Renewable Energy

Lesson Plan

Renewable Energy Lesson Plan

- Recommended level – Years 3-6
- Time taken – 3-4 hours for modules 1 and 3
  2-3 hours for modules 2, 4 and 5
- Expectation – to complete 5 solar-powered working models.

It is recommended that the 5 modules are completed in order. Module 1 includes assembling the solar panel, so this must be completed first.

The activity needs to take place on a sunny day. The solar panels will perform best in the summer term when the sun's rays are most intense (although the motor will still turn in the middle of winter).

N.B. In order to keep the costs to a minimum the kit contains only 5 solar PV panels, so a class of 30 pupils would need to work in groups of 6. It is difficult to co-ordinate a group of 6 pupils and make sure they are all involved in the activity. If there is opportunity to work with half the class at a time or to purchase two renewable energy kits (so that there are only 3 pupils to a group) this would be preferable.

Skills and Learning

STEM Links

- **S**cience: electrical circuits, light, forces, materials, Earth and space
- **T**echnology: electrical systems, design, make and evaluate a product
- **E**ngineering: optimise performance of equipment, propulsion, drag and streamlining, troubleshooting
- **M**athematics: draw 2-D shapes, measure angles, measure distance and time, calculate average speed

Curriculum Learning Objectives – it is recommended to cover these topics prior to the exercise so that the pupils are reinforcing their knowledge and understanding, rather than meeting the topics for the first time.

Science: Light (Year 3)

Pupils should be taught to:

- recognise that dark is the absence of light
- recognise that light from the sun can be dangerous and that there are ways to protect their eyes
- recognise that shadows are formed when the light from a light source is blocked by an opaque object

Science: Electricity (Year 4)

Pupils should be taught to:

- construct simple electrical circuits
- recognise some common conductors and insulators, and associate metals with being good conductors.

Science: Forces (Year 5)

Pupils should be taught to:

- explain that unsupported objects fall towards the Earth because of the force of gravity acting between the Earth and the falling object
- identify the effects of air resistance and friction, that act between moving surfaces

Pupils should explore the effects of friction on movement and find out how it slows or stops moving objects.

Science: Materials (Year 5)

Pupils should be taught to:

- identify and compare the suitability of a variety of everyday materials for particular uses Pupils should be encouraged to think about unusual and creative uses for everyday materials.

Science: Earth and Space (Year 5)

Pupils should be taught to:

- describe the movement of the Earth and planets relative to the sun in the solar system

Pupils should find out about the way that ideas about the solar system have developed, understanding how the geocentric model of the solar system gave way to the heliocentric model.

Science: Electricity (Year 6)

Pupils should be taught to:

- compare and give reasons for variations in how components function

Science: Light (Year 6)

- Pupils should explore the way that light behaves including light sources and shadows
- They could extend their experience by looking at a range of phenomena

Design and Technology (Key Stage 2)

Through a variety of creative and practical activities, pupils should be taught the knowledge, understanding and skills needed to engage in an iterative process of designing and making. When designing and making, pupils should be taught to:

Design and Technology: Design

- design innovative, functional, appealing products that are fit for purpose
- generate, develop, model and communicate their ideas

Design and Technology: Make

- select from and use a wide range of tools and equipment to perform practical tasks
- select from and use a wide range of materials and components according to their functional properties and aesthetic qualities

Design and Technology: Evaluate

- evaluate their ideas and products and consider the views of others to improve their work

Design and Technology: Technical knowledge

- apply their understanding of how to strengthen, stiffen and reinforce more complex structures
- understand and use electrical systems in their products

Mathematics: Measurement (Year 3)

Pupils should be taught to:

- measure lengths (cm/mm)
- record and compare time
- draw 2-D shapes

Mathematics: Measurement (Year 5)

Pupils should be taught to:

- draw given angles and measure them in degrees (°)

Mathematics: Measurement (Year 6)

Pupils could be introduced to compound units for speed and apply their knowledge as appropriate

Mathematics: Geometry – properties of shapes (Year 6)

Pupils should be taught to:

- draw 2-D shapes using given dimensions and angles
- illustrate and name parts of circles including radius and diameter, and know that the diameter is twice the radius

Associated Resources

Instruction sheets

These are intended for the teacher to run through the activity in advance of the lesson.

