Key Stage 5 Worksheet

Podcast: Clean Energy: revolutionary research to generate, store and use renewable energy by chemist, Dr Ian Mabbett

From the series: Exploring Global Problems, by Swansea University

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Introduction

- How we generate, store and use clean (renewable) energy.
- How engineers are making low-cost, printable solar panels that can be used in the developing world. (You can read more about the developing world, from the Royal Geographical Society, **here)**.
- How engineers and scientists at Swansea University are creating 'smart buildings' that make, store and distribute their own renewable energy, acting as 'energy hubs'.

EXPLORING
GLOBAL PROBLEMS

Listen to the podcast: www.swansea.ac.uk/research/podcasts/ian-mabbett/

Open file in your web browser to click on the links.

Background

The SUNRISE project (read more about it here).

In this podcast, Dr Ian Mabbett talks about his work with the **SUNRISE** project, which plans to revolutionise the use of solar power in India. In India, there are currently 300 million people without reliable access to electricity and there is a big, ongoing effort to solve this problem and provide continuous power. However, this will lead to a huge increase in energy usage. If the extra energy required was supplied by burning fossil fuels, vast amounts of carbon dioxide (CO^2) would be released into the atmosphere. Carbon dioxide is a Greenhouse gas and so contributes to global warming. This would, therefore, have an immense impact on the environment and on global climate.

Background continued

Tackling the UN Sustainable Development Goal – ‘affordable and clean energy’

Ian talks about us having the opportunity to ‘leapfrog’ the use of fossil fuels in countries like India and move straight into clean energy futures.

One of the most important ways in which the developed world can support poorer countries to develop is by helping them transition straight to renewable power generation, without first having to rely on fossil fuels. This means that developing countries can grow, without increasing their greenhouse gas emissions.

Using ‘clean’, renewable energy, such as solar power, could reduce the environmental impact of providing reliable energy in India, to an additional 300 million people.

The SUNRISE project aims to provide affordable, clean energy by:

- Developing new solar panel materials to generate, store and use solar energy, which can be built into new buildings.
- Developing ‘printable’ solar panels, which can be produced using similar methods to T-shirt printing. This would allow solar panels to be built locally in India.
- Bringing down the cost of making solar panels and making them more available to people across India.

Discoveries from watching paint dry.

Ian talks about his previous research into ways to dry paint faster, using **near-infrared (NIR)** light and how this led to the development of new types of solar panels. Infrared (IR) light is light with wavelengths of between 700 nanometres (nm) and 1 millimetre (mm). So infrared light waves are longer than the waves of visible light that we can see with our eyes. Light is made from particles, called photons, which contain energy. By researching how solar panel materials interact with and absorb photons, Ian and his research team developed a way to make printable solar panels. To do this the team painted a layer of special liquid onto the panel, when it dries it leaves a porous, spongey surface which can absorb photons and convert their energy into electrical energy. This happens by transferring the photon energy to electrons (small, negatively charged particles) within the material.

The team have even looked at using their new liquid to coat the steel used in buildings, so the buildings would generate and store solar electricity. This technology is already being used in a building at Swansea University.

This is what the solar-powered building looks like.

The building, Swansea University’s Active Office and Classroom was a runner up in a sustainable building competition! You can read more about it here.

Find out more about it

- **Find out more** about Swansea University's active classroom.
- **Watch this Ted Talk** on 'How to bring affordable, sustainable electricity to Africa'.
- **Try this BBC Bitesize** on different energy sources.
- **Read this NASA Climate** article on the causes of climate change.
- **Read more** about the SUNRISE project
- **Discover the research** into printed solar panels.

