Comparing fuels and energy resources (Key Stage 3)

INTRODUCTION

As populations increase, so demand for power grows globally. Continued use of fossil fuels is contributing to a rise in greenhouse gases and, in turn, to global warming. In 2018, unusually high and low temperatures globally, caused people to use more power than ever in attempts to cool or heat their homes.

This lesson introduces the concepts of non renewable fossil fuels and a range of renewable energy resources, in order that children can begin making comparisons between the environmental impacts of different types of energy resources.

Links to National Curriculum

- consider the nature and origin of fossil fuels and renewable sources of energy and how their use has implications for the environment (KS3 Science Unit 7I - Energy resources)

Cross curricular links to:

- KS3 Geography - understand how human and physical processes interact to influence, and change landscapes, environments and the climate; and how human activity relies on effective functioning of natural systems
- Citizenship Education - regarding geopolitical issues around location of fossil fuel

Key Learning Objectives

1) What are fossil fuels?

2) What are renewable energy resources?

3) What are the advantages and disadvantages of the different energy resources?

Notes to Teachers

- These teaching notes run alongside a Powerpoint presentation and all slides are referred to in the notes. The information can be adapted to suit different ages of students by adding/deleting slides on the presentation and varying the level of detail used from the teacher notes.
- Activities given are suggestions only. The main purpose of these resources is to provide key information and visual aids for teachers to adapt to their needs.

Key Vocabulary (in alphabetical order)

biofuel / biomass A type of fuel derived from plant or animal waste material e.g. bioethanol made from sugar cane.

carbon footprint The amount of carbon dioxide people produce in their daily lives.

carbon dioxide A greenhouse gas produced when fuel is burnt.

climate change A phenomenon whereby the Earth's climate warms or cools over long periods of time.

coal A solid fuel made over millions of years from fossilised plants

crude oil A black, viscous liquid formed over millions of years from the remains of fossilised plants and animals.

finite resources Resources that cannot be replaced when they are used up. They are no longer being made, or are being made extremely slowly.

fossil fuels Fuels formed over millions of years deep in the Earth from the remains of dead plants and animals.

geothermal energy Energy derived from the heat found under the Earth in volcanic regions.

global warming A gradual rise in average temperatures over all the Earth's surface.

hydroelectric power Energy obtained from using the power of water that has been held behind a dam.

natural gas A gas that occurs naturally under the sea and land, consisting primarily of methane, but mixed with some alkanes, and sometimes a small percentage of carbon dioxide, nitrogen, hydrogen sulfide, or helium. When

extracted from underground, it can be used for heating, cooking, etc..

National Grid Connects power stations and everywhere electricity is needed in a network

non-renewable resources Resources that can only be used once and will eventually run out, e.g. coal, oil, natural gas.

nuclear power Uses the vast amounts of heat produced by splitting the nuclei of uranium atoms to generate electricity.

pollutant A harmful substance emitted into the air, water or soil.

renewable energy An energy source that will not run out e.g. wind, solar and tidal energy.

solar power Renewable energy that you can get from the sun. Comes in two forms: photovoltaic (electricity from sunlight) and solar heating.

sulphur dioxide A polluting gas which produces acid rain.

tidal energy Power generated by harnessing the movement of seawater caused by tides.

wave energy Power generated using the energy created by waves in the ocean.

1) What are fossil fuels?

Students should learn:
- that coal, mineral oil and natural gas are examples of fossil fuels, which are formed from organic materials over many millions of years.
- that as such, they are effectively non-renewable.
- about the need for fuel conservation

SUGGESTED STARTER ACTIVITY

Slide 3: Invite students to share examples of devices in their homes / the wider community that require energy/power in order to run. Where does this energy come from? Students may already be familiar with gas from home cooking or heating and with oil in heaters or as it relates to petrol. Is anyone able to explain where their electricity comes from?

Invite discussion of the term fossil. How might this link to the idea of energy?