- Instructions 1 – Pedestal fan
- Instructions 2 – Fairground ride
- Instructions 3 – Electric boat
- Instructions 4 – Spinner
- Instructions 5 – Sun alarm

Presentations

These are for conducting the actual lesson. Teacher notes for each of the modules providing hints, tips and other useful information to help the class with the activities are provided later in this lesson plan.

- Presentation 1 – Pedestal fan
- Presentation 2 – Fairground ride
- Presentation 3 – Electric boat
- Presentation 4 – Spinner
- Presentation 5 – Sun alarm

Worksheets

These are for pupils to complete after the activity to help capture and record what they have learnt. Suggested answers to each of the worksheets are provided at the end of this lesson plan.

- Worksheet 1 – Pedestal fan
- Worksheet 2 – Fairground ride
- Worksheet 3 – Electric boat
- Worksheet 4 – Spinner
- Worksheet 5 – Sun alarm

Equipment needed

Parts included in class kit:

- 5 solar power educational kits
- 10 crocodile leads
- 5 buzzers
- 10 AA battery holders
- 30 coloured LEDs
- 100 card discs
- 10 motor pulleys
- 25 foam sheets 30 cm x 30 cm
- 100 assorted pompoms

Check you have received the correct contents in your class kit. Please let TTS know if there are any problems as soon as possible.

Tools and consumables (not included in class kit):

- 5 AA cells (these are often called batteries). Zinc cells are recommended, rather than alkaline or rechargeable cells.
- Small bowl per group to put small components in during the activity so they don't get lost (for example the nuts and washers from the solar panel and the motor pulley)
- Rulers
- Pencils
- Felt tip pens
- Protractors
- Large scissors
- Transparent sticky tape in dispensers
- Sheets of card roughly A4, e.g. old cereal box
- Pairs of compasses (if you don't have compasses, you can draw round bottle lids or wheels)
- Cool melt glue guns and glue sticks (several needed, e.g. 3-4, as there could be a queue to use them!). Note: High melt temperature glue guns should not be used, as they can cause nasty burns.
- A small container with lid (such as a labelled plastic food container), to store the smaller components safely after use so they don't get lost. For example, the motor pulleys and propellers, and the plastic spanners and spare contacting strips for the solar panels.

For module 3 – electric boat

- Water tray or paddling pool
- Cylindrical pencils to balance the boat on (or 20 cm lengths of circular wooden rod)
- Stopwatch
- Measuring tape

Preparation needed

Select a sunny day on which to run the activity!

Build sample models to explore any pitfalls following the instructions given in the blogs. As there are only 5 renewable energy kits you will then need to disassemble your models so that the pupils can re-use the solar energy kits.

Print out a copy of the relevant worksheet for each group. Print it double sided to save paper.

It is recommended to test the models outside in the sunshine, although the solar panels will also work with the sun passing through a window.

To run module 3 (electric boats) you will need access to a water tray or paddling pool with about 3 cm of water in it.

Risk Assessment

Conduct a risk assessment before undertaking the activity. A sample risk assessment is given below; you can use this as a starting point when writing your own. (L=low, M=medium, H=high)

Activity	Identified Hazard	Initial Risk Rating L/M/H	Control Measures	Controlled Risk Rating L/M/H
Use of glue guns	Burns	H	• Children should be supervised by a responsible adult at all times when using the glue guns. • Explain to children how to use the glue guns. • Warn them that the ends are very hot. Use only low melt temperature glue guns. If burned hold under running water for ten minutes. • Don't switch on the glue guns until after the safety briefing. • In some schools, children wear safety goggles when using glue guns.	M
Accidentally short-circuiting battery	Burns, smoke inhalation	M	• Explain how to avoid short circuits. • Use only zinc chloride cells, not alkaline or re-chargeable ones as these can get very hot if short circuited.	L
Use of scissors	Injury e.g. to fingers	M	• Make the children aware of the dangers. • Do not give out the scissors until after the safety briefing.	L
Looking directly at the sun	Damage to eyes	M	• Explain to the children why they must not look directly at the sun.	L
Damaging eyes with rotating parts	Bruising or damage to eyes	M	• Explain to the children that they must not put rotating parts such as propellers or model fairground rides near their eyes.	L
Use of tape dispensers	Injury, e.g. to fingers	M	• Make the children aware of the dangers. • Show them how to use the tape dispensers safely.	L
Running extension leads along floor for glue guns	Trip hazard	M	• Avoid using extension leads if possible. • Otherwise make sure extension leads are run where they cannot be tripped over.	L
Damaged extension leads or glue gun leads	Electrocution hazard	H	• Conduct a visual check of all electrical items before session, to ensure the leads are undamaged.	L