Questions

Interactive: Click on box to start typing

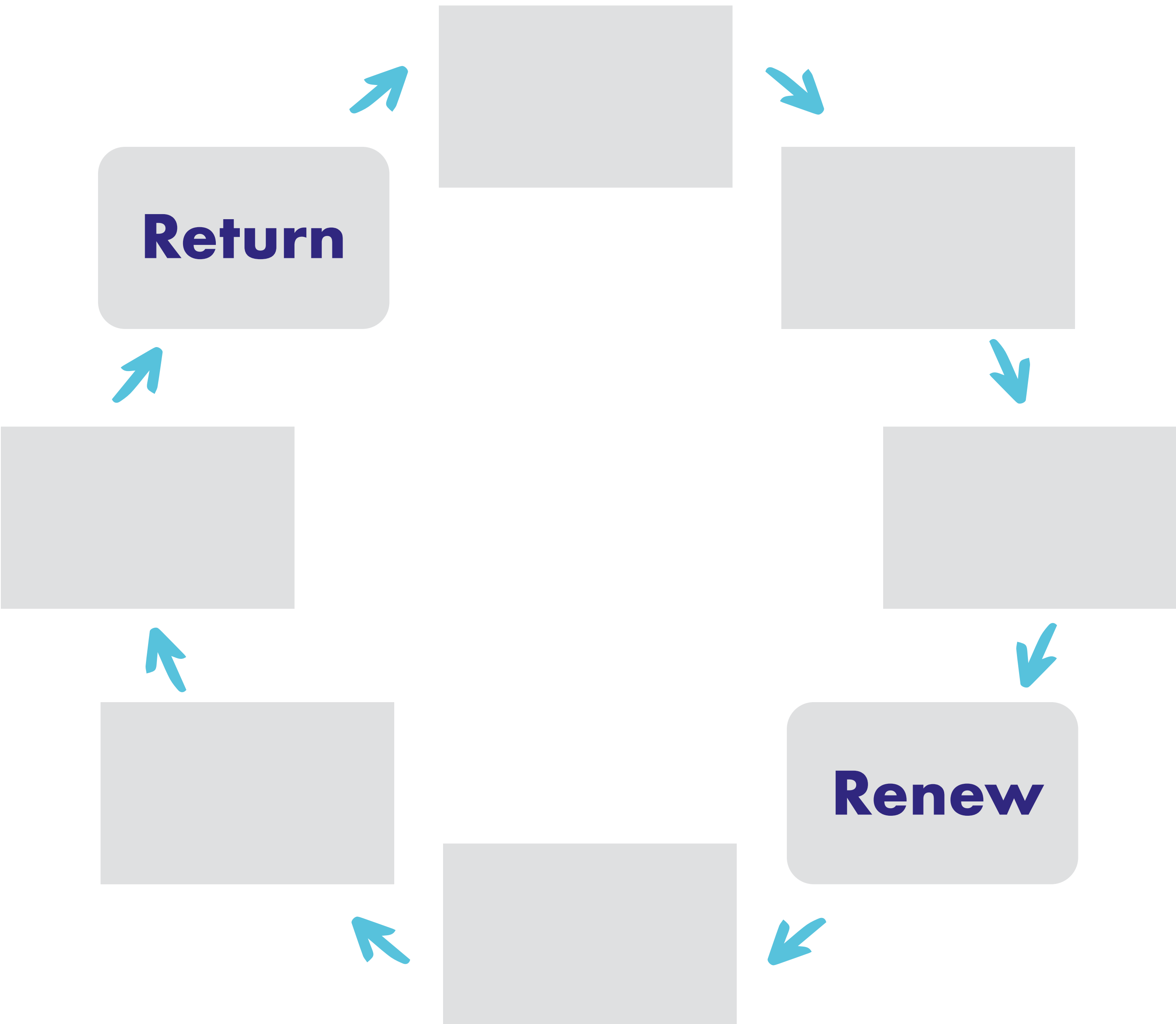
What are the benefits of using solar power to meet India's energy requirements, rather than using fossil fuels?

Explain how a photovoltaic solar panel generates electricity.

Ian talks about the importance of considering a circular economy when designing products, such as solar panels.

i. What does he mean by 'circular economy'?

ii. Draw an example of what a circular economy cycle might look like for a product you own, maybe trainers, or jeans or your phone. There's a video explaining more about what the circular economy **here.**



Exercise

Background information:

A typical rooftop photovoltaic (PV) solar panel:

The Sun has a surface temperature of 5800 Kelvin (K) and a radius of 700,000 kilometres (km). The Earth is1.5 x 10^{11} metres (m) from the Sun.

Questions

Q1. Calculate the Sun's power output (luminosity) using the Stefan-Boltzmann law.

Stefan-Boltzmann law:

$$L_\odot = 4\pi R_\odot^2 \sigma T_\odot^4$$

Where $L_\odot$ is the Solar luminosity, in watts (W).

$R_\odot$ is the Solar radius in metres (m).

$T_\odot$ is the surface temperature of the Sun, in Kelvin (K).

σ is the Stefan-Boltzmann constant = 5.7 x 10^{-8} $Wm^{-2}K^{-4}$.

Q2. Calculate the intensity of the Sun's radiation received at the Earth's atmosphere using the following equation:

$$I = \frac{L_\odot}{4\pi r_E^2}$$

Where I is the intensity, in watts per square metre (Wm^{-2})

$L_\odot$ is the Solar luminosity, in watts (W).

r_E is the Earth-Sun distance, in metres (m).

Q3. The Earth's atmosphere reflects and absorbs solar radiation, reducing the intensity of the Sun's radiation which reaches the Earth's surface. If we assume that the maximum intensity of the Sun's radiation which reaches the Earth's surface in the UK is 50% of that reaching the Earth's atmosphere, calculate how much power reaches the surface of the Earth in the UK, per square metre (m^{-2}).

Q4. Calculate the maximum power output of a 1.5 square metre (m^2) solar panel in the UK, if the solar panel has an efficiency of 15%. Use the equation:

$$\text{efficiency} = \frac{\text{energy output}}{\text{total energy input}} \times 100\%$$

Q5. How many of these solar panels are required to power a 2.4-kilowatt (kW) kettle?

For teachers and home schoolers

Links to Science in the National curriculum for Wales (KS5)

AS Level Physics

- The fact that light can be shown to consist of discrete packets (photons) of energy.
- The fact that the visible spectrum runs approximately from 700 nm (red end) to 400 nm (violet end) and the orders of magnitude of the wavelengths of the other named regions of the electromagnetic spectrum.
- The equation:

$$\text{efficiency} = \frac{\text{energy output}}{\text{total energy input}} \times 100\%$$

A2 Level Physics

- The need for thermal equilibrium: that is the balance between energy inflow from the Sun and energy re-radiated from the Earth in the context of global energy demand and the effect of CO^2 levels in the atmosphere.
- The common sources of renewable and non-renewable energy and be able to compare their development and use both in the UK and internationally.
- How to perform energy conversions using photovoltaic cells (including efficiency calculations).
- The intensity of power from the Sun I=P/A and the inverse square law for a point source.

Swansea University Science for Schools Scheme

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