

## Pillars: Energy, Industry and Infrastructure &amp; Cities

## Overall learning objectives

- To gather and use data to construct Sankey diagrams to illustrate efficiencies and support conclusions.
- To explain how light bulbs can transfer energy and the concepts behind different light bulb technologies, and to use ideas about reflection to design a flood light reflector.
- To evaluate the impact of different technologies on society and different technological approaches to a challenge.
- To conduct cost benefit analysis and evaluate different solutions using set criteria.

## Overall learning outcomes

- Students will have analysed two different sorts of bulb in terms of how they work and how energy efficient they are.
- Students will have used ideas about reflectors to design and test one of their own to meet a particular brief.
- Students will have decided how to apply multiple success criteria.

## Curriculum learning objectives

## Students should have the opportunity to:

## Maths

- Select appropriate mathematical tools and methods, including ICT.
- Use existing mathematical knowledge to create solutions to unfamiliar problems.
- Understand that mathematics is used as a tool in a wide range of contexts.
- Identify the mathematical aspects of the situation or problem.
- Make accurate mathematical diagrams, graphs and constructions on paper and on screen.

## Science

- Describe how explanations of many phenomena can be developed using scientific theories, models and ideas.
- Recall, analyse, interpret, apply and question scientific information or ideas.
- Use both qualitative and quantitative approaches.
- Present information, develop an argument and draw a conclusion, using scientific, technical and mathematical language, conventions and symbols and ICT tools.
- Describe the use of contemporary scientific and technological developments and their benefits, drawbacks and risks.
- Consider how and why decisions about science and technology are made, including those that raise ethical issues, and about the social, economic and environmental effects of such decisions.
- Explain how energy transfers can be measured and their efficiency calculated, which is important in considering the economic costs and environmental effects of energy use.
- Explain how radiations, including ionising radiations, can transfer energy.

## Technology

- Consider issues that affect their planning.
- Check design proposals against design criteria, and review and modify them if necessary as they develop their product.

## Set the scene for the topic

### Introduction

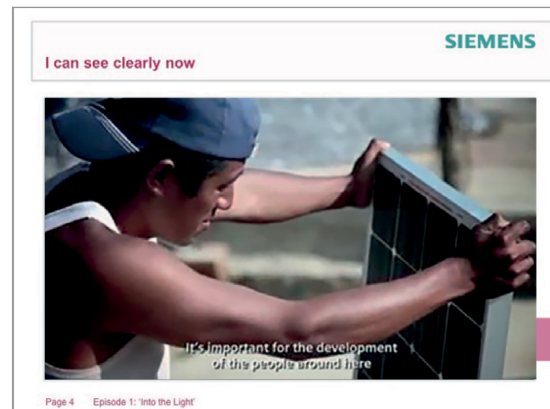
This episode is designed to set the scene and place the topic in a social as well as technical context. This topic is about the effective use of photovoltaic cells and how their use has transformed the lives of villagers in rural Mexico. The first episode sets the scene by showing how the provision of lighting is not only a technical process but has a social impact too.

### Learning objectives

- Students will understand how technical developments such as lighting can have a significant social impact.

### Learning activities

1. Explain that this topic is about lighting and how it can change the way that people live their lives.
2. Show the video “Light Close to Everyone” and ask students to consider these questions
  - a) How did the installation of lighting change the lives of the villagers?
  - b) How did the use of photovoltaic cells make it more practical?
  - c) Describe the quality of the lighting and how well it illuminates the inside of houses.
3. Ask students to talk about the lighting they are used to at home and school and compare it with the illumination provided in the villages shown in the video.
4. Explain that their challenge in this topic is to plan and produce a reflector and supporting information for a design for cheap and even illumination.



### Outcomes

- Students will be able to describe the importance and impact of domestic lighting

## Students to examine technologies

### Introduction

The purpose of this episode is to familiarise students with the technology behind filament and low energy light bulbs.

### Learning objectives

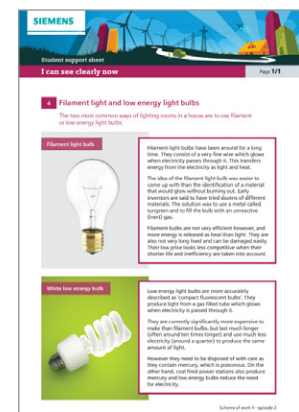
- Students will be able to explain how both filament and low energy light bulbs work.

### Additional resources required

- Filament light bulb
- Low energy light bulb

### Learning activities

- Explain to students that the two most common ways of lighting rooms in a house are to use either filament or low energy light bulbs, though now the filament bulbs in use are either old ones still working or for certain applications such as in refrigerators or cooker hoods. Say that both types of bulb transfer energy from a flow of current to heat and light. However the amount of current used, the amount of heat released and the life expectancy are quite different for the same amount of usage.
- Show the students a filament light bulb. Ideally use a clear bulb so that the filament is clearly visible. Explain that as current flows through the fine wire it glows. Support the explanation with the use of the fact sheet.
- Then show students a low energy light bulb. Ideally this should emit a similar amount of light to the filament bulb. Support the explanation with the use of the fact sheet and a simple demonstration.
- Explain that low energy bulbs have been introduced because although they were initially more expensive and the early ones didn't get to full brightness immediately, they produce less heat for the same amount of time being used and last longer.