You might like to watch YPTE's video on How Electricity Is Made
https://ypte.org.uk/videos/how-is-electricity-made

TEACHING INPUT

Slide 4: Coal, **crude oil** and **gas** are called "**fossil fuels**" because they have been formed from the fossilised organic remains of prehistoric plants and animals. For more than a century, burning fossil fuels has generated most of the energy used to power our cars, homes and businesses Even today, oil, coal, and gas provide for about 80% of the world's energy needs.

Slides 5 & 6: Coal is made over millions of years from fossilised plants that are crushed underground at huge pressures and high temperatures. This forms a solid material that is mined from the ground. Coal is considered a **finite** or **non renewable** resource as it has taken so many millions of years to form and cannot be replaced once it is used up. Very large amounts of electricity can be generated in a power station using coal. But burning coal produces more carbon dioxide (a greenhouse gas) than burning gas or oil.

Slide 7: Natural gas is easy to transport along pipes, and gas power stations produce less pollution and roughly half the carbon dioxide produced by burning coal. It has been used in China for thousands of years to heat water and was first used in England for lighting street lamps and, occasionally, houses. Nowadays, gas is used in numerous ways. Global consumption of natural gas rose by 195 billion cubic metres (bcm), or 5.3% in 2018, one of the fastest rates of growth since 1984, accounting for almost 45% of the entire

growth in global energy consumption.

Slide 8: As well as being burned in power stations, natural gas is used by many people to heat their homes. Natural gas currently provides more than 80% of our heating needs and around 30% of our electricity generation. Most of the UK's gas comes from the North Sea, but, with supplies expected to decline significantly, by 2030 the UK will be buying at least 70% of its gas from outside the UK.

Slide 9: Crude oil (called "petroleum") is made from fossilised animal and plant remains. It is easier to get out of the ground than coal, as it can flow along pipes. This also makes it cheaper to transport. Oil is generally drilled from the ground, on land or at sea. Once extracted, the oil is transported to refineries by tankers, trucks or pipelines to refineries, where it can be transformed into usable fuels such as petrol, diesel and jet fuel as well as products such as plastic or paint.

Slide 10: Discussion: How many vehicles can the students think of that are required in their communities? Think about the cars or coaches they travel in to school, ambulances, delivery lorries or fire engines. How are these powered? What might be alternatives to using so much oil in vehicles? (Travelling by bicycle or on foot, using electric vehicles etc)

Slide 11: A 2018 report by BP predicted that we have about 50 years worth left of oil if we keep using it at the same rate that we do currently. This is considered by some people to be a very optimistic prediction and it doesn't take any increase in global population (and therefore increased demand for oil) into account. Nor does it consider that we need to leave oil in the ground in order to avoid catastrophic climate change. At the moment, we rely on oil for the production or transportation of almost every product we use today, from food and medicines to computers and phones.

Slide 12: As well as producing greenhouse gases and other emissions when burned, oil can have devastating effects on the environment when it spills during transit due to an accident. Oil damages the fur and feathers or marine life, so that animals and birds can no longer keep themselves warm. It also poisons the creatures as they try to clean themselves. Depending where the spill happens, it can kill thousands or animals, as well as polluting the waterways.

Slide 13 & 14: Most of the UKs electricity comes from burning fossil fuels. In a power station, coal is crushed to a fine dust and burnt. Oil and gas can be

burnt directly. The burning fuel is used to heat a large volume of water to produce steam. The steam flows at pressure to turn a turbine, a bit like a large propeller. The turbine spins at high speed - up to 3,000 revolutions per minute - and is used to spin a large magnet inside massive coils of copper wire. This generates a flow of electrons, through the copper wire, which is the electricity we use in our homes, schools, etc.
The steam that has passed through the power station's turbines has to be cooled, to condense it back into water before it can be pumped round again. This is what happens in the huge "cooling towers" seen at power stations.

