



Fusion 3: P1.1 – Energy and Electricity		
National Curriculum Link up •1.1a, b; 2.1a, b and c; 3.1a, c; 3.2a		
Learning Objectives Pupils should learn: That humans require energy resources for their individual survival and for society as a whole. That electricity is an important secondary energy resource in developed countries owing its ease of transfer.	Teaching / Learning activities Lesson structure Starter – Hot heads Show the pupils a set of infra-red images of humans to see the energy radiated. Discuss why some parts, including the head, are hotter than others. If possible show images that compare people who have exercised and some who are resting so that you can discuss energy transfer during exercise. (5–10 mins) Main In this first topic the pupils refresh their ideas about energy and energy transfer, particularly the transfer of electrical energy. They should remember that energy is required to do things (or as scientists say 'do work') and that different amounts of energy are needed to do different tasks. The pupils will need to be reminded about the unit of energy: the joule. Give them some extra examples so that they can understand the idea about how much energy one joule is, in addition to those in the pupil book. Let the pupils think about the importance of electricity to our society for a moment. Without a readily available supply, their lives would be completely different. They should understand that using electricity allows us to transfer energy very effectively, giving us easy access to energy wherever we need it. We can also transfer electricity to other types of energy fairly easily. See if the pupils can think of devices that transfer electricity into kinetic (movement energy) (a motor), light (lamp), heat (heating element), sound (loudspeaker or headphones). You could demonstrate some devices to show just how easy these transfers are to control. The pupils now have to look at how we meet the vast demand for electricity. You can find the actual demand met by the UK national grid over the last 24 hours (or longer periods) at the following web address: http://www.nationalgrid.com/uk/Electricity/Data/Realtime/Demand/demand24.htm or search the www.nationalgrid.com website if the location has moved. The values vary between 25 and 60 gigawatts; show the pupils the size of these numbers by writing them out in full – 60 000 000 000 joules each second at peak demand. To meet demand we have to have a large, flexible, system of electricity generation. The pupils can explore the basics of this in the 'We have the technology ...' task. They will look in more detail at some of the ways of generating electricity over the next few lessons. Plenary - Dark futures Let the pupils imagine that it is 2025. The UK didn't plan for future energy demand and now electrical blackouts are commonplace. The pupils have to write about or discuss how their experiences getting to school and during the school day would be different if there was no electricity all morning. (10–15 mins)	Teaching suggestions <ul style="list-style-type: none"> • Special needs. Provide differentiated versions of the energy resources information sheets. These should present the key information only so that the pupils see the main ideas. You should also provide follow-on sheets with extra details so that the pupils can find out more about the approaches that interest them most. • Extension. Provide differentiated versions of the energy resources information sheets. These should present the key information only so that the pupils see the main ideas. You should also provide follow-on sheets with extra details so that the pupils can find out more about the approaches that interest them most. • Learning styles. <i>Visual:</i> Interpreting a diagram to identify energy resources. <i>Auditory:</i> Discussing the energy requirements of different people. <i>Kinaesthetic:</i> Searching for information on the internet. <i>Interpersonal:</i> Discussing different energy resources. <i>Intrapersonal:</i> Interpreting a diagram. • Homework. Pupils can find additional information about an energy resource of their choice. They could present this information at an appropriate point over the next few lessons; particularly in lesson P1.8 where they assess the sustainability of the resources.
Learning Outcomes <i>All pupils should be able to explain why we need energy resources.</i> <i>Most pupils should be able to list a variety of resources used to produce electricity.</i> <i>Some pupils should also be able to explain why electricity is an important secondary resource in terms of the ability to transmit the energy and transfer it easily.</i>	Additional teachers notes We have the technology ... - Equipment and materials required Samples of electric motors, heaters, loudspeakers and lamps. Safety. No obvious hazards.	



