a Golf Ball</td>
<td>Solar Vehicle</td>
</tr>
<tr>
<td><img src="image4" alt="Computer" /></td>
<td><img src="image5" alt="Golf Ball" /></td>
<td><img src="image6" alt="Solar Vehicle" /></td>
</tr>
<tr>
<td>Tractor</td>
<td>Rainbow</td>
<td>Bell</td>
</tr>
<tr>
<td><img src="image7" alt="Tractor" /></td>
<td><img src="image8" alt="Rainbow" /></td>
<td><img src="image9" alt="Bell" /></td>
</tr>
<tr>
<td>Electric Drill</td>
<td>Batteries</td>
<td>Ceiling Fan</td>
</tr>
<tr>
<td><img src="image10" alt="Drill" /></td>
<td><img src="image11" alt="Batteries" /></td>
<td><img src="image12" alt="Ceiling Fan" /></td>
</tr>
<tr>
<td>Picture Cards</td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Candle Burning</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image1.png" alt="Candle Burning" /></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Playing Violin</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image2.png" alt="Playing Violin" /></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>iPod</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image3.png" alt="iPod" /></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Soccer</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image4.png" alt="Soccer" /></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Playing Pool</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image5.png" alt="Playing Pool" /></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Light Bulb</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image6.png" alt="Light Bulb" /></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Waterfall</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image7.png" alt="Waterfall" /></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fruit</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image8.png" alt="Fruit" /></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Vegetables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image9.png" alt="Vegetables" /></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Coal</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image10.png" alt="Coal" /></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gasoline</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image11.png" alt="Gasoline" /></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
TEACHER OVERVIEW

In order to be more efficient with our energy resources, we need to be sustainable in our practices. This means wasting as little energy as possible so that we can be both environmentally and economically friendly. Texas is an untapped reservoir of energy efficiency. In some of our leading industries, the percentage of energy rejected is close to or exceeding the amount of energy that is actually being used.

### Efficiency of Texas energy consumption in 2014

![Graph showing energy consumption and efficiency in Texas in 2014](source)

The total amount of energy rejected is so vast that it would be able to power every household in Texas for more than four years. What’s more, it could power the city of Houston for 65 years, the city of Austin for 151 years, and the city of Waco for a staggering 1,153 years. Imagine the difference we could make if we could make our current resources go further. Cutting down on energy waste frequently means capturing excess energy for another purpose. The transportation sector generates the most wasted energy, generally in the form of heat. If that heat can be captured and used in another process, the amount of waste is reduced and energy is used more efficiently. However, capturing heat and finding a productive use for it adds cost and may not be economically efficient in every situation, especially if driven by government incentives such as tax breaks rather than by the free market.

### Use of Energy

Using external energy sources is a human activity. Unlike other organisms, we transform our environment by capturing external energy sources and use those energy sources for food preparation; to light our homes, schools, and other buildings; to warm and cool our enclosed spaces; to power technology; to transport us as well as goods from place to place; and generally to live the lives to which we are accustomed.

Knowledge of various energy sources, efficiency of the sources, capture of energy, abundance, and availability can and will alter our reliance on single-source energy supplies. The results of this knowledge will become more critical as we discover all energy sources have pros and cons associated with them.

### Renewable and Non-renewable Energy

It is important that we understand that all environmental issues are complex and interrelated. Three pivotal components of all environmental studies—environmental, social, and economic—must be addressed. Cessation of all non-renewable energy
sources would be devastating to us socially as well as economically because renewable energy sources generally lack the efficiency of the mineral-based fuels such as oil, natural gas, and coal we primarily rely on today.

For these and other reasons, there is debate as to the renewability and non-renewability of energy sources.

A definition of renewable energy might include terms such as, “replaced or replenished by natural sources” or “not depleted by moderate use.” However, when we consider the manufacture of components used in some renewable energy sources such as solar or wind, we find they are not completely renewable and often depending on large scale mining of rare earth minerals in remote places around the world. Additionally, the environmental footprint of some renewable energy sources may exceed the footprint of some energy sources considered to be non-renewable.

Non-renewable energy may be defined as “an energy source that exists in a fixed amount in our environment,” such as fossil fuels. With recent discoveries and technological advancements, some non-renewable energy sources may be more plentiful than previously thought and be able to be harnessed while protecting the environment.

**ENERGY SOURCES**

The following chart details where Texans get their energy.

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Trillion BTU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Interstate Flow of Electricity</td>
<td></td>
</tr>
<tr>
<td>Other Renewables</td>
<td></td>
</tr>
<tr>
<td>Biomass</td>
<td></td>
</tr>
<tr>
<td>Hydroelectric Power</td>
<td></td>
</tr>
<tr>
<td>Nuclear Electric Power</td>
<td></td>
</tr>
<tr>
<td>Other Petroleum</td>
<td></td>
</tr>
<tr>
<td>Residual Fuel</td>
<td></td>
</tr>
<tr>
<td>Jet Fuel</td>
<td></td>
</tr>
<tr>
<td>Distillate Fuel Oil</td>
<td></td>
</tr>
<tr>
<td>Motor Gasoline excl. Ethanol</td>
<td></td>
</tr>
<tr>
<td>Natural Gas</td>
<td></td>
</tr>
<tr>
<td>Coal</td>
<td></td>
</tr>
</tbody>
</table>

Source: Energy Information Agency

**ENGAGE: Sources**

This activity will give students an idea of how much they rely on energy sources every day and where that energy comes from. Place the students in small groups of 2 - 4. Give them 5 - 10 minutes to list all the ways they have used energy that day.

**Guiding questions:**
- What does the word energy mean? *(The ability to do work)*
- What does the word work mean? *(A force causing an object to move)*
- Does energy only refer to electricity? *(No)*

As a large group, have the students determine general purposes for energy: transportation, light, cooking, heating or cooling, entertainment, cleaning, etc. Then have the groups classify their brainstormed lists according to general purposes. This step could spark some discussion and debate. For example, watching TV or using a computer could be classified as entertainment. It could also be classified as a way to gain information. Guide their discussions by suggesting that there could be more...
than one correct answer. Encourage them to back their ideas with proof. If a student argues that watching TV is an example of entertainment, their proof might be that they watch a specific TV show.

Have each group record their ideas on a chart of their design.

**EXPLORE: Energy Mind Map Activity**  
*(See worksheet: Energy Mind Map)*

In this explore activity, the students will become familiar with a variety of energy sources. The activity is flexible enough that it can be assigned multiple ways: individually, in groups, whole class. If the teacher assigns each group or individual to only complete one mind map about a single energy source, it is important that they share their findings with others.

