KS4 Here comes the Sun

Overall learning objectives

- Gathering data and applying it to justify arguments.
- Understanding the process of energy transfer, explaining the operation of internal combustion and photovoltaic cells and applying understanding to propose how clean technologies can be promoted.
- Understanding technical and social systems and comparing alternative solutions.
- Evaluating solutions to identify fitness for purpose.

Overall learning outcomes

- Gathered evidence and justified recommendations for different energy supplies.
- Proposed how a move to the use of more sustainable energy sources can be encouraged.

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.
- Engage in mathematical discussion of results.

Science

- 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.
- Describe how electrical power is readily transferred and controlled, and can be used in a range of different situations.

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Energy Challenger

Introduction

The purpose of this episode is to set the scene. The video shows that in the featured villages, the quality of life in terms of the provision of electricity, clean water and sanitation has been markedly improved.

Learning objectives

- To understand the factors affecting decisions about energy sources

Learning activities

1. **Explain that the group are going to watch a short video which features a number of villages along a river valley which have had technologies involved designed to improve their quality of life.**
2. **Show the video "Project Asha – enhance living conditions through integrated development" and encourage students to consider the changes the villagers have experienced.**
3. **Ask students to consider these questions:**
   a) How does the electricity supply change the lives of the villagers?
   b) Why use photovoltaics to produce electricity rather than a generator powered by a petrol engine?
   c) Can you see any disadvantages to the provision of electricity in this way?

Outcomes

- Students will have understood how electricity was supplied to these villages.
- Students will have formed views about the suitability of the technology.

Students to examine technologies

Introduction

The purpose of this episode is for students to explore the nature of the different technologies and evaluate the advantages and disadvantages of each. It is, therefore, not only about information acquisition but also the identification of key factors that might lead to the adoption or rejection of that technology.

Learning objectives

- To understand how a petrol-generator and photovoltaic cells work and identify their relative advantages and disadvantages
- To apply the concept of energy transfer to each technology

Learning activities

1. **Explain that this episode is going to be about comparing two different methods of producing electricity.**

2. **This part can be organised in two different ways. Students should be organised into groups; one way of delivering this would be for half the students in a group to study one technology and the other half the other. This would promote the importance of the articulation and sharing of ideas in the group. The other way is for all students to study both.**

   a) Finding out about the petrol generator: fact sheet 1 and (ideally) a demonstration or (alternatively) a video clip. Students should understand the fuel is burned and energy transferred as kinetic energy to drive a generator, which produces electricity. It is portable and reliable but releases polluting gases.

   b) Finding out about photovoltaic cells: fact sheet 2 and an experiment to investigate, using one or more solar cells and a voltmeter to show that a potential difference is produced when light falls on it. Students should understand that energy from light is converted to electrical energy and that the output is related to the amount of light and the area of the cells. This can be shown by altering the intensity of the light and the number of cells.

3. **Students should then work in groups to identify key points about the advantages and disadvantages of each technology and summarise these.**

Outcomes

- Students can explain the operation of each technology with reference to energy transfer, the fuel needed and waste produced.
- Students will have compared the advantages of each with respect to the required application.

Students to use data on power generated to compare outputs from systems

Additional resources required

- Solar cells
- Voltmeter

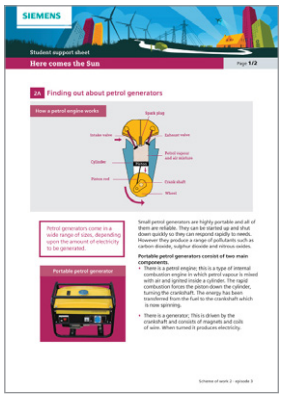
Introduction

The purpose of this episode is to move students' understanding from qualitative to quantitative. Understanding that photovoltaic cells provide an alternative energy supply is important but how viable they are will be influenced by, amongst other factors, size and cost.

Learning objectives

- To identify the key factors about each system including initial cost, running cost, space requirements, waste products and power output.
- To use these factors to develop an understanding of the comparative merits of the two systems.