### Outcomes

- Students can explain the difference in operation between filament and low energy bulbs and why there has been a switch to the latter.

## Teacher to demonstrate comparison using power meter to compare energy consumption and efficiency, and using light meter to compare effect

### Additional resources required

- A power meter
- A light meter
- Selected appliances
- Filament light bulb
- Low energy light bulb

### Introduction

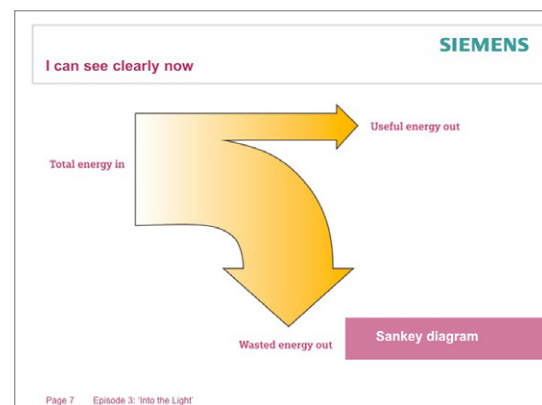
The purpose of this episode is to make it clear how the energy transfers between the two types of bulbs differ in their proportions, how the transfers can be represented graphically by using Sankey diagrams and how this indicates the relative efficiency.

### Learning objectives

- Students will be able to compare the relative proportions of light and heat released by different types of bulbs.
- Students will be able to represent energy transfers quantitatively using Sankey diagrams.
- Students will be able to calculate and compare efficiencies of the bulbs.

### Learning activities

1. Explain that the purpose of this activity is to compare how efficiently each type of bulb transfers energy from electricity to light. Say that you will also be showing how this can be usefully communicated using a special kind of diagram called a Sankey diagram.
2. Show how you can use a power meter to display the amount of power any mains appliance uses (you may want to have some other appliances for the sake of comparison) and that you are going to use it with the two bulbs (one filament and one low energy). Explain that you chose the bulbs to be similar in terms of light intensity; you could demonstrate this by dimming other lights in the room and using a light meter to measure the light output from a set distance. If it is difficult to match the bulbs in terms of light intensity, select a low energy bulb that has a slightly higher light output (it will still have a much lower input). Using the light meter is a useful introduction to that piece of equipment for later on in the topic.
3. Measure and display the power used by each of the bulbs in Watts. Ask students to comment on the difference. Explain that 1 Watt of power indicates that 1 joule of energy is being transferred every second.
4. Explain how we can show the amounts of energy being supplied to a device and released from it by using a Sankey diagram. Explain that:
  - a) The width of the arrows is related to the amounts of energy.
  - b) Total energy input equals total energy output.
  - c) The input is shown on the left and the output(s) on the right.
  - d) The useful output is shown by a horizontal arrow and the wasted output by an arrow on the right curving downwards.



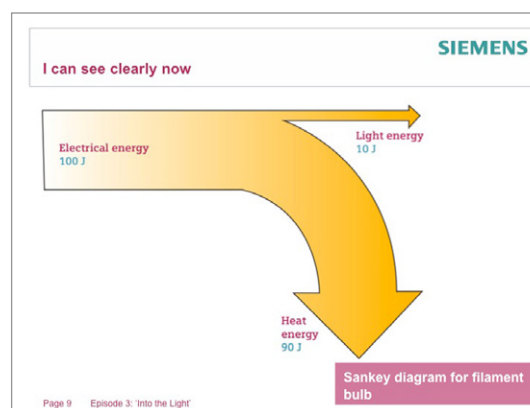
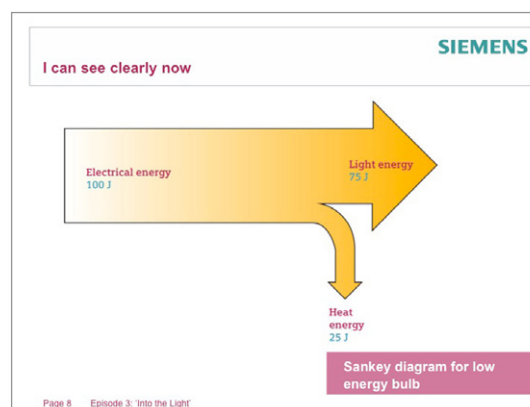
5. Explain that a typical filament bulb is around 10% efficient, so 10% of the output is light and shown horizontal; 90% is wasted as heat. Say that a typical low energy bulb is 75% efficient, so 75% of the output is light and shown horizontal; 25% is wasted as heat.

6. Now ask students to work in groups to draw the Sankey diagrams for a filament bulb and a low energy bulb, each releasing 10J of light per second i.e. 10W (using the efficiencies given above).