The National Energy Education Development Project has a great energy information book that your students can access as one of their sources of information. It is a comprehensive classroom resource containing fact sheets that introduce students to energy, and describe energy sources, electricity, consumption, efficiency, conservation, transportation, climate change, and emerging technologies. The information book can be used as a resource for many energy activities.

**EXPLAIN: Natural Gas**

The Explain activity will trace Texas’ largest energy source, natural gas, from its formation to one of many uses. Start the activity with a quick demonstration to ensure student understanding of one of the concepts involved in the formation of natural gas. This activity can be done as a teacher demonstration for a whole class or in small groups for a more hands-on approach. The supplies that you need are:

- An empty 2-liter soda bottle, label removed
- An unopened condiment package
- Water

Before starting the demonstration, drop the condiment package into a cup of water to make sure that it will only slightly float. For the demonstration, fill the soda bottle completely full with water. Drop the condiment package into the bottle and seal the bottle with the lid. Have the students make some observations.

Then, squeeze the sides of the bottle. This will make the condiment package drop to the bottom of the bottle. Questions to ask include—

- Why do you think the condiment package was floating at first? *(Answers might include that it is less dense or that there is air in the package.)*
- What changes do you see in the outside of the packet? *(Depending on the type of packet used, you may notice the outside of the packet becomes wrinkled when you squeeze the bottle.)*
- What do you think caused the package to drop to the bottom when the bottle was squeezed? *(Pressure caused the compaction of the molecules in the packet which caused the packet to become more dense. When the pressure is released, the molecules will spread apart again, making the packet less dense.)*

This demonstration shows how natural gas can be removed from underground wells. The natural gas is compressed and when that pressure is released, the gas becomes less dense and will flow upward toward the surface where it can be removed and processed.
**ELABORATE: Poster Activity**

For this activity the students will be making a close examination of two different viewpoints of an energy source. Texas is the only state in the nation with its own electric grid. Most electricity generated in Texas is sold into a wholesale market regulated by the Electric Reliability Council of Texas, or ERCOT. The electricity is then bought by a variety of retail electric providers, distributed through transmission lines and sold to end consumers such as homeowners, businesses, and industry. This means that the electricity used by those customers comes from a variety of sources including coal, natural gas, nuclear, wind, solar, biomass, and hydroelectric energy. Divide the class into groups and assign one of the above energy sources to each group. Have the students work individually or in pairs to create a poster that explores the pros and cons to their assigned energy source. Topics to cover should include—

+ Availability of resource
+ Cost
+ Pollution
+ Impact to plant and animal habitat
+ Renewability

The following chart identifies how Texans get their electricity.

**Texas electricity sources, 2016**

![Chart showing electricity sources in Texas, 2016](chart.png)

*Source: Energy Information Agency*

**EVALUATE: Town Hall Meeting**

*(See worksheet: Town Hall Meeting)*

To give students an opportunity to examine the issues surrounding using fossil fuels or alternative energy sources to supply our electricity needs, the students will participate in a mock town hall meeting. Each student will be randomly assigned a part to play. After assigning their parts, give the students class time to research all sides of the issue, discuss with like-minded citizens of the community what their opinions are, and come up with a statement that expresses their viewpoint.

**ADDITIONAL LEARNING ACTIVITIES**

*(See worksheet: Additional Learning Activities)*

+ Take a walk around your school and make notes about where you find signs of energy usage (power lines, neon signs, phone lines, office buildings or stores, street lamps, cars). Ask students where they think the energy comes from. Do they think it is renewable or non-renewable?
Energy Bumper Sticker: Ask students to bring magazines and newspapers from home. Divide the class in teams according to the number of energy sources studied in class. Ask the students to create a bumper sticker of a specific energy source assigned to them. Ask them to write their specific energy source in big letters in the center of the bumper sticker. Allow them to use different artistic skills as desired to illustrate the following:

- **a.** What the energy source is;
- **b.** How that energy source can be used in transportation;
- **c.** Which energy resources could be substituted for it.

After completion of the bumper sticker, promote a class discussion by allowing the students to share with the class what they have created and analyzed. Reveal things that could be done to save energy and money. Have students complete chart.

---

**ENDNOTES**

WORKSHEETS
EXPLORE: Energy Mind Map Worksheet

Complete an Energy Mind Map for your assigned energy source using this guide.

- **ENERGY TYPE**
  - Describe this energy source.

- Description of the process that changes the energy to a form we can use.

- What are some pros of using this type of energy?

- What type of environment is best for this type of energy?

- What are some cons for using this type of energy?

- Do you think this energy source would be useful where you live?
Complete an Energy Mind Map for your assigned energy source following the guide.
Natural gas can be used for many things, including: heating homes, cooking, generating electricity, fueling vehicles, and manufacturing plastics.

Millions of years ago small organisms called Phytoplankton lived in the ocean. Phytoplankton gets its energy from the sun.

The gas made its way slowly upward through permeable layers of rock to the surface unless it reached a layer it couldn’t get through.

Pressure from the layers of sediment covering the ancient organisms, along with heat, changed the decaying organisms into natural gas.

People drill gas wells to collect the natural gas.

The gas is transported to a processing plant where it is cleaned and made ready for use.

Phytoplankton and the Zooplankton that ate it sank to the bottom of the sea when it died.
Phytoplankton and the zooplankton that ate it sank to the bottom of the sea when it died.

Pressure from the layers of sediment covering the ancient organisms, along with heat, changed the decaying organisms into natural gas.

The gas made its way slowly upward through permeable layers of rock to the surface unless it reached a layer it couldn't get through.

People drill gas wells to collect the natural gas.

The gas is transported to a processing plant where it is cleaned and made ready for use.

Natural gas can be used for many things, including heating homes, cooking, generating electricity, fueling vehicles, and manufacturing plastics.
**Town Hall Meeting**

You are a member of the Texas town of Live Oak Hollow. Live Oak Hollow is a small farming and ranching community. There is a nearby Texas state park that has a small lake for fishing and canoeing. People visit the park during the spring, summer, and fall months to camp and hike. Because of the nearby state park, Live Oak Hollow has a few businesses that are attractive to tourists: a motel, several restaurants, and a bait shop. Even though the park brings visitors to Live Oak Hollow, the town’s population is slowly shrinking. Most of the recent high school graduates have moved away in hopes of finding better jobs. As a result, several of the businesses in Live Oak have had to close.

The mayor of Live Oak Hollow has called a town hall meeting to discuss a potential new business. Bluebonnet Gas Company has located a large natural gas reservoir near town. They are interested in adding several gas wells and a small gas processing plant outside of town. They would also need to build an office building in town.

