PUPIL RESEARCHER INITIATIVE

Green Heating

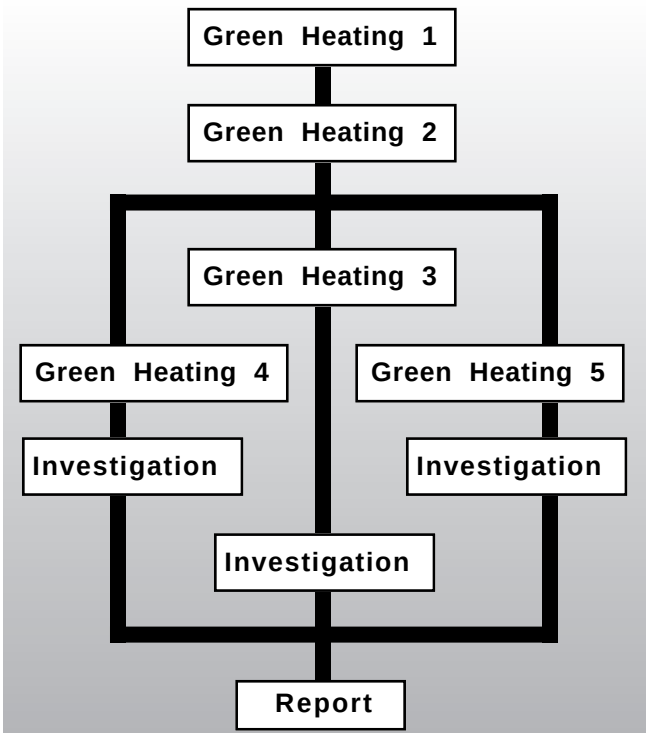
Pupil Research Brief

Teachers' Notes

Syllabus Coverage *Subject Knowledge and Understanding*

- ❑ all types of electromagnetic radiation form a continuous spectrum
- ❑ when radiation is absorbed the energy it carries makes the substance which absorbs it hotter
- ❑ infrared radiation is absorbed by the skin and is felt as heat
- ❑ different wavelengths of electromagnetic radiation are reflected, absorbed or transmitted differently by different substances and types of surface
- ❑ dark, matt surfaces are good absorbers of radiation
- ❑ light, shiny surfaces are good reflectors of radiation
- ❑ thermal energy is the transfer of energy by waves, and particles of matter are not involved

Route through the Brief



Introduction

In this Brief pupils carry out simple investigations to find out which colour and type of surface is best for absorbing infrared radiation so that it can be used in a solar panel. They are given background information about solar panels and about infrared radiation from the Sun, and they are provided with information about how a scientific investigation is conducted.

They must plan an investigative procedure to answer the question posed in **Green Heating 3**, or to test the hypothesis set out in **Green Heating 4**, or to find out if the prediction made in **Green Heating 5** is correct or not.

They should submit their plans for approval and then carry out the investigation. Reports should be written after the investigation has been conducted.

Experimental and investigative skills

- planning an experiment
- obtaining evidence
- analysing evidence and drawing conclusions
- evaluating evidence

Prior knowledge

Before attempting this Brief pupils should have learned about heat transfer by conduction, convection and radiation. Some knowledge of the electromagnetic spectrum would be useful, and pupils should also know about reflection of light off plane surfaces.

Pupil Research Brief

Teachers' Notes continued

Pupil grouping

Pupils could work in a number of groupings during this Brief. Suggestions are :

Initial briefing	-	whole class; teacher introduces topic and sets the context for the activities
Background paper - Green Heating 1		individuals or pairs
Carrying out investigation	-	pairs or small groups
Analysis of results	-	pairs or small groups, or individually if the work is to be assessed
Communication	-	completion of written reports (individual or small groups). Small group presentation to whole class (optional).

Timing

This Brief is likely to take about 3 hours of classroom time. The planning of the investigations can be set as homework, as can the writing of the report.