Fusion 3: P1.2 – Energy in store National Curriculum Link up •3.1a, 3.1c		
Learning Objectives Pupils should learn: That moving objects have kinetic energy. That energy can be stored as gravitational potential energy, elastic potential energy and chemical potential energy.	Teaching / Learning activities Lesson structure Starter - It's a wind-up Wind-up and release an elastic powered aeroplane so that it travels across the lab. Ask the pupils to describe the energy transfers that have taken place. Where has the energy that you stored in the elastic gone once the plane has landed? (5–10 mins) Main In this lesson the pupils get to grips with two concepts that often cause difficulty: kinetic and potential energy. Be careful with the term 'potential energy', as it is a term that covers a range of situations where the energy isn't being 'actively' transferred such as nuclear energy, elastic potential energy and chemical potential energy. Let the pupils try to list the factors that affect the amount of kinetic energy that an object has; most will realise that the faster an object is moving the more energy it has and the larger (more massive) it is the more energy there is too. The pupils should also try to think of the factors that affect the potential energy an object has. They should realise that the higher up the object is, the more energy it has. Some will also realise that heavier objects will have more potential energy too. Demonstrate some masses oscillating on elastic bands to show exchanges of elastic and gravitational potential. Make sure that you show some masses on springs to show that elastic potential energy is not <i>only</i> stored in elastic; it is in any stretched material. You can demonstrate some simple chemical stores of energy. A fuel can be burnt with obvious energy release, a neutralisation reaction will be exothermic or a chemical 'light stick' can be broken to produce light energy. It isn't really possible to demonstrate nuclear energy at this point; the pupils just need to know that some elements store large amounts of energy that can be released in some power stations. The pupils can now examine the set of toys in ' Energy toys '. They should be allowed to explore how they operate and make notes of diagrams of the energy transfers taking place. Plenary - Toy racers The pupils can use the wind-up toys from earlier in the lesson and see which will travel the furthest when fully wound up. They may need to design a track that will keep the toys travelling in a straight line. (5–10 mins)	Teaching suggestions <ul style="list-style-type: none"> • Special needs. Partially completed energy transfer diagrams can be used to help describe the energy transfer processes. • Extension. The pupils could look at nuclear energy in more depth, finding out about the changes inside a nucleus that release energy and produce new elements. • Learning styles Visual: Observing how toys operate. Auditory: Explaining how energy is transferred in a range of devices. Kinaesthetic: Examining toys. Intrapersonal: Imagining energy transfers taking place. Interpersonal: Discussing the possible energy transfers. • Homework. The pupils can design their own toy, or other device, that operates using stored energy.
Learning Outcomes <i>All pupils should be able to state that moving objects have kinetic energy and that energy can be stored in different ways.</i> <i>Most pupils should be able to describe the energy transfers that take place in simple toys.</i> <i>Some pupils should also be able to state the factors that affect the amount of kinetic energy or gravitational potential energy an object has.</i>	Additional teachers notes Equipment and materials required. Starter – Wind-up elastic, aeroplane. Demo in main lesson - Various masses, elastic cord, springs, retort stand, boss and clamp, G-clamp. Spirit burner, light stick, hand warmer. Energy toys - As wide a range of small battery-powered, wind-up, spring or elastic-powered toys as possible. Most of the wind-up toys will be movement based but the battery operated ones can have a range of effects. Safety Individual toys may present hazards. Mobile toys could present trip hazards if used on the floor.	



Fusion 3: P1.3 – Electricity from chemicals		
National Curriculum Link up •3.1a, 3.1c		
<p>Learning Objectives Pupils should learn: That cells can be combined into batteries to produce a higher potential difference.</p> <p>That cells transfer chemical energy in electrical circuits.</p>	<p>Teaching / Learning activities Lesson structure Starter - Circuit sense Show the pupils a set of the common circuit symbols that they will be using during this topic. They need to match these up with real components that you have provided and explain what each one is used for. (5–10 mins)</p> <p>Main The pupils should have already encountered a range of models for describing electric circuits and you should ask them for their ideas before starting this lesson. This information can be used to inform your teaching during this and later lessons. Show the pupils the two terminals of the cell, positive and negative, and ask them which way the current will travel in a circuit. There may be some pupils who describe the electrons travelling from the negative to the positive terminal. Explain to them that this is correct in metal wires but that, due to an unfortunate assumption made in the 19th century, we always describe a current as travelling from the positive terminal to the negative. Voltage is described here as the 'push' that causes a current. A single cell causes a small push, whereas a battery produces a larger push and mains supply can produce a much greater push. This is a sufficient level of understanding for pupils at KS3. The pupils should have used a voltmeter before, but demonstrate how to measure a voltage again before allowing them to carry out the 'One (volt) plus one (volt) makes . . . ?' task. This is a fairly simple exercise but it is important that the pupils get to handle a range of cells and familiarise themselves with electrical meters once more. You can show the pupils the internal structure of a cell with the 'Locked in a cell' demonstration. They should be made aware that different cells contain a range of toxic materials including acids, alkalis, lead, cadmium and even mercury. Because of this, most batteries should not be disposed of with normal household waste. Make a simple chemical cell using zinc and copper in acid with the 'Locked in a cell' demonstration. Add more cells explaining that each one is able to add to the total voltage and so you have made a battery. You may want to light a low power bulb with the set-up to demonstrate that the cell can provide energy.