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Topic 2:

Energize!

Lesson Plans for Children and Youth

Rise Up Against Climate Change!

A school-centered educational initiative of the Inter-American Development Bank

IDB

Rise Up
Against Climate Change

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Rise Up Lesson Plans

IDB 2016

Rise Up

Against Climate Change

Rise Up is a climate change education initiative of the Inter-American Development Bank that seeks to encourage children and youth to use their creativity and energy to come up with feasible, sustainable, long-term strategies to mitigate and adapt to climate change. This set of lesson plans is one of nine on different climate change topics that can be used independently or together with the other lesson plans and materials of the Rise Up initiative, including instructional videos, learning games and a Green School Toolkit. Each set of lesson plans includes an introductory text about the topic that can serve as a background material for the teacher or as a text for older students. The lesson plans can be used at the primary and secondary levels of education; they are divided into basic, intermediate, and advanced plans to help each teacher determine what activities are appropriate for his or her students. To find all the Rise Up materials please go to **www.iadb.org/riseup**

Emiliana Vegas, Chief, Education Division,
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Energize!

General Introduction to the Lesson Plans

The universe is energy, we are energy

What one thing does everything in the universe have in common? Energy—everything in the universe is made up of atoms, and all atoms contain energy.

Our bodies are made from many different **elements** (carbon, hydrogen, oxygen, iron, calcium, etc.). Energy is what holds these elements and their particles together.

But energy does not stand still—it is always moving and changing its form. We see this in our own bodies when we eat and drink—taking in food and fluids from the environment for energy—keeping us alive.

Cities operate in much the same way we do, but on a much larger scale. Cities use light, heat, and ultraviolet radiation from the sun to transform substances—water, food, raw materials, and other inputs—into goods and services for their inhabitants or for trading with others. Cities also transform the sun's energy into forms such as electricity, heat, and noise. They produce waste (pollution) as well.

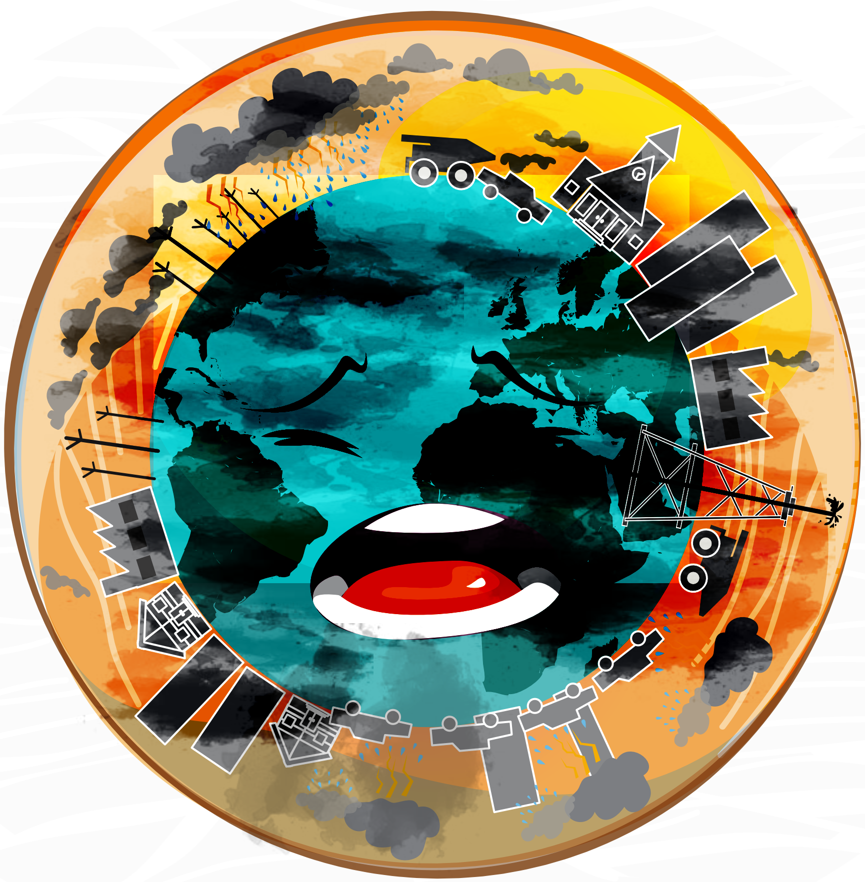
What does all this have to do with the climate?

Have you ever felt sick after eating too much or too quickly? This is called indigestion (figure 1). The earth can also get ***energy indigestion*** when its inhabitants—particularly we humans—consume too much energy too quickly.

Over the past 50 years, the earth has been suffering from a type of chronic energy indigestion known as ***climate change***, which had resulted in unpleasant and even disastrous consequences for humans.

However, because humans are responsible for causing much of this energy indigestion, we also have both the potential and the duty to help "calm the storm." One way we can do this is by learning about solar energy—how it reaches us, how we can transform and use it, and how we can develop and apply strategies to use it more efficiently so that we can "cure" the earth of climate change.

Figure 1. Energy indigestion is what happens when we consume too much energy too quickly



Energy makes things happen

All living things need energy to stay alive, from the smallest bacteria to the largest whale. However, living beings cannot create the energy they need to sustain life on their own—they must get energy from an external source.

Everything on the earth takes in energy from its primary source—the sun—but *living beings*—have many different ways of getting and using energy.

Regardless of how it is taken in or used, every living being—and every thing on the earth—constantly transforms and transfers energy. To see how this works, let's look at the example of an orange tree. Like all living things, the tree absorbs solar energy and converts it into stored chemical (potential) energy. The tree uses that energy to grow, making leaves, branches, flowers, and fruit. When it is "full" of potential chemical energy (oranges), its fruit falls from the tree to the ground. As the oranges fall, the potential energy (gravity) that held the oranges in the tree is transformed into kinetic energy (motion). When the oranges hit the ground, their kinetic energy is transformed into heat (caloric energy) by the force of the impact (friction). When people eat the oranges, their bodies convert the chemical energy in the oranges into kinetic energy that can be used for many things, such as moving muscles.

All things are made up of, use, and transform energy. As an example, consider the engine of a car. Like every other thing, the engine consists of energy-containing atoms. It works by burning gasoline. Gasoline contains chemical energy that comes from oil. Oil is created when plant and animal remains are compressed by gravity for thousands of years. When a car's gas burns, its stored chemical energy is released into the engine, causing an explosion that generates enough pressure to move the pistons and wheels, making the car move.Because all things are constantly *transforming energy* (from one kind into another) and *transferring energy* (from one object to another), scientists developed the law of energy conservation, which basically says that energy can neither be created nor destroyed—it can only be transformed.

Making sense of energy

There are two main categories of energy:

- **Potential** or stored energy, which can be associated with the position or height of an object, such as a swing at its highest point or a compressed spring.
- **Kinetic** or moving energy, such as a ball that has been kicked or a cascading waterfall.

In addition to these two broad categories, we also classify energy into physical types:

- ***Mechanical energy*** involves physical movement, such as turning blades in a power plant turbine.
- ***Heat or thermal energy*** is generated by temperature changes, such as steam from boiling water.
- ***Chemical energy*** involves reactions that emit heat or generate movement, such as the heat generated by our bodies in response to the energy in the food we eat.
- ***Electrical energy*** is generated from the flow of very small particles—called electrons—and the magnetic characteristics of atoms. Electrical currents power many appliances.

Energy can also be classified as **renewable** or **nonrenewable**, depending on how quickly it can be replenished after being used (figure 2).

Fossil fuels like coal and oil are considered nonrenewable resources because it takes millions of years for the earth to make them. Because humans are using these resources much more quickly than the earth can make them, there is a real danger that they will be depleted in the not-too-distant future.

Renewable energy, on the other hand, is regenerated as quickly (or almost as quickly) as it is used, and we do not expect to run out of it anytime soon. Examples of renewable energy sources include solar, wind, biomass (such as wood and plants), hydroelectric (water), marine, and geothermal (the heat inside the earth).

Energy and development: An uneasy relationship

Energy is extremely important for the development of society. In fact, industrial and post-industrial development were only possible after humans discovered new forms and sources of energy, which led to the creation of new mechanical devices, replacing human operators, increasing productivity, and often improving living conditions.

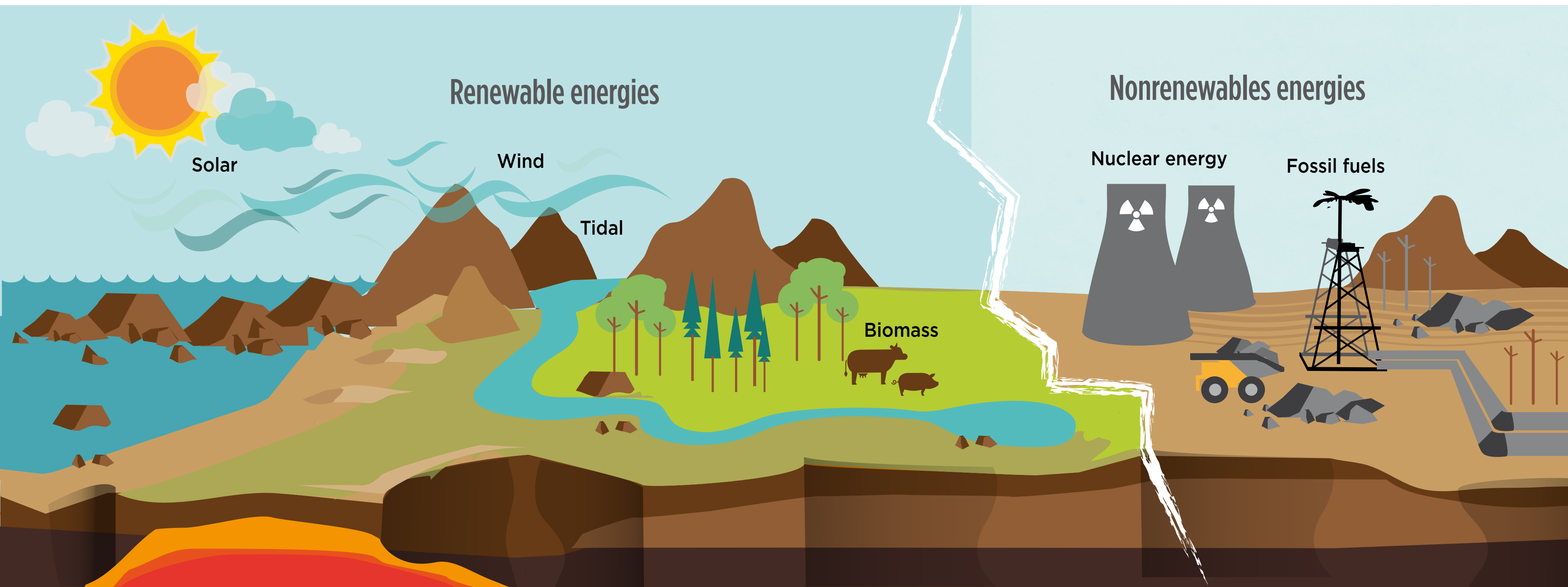
However, most of the energy we use today comes from fossil fuels—the largest contributors of greenhouse gases (GHG) and consequently, the main drivers of climate change. We use fossil fuels to heat and power our homes, cars, planes, factories, and even the agricultural equipment that helps us produce food.

But all of these new technologies have left us with a conundrum: the more fossil fuels we use to make life easier and more enjoyable, the more we contribute to climate change. However, we can reduce GHG emissions and preserve the environment by changing some of our daily behaviors to use less energy. As an example, we can ride bicycles to school instead of taking buses.

Some people are trying to reduce their energy consumption, but they are in the minority. Generally, people and countries demand *more* energy as their economies develop and lifestyles improve. The challenge facing Latin America and the Caribbean, as well as the rest of the world, is how to continue making progress and improving lives while not contributing to—or possibly even reversing—climate change.

Economic progress offers people access to more appliances, larger homes, and other goods and services, most of which need electricity. This presents a great challenge, but there are some ways we may be able to accommodate these competing goals. One approach is to developing more energy-efficient versions of technologies we rely on, such as lighting, heating, transportation, and production systems. These technologies would need much less energy than their older counterparts but would provide similar

Figure 2. Energy comes in renewable and nonrenewable forms



benefits, enabling us to continue enjoying a high standard of living while at the same time reducing our demand for energy. A power-saving lamp is an example of an energy-efficient technology. Another way to reduce our reliance on fossil fuels and stop the climate crisis from worsening is to develop new ways to capture and use renewable energy sources.

Of course, the best solution would likely involve a combination of strategies. For example, if everyone had access to both inexpensive sources of renewable energy and energy-efficient lighting, heating, and cooling systems, all of our houses and buildings could use sunlight for lighting and heating and air currents for cooling. Whatever the approach, it is clear that while we need electricity to power our homes and lives, it does not have to come from oil or coal. We can get the energy we need from both nonrenewable and renewable sources. Let's now look at the different types of nonrenewable and renewable energy, where each type comes from, and how each is currently being used.

Fossil fuels and nonrenewable sources of energy

The second half of the eighteenth century was the starting point of the Industrial Revolution. The invention of the steam engine prompted many changes that improved living conditions. Torches were replaced by light bulbs, horse-drawn carts by cars and trains, and manual machines by faster, more efficient steam-driven engines. These new inventions used energy, so our demand for fossil fuels quickly increased. Today, even though fossil fuels are a major source of pollution and their production and transformation have a significantly negative impact on human health and the environment, they are still comprise our main sources of energy. We are currently using nonrenewable energy sources much more quickly than the earth can make them—and scientists think we will run out of them before too long! The main fossil fuels are natural gas, oil, and coal.

Natural gas

- A mixture of gases, primarily methane; found in the earth's crust and in swamps.
- Used for cooking, heating water, and building; emits less greenhouse gases when burned than coal or oil.

Oil

- A thick black liquid extracted from deep layers of the earth.
- Requires processing to separate its components: gasoline, diesel, jet fuel, and other fuels.
- Emits large amounts of carbon dioxide when burned.

Coal

- Extracted from underground mines or open pits.
- Most abundant fossil fuel; world's largest source of electricity and heat.
- Major pollution source due to its GHG emissions.

The impact of fossil fuels

Why is using fossil fuels for energy so bad for the climate? Because burning coal and other fossil fuels emits gases such as CO2, sulfur oxide, and nitrogen oxide. These gases linger in the atmosphere, increasing the greenhouse effect and warming the earth.

Sulfur oxide and nitrogen oxide contribute substantially to acid rain when they react with water vapor and form sulfuric and nitric acids. Acid rain affects forests by lowering their pH, which affects their fertility. Acid rain also creates conditions in which it is impossible for some aquatic fauna to survive, thereby affecting the ecosystems in rivers and other bodies of water.

A similar effect can be found on land. The acid rain lowers the pH of the soil, leading to the extinction of some terrestrial species. Not to mention the severe impact that the infrastructure needed to exploit and transport fossil fuels, such as oil wells, pipelines, refineries, gas lines, and offshore platforms, has on the soil, subsoil, and living creatures that live there.

All of these processes change the physicochemical conditions of the air we breathe, the water we drink, and the soil in which we plant and harvest the food we eat.

Thermoelectric plants and the environment

Although electricity occurs naturally (in lightning, for example), we have not yet figured out an effective way to capture and store it. As a result, we invented artificial ways to create electricity—such as power plants.

Thermal power plants make electricity by burning fossil fuels, such as oil, coal, or natural gas (figures 3 and 4). They consist of a boiler, a turbine, and a generator. The boiler burns the fuel and produces enough heat to boil water, turning it into steam. It then travels at a high pressure through the turbines, turning the blades of a rotor. The mechanical energy from the rotor blades feeds into the generator, which uses it to make electrical energy. Sometimes, this energy is transformed into other forms of energy, such as thermal, light, or mechanical—all of which are necessary for machinery to operate.

In addition to emitting greenhouse gases that contribute to climate change, plants without the proper technology can also contaminate groundwater by leaching heavy metals, acidify bodies of water, destroy ecosystems through land transformations, pollute seas and coasts when spills occur, and degrade forests. Even the temperature difference between the water in the original body of water and that used by a thermoelectric plant for cooling purposes could negatively affect aquatic life when the warmed water is returned to its source.

Figure 3. How a thermal power plant works

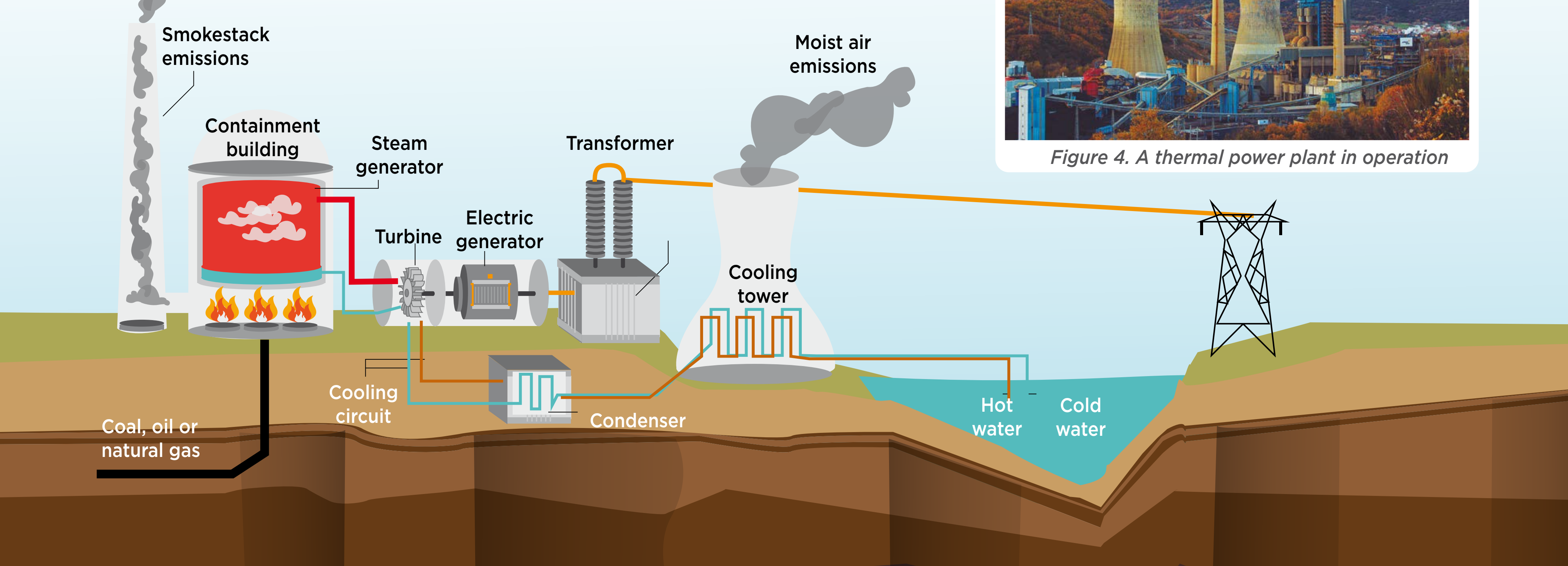


Figure 4. A thermal power plant in operation

Renewable energy sources

Renewable energy sources, on the other hand, can be quickly regenerated, are virtually inexhaustible, and are easily used. They emit a negligible amount of greenhouse gases compared with traditional fossil fuels.[1] And unlike fossil fuels, renewables can be used to produce electricity at the site where they are exploited—a process known as *distributed* generation.

There are many kinds of renewable energies, including solar, wind, hydro, geothermal, tidal, wave, and biomass. They all share one common source though—directly or indirectly, they all come from the sun's energy.

Formed 5 billion years ago and expected to exist for roughly another 5 billion years, the sun is considered an inexhaustible energy source, unlike fossil fuels. Every day, the earth gets as much energy from the sun as all human beings consume in one year. Unfortunately, we have not yet discovered an inexpensive way to capture and store the sun's energy in large quantities.

For thousands of years, ancient architects and engineers used the sun to their advantage. For example, 2,500 years ago in Greece, Socrates designed his house to exploit the benefits of the sun in every season—it would stay warm in the winter and cool in the summer. This type of passive solar energy is still used today in bioclimatic architecture designs, which work with the sun to provide heat during the winter and air conditioning during the summer. Passive solar energy is only one of the ways renewable energy is used. Humans have also developed ways to actively transform solar and other renewable energies into electricity, heat, and fuel. To better understand what this means, let's explore the different renewable energy sources—their advantages and disadvantages, where they come from, and how they work.

1 If renewable sources are used to produce electricity with a specific technology or machinery, the emissions produced during construction of that machinery and the plant itself are considered as if they were emissions from the electricity produced from the renewable resource. These emission levels are much lower than those from fossil fuels.

Sun

- » The earth's largest energy source.
- » Solar energy used by thermal systems in water heaters and heating systems.
- » Photovoltaic systems convert sunlight into electricity.
- » Does not emit greenhouse gases.

Wind

- » Can transform kinetic energy from air currents into other forms of energy.
- » Long used to move sailboats and windmill blades that power machinery and extract groundwater.
- » Virtually zero greenhouse gas emissions.

Water

- » The force of falling water in dams and rivers powers turbines, driving generators that produce electricity.
- » Hydropower fueled the growth of large American cities in the early nineteenth century.
- » Produces less greenhouse gases than fossil fuels.

Marine energy

- » Energy from changing tides and waves can generate electricity.
- » Energy is generated from temperature differences in ocean water.
- » Does not emit greenhouse gases.