Activities

The teacher should issue the pupils with the **Study Guide** which provides pupils with a summary of what they should produce as they work through the Brief. It can also act as a checklist so that they can monitor their own progress. Then hand out **Green Heating 1** to pupils. This gives information about how solar panels use infrared radiation from the Sun to heat up water. The Brief requires pupils to carry out an investigation concerned with the type of surface that absorbs infrared radiation best. The sheet **Green Heating 2** gives pupils information about the procedures scientists use in carrying out research work.

There are 3 sheets that can be used by pupils as the starting point for their investigation. **Green Heating 3** requires pupils to plan an experiment to answer the question "what colour surface is best at absorbing infrared radiation ?"

Green Heating 4 sets out the hypothesis 'a solar panel with a matt black surface is better at heating water than a panel with a light shiny surface, since dark surfaces absorb more heat'. Pupils are required to plan an experiment to test this hypothesis.

Green Heating 5 contains the prediction "if infrared radiation is a form of electromagnetic radiation like light, then surfaces that reflect light will reflect infrared radiation". Pupils have to design an experiment to test if the prediction is correct or not. In order to plan their experiments they can be issued with the **Investigation Flowchart** (see appendix to General Teachers' Notes). Pupils can use this flowchart to help them plan their investigations. It is intended that pupils use only one of the investigation sheets - answering the question, testing the hypothesis or confirming or refuting the prediction. It is up to the teacher to choose which sheet to use, or to use all three within the same class. Since pupils are asked to devise their own experiment, they may require guidance as to what is possible to do with the equipment available in a school laboratory. It may be useful to set out a bench with a range of materials and apparatus and ask pupils to select only from these the equipment they will use to carry out their investigations.

Investigation details

These will vary from class to class and it is not possible to be specific about the investigations that will be carried out. However, some ways of carrying out the investigations are suggested below.

The question posed in **Green Heating 3** could be answered very simply by wrapping paper of different colours round thermometer bulbs and placing them equidistant from a source of heat radiation - a 60 W light bulb, for example.

Pupils need to be warned not to allow the thermometers to go above 100^{o}C, or else they may burst.

The hypothesis in **Green Heating 4** can be tested by wrapping matt black paper round one small beaker or test tube containing some water, and shiny white paper round another. These are placed equidistant from a source of heat radiation and the temperatures of the water in both beakers can be monitored at regular intervals.

The predictions in **Green Heating 5** can be tested with a similar experiment, as well as replacing the paper with aluminium foil.

Using IT. Pupils could use temperature sensors or infrared sensors to monitor changes in temperature.

Pupil Research Brief

Teachers' Notes continued

Safety issues

PLEASE NOTE: It is also important that you prepare your own risk assessments for the practical work in this Brief in the usual way.

Hot and radiant surfaces: danger of burns

If burned: hold affected area under flowing cold water for at least 10 minutes. If anything other than very minor (shallow, less than 5mm diameter), seek medical attention.

Assessment issues for *Experimental and Investigative Science* (National Curriculum for England and Wales, Northern Ireland Curriculum)

P	Planning	O	Obtaining evidence
A	Analysing evidence	E	Evaluating evidence

Three sheets taking pupils through the planning process:

Green Heating 3	Asking Questions
Green Heating 4	Hypothesising
Green Heating 5	Predicting

There is also an Investigation Planning Flowchart which pupils can use to help them plan their investigation. The use of these sheets will have to be taken into account when assessing **Skill Area P**, although the full range of marks should be available for investigations based on Green Heating 4 and Green Heating 5 since no investigation methods are provided. Investigations based on Green Heating 3 may be restricted to low-middle marks.

Skill Areas 0, A and E. All mark ranges should be available for investigations based on Green Heating 4 and Green Heating 5. Low to middle marks for those based on Green Heating 3. Analysis and evaluation of evidence will require pupils to demonstrate knowledge and understanding of absorption and reflection of electromagnetic radiation. How they do this could influence their achievement in **Skill Areas A and E**.