</p> <p>Plenary - Hazard matching The pupils can use a list of the chemicals present in a range of cells and batteries and find out the hazards associated with them from hazard sheets or the internet. These chemicals can include zinc chloride, ammonium chloride, lead, sulfuric acid, cadmium and lithium compounds. Ask: 'How are the chemicals disposed of or recycled?' (10–15 mins)</p>	<p>Teaching suggestions</p> <ul style="list-style-type: none"> • Special needs. Provide the pupils with worksheets showing the physical and circuit diagrams of the combinations of cells that they are going to test. The students should be encouraged to compare the two different ways of representing the circuits and decide which is best. • Extension. Which is best, a zinc carbon battery or an alkaline one? The pupils should design a test to see how much better the alkaline one is in a range of different applications, including ones that draw a small current and ones that draw a large one. They can then decide if the extra cost is worthwhile. <p>• Learning styles Visual: Examining the structure of electric cells. Auditory: Listening to a description about how a cell operates. Kinaesthetic: Measuring the output voltages of cell combinations. Intrapersonal: Considering the advantages and limitations of different types of cell. Interpersonal: Collaborating on circuit building.</p> <ul style="list-style-type: none"> • Homework. Pupils could also look into the history of the battery starting with Alessandro Volta up to the more modern, lithium ion polymer batteries developed in the 1990s.
<p>Learning Outcomes <i>All pupils should be able to state that a cell releases electrical energy because a chemical reaction takes place within it.</i> <i>Most pupils should be able to measure the output voltage of different cell combinations.</i> <i>Some pupils should also be able to explain why a cell or battery becomes exhausted in terms of reactions within it.</i></p> <p>How Science Works Communicate effectively and use appropriate scientific terminology and conventions in discussion and written work. (1.1c)</p>	<p>Additional teachers notes Equipment and materials required. Per group: four 1.5 or 1.2 V cells in holders, a voltmeter and connecting leads. Demo - A 'D' sized zinc carbon cell and an alkaline (zinc and manganese dioxide) cell (opened). Two zinc and copper electrodes, four crocodile clips, two 250 cm³ beakers, 1.0 mol/dm³ hydrochloric acid, a voltmeter and connecting leads, bulb. Safety. Short circuited batteries can overheat. Wear eye protection and plastic gloves when handling the opened cells. Pupils must not handle the open cells. Hydrochloric acid: CLEAPSS Hazcard 47A.</p>	



Fusion 3: P1.4 – Electricity from movement		
National Curriculum Link up •3.1a, 3.1c		
Learning Objectives Pupils should learn: That kinetic energy from the wind can be used to generate electricity using a turbine attached to a windmill. The larger the turbine or faster the wind the more energy can be transferred.	Teaching / Learning activities Lesson structure Starter - Wind farms in action There are many high quality video clips on the internet or from science TV programmes showing wind farms in action. These will help the pupils appreciate the concepts later in the lesson. (10–15 mins). Main The 'Turbine testing' task serves as an introduction to using the equipment for the proper investigation later. Make sure that the pupils are able to set up the equipment safely and stably and that they can take measurements with the voltmeter. The output will not be sufficient to light a bulb. Discuss the energy transfers taking place in the wind turbine. Be sure to point out the energy losses in the system; friction causes heating and (as the pupils will see in P1.6) the current heats the wires. The pupils should realise that the greater the wind speed, the faster the turbine turns and the more electricity is generated. Link this to increased kinetic energy in the wind. The relationship is not linear, however, doubling the wind speed should double the kinetic energy but the energy output will not double. This is because the blades are more efficient at capturing energy at certain wind speeds. The pupils may be able to find the optimum speed for their blades. The activity 'Investigating wind power' takes up a significant amount of time. You should assign different groups different variables to investigate and then get them to share their conclusions with the rest of the class at the end of the practical activity. The pupils need to develop skills in taking repeat readings to improve the reliability of their data in experiments where individual readings may be suspect like this one (HSW). Plenary - Location, location, location Provide the pupils with a map of the UK (or northern Europe) marked with the average wind speeds. Several can be found online. They should choose a location for a large wind farm and explain the advantages and disadvantages of these choices. (5-10 mins)	Teaching suggestions <ul style="list-style-type: none"> • Special needs. Pupils should perform the simplest investigations, e.g. testing if wind speed affects output voltage. The students could test the output voltage produced when the wind setting is high, medium and low (a variable speed hairdryer at a fixed distance should be suitable). • Extension. In the 'Investigating wind power' activity, the pupils should be asked to look at the area the blades sweep out (the whole circle) and see if this is related to the output voltage. • Learning styles Visual: Designing (and improving) wind turbines. Auditory: Explaining the patterns in their results. Kinaesthetic: Testing and constructing wind turbines. Intrapersonal: Researching information on wind turbines. Interpersonal: Working in groups. • Homework. Summary question 3 can be the basis for a report on wind farms. The pupils could also write a letter of support or objection to a proposal for a local wind farm.