Geothermal energy

- » Steam from the earth's hot core is used to power turbines that drive generators to produce electricity.
- » There is considerable untapped potential to exploit geothermal energy in Latin America.
- » Emits far less carbon dioxide than fossil fuels.
- » Virtually zero greenhouse gas emissions.

Biomass

- » Comes from organic matter in living organisms.
- » Types include:
    - Biogas: Bacteria convert organic waste into methane gas.
    - Biofuels: Burning, distilling, or fermenting plant or animal materials to make heat, such as biodiesel and bioethanol.
    - Wood: Burned for heating.
- » Amount of greenhouse gas emitted varies by process (combustion, distillation, or fermentation).

Advantages of renewable energy

- » Local energy sources can be tapped and used in the same vicinity, promoting independence from external sources and generating local employment.
- » The variety of sources—sun, water, wind, tides, biomass, and the internal heat of the earth—ensures flexibility and price stability; the resources themselves are free.
- » Energy is produced continuously from natural forces.
- » Complementary sources of energy can be used alongside conventional energy sources to lower demand.
- » Emissions of greenhouse gases are much lower than for nonrenewable energy sources.

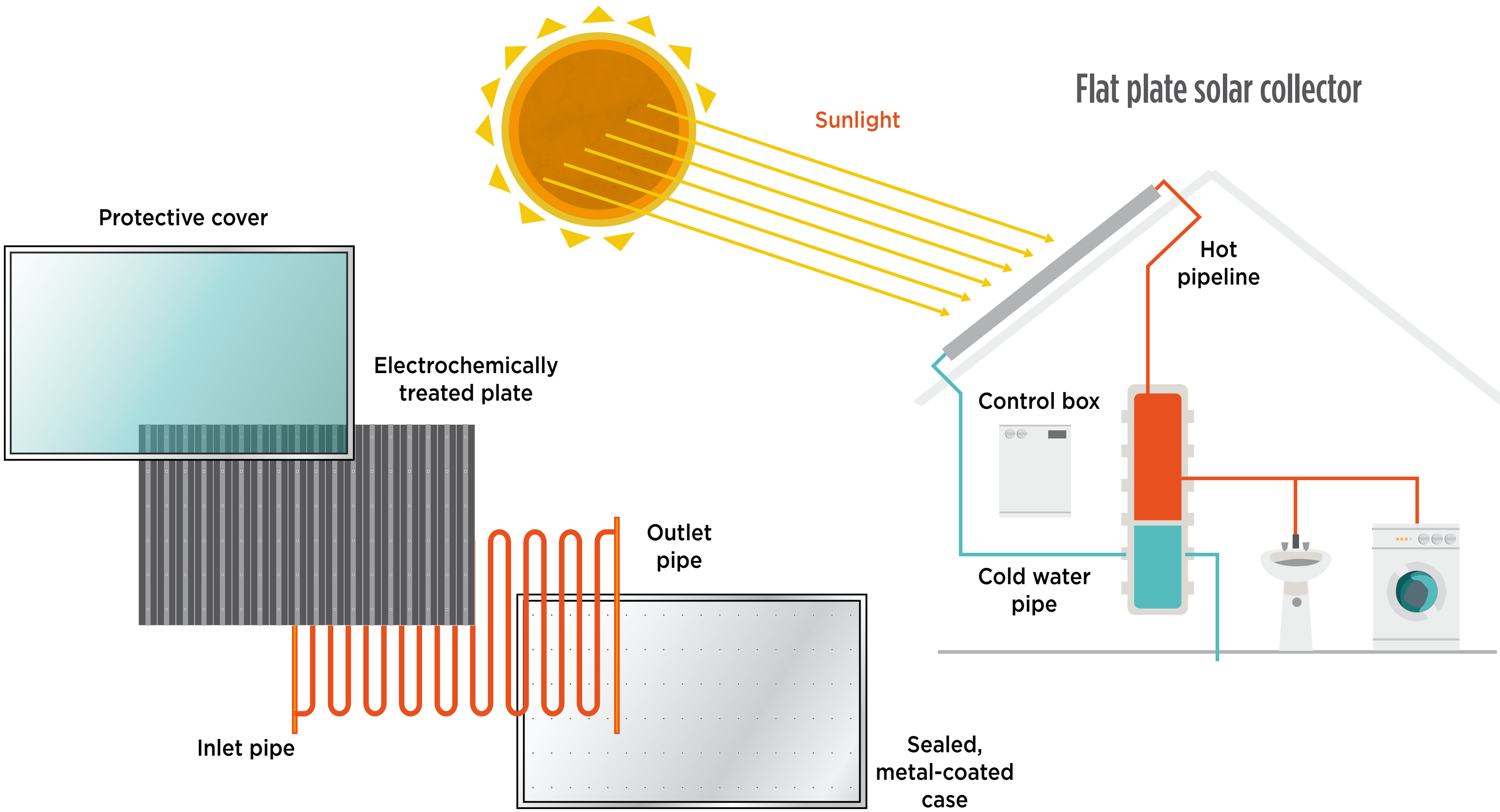
Disadvantages of renewable energy

- » With their high visual impact, wind turbines affect landscape aesthetics.
- » Unless the risks are properly mitigated, wind turbines located along bird and bat habitats and along migratory routes can have negative environmental impacts, including harm to wildlife. There is also concern about the potential deforestation of woodlands by large hydroelectric dams, which can interrupt the routes of migratory fish.
- » The technology for producing equivalent amounts of power (or to deliver the same amount of energy) as nonrenewable sources is limited. Additional renewable energy installations are needed. Solar and wind resources are variable—investments are needed to develop more efficient technologies to store energy from renewable sources as electricity so that it does not have to be produced and used simultaneously. However, geothermal energy can provide power as needed.
- » Burning wood releases CO2 emissions into the atmosphere and causes respiratory disease.

What is solar thermal energy?

Thermal means heat. We use solar thermal energy to heat water for showers, washing machines, and dishwashers. A *flat plate collector* is used to trap the sun's energy (figure 5). It is a metal box with a transparent lid that is usually made of glass and metal tubes joined together by a black metal plate. Cold water circulates inside the box and as it passes through the tubes is heated by the sun. These collectors can even heat water to its boiling point of 100˚C!

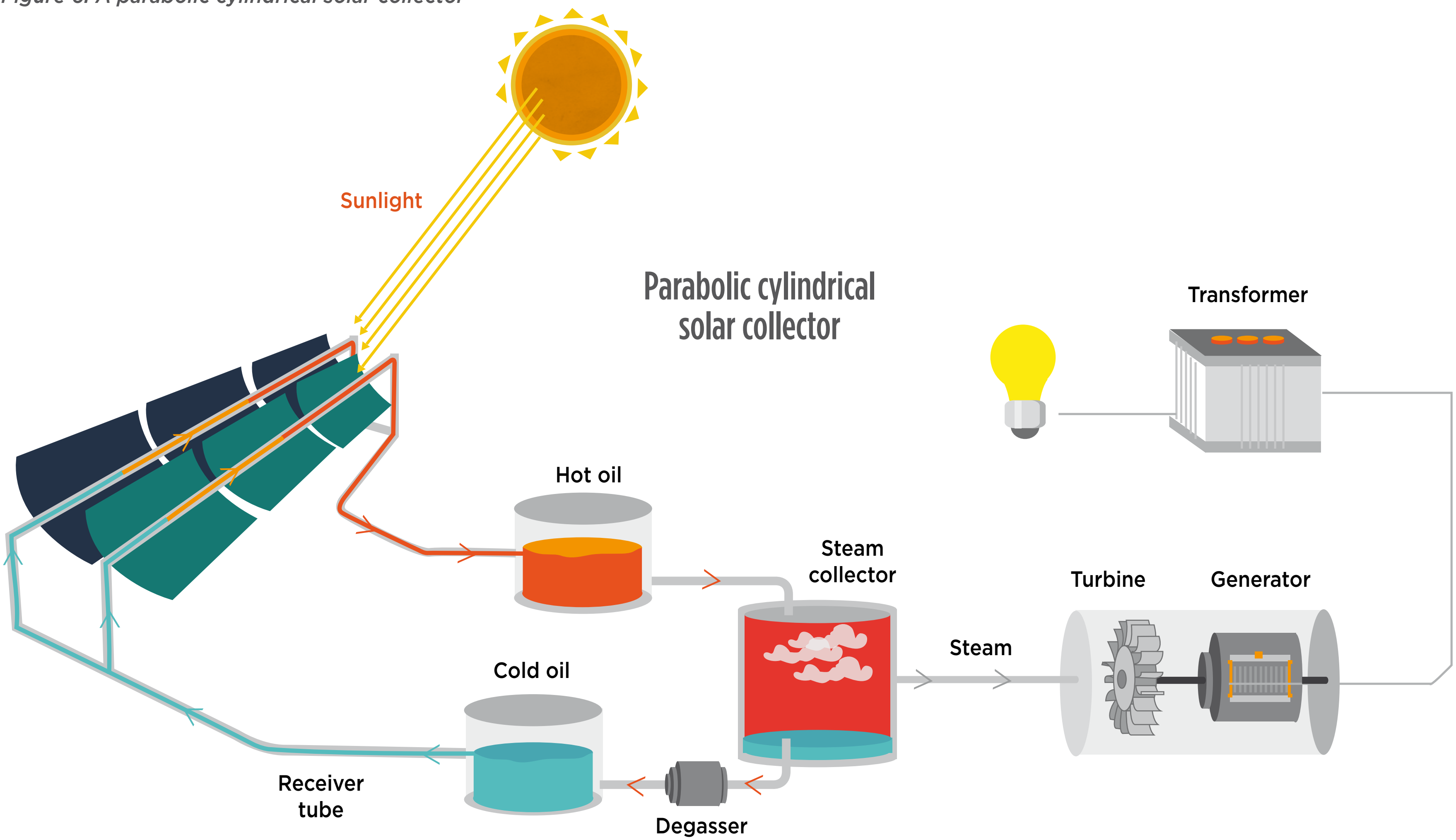
Figure 5. A flat-plate solar collector



Solar thermal power

Thermoelectric power plants use either parabolic cylindrical collectors (figure 6) or a central receiver to reflect sunlight onto a fluid-filled tube. The fluid in the tube warms in the sunlight and causes the water inside a heat exchanger to reach the boiling point, converting it into steam. This steam drives the turbine, powering the generator that produces electricity. By focusing the sun's rays like laser beams on the tubes, these systems can heat the fluid inside to very high temperatures (400˚C–1000˚C), producing enough water vapor to generate an abundance of electricity. These systems can power light bulbs, televisions and other appliances, industrial machinery, and even entire communities and cities.

Figure 6. A parabolic cylindrical solar collector



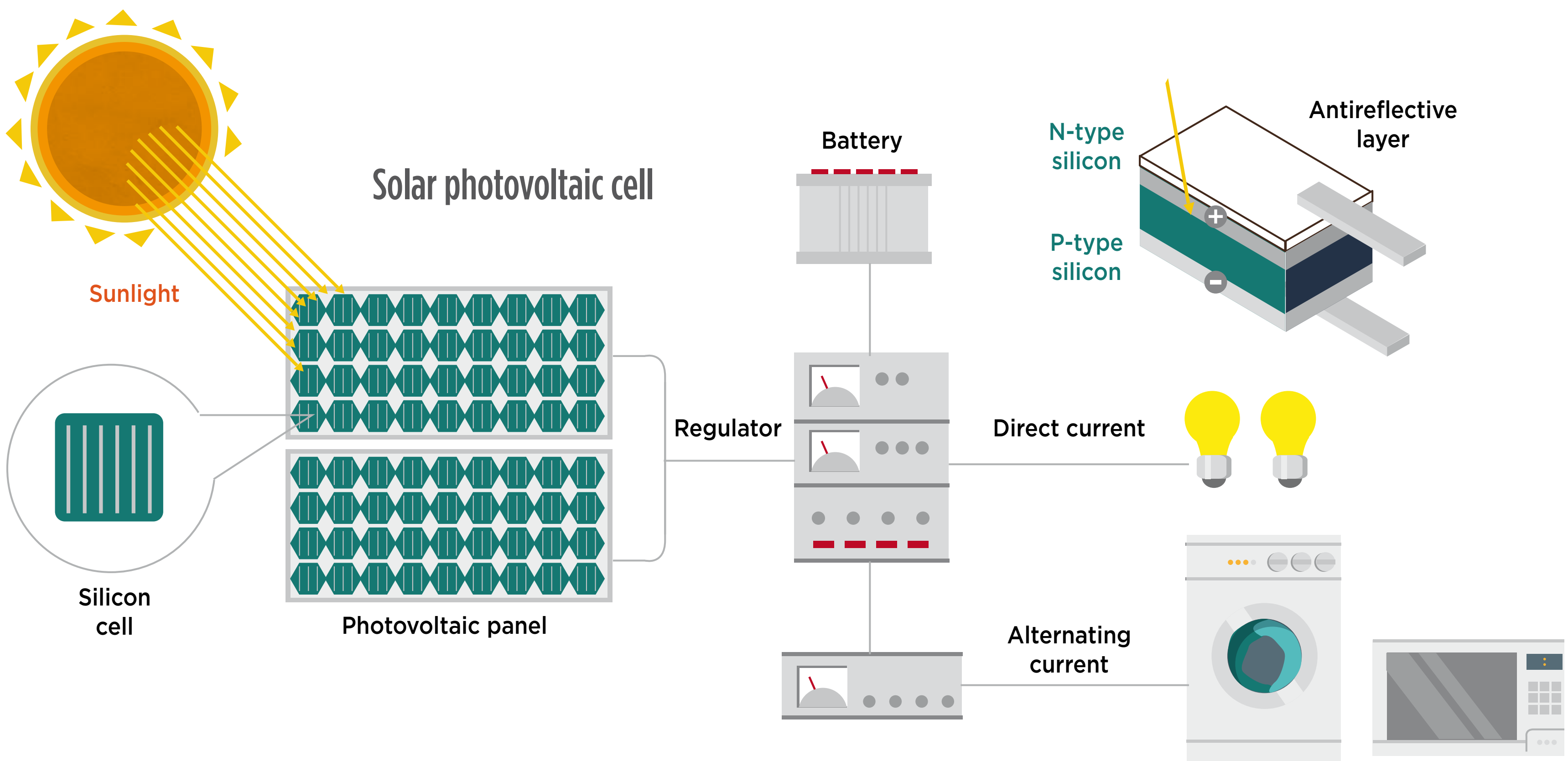
Solar photovoltaic energy

Solar photovoltaic systems convert solar energy into electricity using a device called a photocell (also known as a solar cell, photovoltaic cell, or photoelectric cell). The prefix photo means that the cell is sensitive to light, or *photosensitive*, like the paper on which photographs are printed.

When sunlight (or solar radiation) particles—called *photons*—collide with the silicon atoms in the photocell, the electrons inside the atoms break off and begin to move about freely, thus generating electricity. To capture this electricity, hundreds of photovoltaic cells (figure 7) are grouped and connected together with wires, forming a photovoltaic/solar panel. When connected in this way, the cells can supply enough electricity to recharge a battery, and that battery can store energy to be used when there is no sunlight.

When connected to a conventional distribution network in a home or building, the electricity from these systems complements the supply of electricity from fossil fuel plants, which ultimately reduces CO2 emissions. Solar panels can make enough electricity to power domestic appliances, but they are not used to heat water because doing so would be expensive and inefficient. Solar thermal energy is better suited for heating water.

Figure 7. A solar photovoltaic cell

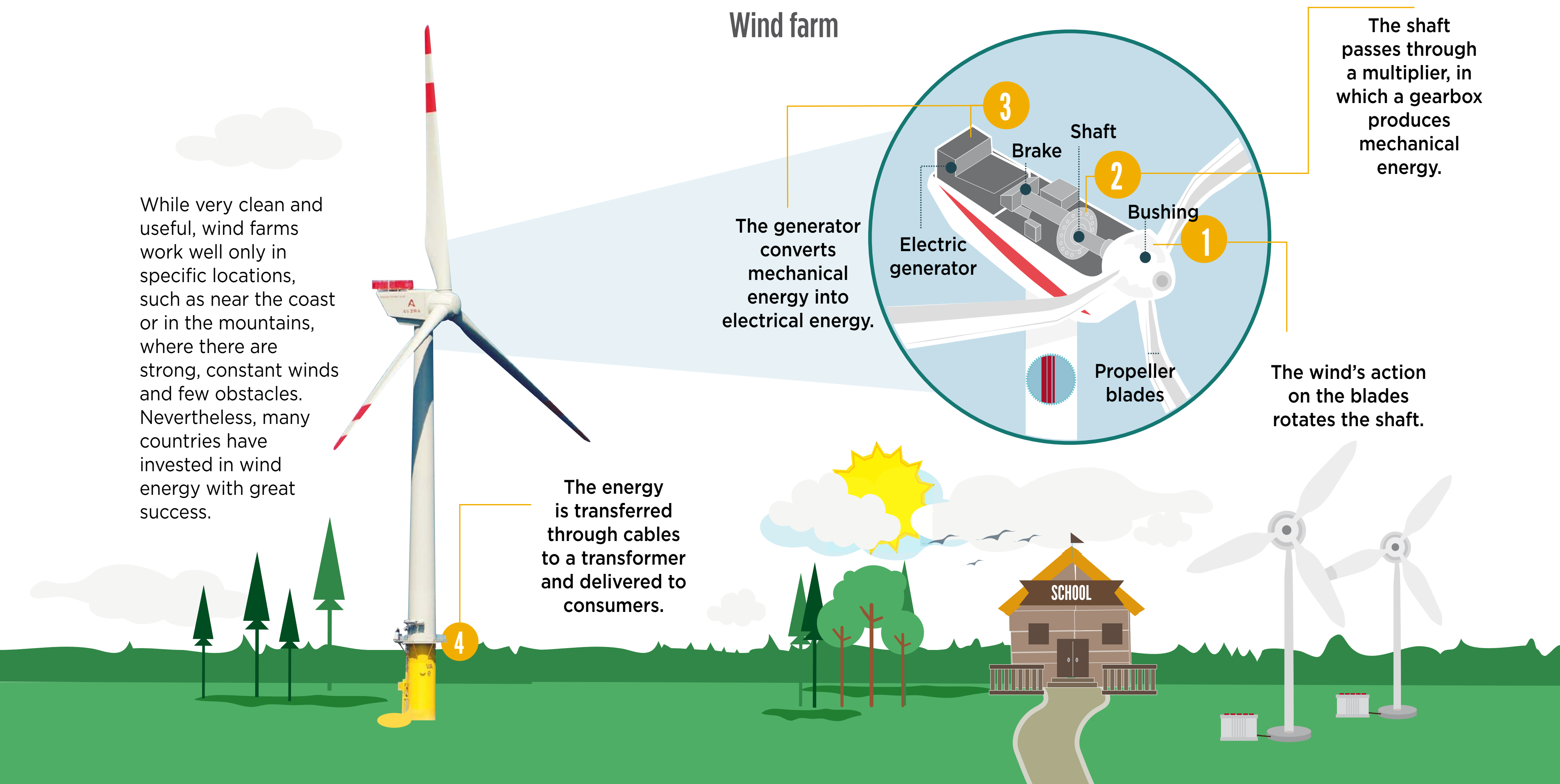


Making electricity from the wind

Wind energy has been used for over 4,000 years to propel sailboats, and for many regions of the world, it is an excellent choice for an alternative energy source. In the early twentieth century, Denmark and the United States were among the first countries to use windmills to generate electricity from wind energy. But it wasn't until the mid-1900s that wind turbines began to power the electrical grid. Kinetic wind energy turns the blades of the wind turbines, which then power a generator that converts the kinetic energy into electricity.

Locations with more than one wind turbine are called *wind farms* or *wind parks* (figure 8). Wind farms can generate plenty of electricity, and some countries—such as Denmark—get a large percentage of their energy from the wind. Today, Denmark gets one-third of its energy from the wind. By 2020, an estimated 50 percent of its energy will come from wind farms.

Figure 8. A wind farm



While very clean and useful, wind farms work well only in specific locations, such as near the coast or in the mountains, where there are strong, constant winds and few obstacles. Nevertheless, many countries have invested in wind energy with great success.