Scottish syllabus coverage

Standard Grade Physics - *Energy Matters*

Further pupil research opportunities

Pupils could try to make a model solar panel. A shallow box is lined with aluminium foil, plastic tubing is wrapped around nails, so that it snakes up and down the length of the box. The tubing is covered with black paper and a sheet of perspex is placed on top. A trickle of water is fed in from the bottom and let out at the top. If this is angled towards the Sun on a warm, sunny day, the temperature of the water coming out of the panel should be several degrees warmer than it was when it entered the panel.

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Green Heating

Setting the Scene

You will investigate how solar panels work. You will carry out an investigation based on a question, an hypothesis, or a prediction, relating to the science of solar panels

Pupil Research Brief

Study Guide

Syllabus Targets *Science you will learn about in this Brief*

- ❑ all types of electromagnetic radiation form a continuous spectrum
- ❑ when radiation is absorbed the energy it carries makes the substance which absorbs it hotter
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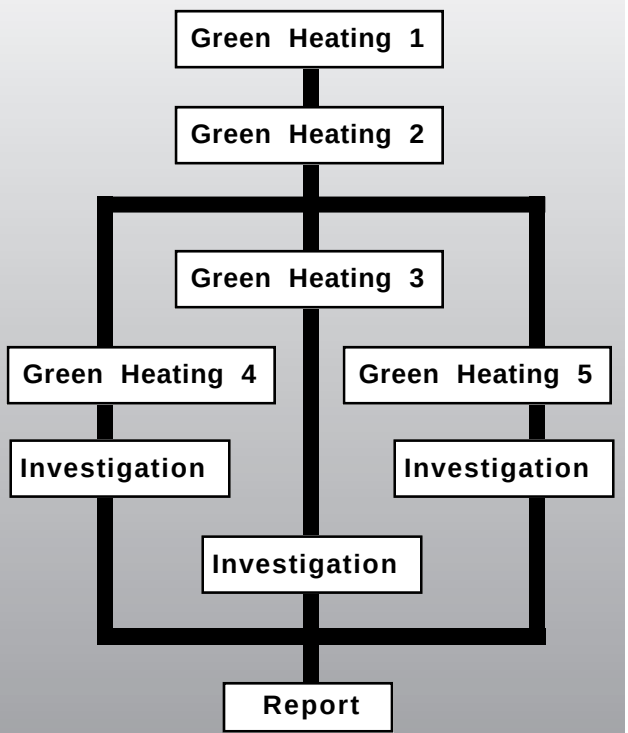


Outcome Checklist

You will carry out an investigation based on a question, an hypothesis or a prediction. You will write a report of your findings. You can use an Investigation Flow Chart to help you plan your investigation. You should make sure you produce the following items as you work through the Brief.

