LEARN & SAVE

LET'S LEARN AND SAVE WITH THE ENERGY MASTERS

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Organization of
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WELCOME

There once was a planet called ENERGIA. Its inhabitants knew everything there was to know about energy. They also knew one very important rule: energy is neither created nor destroyed; it can only be transformed from one state to another.

Energia had two main families. The first was the Sustainable Sources family. There were seven members. Their names are Hydrous, Wavy-Kid, Wonder Winder, Volkano, the Sunder brothers, and Biotyfuel. This family provided Energia with all the clean renewable energy they needed to run their cars, buses, trucks, and other transportation systems as well as their lights and the rest of their households.

The second family was the Non-Renewable Sources family. This was an old, noble family with four members. Their names are Sir Oiler, Lord Nukleus, Koal Knight, and Lady Gassna. The Energians, the Sustainable Sources family, and the Non-Renewable Sources family all came together to make a promise. They agreed that the members of the Non-Renewable Sources family would live quietly in the planet's core because if they were used to generate energy, they could harm Energia's environment.

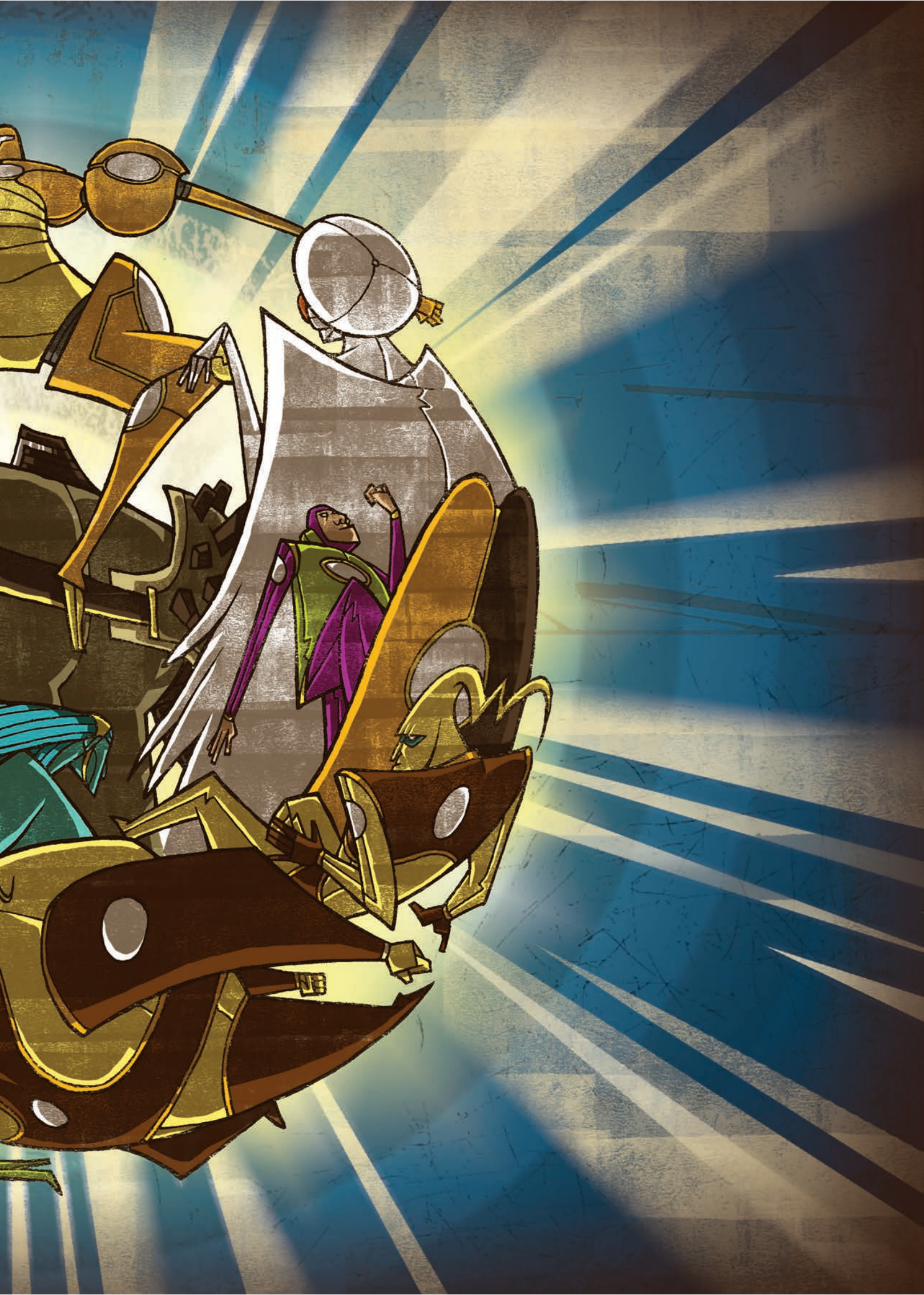
Unfortunately, one member of the Non-Renewable Sources family broke the promise and told a powerful energy company called ENERGOX about the secret hiding place. No longer protected within Energia's core, the Non-Renewable Sources family was used day after day, year after year to generate energy. This caused so much damage to Energia that the planet was destroyed nearly a billion years later.

Because of this tragedy the Non-Renewable Sources family and the Sustainable Sources family made a new promise. They swore that they would both live in harmony together in the universe and would protect other planets from being destroyed like Energia. Hydrous, Wavy-Kid, Wonder Winder, Volkano, the Sunder brothers, Biotyfuel, Sir Oiler, Lord Nukleus, Koal Knight, and Lady Gassna have all noticed that our Earth is in danger. They are here to help us today.

Read on to meet them and let's all learn and save with the energy masters!!!

CHAPTER **01**

LEARNING ENERGY



On Earth, energy exists in everything. It makes changes possible. The Earth's inhabitants, the Earthlings, use energy to power everything they do. Earthling scientists work hard to uncover the secrets of energy. They do not know everything yet, but they found that one of the main laws of energy is one that, you will remember, was already shared with us by the Energians:

"ENERGY IS NEITHER CREATED NOR DESTROYED; IT CAN ONLY BE TRANSFORMED FROM ONE STATE TO ANOTHER".

Holding this law as true, we can say that when somebody uses energy, it does not disappear; it simply changes from one state to another. Let's use the law to try to identify the changes in the examples in the pictures below:

Image 1: Wind turbines use air flow to generate electricity.
Image 2: When you ride a bike, your body converts the chemical energy produced by your muscles into mechanical energy. The bicycle is the most efficient form of transportation. It uses five times less energy than your body uses when you are walking!

Not all energy is the same; it exists in different forms: heat (also called thermal energy), light (also called radiant energy), motion (also called kinetic energy), electrical, chemical, nuclear, and gravitational.

POTENTIAL

Chemical Energy
Is energy stored in the bonds of atoms and molecules.

Mechanical Energy
Is energy stored in objects as a result of tension and compression.

Nuclear Energy
Is energy stored in the nucleus of an atom, where it holds the nucleus together.

Gravitational Energy
Is energy stored due to an object's position above the surface of the Earth, or its height. The amount of gravitational energy an object contains increases in proportion to its height and weight – so the higher and heavier and an object, the more gravitational energy it contains.

KINETIC

Radiant Energy
Is electromagnetic energy that travels in transverse waves.

Thermal Energy
Is the vibration and movement of the atoms and molecules within substances.

Motion Energy
Is energy stored in the movement of objects. The faster they move, the more energy is stored.

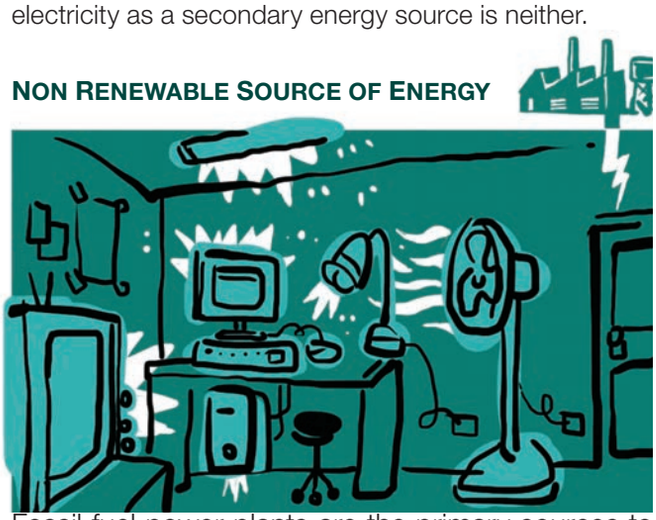
Sound
Is the movement of energy through substances in longitudinal (compression/ rarefaction) waves.

Electrical Energy
Is delivered by tiny charged particles called electrons, typically as they move through a wire. Lightning is an example of electrical energy in nature.

Earthlings have learned to generate electricity. We use electricity to power appliances, lamps and other light sources, and heating and cooling systems for our houses, schools, and businesses. Because it can power so many things, electricity is one of our most widely used forms of energy.

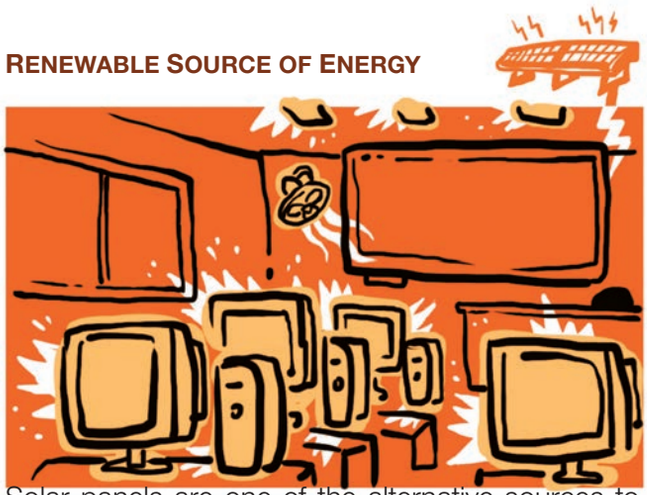
Earthling scientists say that electricity is the flow of electrical power or charge. Electrical charge is a basic part of nature – that means it occurs naturally. Still, we cannot use electrical charge directly from nature to power our world. The electricity we rely on is generated by converting other sources of energy like nuclear, solar, or coal-based energy. This means that electricity is a secondary energy source, or an energy carrier. Nuclear, solar, and coal-based energy are all primary energy sources and they can be further classified as either renewable or non-renewable sources of energy. Remember, though, that only primary energy sources can be renewable or non-renewable, so electricity as a secondary energy source is neither.

Non Renewable Source of Energy



Fossil fuel power plants are the primary sources to provide electricity

Renewable Source of Energy



Solar panels are one of the alternative sources to provide electricity

When Earthlings generate electricity, we need a means of measuring how much of it we use. Electricity is measured in watts and kilowatts. A kilowatt-hour (kWh) on our planet represents the energy used if 1000 watts work for one whole hour. We can figure out the total number of kilowatts used per hour by multiplying the number of kilowatts by the number of hours for which electrical energy was used.

A utility bill usually shows what a household is charged for the kilowatt-hours the Earthlings that live in it have used. Earthlings who want to conserve energy and save money know that it is always smart to have an electricity saving plan in order to keep an eye on the kilowatts per hour used each month.

Street electricity counters in Antigua.
Photo: Courtesy of Egis International (copyrighted)

- On average, the rate for electricity is EC USD 0.83 per kWH and Bahamian USD 0.20 per kWh.
- Although all Caribbean electricity consumers pay a high rate, there are still some rate differences between Caribbean countries. Dominicans pay the highest rate per kWH while Bahamians pay the lowest one.
- Fireflies produce light using the chemical energy contained in their food. Did you know that they produce light more energy efficiently than light bulbs? Some deep-sea squids and cave-dwelling gloworms also change the chemical energy from their food into light.

CHAPTER **02**

SOURCES OF ENERGY

Sources of Energy

Earthling scientists put energy sources into two groups:
Renewable Energy Sources: energy sources that can be recreated in a short period of time.
Non-Renewable Energy Sources: energy sources that we are currently using up faster than they can be recreated.

The table below shows different types of non-renewable and renewable sources of energy.

Non-Renewable Sources of Energy	Renewable Sources of Energy
Fossil Fuels (Oil, Natural gas, Coal) Nuclear (Uranium)	Solar, Wind, Geothermal, Hydropower, Biomass, Wave

Fossil Fuels as Non-Renewable Sources of Energy

Oil, natural gas, and coal are all called fossil fuels. Fossil fuels are formed within the Earth's core (remember the secret hiding place of the family of Non-Renewable Sources in the core of Energia!). It takes millions of years for fossil fuels to be created. They are formed by heat from the Earth's core, and pressure from layers of rock and soil. These two forces, heat and pressure, act on the remains of dead plants and animals. These remains are called fossils, which is where fossil fuels get their name.