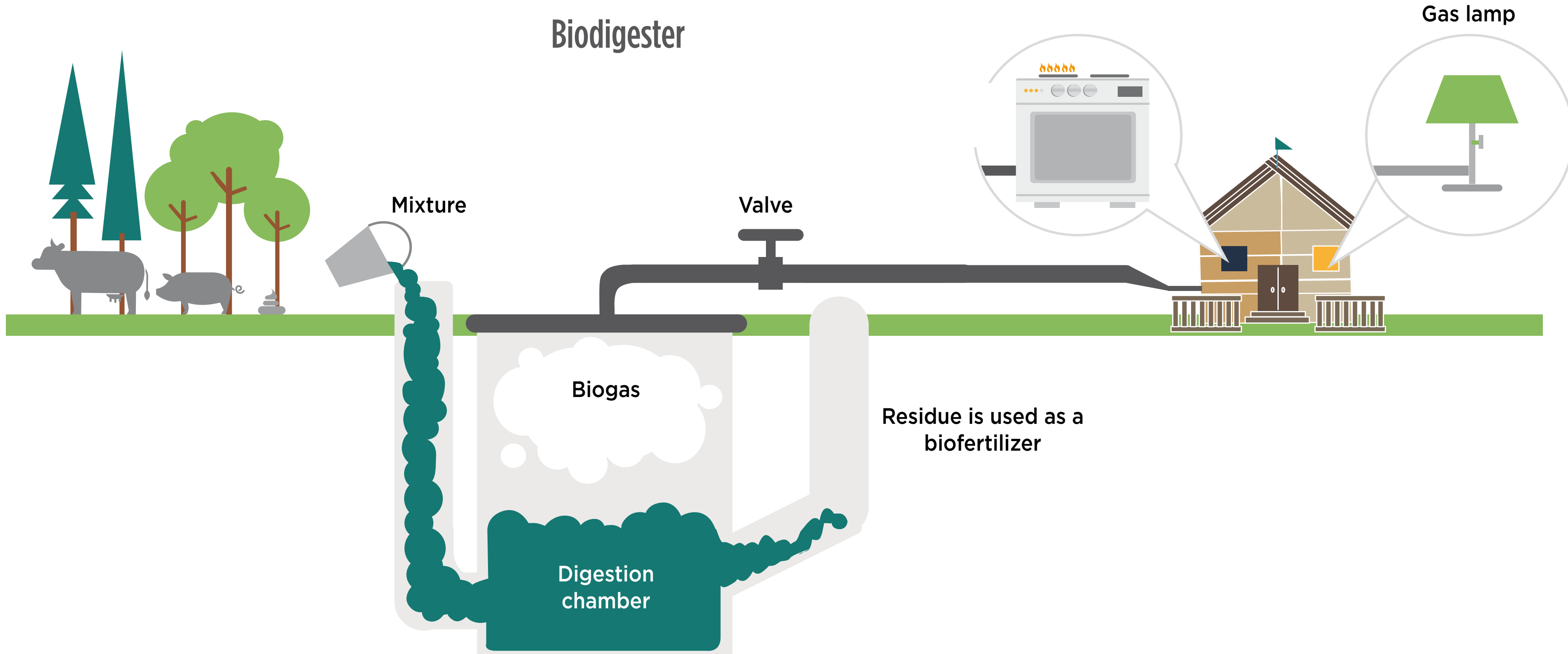
Valuing biomass

Food waste, branches, tree bark, tree trunks, agricultural waste, manure, and dead plants can all be used to produce energy. People have burned wood to heat water and prepare food for a very long time, but the use of biomass fuel hurts our environment. It emits greenhouse gases, adds to deforestation, and pollutes homes, endangering human health. However, new inventions like efficient cooking stoves present realistic and interesting alternatives for people in rural areas.

Today, we can make renewable energy from biomass. Microorganisms, for example, make biogases—such as methane and hydrogen—when they break down organic materials in the absence of oxygen, a process called **anaerobic digestion.** This process is carried out in a dark, humid, airless tank (called a biodigester) made from metal, bricks, or plastic. The bacteria's gases can be used to power stoves, gas lamps, and even spin turbines to make electricity. Biodigesters are common on farms that produce a lot of manure, food, and agriculture waste.

Biological conversion is another way to get renewable energy from biomass. It involves fermenting sugars and starch from palm leaves, sugar cane, corn, and wheat to make ethanol, methanol, or biodiesel for motor vehicles. When burned, these biofuels liberate the carbon dioxide that was previously fixed as organic matter in the growing process, so if done efficiently, this process can be carbon neutral, meaning the net output of CO_2 is almost zero.

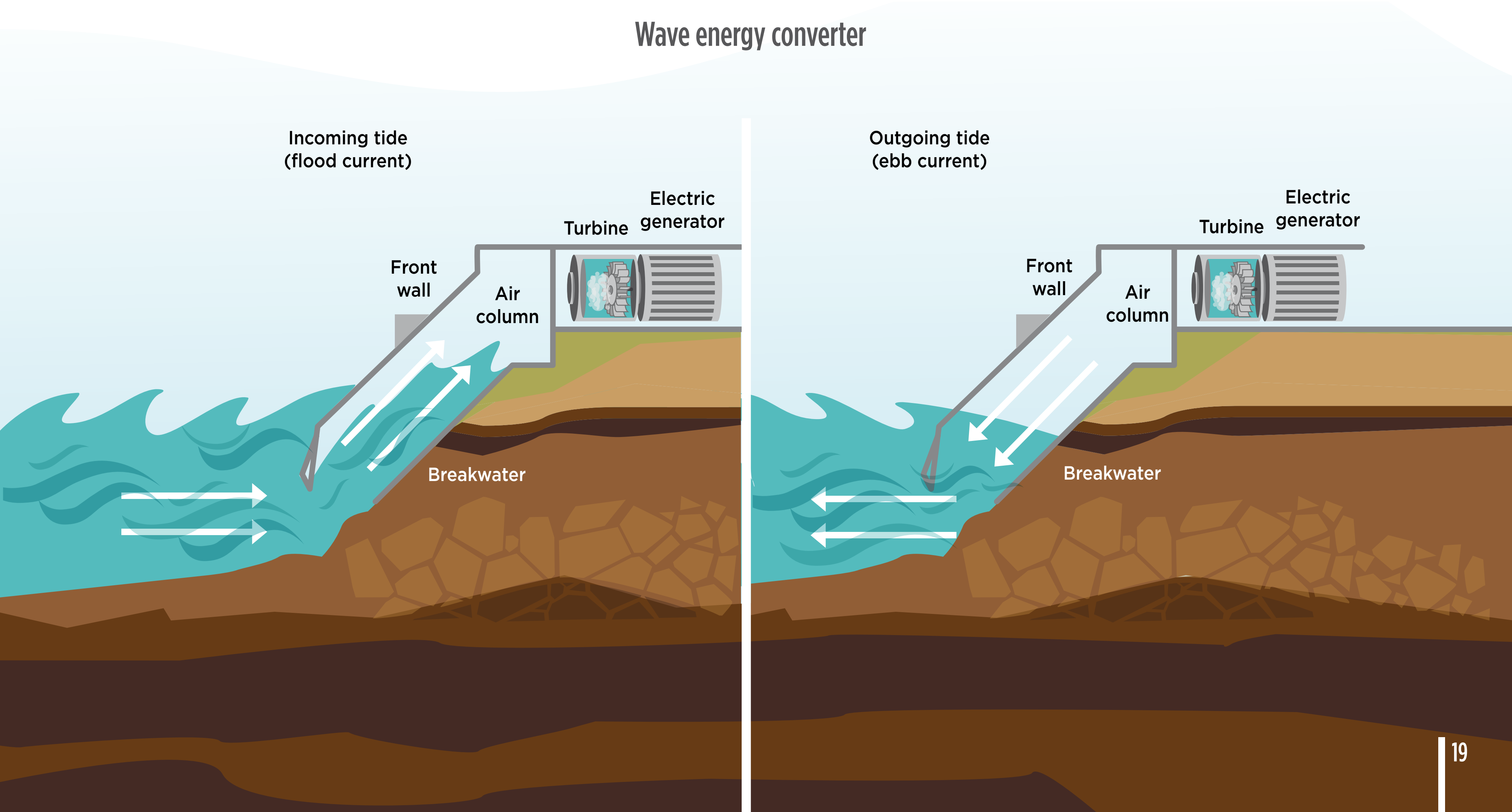
Figure 9. A biodigester



Wave energy

Waves are caused by wind blowing over the surface of the ocean. Waves travel long distances without losing energy, allowing us to capture their kinetic energy as they approach the coastline, close to the site of consumption for the world's many large coastal cities (figure 10). The energy contained in waves varies, but in general, the farther away they are from the equator, the more energy they contain. However, local conditions, such as the type of coast and the ocean depth, also affect the energy levels of waves.

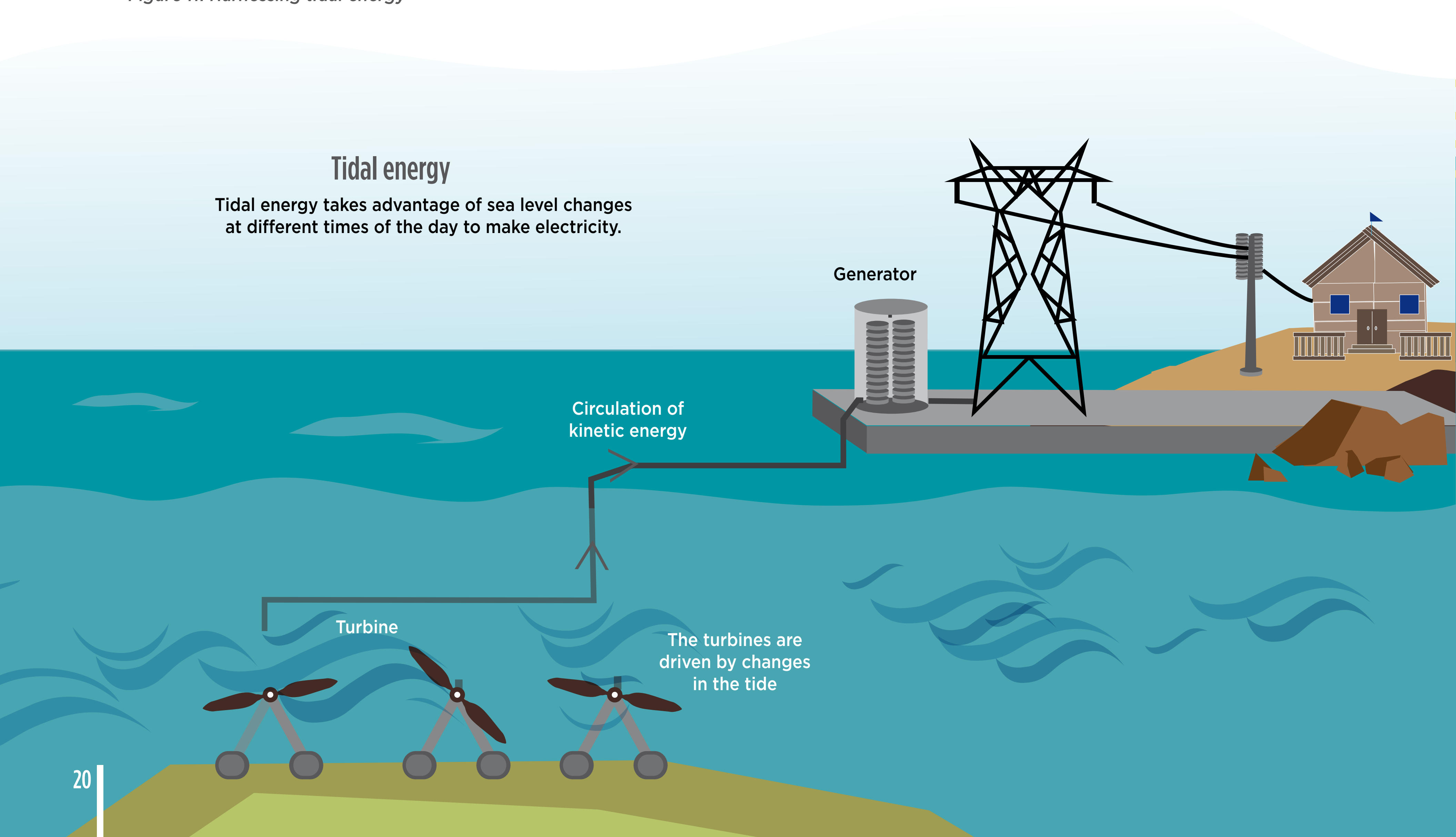
Figure 10. A wave energy converter



Tidal energy

Tidal energy takes advantage of sea level changes during the day to make electricity (figure 11). For this system to be profitable, there must be at least a three-meter difference between high and low tides, and there are only a few places in the world that satisfy this condition. In addition, the system has to be situated close to the mainland to facilitate energy transport.

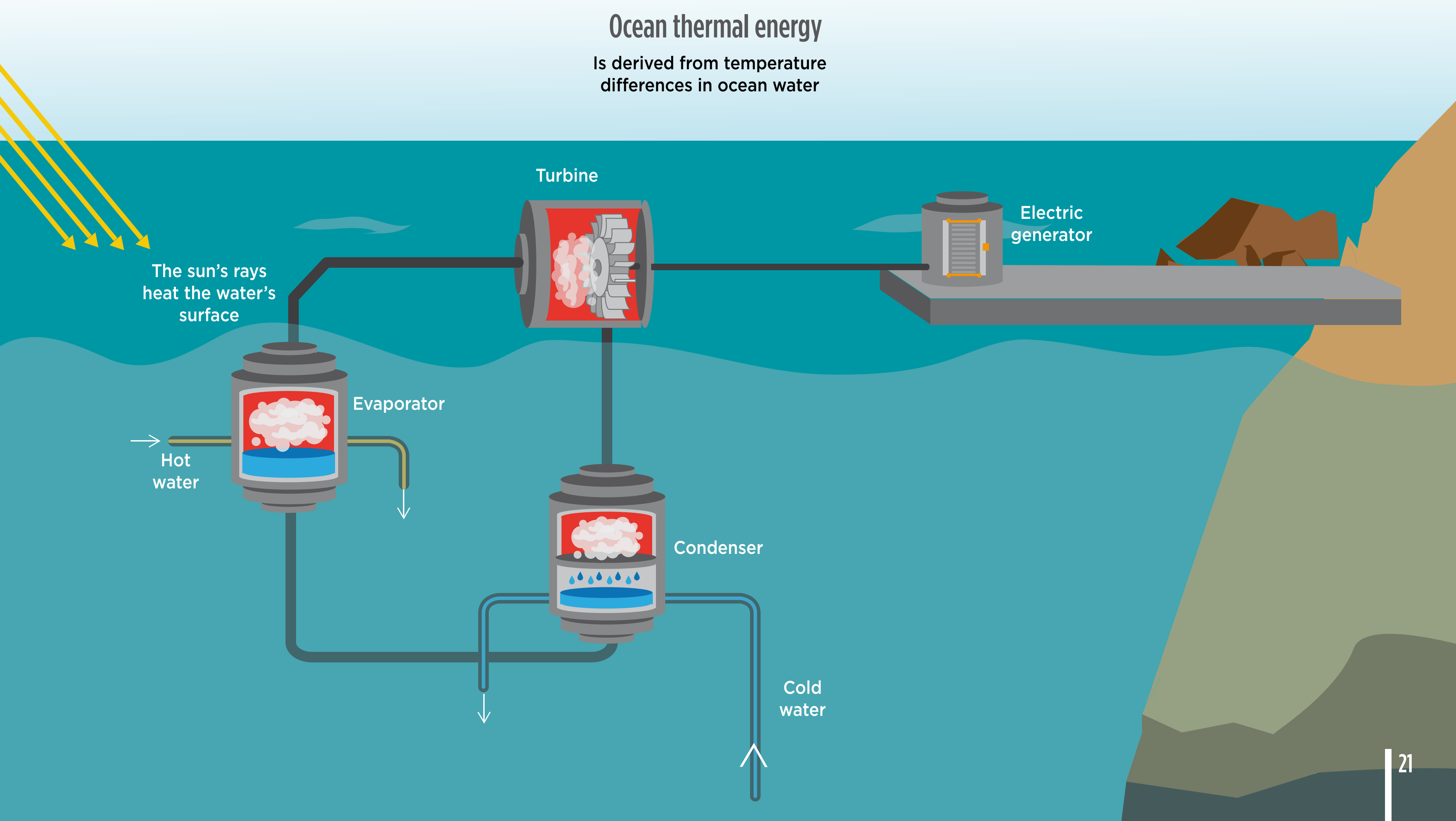
Figure 11. Harnessing tidal energy



Ocean thermal energy

Ocean thermal energy uses the temperature differences in ocean water to heat fluid inside a heat exchanger (figure 12). The hot fluid evaporates and the resulting steam drives a turbine, which powers a generator, producing electricity.

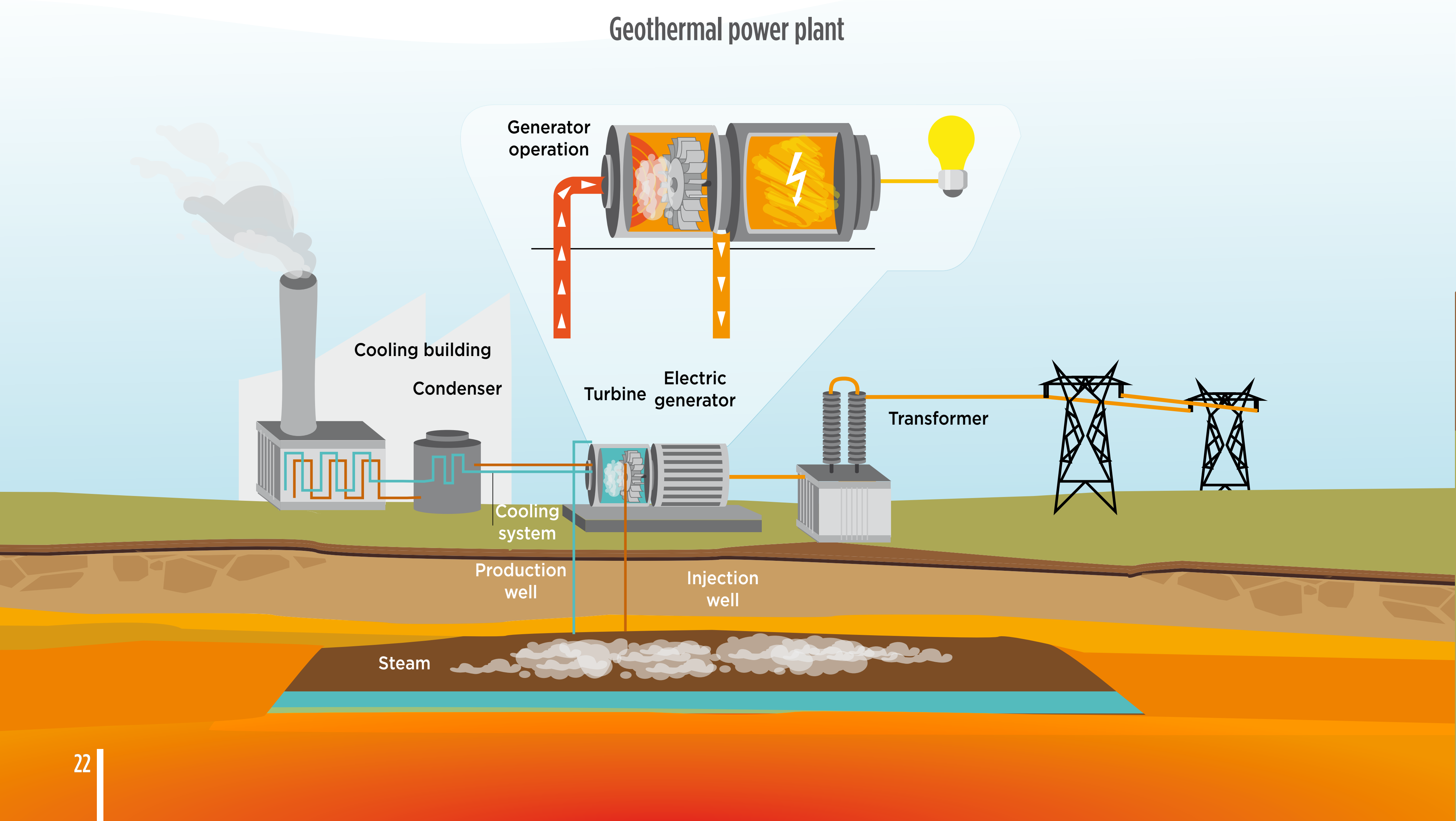
Figure 12. Ocean thermal energy



Geothermal energy

Geothermal power comes directly from the sun or from heat deep inside the earth (figure 13). We can catch glimpses of this heat in steam coming from hot springs and geysers and in lava from volcanoes.

