



Lesson 3: Energy Takes Many Forms

Overview

Students revisit the energy descriptions and maps they made for the interaction stations in Lesson 2 and identify the forms of energy involved. Students begin to consider the energy transformations that take place as energy is transferred.

Teacher Background

Students are becoming more and more aware that energy is always a “player” when changes occur. Nothing happens without energy; it is always present. While we cannot “see” energy, we can see its evidence. Furthering students’ ability to recognize the involvement of energy through exploration of its different forms is the main focus of this lesson.

Energy is found in many different forms. Commonly identified forms of energy are mechanical (motion), gravitational potential, thermal, chemical, electrical, radiant, and elastic (stored mechanical). As noted in the *National Science Education Standards*, “the natural and designed world is complex; it is too large and complicated to investigate and comprehend all at once (National Research Council, 1996).” Scientists, depending on their purpose, create boundaries and define smaller units of investigation. This approach allows the study of particular ideas and phenomena in a manner that is convenient and manageable. Such organization can make an idea more accessible and aid in its comprehensibility. As teachers and students look to outside resources that describe forms of energy, they may notice differences in the number and complexity of energy forms presented. For example, some consider sound a form of energy. Others view sound as “evidence” of energy as opposed to a form, the idea being that we hear sound because something is moving. This is an example of the nature of the discrepancies teachers and students may encounter as they look to different resources for information regarding forms of energy. Discrepancies, for the reasons discussed above, should not cause apprehension or confusion but rather should be viewed as alternate perspectives or ways of organizing information, putting boundaries around an abstract and complex topic.

Another distinction used in categorizing forms of energy is potential and kinetic energy. Potential energy can be thought of as energy that is stored or energy that is available to make things happen.



Chemical, gravitational potential, and elastic (stored mechanical) energy are examples of potential energy. Some scientists avoid use of the word "stored" because it inaccurately depicts energy as a something that is contained within a substance. Some prefer to describe potential energy as energy available to make things happen, but not bringing about change at the moment. In other words, potential energy is capable of bringing about change but that change hasn't happened yet. An object's potential energy exists because of its position, nature the arrangement of its parts (its chemical make up), and it is energy that is available for use. Kinetic energy refers to the energy of motion. It is the energy of objects that are in motion. Mechanical (motion), thermal, electrical, and radiant energy are examples of kinetic energy. Consider reviewing the article "What is Energy" from Teachers' Domain for additional clarification on energy forms. http://www.teachersdomain.org/assets/wgbh/hew06/hew06_doc_lpawhatenergy/hew06_doc_lpawhatenergy.pdf

The concept of energy transfer is made explicit in this lesson. Students become familiar with different forms of energy and use this information to describe energy transfers from energy sources to energy receivers. They become aware that as energy is transferred, it can change form, or in other words, it can be transformed. Students add this lens to their energy picture as they reexamine the interaction station work from Lesson 2.

This summary from the research base of *Benchmarks for Science Literacy* indicates that students may view energy transfers and transformations linearly and notes the challenges students have in identifying the involvement of certain energy forms: "Middle- and high-school students tend to think that energy transformations involve only one form of energy at a time (Brook & Wells, 1988). Although they develop some skill in identifying different forms of energy, in most cases their descriptions of energy change focus only on forms that have perceivable effects (Brook & Driver, 1986). The transformation of motion to heat seems to be difficult for students to accept, especially in cases with no obvious temperature increase (Brook & Driver, 1986; Kesidou & Duit, 1993). Finally, it may not be clear to students that some forms of energy, such as light, sound, and chemical energy, can be used to make things happen (Carr & Kirkwood, 1988). (*Benchmarks for Science Literacy*, p. 338)."

In this lesson, students are encouraged to modify the way they have been mapping the energy transfers by adding details to show energy transformations involving more than one form more accurately. For example, students could show the involvement of multiple energy forms by using multiple arrows side-by-side rather than arrows positioned in sequence. Students may not yet readily recognize or accept that heat is almost always given off as energy transfers occur. This will be made more explicit in Lesson 5.



Initially, students may view energy interactions simplistically. As students learn to recognize different forms of energy, they will begin to extend their thinking to include such things as the transfer of chemical energy in the food they eat to the motion of energy in their muscles, which in turn is transferred to the spring (coil) in the Wind Up Car as it is twisted or compressed, and so on. Students' understanding of energy transfers may vary greatly. As students reexamine their interaction station descriptions and maps, push them to provide as much detail as they can, including forms and transfers for which they observe evidence. When discussing students' findings, accept reasonable explanations and focus on students' rationale rather than highlighting one "correct" energy map for each interaction.



Key Ideas

- Energy exists in many forms.
- Energy can move from one place, object, substance, or system to another.
- Energy can change from one form to another.

Lesson Goals

Students will:

- identify and describe different forms of energy including chemical, elastic, electrical, gravitational potential, heat, light, and motion.
- recognize that energy moves from place to place and changes forms to make things happen.



Vocabulary

chemical energy: the energy stored in a material's chemical make up.

elastic (stored mechanical) energy: energy stored in objects or substances when they are stretched or compressed.

electrical energy: the energy in the movement of an electric charge.

energy transformation: energy changing forms.

energy transfer: the movement of energy from one object, substance, or system to another.

gravitational potential energy: the energy something has due to its place or position.

kinetic energy: energy in motion

mechanical/motion energy: the energy of moving objects.

potential energy: energy that is available, ready to be used but is not bringing about change at the moment (stored energy).

radiant energy: energy that moves in waves.

thermal energy: the collective energies (kinetic and potential) of molecular motion of a substance. Atoms and molecules make up all substances, and these atoms and molecules are always moving. The higher the temperature, the faster the atoms and molecules that make up the substance are moving and thus the more thermal energy the substance has. The amount of thermal energy a substance has takes into account the amount of matter in the substance. The greater the amount of matter, the more thermal energy a substance has. This is why an iceberg contains more thermal energy than a cup of boiling water.