Teacher notes – referring to the relevant numbered slides in the Presentation

Presentation 1 – Pedestal Fan

Slide 4	**Fossil fuels and climate change** • The graph shows how steeply carbon emissions are rising.
Slide 8	**Work safely** • Don't cut yourself or burn your fingers. • Use cool melt glue guns to avoid serious burns. • Don't put the fan near your eye. • Don't look directly at the sun as you could damage your eyes.
Slide 19	**What did you learn?** • Most of our energy comes from burning fossil fuels. • This causes climate change. • Sources of renewable energy include hydro-electric (water) power, wind and solar. • The solar panel needs to be at right angles to the sun's rays to get best performance. • Shadows are formed when the light is blocked by an opaque (i.e. not see-through) object. • The solar panel produces electricity when sunlight falls on it – this electricity is used to turn the motor. The propeller mounted on the motor pushes the air to produce a breeze which makes you feel cool.

Presentation 2 – Fairground Ride

Slide 6	**Work safely** • Don't cut yourself or burn your fingers. • Use cool melt glue guns to avoid serious burns. • Don't put your eye near the rotating fairground ride. • Don't spike yourself with the compasses. • Don't look directly at the sun as you could damage your eyes.
Slide 11	**Colour in the card disc** • The radius is half the diameter.
Slide 14	**How does the ride work?** • If the strips weren't firmly attached then they would fly off. • This would obviously be very dangerous on a real fairground ride. • Gravity pulls the passengers downwards.

	• As the ride rotates the passengers need to be pulled inwards to make them go round in a circle – otherwise they would continue travelling in a straight line. The faster the ride goes the more they fly out. • Air resistance slows them down.

Slide 16	**What if the sun doesn't shine?** • After removing the motor contacts from the solar panel, make sure the washers and nuts are re-fitted to the panel so they don't get lost. • Make sure the metal parts of the crocodile clips don't touch or you will short circuit the battery. • You have to clip onto the metal end rather than the plastic cover because metal is a conductor of electricity and plastic is an insulator. • If you swap the clips over the ride should rotate the other way.

Slide 17	**What did you learn?** • Renewable energy is energy from sources which do not get used up. • When the wind doesn't blow, for example, you cannot extract energy from it. • Energy is often stored in batteries. These are many other ways of storing energy as well. • Gravity acts downwards, 'centripetal' force pulls the passengers inwards so they travel round in a circle, air resistance slows them down. • Metal conducts electricity. • Plastic is an insulator (and so are lots of other materials).

Presentation 3 – Electric Boat

Slide 5	**Work safely** • Don't cut yourself or burn your fingers. • Use cool melt glue guns to avoid serious burns. • Don't put the fan near your eye. • Don't look directly at the sun as you could damage your eyes.

Slide 9	**How will the boat work?** • The polystyrene foam sheet is very buoyant (i.e. it floats well) and does not absorb water. • It is also easy to cut with scissors and join the parts together with the glue gun. • Gravity pulls the boat down. • Upthrust (provided by the water) pushes the boat up. • If the force pulling it down is bigger than the force pushing it up it will sink. • The friction acting between the boat and the water slows it down. This is water resistance or 'drag'. • The fan pushes the air backwards; the opposing force of the air on the fan pushes the boat forwards.

Slide 11	**Design your boat** • You can balance the boat on the cylindrical pencil and adjust the position of the parts to get it roughly balanced. • You need to use a lot of polystyrene foam to support the heavy parts. Be careful not to make the base too small. It is advisable to use a triple layer of foam. • A streamlined boat has a hull shape designed to feel less resistance from the water as it travels. When you streamline your model you adjust the shape to help it pass through the water more easily, for example by making the front pointed. • You can add fins or similar to your boat to help it go straight. Don't make them too deep so they get stuck on the bottom of the paddling pool.