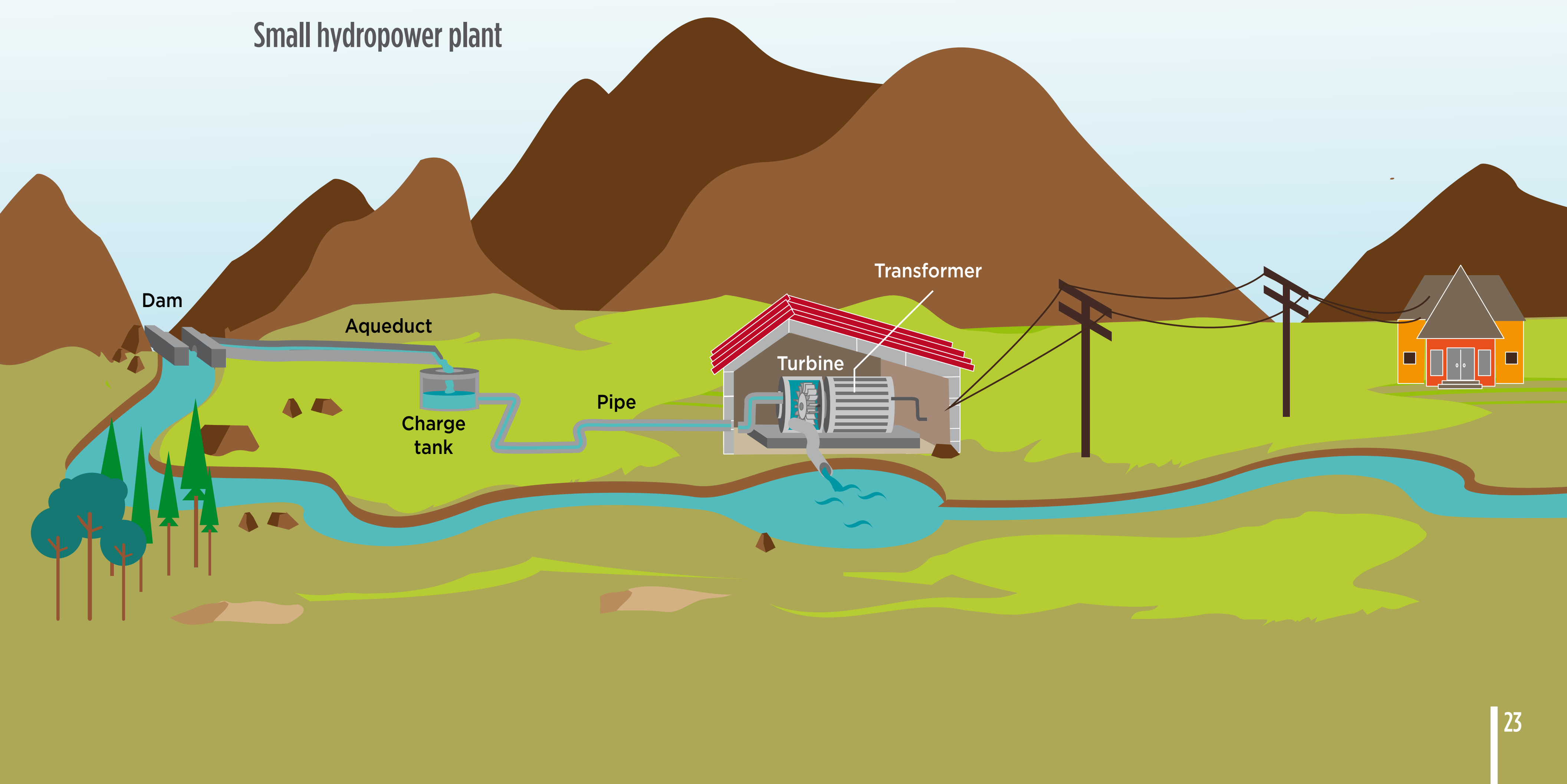
Figure 13. A geothermal power plant



Small hydropower plants

Unlike large hydropower plants, small plants are renewable energy sources because, in addition to having an endless water supply, they do not negatively affect the environment. They can be installed on riverbeds or in water storage tanks located in temporary river diversions (figure 14). The natural movement of the water drives a turbine that is connected to a generator, which converts the kinetic energy into electricity.

Figure 14. A small hydropower plant



Controversial energy sources: Large hydropower and nuclear power

Large hydropower

Built on rivers, hydropower plants use large dams to capture energy from flowing water. The plants use energy from strong river currents or falling water to drive turbines and power electricity generators. In other words, the plant first converts the water's potential energy into mechanical energy, and then into electricity.

Several Latin American countries, including Brazil, Venezuela, Mexico, Paraguay, Argentina, and Colombia, use hydropower as a primary source of energy. In Brazil, hydroelectricity accounts for some 14 percent of the primary energy matrix. Its large rivers have permitted the country to install large hydropower plants, such as the Itaipu plant on the border between Brazil, Paraguay, and Argentina. The second largest hydropower plant in the world, Itaipu produces 93.4 million megawatt hours (MWh) of electricity per year.

Some people believe hydroelectric plants can reduce the effects of climate change because they do not emit greenhouse gases and toxic particles, and they do not cause acid rain. Further, they have very low operating costs, they require no refrigeration or heating systems, and they make energy using an inexhaustible resource—the water cycle.

However, hydropower plants also have significant environmental and social impacts. Their construction changes ecosystems by altering riverbeds, reducing biodiversity and damaging natural habitats. We can't even say that hydropower plants do not produce greenhouse gases because the dams that are built as part of the process cause flooding and destroy vegetation. Those decomposing trees and plants create decaying matter that affects aquatic organisms and releases methane (CH_4), a powerful greenhouse gas.

Sometimes, the water held by a dam floods vast forested and field areas and even populated areas, affecting the lives and livelihoods of communities living near the hydropower plants. Farming communities, for example, can lose hectares of crops, and fishing communities are affected because damming the water impedes the normal spawning cycle of many fish species.

Due to these environmental and social impacts, local communities and environmentalists have strongly protested against the construction of hydropower plants, dams, and reservoirs. These protests have contributed to a difficult debate among diverse and sometimes contrary voices and opinions about the need to protect livelihoods, the environment, and biodiversity if it directly conflicts with the need for energy development and security.

Nuclear power

Nuclear energy is very controversial. The March 2011 radioactive catastrophe at Japan's Fukushima nuclear plant hit by a tsunami following a strong earthquake has revived a debate that began with several prior nuclear power accidents Among the most memorable are the 1986 Chernobyl accident in the Ukraine that was caused by poor structural maintenance and questionable operating procedures and the 1979 Three Mile Island accident in the United States, which claimed no victims and where radiation leakage did not occur beyond the limits of the plant.

Nuclear energy is made naturally by stars—including the sun—and in the natural decomposition of radioactive elements deep inside the earth. These elements heat the earth's core, move tectonic plates, produce volcanism, and provide geothermal energy. But most of our nuclear energy comes from complex industrial processes that occur in nuclear reactors that generate electric, thermal, and mechanical energy. The energy comes from splitting the nucleus of an atom into two or more nuclei (nuclear fission) or joining nuclei together to form a heavier nucleus (nuclear fusion).

Nuclear power plants make electricity from heat produced by the fission of an atom's nucleus, usually Uranium-235. Fission occurs in the plant's reactor, and the resulting heat converts water into steam. The steam's energy rotates a turbine, which as it turns, drives the generator to make electricity.

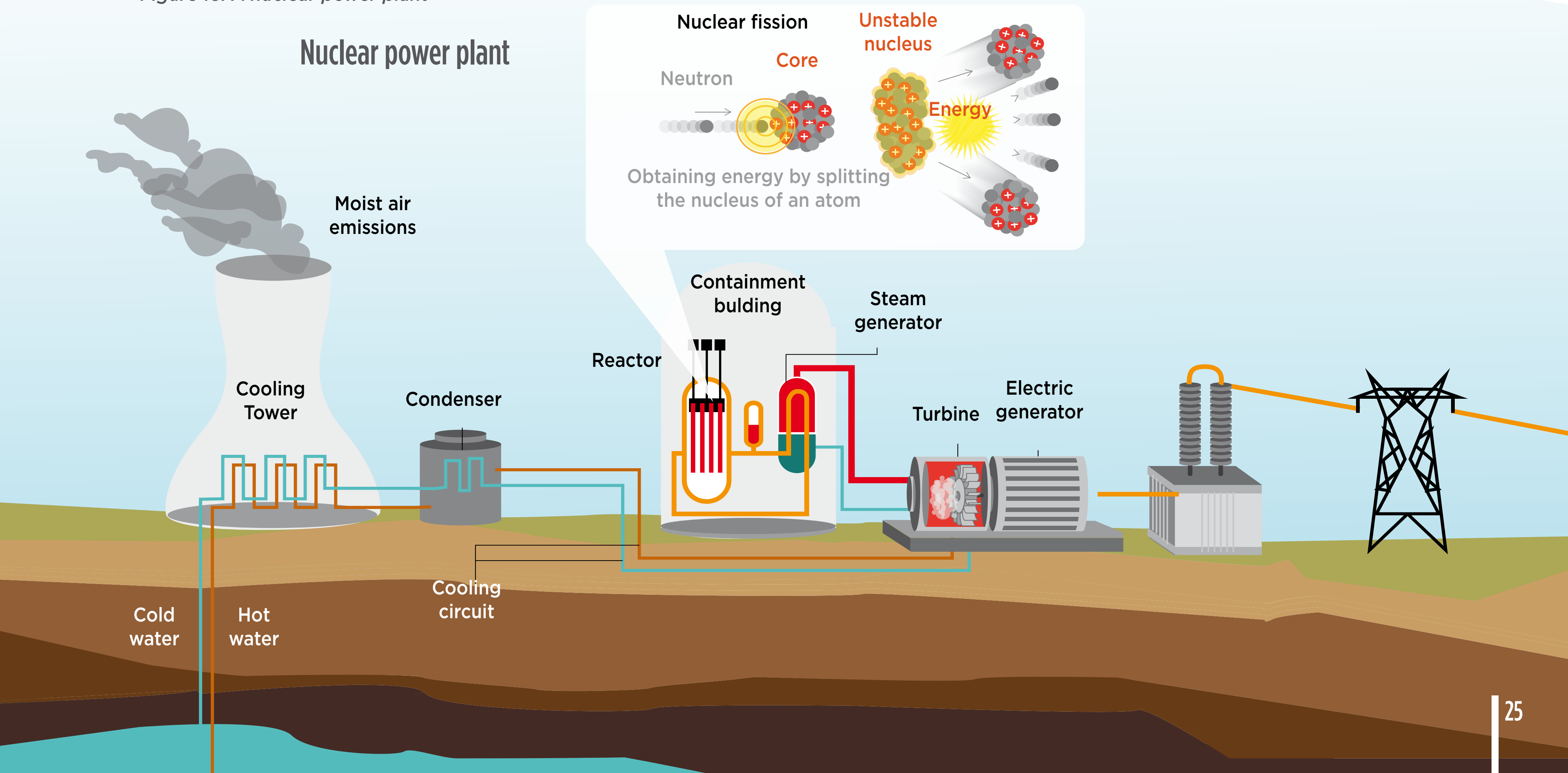
What are the advantages of nuclear energy?

- Almost zero emissions of greenhouse gases or other pollutants associated with fossil fuels.
- Improves air quality and decreases respiratory diseases.
- Uses relatively little fuel to produce energy compared to other electricity generation methods; lower transportation costs and less waste.
- Reduces dependence on fossil fuels.

What are the disadvantages?

- High risk of radioactive contamination due to accidents.
- Makes hazardous radioactive waste that is hard to eliminate, dispose of, or keep in storage.
- High installation and maintenance costs.
- Significant pollution and environmental impact from uranium extraction.
- Risk of fuel being used for military applications.

Figure 15. A nuclear power plant



Sustainable energy for all

Renewable energy sources like the wind, geothermal energy, moving water in rivers and oceans, biomass, and solar do not affect climate change or create environmental damage the way nonrenewable sources like fossil fuels do. Plus, we aren't likely to run out of renewable energy sources because of their rapid self-regenerating nature. Some renewable energy sources do have some negative environmental impacts though, but while imperfect, are still our best bet for making sustainable energy. The United Nations Development Program (UNDP) defines sustainable energy as energy produced and used in ways that promote long-term human development in all of its social, economic, and environmental dimensions.

World leaders believe sustainable energy is important for reducing so-called *energy poverty*, which affects over 1.4 billion people lacking access to modern energy, 85 percent of whom live in rural areas. Each year, 2.5 million people, mostly women and children, die from respiratory diseases because they depend on traditional biomass (firewood) and coal as their main energy sources at home.

Unfortunately, even with the high mortality rate and latent energy crisis, investments in renewable energy remain limited; there are only a few policy incentives that encourage it. To remedy this, the United Nations declared 2012 *the International Year of Sustainable Energy for Everyone* to raise awareness about the importance of increasing access to sustainable energy, energy efficiency, and renewable energy at local, national, regional, and international levels.

As you begin carrying out these lesson plans, consider that, in general terms, we tend to think about energy at the country or regional level. But it's important to think about local sources of energy as well. What type of energy supplies our school community? How is it generated and how does it get here? Is there a power generation unit close to the school? Where? Can we visit it or invite a technician to tell us how it works? What is our school's average monthly energy expenditure? How can we get that information to teachers, staff, students, and families?

Lesson Plans at the Basic Level

1

Basic lesson plan 1: The power of energy

General objectives

» Understand that we are energy.

» Introduce energy forms and sources—fossil fuels and renewable energy sources.

» Identify renewable and nonrenewable energy sources.

Class activity 1: Identifying energy

Objective	Time	Place
Understand that living beings are expressions of energy.	20 minutes	Outdoors

Materials

» Board, markers, notebook, pencils

Preparation

Find places at school for students to observe energy in nature, human activities, food preparation, use of electrical appliances, etc.

Step by step

» Talk to your students about energy. Ask them where energy comes from, when they use it, and what for? Does energy have to be recharged? How can they recharge their energy? Write their ideas on the board.

» Explain that all actions take energy, from moving an object to the wind blowing on a flag. Life is not possible without energy. We use energy to walk, talk, and play. We use it in vehicles, household appliances, and light bulbs. Wherever there is heat, movement, light, sound, or life, there is energy.

» Ask the students: can energy be seen, felt, or heard? Can you smell or taste energy?

» Take your students on a tour of the school and tell them to look for forms of energy.

» Upon returning to the class, ask students to complete the following sentences in their notebooks:

- At my school, I can **feel** energy through ______________________.
- At my school, I can **smell** energy through ______________________.
- At my school, I can **see** energy through ______________________.
- At my school, I can **listen** to energy through ______________________.
- At my school, I can **taste** energy through ______________________.

» Remember that energy is everywhere: we can hear music or sounds, feel the wind or the sun's heat, taste and smell food, and see lights, and the sun.

» Talk with your students about where the energy comes from that they use to walk, run, and talk.

» Explain that energy comes from the sun and is transferred to them through their food. (See the introductory text at the beginning of this class.)

Class activity 2: Experiment with renewable and nonrenewable energy

Objective	Time	Place
Identify sources of renewable and nonrenewable energy.	30 minutes	Classroom

Materials

» Candle, matches or lighter

» Energy source cards (9) (figure 16)

» Video "Ready to get energized?" At www.iadb.org/riseup

Materials for each student

» Photo or image of a pinwheel, pencil with an eraser, tack, scissors and pinwheel template (figure 17)

Preparation

» Print one pinwheel template per student.

» Organize materials. Students work individually.

» Watch the video.

Step by step

» Talk to your students about what the word **renewable** means. Explain to them that it comes from the verb *to renew*, meaning to return something to its original state or to make it like new. For example, our grandparents used to flip over their shirt collars when one side wore out. Ask your students for examples of things they or their parents have renewed and used again (such as toys or clothes). Then ask the student what things cannot be renewed.

» Explain that depending on its origin, energy can be classified as either renewable or nonrenewable. Invite them to watch "Ready to be energized?" at www.iadb.org/riseup.

» Show the energy sources cards to your students one by one. Talk about the different types of energy. Are they renewable or nonrenewable? It is important to discuss why different types of energy are renewable or nonrenewable.

» Show your students a photo of a pinwheel and ask if they know what kind of energy the toy uses.

» Give students the pinwheel template (figure 17) and have them create their own pinwheels by cutting along the dotted lines and making a hole on the black dot so they can attach it to their pencil eraser using a pin.

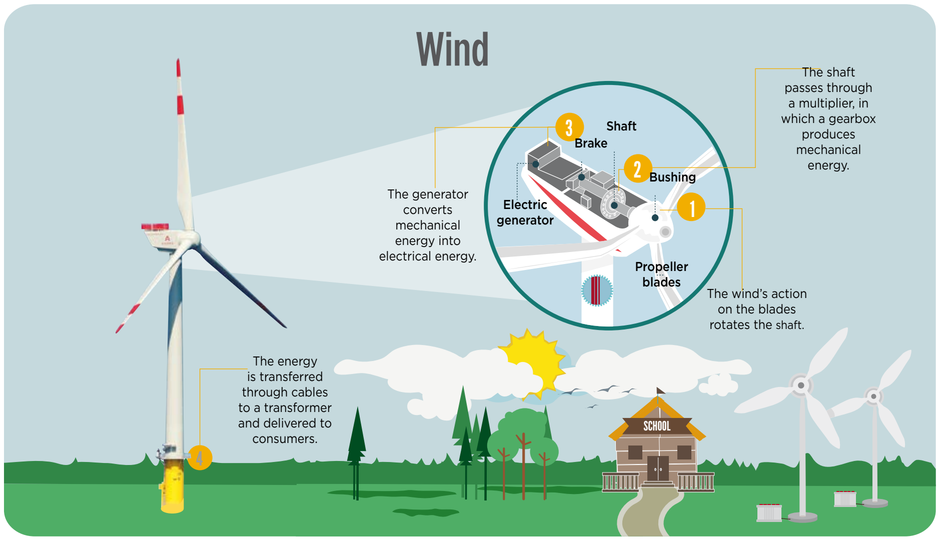
» Once the students have their pinwheels, ask them to go outside and seek out wind to make their pinwheel turn.

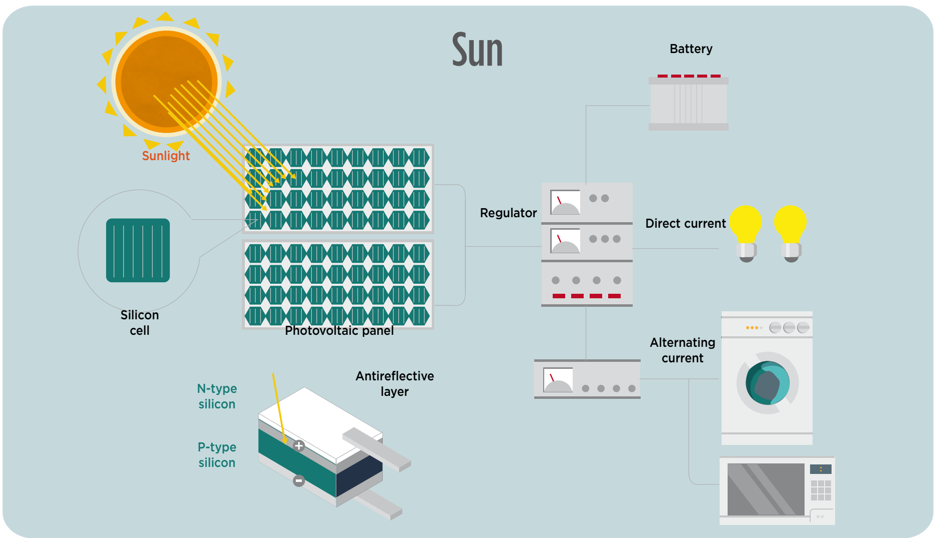
» Ask the following questions:

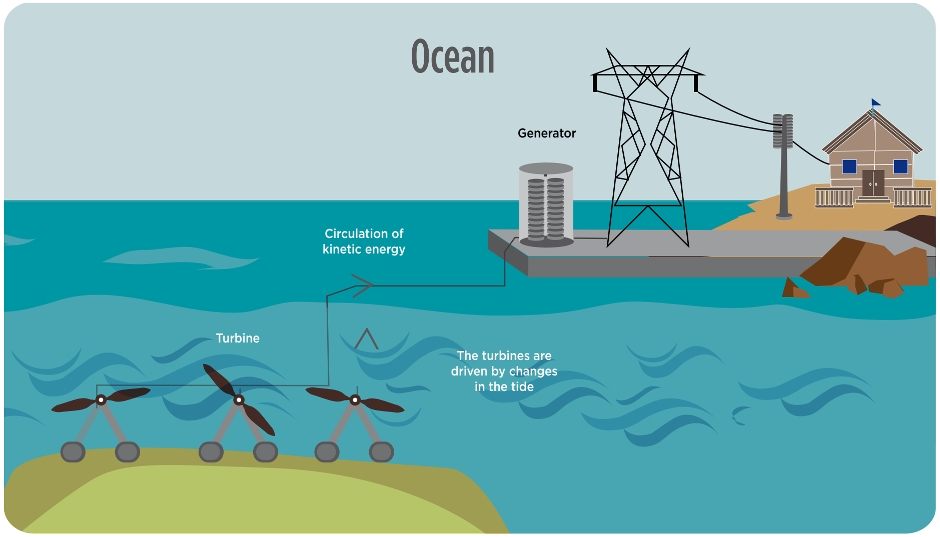
- What made the pinwheel turn?
- How many times did you use wind to make a pinwheel spin?
- Did the spinning pinwheels change anything in the environment? Did they emit smoke, gases, or anything else when they spun? Do pinwheels use renewable or nonrenewable energy? Emphasize that rotating the pinwheel does not produce any gases; all it needs is wind.

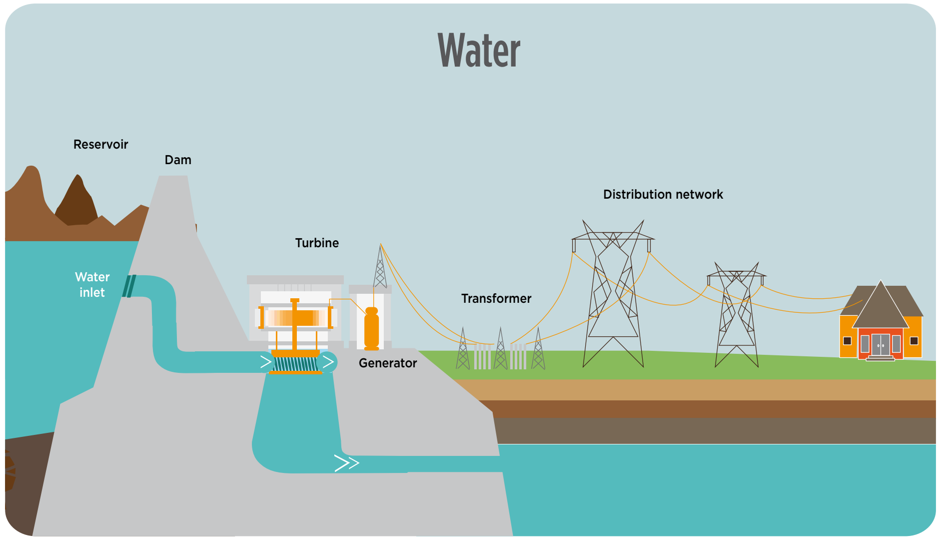
» Explain that the pinwheel works like a wind turbine—a machine like a windmill with blades that convert wind into electricity. It is an example of a renewable energy source.

