Descriptions of Energy Connections for Suggested Items in Energy Discovery Box

Note: *The descriptions included here are for the purpose of providing background information for the teacher. It is not expected that students be familiar with the extensive connections outlined below. The descriptions aim to help teachers recognize various facets of information that students may be trying to piece together and aim to provide insight as to students' commonly held ideas or current perceptions of energy. Students will have an opportunity to revisit Energy Box items in Lesson 8 and should be able to articulate more sophisticated and networked connections.*

Coal: Coal is a combustible black or brownish-black sedimentary rock composed mostly of carbon and hydrocarbons. It is the most abundant fossil fuel produced in the United States. Nearly half of the electricity generated in America comes from burning coal. When coal is burned, energy is released. This energy, stored in the sugars assembled by plants that lived hundreds of millions of years ago when the earth was partly covered with swampy forests, is chemical energy. For millions of years, layers of dead plants accumulated at the bottom of the swamps and were covered by layers of water and dirt, halting decomposition, and trapping the energy of the dead plants. Heat and pressure from the upper layers compressed the plant remains into coal. The energy stored in these ancient plants is released when the coal is burned. Coal is a nonrenewable energy source (a fossil fuel) because it takes millions of years to form.

Students may connect coal as a substance that is burned, for example, to fuel trains. Maine has no coal burning power plants or coal mines so students may have limited familiarity with coal.

Energy bar or drink: Food contains chemical energy. The chemical make up (the arrangement of atoms or molecules) of foods determine how much energy they store. The amount of energy available in different foods is measured using a calorimeter.

Scientifically, foods are organic substances containing carbohydrates, proteins, and/or fats and serve as both fuel (an energy source) and building material for an organism. Foods labeled as energy bars typically contain a high concentration of carbohydrates, along with proteins and fats, to give the body fuel it needs to function. During digestion, chemical reactions occur that release the energy stored in the food. Most energy drinks make people feel intensely energized because they offer a quick source of easily and quickly metabolized food and/or often contain other chemicals such as caffeine, that stimulate the central nervous system. This period of high energy is often followed by a sudden period of lethargy. Students often think of energy as a substance and foods labeled using the words “energy” or “power” may reinforce this notion. Because of their labeling, students may believe that “energy bars” or “energy drinks” are somehow enriched with or possess a special "energy" quality, but in fact, all food (as defined scientifically) is an energy source. Water, vitamins, minerals, caffeine, and spices are non caloric and while some of these may be substances needed by living things and are ingested by organisms, they do not provide living things with energy.

Corn: Corn or maize is the most widely grown crop in the Americas. In fact, as revealed in *The Omnivore's Dilemma: A Natural History of Four Meals* by Michael Pollan, corn is an inextricable part of the American diet. A myriad of foods are made from or contain corn and corn is prevalent in livestock feeds. In recent years corn has been used to make fuels such as ethanol for vehicles and as an ingredient in some plastics. Corn is a plant (a grass) and like most plants, corn is photosynthetic. It is through the process of photosynthesis that carbon dioxide is converted into sugar using energy directly from the sun.

Students will likely identify corn as a food for people and livestock. They may also be somewhat familiar with fuels derived from corn.

Subway ticket or map or some item representative of public transportation: All forms of transportation require an energy source. Currently, the most prevalent modes of transportation, public or otherwise, rely on fossil fuels as their energy source. Gasoline, diesel, natural gas, and propane are all fossil fuels that are commonly used as fuels for public buses. These fossil fuels are formed similarly to coal, one key difference being that coal comes primarily from land vegetation – trees and large ferns that lived millions of years ago while petroleum products (those derived from crude oil, such as gasoline, diesel and jet fuel, and heating oil) generally come from the fossil remains of microscopic animal and plant-like marine organisms (zooplankton and phytoplankton). Crude oil formed as layers of decaying remains build up and become compacted by intense heat and pressure. After crude oil is removed from the ground, it is sent to a refinery. The oil is separated into petroleum products, including gasoline and diesel. Most modern trains are powered by diesel locomotives or by electricity supplied by overhead wires or additional rails. Over millions of years, as crude oil forms, pockets of "natural" gas get trapped. Natural gas and propane are similar but not the same substance. Propane is derived from natural gas as it is being processed. Natural gas is a mix of many gases and propane is chemically pure. Subway systems that Maine students are likely to be familiar with (Boston and New York) run on electricity. As noted above with coal, nearly half of the United States' electricity is generated by burning coal.

In addition to identifying some of the energy sources used to fuel public transportation, students may also make connections to some of the benefits of using public transportation, such as reducing the number of automobiles on the roads, which reduces emissions and helps conserve energy sources.