Your teacher has given you a new identity. After you have read the card, complete the information below. You may discuss your ideas with other people.

Why would you be interested in going to a town hall meeting about the possibility of Bluebonnet Natural Gas coming to Live Oak Hollow?

Would you be for or against having Bluebonnet Natural Gas build several gas wells and a processing plant? Why?

Prepare a statement to read at the town hall meeting. You will only have 3 minutes to make your case for or against plans to bring Bluebonnet Natural Gas to Live Oak Grove.
## Community Member Identity Cards

<table>
<thead>
<tr>
<th>Name</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mayor Reeves</strong></td>
<td>- Has lived in Live Oak Hollow all his life.</td>
</tr>
<tr>
<td></td>
<td>- Started working for local construction company after graduating from Live Oak High School.</td>
</tr>
<tr>
<td></td>
<td>- Now owns his own construction company in addition to being town mayor.</td>
</tr>
<tr>
<td><strong>Gloria James</strong></td>
<td>- Truck driver.</td>
</tr>
<tr>
<td></td>
<td>- Her commercial driver’s license (CDL) allows her to drive a truck of any size, including trucks carrying hazardous materials.</td>
</tr>
<tr>
<td></td>
<td>- Drives long distances for her job.</td>
</tr>
<tr>
<td><strong>Maybell Reeves</strong></td>
<td>- Wife of Live Oak Hollow mayor.</td>
</tr>
<tr>
<td></td>
<td>- Owns small downtown beauty parlor.</td>
</tr>
<tr>
<td></td>
<td>- Employs three other people in her shop.</td>
</tr>
<tr>
<td></td>
<td>- Most customers are older women who get their hair done every Saturday.</td>
</tr>
<tr>
<td><strong>Dr. Ian Sutherland</strong></td>
<td>- Has a medical clinic in Live Oak Hollow.</td>
</tr>
<tr>
<td></td>
<td>- Concerned about the number of children in Live Oak Hollow who have asthma.</td>
</tr>
<tr>
<td><strong>John Highlander</strong></td>
<td>- Teaches biology and environmental sciences at Live Oak High School.</td>
</tr>
<tr>
<td></td>
<td>- Camps and hikes during the summer.</td>
</tr>
<tr>
<td></td>
<td>- Favorite hobby is wildlife photography.</td>
</tr>
<tr>
<td><strong>Larry and Judy Holtzer</strong></td>
<td>- Own ranch just outside of Live Oak Hollow.</td>
</tr>
<tr>
<td></td>
<td>- Large natural gas reservoir is under their property.</td>
</tr>
<tr>
<td></td>
<td>- Do not own mineral rights to their land.</td>
</tr>
<tr>
<td><strong>Sid Davis</strong></td>
<td>- Owns and operates small motel on the edge of Live Oak Hollow.</td>
</tr>
<tr>
<td></td>
<td>- His motel has 16 rooms, but usually only 2 or 3 are rented out at one time.</td>
</tr>
<tr>
<td></td>
<td>- Very interested in bringing more tourists to Live Oak Hollow.</td>
</tr>
<tr>
<td><strong>Eliza Johnston</strong></td>
<td>- Owns Bean There Coffee Shop downtown.</td>
</tr>
<tr>
<td></td>
<td>- Coffee shop serves breakfast and lunch daily.</td>
</tr>
</tbody>
</table>
MAVIS STRAYHORN
- Naturalist.
- Home is several miles out of town.
- Has installed solar panels on her roof.
- Has water collection system.

LEO PENA
- Family has lived in Live Oak Hollow for many years.
- Retired machinist who worked in a factory 20 miles away.
- Recently elected to the city council.

JUNE FISCHER
- Started small business at her home just outside of town.
- Raises and sells organic vegetables.
- Interested in adding beehives and harvesting honey to sell.
- Live Oak Creek is an important water source for her garden.

CARLOS GARZA
- Supervisor for state park close to Live Oak Hollow.
- Park has small lake that attracts fishermen as well as migrating birds.

GRACE ALONZO
- Checker at Live Oak Hollow grocery store.
- Mother of two young children.
- Takes children to state park to hike and fish.

EDITH PLUNKETT
- President of 1st National Bank in Live Oak Hollow.
- Most of the bank’s business involves small bank accounts for individuals and personal loans.
- Needs large commercial accounts for her bank to grow.

MARIAN WOOD
- 1st grade teacher at Live Oak Elementary School.
- Has noticed in recent years that the number of students at school is shrinking because young families are moving away to find better jobs.

CLIVE PULLMAN
- Owns engine repair shop.
- Business primarily involves repairing vehicles driven by Live Oak Hollow residents.
- Can also repair large truck engines.
JUNIOR PEREZ
- Family recently moved to Live Oak Hollow to help take care of his elderly grandmother.
- Works for offshore drilling company and spends three out of every four weeks on a drilling rig in the Gulf of Mexico.

JASPER REED
- Plant manager for Bluebonnet Natural Gas Company in Juniper Grove.
- Has come to Live Oak Hollow to see about the possibility of expanding the company and building an office and natural gas processing plant in Live Oak Hollow.

SHELBY MOORE
- Office manager for Bluebonnet Natural Gas Company in Juniper Grove.
- Would live in Live Oak for a few months to help hire and train new office staff if Bluebonnet Gas Company opened office and plant in Live Oak.

JAMES AND LISSA MARTIN
- Own and operate lawn care and landscaping company.
- Design and maintain flowerbeds and other green spaces for businesses and homeowners in Live Oak Hollow.

MARILYN SMITH
- Has worked for Bluebonnet Natural Gas Company for 27 years.
- Started out as field service technician and has worked her way up to be a safety inspector.
- Would move family to Live Oak Hollow if Bluebonnet built new plant there.