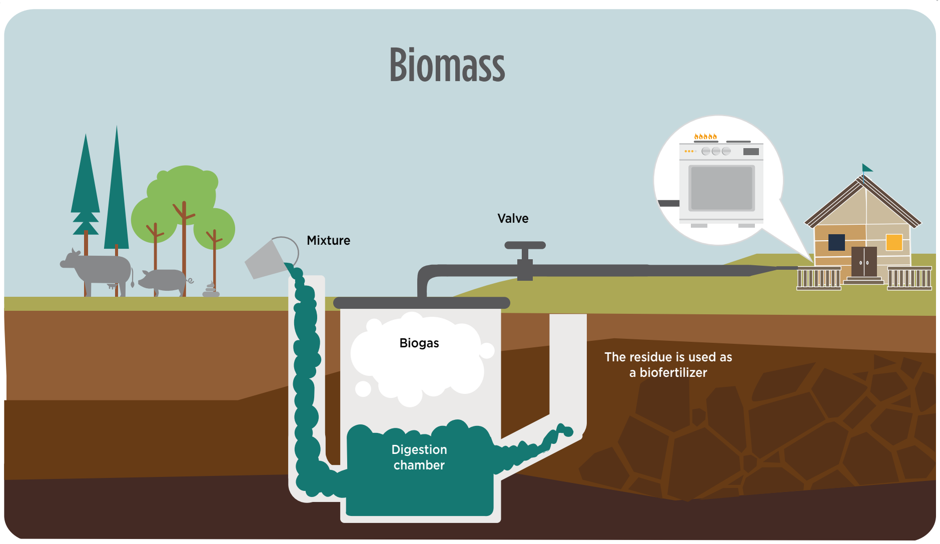
Figure 16. Energy source cards

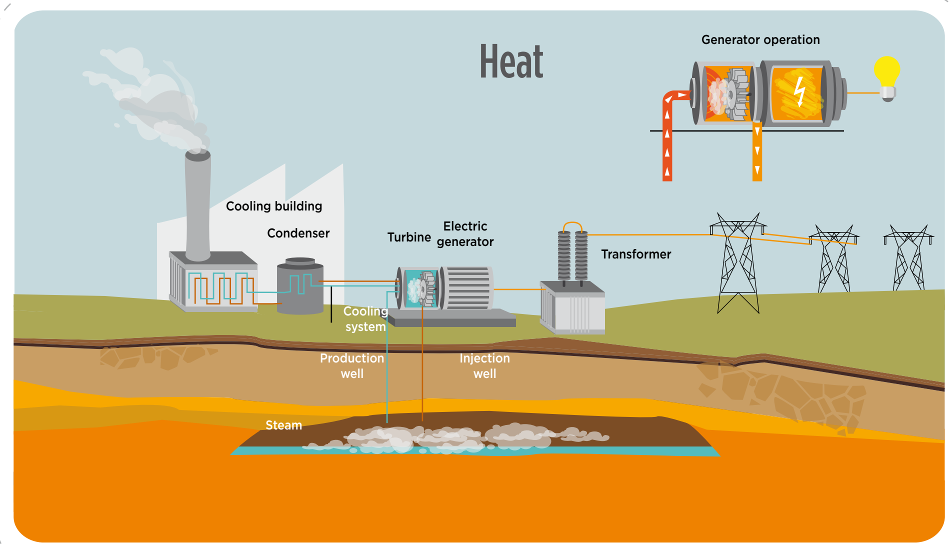


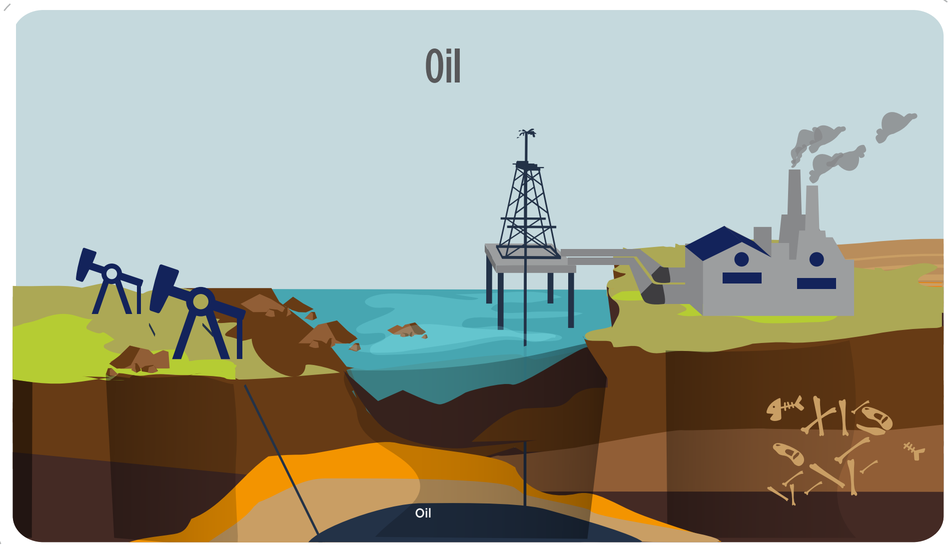


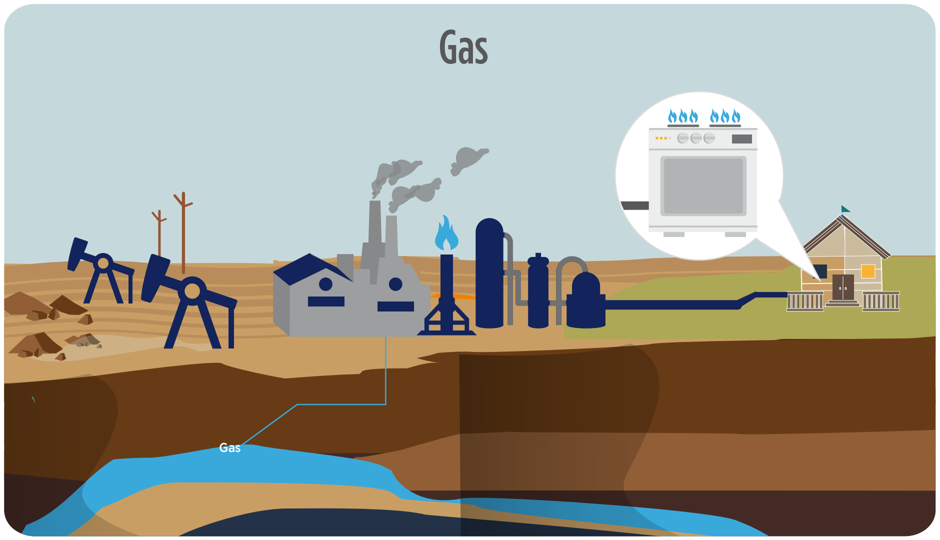



Water
Reservoir
Dam
Water inlet
Turbine
Generator
Transformer
Distribution network


Biomass
Mixture
Valve
Biogas
Digestion chamber
The residue is used as a biofertilizer


Heat
Generator operation
Cooling building
Condenser
Turbine
Electric generator
Transformer
Cooling system
Production well
Injection well
Steam


Oil
Oil


Gas
Gas

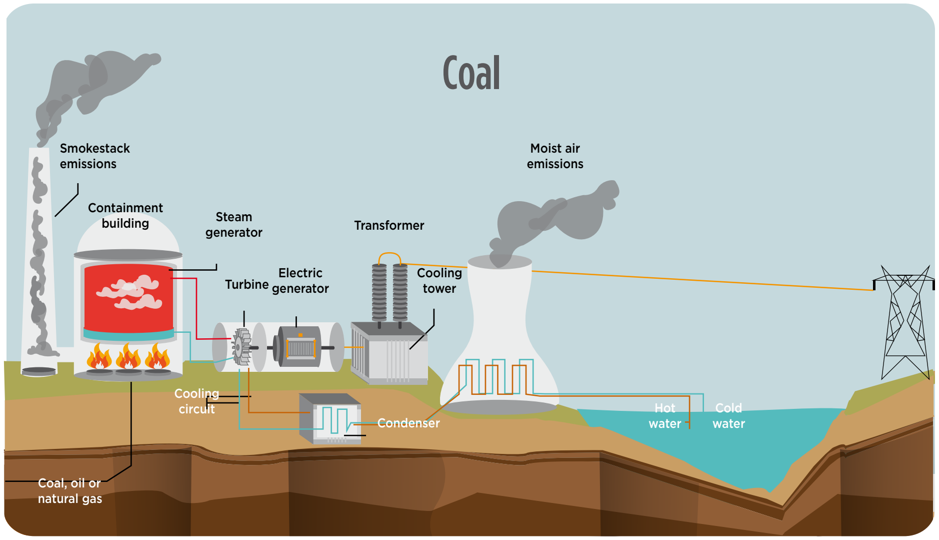
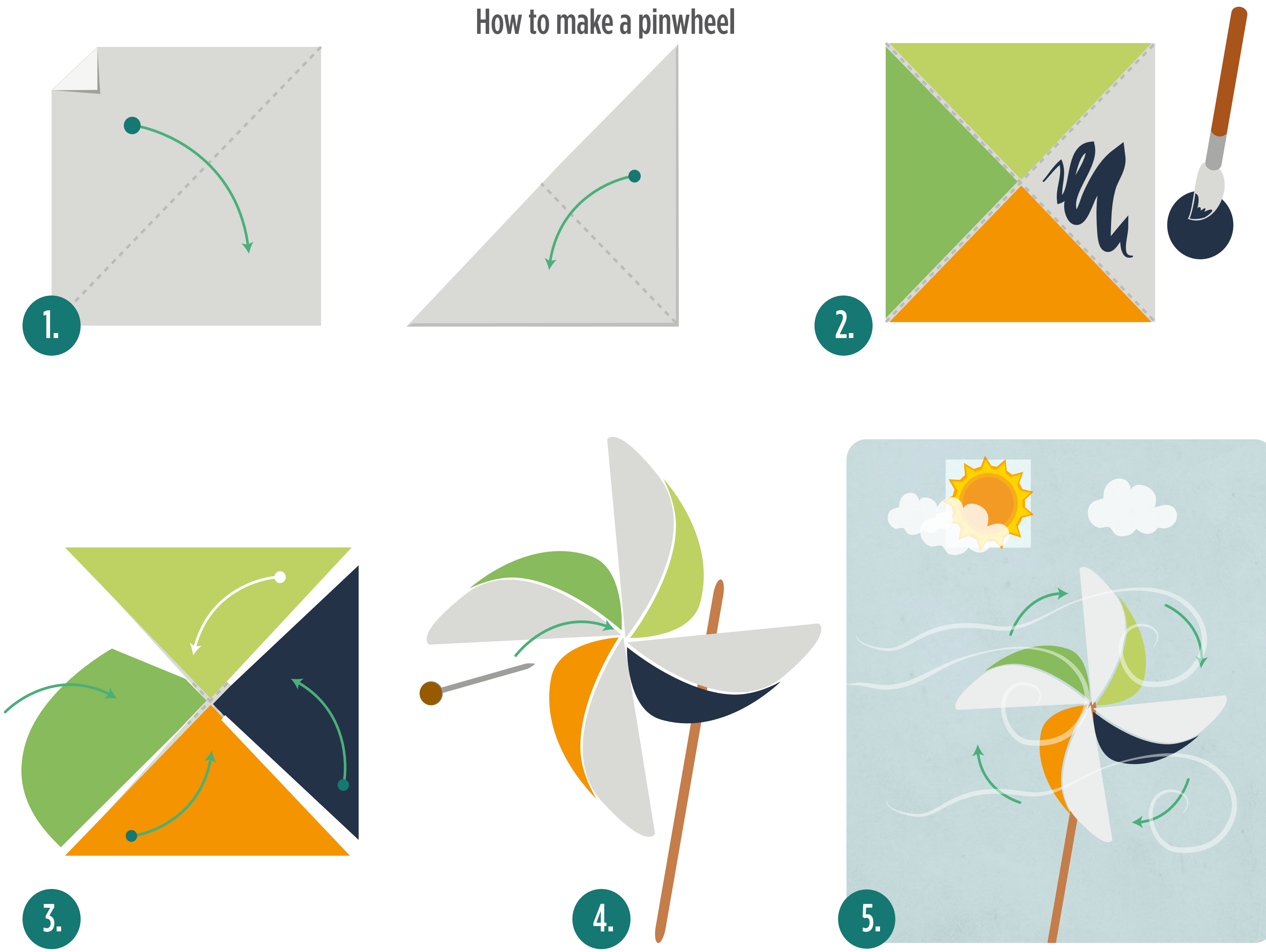
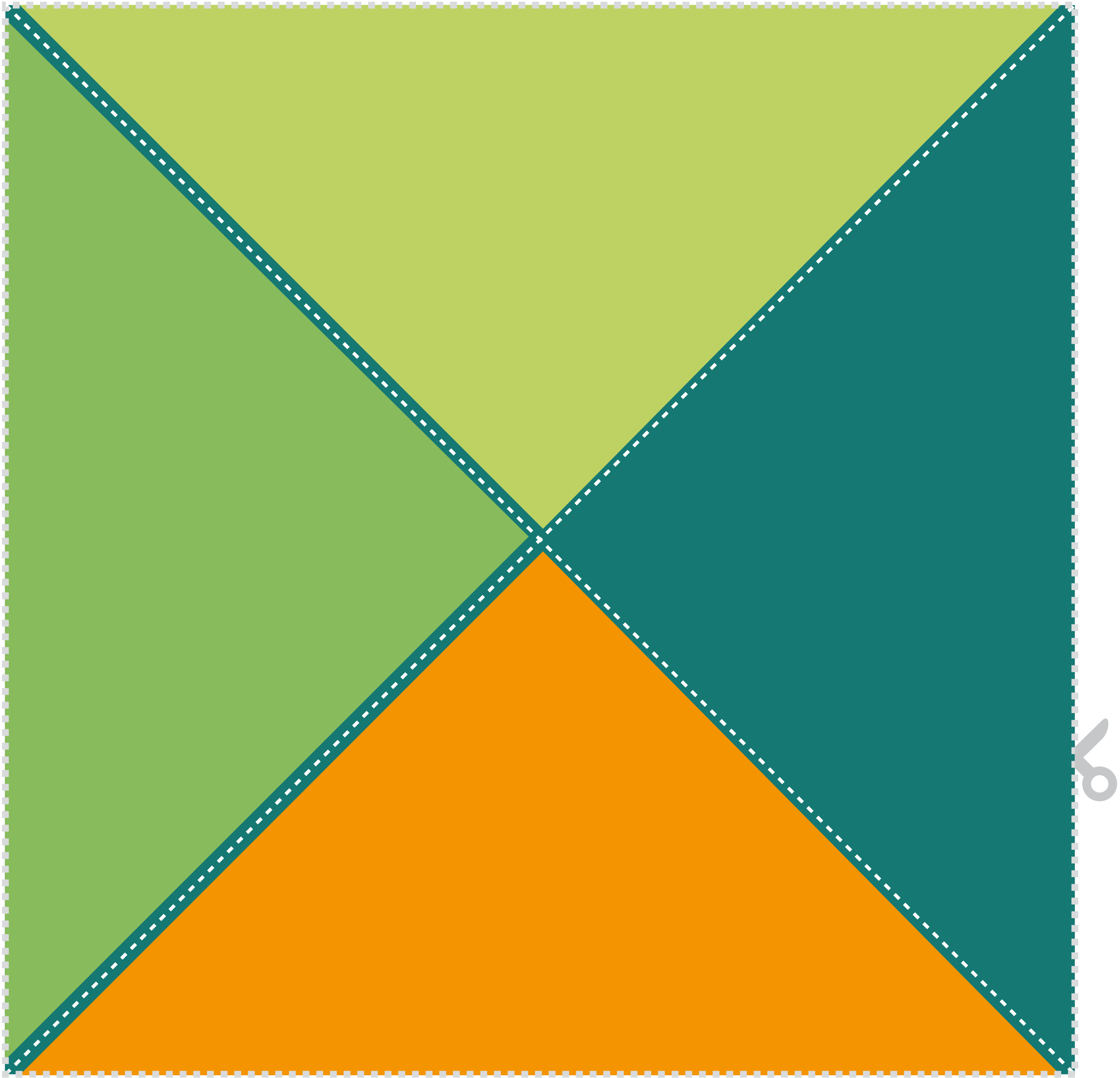

Coal
Smokestack emissions
Containment building
Steam generator
Transformer
Moist air emissions
Electric generator
Turbine
Cooling tower
Cooling circuit
Condenser
Hot water
Cold water
Coal, oil or natural gas

Figure 17. Pinwheel template





Class activity 3: Rise up for smart energy—an online game

Objective

Understand and identify renewable and nonrenewable energy sources.

Procedure

Invite students to play an online game about energy sources. Have them watch background material (the "Can the planet have indigestion?" and "Cleaning energy" videos at www.iadb.org/riseup and the introductory material to this set of lesson plans) and note the characteristics of the energy sources that appear in the game—natural gas, oil, coal, sun, wind, water, geothermal, biomass, and nuclear energy—including whether each is renewable or nonrenewable.

Formative assessment

Before proceeding to the next topic, make sure your students can:

- » Identify energy sources in nature.
- » Recognize and differentiate renewable and nonrenewable energy sources.
- » Use the energy cards to ensure that students comprehend these concepts. Have students select three sources and explain in their notebooks why they are renewable or nonrenewable.

Integration with other subjects

Mathematics: Using the pinwheel, choose three sites at school and determine how many times per minute it rotates at each site. Where does it rotate the fastest?

Science: Study how fossils are made.

Remember

Energy is continuously transformed and transferred.

Energy from the sun powers photosynthesis in plants so they can make food and grow. The energy we get from food allows us to walk, run, and think. Energy from fuels powers cars, trains, and ships. Energy propels a pushed swing back to its original position.

Oil, gas, and coal are fossil fuels.

The largest source of renewable energy is the sun. Formed 5 billion years ago, the sun is now halfway through its lifetime, with another 5 billion years to go. We will be able to use the sun as a source of energy for a very long time.

Tips for teachers

Invite your students to designate a place in the classroom as the "energy spot"—come up with a special name for it. Decorate it with drawings, phrases, and cutouts representing what energy means to them.

On a daily or weekly basis, showcase the students' work in the classroom's energy spot, and use it to reinforce concepts related to energy.

Suggested reading and viewing

- » "IUSES," or Intelligent Use of Energy at School (www.iuses.eu/), is a site devoted to "a new way of teaching energy saving in everyday life. It offers materials for teachers and students.
- » "Our Planet," an environmental news site (www.ourplanet.com/) includes a youth portal called Tunza ("for youth, by youth and about youth") with topical materials viewable online and downloadable as PDFs. An article on biofuels was published in January 2013.
- » Several videos available on the BrainPOP portal for animated curricular content (http://educators.brainpop.com/about/) explain energy issues in a practical way, including videos on different forms of energy, solar energy, and fossil fuels.

2

Basic lesson plan 2: Energy to serve humanity

General objectives

- » Identify different sources and types of energy used in everyday life.
- » Discuss our dependence on electrical appliances.
- » Understand how solar energy is transformed into electricity

Class activity 1: Energy at home

Objectives	Time	Place
» Identify the forms of energy used at home. » Discuss our dependence on electrical appliances.	» 5 minutes for the initial instructions » 40 minutes in the following class	Classroom

Materials

- » Notebook, pencil, eraser

Step by step

- » Talk about how we use energy at home. What type of energy is used for cooking? Heating? In water heaters or appliances? Electricity in our homes can come from many different sources.
- » Invite students to think about the energy in their own homes in this way.
- » Ask them to draw a table like the one below in their notebooks. Draw a table on the board with the column headings: Location, Objects that use power, and Power source.

Sample energy use table

Location	Objects that use power	Power source
Example: Kitchen	***Stove***	Natural gas
	Wood-fired oven	Logs
	Microwave oven	Water (hydroelectric)
Example: Room 1	Lamp	Water (hydroelectric)
	Sound equipment	Water (hydroelectric)
Example: Room 2	Iron	Water (hydroelectric)
	Telephone	Sound Waves

In column 1, have students list each room in their house. In column 2, have them list objects that use energy, such as a stove. In column 3, have them list the energy source, such as natural gas.

» Provide your students with a few examples to give them ideas and guide the activity.
» In the next class, ask students to work on their energy use tables in pairs so they can compare their results.
» Ask them how many appliances they have at home that need electricity and what parts of their houses had the most electrical appliances.
» Ask them to identify which energy sources in their tables are renewable and which are nonrenewable.
» Have them think about the items that require electricity and ask whether they are all really necessary to live. Which could they do without? Which do they need?
» Discuss our dependence on nonrenewable energy.
» Discuss the importance of replacing fossil sources for renewable sources of energy with your students. Consult the introduction of this set of lesson plans or the videos on energy at www.iadb.org/riseup.

Class activity 2: Experiment with organic waste, a type of renewable energy

Objective	Time	Place
Understand that we get energy from biomass	4 hours	Classroom

Materials

» 6 sets of: 60 dried peas or beans, 6 plastic sandwich bags
» Water

Preparation

Soak the peas or beans overnight.