Wind up or other "human-powered" mechanical toy or device: A number of simple toys and devices- slingshots, bows and arrows, wind-up toys, watches, balloons, music boxes, and bungee cords use the energy of deformed (compressed or stretched) materials. Elastic energy is the energy stored when elastic materials are stretched or compressed. Materials that have elastic properties (such as rubber bands or springs) can be "reshaped" but naturally revert to their original shape when the force causing the deformation is removed. Many wind-up toys contain a spring that becomes compressed or tightened as it is turned by a key. After release, the spring reverts back to its original, decompressed position often turning a series of gears that make the toy "go" and/or produce other interesting effects such as sound or light.

Students readily associate energy with things that are in motion and mechanical devices. They may also make the connection that "human power" is the source of energy for the wind up toy. Some may connect a person's energy back to the food the person ate and ultimately the sun.

Mitten: Maine students are undoubtedly familiar with mittens and know something about why one wears mittens outside in the colder months. The mitten is included in the Energy Discovery Box because many students believe that insulating objects produce their own heat. Children often think of heat as an intrinsic property of a material or object. In other words, students often think of materials as being inherently hot or cold or as containing a certain amount of "hotness" or "coldness." Heat is a form of energy - not a substance - yet it is often described as one. The mitten is not in and of itself "warm." The mitten does not give off heat. The mitten is not a heat source and it does not have a higher starting temperature than its surroundings. The person wearing the mitten gives off heat. The fiber that the mitten is made from has insulating properties that are effective in slowing the transfer of heat energy so the mitten "holds in" the body's warmth thus making the person feel warmer. (See Lesson 1: The Mitten Problem, Energy Heats Maine)

Reusable foil-lined insulated shopping bag: Many products designed to keep things hot or cold (thermoses, travel mugs, home insulation, space or emergency blankets) utilize reflective materials. A key piece to remember as students discuss heat is that "heat" moves – "cold" does not. Materials and substances warm up or cool down because of heat transfers. Foil insulation slows the movement of heat by reflecting infrared radiation. In the case of a silver-lined thermos bottle, the silver lining inside reflects keeps the food hot by reflecting the hot food's infrared radiation back to itself. For the same reason, the most effective way to use an emergency or space blanket is to keep the silver side towards the body.

Students may connect energy to reusable bags by describing the insulating properties of them. They also may realize that reusable bags, unlike plastic bags, are not petroleum based. Students may further know that energy is used to produce and distribute both types, and the reusable feature saves energy.

Solar powered calculator: Calculators are one example of a growing number of solar powered devices available to consumers. Solar powered calculators use solar or photovoltaic (PV) cells which convert sunlight directly into electricity. When light strikes a cell, a certain portion of that light is absorbed by a specially treated material (semiconductor). This material allows the free flow of electrons (electricity). This free flow of electrons, an electric current, can be drawn off and used to power a calculator. For more detailed information, consider reviewing "How Do Photovoltaics Work" by Gil Knier at http://science.nasa.gov/headlines/y2002/solarcells.htm. This resource contains more information about how solar cells work and the history of the development of solar cells.

Students have undoubtedly owned or used a solar powered calculator or some other solar powered device. Students may think that it is the sun or the heat from the indoor lighting rather than its light itself that is being absorbed by the cells. While students do not need to develop an understanding of the complex workings of solar panels, they should recognize that it is light and not heat that is absorbed by a PV cell. Students will probably also be familiar with the use of solar modules on homes and businesses.

Instant cold pack: Typically first aid kits are stocked with "instant" cold packs for quick and convenient treatment of an injury. The packs are made of chemicals (ammonium nitrate and water) that, when mixed together, become "cold." The two chemicals are initially in separate compartments in the pack. When the cold pack is needed, the inner compartment in the pack is broken allowing the chemicals to mix. The chemical reaction that takes place is endothermic (absorbs heat).

It may be counterintuitive for students to associate things that are "cold" with energy. All matter has thermal energy.

Additional information about thermal energy can be found in the teacher background sections of Lessons 1-3 in Energy Heats Maine and/or by visiting NSTA's Learning Center Energy: Thermal Energy, Heat, and Temperature http://learningcenter.nsta.org/product_detail.aspx?id=10.2505/7/SCB-EN.3.1

Battery (D-cell) and/or battery operated flashlight: As in many other electrical devices, flashlights house the components of simple circuits. A circuit is an unbroken path or closed loop which allows electrical energy to flow. The flashlight's components include a pathway for electric current. In a flashlight, the electric current goes through the metal wire (attached to a switch), through the metal spring, through the batteries, through the base of the light bulb, across the filament of the light bulb (if the bulb is an incandescent type), and through the side of the bulb. Without this complete pathway the flashlight will not light.