7. Take feedback. Draw out responses and show that the filament bulb will be releasing 90J of heat per second (90W) and using 100J/s (100W). Explain that the low energy bulb will be releasing 3.3J of heat per second (3.3W) and using 13.3J/s (13.3W). If these are drawn to the same scale they will indicate quite clearly the difference in energy usage. Point out that the Sankey diagram indicates clearly that the filament bulb has an efficiency of 10% (useful output/total input –  $10/100$ ) and the low energy bulb of 75% ( $10/13.3$ ).

8. Point out that bulbs also use energy in their manufacture and cost money to buy so the life expectancy of the bulbs is important. Low energy bulbs last, on average, around eight times longer.

9. However it is also important to say that the term 'wasted energy' is a value judgement. Ask students to consider whether this is true. Take feedback and draw out that bulbs are sometimes specifically used as a heat source (such as keeping newly hatched chicks warm) and sometimes generally add to heating, such as in a house on a cold evening. It could be argued that they are then more efficient as more of the output is useful.



## Outcomes

- Students understand how the efficiency of the bulbs compare.
- Students know how to display the energy transfers quantitatively using a Sankey diagram.
- Students will be able to calculate efficiency of a system and explain its significance.

## Students then design the reflector for bulb that will produce most even illumination over a stipulated area with the bulb at a stipulated height

### Introduction

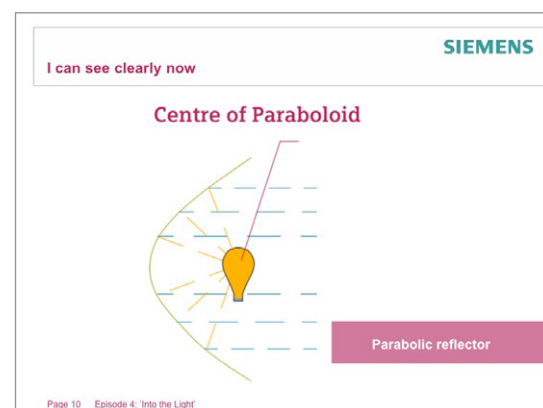
This episode is designed to get students working in groups, generating ideas and using material to devise a practical solution.

### Learning objectives

- Students will apply ideas about reflection to design a reflector.
- Students will be able to explain the ideas behind their design and how it is intended to succeed.

### Learning activities

1. Explain to students that the purpose of this activity is for them to design a reflector for a low energy bulb to produce as strong and even an illumination as possible. They will be able to research their ideas, construct them and test them.
2. Explain that the brief is to reflect light from a low energy down onto an area, in the way that a floodlight works. The bulb will be suspended 1m above the bench and the illumination has to be as even as possible over a circle, 1 metre in diameter.
3. Encourage students to research designs for reflectors. They might look at designs for car headlamps, satellite dishes, torches, etc.
4. Students should then make their design. There will need to be clear guidelines about how it is to be attached to the bulb holder, the materials and the proximity to the lamp; this is, of course, part of the design process.
5. Discuss safety aspects of this and agree ways of ensuring that these are observed in the design process.



### Outcomes

- Students will have used ideas from the topic and their own research to design and construct a reflector.

## Designs to be tested and peer assessed

### Introduction

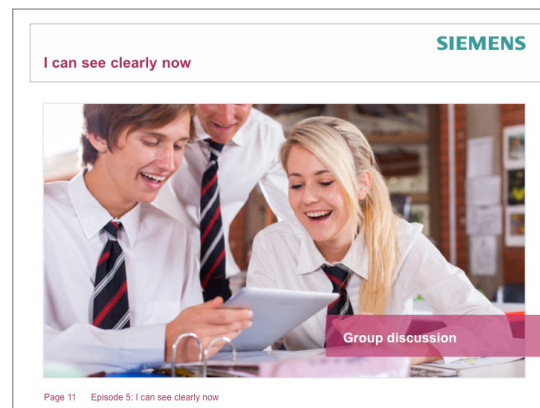
The purpose of this episode is not only to test designs but also to explore the use of success criteria. The brief was to produce illumination that is not only larger in size but also even.

### Learning objectives

- Students will explore the use of success criteria to judge the effectiveness of a design.
- Students will test a design to determine the extent to which it meets the criteria.

### Learning activities

1. Explore with students the idea that with the success criteria calling for strong and even illumination, that both of these need to be taken into account to identify the most effective design. Ask students to consider what might happen if one or the other was effectively ignored. Students may suggest solutions; one would be to take light meter readings at various points in the circle and average them to get an overall score.
2. Discuss safety aspects of this and agree ways of ensuring that these are observed in the testing process.
3. The various designs should be tested and judged.
4. Students should be asked to critically appraise their designs, to identify the strengths and the areas for development. There is an opportunity for peer assessment here as well.



### Outcomes

- Students will have decided how to apply multiple success criteria to judge a successful outcome.
- They will have evaluated their own design.