Preparation

- Become familiar with the descriptions of the forms of energy on Student Handout 3.1. Make a set of Forms of Energy cards for each student. Consider copying the Student Handout 3.1 on to cardstock for added durability. Bind sets together with a paper clip or place them in an envelope or small resealable bag. Have students put their names on the backs of their cards. Alternatively, have students research the different forms of energy and create an interactive graphic organizer (Foldable) that they can use as a reference throughout this lesson. See steps 2 and 3 for more details.
- Keep interaction stations accessible to students. While it is not necessary to set up the stations around the classroom, students may find it helpful to investigate the interactions a second time as they reexamine their energy descriptions and maps.
- Become familiar with the types of energy transfers and transformations students are likely to identify as they review the interaction stations maps and work through the “Energy Scenes.” Teacher Resources 3.1 and 3.2 describes some of the transfers and transformations that students may notice.
- Prepare two overhead transparencies of Student Handout 3.2: Frayer Model Template or create a copy of the framework on chart paper if using this portion of the lesson (See Step 8).



Safety

As noted in Lesson 2, make certain that a safe source of heat (ex: a lamp and not an open flame) is used when demonstrating the paper spiral. Be certain to hold or hang the spiral several inches away from the heat source to prevent catching the paper on fire. Teachers and students should wear safety goggles when using the poppers. If using a sound tube in Station 6, provide ample space for students to swing tube without hitting others. Hot tap water is sufficient for Station 7.

Materials

Item	Quantity
For demonstration: <ul style="list-style-type: none">• Wind Up Car• Lamp with incandescent light bulb	1
Scientist's Notebook	1 per student
Accessibility to Interaction Stations from Lesson 2	1 set
Student Handout 3.1: Forms of Energy	1 set cut into cards for each student
Student Handout 3.2: Frayer Model Template	2 per student and 2 for teacher
Student Handout 3.3: Energy Scenes	2 scenes per student minimally
Chart paper	½ sheet for each student pair plus a few extra sheets
Markers	1 per group of students
Teacher Resource 3.1: Interaction Stations Teacher Notes Identification of Energy Sources, Receivers, and Forms	1 for teacher
Teacher Resource 3.2: Energy Scene Teacher Notes	1 for teacher
Computer with internet access (optional, for additional research on forms of energy)	1 per student



Time Required: 3 sessions

- Session 1: Teacher introduces forms of energy, review of key terms; students discuss energy forms in small groups
- Session 2: Groups meet to select one energy description from their prior station work, and discuss and map description on chart paper to share
- Session 3: Teacher and students debrief energy descriptions and maps and work on energy scenes.

Connection to *National Science Education Standards (NSES)*, *Benchmarks for Science Literacy (BSL)*, and *Maine Learning Results (MLR)*

- Describe several different types of energy forms including heat energy, chemical energy, and mechanical energy. MLR D3 (6-8) h
- Energy appears in different forms and can be transformed within a system. Motion energy is associated with the speed of an object. Thermal energy is associated with the temperature of an object. Gravitational energy is associated with the height of an object above a reference point. Elastic energy is associated with the stretching or compressing of an elastic object. Chemical energy is associated with the composition of a substance. Electrical energy is associated with an electric current in a circuit. Light energy is associated with the frequency of electromagnetic waves. BSL 4E/M4 (6-8)
- Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. Energy is transferred in many ways. NSES B(5-8) 7
- Electrical circuits provide a means of transferring electrical energy when heat, light, sound, and chemical changes are produced. NSES B(5-8) 10





Teaching The Lesson

Engage

1 Review goals of Lesson 2

Draw the energy map for the Wind Up Car on the board. Refer to the map as the outcomes of Lesson 2 are reviewed.

Energy Source		Energy Receiver
twisted spring	→	car's gears connected to wheels

Say to students: *In the previous lesson, you investigated how objects at different stations were “interacting” by observing what happened in each station. You made claims and supported these claims with evidence. You identified the energy sources and energy receivers. As you identified the energy sources and energy receivers, you included arrows to represent the presence of energy in these interactions.*

Ask students: *Could we see energy in these different situations? Use this question to remind students that we cannot “see” energy but we can detect evidence of energy – evidence was the focus of Lesson 2. Students supported their claims with evidence of changes they observed as they worked through the various stations. Use the example of the plastic bag to illustrate this idea.*

Ask students: *How did you know energy was involved as the bits of paper “jumped up” and stuck to the plastic shopping bag? Could you see the energy? Reinforce the idea that we cannot see energy but rather the evidence of energy - we observe a change. Remind students that energy is the ability to change an object or substance in some way. In the case of the plastic bag, energy changed the motion of the paper.*



2 Introduce forms of energy.

Explain to students that in this lesson, we will be studying more closely the nature of energy in the interactions (point to the arrows in the maps). Explain to students that it is easier to take notice of evidence of energy if they are able to recognize some of the different forms energy takes and the characteristics of these forms. Note that scientists categorize energy into different groups most often referred to as “forms of energy” and that many of these forms may be familiar.

Provide each student with a set of “Forms of Energy” cards.

Give students a few minutes to work in pairs to review the descriptions and brainstorm additional examples of the different energy forms. As students examine the cards, discuss the following:

- Which of these forms are you already familiar with?
- What are some of the similarities between the various forms?
- What are some of the differences between the various forms?