Students are likely to be familiar with flashlights and will most likely connect the components of the flashlight with energy. Students may recognize that batteries are an energy source and may know that there are chemicals inside the battery that react, acting like a "pump" to move electrical charges through the circuit. The electrical charges are already present in the wires and bulb. The battery, when connected properly, gets the charges moving. Many people think that batteries (and generators) send out a substance that gets "used up" but this is not true. When batteries "die" they do not "run out of electricity" but rather the battery's chemical reaction fails to fuel the movement of the electrical charge.

Students may be aware of other types of flashlights such as mechanically powered flashlights, those that have LED (light emitting diodes) rather than incandescent bulbs and/or those that use rechargeable batteries. (See Lesson 2: Circuits and Electric Light, Energy Lights Maine)

Cell phone: In recent years, there has been a dramatic rise in the number of consumer electronics in households. Today's teens are intimately familiar with cell phones and other small consumer electronics items such as portable music players, hand-held video games, TVs, DVD players, and laptops. These gadgets and the accessories that support them account for one of the most rapidly growing areas of energy use. Consumer electronic products consume about 15% of the electricity we use in our homes today. (Source: ENERGY STAR www.energystar.gov).

Students will most likely make the connection that cells phones require an energy source and in the case of the cell phone this energy source is a rechargeable battery. They may not be aware of the increasing percentage of energy use attributed to consumer electronics. Cell batteries must be periodically connected to an electrical source to recharge. Cell phone and other chargers that are plugged into an electrical source continue to draw electricity even when the device is fully charged. (More about phantom or vampire energy is included in the power strip description.) This idea is investigated in Lesson 7 of Energy for Maine as students use the Kill A Watt meters to monitor energy use.

Bottle of water: Numerous connections can be made with a bottle of water and energy. The most basic connection that students are not likely to be aware of is that the water has potential energy.

Students may make energy connections to water by associating the generation of electricity to hydroelectric dams (See Lesson 6: People Have the Power! Electrical Generation, Energy Lights Maine). They may also describe the movement of water through the water cycle or energy's role in water's change of state including in the context of weather. Students may be of connections similar to those described under the reusable insulated shopping bag or in the energy expended to manufacture and deliver convenience items.

An additional connection students may make is water's connection to living things. Students recognize that living things need water. However they may believe that living things use water in the same way that they use food. Living things need water, not as an energy source, but as the medium in which numerous simple chemicals dissolve, making water a key factor in the myriad of chemical processes necessary for sustaining life. (Refer to the energy bar/drink description for more information.)

Another connection students may make is the use of water for hydrogen powered cars. Visit the sustainable energy section of Chewonki's website to learn more about hydrogen's connection to energy. http://www.chewonki.org/pathways/interactive_poster/default.shtml

Pinwheel: Wind is caused by air flowing from high pressure area to low pressure area. As the sun heats up a certain area of land, the air around that land absorbs some of that heat. The hotter air above the land begins to rise very quickly. This happens because a given volume of hotter air is lighter than an equal volume of cooler air. When that lighter hot air suddenly rises, cooler air flows in. That air rushing in is wind. If an object such as a pinwheel or a wind turbine blade is put in the path of that wind, the wind will push on it, transferring some of its own energy of motion to the blade. This is in essence how a wind turbine, pinwheel, or boat sail "captures" energy from the wind.

Students are most likely familiar with the idea of harnessing wind to generate electricity but probably have not given much thought to the energy transformations and transfers that occur during this process. Students may also be aware of the pros and cons of wind power. (Connect to Lesson 7: Around and Around They Go – Turbines, Energy Lights Maine)

Clothespin: Using a "solar" clothes dryer utilizes the radiant energy of the Sun. The clothes on the line are wet. They have water left in them from being washed. The clothes become dry as the water leaves them. This happens from the effects of the Sun evaporating the water off the clothes. Evaporation is the process by which water is converted from its liquid form to its vapor form and thus transferred from land and water masses to the atmosphere. The rate of evaporation depends upon:

- Wind speed: the higher the wind speed, the more evaporation
- Temperature: the higher the temperature, the more evaporation
- Humidity: the lower the humidity, the more evaporation

It is not uncommon for Maine families to dry their clothes on a clothesline. They may connect using a clothesline as opposed to using an electric or gas dryer to dry clothes as an energy-saving measure. While the practice of using a clothesline is common in Maine, students may not connect this idea to evaporation and the energy associated with this process. Students may have a number of misconceptions about where the water goes when it evaporates. Some students believe that the water simply "disappears" or goes directly to the clouds.