The natural processes by which fossil fuels are formed happen every day. The problem is that they happen far too slowly (a few million years too slowly!) to keep up with how quickly we are using the fossil fuels we currently have on Earth (we call these our fossil fuel reserves). Because fossil formation does not keep up with our use of fossil fuels, we will have to find renewable – or sustainable –forms of energy when our supply runs out. The energy masters are here to warn us that it is smarter to start using renewable energy now!

Why should we take their advice? Because switching from fossil fuels to sustainable energy is smart for two reasons. We already discussed the first reason. (Do you remember us learning that one day in the future we will run out of fossil fuels?) The second reason is because making the change will help us protect our environment. Global warming is one of the biggest threats to our environment today. Using fossil fuels (to generate electricity, for example) produces one third of the world's global greenhouse gas emissions. Greenhouse gas emissions are one of the causes of global warming. If the Earth's climate changes as a result of global warming, our own special part of the Earth – the Caribbean – will be threatened. Other environmental consequences of overusing fossil fuels are air pollution, acid rain, and oil spills.

Thermoelectric plants cause pollution when they release smoke into the atmosphere.

The Fukushima nuclear plant in Japan was damaged during the 2011 earthquake, causing worldwide fear of a nuclear catastrophe.

Oil spills like this 2010 spill in the Gulf of Mexico caused a lot of damage to marine ecosystems in the region.

NON RENEWABLE
SOURCES OF ENERGY

Sir Oiler

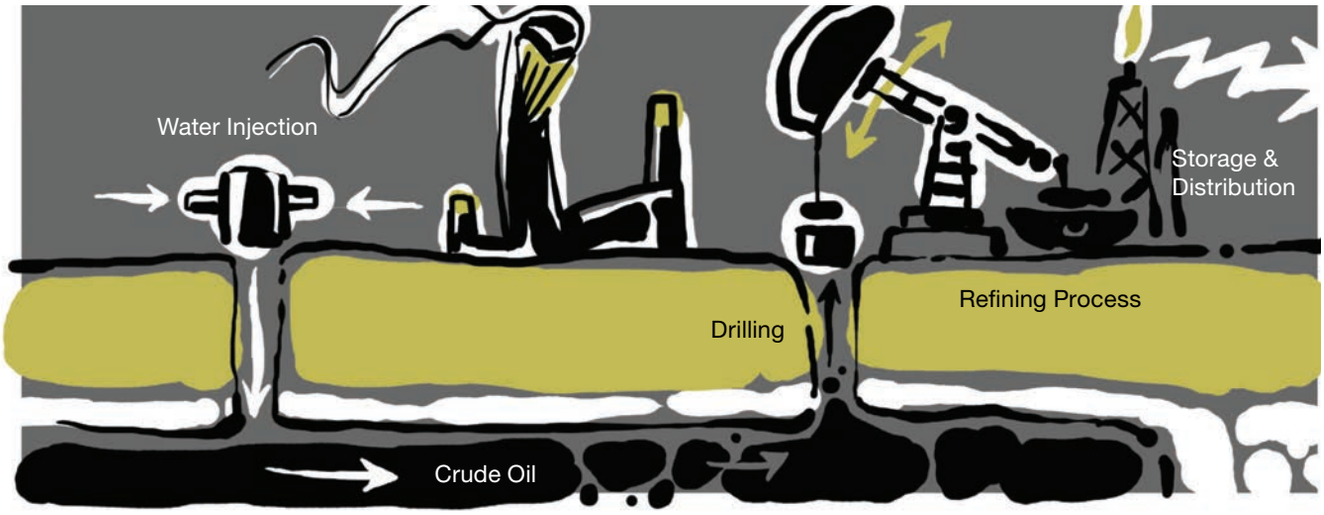
Gender: Male
Age: Unknown
Size: 5 meters-17 feet
Characteristics: Sir Oiler comes from the beginning of time like his brother, Koal Knight, and his sister, Lady Gassna. He is brave, but a bit shy. He knows the entire universe's secret, but not much is known about him. This gives him an important status in the Non-Renewable family and makes him the key decision-maker. Because of his build he is very flexible and fast – indeed, the quickest member of his family. He hates water, but has a passion for fire, which he can control. His weapon of choice is a dagger. All things considered, he has great powers!

Defining Oil

Oil is a fossil fuel. (Remember, how fossil fuels are formed?) The oil we have on Earth was formed millions of years ago from the remains – or fossils – of long-dead marine animals and plants, which were, over several geological ages, covered and compressed by layers of sand and silt. Heat and pressure from these layers of sand and silt transformed the fossils into what we Earthlings know as crude oil.

You wouldn't know how important crude oil is just by looking at it. Crude oil is a smelly, yellow-black liquid usually found deep underground in reservoirs. Because it exists so deep underground, we had to invent a special method (see the diagram below) to reach it.

Producing Electricity from Oil



Above the hole, a structure called a 'derrick' is built to house the tools and pipes going into the well. When finished, the drilled well will bring a steady flow of oil to the surface.

After crude oil is removed from the ground, it is sent to a refinery by pipeline, ship, or barge. At a refinery, different parts of the crude oil are separated into useable petroleum products: motor gasoline, diesel, jet fuel and other products.

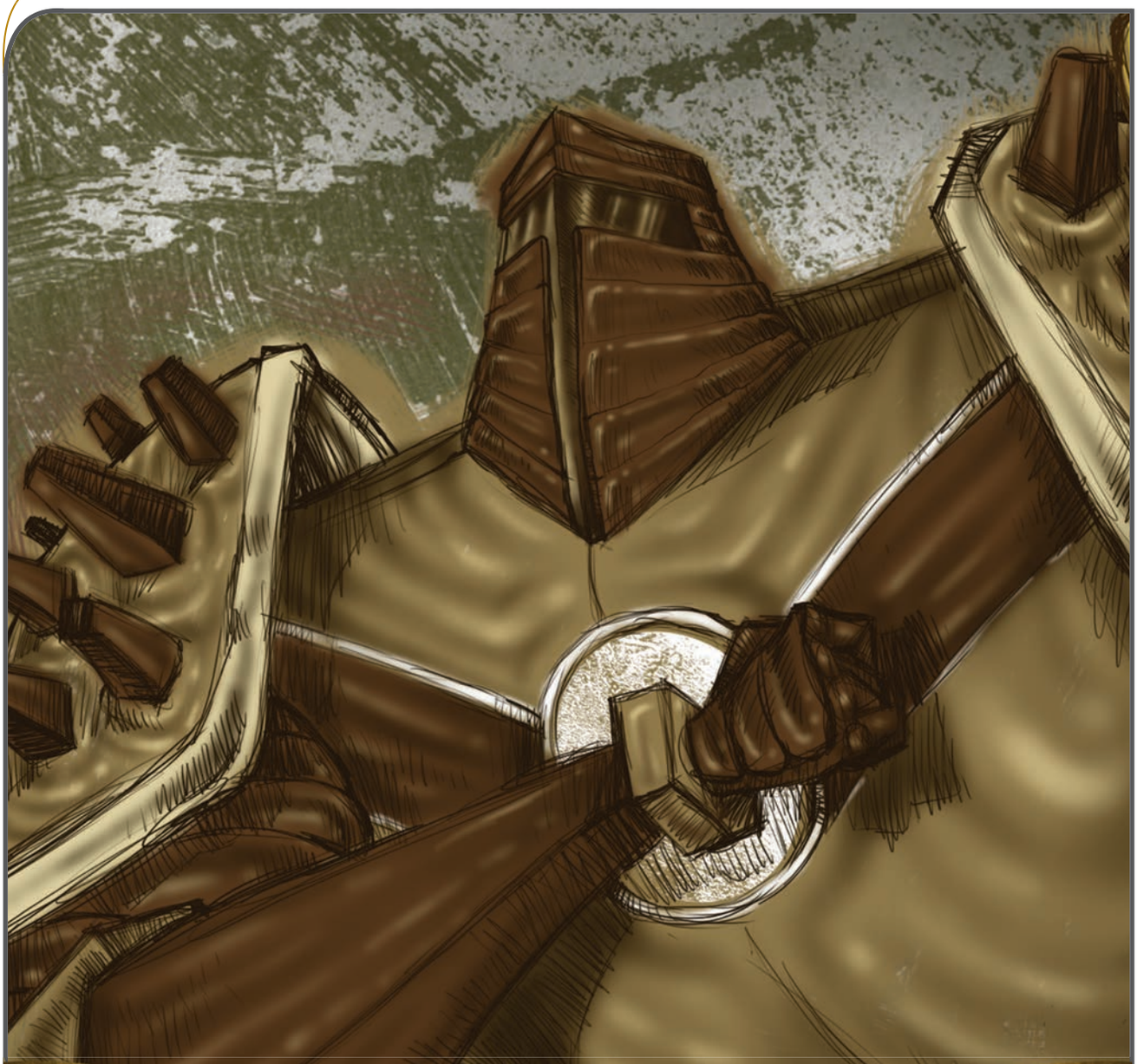
Oil and the Environment

Without an agreement to confine Sir Oiler and the other members of the Non-Renewable family to their rightful place within the Earth's deepest layers, our energy sources are left out in the open, unprotected from companies like ENERGOX. These companies use non-renewable energy sources to make money without much care for the environment, which can be harmed by air pollution, oil spills, acid rain, and more.

Oil products allow us to perform many important tasks, but the emissions and by-products generated from burning oil products are as harmful as the oil is helpful. For instance, carbon dioxide, a by-product of burning oil, is a greenhouse gas and a major source of global warming. Sulfur dioxide causes acid rain. Nitrogen, which oxidises as unstable organic compounds, contributes to ground-level ozone.

Even without being burned, oil can cause environmental damage. For example, large quantities of oil sometimes spill during oil production and transportation. Oil spills cause harm to oceans, seas, and marine life.

- Most of the Caribbean islands (except Trinidad and Tobago and to a lesser extent Belize) are net importers of crude oil and refined oil products, which they buy mainly from (countries outside of the Caribbean).
- Caribbean islands consume approximately 240 000 boepd (barrels of oil equivalent per day). Nearly 95% of that comes directly from fossil fuels.
- Trinidad and Tobago controls the majority of the Caribbean's oil production. The largest oil producer in the country is the state-owned Petroleum Company of Trinidad and Tobago (Petrotrin).



KOAL KNIGHT

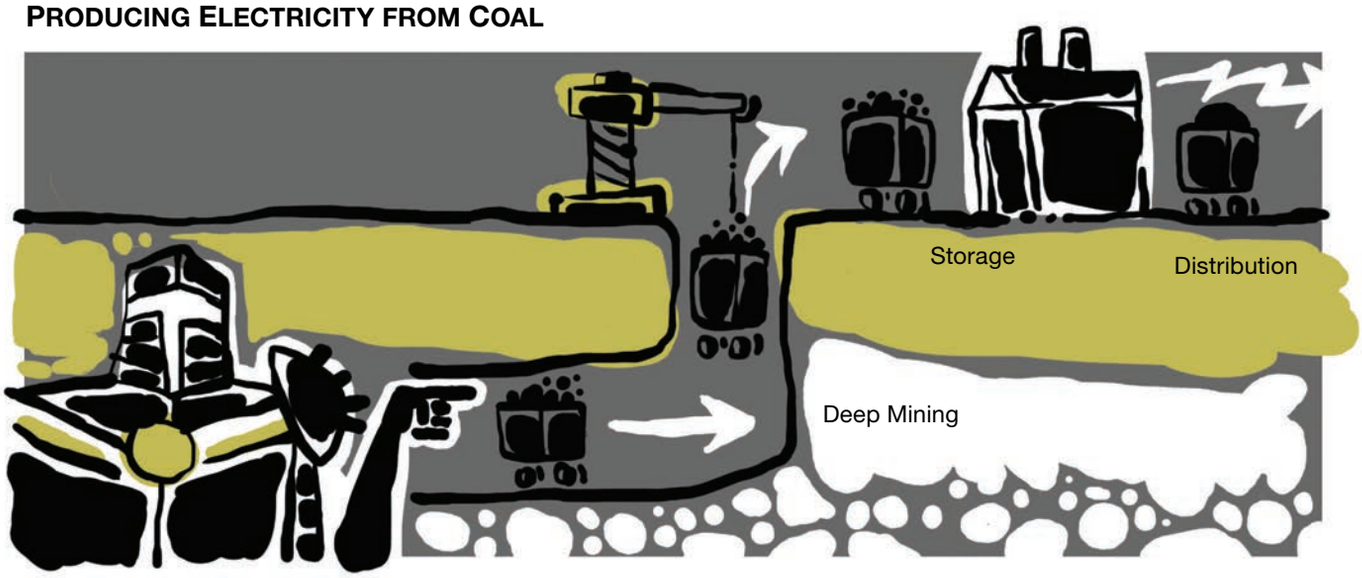
Gender: Male
Age: Unknown
Size: 4 meters-13 feet
Characteristics: Koal is very old, almost as old as the universe itself. He is not very smart and sometimes he can be clumsy. He is usually calm, except in stressful situations when he transforms into a fierce machine of terror. The Knight wears a suit of armour crafted by powerful friends. Its huge shoulders and elbow pads make it the only thing that can accommodate Koal's large body. The Knight carries a pair of enormous coal sticks that he can throw and recover at any time. Together with another of his weapons, an axe given to him by a famous warlord, the Knight is an energy warrior. Although he is a warrior, he enjoys the company of his family members and is always in the company of his two brothers Sir Oiler and Lord Nukleus, and his sister,Lady Gassna.