Instruct students to add their own examples to the cards by drawing a representative picture for each example. Check for accuracy.

3 Introduce kinetic and potential energy.

Students may have already noticed that some of the forms described are stored forms of energy and some are *moving forms* of energy. Explain to students that scientists often categorize different forms of energy into two groups: potential energy and kinetic energy.

Discuss the terms “potential” or “kinetic.” Students are likely to be familiar with the word “potential” in its general sense – perhaps as it is used to describe something or someone “having potential.” In this sense, it is referring to something that could develop or result. Example: With a little practice, she has the potential to become a competitive swimmer. Ask students what they think “potential energy” might refer to. Share with students that potential energy can be thought of as energy that is stored or available to make things happen but is not bringing about change at the moment. Explain to students that potential energy is capable of bringing about change but that change hasn’t happened yet. Its energy potential exists because of the object’s position or because of the arrangement of parts (its chemical make up). Also explain that because we can’t see or touch energy this idea is very difficult to understand even for adults!

Take the same approach with the term “kinetic.” Kinetic is most likely not as familiar to students but they may be familiar with kinetic sculptures, toys or “kinesthetics” as in physical education. Explain that kinetic energy refers to energy of motion. It is the energy of objects that are in motion.

As potential and kinetic energy are being examined, demonstrate the difference using a simple example such as dropping a basketball. When the basketball is held in a person’s hands, ready to be released, it has a certain amount of potential energy due to its position. (The notion that something has energy due to its position is challenging for students). As the ball is released, its potential energy changes (is transformed) into kinetic energy.

Ask students, in pairs, to reexamine the Forms of Energy cards and group the forms into two piles – kinetic and potential. Ask students record their groupings in their scientists’ notebooks along with



a brief note about why each was put into a particular category. Students could be asked to organize their ideas about energy forms and kinetic and potential energy by making a tabbed interactive graphic organizer. (See example in photo at the right.)

Alternatively or as reinforcement, provide students with the names of different forms of energy and have them conduct their own research. Students could be asked to organize their ideas about energy forms and kinetic and potential energy by making a tabbed interactive graphic organizer.



Explore

4 Demonstrate mapping forms of energy.

Redirect students' attention to the energy map for the Wind Up Car drawn on the board.

Develop more fully the idea that energy can move from object to object (be transferred) and as it does so, it can change forms (be transformed). Explain to students that momentarily they will revisit their interaction station energy descriptions and maps from the previous lesson, focusing on the forms of energy involved in each of the stations. They will also begin examining transfers and transformations of energy involved.

As the ideas of energy transfer and energy transformation are developed, post a description of them as a reference for students as they work through the next few lessons. Students typically confuse the two terms.

Before introducing students to the process for adding forms of energy to their maps, remind students of the following:

- During an interaction, something is the supplier of the energy (the energy source) and something is the receiver of energy. (Students have already identified the energy sources and receivers in the stations.)
- The movement of energy from source to receiver is referred to as an energy transfer.
- In all of the stations, energy transfers occurred.
- Arrows were used to represent energy transfers.

Students will add the forms of energy involved in each station to their maps. Use the following example to demonstrate how students will do this:

In the case of the Wind Up Car, the spring (coil) is twisted or compressed. Ask students to refer to their Forms of Energy cards to identify the form of energy stored in the twisted spring. Have students add the specific form or form(s) to their maps as shown.



Ask students to describe the energy transfer that takes place once the spring is released (stored mechanical energy is transferred to mechanical (motion) energy). Add this detail to the map as shown.

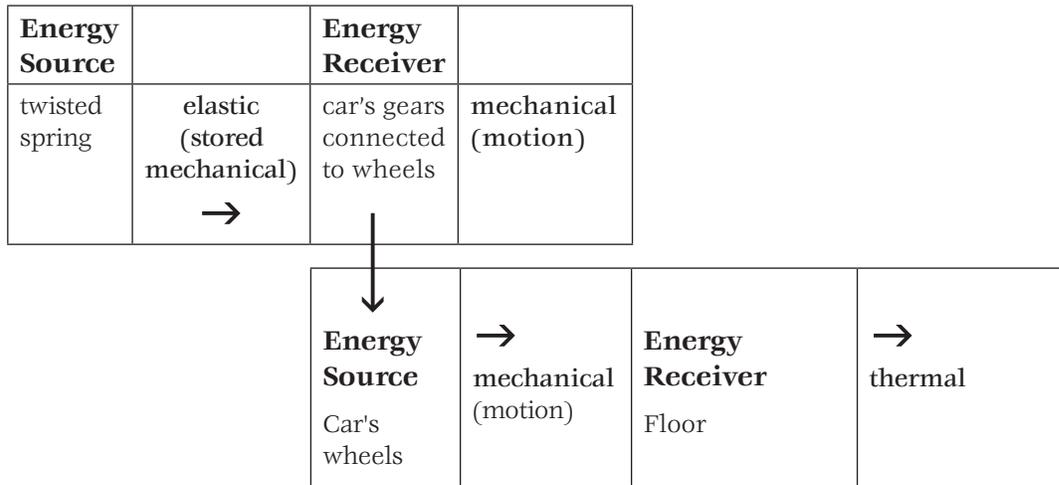
Energy Source		Energy Receiver	
twisted spring	elastic (stored mechanical) →	car's gears connected to wheels	mechanical (motion)

Reaffirm that the map has become more descriptive of what is happening with energy in this situation.

