In partnership with

UNIVERSITY OF CAMBRIDGE

SPACE TO EARTH CHALLENGE

Space, Sports, Sun and Safety

KS 2/3 Project 7 – Energy from the Sun

Energy is the ability to do work. Sometimes when energy is transferred, a force acts which moves something: lifting a book, cycling uphill, walking up stairs, kicking a football. The word 'work' in science has a special meaning. We say that work is done on an object when a force moves that object. The unit in which energy is measured is called a joule (J). The amount of energy (in joules) transferred per second is measured in watts (W). One watt is therefore the transfer of one joule every second. Power stations output many megawatts (millions of watts).

In one second the Sun produces as much energy, 4×10^{26} J, as the world would use in a million years. Indeed almost all the energy we use here on Earth originally came from the Sun. The aim of this activity is to explore how the Sun's energy is produced and how it reaches the Earth's surface. Also to explore ways in which we can harness the Sun's energy for our homes, for transport, in sports activities and in space, for example on the ISS. Some useful background information on energy from the Sun and how we can harness it can be found on the Sun|trek website (Earth's Energy Resources).

OBJECTIVES

- To learn how the Sun's energy is produced and transferred.
- To learn that the Sun radiates energy over a wide range of wavelengths in the electromagnetic spectrum, beyond the visible.
- To learn that some of the Sun's radiation is absorbed and reflected by the Earth's atmosphere.
- To learn how we can harness the Sun's energy on Earth, in sports and in space.
- To learn about the greenhouse effect.
- To learn about the Ozone hole.
- Find out about Albert Einstein.
- Find out about James Prescott Joule.

RESOURCES

- Some of the Images in .ppt resources
- Map of world sunshine
- Penetration of UV radiation through the Earth's atmosphere (in resources)
- Diagram of Sun's energy from core to surface
- Diagram of the Greenhouse effect

principia

principia mission

Venture Thinking

IF THE IDEAS FOUNDATION

british triathlon foundation trust

UK SPACE AGENCY

esa

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FACT FILE

The measure of energy 'Joule' is named after James Prescott Joule, 1818 -1889, born in Salford, Lancs. Joule managed a brewery and did some science as a hobby. However his work on energy was exceptional and he became a Fellow of the Royal Society, FRS. A statue to honour of Joule stands opposite Manchester Town Hall.

The Sun's energy is produced in its core by a process called nuclear fusion. Four hydrogen nuclei (core of the atom) are changed into a helium nucleus, and when this happens a small amount of mass is changed into a large amount of energy in accordance with Einstein's equation, $E = m \times c^2$. Here E is energy, m is mass, c is the speed of light. This energy is then transferred by radiation, and then by convection beneath the Sun's surface, and finally radiated away, reaching us on Earth.

Some of the sunlight is absorbed by different layers of the Earth's atmosphere. The amount of sunlight falling on the Earth is different in different parts of the world, and also varies with the seasons and the time of day.

The greenhouse effect is essential to life on Earth. If the Earth's atmosphere did not create a greenhouse effect, the Earth would freeze over. However, if we turn up the thermostat too much by increasing the greenhouse effect, we may produce too much global warming, which in turn may change our environment forever. The greenhouse effect, which occurs in the Earth's atmosphere, creates a barrier to stop heat escaping from the Earth. It effectively forms a cosy layer around the Earth, which keeps the surface temperature at an average of 15°C. Without our atmosphere and the greenhouse effect, the surface of the Earth would be a very chilly -18°C. Some of the radiation from the Sun is absorbed by the land and oceans. This heats the surface and this heat energy is carried away by convection in the atmosphere and by infra-red radiation. Much of this infra-red radiation is absorbed by the gases in the Earth's atmosphere such as water vapour, methane, nitrous oxide and carbon dioxide. As a result, the atmosphere itself warms up and radiates energy not only out into space, but back towards the Earth. This is a complex process we call the Greenhouse Effect. If we pump too much of the 'greenhouse gases' (those mentioned above) into our atmosphere, then the Earth's surface gets warmer. This is what is happening, and somehow we need to stop it! The governments of all the countries in the world are working together to try and slow down 'Global Warming'. The consequences of 'Climate Change' or Global warming' are very serious: for example, more severe weather, storms, rise in sea levels (causing flooding), droughts in some areas, extinction of some animals.