Defining Coal

Coal is a combustible black to brownish-black sedimentary rock made up mostly of carbon and hydrocarbons. Because coal is a fossil fuel, Earth's current coal deposits were formed by a process similar to the one we talked about for oil formation. Millions of years ago, dead plants at the bottom of Earth's swampland were covered by layers of water and dirt. The water and dirt trapped the energy contained in the plant remains and exerted so much heat and pressure on them that over time they transformed into what we now know as coal.

Earthling scientists have identified four types of coal: anthracite, bituminous, sub-bituminous, and lignite.

Producing Electricity from Coal



Coal and the Environment

When coal mining is not done according to important rules that help protect the environment, it can have a negative impact on ecosystems. For example, it can affect water quality in nearby rivers, streams, lakes, and other bodies of water. It can also change landscapes, ruining some of our scenic views. A type of coal mining called surfacing mining may involve harmful practices like mountaintop removal. On some occasions, mountaintop removal produces enough debris to literally choke mountain streams. Another type of coal mining, underground mining sometimes leads to companies abandoning underground mines. Abandoned mines can give off acidic water.

Anytime coal is burned, it produces gas emissions that have negative effects on the environment and on human health. The principal emissions produced when coal is burned (or combusted) are sulfur dioxide (SO2), nitrogen oxides (NOx), carbon dioxide (CO2), mercury, and other heavy metals.

- Coal has been used as an energy source for hundreds of years. The World Coal Institute tells us that coal was traded internationally as far back as the ancient Roman Empire.
- One kg of coal can supply enough electricity to power ten 100-watt light bulbs for about two hours.
- The Energy Information Administration (EIA) tells us that the demand for coal in developing countries like ours is expected to double through 2020.

LADY GASSNA

Gender: Female
Age: Unknown
Size: Undetermined
Characteristics: Lady Gassna is the oldest sister in the Non-Renewable family, so she commands much respect. The Lady loves her brothers very much and pretends to agree with all of their ideas. Some people claim that she is secretly blind with envy because she thinks that she should be the leader of the family. Thirsty for power, she is often suspected of betrayal. Her gaseous build allows her to be very slippery. She is a mistress of camouflage (she is very good at hiding!) and can get into almost every location without anybody noticing her. She is also skilled at handling toxic gases. Her best power is that she can teleport (appear and disappear from any location) anytime she wants. True to her untrustworthy reputation, she is secretly planning to sign a contract with the evil utility company ENERGOX.

Defining Natural Gas

Natural gas is formed by a process similar to the ones we described for oil and coal. The main component of natural gas is methane. Over millions of years, plant and animal remains built up in thick layers and were changed into natural gas by the action of pressure and heat.

Once gas is found underground, it flows up onto the surface through a drilled well, and then into large pipelines. Methane and the other gases that make up natural gas (such as butane and propane, which are also known as by-products), are separated and cleaned at a gas processing plant.

Producing Electricity from Natural Gas

Natural Gas and the Environment

Although natural gas has many characteristics that make it an efficient, relatively clean, and economical source of energy, there are, as with other non-renewable energy sources, its production and use can cause environmental and health problems. For example, many of the areas now being looked at and developed for natural gas production are relatively untouched natural spaces. Some make up what little is left of the world's wilderness. Developing these areas for natural gas production may negatively affect nearby wildlife and human life.

- Puerto Rico and the Dominican Republic import liquefied natural gas (LNG) from Trinidad and Tobago for power generation.
- Natural gas is colourless, odourless, and tasteless, so we add a chemical that smells like sulfur – mercaptan – to it before it is distributed. Mercaptan gives natural gas an unpleasant, easily recognizable smell. This artificial smell is a safety measure. It means that if there is a leak, natural gas will be easily detected in the air and is likely to cause anyone harm.

LORD NUKLEUS

Gender: Male
Age: Unknown
Size: 7 meters-23 feet

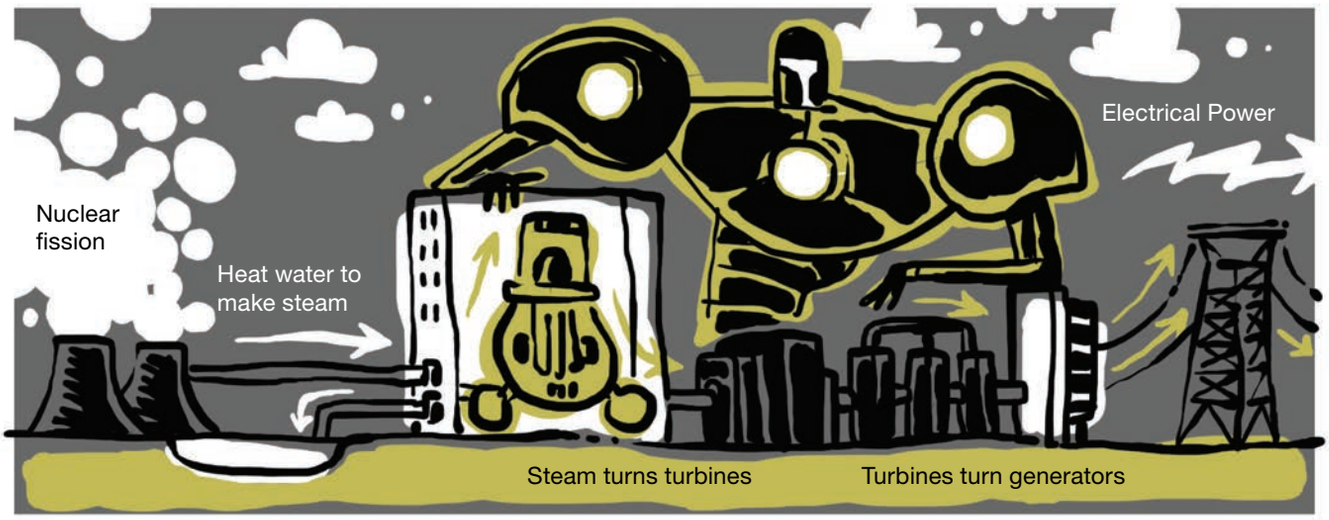
Characteristics: According to some legends, Lord Nukleus is the oldest of the Non-Renewable family's brothers. Even so, the family is very protective of him and keep him well-hidden. Because they were so good at hiding him, he was the last member of the Non-Renewable family to be discovered by the greedy utility company ENERGOX. When ENERGOX finally found him, they handed him over to one of their mad scientists, who performed extreme experiments on him. The experiments made Lord Nukleus much more powerful than he was before, but they were very painful, so Lord Nukleus now hates all scientists and laboratories. It is said that Nukleus is the most powerful being of his kind. In fact, he has unlimited power, which is his best quality, although it is sometimes a threat to himself and others. He also has excellent leadership and communication skills, and is often able to use diplomacy to control the difficult relationship between his brothers. These gifts made him the family's first choice for leader. Of course, this fact was very upsetting to his power-hungry sister, Lady Gassna. Because of her jealousy, she started a rumour suggesting that the Lord is a really a Lady in disguise – a secret that if confirmed and revealed, could cause Nukleus' downfall and send the universe into energy chaos.

Defining Nuclear Power

Earthling scientists discovered nuclear energy in the 20th century. After first finding that energy was stored in the nuclei of atoms, they developed two processes to release it so that we could use it. The first came to be known as nuclear fusion, which is when atoms are combined or fused together to form a larger atom. The second came to be known as nuclear fission, which is when atoms are split apart to form smaller atoms, releasing energy in the process.

We can use nuclear energy to generate nuclear power. This involves heating water to produce steam. At nuclear power plants, we have reactors that hold nuclear fuel, which is primarily made up of uranium. When uranium fuel atoms are hit by neutrons they fission, or split, releasing heat and more neutrons. Under controlled conditions, these second generation neutrons (that is, the neutrons that are released after the first set of neutrons make contact with the uranium fuel atoms) can be made to strike more uranium atoms, splitting more atoms to create more neutrons, and so on. This results in a chain of continuous fission, which constantly releases heat. This heat is used to change water into steam. The steam, in turn, spins a turbine that generates electricity to be used by Earthlings like you and I.

Producing Electricity from Nuclear Power



Nuclear Power and the Environment

In contrast to power plants that rely on fossil fuels, nuclear reactors do not produce carbon dioxide or other air pollutants while operating. Despite this advantage, it takes a lot of energy to mine and refine uranium ore in order to make reactor fuel. (Remember we said that uranium fuel is used in reactors in nuclear power plants?)

The main environmental problems with using nuclear power are the effects of radioactive waste such as uranium mill tailings, spent or used reactor fuel, and other waste products. These products are dangerous because they can remain radioactive for thousands of years. (Anything radioactive is a threat to human health!) Although it is not very likely that there will be an uncontrolled nuclear reaction, if it were to happen the radioactive particles inside a nuclear power plant could contaminate the air and water for hundreds of miles around.

- The steam that comes out of nuclear cooling towers is really high temperature water.
- The International Nuclear Event Scale (INES) is a scale that is used to rate the severity of nuclear accidents. It goes from 0 to 7. The scale was developed by the International Atomic Energy Agency (IAEA).
- The worst nuclear accident in history is the Chernobyl disaster. It happened in 1986 at the Chernobyl Nuclear Power Plant in the Ukrainian Soviet Socialist Republic (now Ukraine). The Chernobyl disaster is the only event to receive an INES score of 7.
- Canada produces 16% of its electricity using nuclear fission.

Renewable Energy

So far, we have talked about all the members of the Non-Renewable family, defined fossil fuels and learned how they are formed and how they could harm our environment. Luckily, we have alternatives to using fossil fuels. These alternative energy sources are receiving a great deal of attention these days. Everyone is talking about them: scientists, teachers, politicians, energy consumers (people who pay energy bills) and our friends the energy masters! This is because alternative energy sources are not only renewable (remember, we said that renewable energy sources can be easily replenished), they also cause fewer environmental and health problems than fossil fuels.

Many countries around the world are developing state and private sector policies so that they can use more renewable energy sources in order to keep the environment healthy. One of these policies is the Kyoto Protocol.

Kyoto Protocol

The Kyoto Protocol is a set of rules written as part of an international environmental treaty called the United Nations Framework Convention on Climate Change (UNFCCC/FCCC). The Protocol was accompanied by a more detailed set of rules about how it should be put into action. These rules were adopted at an annual convention called Conference of the Parties in Marrakesh in 2001 and are called the Marrakesh Accords.

The purpose of the Kyoto Protocol is to reduce greenhouse gas emissions. Because carbon dioxide is the primary greenhouse gas that is sent into the atmosphere by human activities, it is the main target when it comes to reduction efforts.

The Protocol was set into action in Japan on December 11, 1997. Let's use Japan as an example to talk about how the Protocol works to reduce the volume of greenhouse gases being released into the atmosphere. When the Protocol was put into action in Japan, it meant that Japan was given a limit on how much greenhouse gas it could send out into the atmosphere. So, if Japan (or any other country that agrees to the Protocol) goes over the limit, there will be a penalty, like a punishment. The penalty is a lower greenhouse gas emission limit for a specific period of time directly after the violation (or rule-breaking).

Countries are responsible for finding their own ways (individually-designed measures) to stay within their emission limits, but the Protocol gives three helpful ways ideas:

- Emissions trading – known as "the carbon market" is where companies buy licences, permits or "carbon credits" from the government. A company's carbon credit gives it the right to emit a certain volume of greenhouse gas. If a company needs more carbon credit, it must buy from a company that does not need to use as much. Because there is a limited amount of carbon credits, the government can make sure the country stays under the emission limit.
- Clean development mechanism (CDM) allows industrialized countries (such as the United States, Canada, and the United Kingdom) to invest in projects that reduce the amount of greenhouse gas given off in developing countries. Any emission reduction that happens in the developing countries as a result of the project is credited to the industrialized country that invested in the project.
- Joint implementation (JI) allows a country to invest in another country's emission reduction and gain points toward its own emission limit.