Ask students what they think happens to the mechanical (motion) energy of the wind up car.

Where does it go? Do energy transfers stop? (The car's mechanical energy is transferred to the floor as thermal energy because there is friction between the floor and the car's wheels. Make sure that students recognize that it would take very sensitive equipment to measure the temperature change taking place here.)

How could this additional transfer be represented? (By adding an additional step and arrow to the map):



Clarify questions students have about the additional step and arrow that has been added at the end of the energy map. Students may wonder if energy transfers could go on forever. Discuss with students the idea that energy does not disappear, but does continue to be transferred though it is increasingly harder to detect such transfers. For example, in this situation thermal energy from the floor would be transferred to the surrounding air molecules and so on and so forth. The energy doesn't "disappear" but rather diffuses away as radiation and random molecular motion.

Explain to students that for the sake of mapping energy transfers and identifying forms, we'll not attempt to map the extremes. Point out to students that the arrow at the end of the energy map shows that energy transfers keep going.

Ask students to observe a new “interaction” – that which occurs when an electric lamp is switched on. Place a desk lamp which contains an incandescent light bulb in a place visible to all. Plug the lamp into an electrical outlet. Switch on the lamp. Leave the light on as students make their observations. (Do not allow students to touch the bulb!)

Begin by asking: *What evidence is there that an interaction is taking place?* As a class, practice creating an energy map, identifying the energy source, energy receiver, and forms of energy involved. Refer back to the wind up car as one example. Point out that in the example below, more than one form of energy is involved – there is evidence that both heat and light are given off.

Energy Source		Energy Receiver	
electrical outlet (power plant)	electrical →	lamp (incandescent light bulb)	light (radiant) → and heat (thermal) →

Note: Be sure that students are introduced to the idea that more than one form of energy can be involved at a time. As described in the teacher background section for this lesson, many students believe that energy transformations involve only one form of energy at a time. While a more formal introduction of energy transformations takes place after students revisit the stations, bringing in this possibility using an example that provides readily observable forms, such as the pinwheel, is important.



5 Revisit interaction station maps, noting energy forms.

Provide students time to review their maps. Encourage students to use their Forms of Energy cards as a reference. Make stations accessible to students in case they need to revisit them to refine their ideas. Now that students are more familiar with different forms of energy they may notice evidence of additional forms of energy. Some may want to expand their maps to include intermediary sources and receivers.

As students work, circulate among groups. Support students as needed, ask probing questions, and listen to and make note of students' ideas.

Alternatively, assign student groups one or a few stations to reexamine.

Reflect And Discuss

6 Post maps on chart paper.

Consider grouping students differently in this part to stimulate new thinking and cross discussion. Ask students to work in pairs to select one energy map that they find interesting. (Or, if students were assigned a specific station, have them prepare their assigned station.) Encourage pairs to look back through their scientists' notebooks and review the details of their station maps. Students might find a particular station map interesting because it involved multiple energy forms and/or transfers, or they observed something new or different when they revisited it, or the station involved forms that they were not really certain about- a station in which they still have questions. After students have selected an interesting station map, ask students to put their map onto a piece of chart paper in preparation for the scientists' meeting. A ½ sheet of chart paper is probably sufficient for most maps.

7 Hold a scientists' meeting.

Instruct students to gather in a circle and bring their scientists' notebooks and selected map on chart paper. Have students post their maps in a place visible to all. Post a spare piece of chart paper in the room that can be used to make note of questions that arise as students discuss their findings. Ask students to examine the maps of their classmates one at a time as they are each posted. Use the suggested prompts to initiate a discussion of students' findings:

- *What do you notice about the posted energy maps?* Students may notice a variety of things. Some pairs may choose to share the map of same stations. If this is the case discuss the similarities and differences in their maps. If there are a variety of energy maps, ask students to comment on the variety of forms the maps show. Call attention to any discrepancies among maps of similar stations; ask students about the evidence they observed or noticed that indicated to them a particular form(s) of energy was involved in the station. At some point, be certain to weave into the conversation the reasons groups selected the maps they did.
- *Other than identifying the form of energy in your energy maps, how did your energy maps change as you revisited them a second time?* Students may have noticed things that they didn't notice before because they were more aware of other forms of energy. Students may have also added more detail to their maps by including additional sources and receivers of energy.



Ask students to compare the “before transfer” energy forms to the “after transfer” energy forms.

- *What do you notice about the “before transfer” energy forms and the “after transfer” energy forms? Are the same forms present or are they different? Or is there some combination?*

Make explicit to students that as energy is transferred from one object or place to another, it can change form. When energy changes form, it is called an energy transformation. Make certain that students understand that it is not “new” energy – it has not been “created” but rather the energy that is present changed form and sometimes, as they’ve noted in their energy maps, it has been transformed or changed into more than one form. Identify and discuss transformations using the examples in their posted energy maps or those found in their scientists’ notebooks.

Students often use the terms energy transfer and energy transformation interchangeably. Take time to establish the difference between energy transfers and energy transformations using their station work. Encourage students to refer back to their scientists’ notebooks during the discussion:

- *Does energy always change form as it is transferred from one object or place to another?* No, in some cases the form stays the same. Ask students to support their answers with evidence from their posted maps and/or from other stations as recorded their scientists’ notebooks.
- *Does energy sometimes change into more than one form?* Yes, this occurred in several stations. Ask students to support with evidence from their posted maps or from maps recorded in their scientists’ notebooks.
- *Do you think that energy can make something happen without being transformed?* Yes, energy can be transferred without being transformed.