TERRANCE DEAVERS
- Works as mechanic for Bluebonnet Natural Gas Company.
- Would move to Live Oak Hollow if Bluebonnet Natural Gas built plant there.
- Would become head mechanic for the company if Bluebonnet Natural Gas built plant in Live Oak Hollow.
## Additional Learning Activities Worksheet

### Energy Use and Reduction Table

<table>
<thead>
<tr>
<th>Energy Use Activity</th>
<th>How does this reduce energy use?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live close to regular activities such as work and school.</td>
<td></td>
</tr>
<tr>
<td>Use your body’s energy rather than another energy source—walk, ride a bicycle, use stairs.</td>
<td></td>
</tr>
<tr>
<td>Buy local food whenever possible—it’s more than just a healthy option.</td>
<td></td>
</tr>
<tr>
<td>Line-dry laundry.</td>
<td></td>
</tr>
<tr>
<td>Turn off lights, computers, appliances when not in use.</td>
<td></td>
</tr>
<tr>
<td>Keep thermostat lower in winter and higher in summer.</td>
<td></td>
</tr>
<tr>
<td>Buy fewer disposable items and items with less packaging.</td>
<td></td>
</tr>
<tr>
<td>Insulate homes and climate-controlled structures.</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td></td>
</tr>
</tbody>
</table>
Unit 3

ENERGY RESOURCES
TEACHER OVERVIEW
Units 1 and 2 focused on energy resources and energy efficiency. They explored energy and its forms and the costs and benefits of energy resources that are currently available. Unit 3 explores in depth the energy resources that are abundant in Texas. Texas is at the forefront of the energy industry in the nation, both with natural resources and refining capacity.

TEXAS ENERGY RESOURCES
The state of Texas is fortunate to have a rich supply of renewable and non-renewable energy sources. Here are some quick facts about energy in Texas according to the U.S. Energy Information Administration¹:

- In 2016, Texas was the leading crude-oil producing state, producing more than a third of the nation’s crude oil.
- As of January 2017, the 29 petroleum refineries in Texas had a capacity of over 5.6 million barrels of crude oil per day and accounted for 30 percent of total U.S. refining capacity.
- Texas accounted for over 25 percent of U.S.-marketed natural gas production in 2016, making it the leading natural gas producer among the states.
- Texas leads the nation in wind-powered generation capacity with more than 21,450 megawatts since 2014. Texas wind turbines have produced more electricity than both of the state’s two nuclear plants.
- Texas is the nation’s largest producer of lignite coal. About 40 percent of the coal-fired power plants in Texas burn lignite for electricity generation.

Table 1. Texas primary energy production by source (201)²

<table>
<thead>
<tr>
<th>Source</th>
<th>TRILLION BTU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>5000</td>
</tr>
<tr>
<td>Natural Gas- Marketed</td>
<td>8000</td>
</tr>
<tr>
<td>Crude oil</td>
<td>7000</td>
</tr>
<tr>
<td>Nuclear Electric Power</td>
<td>3000</td>
</tr>
<tr>
<td>Biofuels</td>
<td>2000</td>
</tr>
<tr>
<td>Other Renewable Energy</td>
<td>1000</td>
</tr>
</tbody>
</table>

Source: Energy Information Agency
Table 2. Texas primary energy consumption by end-use sector (2016)  

24.8%  
12.6%  
12.2%  
50.4%  

Commercial  Residential  Industrial  Transportation  

Source: Energy Information Agency

ENGAGE: Where in Texas?  
(See Worksheet: Where in Texas?)

This activity will acquaint the students with the location of natural resources and power plants in Texas. Discuss as a class where the energy used every day comes from.

Objective
The objective of this unit is to—

+ Familiarize students with the location of natural resources and power plants in Texas;
+ Investigate how natural resources such as water, oil, and natural gas are stored underground in rocks;
+ Delve deeply into the primary energy resources; and
+ Investigate how hydraulic fracturing (fracking) has made massive oil and gas resources available.

Materials

+ Worksheet Where in Texas?  
+ Computer with internet access  
+ Pencil  
+ Colored pencils  
+ Texas map

Guiding questions:

+ Does your local city have its own power plant? (At this point they may not know.)
+ What natural resource is used to produce the electricity? (Accept any ideas they have.)
+ Where does that natural resource come from? (Answers will vary; at this point, accept their ideas.)
+ Where does the gasoline come from that powers their parents’ cars?

Students probably will not know the answers to these questions at this point. The idea is to get them started thinking about the natural resources we have in Texas and how they are used to produce the energy we use every day.
Place the students in groups of two with one computer per group and make sure all have located the website http://www.eia.gov/state/?sid=TX. You may have to guide them in using the map. There is a tremendous amount of information on the map that can be observed by checking and unchecking different layers. The worksheet questions are designed to help them observe closely and make connections between different map layers.

After completing the activity, discuss the questions as a whole class. Emphasize any ideas that have changed from before exploring the map.

**EXPLORE: Making a Sedimentary Rock & Porosity and Permeability of Rock**

*See worksheets: Making a Sedimentary Rock and Porosity and Permeability of Rock*

The fossil fuels that are so abundant in Texas are found stored in sedimentary rocks, which are formed from bits and pieces of other rocks and may include sand, clay, pebbles, seashells, and pieces of organic matter such as leaves. These bits and pieces settle out of water or are deposited by wind and build up in thick layers so that the lower layers are under great pressure. Then minerals in water flowing through the buried sediments crystalize and bond the pieces into solid rock. The rock layers which form deep in the earth may then be uplifted and exposed at the surface. In the Texas Panhandle, Palo Duro Canyon was formed during the Pleistocene as the Prairie Dog Town Fork of the Red River cut down into rock layers that were deposited millions of years ago. The rock layers exposed in the canyon include sandstone, shale, siltstone, and conglomerate, and most of those visible were deposited during the Permian and Triassic periods. Fossils of animals such as phytosaurs, amphibians, fish, saber-toothed cats, rhinoceroses, and tortoises are found in different layers. The type of animal fossils found in a rock formation tells us something about the environment when the sediments were deposited.

Lab Activity 1, **Making a Sedimentary Rock**, has students model lithification, or one way sedimentary rocks are formed. After the “rocks” have dried, guide students in observing their rocks. Ask questions such as: Can you see the salt? How does it hold the pieces together? Are there spaces between the particles? What would represent fossils?

Give students some common materials such as a kitchen sponge, a block of Styrofoam, a block of wood, etc., and a cup of water and a dropper (or a dropper bottle). Do not tell them what to do; ask them what they are going to do. They should conclude that they can put a drop of water on the different materials and see what happens to each. Is the water absorbed, or does it just sit on top of the object? Encourage them to observe the objects closely and try to figure out why the water does what it does.

Ask them guiding questions and encourage them to talk with each other to try to figure out what to do and why the water responds differently on different objects. Then introduce Lab Activity 2, **Porosity and Permeability of Rock**. Have students predict what each of the samples they are given will do when water is added to them.

**Notes:**

- Be sure to use gym chalk (magnesium carbonate) and not chalkboard chalk (calcium carbonate) for this activity. The chalkboard chalk dissolves too easily. You can order the gym chalk online or perhaps borrow some from the gymnastics team if your school has one.
Rock samples need to be small enough to fit into the graduated cylinder in order to find their volume. You may need to break them up if they are too large. It is okay to use several small pieces rather than one larger piece.