Learning Outcomes <i>All pupils should be able to state that a wind turbine transfers kinetic energy to electrical energy.</i> <i>Most pupils should be able to carry out an investigation into the most efficient design for a model wind turbine.</i> <i>Some pupils should also be able to evaluate the investigation into wind turbines.</i> How Science Works Recognise that different decisions on the use and application of scientific and technological developments may be made in different economic, cultural and social contexts. (1.1b) Use and apply independent and dependent variables in an investigation by choosing an appropriate range, number and value for each one. (1.2b)	Additional teachers notes Equipment and materials required Turbine testing and Investigating wind power - Model wind power kit and voltmeter. Safety If a hairdryer is used, it should be set on cool to avoid the possibility of causing burns.	



Fusion 3: P1.5 – Electricity from fuels		
National Curriculum Link up •3.1a, 3.1c		
Learning Objectives Pupils should learn: The stages involved in generating electricity in a fossil fuel power station. That electricity generation wastes energy as heat.	Teaching / Learning activities Lesson structure Starter - Limitless supplies Ask the pupils to explain the difference between renewable energy resources and non-renewable ones. Ask: 'Are nuclear and wood renewable or not?' The pupils should explain their answers. (5–10 mins) Main There are many simulations of power stations available and these will be very useful in showing the pupils what is happening inside. It will be difficult for some to grasp the scale of the equipment used inside a real power station; try to find some images of the equipment with people in them to show scale. Steam turbines don't really resemble windmill blades very much, even though they are often compared to them by pupils. They are large, highly engineered sets of steel plates designed to be as efficient as possible at transferring the kinetic energy of the steam into rotation of the generator shaft. Once the pupils are clear about the stages in a power station, they can focus on the range of energy transfers taking place. They should be made aware that there is energy wasted at each stage and that it is important to minimise this loss. Some pupils will find handling percentages difficult, you may want to translate them into fractions to see if this helps out. The most important thing is that they understand that we lose a lot of energy because a power station is not very efficient. A significant amount of energy is wasted when the steam is condensed back into water so that it can be easily pumped back to the boiler. This energy is dumped into the atmosphere in the cooling towers creating artificial clouds. Some power stations provide some of this excess thermal energy to heat greenhouses nearby. Fossil fuel power stations are a significant source of carbon dioxide and the lesson provides an opportunity to discuss global warming issues if you wish. Plenary - Ask: 'What pollution problems are associated with burning fossil fuels?' The pupils should try to describe the chemical processes that cause production of carbon dioxide and sulfur dioxide before describing why these two gases are a problem for the environment. (10–15 mins)	Teaching suggestions <ul style="list-style-type: none"> • Special needs. Provide a power station diagram for the pupils to annotate with the details they learn. This should include all of the key parts (furnace, boiler, turbines and generator) and possibly an indication of the energy loss to the surroundings at each stage. • Extension. The pupils can look more closely at the design of generators. How are they made to give a maximum output? Is the output voltage constant as they rotate? Connecting one to a CRO should give a better picture. • Learning styles Visual: Exploring a model of a power station. Auditory: Describing how a steam generator can be made to spin. Intrapersonal: Considering the environmental impact of power stations. Interpersonal: Discussing the energy loss in power stations. <ul style="list-style-type: none"> • Homework. The pupils can find out about the nearest power station. Ask: 'What fuel does it use, how much fuel, how much energy is produced and how many people work at the plant?'