Note: *Some amount of energy is (almost) always transferred as heat. However, sometimes the amount of heat given off is imperceptible. This idea will be developed more in Lesson 5.*

Bring the discussion to a close by summarizing key ideas of this lesson.



8 (Optional) Clarify terms energy transfer and energy transformation using Frayer Model.

Help students deepen their understanding of energy transfer and energy transformation with a Frayer Model or similar strategy for each term. The Frayer Model graphically organizes knowledge

about a concept into categories: operational definition, characteristics, examples, and nonexamples. The intent of using the Frayer Model is to help students build a conceptual understanding of terms and in this case, terms that are often confused and used interchangeably.

Students need two copies of Student Handout 3.2: Frayer Model – one for energy transfer and one for energy transformation. It is recommended that the teacher uses an overhead of the template or creates the framework on a piece of chart paper to guide students through the model.

Write in the center oval on one of the handouts “energy transfer.” Begin completing the model by working on the bottom half of the handout. Ask students for examples of energy transfers. Students may suggest that kicking a soccer ball involves an energy transfer from a person’s foot to the soccer ball or that hammering a nail involves an energy transfer from the hammer to the nail. After students have provided several examples, move to the “non-example” category. Students might say that energy stored in a battery or a car parked on the top of a hill are not transferring energy.

Move to the upper right box of the model – the “characteristics” category. Encourage students to think about what the examples they provided in the lower left hand half of the model have in common. Students may suggest that energy transfers are measurable, ongoing, and that in each of the situations energy is moving from one place, object, or substance to another. Lastly, ask students to suggest an operational or working definition for the term energy transfer and enter this in the upper left hand box. Consider revisiting the definition developed in the model later in the unit as students’ thinking evolves.

Use the second blank Frayer Model template to work through the term “energy transformation.” For “examples,” students may suggest that chemical energy in a battery is transformed to electrical and heat energy in a simple circuit or that electrical energy is transformed into radiant (light), mechanical (sound), and thermal (heat) in a television. Students could say that ice cubes cooling a glass of juice or steam condensing would not be examples of energy transformations. Students may find it quite challenging to think of examples that do not involve an energy transformation because in nearly every energy transfer, heat is a factor. Students may suggest that energy transformations are measurable, ongoing, and that in the examples, energy as it is being transferred is changing form(s). Make explicit to students that energy cannot be transformed without being transferred.



9 Assign an “energy scene” [assessment opportunity].

Provide students with several “energy scenes” and ask students to select two. Instruct students to paste the scene into their scientists’ notebooks or on a separate sheet of paper (one scene per side). For each scene, direct students to:

- state a claim for an energy interaction depicted in the scene
- give evidence for the interaction
- make a map showing the energy source, energy receiver, energy transfer, transformation (if present) and energy forms.

Note: *Several energy scenes have been included in this lesson. Scenes could be randomly assigned to students or as noted above, several scenes could be presented and students could be allowed to choose 2 from the set. See Teacher Resource 3.2: Energy Scene Teacher Notes for examples of interactions that students may identify.*

Extensions

Students may:

- investigate energy forms, transfers, and transformations in simple devices. As in Lesson 2, encourage students to bring in toys or other simple devices from home. In addition to describing the interactions that take place and the energy sources and energy receivers, students should be able to describe the energy transfers and transformations that occur in their device.
- view How Stuff Works video clip: *The Seven Forms of Energy*. This five minute video describes seven forms of energy: mechanical, heat, chemical, radiant, electrical, sound, and nuclear. These forms differ slightly from those introduced in this lesson. Be sure to discuss these differences when using this clip. <http://videos.howstuffworks.com/hsw/19076-exploring-energy-the-seven-forms-of-energy-video.htm>
- test how the distance of stretch in a rubber band at rest relates to the distance the rubber band travels after being released in this experiment, Rubber Bands for Energy, from Science Buddies. Please note that in the investigation, energy is defined as the “ability to do work” and be sure that students wear safety goggles when using rubber bands. Provide a safe area away from other students for a shooting range. http://www.sciencebuddies.org/science-fair-projects/project_ideas/ApMech_p017.shtml
- build a kinetic sculpture following these directions from the PBS show Design Squad: http://pbskids.org/designsquad/projects/kinetic_sculpture.html



- build a roller coaster for marbles using foam pipe insulation to investigate how much of the gravitational potential energy of a marble at the starting point is converted to the kinetic energy of the marble at various points along the track. This project, called Roller Coaster Marbles: Converting Potential Energy to Kinetic Energy from Science Buddies, would be an appropriate project for students who want to quantify (using mathematical formulas) energy conversions. The background information introduces the concept of conservation of energy which will be addressed in later lessons of *Energy for Maine*. http://www.sciencebuddies.org/science-fair-projects/project_ideas/Phys_p037.shtml
- learn about potential and kinetic energy firsthand in a two-tiered design challenge. Students design a toy that can propel a ball, first a short and then a longer distance. (Note: Measure distances in metric.) In between the two tasks, the teacher guides a discussion about the conservation of energy. The design project aligns well with the national physical science standards for grades 5-8, but can also be used in grades 3-4. Although gravitational and elastic potential energy are the forms of potential energy addressed here, they are not the only kinds of potential energy. http://www.thetech.org/education/downloads/dconline/Energy_at_Play.pdf
- virtually investigate the relationship between potential and kinetic energy during a roller coaster ride. A pie chart shows how energy is transformed back and forth between gravitational potential energy and kinetic energy as the coaster cars go up and down the hills and around the loop of the track. <http://www.teachersdomain.org/resource/hew06.sci.phys.maf.rollercoaster>

Connection to Maine Agencies

A Maine Energy Education Program (MEEP) is a no cost resource for schools and teachers in Maine. MEEP representatives will come to interested schools, free of charge, to guide and support the concepts in this lesson. MEEP has several programs that supplement concepts in this lesson:

- Electricity & the Environment presentation: Students become aware of electricity in our awareness session. They make electricity from an apple in the Apple Battery experiment and then learn how electricity is made in the real world. Next, with MEEP's PV Fan and Mini-Wind Turbine activities, they make electricity from renewable resources. These activities can be combined with the Great Energy Debate and Energy Jeopardy in a full-day workshop.
- KidWind: Students design and build their own mini wind turbine blades. They then compete to see whose design makes the most electricity.