The water displacement method can be used to find the volume of the rock (an irregular solid). Water’s density is 1 g/mL, so 1 gram of water has a volume of 1 cm$^3$ or 1 mL. For water: 1 g = 1 cm$^3$ = 1 mL

Other types of rock can be used, e.g., scoria or basalt. Just be sure to include sandstone and shale so that the relationship to drilling for oil is clear.

This activity is modified from the Rock Porosity Experiment developed by Tori Hellmann, UCAR AirWaterGas Teacher-in-Residence and found online at AirWaterGas NSF Sustainability Research Network.

EXPLAIN: Infomercial and/or Energy Resources Foldable
(See worksheet: Energy Source Infomercial, Energy Resources Foldable)

For this activity, students will develop an infomercial about Texas energy resources. Divide the class into nine groups. Assign each group an energy source: biomass, coal, geothermal, hydroelectric, natural gas, nuclear, petroleum, solar, and wind. Discuss what an infomercial is with the class. (An infomercial is a long commercial that offers consumer information on a product as it entertains, often following the format of a TV program.) Ask them to describe any they remember, and discuss what makes an infomercial entertaining and notable. (Do they have a celebrity pitching the product? Are they funny? Do they have catchy tunes or catch phrases?)

Have each group research its energy source using websites such as

- http://www.eia.gov/kids/energy.cfm?page=2
- http://seco.cpa.state.tx.us/energy-sources/
- http://www.seco.cpa.state.tx.us/schools/infinitepower/docs/fact-sheet07.pdf

Each group will then create an infomercial of approximately 5-6 minutes in length with the objective of convincing the viewer to use their energy resource. The infomercial should demonstrate the advantages of your energy source. You may choose to have them present their infomercial live to the class (using PowerPoint for background images) or to record their infomercial using a camera, iPad, or phone and then play it for the class to view.

Note:

You may need to emphasize that this assignment is actually a takeoff on infomercials. Where TV infomercials are basically trying to persuade people to buy something that they may not really want or need, the students are presenting factual information about an important energy resource.

There is a free (to students) online storyboard creator, Storyboard That, that you may choose to have your students use to design their infomercial:

For ideas on the structure of this activity, we thank the folks at http://www.omro.k12.wi.us/faculty/Jbish/sports/Infomercial%20Project.pdf.
Texas is rich in natural energy resources. As we saw in the Engage activity, we have abundant fossil fuels, especially oil and natural gas, as well as renewable resources such as wind, solar, and biomass. Over the last decade, there has been a surge of interest in utilizing the rich resources of shale plays, which are large shale formations containing significant amounts of natural gas along with some oil. In Texas, the Eagle Ford (south Texas), Barnett (Dallas-Fort Worth area), Barnett-Woodford (Permian Basin in west Texas), Wolfberry (Permian Basin), and Haynesville-Bossier (east Texas) cover hundreds of thousands of acres. Because shale is a “tight” rock (impermeable), the gas and oil stored there have been unavailable through traditional vertical drilling. However, the process of hydraulic fracturing, or fracking, opens the shale or other tight rock and enables the oil and gas to flow into the well and up to the surface. Fracking fluid is injected into the well at high pressure to start the oil and gas flowing. Fracking fluid is mostly water but also contains a mixture of chemicals, and a proppant such as sand to “prop” the fracture open. The wells can be drilled either vertically or horizontally. Horizontal wells begin with a vertical wellbore, and then the hole is gradually turned horizontally to follow the gas- and oil-containing formation. There may be several horizontal components from the original vertical wellbore, and they may cover several miles. The Barnett Shale was the first in Texas to use horizontal drilling and hydraulic fracturing to produce oil and gas from the dense shale rock.

Students should be introduced to the process of shale formation, and the location of Texas shale plays through the slide show Shale 101.

In order to understand how hydraulic fracturing helps remove the oil and gas from shale, do the activity Model Fracking. To prepare for this activity, the gelatin needs to be mixed, poured, and cooled the day before. For each gelatin bottle, put about 1 cup cold water into a 2-cup glass measuring cup, and empty the 4 packets of gelatin into the water. Allow to sit for a couple of minutes; then stir. Heat the water one minute on high in the microwave and stir to make sure all the gelatin is dissolved. Add another cup of cold water and stir. Pour the gelatin into a clean 18-20 oz. plastic bottle, and place in the refrigerator to cool.

Introduce the activity by showing the students a diagram of a stratigraphic column containing a deep shale play. Discuss with students how and where they might drill to reach the deposit, reminding them that they can only drill about a 10-inch hole to reach the shale.

Here is an example from the Texas Panhandle. The red and green areas are the bed which contains the oil and gas. Help the students to locate the area shown in the cross-section on the map in the lower right corner.
Lead the discussion to consider how more of the formation could be reached beyond the access of a vertical well since the shale is impermeable.

Then pass out materials and have students follow instructions to model the hydraulic fracturing (“fracking”) process.

Figure 1. Bottle of gelatin with large straw inserted
Figure 2. Making holes in smaller straw
Figure 3. Fracked gelatin

EVALUATE: Texas Energy Resources Foldable
(See worksheet: Texas Energy Resources Foldable Worksheet)
ENDNOTES


2. https://www.eia.gov/state/?sid=TX#tabs-3


4. These activities were adapted from (1) Sedimentary Rock, an activity from Rockology 101 developed by the Rogers Group: http://www.rogersgroupincint.com/IndustryResources/Rockology101Activities/ActivitySedimentaryRock/tabid/105/Default.aspx; (2) https://www.airwatergas.org/resources/curriculum/rock-porosity-experiment/.

5. This activity is modified from Make a Fracking Model Activity, developed by UCAR AirWaterGas Teachers-in-Residence Shelly Grandell, Tori Hellman, and Rebecca Bradford and available online at https://www.airwatergas.org/resources/curriculum/make-a-fracking-model-activity/.

For a more detailed description of the hydraulic fracturing ("fracking") process, visit these sites:
http://www.fracfocus.org/hydraulic-fracturing-process
http://www.usgs.gov/hydraulic_fracturing
http://www2.epa.gov/hydraulicfracturing
WORKSHEETS
ENGAGE: Where in Texas? Worksheet

In this activity we will explore where natural resources and power plants are located in Texas.