Learning Outcomes <i>All pupils should be able to describe the structure of a fossil fuel power station and name the important parts.</i> <i>Most pupils should be able to describe the action of each part of a fuel burning power station.</i> <i>Some pupils should also be able to describe how energy is wasted in a power station and the measures used to reduce this waste.</i>	Additional teachers notes Equipment and materials required Safety	



Fusion 3: P1.6 - From electricity to heat		
National Curriculum Link up •3.1a, 3.1c		
Learning Objectives Pupils should learn: That whenever there is an electric current there is a heating effect. The heating effect is caused by the resistance of the material.	Teaching / Learning activities Lesson structure Starter - Warm as toast The pupils should make a list of as many electrical devices as possible that produce heat. Which are deliberately designed to do so? Which produce the most heat and why? (5–10 mins). Main Demonstrate a range of electrical devices, including those designed to provide heating (a kettle, radiant heater) and some that produce heat as a side effect (TV, data projector). The pupils should soon grasp the idea that all electric currents produce a heating effect. You can demonstrate the dangers of the heating effect with the 'Hot stuff' activity. The pupils need to understand the larger current produces more heating. At this point you can discuss the dangers of the heating effect, such as overloaded plug sockets causing fires. You might want to mention some less obvious uses too. For example, hot wires can be used to cut plastics. This can sometimes be seen on modern laboratory work surfaces where the chemical- and wear-resistant surfaces (often Corian or similar) show grooves when hot wires have marked the desk where heat-resistant mats were not used. The pupils should now carry out the 'Water heater' experiment. During the experiment the focus should be on collecting accurate data by keeping the current constant and recording the temperature accurately at precise intervals. Data-logging equipment is ideal for this type of experiment. Once the results are gathered, the pupils should analyse them by plotting a line graph choosing the axes and scales for themselves (HSW). Theoretically, this should show a linear relationship between the time the water was heated for and the rise in temperature. You can discuss with the pupils reasons why the correlation is not exact [this is due to energy loss to the surroundings]. The pupils now move on to explaining the heating effect in terms of resistance and electron movement and collision with atoms. With higher attaining, pupils you may wish to discuss and use the term 'ions'. Resistance can be a difficult concept for pupils to understand; the key point for all pupils is that the higher the resistance, the more heating there is. Plenary - Experimental improvements Can the pupils improve the 'water heater' experiment so that it produces more accurate results? Their ideas should include ways of insulating and reducing evaporation. This covers aspects of How Science Works. (5–10 mins)	Teaching suggestions <ul style="list-style-type: none"> • Special needs. Allowing the pupils to use data-logging equipment will make the practical task and analysis of results more straightforward. • Extension. Find out what superconductors are and where they are used. • Learning styles Visual: Making detailed measurements of temperature. Auditory: Listening to explanations of the heating effect. Kinaesthetic: Carrying out an investigation. Intrapersonal: Making deductions about the cause of electrical heating. Interpersonal: Working in teams during practical investigations. • Homework. Ask: 'Who invented the light bulb?' The pupils can look at the history of the filament lamp from its early development to its imminent demise due to newer, less wasteful, alternatives. Why is tungsten used for the filament?
Learning Outcomes <i>All pupils should be able to state that a wire will heat up when a current passes through it because of electrical resistance.</i> <i>Most pupils should be able to describe situations where the heating effect is useful and some where it is not.</i> <i>Some pupils should also be able to describe resistance in terms of electron collisions with metal atoms (ions) in a wire.</i> How Science Works Use and apply qualitative and quantitative methods to obtain and record sufficient data systematically. (1.2d)	Additional teachers notes Equipment and materials required. A range of electrical devices, e.g. kettles, heaters, lamps, etc. A low voltage power supply, connecting leads, 5 cm length thin Nichrome (or similar high resistance) wire, heat-resistant mat, wire wool, 2 crocodile clips. Water heater - Sealed water heating element (i.e. immersion heater), d.c. power supply, ammeter, 250 cm ³ beaker, connecting leads, thermometer (ideally 0.5°C precision) and stop-clock. Datalogging equipment and temperature sensors work very well. Safety. Take care with hot wire and clips. Make sure that the water is not heated to anywhere near boiling point. Keep power supplies away from water.	