More information can be found on the MEEP website: www.mEEPnews.org/classroomactivities

Project Learning Tree Energy Chains: Students explore how energy changes form as it moves from one object to another. This activity includes the students acting out the energy transformations. Contact Patricia Maloney at PLT for more information.

<http://www.maintreefoundation.org/programs/plt-index.html>

For schools in Aroostook County, a Maine Public Service (MPS) representative will come to interested schools, free of charge, to guide and support concepts developed in this lesson. A description of programs is available at www.mainepublicservice.com. Click on the education section of the site. To schedule a presentation contact Nancy Chandler at 207.760.2556 or nchandler@mainepublicservice.com.

Online References and Resources

Energy Information Administration: Energy Kid's Page "Scientific Forms of Energy."

<http://www.eia.doe.gov/kids/energyfacts/science/formsofenergy.html>

Watson, D. (2005). FT Exploring Science and Technology: Energy Introduction Page. <http://www.ftexploring.com/energy/energy.html>

WGBH Educational Foundation. (2002-2009). Teachers' Domain: "What is Energy?" http://www.teachersdomain.org/assets/wgbh/hew06/hew06_doc_lpawhatenergy/hew06_doc_lpawhatenergy.pdf

Wisconsin Energy Education Program (KEEP). (2002). What is Energy? <http://www.uwsp.edu/CNR/wcee/keep/Mod1/whatis/energyforms.htm>

Frayser, D., Fredrick, W.C. and Klausmeier, H.J. (1969). NSTA's Science Objects: Different Kinds of Energy www.nsta.org

JASON Mission Center
http://www.jason.org/digital_library/6302.aspx

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melting icicles by: Muffet
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Wind Energy – A New Kind of Power Generation in Panama by:
thinkpanama
<http://www.flickr.com/photos/23065375@N05/2236367463/>

Campfire by: AviatorDave
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My old Graphic calculator, had this since sixth form by: TarikB
<http://www.flickr.com/photos/tarikb/15784453/>

early-admission paratrooper training- the Johnny jump-up_MG_6554
by: sean dreilinger
<http://www.flickr.com/photos/seandreilinger/549949296/>

washing the dishes by: annarama
<http://www.flickr.com/photos/annarama/117031515/>

Fireworks 3 by: bobtravis
<http://www.flickr.com/photos/bobtravis/696330656/>

Slinky Boy! by: girlnamedfred
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over half eaten by: sharynmorrow
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Forms of Energy

<p style="text-align: center;">Chemical Energy</p> <p>Chemical energy is the energy stored in materials such as food, batteries, and gasoline. The chemical make up (the arrangement of atoms and molecules) of these materials determine how much energy they store.</p> <p style="text-align: center;">Examples:</p>	<p style="text-align: center;">Mechanical (Motion) Energy</p> <p>Mechanical (motion) energy is the energy of moving objects. A soaring soccer ball, flying bird, a spinning wind turbine are all examples of motion energy.</p> <p>Sound is evidence of mechanical (motion) energy. Sound is a vibration or wave of air molecules caused by the motion of an object.</p> <p style="text-align: center;">Examples:</p>
<p style="text-align: center;">Elastic (Stored Mechanical) Energy</p> <p>Elastic energy is the energy stored in objects when they are stretched, compressed, twisted, or bent. Objects such as our skin, metal springs, trampolines, and rubber bands resist being stretched out of shape. As a stretched rubber band or a compressed spring is released, elastic energy is released to cause a change. As a tightly wound rubber band connected to a toy paddle boat is released, the boat paddle turns in water, moving the boat forward.</p> <p style="text-align: center;">Examples:</p>	<p style="text-align: center;">Thermal Energy</p> <p>Particles – the atoms and molecules making up all matter – are in constant motion. Thermal energy is the collective energy (kinetic and potential) a substance or system has due to this constant motion. The higher the temperature, the faster the atoms and molecules that make up the substance move and the more thermal energy that substance has. Thermal energy of a substance takes into account the amount of matter. The greater the amount of matter, the more thermal energy a substance has. This is why an iceberg contains more thermal energy than a cup of boiling water.</p> <p>Heat is thermal energy that is being transferred.</p> <p style="text-align: center;">Examples:</p>





Radiant Energy

Radiant energy moves in waves. Radiant energy includes visible light, x-rays, infrared radiation, microwaves, ultraviolet light, and radio waves. Light, ultraviolet, and infrared energy are particularly important to living things. Without light energy there would be no life on Earth. Sunlight energy warms the Earth, keeping temperature suitable for living things. Sunlight provides the energy plants need to make food.

Examples:

Electrical Energy

Electrical energy is the energy in the movement of electric charges (electrons).

Examples:

Gravitational Potential Energy

Gravitational potential energy is the energy something has due to its place or position. Water in a reservoir behind a hydropower dam or a sled sitting at the top of a hill has gravitational potential energy. When things fall, their gravitational potential energy makes something happen. For example, falling water spins turbines and falling sleds move kids down hills.