Wind Farm at Maddens Estate in Nevis

Reservoir in Saint Vincent

Geothermal test well in Wotten Waven, Dominica

Solar Panels at Administrative Building in Kingstown, Saint Vincent

RENEWABLE
SOURCES OF ENERGY

SUNDER BROTHERS

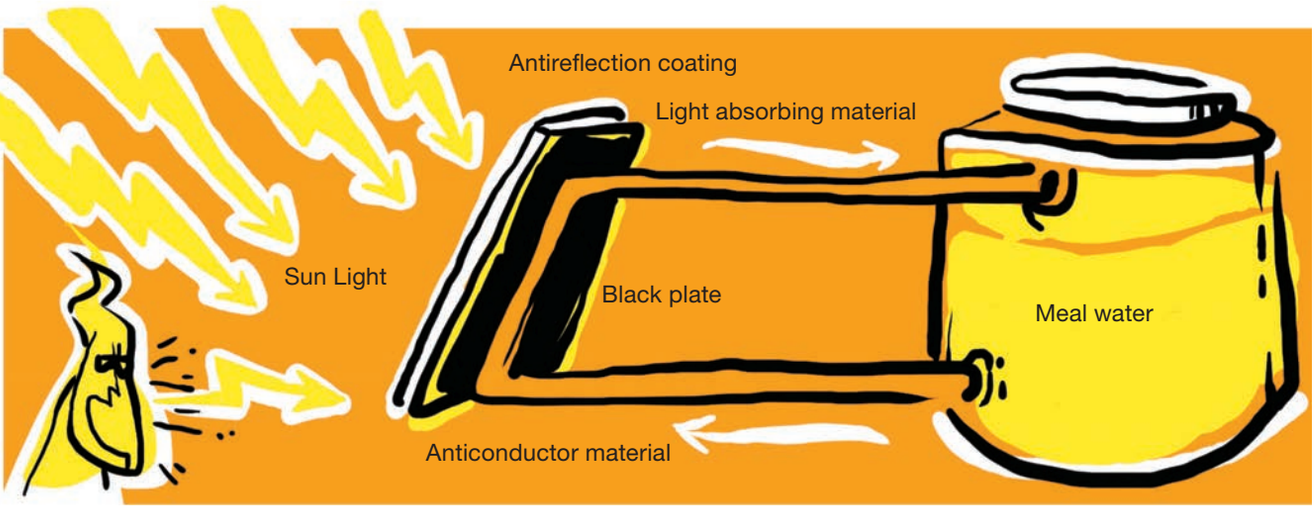
Gender: Male
Age: 22 years old
Size: 1.6 meters-5 feet (Alan Sunder) and 2 meters-6.5 feet (Jimmy Sunder)
Characteristics: The Sunders, Alan and Jimmy, are twin brothers. They were originally created to protect their father, Energia's sun. They are good at protecting the sun because they can easily flush huge fire balls and solar flare-ups. When they discovered that they could combine their bodies to form a superior being called Sunnit, who is a giant with unlimited powers, they made a promise to fight to defend energy until the end of the universe. Alan is the faster of the two brothers. He is mischievous and clever. Jimmy is not as fast, but he has incredible strength and a noble, sensitive, humanitarian personality. When fitted together, the twins' suits become a powerful solar weapon. Both brothers wear special vests with solar panels on them so that they can always recharge energy. Although the Sunders are inseparable, they, like most siblings, frequently clash and argue because of their differences. Fortunately, their disagreements are always easily put to rest by sharing a pleasant sun bath!

Defining Solar

Solar energy has been generated naturally since the beginning of time. The sun's rays provide one of the most attractive alternative energy sources. The rays are so powerful that they reach our Earth from millions of miles away. The energy contained in them is called solar radiation. Solar radiation is used to heat water and other fluids, and spaces like houses and other buildings, but it can also be converted into other forms of energy, such as electricity.

Solar technology is either passive or active depending on the way the energy is captured, converted, and distributed. Active solar techniques use photovoltaic panels (solar panels) and solar thermal collectors (solar water heaters) to harness solar energy. Passive techniques include orienting a building so that it faces the sun, choosing building materials with thermal mass properties (that is, materials that help regulate indoor temperatures while outdoor temperatures are fluctuating), and using materials with light dispersing properties (because light dispersion helps regulate heat).

How does Photovoltaic Work?



Solar panel in a national park in New Providence, Bahamas. **Photo:** courtesy of Egis International (copyrighted)

Advantages and Disadvantages

Although solar energy is a renewable and clean source of energy, it has its own disadvantages. For example, the amount of sunlight that reaches the Earth's surface is not always constant. It varies depending on location, time of day, time of year, and weather conditions, making solar one of the less reliable energy sources.

- Most of the Caribbean islands have already taken steps toward using solar energy. Take Barbados and Saint Lucia for example: solar water heaters have already reduced household energy costs by 3%since March 2011.
- In the Commonwealth of Dominica, which has the highest electricity rates in the Eastern Caribbean, the government gives tax breaks to people who buy and install solar energy panels. The State set an example for private citizens by installing solar-powered streetlights on the main streets of Roseau, the country's capital.
- In 15 minutes, the sun radiates as much energy onto our globe as humans use during an entire year. Just imagine what great energy masters we would be if we could channel all that energy!

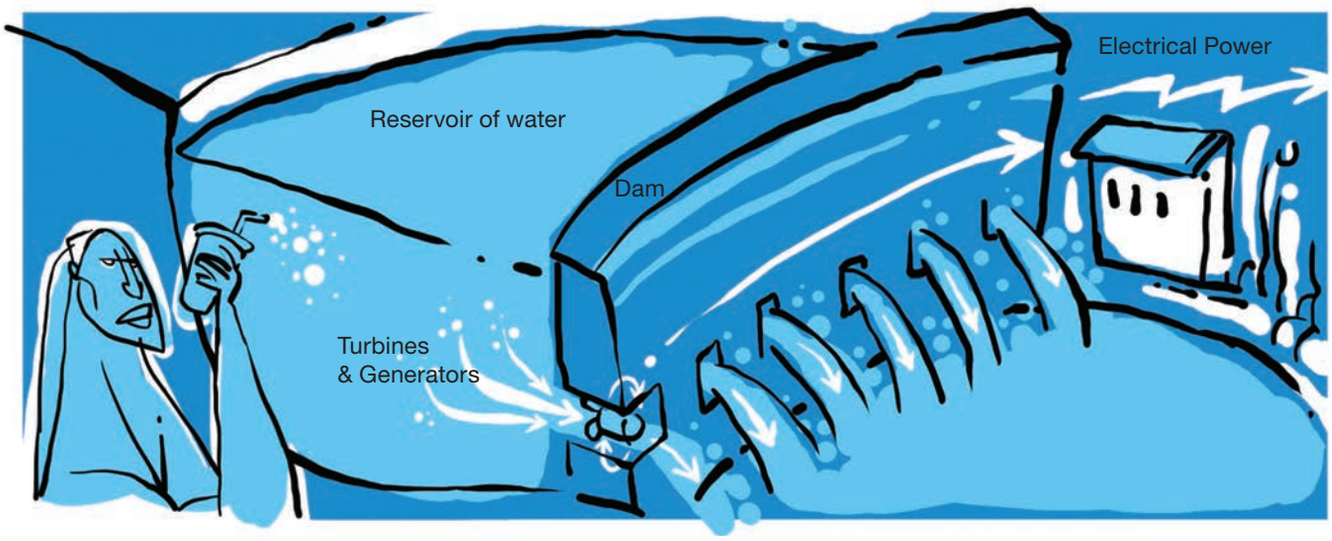
HYDROUS

Gender: Male
Age: 35 years old
Size: 2 meters-6.5 feet
Characteristics: Hydrous is the last survivor of the Wattas. His family was betrayed, attacked and destroyed during a drought in Energia while he was away looking for a better place to settle. He is very fast in water and is able to speak the language of rivers and lakes. His fine membrane allows him to keep his body hydrated on dry land for a while, but he cannot survive out of water for long. Because of what happened to his family, he finds it difficult to trust others and he is always on the alert for enemies. His hands and feet are adapted to manage big masses of water – an advantage that he can use as a weapon.

Defining Hydropower

Moving water is one of the oldest sources of energy on our planet Earth. Our ancestors used it thousands of years ago to turn paddle wheels, which helped them perform jobs like grinding grain. Let's think about the paddle wheel example as we discuss how we use the mechanical energy stored in moving water.
Earthling scientists tell us that the amount of available energy in moving water is determined by the flow or fall of the water. The more rapid or heavy the flow, the more mechanical energy the water will generate. Similarly, the greater the water head, the more energy it will produce. So, if we were looking for moving water to turn a device like a paddle wheel, we would want rapidly moving water from a large water head.
Moving water is used on a large scale to produce hydroelectric power. In order to generate hydropower, water is trapped in reservoirs created by dams. It is then released as needed to generate electricity. Water is built up, held, and then released so that its potential energy – that is, the energy it has when it is held back in a dam – can be converted to kinetic energy when the water is freed and allowed to fall down a distance called a penstock so that it can turn water turbines (devices similar to a paddle wheel) and generate electricity.

Producing Electricity from Moving Waters



Reservoirs sometimes cover important na-tural areas, agricultural land, and archaeological sites, or force people to relocate. **Photo:** Reservoir in St Vincent, courtesy of Egis International (copyrighted)

Advantages and Disadvantages

Hydropower (or hydroelectric) generators do not emit air pollutants, but hydropower dams, reservoirs, and generators can cause other environmental problems. Reservoirs and dams can change natural water temperatures, water chemistry, flow characteristics, and silt loads. These in turn can lead to unnatural ecological changes, (which affect living things or organisms and their physical surroundings, habitats or homes). They can also cause changes to rock and land forms both upstream and downstream of the river that hosts the dam.

These changes may negatively affect plants and animals whose habitats or homes are in and around the river, or in the deltas that form at the river mouth or estuary (that is, where the river empties into the ocean). Greenhouse gases, carbon dioxide, and methane may also form in reservoirs and be sent out or emitted into the atmosphere.

- Dominica generates 40 % of its electricity from hydroelectric sources. Suriname, Jamaica, and Saint Vincent also generate hydroelectric power, but on a smaller scale.
- The most powerful hydropower station is the Itaipu power station on the Paraná River near the border between Brazil and Paraguay. Itaipu was opened in 1984. The station has since then achieved its ultimate capacity of 13 320 MW.
- The word hydropower comes from the Greek word hydro meaning water.
- Hydropower can be generated from different bodies of water and from water under various conditions. These include river currents, river dams, ocean waves, and ocean tides.

WAVY-KID

Gender: Male
Age: 14 years old
Size: 0.9 meters-2.9 feet
Characteristics: They say he is Neptune's love child with a human woman. Indeed, Wavy-Kid has been developing aquatic powers like Neptune's since his early childhood – although he still doesn't manage them very well. According to legend, he is destined to be king of the seas and lord of the lost continent, Atlantis. He is always in the company of a strange being that likes to adopt the shapes of different ocean objects. The being's favourite forms to take seem to be Surf Board, Wind Surf, Hydro Sky, and Water Bike. Wavy-Kid is protected by a special neoprene suit that helps him regulate his body temperature and control the large volumes of sand that he uses in battle. A true rebel teenager, he is very funny and a little irresponsible!!!

Defining Tidal and Wave Power

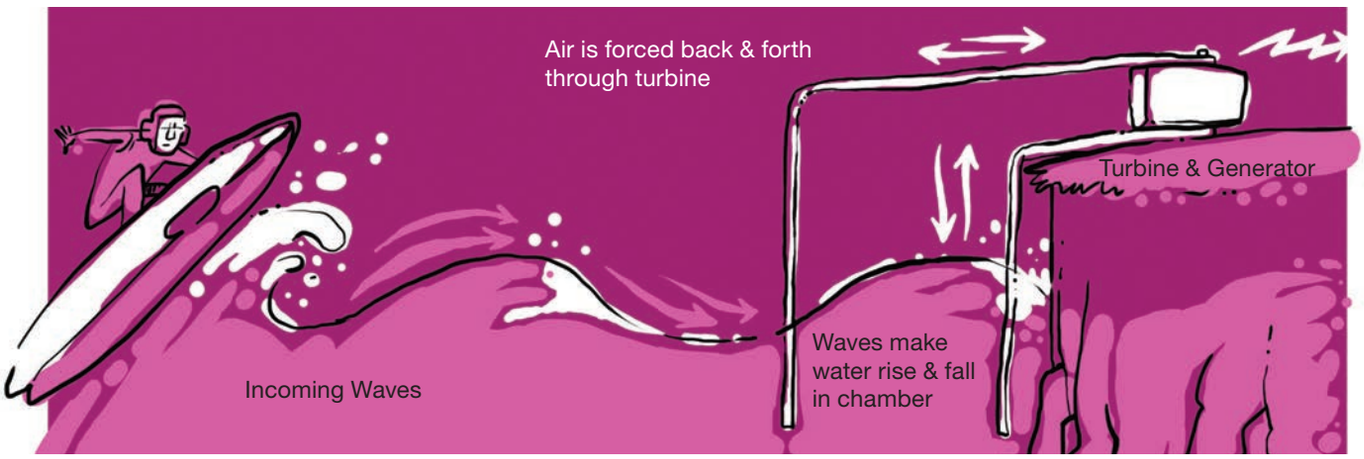
Did you ever wonder why we have tides in our oceans? Well, Wavy-Kid is here to give us the answer! We know that the moon and the sun both exert a gravitational pull on the Earth. We also know that the Earth is constantly rotating on its axis. These three forces act on the Earth's oceans to create tides.