Materials

- Computer with internet access
- Pencil
- Colored pencils
- Texas map

Procedure:

1. Go to http://www.eia.gov/state/?sid=TX.
2. Enlarge the map to full screen by clicking on the arrows in the bottom right corner of the map.
3. Enlarge Texas to fill most of the screen using the scroll bar in the upper left corner of the screen. (Use the Escape button on your keyboard to get out of the large view and go back to the web site.)
4. In the upper right corner, click on the Layers/Legend tab. When it opens, click on the red X to remove all symbols.
5. Under Map Layers, click on the box next to All Coal Mines. Notice where they are and mark them on your map using a black triangle.
6. Uncheck the Coal Mines and check a different power plant type.
7. Create a color/shape key for each of the types of power plant in the table below.
8. Go down to All Power Plants and click on Biomass Power Plant. On your map, mark where these power plants are located. Count approximately how many there are and then uncheck them.
9. Do the same for each of the following types of power plants: Coal, Geothermal, Hydroelectric, Natural Gas, Nuclear, Petroleum, Solar, and Wind.

<table>
<thead>
<tr>
<th>Power Plant Type</th>
<th>Key</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coal</td>
<td>▲</td>
<td></td>
</tr>
<tr>
<td>Geothermal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydroelectric</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural Gas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nuclear</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Petroleum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Map of Texas
1. On the Layers, scroll down to Fossil Resources and check Coal Field. Very lightly with the pencil, shade in the areas of Texas on your map which have coal fields.

2. Uncheck the Coal Field and check the Tight Oil/Shale Gas Play. Lightly enclose these areas with the pencil and fill with hatch marks.

3. Uncheck the Tight Oil/Shale Gas Play and check the Sedimentary Basin. Lightly enclose these areas with pencil and fill with dots.

Note: These Fossil Resource areas may overlap in places.

4. Now uncheck the Sedimentary Basin and go to the Oil and Gas Wells and Platforms and check the Oil and Gas Wells. Notice where they are located. If you zoom in close, you can distinguish individual wells. The brown dots are oil wells and the blue dots are gas wells.

5. Uncheck the Oil and Gas Wells, go to Oil/Gas Refining and Processing and check Petroleum Refinery. Where are most of the refineries located?

Think about where the oil and gas wells are located and where the Petroleum Refineries are located.

1. Why are the refineries located where they are?

2. How does the oil and gas get to the refineries? To find out, click on the Pipelines and Transmission button and look at where the different kinds of pipelines are located. You can click on each kind of pipeline individually and see where they go.

3. Uncheck the Petroleum Refinery and the Pipelines and Transmission boxes, go to Oil/Gas Refining and Processing, and check the Natural Gas Processing Plant. Where are they located?

4. Now check the Natural Gas Power Plant and see how the two are related.

5. Uncheck Natural Gas Power Plant and check Geothermal Potential. Notice the locations of the shaded areas.

6. Uncheck the Geothermal Potential.
Answer the following questions:

1. Which type of power plant is most common in Texas? Why do you think that might be?

_______________________________________________________________________________________
_______________________________________________________________________________________

2. How many geothermal power plants are located in Texas? Why do you think that is the case?

_______________________________________________________________________________________
_______________________________________________________________________________________

3. Where are hydroelectric power plants located? Why?

_______________________________________________________________________________________
_______________________________________________________________________________________

4. Most wind power plants are located in the west/northwest part of Texas. Why do you think this type of power plant is located near Abilene and Amarillo and not near Houston or Tyler?

_______________________________________________________________________________________
_______________________________________________________________________________________

5. Texas only has a few solar power plants, mostly located near Austin and San Antonio. Why do you think Texas has not invested in more solar power?

_______________________________________________________________________________________
_______________________________________________________________________________________

6. How does the location of the oil and gas wells relate to the location of the tight oil/shale gas plays and the sedimentary basins?

_______________________________________________________________________________________
_______________________________________________________________________________________

7. Where are most of the petroleum refineries located? Why do you think they are located there?

_______________________________________________________________________________________
Problem: How do sedimentary rocks form?

Introduction

Sedimentary rocks are formed from bits and pieces of other rocks and may include sand, clay, pebbles, seashells, and pieces of organic matter such as leaves. These bits and pieces settle out of water or are deposited by wind and build up in thick layers. Then minerals in water flowing through the buried sediments crystalize and bond the pieces into solid rock. The rock layers may then be uplifted and exposed at the surface. In the Texas Panhandle, Palo Duro Canyon was formed as the Prairie Dog Town Fork of the Red River cut down into rock layers that were deposited millions of years ago. The rock layers exposed in the canyon include sandstone, shale, siltstone, and conglomerate. Fossils of animals such as phytosaurs, amphibians, fish, saber-toothed cats, rhinoceroses, and tortoises are found in different layers. The type of animal fossils found in a rock formation tells us something about the environment when the sediments were deposited.

Materials

+ Bowl or container for mixing materials.
+ Sand, silt, clay, small gravel, and a few crushed shell pieces and crushed dry leaves.
+ Epsom salt.
+ 250mL beaker.
+ Spoon.
+ Small paper cup.
+ Water.
+ Hand lens.
+ Rock samples such as sandstone and shale.

Procedure

1. Measure 50mL of Epsom salt in the dry beaker and pour into the mixing bowl.
2. Measure 100mL of water in the beaker and pour into the mixing bowl.
3. Stir until most of the salt is dissolved.
4. In the paper cup, place about 3-4 cm of the mixture ingredients and mix thoroughly. Add enough of the salt solution to just cover the sand mixture. Mix well.
5. Let the mixture stand until dry (2-3 days).
6. After the mixture is dry, cut off the paper cup.
7. Observe the “rock” closely. Can you see the salt? How does it hold the sand together? How does the rock you created compare to the actual rock samples?
EXPLORE: Porosity and Permeability of Rock Worksheet

Introduction
Oil, gas, and water may be held in and/or move through rocks. How is this possible? In this lab activity, we will examine porosity and permeability of different types of rocks.

Materials
+ Kitchen sponge
+ Block of Styrofoam
+ Block of wood
+ Cup of water
+ Dropper or dropper bottle.

Put drops of water on various materials. Why does water respond differently?

Sedimentary rocks are able to hold fluids (liquids and gases) because of the physical properties of porosity and permeability. Porosity is the term used to describe how much pore space (space between the grains) is in the rock. Permeability refers to the ability of the fluids to move through the rock. Therefore, porosity describes the ability of the rock to hold a fluid and permeability is the measure of how easily the fluid can flow through the rock.

In drilling for oil and gas, conventional drilling extracts oil and gas that flow easily through rock and collect in areas where they can easily be brought to the surface by drilling vertical wells. Unconventional drilling methods, including horizontal wells and hydraulic fracturing (fracking), involve pumping a mixture of water, sand, and chemicals into the well at high pressure in order to create fissures in the shale rock, which increases permeability and allows the hydrocarbons to escape.