Fusion 3: P1.7 – Paying the price National Curriculum Link up •3.1a, 3.1c		
Learning Objectives Pupils should learn: That amounts of energy can be measured in joules, but larger amounts are often measured in kilowatt-hours or 'Units'. Electricity supply companies charge people for each Unit used in their homes.	Teaching / Learning activities Lesson structure Starter - Energy in the news Show the pupils some recent newspaper (or web-based) stories about energy prices. These can include price rises for fuels too. Ask: 'What affects the price of fuel?' The pupils can discuss the reasons for recent changes. (10–15 mins) Main The pupils will be aware that electricity is not free and most of them will have seen the electricity meter in their house. Do not encourage the pupils to seek this out at home. They should ask where it is but not test out any of its functions. You can demonstrate that two different brightnesses of lamp are using different amounts of electricity by connecting them to an energy meter. Alternatively, use an ammeter and voltmeter combination to calculate the power input (see the practical task). The pupils can now try to make an energy reading of their own with the 'Using an energy meter' activity. If you don't have enough it is still worth trying the task using ammeters and voltmeters to make measurements; provide a worksheet showing how to convert these measurements into energy readings. The kilowatt-hour can cause considerable confusion, especially as it is called a Unit. You can explain that the kW h is used because a single joule is too small an amount and people may be confused if they receive a bill for 288 000 000 joules at 0.000 004 pence each. It is more sensible to have a bill for 80 Units (80 kW h) at 15 pence each. You can show an electricity bill and explain what the parts mean. A copy of the school bill always impresses the pupils with the cost of running a large building. All of the computers and data projectors, and so on, have pushed these even higher. Real bills can have a standing charge added too, so you should mention that this is basically a service charge for the electricity company to maintain the cables and other parts of the network. If you have an energy meter capable of measuring the energy supplied to mains operated devices, it is useful to show it in operation so that the pupils can appreciate the differing amounts of energy required by different devices. Show some light bulbs, a radio, a small TV, heating element and a kettle. It should be obvious that the devices designed to cause heating require the largest amounts of energy. Plenary - It costs more than money Environmental groups believe that reducing our electricity-use is not just about reducing our bills; in fact some groups want us to pay more for using less. Let the pupils discuss what they think the ideas behind these opinions are. Do they agree? (10–15 mins)	Teaching suggestions <ul style="list-style-type: none"> • Special needs. Extra support may be needed with some calculations. • Extension. The pupils can incorporate the standing charges from bills into some calculations. • Learning styles Visual: Recording precise readings from meters. Auditory: Discussing the types of device that use most electricity. Kinaesthetic: Measuring energy-use. Intrapersonal: Appreciating that the more electricity we use, the more we have to pay for it and the more it affects the environment. Interpersonal: Discussing ways to reduce electricity bills. <ul style="list-style-type: none"> • Homework. The pupils can find out the power ratings of the devices used at home. Ask: 'How wasteful is their TV in standby mode?'
Learning Outcomes <i>All pupils should be able to state that an electricity meter measures the Units used in a house over a period of time so that the user can be charged.</i> <i>Most pupils should be able to calculate the cost of electricity used from meter readings.</i> <i>Some pupils should also be able to make comparisons about the amount of energy different devices require.</i>	Additional teachers notes Equipment and materials required Per group: An energy meter, power supply connecting leads, water heating element, 250 cm ³ beaker, lamp (2 W and 6 W) Safety Pupils should not be measuring mains voltages in this experiment.	



Fusion 3: P1.8 – Seeking sustainability		
National Curriculum Link up •3.1a		
Learning Objectives Pupils should learn: That unsustainable energy resources are in limited supply or can cause significant environmental damage. Sustainable energy resources have less environmental impact and will not run out, but they may have other disadvantages that limit their usefulness.	Teaching / Learning activities Lesson structure Starter - Fact, falsehood or opinion? Give the pupils a set of statements about energy resources: some of which are fact, some of which are false and some of which are opinions. The pupils need to sort them into the three groups. They can then decide which opinions they agree with and which they disagree with. (5-10 mins) Main In this lesson, the pupils will assess the sustainability of the techniques used for energy production. There are two aspects of sustainability to consider. Is the resource limited? Unless new reserves of oil and gas are discovered these resources will become unrealistic to extract during the pupils' lifetimes. Occasionally pupils will ask why no new fossil fuels are being made; point out that they are but at too slow a rate. The second problem with fossil fuels is the carbon dioxide emissions. Pupils will readily link this to global warming and climate change. The two points show that the use of fossil fuels is unsustainable. Biofuels are often said to be sustainable and carbon neutral, but some studies cast doubt on their long-term future. The land required for growing some fuel crops is enormous; fertilisers and pesticides are often used and the processing of the fuel can be quite expensive. The pupils should think about these issues and the idea that the land may be needed to grow food for rising populations instead. Now point out some of the ideas that have been covered: wind power, wave power and solar power. Ask the pupils about the