Slide 16	**Extension activity – optional** • The batteries and crocodile leads are those used in module 2. • When comparing performance, remember that the boat will be significantly lighter without the solar panel, so the drag should be reduced because less of the boat hull is in the water.

Slide 17	**What did you learn?** • Roughly a quarter of our energy is used in transport. • About 90% of this comes from burning fossil fuels which causes climate change. • Gravity acts downwards. • Upthrust from the water opposes this. • The fan pushes the air backwards, and the opposing force from the air acting on the fan pushes the boat forwards (propulsion). • The friction between the boat and the water acts to slow the boat down – this is called water resistance or drag. (This is far more than air resistance because water is much denser than air.) • Polystyrene foam sheet is very buoyant (floats well), doesn't absorb water and is also easy to cut and join.

Presentation 4 - Spinner

Slide 6	**Work Safely** • Don't cut yourself or burn your fingers. • Use cool melt glue guns to avoid serious burns. • Don't spike yourself with the compasses. • Don't look directly at the sun as you could damage your eyes

Slide 11	**Make Maxwell's disc** • The radius is half the diameter. • This experiment was invented by James Clerk Maxwell in the 1850s as part of his research into colour vision and how different people see mixtures of colours.

Slide 12	**Make a Newton disc** • In the 1670s, Isaac Newton proved that sunlight could be divided into primary colours. • He concluded that mixing primary colours together could produce white light.
Slide 13	**Make a model of the solar system** • There are lots of limitations of this model! For example: • The relative sizes of planets are not representative • The relative spacing is not representative • The planets should travel on different orbits • The Earth should rotate about its own axis to create day and night
Slide 14	**Make a Benham disc** • You should see different colours, particularly when the disc is rotating slowly. • The reasons for the optical illusion are not understood but may relate to the behavior of colour receptors in the eye. • This could prove useful for diagnosing eye diseases.
Slide 15	**Design your own models** • The first model represents Saturn's and its rings. • The rings appear solid but are thought to consist of lots of separate particles of dusty ice. • The particles appear to form solid rings because there are so many of them and the sun reflecting off the ice makes them look bright. • The second model represents rockets orbiting the Earth.
Slide 16	**What did you learn?** • Solar energy can be used to heat up water or produce electricity. • When light falls on a solar PV panel it produces electricity. • In the geocentric model of the solar system the Earth is at the centre. • In the heliocentric model of the solar system the sun is at the centre. • The sun is considered to be at the centre nowadays. • A rainbow is formed when sunlight is split into its component colours by raindrops. • Light energy from the sun is converted by the solar panel to electricity; this is then converted to kinetic (movement) energy as the motor rotates.

Presentation 5 – Sun Alarm

Slide 2	**What could you use solar PV for?** • You could use solar PV for lots of things, including lighting, refrigerating food, pumping drinking water, irrigating crops, powering mobile phone masts, televisions and radios, sewing machines...

Slide 5	**Work safely** • Don't cut yourself or burn your fingers. • Use cool melt glue guns to avoid serious burns. • Don't look directly at the sun as you could damage your eyes.
Slide 9	**Light up the LED** • You bend the LED legs apart so the metal ends of the crocodile clips don't touch. • Bend them gently to avoid snapping them off. • The crocodile clips need to be connected to the same contacts to which the motor was connected. • Positive (+) and negative (-) signs are moulded into the plastic by the terminals • If the LED is connected back to front it won't light up.
Slide 10	**Make the buzzer sound** • Make sure you clip onto the metal ends of the buzzer wires, not onto the plastic insulation. • The buzzer only works when connected one way round. • So, if in the previous step you had just connected the LED back to front, then you may end up connecting the buzzer back to front. • This makes a useful exercise in troubleshooting!
Slide 11	**Make both the light and buzzer come on** • It is quite fiddly to clip onto both the buzzer wire and the LED leg at the same time. • Plastic is an insulator, so if you clip onto the plastic sleeve instead of the metal end of the wire then the electricity can't flow so the buzzer won't sound.
Slide 12	**Construct a stand** • The pupils can design any stand they want – it doesn't need to look anything like the example shown.
Slide 14	**Try using wind power** • Make sure the metal ends of the crocodile leads aren't touching one another. • Make sure the motor contacts aren't touching one another either.
Slide 15	**Use wind power to light the LED** • Make sure the metal ends of the crocodile leads aren't touching one another. • Make sure the motor contacts aren't touching one another either. • If the pupils can't blow hard enough to get the buzzer to buzz, then they are unlikely to get the LED to light. • You could demonstrate this to them instead.