Learning activities



1. **There needs to be some discussion about what a back-up power supply is required to cover. This will make the activity quite accessible as an internet search on "solar powered lighting" this will produce a string of results which students will be able to process easily. Some students may have first hand experience of using solar powered lighting in their gardens; this can be drawn upon.**

2. **Students need to consider what the key factors are about using a petrol generator that will determine how attractive an option this is. Ask students to work in groups to discuss and agree on key factors to ascertain.**

3. **Then take feedback and draw up a list of key factors. These might include:**
   a) Cost of the generator
   b) Cost of fuel
   c) Fuel consumption
   d) Start-up time
   e) Power output
   f) Waste produced
   g) Noise level

4. **Then repeat with the photovoltaic cells. In this case the factors might include:**
   a) Cost of purchase
   b) Area
   c) Power output

Learning activities, cont'd

5. It may then be worthwhile reviewing the initial assumption about what is to be powered. As soon as the requirements start to run to space or water heating the practicalities start to look rather different. Students could explore what a power allocation of, say, 3kW would run if used with, for example, room heaters and electric kettles. This would be within the range of a small petrol generator but would need a large area of solar cells and could easily run to 15m^2 or more. This moves the activity to one that is arguably more realistic though is harder to quantify, so it may be necessary to have data available for students to use. However, students need to understand that for some of these factors definitive data is not going to be possible as it depends upon a range of factors and also what is considered acceptable.

Outcomes

- Students will have explored the factors related to selecting a power source and attempted to put values on these.
- Students will have made some calculations to quantify the scale of the provision.

Students to consider the question of storing energy and how, in each case, this can be achieved

Introduction

The purpose of this episode is to challenge students to consider how energy can be stored, as this is a key factor. Students should understand that whereas the petrol generator is started up 'as and when', the photovoltaic cells will only work in the daylight. However, this doesn't mean that they aren't a viable alternative.

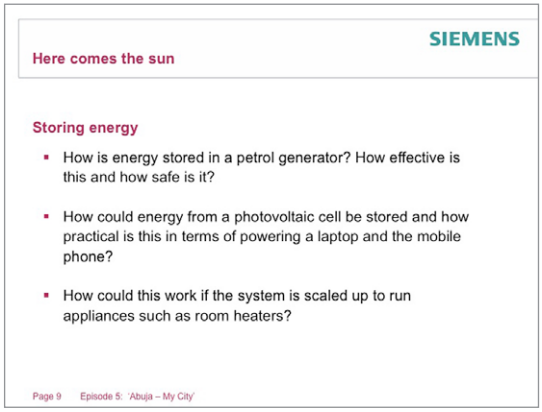
Learning objectives

- To consider the importance of storing energy.
- To explore how different systems store energy in different ways.
- To consider the impact of this on decisions about selecting an appropriate power system.

Learning activities

1. **Ask students to consider whether the question of energy storage is important and how this might relate to the petrol generator and photovoltaic cell options.**

2. **Ask students to consider these questions:**
   a) How is energy stored in a petrol generator? How effective is this and how safe is it?
   b) How could energy from a photovoltaic cell be stored and how practical is this in terms of powering the laptop and the mobile phone?
   c) How could this work if the system is scaled up to run appliances such as room heaters?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Here comes the sun

Storing energy

- How is energy stored in a petrol generator? How effective is this and how safe is it?
- How could energy from a photovoltaic cell be stored and how practical is this in terms of powering a laptop and the mobile phone?
- How could this work if the system is scaled up to run appliances such as room heaters?

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3. **Take feedback and draw out these points:**
   a) Petrol is a practical way of storing energy but there are safety considerations.
   b) Photovoltaic cells could be used to store rechargeable batteries, which can then be used to power devices such as laptops and mobile phones (which, of course, have them installed already) but could be used as a back-up supply, especially at night-time. Cells, batteries, laptops and mobile phones all run at low voltages.
   c) However, room heaters need a higher voltage and considerably more power. The batteries would need to be much larger and would take up a lot of space. (There would also need to be an inverter fitted to convert the low voltage d.c. to higher voltage a.c., which would to the installation costs and complexity.)

Outcomes

- Students will have considered how energy can be stored in each system and how practical it is.
- Students will have used this to inform their views about the advantages of each system.