Tides account for changes in water level. The water level near the oceans' shores can change by up to 40 feet between tides. Even with these water level changes, tidal power is more predictable than both wind energy and solar power. In order to produce tidal energy economically, we need a large enough tidal range – that is, a tidal range of about 10 feet.

Tidal plants often use a simple system. A dam known as a barrage is built across an inlet or bay. Gates called sluice gates are built onto the barrage. These allow the tidal basin to fill up on incoming high tides, and empty through a turbine system when the tides are going out.

Wavy Kid's water world offers up another source of energy in addition to tidal power. Ocean waves contain a lot of energy and are a great energy source. Waves are created when wind blows over the surface of the ocean. One way to harness wave energy is to bend or focus the waves into a narrow channel. This magnifies their power and size. The waves can then be channelled into a catchment basin or applied directly to spinning turbines.

Producing Energy from Tidal Sources



When we use waves to generate power, we risk disturbing marine life. We could cause changes in the types of marine animals and plants that live near the shore and changes to how these organisms' distribute themselves. Generating power from waves can also affect human activities by interfering with mooring and anchorage lines. **Photo:** Courtesy of Egis International (copyrighted)

Advantages and Disadvantages

Tidal and wave power are both renewable sources of energy; however, as we have seen with other renewable energy sources, they have some disadvantages. A possible disadvantage of tidal power is the effect a tidal station can have on the plants and animals that live in river estuaries (or river mouths).

Tidal barrages can change the tidal level in tidal basins and increase turbidity or muddiness. Barrages can also make it difficult for boats to navigate the ocean. Similar effects can cause unwanted electricity to be generated from waves.

- The energy from waves alone could support the entire world's electricity needs. The total power contained in breaking waves is estimated to be approximately 2 to 3 million megawatts. In some locations, wave energy density can average 65 megawatts per mile of coastline.
- The Caribbean islands are challenged when it comes to tidal power. The region currently has no tidal plants, and there are only a few sites where tidal energy could be produced economically.

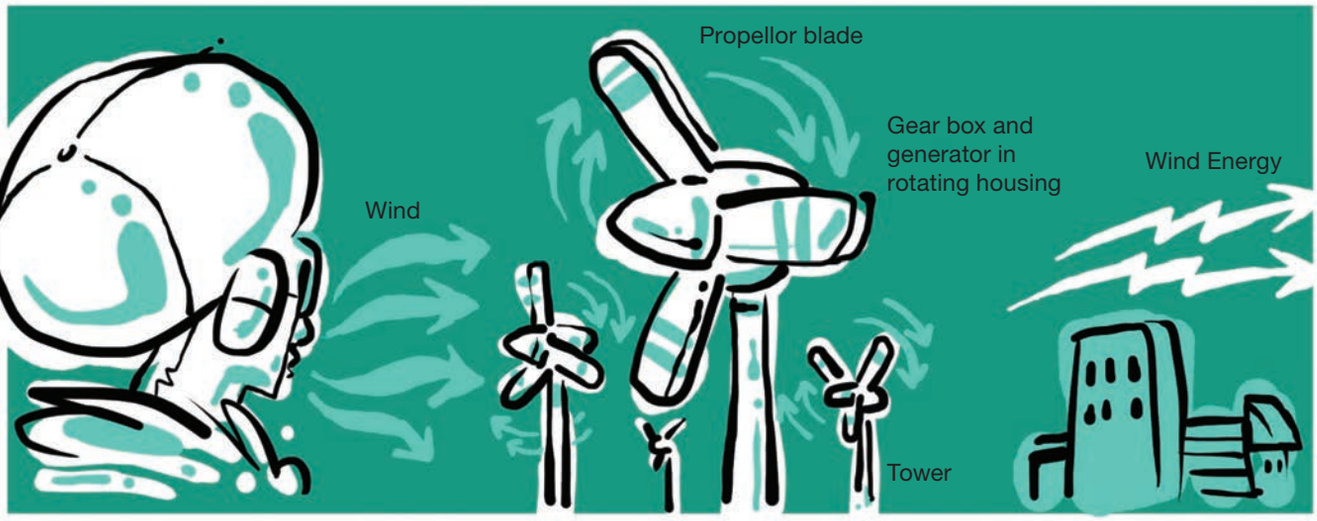
WONDER WINDER

Gender: Female
Age: 29 years old
Size: 1.2 meters-3.9 feet
Characteristics: She is the most important member of the Winders tribe. Her power is to control air, storms, and typhoons. She can change the weather whenever she wants. Her body contains only oxygen, so she is very light and can fly. When she is still, she levitates or floats on air. She wears a wind cap that she can unfold to let out three spinning blades that beat and direct the wind wherever she wants it to go. Her cape is another one of her special gadgets. It can take on aerodynamic forms: smooth shapes that help her go faster!!!

Defining Wind Power

Wind is air in motion. It exists as a result of the uneven heating of the Earth's surface by the sun. During the day, the air above land heats up more quickly than the air over water. The warm air over land expands and rises, and some of the heavier, cooler air rushes in to take its place, creating wind. At night, wind directions are reversed because the air cools more quickly over land than over water. Farmers have been using windmills to harness the energy contained in wind movements for many years. They have used it to perform tasks like pumping water from wells. Today, wind energy is mainly used to generate Earth's most used form of energy. Remember, what it is? Electricity!

Producing Electricity from Wind

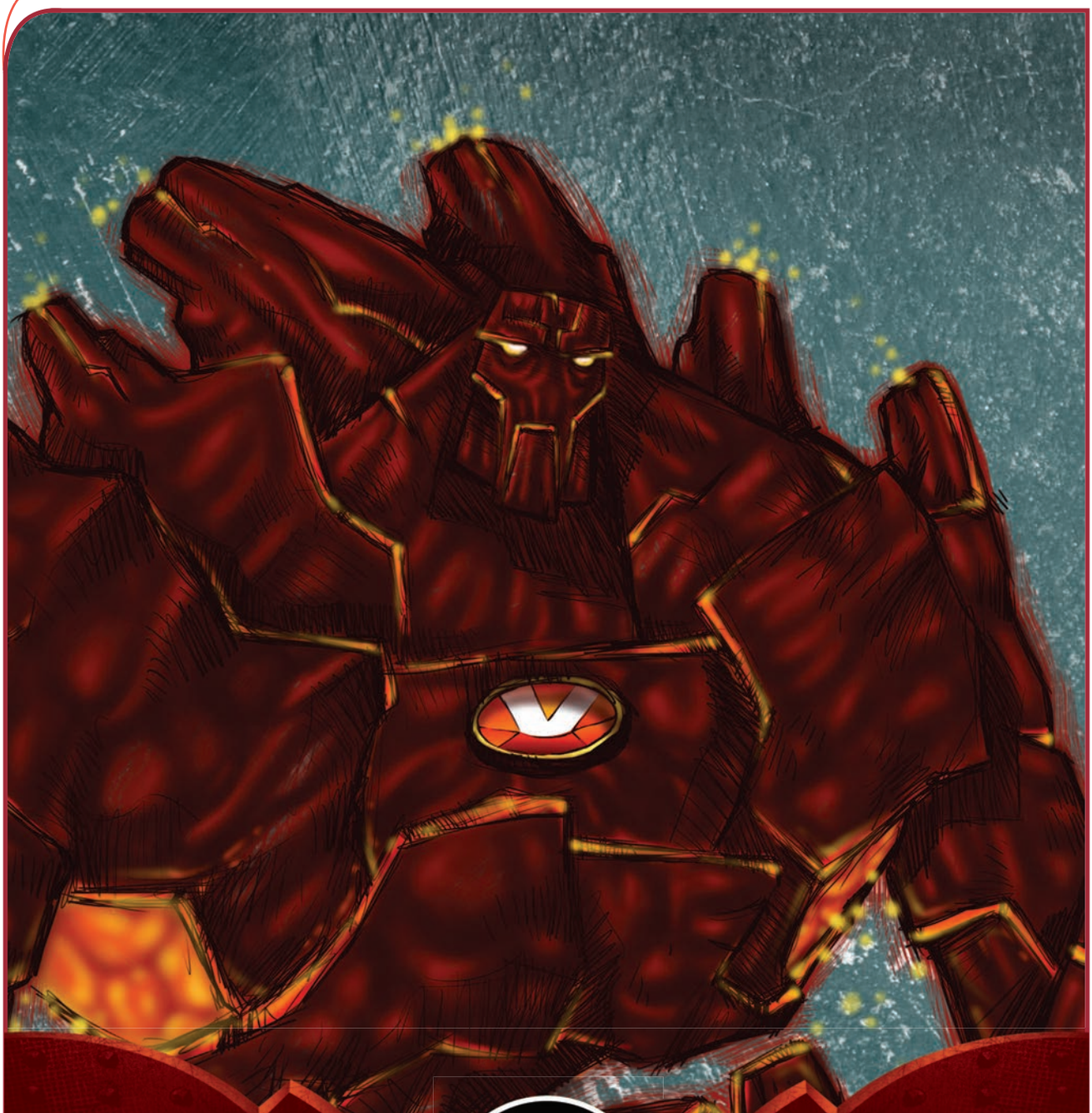


Many wind projects or wind farms such as the Wind Farm at Maddens Estate in Nevis are located on land that can be used to grow crops, graze animals, or grow forests. Remember our discussion about hydropower and reservoirs being located on land that could be used for other purposes? Well, land use is also an issue for wind energy.
Photo: Courtesy of OAS

Advantages and Disadvantages

Wind is a clean source of energy. It causes fewer environmental problems than most other energy sources. Wind turbines, often called windmills, do not (except for a few rare exceptions) release emissions that pollute the air or water. When windmills are used to generate electricity, they reduce the amount of fossil fuel that is burned. When less fossil fuel is burned, there is less air pollution, less carbon dioxide and other greenhouse gases are emitted, and less water (needed in fossil fuel power plants) is used. We can say that windmills have a small environmental footprint (that is, they cause very few environmental problems) relative to the volume of electrical energy they can produce.

- Wind power was used by the earliest civilizations to grind grain, pump water, and power sailboats.
- The Lesser Antilles contain the Windward Islands in the south and the Leeward Islands in the north. The words "windward" and "leeward" are related to the amount of wind each cluster of islands receives Saint Vincent, for instance, has average winds of 16.77 miles per hour, and Saint Lucia has average winds of about 18 miles per hour. Both Saint Vincent and Saint Lucia are members of the Windward Islands.
- Historically, windmills have been used in the Caribbean since the 1900s. They were prominent pieces of equipment in the sugar industry. For example, the Dutch windmill was the industry standard for over 200 years. Because of the Caribbean's trade winds, windmills were fast, powerful, and reliable.
- The world's largest wind farm is the Horse Hollow Wind Energy Center in Texas. It has 421 wind turbines. They generate enough electricity to power 230 000 homes per year.



