PUPIL RESEARCHER INITIATIVE

# Green Heating

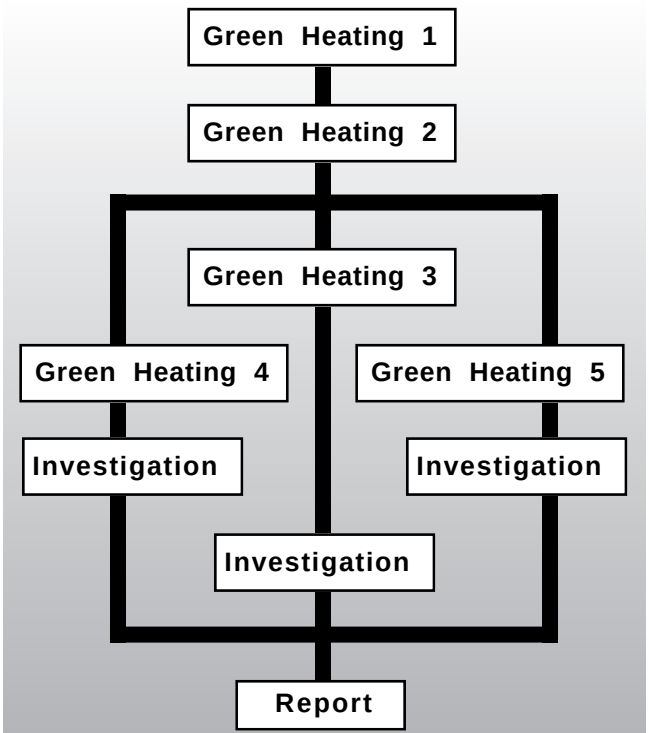
## Pupil Research Brief

## 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.