Slide 15: Burning fossil fuels causes pollution as gases, such as carbon monoxide, are released into the atmosphere. Burning coal produces **sulphur dioxide**, an acidic gas that contributes to the formation of acid rain. Fossil fuels also produce **carbon dioxide** when they burn. In 2018, global carbon emissions rose at their highest rate for 7 years and reached a new record level. Increasing carbon emissions in the atmosphere have been shown to cause **global warming**, which is speeding up climate change.

Slide 16: Nuclear power is generated using fuels such as uranium or plutonium, which are metals mined in various parts of the world. Nuclear power produces huge amounts of energy from small amounts of fuel, without the pollution that you'd get from burning fossil fuels. Nuclear power is reliable, but a lot of money has to be spent on safety - if it does go wrong, a nuclear accident can be a major disaster. The nuclear reaction created in a nuclear power station is still used to heat water to create steam, which is used to spin the magnet inside a generator to create electricity. Uranium is not technically a renewable resource as once all of it is mined, there will be no more. (Students may enjoy the stretch challenge of learning about the use of fast breeder reactors to convert uranium into other nuclear fuels!)

2) What are renewable energy resources?

Students should learn
- that renewable energy resources include wind, waves, running water, sunlight, biomass and some geothermal sources

SUGGESTED ACTIVITY

Explain that the students will now find out about a range of renewable resources and that they will need to consider the pros and cons of each. Provide students with a copy of the pros and cons sheet (below) and complete the section for fossil fuels together, based on learning so far. Model note taking for efficiency.

You could also watch YPTE's video on renewable energy
https://ypte.org.uk/videos/renewable-energy

TEACHING INPUT

Slide 17: A renewable resource is a natural resource that can be replenished within a human lifetime, not over millions of years. An example is wood which can be replanted, or wave power which is naturally occurring without depletion.

Side 18: Deep underground, the Earth's rocks are naturally very hot. We can turn their heat energy into electrical energy to use in our homes – we call this **geothermal energy**. It is a very clean way to produce electricity, with fewer carbon dioxide emissions than natural gas (although it can release hydrogen sulfide, which smells a bit like rotten eggs!) Unlike wind or solar power, it is also available every day of the year. However, it is usually expensive to drill down and there are only limited areas where it is possible to carry out the process.

Slide 19: In Iceland, many of the buildings and even swimming pools are heated with geothermal hot water. Iceland has at least 25 active volcanoes and many hot springs and geysers. This makes geothermal energy a sensible option.

Slide 20: Solar energy - Even though it is 93 million miles away, the sun is the primary source of energy for all life on earth! Energy from the sun can be transferred into electrical energy using solar cells. Solar panels can be used to heat water in homes and provide electricity. Surplus electricity can even be sold back to the **National Grid**.

Slide 21: Solar power was originally developed in order to provide electricity for satellites, but these days many of us own products powered by solar (photovoltaic) cells, from calculators to garden lights. These are different from solar thermal panels, which use energy from the Sun to heat up water. Both may be put onto house roofs so that they can absorb the Sun's energy.

Slide 22: Solar power is useful in places that receive a lot of daylight and can be used in many remote locations that don't have access to other forms of electricity (off-grid). Solar power is also sometimes used to power traffic signs. These often have speed detectors built into them so they only come on when drivers approach them, wasting even less energy.

Slide 23: Photovoltaic (PV) solar panels are now a common site on homes and there are also much larger 'solar farms', huge fields of PV panels, generating significant amounts of electricity here in the UK. In fact, renewables are predicted to have produced more electricity than fossil fuels in the UK for the first time in 2019.

Slide 24: As well as those featuring PV panels, which can convert sunlight straight to useable electricity, there are also types of solar power plants which focus or collect heat from the sun to generate steam to feed a turbine and generate electricity.