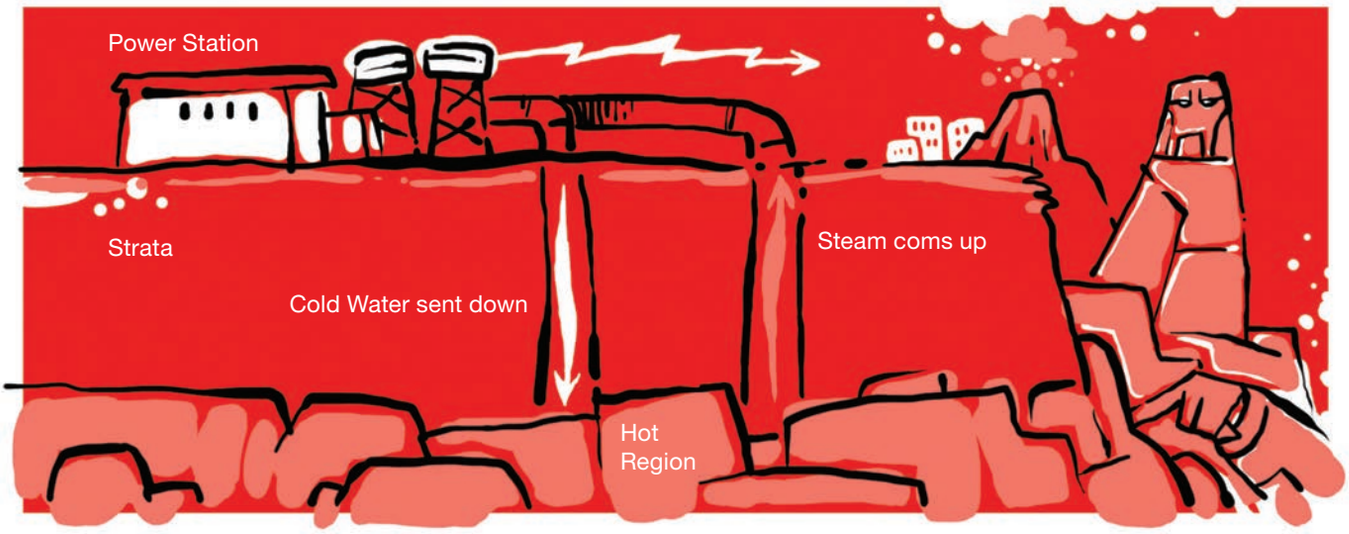
VOLKANO

Gender: Male
Age: 40 years old
Size: 2.6 meters-9 feet
Characteristics: There are two very different stories about Volkano. The first says he was born in Energia's core and only came out when a huge volcanic eruption threw him into the sea. The seawater made his skin solid, but could never quite manage to put out his internal fire. The second is the more popular story. It says that he was once an important scientist who studied volcanoes and was working hard to develop a special substance that would stop them from erupting. One day, during one of his experiments, Volkano was thrown into his own mystery substance. The substance was very hot and had lots of strange scientific properties. It transformed Volkano into the magma-dripping, rocky being that we see before us. This new Volkano gets angry easily. Be careful! He can shoot lava balls out of his mouth at high speed. He also carries mini volcanoes on his shoulders. Those volcanoes are not only symbols of his past; they allow him to fly thanks to the propelling force of volcanic combustion.

Defining Geothermal

Just like on Energia, geothermal energy on Earth comes from deep inside our planet. Slowly decaying radioactive particles within rocks inside the Earth are constantly producing temperatures that are even hotter than the sun's surface. When the substance that produces this heat – magma – comes out of the Earth's core, we can recover its heat energy as steam or hot water.

Producing Electricity from Geothermal Sources



Geothermal Plant in Bouillantes, Guadeloupe. Photo: Courtesy of Egis International (copyrighted)

Advantages and Disadvantages

Geothermal energy is often used to heat homes and produce electricity. In order to generate electricity using geothermal energy, we must dig deep wells to reach the hot underground water or steam and pump it to the surface.

Because no fuel is needed, no pollution is produced when geothermal energy is used, so this source of energy does not contribute to the greenhouse effect or global warming. In fact, once a geothermal power station has been built, the energy is almost free. The plant may use some energy to run its pump, but the volume used is negligible (hardly any) and can be taken from the energy that the plant is producing.

- Geothermal energy can be found in underground reservoirs or on/near the Earth's surface in the form of volcanoes, hot springs, and geysers (springs that shoot water and steam).
- Guadeloupe is the only Caribbean island that produces electricity using geothermal energy. The governments of Saint Kitts and Nevis and Dominica have similar projects underway.
- There are at least five other Caribbean islands that are located in areas with solid potential for harnessing geothermal power. They are Saba, Grenada, Saint Lucia, Saint Vincent and Martinique.
- Geothermal energy is Iceland's primary source of energy.

BIOTYFUEL

Gender: Female
Age: 25 years old
Size: 1.3 meters-4.3 feet

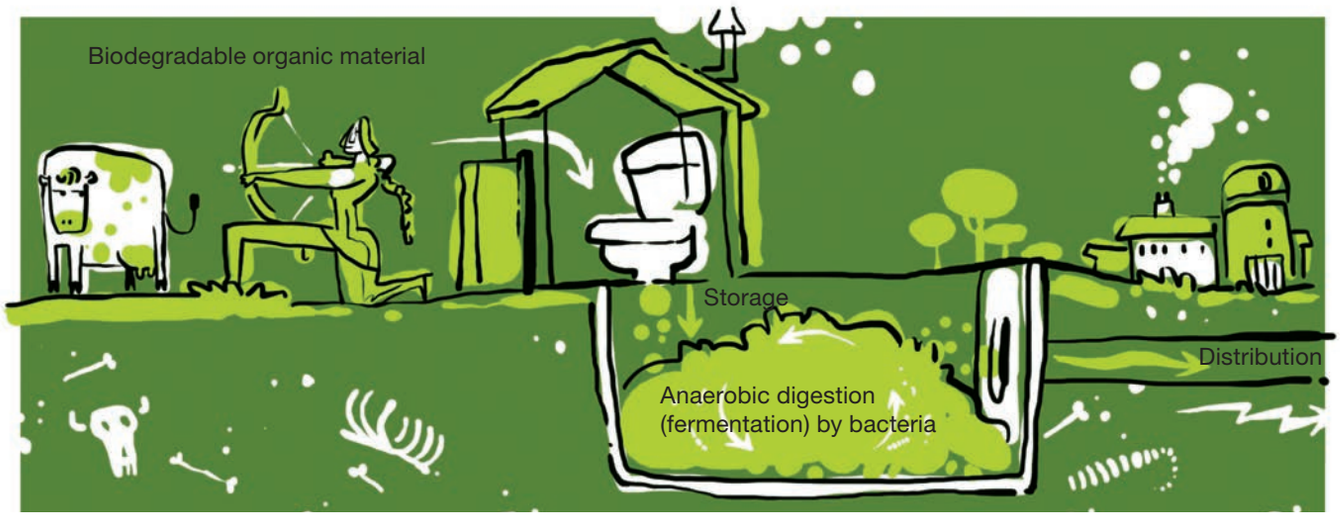
Characteristics: She is an exceptional huntress, who can communicate with animals and plants. She enjoys being at one with nature, and over the years, she has come to know it inside out, often using natural resources to generate energy as she pleases. Armed with her Byo-Arch and Byonic Arrows, she is a powerful partner in war. She loves company, but is very shy and is not seen often. There is no one whose company she enjoys more than her family, but her love for them is so deep that she keeps them hidden in a secret American forest where they wait for the end of the Energy War. Don't worry about Biotyfuel being left out in the open: she is able to transform into any animal or plant she wants. She does this to confuse her enemies and keep herself safe.

Defining Biomass

When plants photosynthesize, they convert energy from the sun into chemical energy, which they store as glucose (or sugar). Green leafy plants that are able to do this can be used as biomass fuels. When burned, the chemical energy in biomass is released as heat. Some examples of biomass fuels are wood, crops, manure, and certain items of garbage. Wood waste and garbage can be burned to produce steam for making electricity, or to provide heat to buildings like our homes and businesses.

Burning biomass is not the only way to release its energy. Biomass can be converted to other useable forms of energy. It can be converted into transportation fuels like ethanol and biodiesel, or methane gas, which is given off by rotting garbage and agricultural and human waste.

Producing Electricity from Biomass Sources



In some countries, wood and charcoal are used to for cooking and to provide heat to homes. When societies rely on wood as an energy source, they often cut trees down faster than they can be grown back. This is called deforestation and it is bad for the environment.
Photo: Courtesy of Egis International (copyrighted)

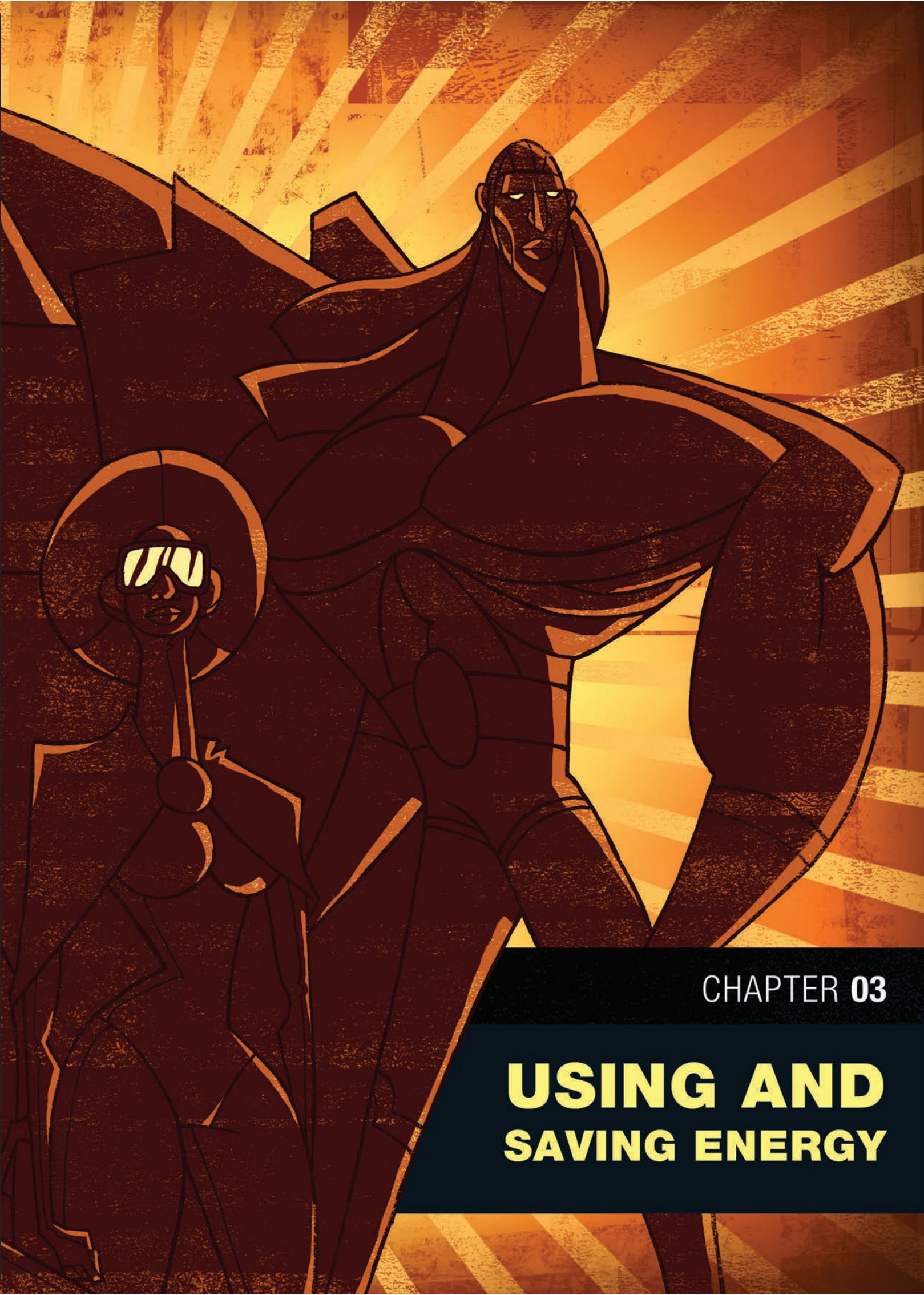
Advantages and Disadvantages

Biomass is definitely a renewable energy source: we can always grow more trees and crops, so we will always have waste to use as biomass. Still, as we have seen with other renewable energy sources (do you remember what they are?) using biomass for energy has both advantages and disadvantages.

Burning biomass could either reduce air pollution or increase it. The effect depends on the type of biomass that is burned (some types produce more air pollution than others) and the type of fuel or energy source biomass replaces. For example, burning biomass produces less air pollution than burning fossil fuels like oil and coal, but may not produce less air pollution than using natural gas.

When learning about biomass, we must also consider how getting materials to use as biomass affects the environment. In some parts of the world, large forests are destroyed so that the land can be used to grow sugar cane for ethanol production, and soybeans and palm-oil trees to make biodiesel.

- Biomass energy is being used in some parts of the Caribbean to produce cooking gas. The smaller Caribbean islands, however, do not produce enough waste to make biomass energy economical.
- The word „biomass" means natural material.
- Biomass has been around since the beginning of time when man burned wood to cook and produce heat.



CHAPTER **03**

USING AND SAVING ENERGY

Using Energy

We use a lot of energy in our homes, businesses, industries, and for personal travel and transportation of goods.

Home Use

Our homes are comfortable because we use energy to power our domestic worlds. Energy supports our lighting systems, powers the instruments we use to conserve our food, and allows us to take relaxing showers, perhaps even in warm water. The ability to cool and heat our homes is yet another gift Earthling scientists have given us through modern technology. Despite our pride in our society's technological advances, we must keep in mind that it takes a lot of energy to make a comfortable modern home. That's why our friends the energy masters are here! They can teach us to save energy!

Commercial Use

Offices, hospitals, schools, police stations, churches and other places of worship, warehouses, hotels, shopping malls and other commercial buildings use more than half of the total energy they consume (most commonly provided by electricity and natural gas) to power their heating and cooling systems.