Slide 16	**What did you learn?** • If living in a remote village without mains electricity, solar PV could be used for lighting, refrigerating food, pumping drinking water, irrigating crops, powering mobile phone masts, televisions and radios, sewing machines… • An LED only works one way round. • So does the buzzer. • The LED converts electrical energy to light energy. • The buzzer converts electrical energy to sound energy. • The metal ends of the wires conduct electricity; the plastic sleeve does not. • STEM stands for Science, Technology, Engineering, Maths • Combining the learning of these subjects together should make it easier to understand how they are relevant and can be applied in real life.

Worksheet 1 – Pedestal Fan - suggested answers

ENERGY	
Name some things we use energy for.	Transport, houses (e.g. heating), industry and many other things!
Where does most of our energy come from?	Burning fossil fuels
Suggest a problem with this.	This produces greenhouse gases which cause climate change; also the fossil fuels are used up and not replaced.
Suggest an advantage of renewable energy?	It does not produce greenhouse gases which causes climate change; renewable energy does not get used up
Name some sources of renewable energy.	Water (e.g. hydro-electric), wind, solar
ELECTRICITY	
When you connect up the motor, how can you get it to rotate in the opposite direction?	Swap over the motor connectors attached to the solar panel.
To get as much electricity as possible from a solar panel, what orientation should it be at relative to the sun's rays?	The solar panel should be at right angles to the sun's rays to optimise its performance.
LIGHT	
What could happen if you look directly at the sun?	You could damage your eyes.
What causes shadows to form?	Shadows are formed when the light is blocked by an opaque object.
EXTENSION QUESTION	
Explain how a solar powered electric fan works.	Sunlight falling on the solar panel causes electricity to be produced. The solar panel is connected to the motor, and electricity travelling round the circuit makes the motor turn. A propeller is mounted on the motor. The propeller is shaped so that when it rotates the blades push the air, making a breeze. This breeze makes you feel cool.

Worksheet 2 – Fairground Ride - suggested answers

ENERGY	
What is renewable energy?	Renewable energy is energy which comes from sources which are not used up, such as the wind or the sun.
Explain what is meant by a 'variable' renewable energy resource.	This is a resource where the amount of energy available can change due to the nature of the energy source, for example wind turbines only produce electricity when the wind blows, and solar panels do not produce electricity at night.
Suggest a way to store energy for when you need it.	Energy can be stored as chemical energy in batteries. There are lots of other ways to store energy, e.g. making hydrogen for use in hydrogen powered vehicles, pumping water uphill, spinning a flywheel.
How can you reduce the amount of electricity produced by your solar panel?	You can cover it, e.g. with your hand, or turn it away from the sun.
ELECTRICITY	
Explain what is meant by an electrical conductor and an electrical insulator.	An electrical conductor allows electricity to pass through it. An electrical insulator does not.
FORCES	
Which force acts downwards on the fairground passengers?	Gravity acts downwards on the passengers.
What force acts to slow the ride down?	Friction, mainly produced by air resistance acting on the passengers.
LIGHT	
If you were to mix red and blue light, what colour would you see?	Mixing red and blue light gives magenta (purple).
EXTENSION QUESTION	
Explain why the passengers fly out to the sides as the ride rotates.	As the ride rotates the passengers need to be pulled inwards to make them go round in a circle – otherwise they would continue travelling in a straight line. The faster the ride goes the more they fly out.