Examples:



Frayer Model Template

Operational Definition	Characteristics
Examples	Non Examples

(An empty oval is positioned in the center of the four quadrants, overlapping the horizontal and vertical dividing lines.)





Energy Scenes

Skateboarder



Guitar



Frisbee Dog



Melting Icicles



Tap Dance



Hot Air Balloon



Juggling



Wind Turbine



Campfire



Lava Lamp



Solar Calculator



Baby Bungee



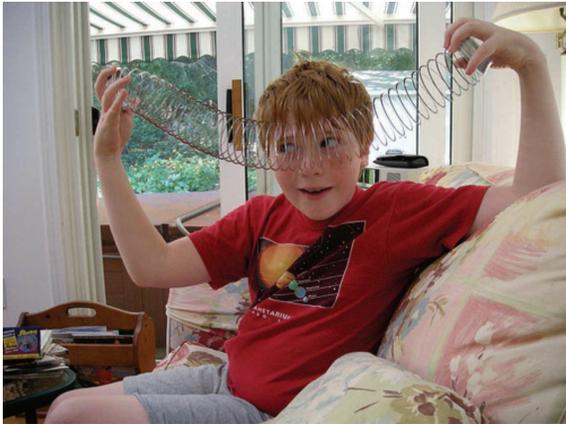
Washing Dishes



Fireworks



Slinky



Eating a Sandwich





Interaction Stations Teacher Notes

Identification of Energy Sources, Receivers, and Forms

Station 1: Hands

Energy source (ES): hand (chemical, mechanical/motion) → Energy receiver (ER): hand (mechanical/motion, thermal - heat)

Station 2: Plastic Shopping Bag

Energy source (ES): plastic bag (electrical – static electric charge) → Energy receiver (ER): paper (mechanical/motion)

Station 3: Paddle Ball

Energy source (ES): hand/paddle (chemical, mechanical/motion, gravitational potential) → Energy receiver (ER)/Energy source (ES): ball on elastic tether and elastic tether stretched (mechanical/motion, elastic, gravitational potential) → Energy receiver (ER): ball, paddle, elastic tether (elastic, mechanical/motion, thermal)



Station 4: Electric Circuit

Energy source (ES): battery (chemical, electrical) → Energy receiver (ER): light bulb (thermal and radiant)

Station 5: Solar Powered Propeller

Energy source (ES): sun (radiant) → Energy receiver (ER)/Energy source: panel (electrical) → Energy receiver (ER): motor/propeller (mechanical/motion)

Station 6: Noise Maker

Energy source (ES): air (mechanical/motion) → Energy receiver (ER): noise maker (mechanical/motion – sound emitted due to vibration of air molecules)

Sound will be emitted as students blow into the horn due to vibration of air molecules.

Station 7: In Hot Water

Energy source (ES): hot water (thermal) → Energy receiver (ER): spoon (thermal – heat)

Station 8: Beads

Energy source (ES): sunlight (radiant) → Energy receiver (ER): beads (chemical)

■ **Note:** *UV beads contain pigments which react with ultra-violet light from the sun.*

Station 9: Spinning Top

Energy source (ES): hand (mechanical/motion, chemical) → Energy receiver (ER): top (mechanical/motion – including sound, radiant - light)

Station 10: Yo-Yo

Energy source (ES): position of yo-yo (gravitational potential energy) → Energy receiver (ER): yo-yo (mechanical/motion)

Station 11: Pop Up Toy

Energy source (ES): hand (chemical, mechanical/motion) → Energy receiver (ER)/ Energy source (ES): compressed spring (elastic) → Energy receiver (ER): toy (mechanical/motion, gravitational potential)

Station 12: Waves

Energy source (ES): finger (chemical, mechanical/motion) → Energy receiver (ER): water and float toy (mechanical/motion)





Energy Scene Teacher Notes

Students may identify different or additional interactions than those described here. Use the notes provided as a guide. Also note that while students are not making observations first hand or directly collecting evidence of the interactions represented here they will make claims and offer evidence based on their prior experiences.

Skateboarder

Claim (C): The skateboarder interacts with the skateboard.

Evidence (E): The skateboarder's foot pushes against the ground, causing the skateboard to move forward.

Energy source (ES): skateboarder's foot (chemical and mechanical/motion energy) → Energy receiver (ER): skateboard (mechanical/motion, thermal – heat/friction)

Students may also say that the skateboarder and/or skateboard (ES/ER) has gravitational potential energy when airborne. They may also cite the food the person ate or the sun as the energy source.



Guitar

Claim (C): The person's fingers interact with the guitar strings.

Evidence (E): When the person's fingers strums the guitar strings, the strings move causing air molecules (and eventually a person's ear drum) to vibrate.

Energy source (ES): person's fingers (chemical and mechanical/motion) → Energy receiver (ER): guitar strings (mechanical/motion, thermal - heat – heat/friction)

Students may also identify the food the person ate or the sun as the energy source.

Frisbee fetching dog

Claim (C): The dog interacts with the frisbee.

Evidence (E): The dog jumps in the air (change in dog's motion) and catches the frisbee in it's mouth, stopping the motion of the frisbee.

Energy source (ES): dog's muscles (chemical and mechanical/motion energy) → Energy receiver (ER): frisbee (mechanical/motion, thermal – heat/friction)

Students may also say that the dog and/or frisbee (ES/ER) has gravitational potential energy as they are airborne. Students may also identify the food the dog ate or the sun as the energy source.

Melting icicles

Claim (C): The icicles interact with the sun.