The longest operating solar thermal plant in the world, the Solar Energy Generating Systems (SEGS) in the Mojave Desert, California (pictured right), uses curved (parabolic) solar collectors. These focus sunlight onto a receiver tube that runs down their centre. The liquid inside this tube is sent to a heat exchanger to boil water and drive a steam turbine generator. The reflectors move in order to track the sun and their shape allows them to focus between 30 and 100 times normal sunlight levels on to the collector.

Another type of solar power station uses a solar power tower, like this one (left) at the Gemasolar Thermosolar power station in Spain. Here, thousands of mirrors reflect sunlight on to the tower, which heats it up. This focused sunlight is concentrated up to 1,500 times more strongly than direct sunlight alone. Some solar towers use heated air to drive a turbine, but Gemasolar is a station that uses nitrate salts. Cold salt is pumped up to the top of the tower at the central receiver, where it gets heated up. The molten salt is carried back to the hot storage tank where it is stored at 565°C. Salt from the hot storage tank is transferred to the heat exchanger through pipes and condensed to form steam. This steam is used to run the turbine and produce electricity.

Slide 25: Solar thermal panels can also be used to heat water and many houses now use these. Some heat the water directly and others work by transferring heat from the collector to your water tank through a separate circuit and a heat exchanger. The sun shines directly on the panel and heat collected by the panel warms up water (or oil or another fluid) that flows through a circuit of pipes into a copper coil inside your hot-water tank. An immersion heater or boiler can be used to top up the heat if it isn't a warm enough day.

Slide 26: Tidal energy uses the rise and fall of the sea's tides to drive generators and create electricity. This is still quite a new form of power. Unlike weather patterns, the tides are predictable, which makes it easier to know where to build turbines for generating tidal energy.

Slide 27: Turbines can be placed in tidal streams that experience very high and low tides. Alternatively, a dam (called a barrage) can be built. As the tide rises, the water flows in through gates in the dam. These close at low tide and water is allowed to flow out past a turbine.

Slide 28: Although tidal energy does not produce harmful emissions once the equipment is built, the environmental impact of a barrage system can be quite significant. The land in the tidal range is completely disrupted. The change in water level in the tidal lagoon might harm plant and animal life. The salinity (salt content of the water) inside the tidal lagoon lowers, which changes the organisms that are able to live there. As with dams across rivers, fish are blocked from moving into or out of the tidal lagoon. Turbines turn quickly in barrages, and marine animals can be caught in the blades. With their food source limited, birds might find different places to migrate.

Slide 29 - 30: The Sun heats our atmosphere unevenly, so some patches become warmer than others. These warm patches of air rise, other air blows in to replace them - and we feel a wind blowing. We can use the energy in the wind by building a tall tower, with a large propellor on the top. The wind blows the propellor round, which turns a generator to produce electricity
By using wind turbines, the kinetic energy of the wind can be transferred into electrical energy for use in homes or businesses. This is called **wind energy**. The turbines are not particularly expensive to build. However, they can be quite noisy and some people believe they are ugly. They are also only effective if the wind is blowing!

Slide 31 - 32: Hydroelectric energy is produced when a dam is built to trap water, usually in a valley where there is an existing lake. Water is allowed to flow at speed through tunnels in the dam, to turn turbines which, in turn, drive generators. The flow of water can be very fast, so can produce a lot of energy, but the building of the dams causes damage to plants and wildlife in the surrounding area.

Slide 33: Many people argue that the harm done to ecosystems by dams far outweighs the benefits of the hydropower that they create. Building dams displaces people who live in communities near rivers as well as drastically altering the natural environment. Many species are affected by the diversion of rivers, or the building of large dams. Europe now has only one remaining undammed river, the Vjosa river, which is in Albania. 38 dams are currently planned for this river.

Slide 34: Ocean waves are caused by the wind as it blows across the sea. Waves are a powerful source of energy, and they are very predictable, which makes it easy to predict how much power can be produced. There are many different types of machines that can be used to harness **wave energy**.