Samantha Cristoforetti, one of ESA's astronauts, took many photos of the giant solar arrays on the ISS. The space station's solar arrays contain a total of 262,400 solar cells and cover an area of about 27,000 square feet (2,500 square meters) – that is more than half the area of a football field. A solar array's wingspan of 240 feet (73 meters) is longer than a Boeing 777's wingspan. Altogether, the four sets of arrays can generate 84 to 120 kilowatts of electricity - enough to provide power to more than 40 homes. The solar arrays produce more power than the station needs at any one time for station systems and experiments. When the station is in sunlight, about 60% of the electricity that the solar arrays generate is used to charge the station's batteries. At other times, some or all of the solar arrays are in the shadow of Earth or the shadow of part of the station. This means that those arrays are not collecting sunlight. The batteries power the station when it is not in direct sunlight.

The astronauts on the ISS carry out some scientific experiments to track the energy coming from the Sun

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(SOVIM, SOLSPEC, SOLACES). It is important to know and understand how the radiation from the Sun changes with time. There is an eleven year cycle of changes in solar activity, but also changes over longer periods of time. It is important to understand how these changes might affect the Earth

ACTIVITY

The students could do these activities together or be put into groups to study different aspects, then brought together to discuss their findings.

The students could:

- Locate the UK on the map, and identify a few other countries.
- List any countries they may have visited, or heard about, and say how hot or cold they think they are.
- Study the map of average hours of sunshine (in resources). Think about the reasons why some countries have more sunshine than others (latitude, weather, clouds, mountains). How might this vary during the year?
- Consider the difference in sunshine, temperature, weather in different countries (UK, Italy, Spain, Africa, India, Canada, Antarctica).
- Would it be easier to harness the Sun's energy in these these countries than in the UK?
- Think about ways in which the Sun's energy could be harnessed in different countries (solar panels, solar cells, wind farms, tidal forces etc…).

Other questions to explore

- Children could read and comment on the 'news press' about the new football stadiums built in Brazil for the World Cup 2014. Where is Brazil? Why is this a good place to harness solar energy? Which year was this press item written? Could solar energy be harnessed in other football stadiums?
- How is solar energy harnessed on the ISS?
- How are lettuces grown on the ISS?

SAFETY

NEVER LOOK DIRECTLY AT THE SUN.

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RESOURCE

*******************News Item***************************

(Taken from De Zeen Magazine http://www.dezeen.com/2013/05/28/brazil-opens-first-solar-powered-stadium-ahead-of-2014-world-cup/)

Brazil Opens First Solar Powered Football Stadium Ahead of 2014 World Cup

Mineirão Stadium, photo by ME/Portal da Copa/Nitro Imagens

A 1960s football stadium in Brazil has become the first of several in the country to be equipped with a solar-powered roof in preparation for next year's FIFA World Cup.

The Mineirão Stadium in the south-eastern city of Belo Horizonte, originally built in 1965, has been fitted with a 1.4MW solar array on its rooftop.

The £10.7 million project will see energy fed back into the grid rather than being used directly by the stadium. Organisers had initially hoped to install solar arrays in all 12 of the 2014 World Cup venues, but with just over a year until the tournament starts, that target appears to have been lowered.

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WEB LINKS

Sun's energy chain:
http://www.suntrek.org/solar-surface-below/solar-energy-chain/solar-energy-chain.shtml

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Met Office, climate change
http://www.metoffice.gov.uk/climate-guide/climate-change/why

Intergovernmental panel on Climate Change: Greenhouse effect
https://www.ipcc.unibe.ch/publications/wg1-ar4/faq/wg1_faq-1.3.html

Sun|trek: greenhouse effect
http://www.suntrek.org/earth-beyond/earths-energy-resources/greenhouse-effect.shtml

ISS – solar panels
http://phys.org/news/2015-04-image-solar-arrays-international-space.html