Step by step

» Ask the students what they do with organic waste at home and explain how organic matter produces gases.
» Divide students into six groups and have each group put ten soaked peas or beans into six bags and squeeze out all the air before tightly closing them.
» Put two bags in a sunny spot, two in a shady spot and two in a dark place, after labeling the bags according to their location: sun, shade, or dark.
» Let them sit for a couple of hours.
» Look at the bags and write down their observations about each group of bags. They should note the appearance of the bags and grains and smell the bags, comparing the results obtained at each site.
» Ask the students: Did the peas or beans make gas? Which site made the most gas? Can this gas be used for energy? Why and how?
» Discuss: Just as the peas or beans made gas, many families living on farms around the world get energy to cook their food and for making electricity from biogas. They get biogas from renewable energy sources including cow and pig manure, food scraps, and agricultural and crop waste, among others.

Class activity 3: The sun's embrace

Objective	Time	Place
Understand how solar energy is transformed into electricity	30 minutes	Outdoors

Materials

- 12 meters of rope with 10 knots spaced 0.5 meters apart; bell or whistle; chalk.

Preparation

Reserve the schoolyard or a similar place to play the game; gather the materials and knot the rope.

Step by step

- Ask the students: Can we convert solar energy into electricity? How? Remind students that the sun is our main energy source. We capture its energy with solar panels. Play the game "The Sun's Embrace" to help them understand the process.
- Draw a 10 m x 10 m square with chalk in the schoolyard to represent the photovoltaic cell.
- Draw a circle 2 m in diameter, about seven steps away from the photovoltaic cell, representing the sun.
- Form a circle by matching the two ends of the rope and place it inside the "photovoltaic cell."
- Divide your students into two groups:
  - Group 1: Electrons. Have ten students stand in the "photovoltaic cell," one at each knot in the rope.
  - Group 2: Photons. Ask five to ten students to stand in the "sun."
- If there are more than 20 students, make several groups of electrons and photons and take turns.
- Remind the students that electricity comes from the electrons' movement and that photons are particles of sunlight.
- Put the bell or whistle outside the photovoltaic cell nearby the student at the end of the rope.
- To begin, photons must hold hands inside the "sun" and electrons must hold onto their knots.
- Start the game by touching the head of a photon, cuing him/her to run up to the photovoltaic cell, tap the electron on the rope's first knot, and return to the sun.
- The electron that was tapped should then tap the electron on the second knot and stay there; the second electron should tap the one on the third knot and stay there; and so on, until the last knot is reached.
- The last electron should run to the whistle or bell and blow or ring it.
- At the sound of the bell or whistle, all electrons shout, "ENERGY!" and the electron that blew the whistle goes to the first knot.
- By now, a second photon should come out and run to tap the student on the first knot to keep the flow of energy going. Continue the game until all the electrons have been tapped.
- Ask the students: What is going on in this game? What has to happen before the electrons can move? What does the tapping represent? Why is it important for electrons to tap their peers? When is electricity produced?
- Explain: Photons provide energy so electrons can make electricity. If the electrons do not move, the current cannot start. Each tap represented the transfer of energy—first, between a photon and an electron and then between electrons. That's why a photon had to tap the first electron—to give it enough energy to transfer to the next one, starting a current of electricity.

Formative assessment

Teacher: Before proceeding to the next topic, make sure your students

- » Can identify the types of energy used in daily life.
- » Understand that organic matter provides energy.
- » Explain how solar energy becomes electricity.
- » Test students by drawing or writing the names of different devices on the board and have them write or say which type of energy they produce. For example:
  - Iron: Caloric energy
  - Light bulb: Light and caloric energy
  - Phone: Acoustic energy
- » Ask students to list five (5) items that contain organic matter and can make energy.
- » Ask students to draw the process for transforming the sun's energy into electricity.

Integration with other subjects

Social Studies: Research the main energy sources in your country.

Civics: Ask five family or community members:

- » What do you know about renewable energy?
- » What types of renewable energy are you familiar with?
- » What are the benefits of renewable energy?

Language: Research renewable energy alternatives in your country and make a booklet explaining how to use them.

Remember

Electricity comes from the motion of electrons.

Electricity can be transformed into heat, light, sound, or movement, as we can see when we use electrical appliances.

Gases from decaying organic matter are renewable energy sources, especially for farm use

With solar panels, we can transform the sun's energy into heat or electricity.

We can choose to use electrical appliances in ways that either increase or decrease greenhouse gases in the atmosphere.

Tips for teachers

Use the experiment and activities to strengthen team-work, communication, and deductive reasoning skills among the students.

Encourage healthy competition during *The Sun's Embrace* by seeing which team can finish the fastest. Emphasize that even when we are competing, we can encourage each other and work together for the benefit of the group.

Suggested reading and viewing

- » The Global Energy Network Institute's GENI initiative (www.geni.org/) discusses renewable energy and the benefits of sustainable energy.

Lesson Plans at the

Intermediate Level

1

Intermediate lesson plan 1: Energy is the engine of the world

Objectives

» Identify the sources of energy used in your country.

» Learn about renewable energy production in Latin America and the Caribbean.

Class activity 1: Experiment with gravity and electromagnetism, two manifestations of energy in the universe

Objective	Time	Place
See how gravity and static electricity work.	30 minutes	Classroom

Materials

» Each group of students must have 1 towel or piece of cloth, 1 stone or heavy object, 5 marbles, 1 comb, and some small pieces of paper

Preparation

Review: The introductory text to this set of lesson plans about energy in our universe. Do the activity on your own in advance.

Step by step

» Divide the class into groups of three and make sure each group has one towel, one stone, and five marbles.

» Ask two students in each group to hold the towel at each end so it gets warm.

» The third student should place the stone in the center of the towel, while the students at each end twist the towel in opposite directions.

» Once the stone is twisted inside the towel, ask the third student to put the marbles on the towel.

» Have each group discuss the following questions:

- What happened when the stone was placed in the center of the towel?
- What happened when the marbles were added?
- Why were the marbles attracted to the stone?
- If the towel represented outer space, what do the stone and marbles represent?
- Why doesn't the moon hit the earth and the planets hit the sun?

» Explain that the stone "curves" the towel, making the marbles roll toward it like gravity attracting things to the earth. Gravity is one of the four fundamental forces that make up the universe. This same force prevents the moon from colliding with the earth or the planets with the sun.

» Ask the groups to put their material aside and have the comb and small pieces of paper nearby.

» Ask a student to rub the comb against wool or his/her hair.

» Then ask the student to put the comb close to the pieces of paper, and see what happens.

» Explain that rubbing the comb on the wool or hair charges it with enough static electricity (electromagnetism) to attract small pieces of paper. Point out that this force operates when two bodies attract or repel one another.

Class activity 2: Where do we get energy?

Objectives	Time	Place
» Differentiate renewable and nonrenewable energy sources. » Identify the sources of energy used in your country.	1.5 hours	Classroom

Materials

» Cardboard, markers, pencils, colored pencils and information on energy production in your country (texts, newspapers, magazines, web pages, etc.)

Preparation

Prior to class, review information about your country's energy sources.

Step by step

» Ask students to make a list of energy sources on the board.

» Divide students into eight groups and assign them one of the following labels: wind, natural gas, water, coal, biomass, solar, nuclear, or oil.

» Tell them that each group represents a source of energy. Ask them to make a poster for their source containing the following:

- How we get energy from it
- Generation of waste/gas emissions
- Is it renewable? (yes/no)
- Is it used in your country? (yes/no)

» Use the information on energy production to guide the students.

» Show one or more energy videos from www.iadb.org/riseup to supplement the posters.

» Discuss if it possible to meet the world's energy needs using only renewable sources of energy.

Formative assessment

Teacher: Before proceeding to the next topic, make sure your students can identify and distinguish among renewable and nonrenewable sources of energy as well as where they come from and which ones are used in their country.

Integration with other subjects

Science: Observe how plants use solar energy. Plant beans in two pots. Once they sprout, cover one pot with a paper bag and let the other face the sun. After one month, observe and record the differences.

Language: Create a newspaper report on renewable energy and its benefits.

Read aloud the following story of a child writing from the future:

Hello friends of the twenty-first century, I am writing to you from the year 2100. I am a child like you, and I want to ask you some things about your era.

What can you tell me about fossil fuels? Our reserves ran out 80 years ago, and my parents tell me that those were very difficult times. Because there was energy rationing, people could no longer use their cars, and public transportation became very expensive.

Fortunately, governments supported renewable energy initiatives and made laws that have enabled us to enjoy those technologies today. Now, we exercise more. The law says people have to use bikes for transportation. If we travel by electric car, we have to share the ride with neighbors, family members, and friends.

What is it like to have all the sources of water that my great-great-grandparents told me about, such as springs, streams surrounded by forests, and long rivers filled with wildlife? There aren't many left now, and since they need a lot of care, we can no longer tour those sites. At least people are more aware of the need to protect our water, and we have campaigns about using it wisely, so we take good care of the water today.

Source: Brigada Planeta, Manual para el Profesor (Planet Brigade, Teacher's Manual). 2010. Smurfit Kappa Cartón de Colombia – OpEPA. Colombia

Ask the students to continue the story, thinking about energy sources that may not be available in the future that this child might have wanted to experience or how our use of energy today may affect the environment.

Social Studies: Ask students to find several articles about renewable energy in their country and then share them with their classmates to create a newscast.

Remember

- Energy is the engine of the world. People convert natural resources into usable energy.
- Renewable energy sources can be regenerated. They include tidal energy, hydraulic energy (reservoirs or dams), wind energy, solar energy, geothermal energy (earth's internal heat), and biomass (organic matter).
- Nonrenewable energy sources are limited. We are consuming them faster than they can be regenerated. They include fossil fuels (coal, oil, and natural gas) and nuclear energy (nuclear fission and fusion of uranium and plutonium).
- How we produce, distribute, and consume energy affects the social and economic structure and growth of countries as well as their conservation efforts.

Tips for teachers

- Organize a visit to a hydroelectric dam, thermoelectric plant, or wind farm near your school.

Suggested reading and viewing

- BrainPOP's video on fossil fuels is available from www.brainpop.com.

2

Intermediate lesson plan 2: Sustainable energy for all

General objectives

- Learn about alternative energies with fewer emissions.
- Try cooking with solar energy.

Class activity 1: Experiment in making a solar oven with cardboard boxes

Objective	Time	Place
Learn about an alternative energy with fewer emissions	1 hour	Outdoors on a sunny day

Materials

- Each group must have the following materials:
- Two cardboard boxes of different sizes, so that when one is inside the other, there are at least 4 cm between the sides.
- Clear plastic sheet
- Matte black metal sheet or tray that will lay flat in the small box
- Sheet of cardboard
- Small balls or pieces of foam (expanded polystyrene)
- Scissors, markers, glue for paper or pasteboard and adhesive tape
- Aluminum foil
- Sunglasses

Preparation

Prepare your oven first so you can help the students with theirs. Wear sunglasses while conducting the experiment and ask your students to wear them too.

Step by step

- Talk about ovens at home: describe what they are and the food they cook.
- What sources of energy are used to operate these ovens (wood, electricity, or natural gas)?
- Invite your students to build their own solar oven (figure 18).
- Ask the students if they think we can cook in a cardboard oven using solar power.
- Ask the students to follow the instructions below:
    - Place the big box face down. Center the small box on back of the big box and outline it. Cut the bottom of the big box along the lines so that the small box fits inside the large one with at least 4 cm between the walls.
    - Cover the two boxes inside and out with aluminum foil, including the lids and bottoms, by gluing the foil to the cardboard and smoothing out any wrinkles with a cloth (step 2 in the manual).
    - Put the small box in the hole in the big box—it must fit tightly (step 3 in the manual).
    - Glue the top flaps from the small box to the ones on the big box, removing any excess (step 4).

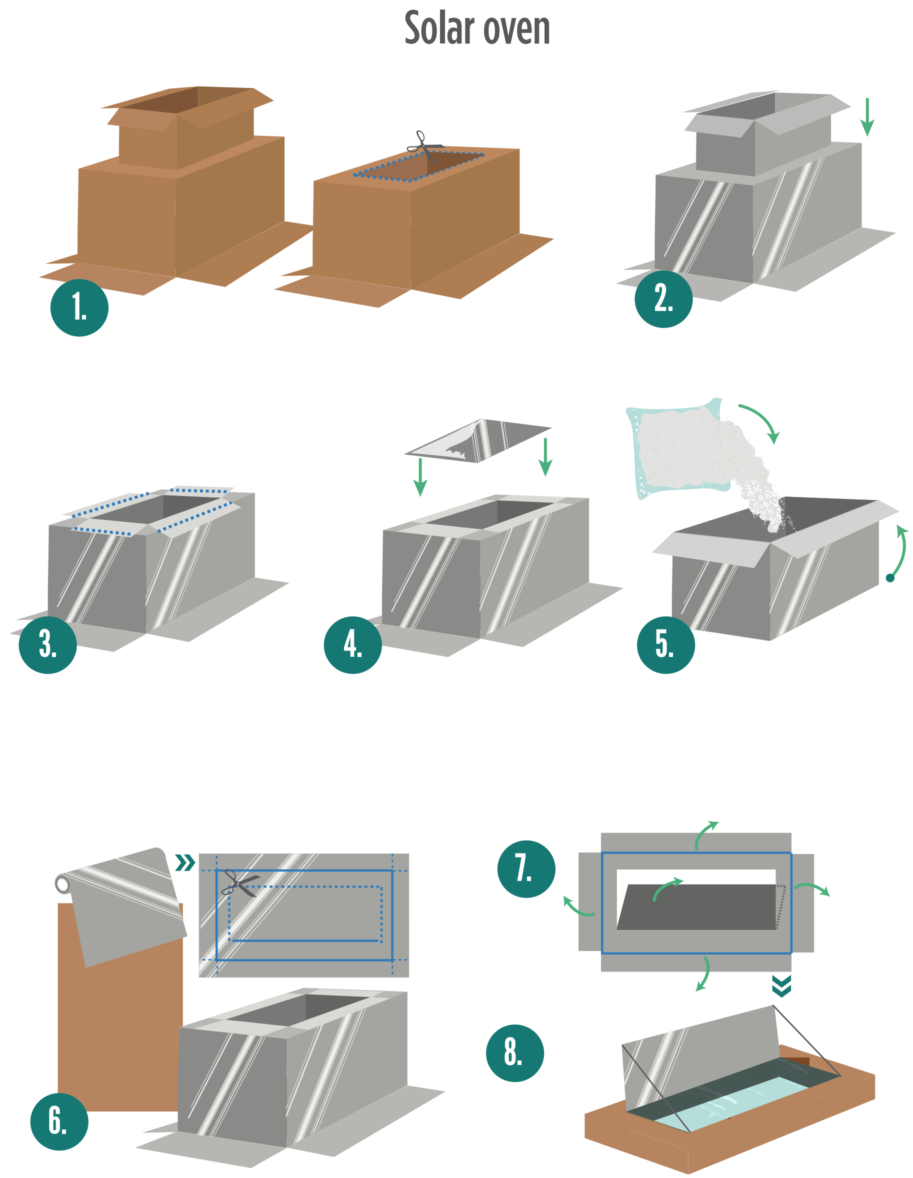
- Insert the tray or metal sheet inside the small box (step 5).
- Place the large box (oven) face up and fill the space between the walls of the two boxes with the polystyrene material. Make sure that there are no empty spaces. Close the lids with adhesive tape (step 6).
- To make the oven lid, use the cardboard sheet. Trace the outer edges of the oven walls on it and bend it along the lines so the flaps fit over the oven. Create a folding window by drawing a rectangle or square (depending on the size of the oven) and cutting along three sides. Cover the inward-facing side with aluminum foil and glue the plastic inside the cut rectangle (step 7).
- Affix small lengths of wire to the folding lid and glue them to both the lid and the base (step 8).

» Explain to the students that we use thermal energy (heat) for cooking and heating water for showers, washing machines, and dishwashers. On a sunny day, the sun generates enough heat to boil water. Food will not burn or get overcooked in a solar oven. It takes about twice as long to cook something compared to a conventional oven, but the solar oven uses no fuel and generates zero emissions.

» Discuss the parts of the oven and their functions:

- Metal tray: Absorbs solar radiation and transforms it into thermal energy.
- Polystyrene: A thermal insulator that prevents heat from dispersing.
- Plastic or glass sheet: Creates the greenhouse effect.
- Folding lid: Can be tilted to reflect maximum sunlight into the box (the tilt is right when the interior is brightest).

Figure 18. Building a solar oven



Class activity 2: Solar apple pie recipe

Objective	Time	Place
Cook food with a solar oven	3 hours	Outdoors on a sunny day

Ingredients and materials

» 2 apples cut into small pieces, 1 yogurt (250 ml), 1 pound wheat flour

» 250 ml oil, 1 tablespoon butter, 1 teaspoon pastry yeast

» ¼ cup of sugar, 3 eggs, 1 mixing bowl, 1 dark pot with a lid, 1 large spoon

» Oven mitts

Step by step

» Tell the students that they will make a delicious apple pie. Ask them: Have you ever cooked at home? Does cooking produce emissions in the atmosphere? Can we cook in a way that doesn't generate greenhouse gas emissions?

» Empty the yogurt into the bowl. Fill the empty yogurt container once with oil, then twice with sugar, and three times with flour. Put all of these ingredients into a bowl. Add three eggs and mix until smooth.

» Add the apple pieces and the pastry yeast.

» Rub the sides of the pot with butter or oil and cover with flour to prevent sticking.

» Pour the batter into the pot and cover it.

» Place the pot in the solar oven.

» Put the oven in the sun, making sure it faces the equator (north in the southern hemisphere and south in the northern hemisphere).

» Cooking time will be about 2–3 hours. When the cake is ready, a knife inserted into the center will come out clean.

» Enjoy!

» Once the pie is cooked, ask the students:

- What kinds of emissions did you see during cooking?
- What are the advantages and disadvantages of using the solar oven?
- What would happen on a cloudy day?

» Ask the students: Why does using solar energy to cook the pie not generate emissions?

Formative assessment

Teacher: Before proceeding to the next topic, make sure your students understand:

» Practical and sustainable alternative energies

» How a solar oven works

» Assess students by having them draw a table with four columns for:

- Activities: Listing all their daily activities that require energy.
- Device used: Name the device they currently use to perform each activity.
- Energy source: Name the energy source used by each device.
- Sustainable alternatives: Ways to lower the impact on the environment, such as using energy more carefully or switching sources or devices.

» Ask your students to draw a solar oven and describe how it works.

Example

Activity	Current use	Source of energy	Sustainable alternatives
Transportation	*Car*	*Oil/petrol*	*Use a bicycle for short distances*
Personal hygiene	*Electric shower*	*Coal (thermoelectric)*	*Take brief showers*
Cooking	*Electrical oven*	*Natural Gas*	*Use solar oven on sunny days*
Hot water	*Washing machine*	*Coal (thermoelectric)*	*Wash with cold water*
Lighting	*Light bulbs*	*Water (thermoelectric)*	*Use energy-saving light bulbs; turn them off when not needed*
Do homework	*Light bulbs*	*Water (thermoelectric)*	*Do homework with solar light*
Leisure (watch television and electronic games)	*Television*	*Coal (thermoelectric)*	*Watch less television and play outside with friends*

Integration with other subjects

Mathematics: Go to http://en.openei.org/wiki/Gateway:America_Latina, select your country, and observe potential energy production with renewable and nonrenewable sources. Graph solar and wind potentials, coal, oil and natural gas reserves; compare countries in Latin America and the Caribbean.

Social Studies: Stage a debate on the benefits and disadvantages of building a wind farm in an area that is home to indigenous communities and many species of birds. Try to reach an agreement.

Roles:

- » Indigenous communities that resist the project because wind turbines affect the landscape and make noise.
- » Representatives of the tourism sector who believe that the park will cause significant visual pollution.
- » Environmentalists concerned about the negative impact of wind turbines on birds.
- » Energy company manager interested in the project's potentially high profits.
- » Governor interested in providing energy to remote populations and in the project's international visibility.

Remember

- » Nature provides all of our energy. We must balance social and environmental needs with rational use and end increasingly intensive exploitation.
- » Rural areas that lack access to electricity have started using solar ovens, greatly improving peoples' quality of life.
- » The best places to use solar ovens are in countries near the equator because the sun's rays are most direct, but they can also be used on sunny days in other parts of the world.

Tips for teachers

- » Expand knowledge and learning opportunities for the community by starting energy saving campaigns.
- » Invite other teachers in your school to plan a day of solar cooking and cook several foods in the solar oven.

Suggested reading and viewing

- » BrainPOP offers a video on solar energy (available at www.brainpop.com).
- » The Rise Up video library (www.iadb.org/riseup) includes a video on biofuels.

Lesson Plans at the Advanced Level

1

Advanced lesson plan 1: Energy transformation

General objective

- Understand energy transformation.

Class activity 1: Abracadabra! Energy, transform yourself!

Objective	Estimated time	Location
Learn about different types of energy and transformation.	30 minutes	Classroom

Materials

- Photographs (figures 19–23)
- Recycled paper to complete the activity table

Preparation

- Use the images suggested for this activity. Note that each image represents a type of energy.
- Find a classroom in the school where you can project these pictures.

Step by step

- Ask the students: What is energy? How is it transformed? What examples can you give?
- Project the photos using the links above.
- Have one student choose a photo, describe the activity depicted, and indicate the energy source(s) for the activity and where the energy was transformed. Let the group discuss the response.
- Review the background information on energy types and transformation.
- Explain that energy fuels the work of both inanimate objects, such as an engine, and living organisms, such the human body.
- Organize students into groups of five and ask each group to use the photos to draw a chart comparing the different types of energy and their transformations.
- Explain that the word energy comes from the Greek word *energeia*, meaning in action or working. It is the property that allows any system to do physical work.