Green Heating 2

- ❑ investigation flow chart showing your plans

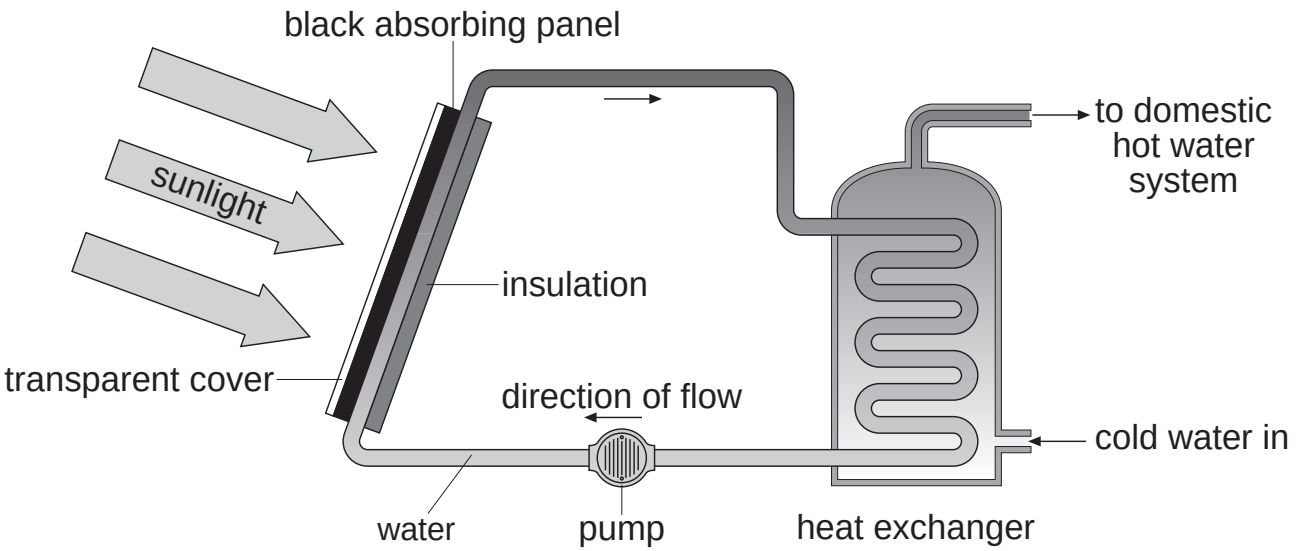
Green Heating 3,4 or 5

- ❑ report on investigation

Green Heating 1

Energy from the Sun can be harnessed and used productively for domestic and industrial purposes. Two of the most common ways of 'collecting' the Sun's energy are using solar panels (which produce hot water) and photovoltaic cells (which produce electricity). Scientists are researching into ways of combining solar panels with photovoltaic cells in the same device in order to use the Sun's energy even more efficiently. However, in this PRB you will concentrate on solar panels

Figure 1. How a solar panel works



Energy reaching the Earth from the Sun can be transferred by solar panels to heat water moving around inside them. This solar energy is called infrared radiation. Radiation arriving at the outer surface is absorbed by the panel. The energy is used to heat water sealed in the solar panel unit. The energy from this water is transferred to the domestic hot water system via the heat exchanger. This hot water is used for houses, hospitals, offices or factories. The more of the Sun's energy that can be transferred to the water, the better the solar panel is. We say it is more efficient.

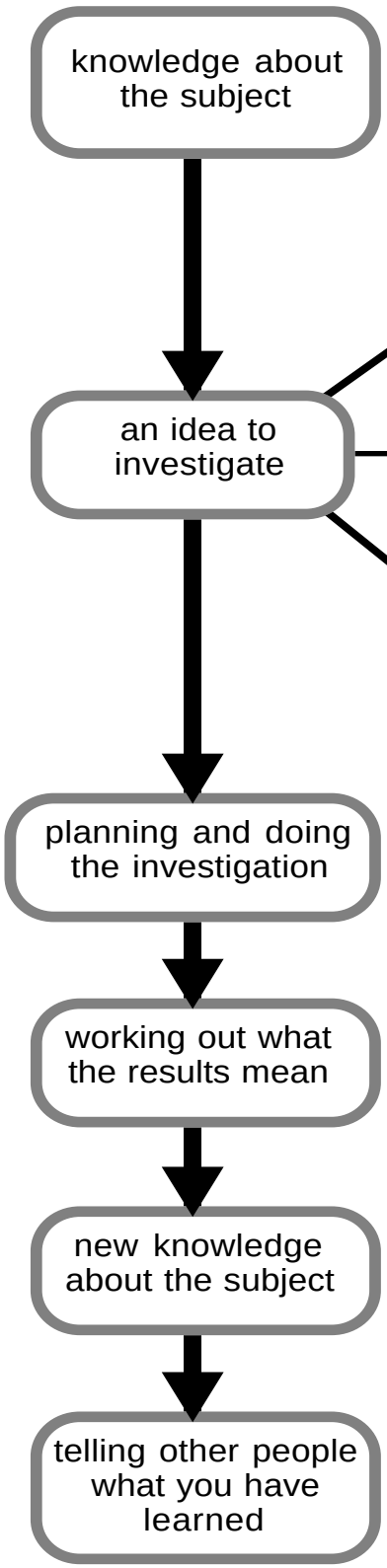
If we know how to make solar panels more efficient we can reduce the amount of energy which comes from burning fossil fuels. Coal, oil and natural gas are fossil fuels.