Slide 35: The problem is that it's not easy to harness this energy and convert it into electricity in large amounts. Machines are needed where the waves from the sea turn turbines, which then turn generators to produce electricity. It takes a lot of machines to produce much electricity and the machines are expensive and can get damaged by storms.

Slide 36: Wave farms can have an impact on local fishing, which is unpopular with people who fish for a living. The noise of some of the machines may also disrupt signals sent by whales to communicate with each other and find food.

Slide 37: Biomass or **biofuel** is biomaterial from living or recently living organisms such as wood, agricultural waste and animal manure. One way to use biomass is to burn it directly, using the heat to turn water to steam, then sending it through a steam turbine, which generates electricity. It can also be turned into burnable gas.

Slide 38: During photosynthesis, energy from the sun is absorbed by plants. This is then stored inside the plant or tree as chemical potential energy. When we burn wood, or other biofuel, we turn this energy into heat. Ethanol is made from crops such as corn and sugarcane that are fermented to produce fuel ethanol for use in vehicles. Biodiesel is produced from vegetable oils and animal fats and can be used in vehicles and as heating oil.

This Biomass energy is a renewable energy as long as we continue to plant trees to replace those we burn.

Slide 39: Burning wood and other natural materials still releases a lot of polluting gases. In fact, for an equal amount of heat or electricity, burning wood releases more carbon dioxide than gas, oil or even coal. However, burning wood is considered to be carbon neutral - as the trees have removed carbon dioxide from the air all the time until they are cut down. It is this same carbon dioxide that is released back into the air as they burn. There is also the risk that a desire for more and more wood to burn could lead to deforestation and a loss of habitats for wildlife.

Slide 40: One of the problems with some renewable energy resources, such as wind or solar power, is that they are dependent on the right weather conditions in order to work. When it is very windy, or sunny, these methods may generate a lot of power. Some companies have started to investigate the use of huge batteries which can be charged up by the energy resource when it is creating a surplus, then can store the energy to be used later at a time of higher demand. Information about just such a battery, built by TESLA, at the Hornsdale Wind Farm, Mid-North South Australia, can be found here: https://ypte.org.uk/news/world-s-largest-lithium-ion-battery-goes-on-grid-in-australia
At the moment, this technology is mainly being implemented by large power stations, but it's also starting to be trialled in people's homes in sunny places such as Australia and South Africa. Here, batteries store energy from home solar PV cells which are linked together with others in a community. Spare energy can also be sold back to the National Grid. In future, this technology could be used in people's homes here in the UK. Energy company Scottish Power has announced plans to install large-scale batteries at some of its wind farms in Scotland.

SUGGESTED ACTIVITIES

Slide 41 - 42: The following activities are designed to give students many opportunities for discussion in order to help them form ideas and opinions about the pros and cons of the different energy resources.

Using the completed advantages and disadvantages sheet as a starting point, discuss students' ideas and combine these to ensure everyone has a range of viewpoints to draw from.

3) What are the advantages and disadvantages of the different energy resources?

Students should learn

- to relate use of energy resources to effects on the environment

Role play debate

Introduce the use of role playing cards (below). Complete what each character is thinking and saying. Use the cards to support students with taking on different characters in a class debate on energy resources. Examples could include scientists from a range of different specialisms, a person protesting about the effects of dams on local wildlife, a villager anxious about unsightly wind turbines blocking their view, a parent of a child with asthma.

Energy resources top trumps (see templates on pages 11-13)

Students could create a set of energy resource 'top trump' cards for use by a younger pupil, or as a quick revision aid. Cards could show positive and negative aspects of each energy resource, such as whether they are expensive to build, reliant on certain weather conditions or whether they have negative impacts on local wildlife.