Energy sources and transformation

Forms of energy	Energy transformation	Illustration
Chemical (example: food)	Kinetic (run)	
Mechanical		
Thermal		
Kinetic		
Electric		

Figure 19. Photo 1

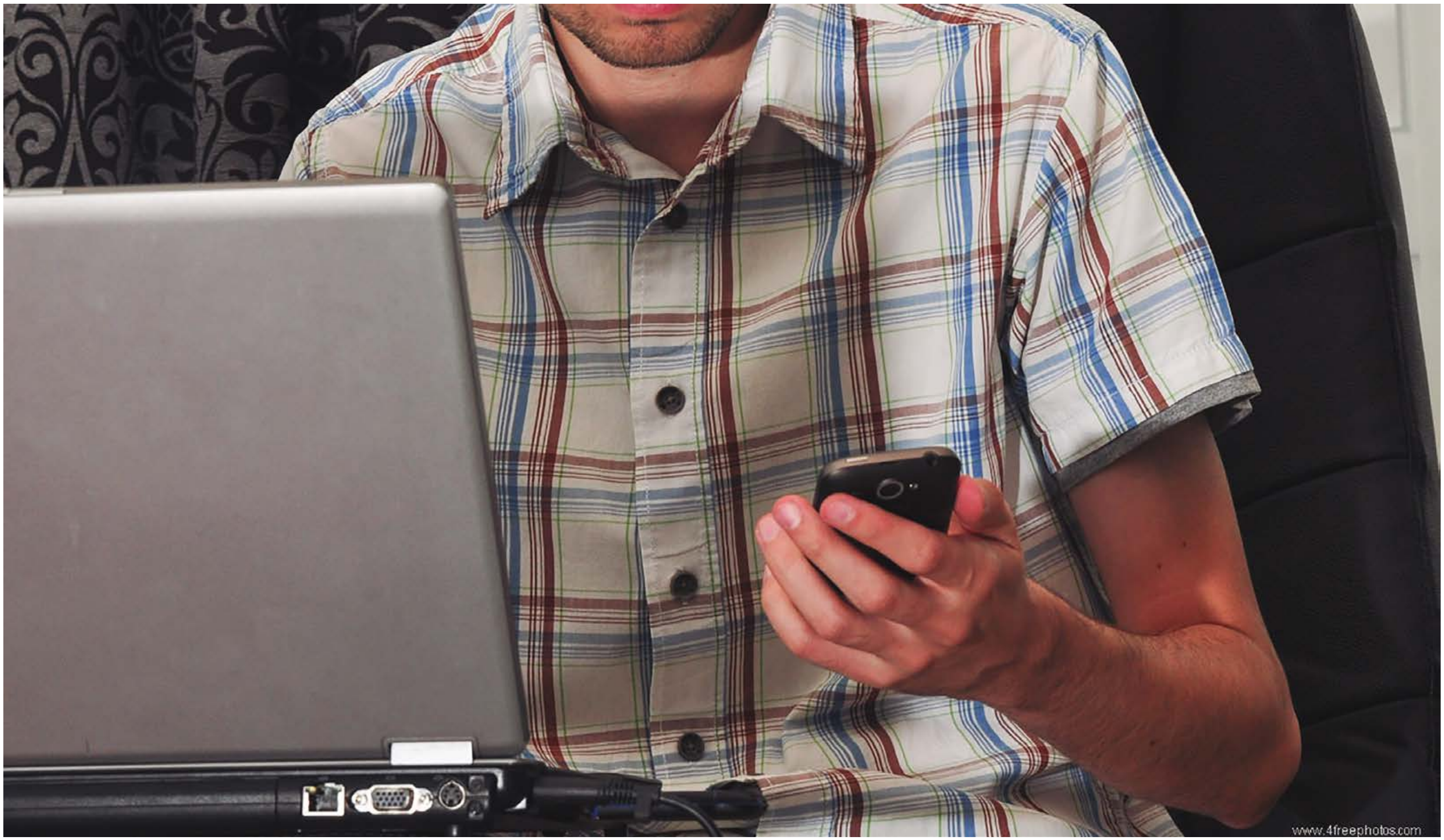


Figure 20. Photo 2

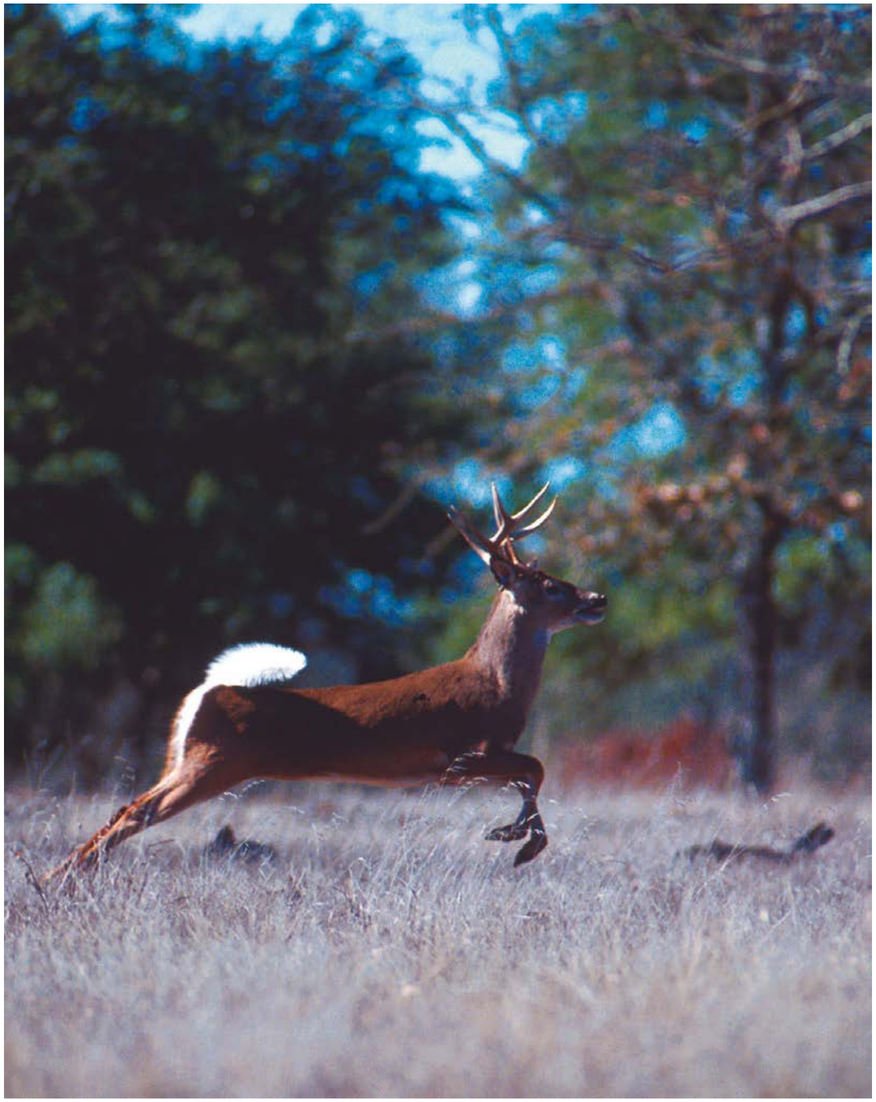
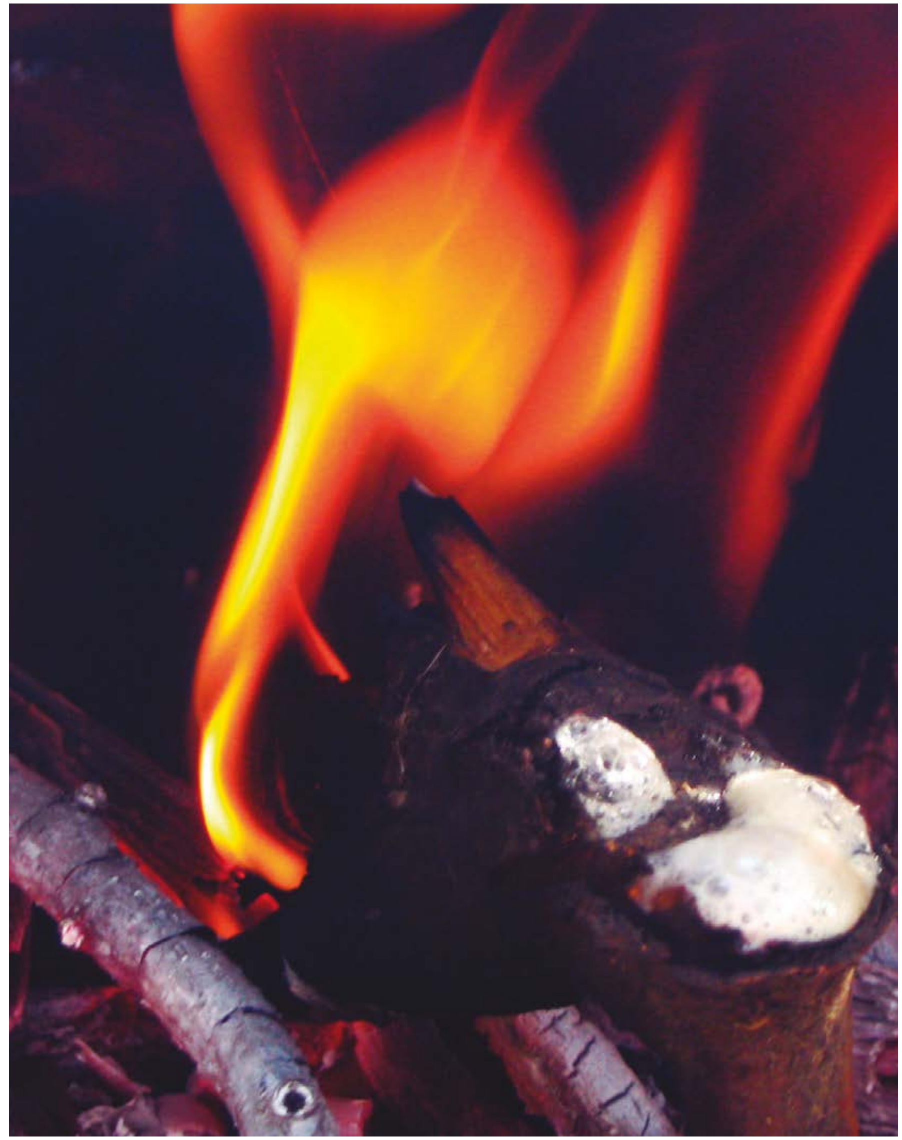


Figure 21. Photo 3

Figure 22. Photo 4

Figure 23. Photo 5



Class activity 2: Experiment with a homemade rocket

Objective	Estimated time	Location
Experience energy transformation.	1 hour	Outside

Materials (figure 24)

- 1 plastic bottle without the lid (small, 33 centiliters or 12 ounces, such as an individual-sized bottle of water)
- 3" x 20" sticks with the approximate diameter of a pencil
- Thick packing tape
- Paper towel (one 30 cm x 30 cm square per group)
- 1 cork
- Baking soda (1 heaping tablespoon)
- White vinegar (approx. 200 ml, 2/3 of the plastic bottle)

Preparation

Perform the experiment ahead of time to make sure it works. If necessary, adjust the quantities. Find an adequate space at the school to perform the activity.

Step by step

- Divide the class into pairs.
- Using tape, attach the three sticks to the bottle so that they stick out about 4 cm from the mouth of the bottle, as illustrated.
- Cut a 3 cm strip of paper towel; use it to cover the cork so it fits the mouth of the bottle.
- Put one tablespoon of baking soda onto the center of the remaining paper towel, as shown in the illustration, and roll it inside the paper like a candy.
- Pour vinegar into the plastic bottle.
- Carefully push the paper "candy" with the baking soda into the bottle and quickly stop it with the cork. Immediately turn the bottle over, place it on the ground, and move away as quickly as possible.
- Once the rockets have launched, ask the students: What types of energy were manifested during the experiment and what transformations occurred? The chemical reaction of the vinegar (acid) with the bicarbonate (base) made carbon dioxide (CO_2—a greenhouse gas) and water. When the gas was ejected backward through the tail of the rocket, we saw Newton's second law in action: for every action, there is a reaction so the rocket went flying in the opposite direction.

Teacher tips

- All the groups can perform the first steps at the same time, but watch each group carefully during the launch, for the sake of safety.
- Ensure that all students watch each rocket launch from a safe distance.
- Encourage students to label their rockets and observe which one travels the farthest or highest.

Formative assessment

Upon completion of this lesson, students should be able to:

- Identify different types of energy
- Explain energy transformation and/or energy transfer

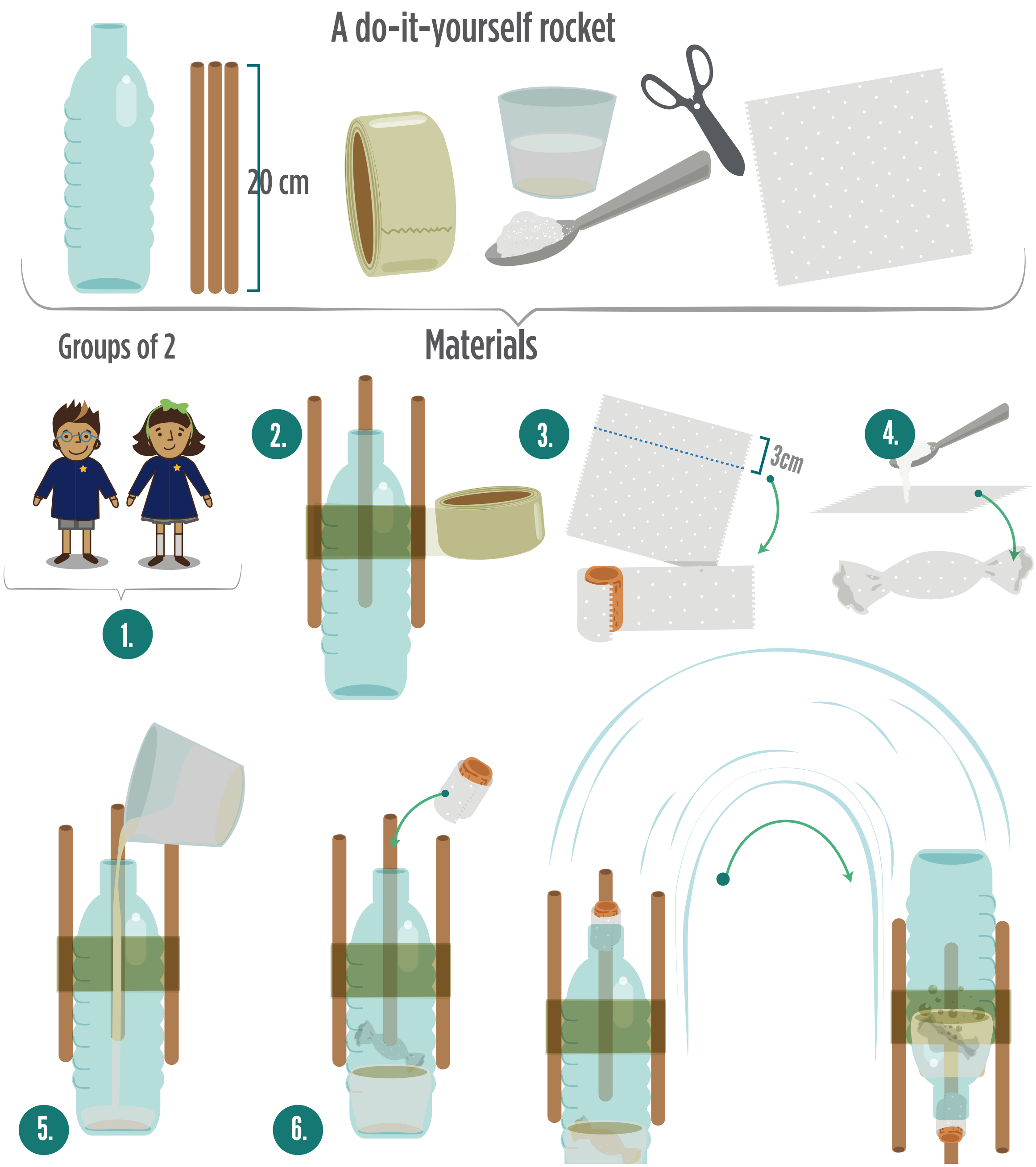
Integration with other subjects

English: Ask students to imagine a day without electricity and write an essay about it.

Physics: Ask students to:

- List the types of energy (potential, chemical, mechanical, kinetic, thermal, and electric) and give examples of each.
- Research the units used to measure energy.
- Research the tools used to calculate energy consumption.

Figure 24. Making a rocket



Remember

- » It takes energy to move anything. Plants need the sun's energy for photosynthesis to make food and grow. Food gives us energy to walk, run, and think. Energy in the form of fuel powers cars, trains, and ships. Energy returns a pushed swing to its original position.
- » There are two broad classes of energy:
  - Potential: The energy associated with the position or height of an object or body.
  - Kinetic: Energy related to the speed or movement of a body.
- » Energy is also classified into types, such as:
  - Mechanical energy: The ability to produce movement.
  - Heat or thermal energy: The increase in an object's temperature.
  - Chemical energy: Heat or movement from chemical reactions.
  - Electric energy: Movement of tiny particles known as electrons from the magnetic properties of atoms.

Suggested reading and viewing

- » For 2010 data on world energy use, including consumption of fossil fuels, consult the World Bank's data bank: http://data.worldbank.org/indicator (Energy and Mining).
- » Argentina's "Escritorio Alumnos" site (http://escritorioalumnos.educ.ar/) has a section on types of energy that includes activities and exercises. (In Spanish.)

2

Advanced lesson plan 2: Fossil fuels—nonrenewable energy sources

General objective

Understand the environmental impact of using nonrenewable energy.

Classroom activity 1: Environmental impact of nonrenewable energy

Objective	Estimated time	Location
Understand the environmental impact of using nonrenewable energy.	1.5 hours	Classroom

Materials

» Articles about the impact of nonrenewable energy on human health, the environment, and food

» Cardboard (enough for each group)

» Colored markers

Preparation

Read the background material and the text box on thermoelectric power. Prior to class, ask your students to find articles about the impact of nonrenewable energy on human health, the environment, and food security.

Step by step

» Ask the students: Who can explain what nonrenewable energy is?

» Organize the class into groups of three and ask them to discuss what they've read on the impact of nonrenewable energies. Ask each group to select one story on each topic: human health, the environment, and food security.

» Give each group cardboard and markers. Have them use their articles to make a comic strip (16 frames maximum) on the impacts of nonrenewable energy. (See sample in figure 25.)

» The comic strips should address the following points:

- Most of the energy we use today comes from nonrenewable sources.
- Nonrenewable sources include oil, coal, natural gas, and nuclear energy.
- Nonrenewable sources regenerate very slowly.
- Nuclear power does not emit carbon directly, but its exploitation does. It also generates radioactive waste, which is very dangerous and difficult to remove.
- Fossil fuel use affects our atmosphere and water, damaging crops, food, marine and terrestrial life, and human health.

Teacher tips

Stage an exhibit of the comics created in class to share with the school community. Add an introductory text to provide context.

Figure 25. A sample cartoon

Class activity 2: Role play on "a nuclear power plant in our town"

Objective	Estimated time	Location
Understand the pros and cons of using nuclear energy.	2 to 3 hours	Classroom

Materials

- Use the Internet or visit your library for age-appropriate reading material about nuclear accidents (such as those at Fukushima, Chernobyl, and Three Mile Island).
- Projector and computer or DVD player (for videos).

Preparation

Read about the nuclear accidents in Fukushima, Chernobyl, and Three Mile Island, and identify their causes and consequences. Have students research the topic in advance, identify their country's nuclear policy, and determine if it needs a nuclear plant. Here are a few of many available resources, but students should conduct their own research.

- 20 Years Later: A Nuclear Nightmare in Pennsylvania. Special Report. Washington Post, March 27, 1999. http://www.washingtonpost.com.
- Chernobyl: 20 Years On. BBC Interactive article. June 12, 2007. http://news.bbc.co.uk.

Assign students a role (below), so they can prepare their arguments:

- Group A
- Group B

Designate a **mediator/moderator** to organize and direct the discussion, giving equal floor time to each representative. Assign three **reporters** to take careful notes and decide whether a

consensus is reached on installing the nuclear power plant. Have a **group of observers** listen to the representatives during the debate. The observers should help the reporters recap the main points and comment on the positions of the participants.

Depending on their assigned role, students should address the following topics:

- Risks to human health
- Nuclear waste
- Power generation alternatives
- Environmental and social impacts of nuclear energy
- Employment generation
- Installation and maintenance costs
- Other concerns

Step by step

- Present the following hypothetical situation: "Given the need to increase electricity production through mechanisms that do not produce greenhouse gas emissions, your country's government intends to install a nuclear power plant in your city or town. A debate has been planned among representatives of various sectors, and you have been called to participate."
- Give Group A ten minutes to make its case. Do the same for Group B. The moderator should ensure order and adherence to time limits.
- Open the floor for questions and counter-arguments (20 minutes).
- Take questions from the observers. (15 minutes).
- Let Groups A and B make concluding remarks (10 minutes per group).
- Let the reporters summarize the arguments (10 minutes).
- Hold a general vote on whether or not to install the nuclear plant. The moderator will tally the votes publicly.