Read the sheet Green Heating 2 This tells you how scientists begin thinking about doing scientific investigations.

Green Heating 2

Scientists do experiments and investigations. They use their knowledge to think of new ideas that they can test. The ideas could lead to new knowledge about the subject they are investigating.

Steps in an investigation



Take one starting point for your investigation

this could be a question - the investigation might lead to an answer to the question - try answering the question on sheet Green Heating 3

this could be an explanation for something which has been observed - the investigation might show whether the explanation is right or not. An explanation is sometimes called an hypothesis. Try testing the hypothesis on sheet Green Heating 4

this could be a prediction about what might happen if... the investigation might show whether the prediction was right or not. Try testing the prediction on sheet Green Heating 5

this could be the starting point for another investigation, to find out even more new knowledge

a written report, a talk, a poster, a script for a programme

Green Heating 3 Asking Questions

You are going to plan and carry out an investigation to find out the answer to the scientific question set out below. Solar panels absorb energy from the Sun. This type of solar energy is called infrared radiation.

Some coloured surfaces absorb most of the infrared radiation which reaches them. Solar panels with these types of surface would be good at heating up water. Other colours reflect a lot of the infrared radiation which reaches them. Solar panels with these types of surface would not be as good at heating up water.

What colour surface is best at absorbing infrared radiation?

Use the **Investigation Flowchart** to set out your ideas.

When you have finished the investigation, write a report on your work. Use your results to help you answer the question. The answer is **not just the results** - you have to **think** about what the results mean - this will give you your answer. The answer may mean you now know something new about solar panels. Write a report, or plan a short presentation to the class, to tell them what you have learned.

Hypothesising

You are going to plan and carry out an investigation to test this hypothesis:

A solar panel with a black matt surface is better at heating water than a panel with a light shiny surface, since dark surfaces absorb more heat.

The science knowledge that the hypothesis is based on is:

electromagnetic radiation such as visible light and infrared radiation is reflected by light shiny surfaces, and absorbed by dark matt ones. Water flowing through a solar panel with a dark matt surface will be heated up by the energy transferred when it passes through the panel material by conduction.

You now have to think about how you can get evidence showing that the hypothesis is correct or not.

Use the **Investigation Flowchart** to set out your ideas.

When you have finished the investigation, write a report on your work. Use your results to think about whether the hypothesis is right or not. The answer is **not just the results** - you have to **think** about what the results mean - this will give you your answer.

You could then use your new knowledge to think of a new hypothesis about solar panels and how they work.

Green Heating 5 Making Predictions

You are going to plan and carry out an investigation to test this prediction:

If infrared radiation is a form of electromagnetic radiation, like light, then surfaces which reflect light will reflect infrared radiation, and surfaces which absorb light will absorb infrared radiation.

The science knowledge that the prediction is based on is:

the different types of electromagnetic radiation form a continuous spectrum, only part of which is visible light. Each part of the whole spectrum is made up of radiation with wavelengths which range from the very short (gamma rays, X- rays) to the very long (radio waves). Visible light is in between these two extremes. Infrared radiation has a slightly longer wavelength than visible light, and so cannot be seen, but since its wavelength is close to visible light, it has similar properties of reflection and absorption.

You now have to think about how you can get evidence to see if the prediction is correct or not.

Use the **Investigation Flowchart** to set out your ideas.

When you have finished the investigation, write a report on your work. Use your results to think about whether the prediction was correct or not. The answer is **not just the results** - you have to **think** about what the results mean - this will give you your answer.

You could then use your new knowledge to think of a new prediction about solar panels and how they work.