Evidence (E): Heat from the sun warms the icicles, making them melt.

Energy source (ES): sun (thermal and radiant - light) → Energy receiver (ER): frozen water (thermal)

Tap dance

Claim (C): The tap shoes interact with the floor.

Evidence (E): The tap shoes strike the dance floor causing the air molecules (and eventually a person's ear drum) to vibrate.

Energy source (ES): dancer's body/feet/tap shoe (chemical and mechanical/motion) → Energy receiver (ER): floor (mechanical/motion, thermal – heat/friction))

Students may also identify the food the person ate or the sun as the energy source.

Hot air balloon

Claim (C): Warm air inside the balloon interacts with the cooler air outside the balloon.

Evidence (E): As warmer air fills the balloon, it rises.

Energy source (ES): propane (chemical and thermal) → Energy receiver (ER): air in the balloon (thermal)

Students may also say that the balloon has gravitational potential energy as it is suspended above the Earth. Students familiar with the science of fire may offer the claim that propane is interacting with an igniter and oxygen and, as evidence of an energy interaction, the fire that results. Fire comes from a chemical reaction between oxygen and a fuel. The fuel has to be heated to its ignition temperature before it will burn. Propane (fuel) is burned in the balloon's burner, the air in the balloon warms up and the balloon rises. The balloon is kept afloat due to density differences between the warmer air in balloon and the cooler surrounding air in the atmosphere.



Juggling

Claim (C): The juggler interacts with the balls.

Evidence (E): The juggler tosses the balls into the air, causing them to rise.

Energy source (ES): juggler's hands/arms (chemical, mechanical/motion, gravitational potential) → Energy receiver (ER): balls (mechanical/motion and gravitational potential)

Students may also identify the food the person ate or the sun as the energy source.

Wind turbine

Claim (C): Air interacts with the wind turbine.

Evidence (E): As the wind blows, there is a change in the motion of the wind turbine blades.

Energy source (ES): wind/sun (thermal, radiant, mechanical/motion) → Energy receiver (ER): wind turbine blades (mechanical/motion)

Depending on students' familiarity with wind, students may or may not include the sun as an energy source. Students may also extend the interaction to include the generation of electricity: Energy source (ES): Wind turbine blades turn (mechanical/motion) → Energy receiver (ER): a shaft inside the turbine that turns a generator (mechanical/motion) / Energy source (ES): generator (movement of magnets over wires inside generator (mechanical/motion) → Energy receiver (ER): wires (electrical and thermal).

Campfire

Claim (C): Match or lighter (fire) interacts with wood.

Evidence (E): The wood changes; it burns, it is hot, and it glows.

Energy source (ES): Match or lighter (chemical energy) → Energy receiver (ER): wood (thermal, radiant, chemical energy)

This may be a difficult interaction for students to discern. Refer to the notes under Hot Air Balloon for more information about fire.

Lava lamp

Claim (C): Heat from the lamp interacts with the "lava."

Evidence (E): When the lava (a waxy substance) in the lamp warms up, blobs of lava rise and cool, then fall.

Energy source (ES): Lamp/bulb (electrical and thermal) → Energy receiver (ER): "lava" (thermal)

Students may also note that the "lava" has gravitational potential energy.

Solar calculator

Claim (C): Light interacts with the solar panel on the calculator.

Evidence (E): The calculator is operable in the presence of light. (Numbers are displayed on the calculator's screen and the device will make calculations.)

Energy source (ES): light (radiant energy) → Energy receiver (ER): solar cells of the calculator (electrical)



Baby Bungee

Claim (C): The baby interacts with the bouncy baby seat.

Evidence (E): As the baby pushes off the floor (jumps), the baby seat (and the baby) moves up and falls back down.

Energy source (ES): baby's legs (chemical, mechanical/motion) and elastic harness on baby seat (elastic) → Energy receiver (ER): baby seat and baby (elastic, mechanical/motion)

Students may also say that the baby and baby seat have gravitational potential energy as they are suspended.

Washing dishes

Claim (C): The person's hand and warm water are interacting with the glass.

Evidence (E): The glass is cleaner and warmer.

Energy source (ES): hands (mechanical/motion) and water (mechanical/motion and thermal) → Energy receiver (ER): glass (thermal)

Students may also say that chemical energy is involved in moving the person's hands and thermal energy is involved to heat up the hot water used to wash the dishes.

Fireworks

Claim (C): Match/lighter/fuse interacts with the chemicals making up fireworks.

Evidence (E): After the fuse is ignited, the fireworks chemicals explode. Sound, heat, and light are given off.

Energy source (ES): match/lighter (chemical) → Energy receiver (ER)/Energy source (ES): fuse (chemical) → Energy receiver (ER): fireworks chemicals (chemical, radiant, and thermal energy)

Students may say that gravitational potential energy is involved before the firework shell (pieces) fall(s) to the ground. Additional information about fire can be found under the notes for the Hot Air Balloon scene.



Slinky

Claim (C): The boy's hands interact with the slinky.

Evidence (E): As the boy pulls and pushes on each end of the slinky, the slinky droops and vibrates back and forth.

Energy source (ES): boy's hands (mechanical/motion), position of the slinky (gravitational potential), make up of slinky (stored mechanical - elastic) → Energy resource (ER): slinky (elastic, mechanical/motion)

Eating a sandwich

Claim (C): A person is interacting with a sandwich.

Evidence (E): Eating the sandwich provides fuel and building material for a person's body.

Energy source (ES): sandwich/food (chemical) → Energy receiver (ER): person's body (chemical, mechanical/motion, thermal)