In this experiment, we will demonstrate how different types of rock absorb water and relate this to where oil and gas are found.

Materials (per group)
+ Small pieces of gym chalk (magnesium carbonate*)
  marble, pumice, granite, sandstone, and shale.
+ 6 small clear plastic cups (8 oz. size)
+ Graduated cylinder (250 mL if available)
+ Electronic balance (or triple-beam if electronic is not available)
+ Water
+ Paper towels
+ Plastic wrap
+ Graph paper

* Note: Be sure to use gym chalk, NOT chalkboard chalk.

Problem
Which of the rock types hold the most water after being soaked for several days? How does this relate to the porosity of the rocks?

Prediction: ____________________________________________________________________________
**Procedure**

1. Find the mass of each rock sample and record in the data table.
2. Determine the volume of each rock sample using water displacement and record.
3. Label each plastic cup with the type of rock, then place 200mL of water in each cup.
4. Place each rock sample in its designated cup and leave it submerged for 10 minutes.
5. After 10 minutes, remove each sample from its cup and dry off excess water with paper towels, find the mass of each and record. Replace the sample in its cup.
6. Repeat every 10 minutes for the rest of the class period.
7. After the last measurement, cover each cup with plastic wrap.
8. After 1 day, dry each sample, find its mass and record. Return samples to cups and cover.
9. Repeat step 8 twice more.
10. After the 72-hour measurement, clean up your materials and complete Data Table 1.

**DATA TABLE 1**

<table>
<thead>
<tr>
<th>ROCK TYPE</th>
<th>VOLUME OF ROCK (mL)</th>
<th>INITIAL MASS (g)</th>
<th>Mass after ...</th>
<th>OVERALL CHANGE IN MASS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>10 min.</td>
<td>20 min.</td>
</tr>
<tr>
<td>Marble</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chalk</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pumice</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sandstone</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shale</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Granite</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

11. Complete Data Table 2, graph your results and answer the conclusion questions.

**Calculations**

To find the porosity of each rock sample, compare the change in the mass of the rock sample to the volume of the rock sample. The change in mass relates to the volume of water absorbed by the rock, because for water, 1g = 1cm³ = 1mL.

Use the following formula:

**Overall change in mass = Volume of water absorbed**

**Volume of water absorbed ÷ Volume of rock sample x 100 = Percent Porosity**

Example: Water absorbed was 7mL, and the volume of the rock sample was 35mL. **7mL ÷ 35 mL x 100 = 20%**
DATA TABLE 2

<table>
<thead>
<tr>
<th>ROCK TYPE</th>
<th>TOTAL VOLUME OF WATER ABSORBED</th>
<th>VOLUME OF ROCK (FROM TABLE 1)</th>
<th>PERCENT POROSITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marble</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chalk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pumice</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sandstone</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shale</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Granite</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Conclusions

1) Which rock had the highest percent porosity? ______________________________________

2) Which type of rock has the potential to hold the most water, oil, or gas? Explain why.
____________________________________________________________________________________

3) If you were looking for a rock formation to hydraulically fracture to find oil or gas, which type of rock formation would you choose and why? Choose from granite, shale, or sandstone. (Hint: think about how porous each of these rocks is and how each was formed.)
____________________________________________________________________________________

4. When a well is drilled and fracked, it often goes down through many layers of rock, including sandstone, shale, and limestone, before reaching the layer of shale that contains oil and gas. Concrete is poured down around the outside of the well, forming a casing all the way down. Why is this important? (Think about the porosity of the different kinds of rock.)
____________________________________________________________________________________

This activity is modified from the Rock Porosity Experiment developed by Tori Hellmann, UCAR AirWaterGas Teacher-in-Residence, and located at AirWaterGas NSF Sustainability Research Network, [https://www.airwatergas.org/resources/curriculum/rock-porosity-experiment/](https://www.airwatergas.org/resources/curriculum/rock-porosity-experiment/).
An infomercial is a long commercial that offers consumer information on a product as it entertains, often following the format of a TV program. Infomercials try to sell everything from jewelry and clothes to special car waxes to exercise tapes and diet foods.

Facts about infomercials:
1. The infomercial industry is worth over $200 billion.
2. Any infomercial 15 minutes or longer must disclose to viewers that it is a paid advertisement.
3. Political candidates may use infomercials to “sell” their views.

**The Assignment:** You and your partners will create an infomercial of approximately 5-6 minutes in length with the objective of persuading the viewer to use your energy resource. The infomercial should demonstrate the advantages of your energy source. You may choose to present your infomercial live to the class (using PowerPoint for background images) or to record it using a camera, iPad, or phone and then play it for the class to view.

You will want to include an introduction, an informative section, a demonstrative section, and a persuasive section, with transitions between sections. Finally, you will need to have a conclusion summarizing the main points.

**Team Name:** ___________________________________________________________________

**Energy Resource:** ___________________________________________________________________

### EXPLAIN: Energy Source Infomercial Worksheet

<table>
<thead>
<tr>
<th>INFOMERCIAL</th>
<th>POSSIBLE POINTS</th>
<th>EARNED POINTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length: Infomercial lasted at least 5 and no more than 6 minutes.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Organization: Information was presented in a logical sequence.</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Knowledge: Infomercial demonstrates full understanding of the energy resource.</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Content: Infomercial explained advantages/benefits of using the energy resource</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Presentation: Enthusiastic and attention-getting. Used props to make infomercial realistic.</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Professionalism: Infomercial shows reactivity and speakers are easy to understand.</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Average from peer evaluations.</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td><strong>Total Points</strong></td>
<td><strong>70</strong></td>
<td></td>
</tr>
</tbody>
</table>

Comments:
**Storyboard for the Infomercial**

Your storyboard must be completed and approved before the creation of PowerPoint slides or filming of the infomercial begins. It is the place to plan what is going to happen in your infomercial, and it consists of images and narration lined up in sequence. You will start with your title and end with your credits (your names). In between, you will illustrate what will be shown as you are saying what you have written in the audio. If you are doing a video and if you have time and the necessary skill, you may edit your video on the computer and add music.

Remember that your objective is to give factual information about your energy resource and to persuade the viewer that it is the best and that they should use it.