Students to consider suitability of photovoltaics for a variety of situations

Introduction

By this stage students will probably have come to the conclusion that photovoltaic cells are a more practical and viable alternative in some situations than others. This episode is designed to support students in identifying immediate applications and more challenging ones.

Learning objectives

- Students will apply their understanding from this topic to identifying applications in which photovoltaic cells have an immediate application.
- Students will be able to back up their recommendations with reasons.

Learning activities

1. **Explain that photovoltaic cells have a more immediate and obvious application in some contexts than others. Say that the purpose of this episode is to support them in identifying what the factors are.**

2. **Present the students with a range of applications and ask them to work in groups to suggest how electricity should be produced and why they have suggested that method. They might select from mains supply, petrol generator or photovoltaic cell. The contexts include:**
   a) Remote weather station
   b) Running a washing machine on remote island with no mains supply
   c) Garden lighting
   d) Hospital operating theatre back-up system
   e) Heating system for a marquee
   f) Funicular railway

3. **Take feedback and discuss decisions. Draw out from this why students decided on certain methods. These factors might include:**
   a) Proximity to mains supply
   b) Amount of energy needed
   c) Impact of certain methods, such as noise and exhaust
   d) Reliability

Outcomes

- Students will have applied their understanding of power systems to range of applications and justified their decisions.
- Students will have identified the factors that might influence why one power system is preferred to another.

Use videos "The last flower" and "Photovoltaics"

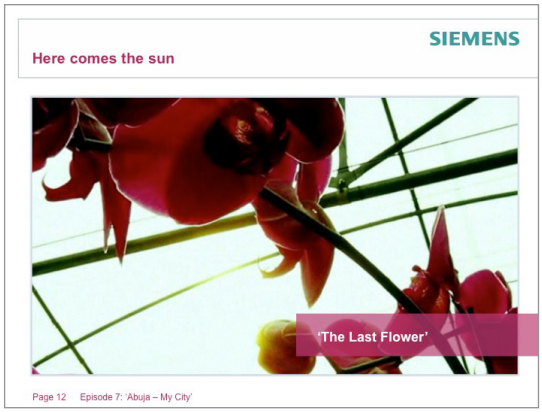
Introduction

The purpose of this episode is to explore the applications of power systems and to emphasise that failures can have particular implications for commercial organisations.

Learning objectives

- To understand how the reliable supply of power is not only useful and desirable but has commercial implications for some organisations.
- To suggest what appropriate responses are to such challenges.

Learning activities



1. **Explain to students that for some organisations the reliable supply of power is critical. This would include medical services, communication systems and a variety of commercial operations. Ask students to suggest other examples.**
2. **Show the video "The last flower" https://www.youtube.com/watch?v=Sdy_EpobzcQ Ask students to work in groups to suggest whether the provision of petrol generators in this situation is an overreaction.**
3. **Now show the video "Photovoltaics". Ask the students to suggest how this might alter their perspective on the potential role of photovoltaic cells in large scale energy provision and whether they are ever likely to be a total solution.**

Outcomes

- To explain how reliability is a key feature of power systems.
- To understand how photovoltaic cells may be a significant part of a large scale system but may not be a total provider.

Students to work in teams to develop and present case as to whether the engineers were right to select photovoltaic cells as an appropriate technical solution.

Introduction

This episode is designed as the culmination of the topic in which students draw together various ideas from different activities to present a view, justify it and propose a way forward.

Learning objectives

- To present key ideas about the role of photovoltaics in developing sustainable energy supplies.
- To suggest ways of promoting their use and encouraging people to make more use of them.

Learning activities

1. **Explain to students that their task is to identify ways in which the use of photovoltaic cells can be promoted, not necessarily as a total solution but as a significant part of reducing pollution.**

2. **Ask students to work in groups and identify:**
   a) The advantages offered by photovoltaic cells.
   b) The kinds of situations in which they are particularly useful.
   c) How they could be used more widely in situations such as remote villages.

3. **Now ask students to prepare a presentation, lasting no more than 60 seconds, which could be used to persuade people to give photovoltaic cells a greater role.**

Outcomes

- To prepare and present a presentation identifying how photovoltaic cells could have a significant role in ensuring a reliable source of energy.