Teacher tips

- Ask students to research nuclear power plant operations prior to the debate.
- Ask them to use examples and facts to defend their positions and remind them to anticipate arguments from the opposing team.
- Ensure that the moderator establishes the ground rules at the outset.

Formative assessment

Upon completion of this lesson plan, students should understand:

- The impacts of nonrenewable energy sources on environmental, human health, and food security.
- The advantages and disadvantages of nuclear power.

Integration with other subjects

Natural Science or Biology: Ask students to:

- Research the impact of radioactivity on human health and living beings (plants and animals).
- Define mutation and research whether the nuclear accidents at Fukushima, Chernobyl, and Three Mile Island caused any cases of mutation. Discuss in class; include news articles written 20–40 years after the incidents.
- Research whether any plant or animal species became extinct after the accidents. Also research the impact of the accidents on ecosystems.
- Research the recommendations and precautions that should be taken to protect human health in the event of a nuclear accident.

Social Studies: Ask students to research countries that are considered nuclear powers and to develop positions on the issue. Also have them research international and multilateral treaties that have been established. Consider sociopolitical and economic commitments to prevent nuclear proliferation and nuclear testing. Research your country's position and participation in treaties.

History:

- Have your students research the history of nuclear weapons and accidents and develop a poster with a nuclear timeline.
- Some of the cities where nuclear accidents occurred are now tourist attractions. Debate whether it's safe to have a museum or if it is appropriate for visitors to learn about the history of what happened.

Chemistry:

- Ask students to make a concept map on nuclear reactions, showing fission, fusion, energy ionization, and energy binding.
- Identify the main elements used in nuclear plants.
- How long do these chemicals remain in the environment? Which chemical reactions occur when they come into contact with other elements?

Remember

- Nonrenewable resources include oil, coal, natural gas, and nuclear energy.
- Nonrenewable energy sources regenerate very slowly.
- Oil, coal, and natural gas emit carbon buried for millions of years into the atmosphere.
- Nuclear power does not emit carbon directly, but it does generate radioactive waste, which is very dangerous and difficult to remove.
- Most of the energy we use today comes from nonrenewable sources.

Suggested reading and viewing

- The site of the United Nations Environment Programme's Regional Office for Latin America and the Caribbean (http://www.pnuma.org/english/index.php) summarizes the relationship between energy and the environment, with links to international programs and policies. Also useful is the UNEP's Energy site (http://www.unep.org/energy/).

3

Advanced lesson plan 3:

Renewable energy to combat climate change

General objective

» Explain the types and uses of renewable energy from the Latin American and Caribbean perspective.

Class activity 1: Where do Latin America and the Caribbean get energy?

Objective	Estimated time	Location
Understand energy sources and distribution in Latin America and the Caribbean.	1.5 hours	Classroom

Materials

» Printouts of figures 26 and 27

Preparation

Read the background material and print out the two charts for this activity (figures 26 and 27).

Step by step

» Ask the students: Other than the sun, what are some renewable energy sources? Can we get electricity from the movement of ocean waves? From [name other sources they did not mention]? As you mention the sources of energy, explain how they work.

» Distribute or project the Primary Energy Supply in Latin America graph (figure 26).

» Divide the class into five groups and hand out the By Country graph (figure 27). Ask students to identify the leading countries in each region by category. For example, in the Andean region, Venezuela is the leading oil producer and consumer.

» Which renewable energy sources are the most environmentally friendly? Which are less eco-friendly? Ask the students to group nonrenewable sources on one side and renewable sources on the other and add the percentages for each country.

» Gather the class back together and ask a few students to share their conclusions.

Figure 26. Primary energy supply in Latin America and the Caribbean, by energy source

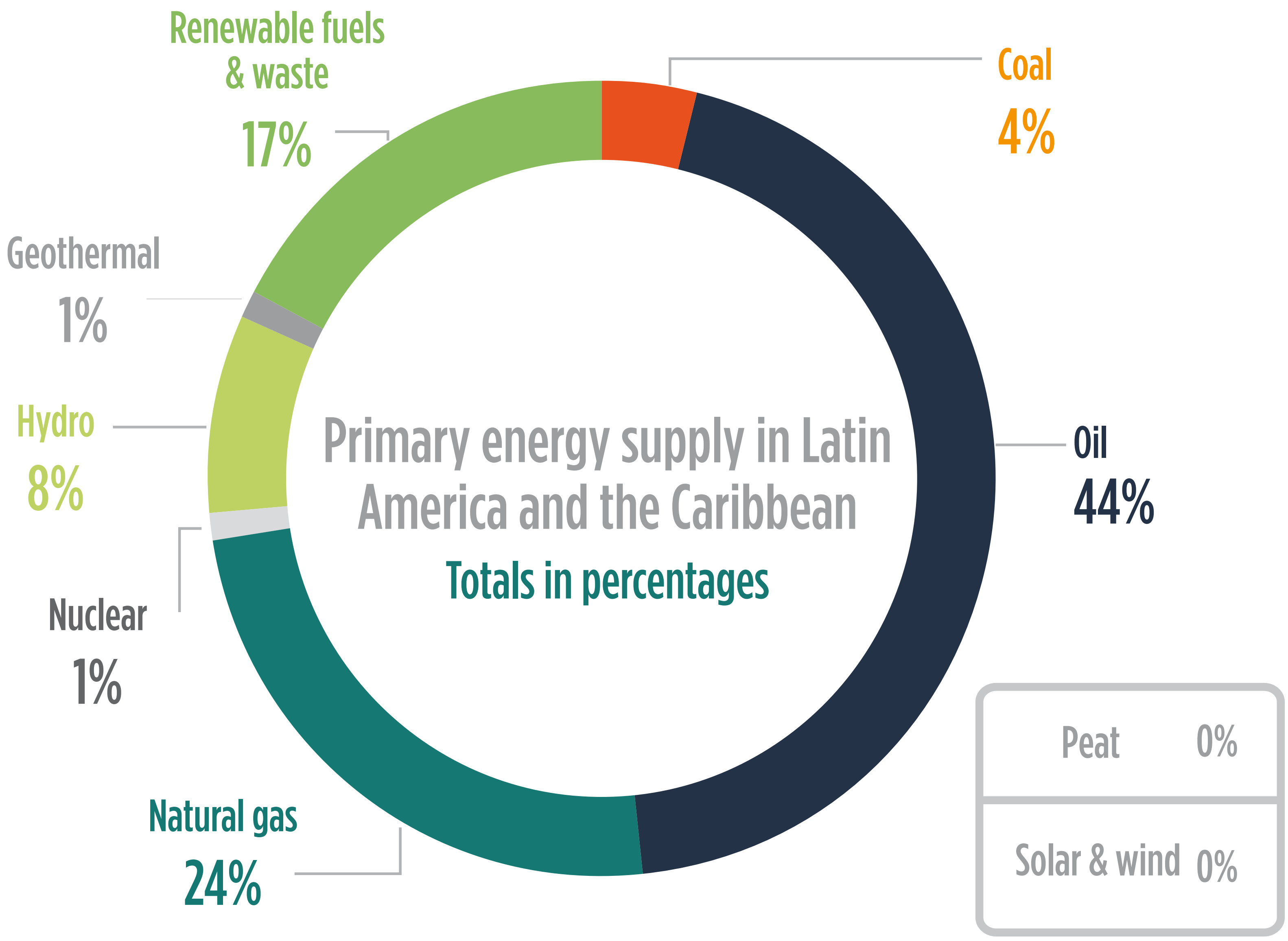
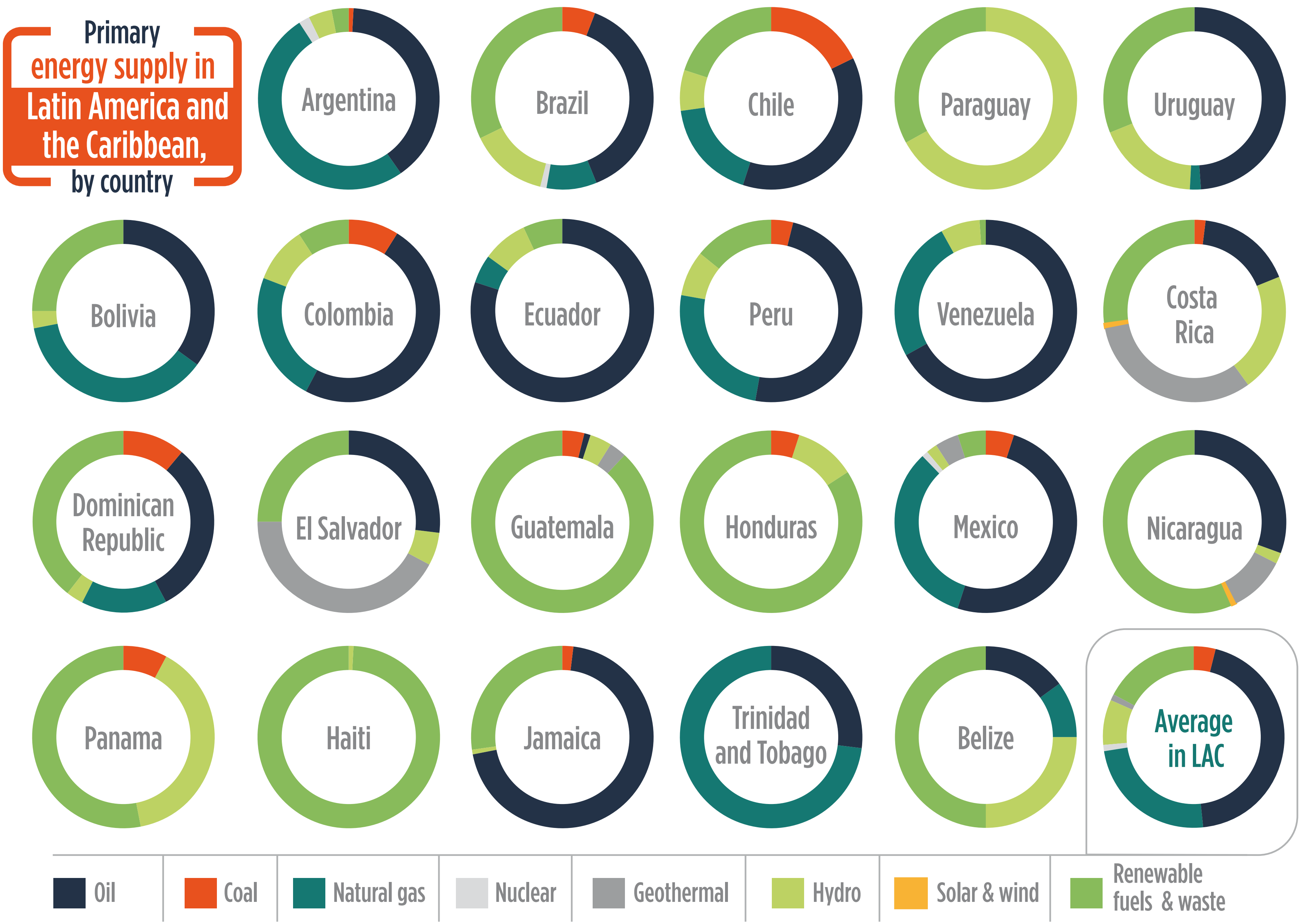


Figure 27. Primary energy supply in Latin America and the Caribbean in 2012, by country



Source: IDB calculations based on IEA data and other sources, http://www.iadb.org/en/sector/energy.

Class activity 2: Behavior change

Objective	Estimated time	Location
Understand how changing our behaviors can conserve energy.	30 minutes, plus follow-up for four weeks.	Classroom and follow-up at home

Materials

- An electricity usage calculator (there are several available online). Alternatively, you can do the calculations with your students or use *The Rise Up School Sustainability Test*, which can be found at www.iadb.org/riseup.

Preparation

- Think about ways to reduce electricity usage at school and home.
- Review the energy sources and the definition of energy efficiency.
- Draw a table like the one below on poster board to help students track their results over the month.

Step by step

- Ask the students: What are some ways to reduce GHG emissions?
- Can you think of any others? Keep the students talking until someone says that the best way is to conserve energy or reduce usage.
- Ask the students: How can we change our behaviors to do that?
- Draw a chart like the one below on the board with your students' ideas.
- Use the IDB's Rise Up test, How Sustainable Is Your School? It can be found at www.iadb.org/riseup, or construct a test of your own with your students. Tell your students that they should take steps to conserve energy and that each must do a weekly self-assessment to measure their progress. The game proposes some activities, but let them know that they can also use the ideas generated in class.

Teacher tips

- Ask students to research their school's energy usage. Where does it come from? Is it a renewable or nonrenewable source? How much energy does the school use? Does usage vary over time? How and why?
- Take a field trip to a power plant or invite a professional in the energy field to talk to the class about the town's energy structures and plans.

Reducing energy demand is up to us

Student	Week 1	Week 2	Week 3	Week 4
Clara				
Alicia				
Martin				

Formative assessment

Upon finishing this unit, students should be able to:

- » Identify renewable and nonrenewable energy sources.
- » Understand the relationship between renewable energy and climate change.
- » Understand that conserving energy is the best way to reduce climate change.

Related subjects

Geography:

- » Use a map of Latin America and the Caribbean to identify the countries in Class Activity 1.
- » Locate the Pacific Ring of Fire and explain why it is named that.

Biology: Wind energy is a source of clean, renewable energy. Investigate its environmental impact.

Chemistry: Research geothermal energy and the chemical reactions in hot springs. Are there any hot springs in your area? Why are they good for human health?

Social Studies: Each month, instruct students to turn off the lights in every classroom, bathroom, and office at the end of the day.

Remember

- » With over 7 billion people on the planet now, demand for energy is higher than ever.
- » Climate change is forcing us to find and use renewable energy sources.
- » Nonrenewable energy sources include oil, gas, coal, and nuclear energy.
- » Renewable energy sources include solar, wind, biomass, hydropower, ocean energy, and geothermal energy.

Suggested reading and viewing

- » "Winds of Change in Oaxaca," a video available from www.iadb.org, describes the largest wind farm in Latin America and the Caribbean.
- » A good explanation of how electricity is generated from geothermal energy is available from the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (http://energy.gov/eere/energybasics/articles/geothermal-technology-basics or search from www.eere.energy.gov/).
- » UNIDO's Observatory for Renewable Energy in Latin America and the Caribbean produces interactive maps with information on energy origins and usage in the region (www.renenergyobservatory.org).

4

Advanced lesson plan 4: Is hydropower clean?

General objectives

- » Analyze the environmental, social, and economic impacts of hydroelectric plants.
- » Stage a debate on whether or not hydroelectric energy is renewable.

Class activity 1: Hydropower plants: A controversial alternative

Objective	Estimated time	Location
Consider the environmental impact of hydropower plants.	2–3 hours	Classroom

Materials

- » The introduction to this set of lesson plans, as well as other materials on hydropower plants that are appropriate for the skill level of your students
- » An image of a large hydroelectric plant (such as figure 28)
- » Optional: YouTube videos (see below)

Preparation

Read the background material and remind students that hydroelectric plants are renewable energy sources but have significant environmental and social impacts. Showing videos will add 1 hour to the activity and require a classroom with Internet access and a projector.

Ask the students: Is energy from large hydroelectric plants renewable or nonrenewable? Why?

Step by step

- » Print figure 28 or find something similar and pass it around the class.
- » Show the National Geographic video on Itaipu Dam. To find it, search on YouTube for “Megastructures: The Itaipu Dam.”
- » Divide students into groups of three and ask each group to research large hydropower plants in different parts of the world and assess their advantages and disadvantages. Examples of hydropower plants are: El Quimbo in Colombia, the Three Gorges Dam and the Yangtze hydropower plant in China, Itaipu in Brazil, Guri in Venezuela, and Belomonte in Brazil.
- » Give each group a copy of the following text: “Society has assumed that energy generation and supply would lead to more equitable social and economic development, and that everyone has the same need for energy; but in reality this isn’t the case. Energy needs depend heavily on where consumers live; the type of residence and appliances they have; and the number of people per household. Industrial demand depends on the type of industry and machinery used. We must consider these realities or we will waste resources.” —L. S. Ortiz, Sustainable Renewable Energy: Use and Participatory Management in Rural Areas, 2005.
- » Ask each group to summarize their research for their classmates.

» Ask the students again: Are large hydroelectric plants renewable sources? Tell them that they are considered renewable, but they are controversial. Ask the students: Why are they are controversial? Stage a debate among community and environmental groups. Allow each group to present its ideas.

» Instruct each group to make a table listing the pros and cons of large hydropower plants and have them write down their conclusions.

» Read each group's conclusions aloud to the class and ask if anyone has anything they want to add.

» Discuss with students that hydropower plants are a potentially useful alternative energy source, but care must be taken in deciding whether or not to use them.

» Ask the students: What is energy efficiency? Explain that it means adopting systems that use less energy to provide the same quantity and quality of service, such as light, heat, transportation, or products.

» Summarize the discussion on nonrenewable energy sources, renewable energy, and the case of hydroelectric plants, pointing out that there are other ways to produce the same amount and quality of energy, such as passive solar energy. For homework, ask students to research passive solar energy.

Teacher tips

The last three steps above are optional. The infrastructure chapter in the Green School Toolkit has examples of passive solar energy use.

Formative assessment

Upon completion of this unit, students should understand the following:

» Operation, impacts, and pros and cons of hydroelectric plants

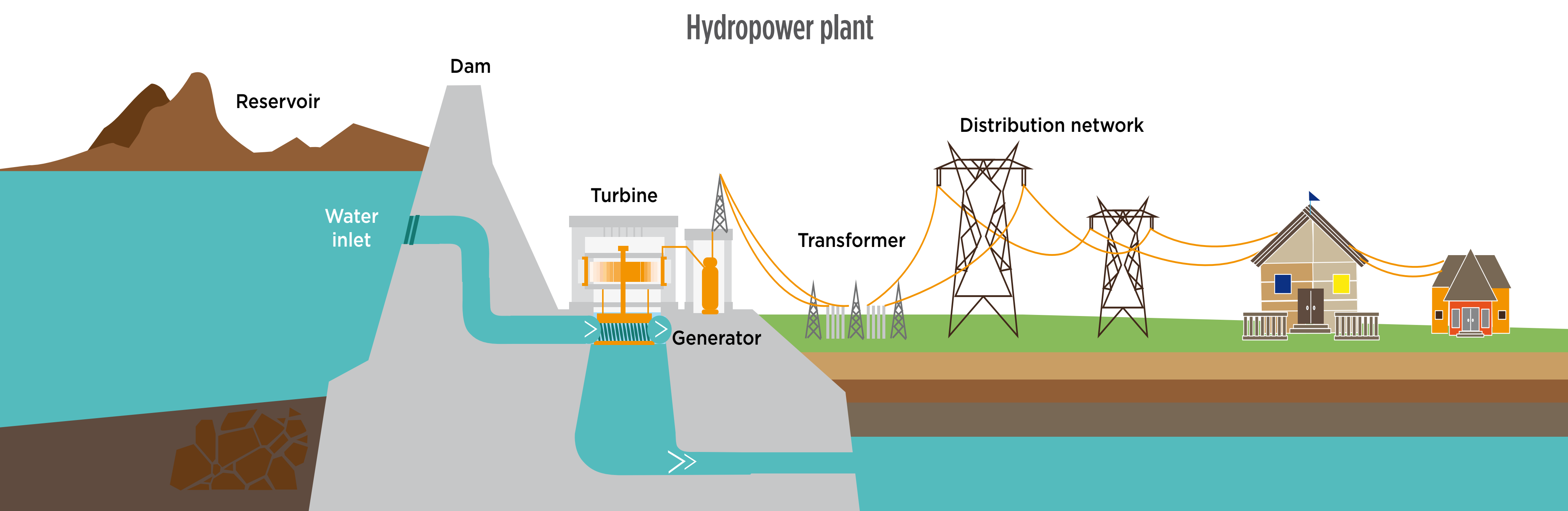
» Differences between small and large plants

» Arguments about whether or not hydropower is a renewable resource

» Alternative energy sources

» Energy efficiency

Figure 28. A hydropower plant



Related subjects

Geography: Create a map of the bioregions and existing or planned hydropower plants in your country or region. Identify topography, landscape, hydrography, and political divisions.

Biology: Delve deeper into the environmental impacts of hydroelectric plants.

Social Sciences: Research and consider the information provided to the public on hydroelectric projects. How can communities and associations participate in their design and implementation? Stage a debate about whether or not communities should be informed, consulted, or invited to participate.

Physics and Mathematics: Calculate the potential of hydroelectric plants.

Language: Write an essay on the pros, cons, and sustainability of hydropower.

Remember

» Hydroelectric plants make electricity from energy generated by moving water, helping to meet the world's energy needs.

» While they are a clean source of energy generation, they also have big environmental and social impacts, such as lost biological and cultural diversity and community displacement.

» Countries must seriously consider the pros and cons of every project, and discussions should involve authorities, associations, and the interested public.

Suggested reading and viewing

» Module 3 of IDB's Green School Toolkit (http://www.iadb.org/en/topics/education/climate-change/green-school-kit,18688.html) deals with environmentally friendly school infrastructure.

» Materials on the sustainability of hydropower are available at www.worldwatch.org.

2016

Energize

Lesson Plans for Children and Youth

Emma Näslund-Hadley, María Clara Ramos, Juan Paredes, Ángela Bolivar, and Gustavo Wilches-Chaux

IDB

Rise Up Against Climate Change!

A school-centered educational initiative of the Inter-American Development Bank