---

**Task Completion Form**

<table>
<thead>
<tr>
<th>Task Completion Form</th>
<th>Check when finished</th>
</tr>
</thead>
<tbody>
<tr>
<td>Researched energy resource and took notes</td>
<td></td>
</tr>
<tr>
<td>Planned presentation and completed storyboard</td>
<td></td>
</tr>
<tr>
<td>Had teacher okay storyboard</td>
<td></td>
</tr>
<tr>
<td>Planned any props that will be needed and who will bring them or found pictures to use</td>
<td></td>
</tr>
<tr>
<td>Practiced the infomercial to be sure it will fit in the time frame</td>
<td></td>
</tr>
<tr>
<td>Filmed infomercial or created PowerPoint using your storyboard</td>
<td></td>
</tr>
<tr>
<td>Presented infomercial to the class</td>
<td></td>
</tr>
</tbody>
</table>

---

**Storyboard Layout**

There is a free (to students) online storyboard creator, Storyboard That, that you may choose to have your students use to design their infomercial: [http://www.ilovefreesoftware.com/29/windows/internet/free-online-storyboard-creator-storyboard-that.html](http://www.ilovefreesoftware.com/29/windows/internet/free-online-storyboard-creator-storyboard-that.html).
<table>
<thead>
<tr>
<th>Audio</th>
<th>Audio</th>
</tr>
</thead>
</table>

**EXPLAIN**: Energy Source Infomercial Worksheet cont’d
EXPLAIN: Energy Source Infomercial Worksheet cont’d

Student Evaluation of Infomercial

Group Names ____________________________________________________________________________

1. Engagement – did the infomercial hold your interest?
   😊 😊 😋

2. Knowledge – did the infomercial demonstrate that the producers understand the resource?
   😊 😂 😢

3. Significance – did the infomercial convince you of the advantages and benefits of using the energy resource in Texas?
   😊 😂 😢

4. Visual aids – did the infomercial use plentiful visual aids that helped explain the presentation?
   😊 😂 😢

5. Overall rating – what did you think?
   😊 😂 😢

6. Identify one good part of the infomercial. Keep it positive! ________________________________

7. Identify one area in which the infomercial could be improved. (You must identify one area!) __________________
Introduction

Shale deposits containing abundant energy resources are often thousands of feet deep within the Earth. They are considered unconventional reservoirs because the shale is impermeable and does not let the oil and gas travel through it into a well. In order to extract the oil and gas, the shale must be fractured, or broken up, creating pathways for the fluids to travel. In this activity, you will model how hydraulic fracturing enables the oil and gas to be brought to the surface. You will see how horizontal drilling enables the shale to be stimulated to produce more oil and gas.

Materials (per group)
+ 4 packets of unflavored gelatin
+ 2 cups of water
+ 1 empty 20 oz. plastic bottle, rinsed
+ Plaster of Paris (to represent the fracking fluid)
+ Large diameter straw (e.g., smoothie or florist straws)
+ Smaller (drinking) straw to fit inside the larger straw
+ Packing tape
+ Ruler
+ Thumb tack
+ Syringe, 35mL
+ Small bowl and spoon for mixing plaster
+ Paper towels

Procedure

1. Mix the gelatin the night before, pour into plastic bottle and chill overnight.
2. Prepare the fracking tube by taking the longer, thinner straw and use a thumb tack to poke 5 holes on each side of the straw in a straight line. Start about 10mm from one end of the straw and make a hole every 5mm on each side. Use a small piece of packing tape to seal the end of the straw nearest the holes.
3. Lay the bottle of gelatin on its side.
4. Insert the large straw, rotating it slowly to bore a hole a little over half of the way to the bottom of the bottle. (Do NOT go all the way to the bottom.)
5. With your thumb over the end of the straw, twist and pull it out slowly so that the gelatin core will come out with the straw. You may have to reinsert and pull again to get all the gelatin.
6. Remove the gelatin core from the straw and carefully reinsert the large straw into the bore hole. It will represent the well casing. Cut off the end of the large straw, leaving about an inch above the mouth of the bottle.
7. Prepare the plaster of Paris by mixing 2 parts plaster to 1 part water, making enough to fill the syringe and straw. (1/2 cup of plaster mixed with 1/4 cup water makes enough for a 35mL syringe.)
8. Remove the plunger from the syringe and put aside. Pinch the end of the straw just above the holes and carefully fill the syringe and straw with the plaster of Paris (fracking fluid) using the syringe as a funnel to fill the straw. You may have to tape it to get the air out of the straw. You can tape the straw to the syringe at this point or just hold it firmly. Reattach the plunger to the syringe without pushing the fracking fluid out. (You may have to dip a little of the plaster out of the syringe. Be sure to have paper towels handy.)
9. Now insert the perforated end of the smaller straw into the well casing straw until the smaller straw extends about 3cm past the end of the borehole straw.
10. Using firm, steady pressure on the plunger, inject the fracking fluid into the gelatin. Observe the fracture pattern of the gelatin.
11. You may leave the fractured gelatin until the plaster hardens and then cut away the bottle and discard the gelatin. The plaster cast of the fracture pattern can then be observed.
12. Sketch and label your model.
Conclusions

- There are ways in which this model represents hydraulic fracturing and ways in which it does not represent actual fracturing. Think about both the gelatin part of the model and the plaster part. Explain what makes and does not make them good simulations of the actual process.

- What does the large straw represent? What would well casing actually be made of in oil wells?

- Can you think of any improvements to the model that would make it more realistic? What are they?

- If you made the fracturing fluid a different density, how might it affect the fracture patterns formed?

- Actual fracturing fluid contains sand grains or other particles. Why are they necessary? (Remember that actual fracturing may be taking place a mile or more underground.)

- Why do oil and gas companies use hydraulic fracturing? What advantages does it have for oil and gas production?
EVALUATE: Texas Energy Resources Foldable Worksheet

Directions
Construct your Accordion Book, following your teacher’s directions. Make the first page your title page, decorating it as you choose. Then each page will be titled one of the energy resources and given the following information. Decorate each page with a drawing to represent the form of energy. On the last page, write a paragraph (5-10 sentences) giving your opinion of what energy resource is the most practical for use in Texas and why.

Neatness and completeness are important!

Texas Energy Resources: biomass, coal, geothermal, hydroelectric, natural gas, nuclear, petroleum, solar, and wind.

On each resource page include the following information:
+ Name of resource.
+ Description/definition – what kind of energy does it produce?
+ Renewable/non-renewable.
+ Advantages and disadvantages of use.
+ Illustration.
+ Where is it found/used?

Grading Rubric

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<th>EARNED POINTS</th>
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Life:Powered is an initiative of the Texas Public Policy Foundation, informing the national discussion about energy resources and advocating for energy policies that promote economic freedom and advance the human condition. By utilizing our abundant, reliable, and affordable energy resources, we promote human health, combat poverty, and improve the quality of life for all people.