sustainability. Are there any other resources that are sustainable in this way? The pupils may mention geothermal or hydroelectric resources. The 'Nuclear question' debate can be handled in a range of ways depending on the time and resources at your disposal. You might like to set aside an additional lesson for extra research time or presentations. The debate can extend into the alternative resources that may be used instead of nuclear power. The final idea here is about reducing the demand for resources so that they can last longer. Throughout this topic the pupils have been encouraged to think about their energy-use. Recap some of the ideas that they have had and revisit the commitments they made to reduce their electricity bills. Plenary - Nuclear lobby The pupils can produce a placard for or against nuclear power. It's more challenging to have to do a two-sided one where one side is pro-nuclear and the other side is anti-nuclear. (10–15 mins)	Teaching suggestions <ul style="list-style-type: none"> • Special needs. Limit the range of resources available for the nuclear debate. You may need to edit some of the information to make it an appropriate level. • Extension. Most scientists accept that fuel-use produces CO₂ and this is a major cause of global warming. What do the others think? Should we wait until all scientists accept the idea; will this ever happen? The pupils can discuss the fact scientists on both sides have vested interests in their positions and evaluate which opinion can best be trusted. Learning styles Visual: Designing presentations. Auditory: Discussing the issues associated with sustainable electricity production. Kinaesthetic: Carrying out active research. Intrapersonal: Forming personal opinions based on evidence. Interpersonal: Debating issues in groups. <ul style="list-style-type: none"> • Homework. If you choose to extend the nuclear debate activity, then some pupils can work on their resources at home.
Learning Outcomes <i>All pupils should be able to give examples of energy reserves that are sustainable or unsustainable.</i> <i>Most pupils should be able to describe how fossil fuel reserves are limited and their continued use may significantly threaten the environment.</i> <i>Some pupils should also be able to make arguments for and against nuclear power as a replacement to fossil fuel power stations.</i> How Science Works. Evaluate the issues, benefits and drawbacks of scientific developments with which they are familiar. (1.1b)	Additional teachers notes Equipment and materials required Access to library and internet.	



Fusion 3: P1.9 – Around the circuit		
National Curriculum Link up •3.1a, 3.1c		
Learning Objectives Pupils should learn: That in a series circuit the current is the same at all points and the voltage is divided across components. That in a parallel circuit the voltage is the same across each branch and the current divides between each branch.	Teaching / Learning activities Lesson structure Starter - Energy transfer Give the pupils a set of symbols for different electrical components (lamp, buzzer, motor, heater) and ask them to draw energy transfer diagrams for them all. They should remember to include the energy wasted as heat. (10–15 mins) Main Describe the behaviour of current in a series circuit. If you have a computer simulation, use it to reinforce the idea that there is only one path for the current to take so all of the current must pass through each component in turn. Check that the pupils do not think that the current is 'used up' or 'gets less' as it travels. Voltage is more difficult to picture. The pupils will be trying to imagine a model of current and voltage in circuits during the next lesson but you will need some analogies to help them through this bit. A voltage or potential difference can be thought of as a bit like a height change. When a current (actually charge) moves around a circuit you can imagine it falling through a height. As it passes through each component its height (voltage) drops a bit until it reaches the bottom. The battery pushes the current back to the starting voltage (height). Some pupils won't grasp the idea, they will re-visit this next lesson but for now they will have to accept that the voltage is 'shared' across the components. The pupils can test the ideas about series circuits with the ' Try it with meters ' task. This is relatively straightforward, but the pupils should attempt to design a suitable circuit on their own (to develop their HSW skills) and then take accurate readings with the meters. Current in parallel circuits is understandable once the pupils accept that the <i>total</i> current can't change. You can say that some of the current goes one way while the rest goes the other; just like a river dividing and rejoining. This is true at any junction in the circuit. Voltage is a bit trickier yet again, as it isn't as easy to imagine. In a river-based analogy, the voltage is a bit like the drop in height that the water goes through (as before). The river splits and rejoins but the water must have gone downhill by the same amount when the river rejoins. The pupils test the theory out with the ' More with meters ' task. As before, they should focus on designing their own circuits to confirm the ideas. Plenary - Circuit analysis Use a set of circuit diagrams of components in series and parallel. The pupils need to determine the values missing from the various meters positioned around the circuits (5–10 mins)	Teaching suggestions <ul style="list-style-type: none"> • Special needs. You can provide the circuit diagrams or even pictures to help with the circuit construction. • Extension. The pupils could explore the behaviour of a circuit that has series and parallel parts. They place two bulbs in series and then a third in parallel with them and measure the current through each branch and voltage across each bulb. Ask: 'Do the results match their predictions?' • Learning styles Visual: Drawing circuit diagrams. Auditory: Describing circuit behaviour. Kinaesthetic: Constructing circuits. Intrapersonal: Understanding the behaviour of current in circuits. Interpersonal: Working in groups to investigate circuits.