Industrial Use

A number of different sources of energy are put to many different uses in the industrial sector. One main use for energy is as boiler fuel. Boiler fuel produces heat. This is used to heat a boiler vessel. The heat is transferred to the contents of the boiler (most often water) and steam or hot water is produced. Energy is also used in what is referred to in the industries as "process heating", which is when energy is used directly to raise the temperature of certain products during the manufacturing process. For example, the temperature of crude oil must be raised in order to separate its components in the process by which petroleum is refined. The same goes for drying paint in automobile manufacturing and cooking packaged foods.

For Transportation

Our transportation systems here on Earth rely heavily on gasoline, which is used mainly to power cars, motorcycles, and light-weight trucks. We also use diesel fuel, which powers heavier trucks, buses, and trains. With recent technological advances, the automobile industry is now producing a class of vehicles that run on electricity, natural gas, propane and/or ethanol. These special vehicles, called hybrid-electric vehicles, combine the benefits (the mechanics) of gasoline engines and electric motors. By so doing, they reduce the amount of fuel required for a vehicle to move.

Did you know??

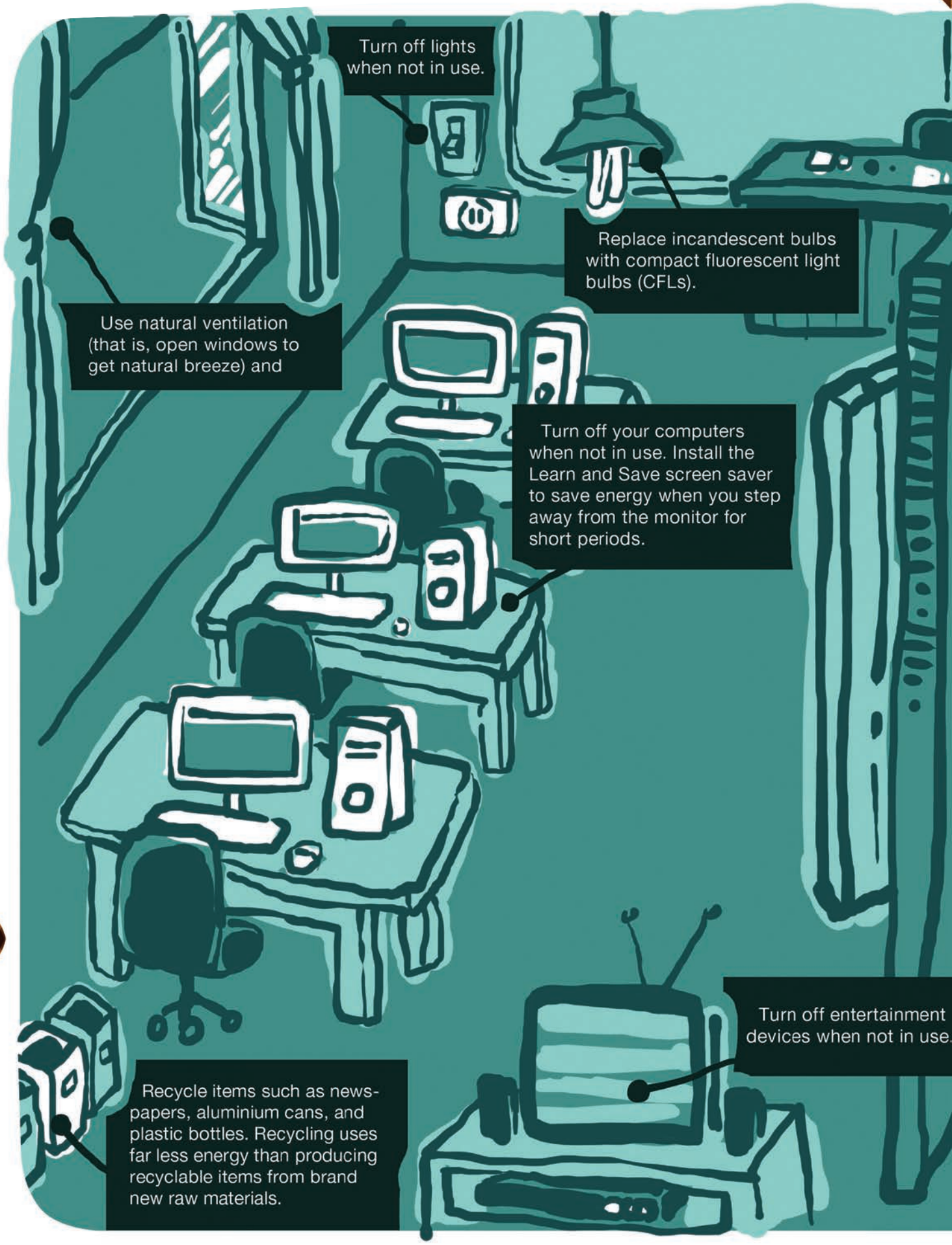
- Almost half of the total electricity that is delivered to each Caribbean nation is consumed by the domestic sector. The commercial sector comes in at a close second, followed by the industries, and then street lighting.
- Energy saving light bulbs use technology that enables them to produce a highly efficient and compact light with only a fraction of the energy used by other light bulbs.
- Energy efficient appliances use less power and are cheaper to run. Because they need less energy, they're responsible for fewer greenhouse gas emissions back at the power station – good news for the environment!
- An energy efficient washing machine uses a third of the energy of an old, inefficient model. It also uses a lot less water.

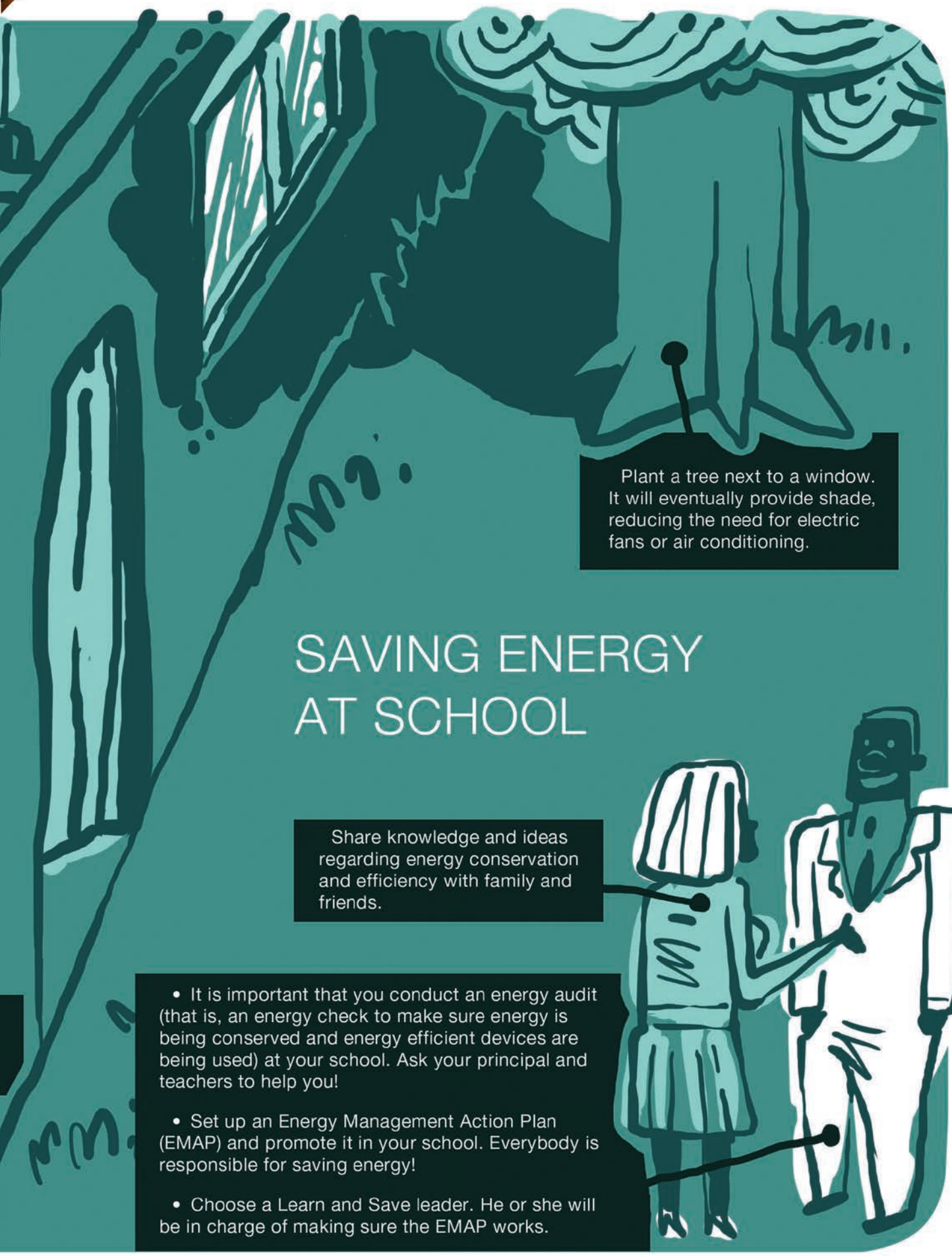
Energy Efficiency and Conservation

The terms energy conservation and energy efficiency have two distinct definitions. There are many simple things we can do to use less energy, or conserve, just as there are a variety of technologies to help us manage the energy we must consume more wisely, or efficiently.

Energy conservation is any behaviour that results in the use of less energy. Turning lights off when you leave the room and recycling aluminium cans are both ways of conserving energy. You will find some more easy energy saving tips from the energy masters as you read on.

Energy efficiency is the use of a device that requires less energy to perform the same function as another (less efficient) device. Can you think of any examples? How about the light bulbs in your house? Some light bulbs are more energy efficient than others. A compact fluorescent light bulb produces the same amount of light as an incandescent ("regular") light bulb, but the fluorescent uses less energy. To remember the difference between energy efficiency and energy conservation, note that while a fluorescent bulb is itself energy efficient (because it is a device that uses less energy), the decision to replace an incandescent light bulb with a compact fluorescent one is an act of energy conservation.


Turn off lights when not in use.
Replace incandescent bulbs with compact fluorescent light bulbs (CFLs).
Use natural ventilation (that is, open windows to get natural breeze) and
Turn off your computers when not in use. Install the Learn and Save screen saver to save energy when you step away from the monitor for short periods.
Turn off entertainment devices when not in use.
Recycle items such as newspapers, aluminium cans, and plastic bottles. Recycling uses far less energy than producing recyclable items from brand new raw materials.

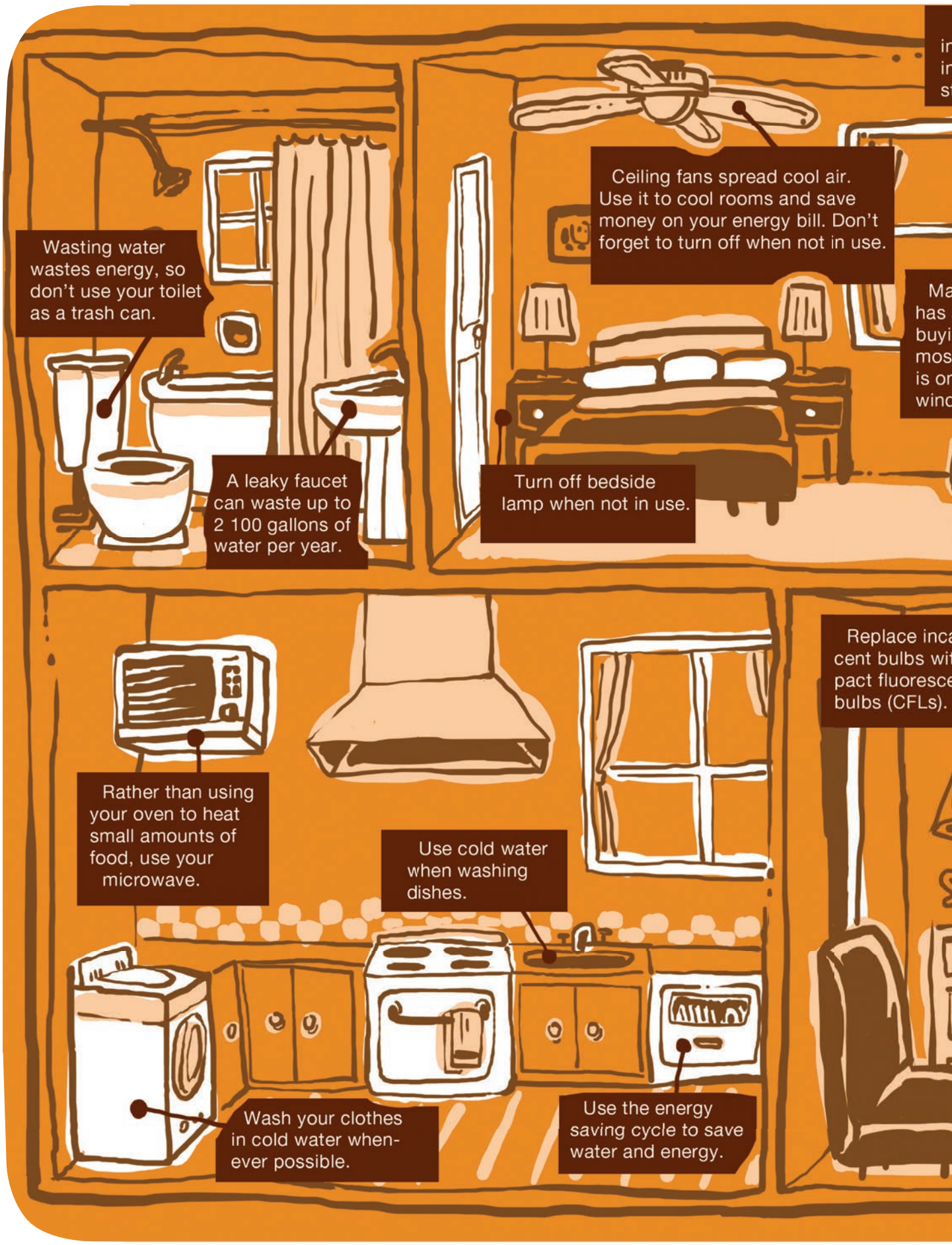


Plant a tree next to a window. It will eventually provide shade, reducing the need for electric fans or air conditioning.