Students may be interested to learn that a bill has been introduced to the United States Senate by North Carolina State Representative Pricey Harrison that would allow people to hang clothes outside to dry nationwide. In some communities this practice is banned. According to the United States Department of Energy's Energy Information

Administration statistics from 2001, about 5.8% percent of residential electricity use goes towards the clothes dryer.

Energy-efficient light bulb: Several connections can be made between energy and energy-efficient light bulbs. Energy "efficient" bulbs, for example compact fluorescent light bulbs (CFLs), use less energy to do the same "job." A 25-watt CFL gives off the same light output (lumens) as the 100-watt incandescent bulb using less energy. The 100-watt incandescent bulb produces much more heat and has a shorter bulb life.

Students may discuss "energy efficiency" and wrestle with what is meant by this term. One of the ideas that will be developed through Energy for Maine is the idea that not all of the energy in a particular device gets used the way it was intended to be used (to achieve the "desired" effects). As energy is transformed, heat is given off. In this situation, heat is not a "desired" effect. It may be tempting to refer to the energy that gets transformed to heat or other undesired forms as energy that is "lost" but this may confuse students as they work toward developing an understanding of the Law of Conservation of Energy (First Law of Thermodynamics). (See Lesson 8: Light Bulbs and Energy Efficiency, Energy Lights Maine)

Power strip: The digital displays, illuminated on/off switches, and other glowing "stand by" lights found on many electrical devices are examples of "phantom loads" or "vampire" energy. These devices receive signals or are ready to operate at any time and because of this, they act like vampires quietly drawing energy even when they are "off." This "lost" energy represents a small but growing percentage of an individual home's electricity use (about five percent), but taken across all U.S. households, adds up to an estimated 65 billion kilowatt-hours of electricity each year. This extra electricity costs consumers more than $5.8 billion annually and sends more than 87 billion pounds of heat-trapping carbon dioxide into the atmosphere each year. (Source: Union of Concerned Scientists). Adapters for rechargeable battery-powered cordless phones, cell phones, digital cameras and music players, and power tools are examples of devices that draw power whenever they're plugged into an outlet, regardless of whether their battery is fully charged—or even connected. Other sources of constant draw include appliances or electronic equipment with standby capability (such as televisions and computer monitors), a remote control, and/or a digital clock display (such as microwaves, DVD players, and stereo systems).

To combat these silent energy stealers, completely disconnect items when not in use. Plugging frequently used items into a power strip makes it easier to completely switch devices "on" and "off" with the click of one button.

Students may recognize power strips as being useful in protecting against electrical surges or as a receptacle for plugging in multiple electronic devices. They may also discuss electrical safety including knowledge of how to safely use extension cords as to not overload circuits. (See Lesson 5: Signs of Safety, Energy Lights Maine)

Speed Limit 55 road sign: In 1974 a 55 mile per hour speed limit was put into law as a provision of the Emergency Highway Conservation Energy Act. The law, called the National Maximum Speed Law prohibited speed limits higher than 55 mph part of a nationwide effort to reduce oil consumption. The law was amended in 1987 to allow 65 mph speed limits on certain roadways and in the 1990's the law was repealed putting the decision at the state level. 55 mph was designated top speed because it was thought to be the most fuel efficient speed saving fuel. As it turned out, the energy saved was minimal (about 1%) or about the same amount a driver could achieve by maintaining proper air pressure in their tires. The 55 mph speed limit did save lives the first year the law was in effect. While there is some discrepancy in most efficient speed limit, many sources indicate it is between 55-65 mph.

Many students associate movement with energy. They may also make the connection that vehicles that travel on roadways are fueled by an energy source (gasoline, diesel, electricity, etc.)

TV remote control: Students will suggest connections between a television remote control and energy in a couple of different ways. Most will recognize the remote contains batteries and make connections similar to those described earlier in the section about battery/battery operated flashlight. Students will likely mention that the remote, when directed at the TV, makes the set turn "on" or "off," allows one to turn up or down the volume, and change channels and other settings. Students may make energy connections to the sound and light energy that results from the TV.

Some may have noticed that an infrared sensor is at work in a remote control. Infrared energy is light that humans cannot see, is part of the electromagnetic spectrum, and is similar to visible light. An infrared remote control sends out pulses of infrared light that represent specific binary codes (series of ones and zeros). These binary code sequences correspond to commands, such as "on" and "off" and volume up or down. The TV has an infrared receiver that decodes the pulses of light into the binary data (the ones and zeroes) that the TV's microprocessor can understand. The microprocessor then carries out the corresponding command.

Replacement or Challenge Items:

Something magnetic	Small motor	Speaker
Satellite image	Rubber band	Cheeseburger
Gyroscope	Tuning fork	Blue jeans