Learning Outcomes <i>All pupils should be able to describe the behaviour of current in a series and parallel circuit.</i> <i>Most pupils should be able to describe how a voltage acts in series and parallel circuits.</i> <i>Some pupils should also be able to use abstract ideas and models to describe current and voltage.</i> How Science Works Explain how the planned approach to answer a scientific question was informed by scientific knowledge, understanding or other sources of evidence. (1.2a)	Additional teachers notes Equipment and materials required Try it with meters - Per group: battery pack or low voltage power supply, two 3 V bulbs, three ammeters, three voltmeters, connecting leads. More with meters - As for the previous experiment. Safety No obvious hazards.	



Fusion 3: P1.10 National Curriculum Link up •3.1a, 3.1c		
Learning Objectives Pupils should learn: That the amount of energy transferred in an electrical circuit is dependent on the current and the potential difference it moves between. That there are a number of ways of modelling a circuit in help explain its behaviour. Different models have different advantages.	Teaching / Learning activities Lesson structure Starter - It's only a model Can the pupils think of any 'models' that have been used in their science course (particle model, model of an atom, model of a cell, etc.)? They should describe this model and what it means. Ask: 'Are there any problems with the model?' (10–15 mins) Main In the final lesson of this topic, the pupils look at the connection between the voltage and energy that can be transferred. They should be aware that high voltages are considered dangerous; you can now connect the idea of danger to the heating effect they saw in lesson P1.6 and their knowledge of the nervous system. One interesting effect of electrocution that's worth pointing out is a grasping effect. During electrocution muscles contract in the arms and legs. This means that if you touch a high voltage electrical cable you will tend to grab it and be unable to let go, because you can't make your muscles relax. Instead of receiving a short shock and leaping away, as portrayed in several films, you are more likely to grasp the cable and fall to the ground. Move on to the idea of transferring electrical energy using very high voltages. The pupils will have seen pylons and be aware of local sub-stations (and their gentle hum) but may not appreciate the scale of the grid. Show them a map, there are many available online, and ask them to locate their town and the nearest power stations. You can mention that the reason that high voltages are used is to transfer the electrical energy as efficiently as possible. The term 'potential difference' is an important one in Key Stage 4. Try to link the idea loosely to gravitational potential energy; as a current (actually charge) travels through a potential difference it transfers energy in a similar way to a mass moving through gravitational potential (changing height). Only a few will really grasp this comparison, but it is worth seeing the ideas in preparation for later study. The pupils now have to think about ways that electrical circuits and electrical energy can be modelled. They will have thought about some of the ideas before, but now is the time for them to put everything together as best they can. This is one of the key processes that need to be addressed in Key Stage 3. In the pupil book, a water-like model has been described; this is similar to the log flume idea they will have encountered in Book 1. You can choose to look at a number of models appropriate to the ability of the groups as described in the ' Understanding the model ' task. Plenary - Summative diagram The pupils should produce a summary diagram or concept map of the material covered in the topic. They should indicate the areas where they have limited understanding so that you can revisit these for revision later. (10– 15 mins)	Teaching suggestions <ul style="list-style-type: none"> • Special needs. A simple model using a factory (battery) and delivery lorries (the current) that carry milk (energy) along roads (wires) or similar can be used. • Extension. Ask: 'Why do we use such high voltages in the national grid?' Couldn't we use higher currents instead? The pupils should find out why it is more energy efficient to have very low currents [reducing the heating effect] and very high voltages [maintaining a high power level]. Learning styles Visual: Imagining circuit behaviour. Auditory: Listening to descriptions of circuit behaviour. Kinaesthetic: Manipulating physics models of circuits. Intrapersonal: Thinking about the dangers involved with high voltage electricity. Interpersonal: Discussing how appropriate different models are. <ul style="list-style-type: none"> • Homework. Make a model: the pupils can design and make/draw a model for electric current.
Learning Outcomes <i>All pupils should be able to explain why high voltages can be dangerous.</i> <i>Most pupils should be able to compare the behaviour of an electrical circuit to a physical model.</i> <i>Some pupils should also be able to develop their own models to help explain circuits.</i> How Science Works Describe the strengths and weaknesses of a range of available models and select the most appropriate. (1.1a1)	Additional teachers notes Equipment and materials required Safety	