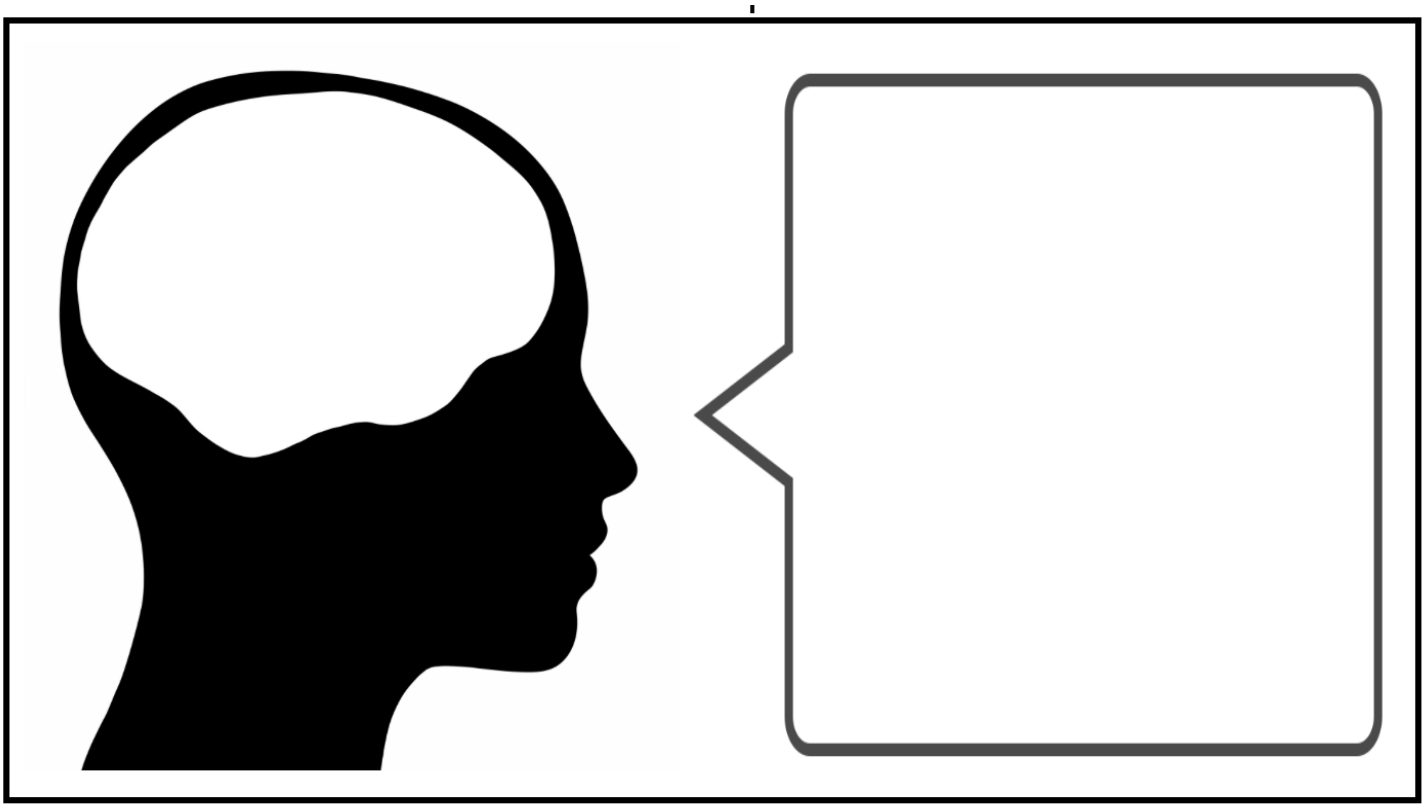
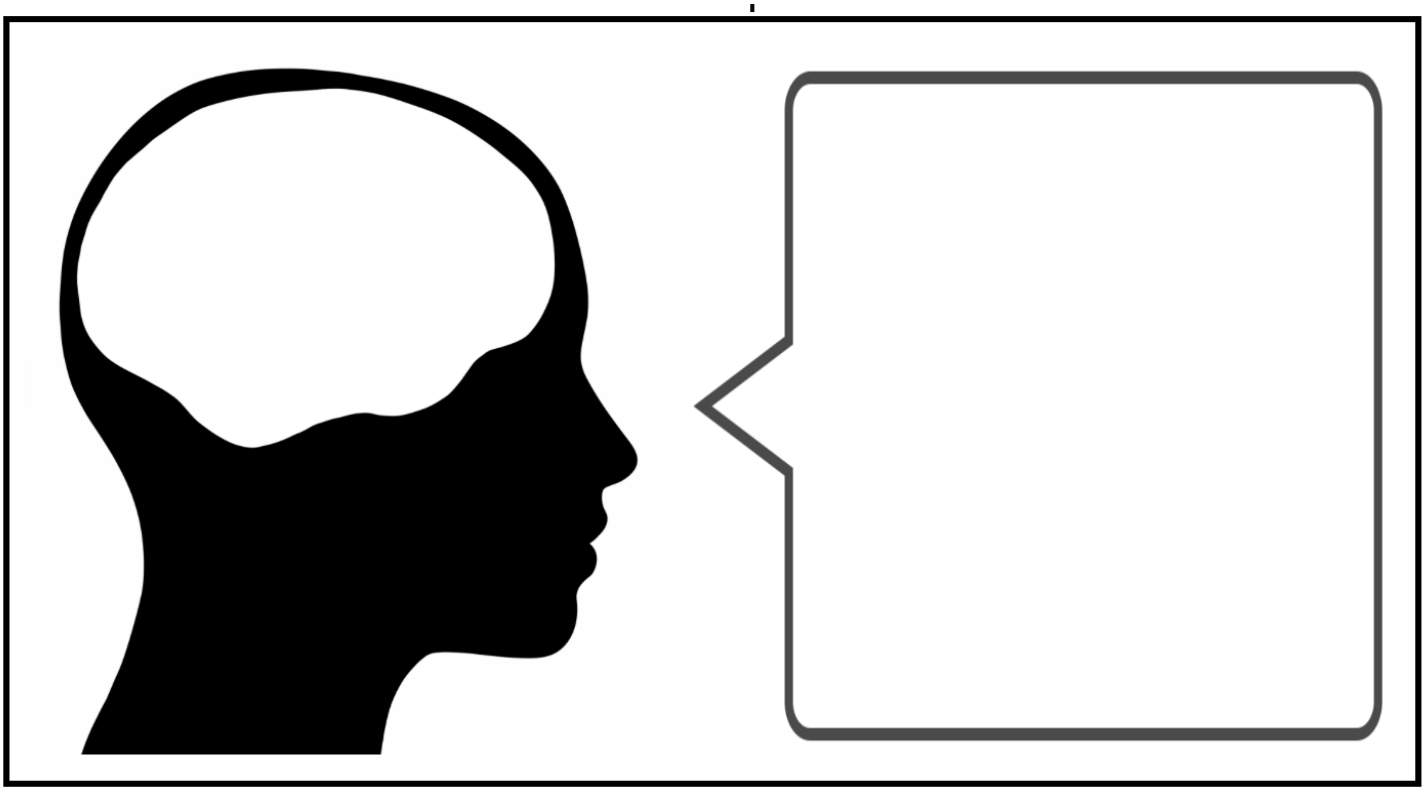
We value your feedback!

Let us know what you thought of this lesson plan by completing this Google Form https://forms.gle/cGAwi9AWXfSZgrYa9. **Thank you!**

Energy Resources: Advantages and Disadvantages

Fuel type	Advantages	Disadvantages
Fossil Fuels (coal, crude oil, gas)		
Nuclear fuel		
Geothermal		
Solar		
Tidal		
Wind		
Hydroelectric		
Wave		
Biomass		

Energy Resources Top Trumps

Solar power

Character role play cards