Worksheet 3 – Electric Boat - suggested answers

RENEWABLE ENERGY	
What proportion of our energy is used in transport?	Roughly 25% of our energy is used in transport.
90% of this energy comes from the same source – what is the source?	Burning fossil fuels.
Suggest an advantage of changing over to electric vehicles.	Electric vehicles have a battery so they can use it to store electricity, which could come from renewable sources. Another advantage is less air pollution.
MATERIALS	
Suggest some reasons why polystyrene foam sheet is useful for making a model boat.	Polystyrene foam sheet is very buoyant (floats well), doesn't absorb water and is also easy to cut and join.

FORCES	
Which force acts downwards on the boat?	Gravity pulls the boat downwards.
What force opposes this?	Upthrust (or the buoyancy) of the water acting on the boat opposes this.
Which force acts to slow the boat down?	Friction acts to slow the boat down, mainly produced by water resistance or 'drag'
MATHS	
How do you calculate average speed?	Divide the distance travelled by the time taken to obtain average speed.
EXTENSION QUESTIONS	
What causes the boat to move forwards?	The fan pushes the air backwards, and the opposing force from the air acting on the fan pushes the boat forwards (propulsion).
Explain what is meant by a 'streamlined' boat.	A streamlined boat has a hull shape designed to feel less resistance from the water as it travels, so it is able to move through the water more easily and quickly.

Worksheet 4 – Spinner - suggested answers

RENEWABLE ENERGY	
What happens when light falls on a solar PV panel?	It produces electricity.
What does PV stand for?	PV stands for Photovoltaic.
There is also another kind of solar panel – what does this do?	Heats up water.
EARTH AND SPACE	
Explain the 'geocentric' model of the solar system.	People used to think that the solar system had the Earth at its centre – this is called the 'geocentric' model of the solar system.
Explain the 'heliocentric' model of the solar system presented by Nicolaus Copernicus in the 16th century.	In the 'heliocentric' model the sun is at the centre of the solar system and the planets orbit around it. This is thought to be the correct model.
LIGHT	
How are rainbows formed?	A rainbow is formed when sunlight is split into its component colours by raindrops.
Explain how a Newton disc should work.	If you colour in the disc with all the colours of the rainbow and then spin it, the colours should appear to mix to give white (or nearly white).
Explain how a Maxwell disc should work.	If you colour the outer ring in red, blue and green then spin it, the colours should appear to mix to give grey. You should then increase the amount of black on the inner ring until the same shade of grey is obtained.
MATHS	
What is the relationship between radius and diameter?	The radius is half the diameter.
EXTENSION QUESTION	

Which energy conversions take place in the solar powered spinner?	Light energy from the sun is converted by the solar panel to electricity; this is then converted to kinetic (movement) energy as the motor rotates.

Worksheet 5 – Sun Alarm - suggested answers

RENEWABLE ENERGY	
Imagine you live in a remote village without mains electricity. Suggest some things you could use a solar PV panel for.	You could use if for lighting, refrigerating food, pumping drinking water, irrigating crops, powering mobile phone masts, TVs, radios...
ELECTRICITY	
Name a material which conducts electricity.	Metal conducts electricity. Many liquids also conduct electricity.
Name some materials which do not conduct electricity (insulators).	Plastic, rubber, dry wood and lots of other materials do not conduct electricity.
Does the LED work if you connect it either way round?	No, the LED only works if connected one way round.
How about the buzzer?	The buzzer only works if connected one way round.
When connecting the LED to the solar panel, which leg of the LED should be connected to the positive terminal of the solar panel?	The long leg of the LED should be connected to the positive terminal of the solar panel.
When connecting the buzzer to the solar panel, should the red or the black wire of the buzzer be connected to the positive terminal of the solar panel?	The red wire of the buzzer should be connected to the positive terminal of the solar panel.
How can you adjust the volume of sound from the buzzer?	You can partially cover the solar panel with your hand or turn it away from the sun.
STEM	
What do the initials STEM stand for?	STEM stands for science, technology, engineering and maths.
EXTENSION QUESTION	
Describe the energy conversions taking place in the sun alarm	Solar energy from the sun is converted to electrical energy by the solar PV panel. This travels round the circuit and is converted to sound energy by the buzzer and light energy by the LED. A small amount of energy is converted to heat due to resistance in the circuit.