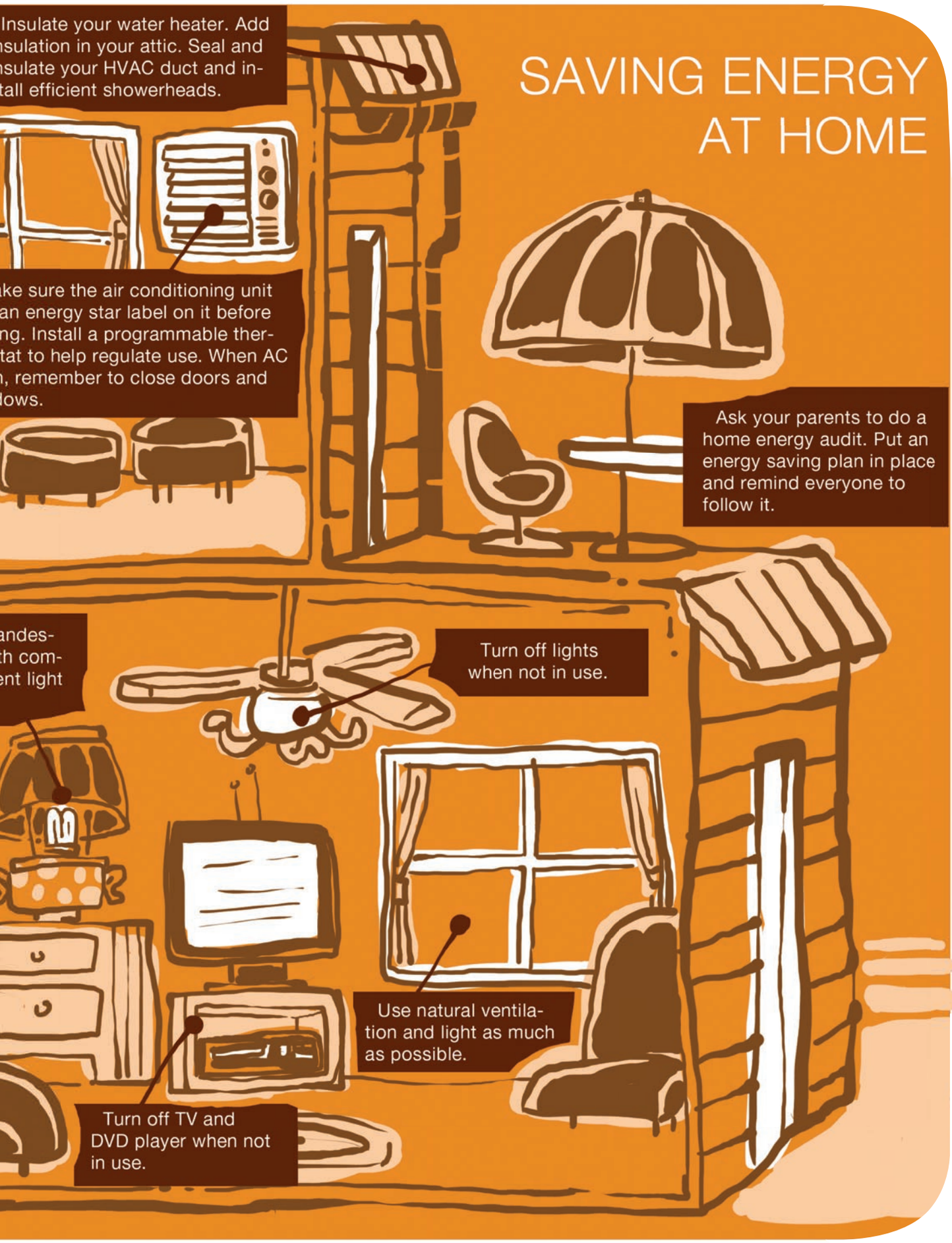
SAVING ENERGY AT SCHOOL

Share knowledge and ideas regarding energy conservation and efficiency with family and friends.

- It is important that you conduct an energy audit (that is, an energy check to make sure energy is being conserved and energy efficient devices are being used) at your school. Ask your principal and teachers to help you!
- Set up an Energy Management Action Plan (EMAP) and promote it in your school. Everybody is responsible for saving energy!
- Choose a Learn and Save leader. He or she will be in charge of making sure the EMAP works.


Wasting water wastes energy, so don't use your toilet as a trash can.
A leaky faucet can waste up to 2 100 gallons of water per year.
Ceiling fans spread cool air. Use it to cool rooms and save money on your energy bill. Don't forget to turn off when not in use.
Turn off bedside lamp when not in use.
Rather than using your oven to heat small amounts of food, use your microwave.
Use cold water when washing dishes.
Wash your clothes in cold water whenever possible.
Use the energy saving cycle to save water and energy.

SAVING ENERGY AT HOME



CHAPTER **04**

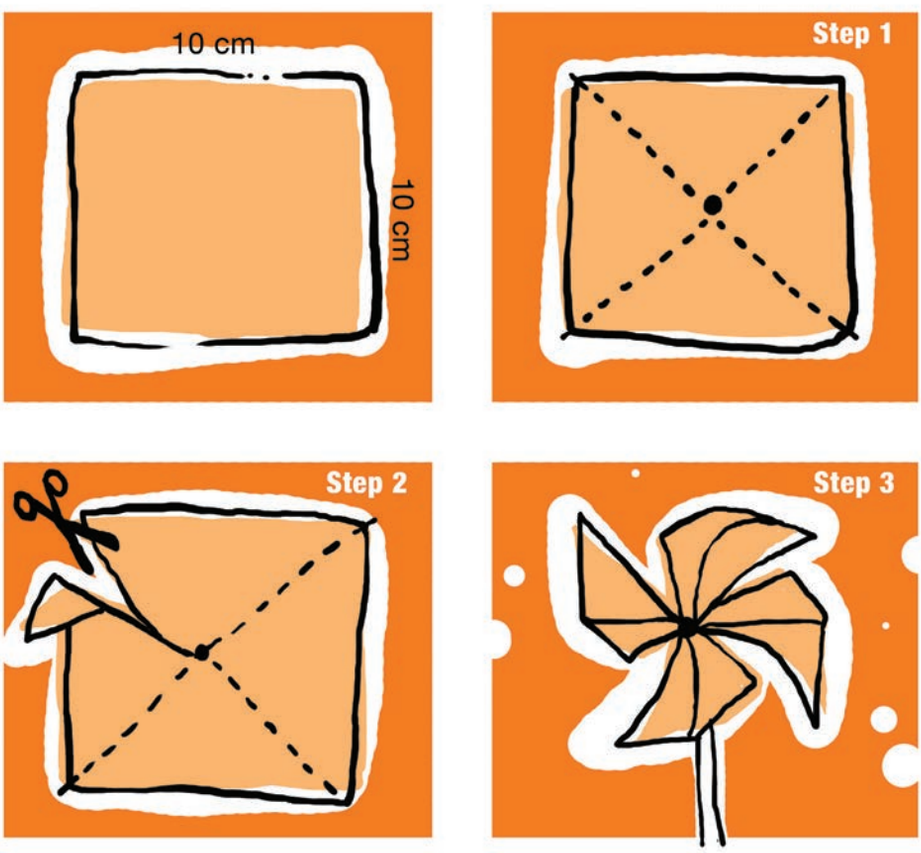
ENERGY ACTIVITIES

How to make Wind Power

Materials
- A number of 10 cm card squares
- Wire
- Pins
- Wood scraps

Procedure (see diagram)
- Take the 10 cm card squares and draw diagonal lines on them. Mark five holes using a pin *note that a space was added here between pin and the dash* – one in each corner and one in the centre.
- Cut along the diagonal lines almost to the centre of the card.
- Bring the corners of the windmill to the centre and drive a hole through them into the wood.

Follow-up
Experiment with different sizes and angles of "sail" using different sizes of cut squares to make the windmill.



PLAY

Based on the characteristics of the Energy Masters and the following situation, stage your own play in your classroom.

Given situation: (note capitalization of "situation"): Sir Oiler, Koal Knight, and Lord Nukleus have been discovered by an extraterrestrial (or alien!) family. The family wants to kidnap the Non-Renewable Energy Masters and use them to get control of energy and power generation on their home planet. The three brothers decide to have a meeting with their friends the Renewable Energy Masters to figure out how to protect themselves…

MAKE A SOLAR COOKER

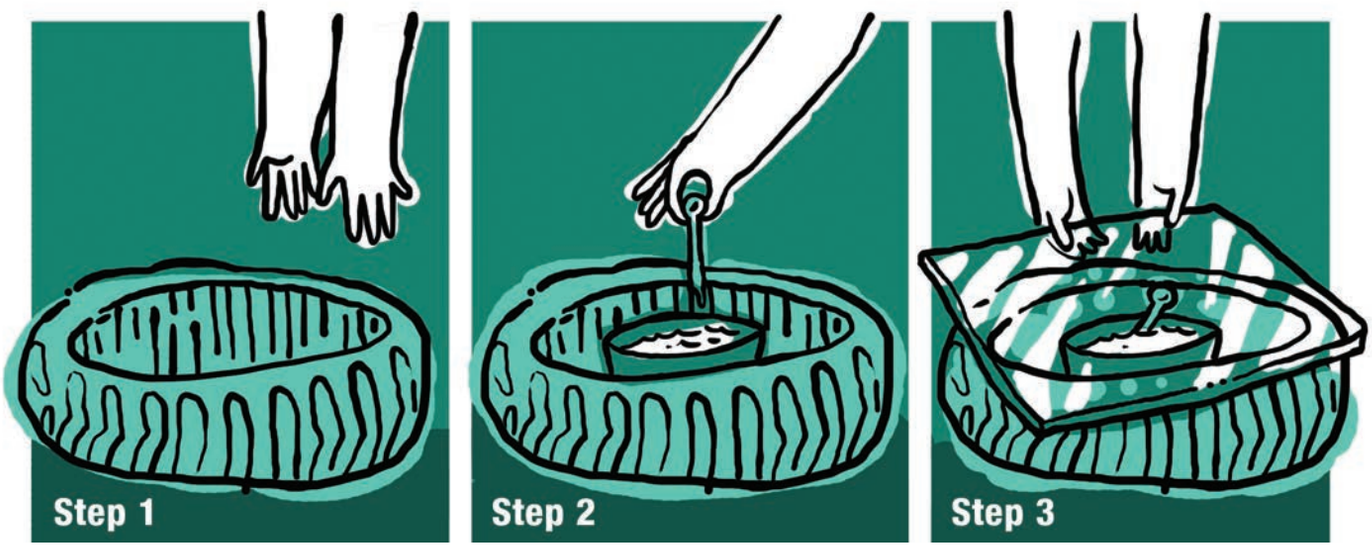
You will need: an old car tire, a sheet of glass, a dish of water, a thermometer.

1. Lay the tire on the ground in a sunny spot.

2. Stand the dish of water inside the tire. Place the thermometer in the water.

3. Cover the tire with the glass. Record the temperature of the water every 2 minutes. How hot does it get?

4. Discuss and test methods for improving your cooker. Heat energy from the sun passes through the glass and heats the air, water and ground inside. The glass helps to trap the heat inside.



PAYING THE BILL

1. Look at these meter readings as examples.

2. Monitor the school's meter reading for one week.

3. What is the reading from Monday to Friday? How many units of electricity were used during the five day period?

4. If each unit of electricity costs 70 cents, how much will the school have to pay for a week's worth of electricity?

5. Do the same in your home.

INDEX

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LEARN & SAVE

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