TEACHER'S GUIDE

The Solar Challenge is an exciting challenge for pupils aged 8-14 years. It enables them to investigate how the generation of electricity using solar cells can transform the lives of people living without access to mains electricity. The challenge is based around Practical Action's work in Gwanda, Zimbabwe.

The Solar Challenge can be used to deliver parts of the science, design and technology and maths curriculum in regular lessons, in an enrichment day, in a STEM/science club or part of a primary-secondary transition activity. Pupils can also gain a CREST Award through taking part in the challenge.

The challenge also offers an exciting Off-Grid! Design competition for pupils to develop a solar based solution to address a real-life problem for rural communities living without mains electricity in Zimbabwe.

The teacher's guide is accompanied by a PowerPoint (PPT) presentation, pupil activity sheets, a poster and certificates. They can all be downloaded for free from practicalaction.org/solar-challenge.

CONTENT

This guide to running The Solar Challenge contains the following:

OVERVEIW

OUTLINE	TEACHING MATERIAL	TIMING (MINS)
Introducing electricity It's electric Electricity in the UK	- Power Point (PPT) slide 2 - PPT slides 3-5	10 mins 5 mins
Starter activity Making The National Grid Renewable energy	- PPT slide 6 - **Pupil activity sheets** (one set per class) - *Making the National Grid - place cards* - *Making the National Grid - power stations* - PPT slide 7	10/15 mins
Solar Energy Uses of solar cells Building circuits to explore the use of solar cells	- PPT slide 8-9 - PPT slides 10-11 - **Pupil activity sheets** (one per pupil) - *Building circuits to explore the use of solar cells* 1) Getting the power 2) How much light? 3) Turning Up the Power	40-60 mins
Heat from sunlight	- PPT slide 12	2 mins
Zimbabwe Electricity in Zimbabwe	- PPT slides 13-15	10 mins
Sustainable Development Goals Gwanda – Zimbabwe Sustainable Development Goals 2,3,5,7	- PPT slides 16-18	5 mins
The Solar challenge What you need to do! Celebrating Success	- PPT slides 19-21 - **Pupil activity sheets** (one set per team) - *Community case studies* - *What does the community in Gwanda need electricity for?* - *How much electricity do appliances use?* - *Appliance energy cards* - *Village map* - *Power to the people! - printed or excel spreadsheet* - Ten units of electricity (one strip per team) - The Solar challenge certificates	60 mins
Sunny solutions in Zimbabwe	- PPT slides 22-23	60 mins
Off-Grid! Design competition Design briefs Judging criteria	- PPT slides 24-27	60-90 mins

LEARNING OBJECTIVES

Through engaging in The Solar Challenge, pupils will:

- Understand what solar cells are and how they can be used
- Solve problems and find solutions to challenges using solar cells
- Explore how the use of solar cells can change people's lives.

CURRICULUM LINKS

STEM subjects provide great opportunities for teachers to include authentic global contexts and global learning. To see where The Solar Challenge supports the delivery of the formal science curricula for England, Northern Ireland, Scotland and Wales pleasego to practicalaction.org/science-curriculum.

RUNNING THE CHALLENGE

We suggest that you read through the PowerPoint (PPT) presentation and pupil activity sheets to help you decide how to run the activities that both lead up to the challenge and The Solar Challenge itself with your pupils.

NB. Some of pupil activity sheets have been differentiated for primary and secondary aged pupils. But depending on the ability range of your pupils – you might choose select activity sheets from both age groups.

INTRODUCING ELECTRICITY

Use PPT slide 2 (It's electric) to encourage the pupils to think about their own use of electrical appliances. You might choose to extend the chart on the PPT slide on a whiteboard to develop a list of the different appliances pupils think of. Then encourage them to consider whether the appliances are powered by battery or mains electricity.

Some pupils may suggest that some appliances can use both (e.g. laptop computer). Acknowledge this as a valid point but encourage them to distinguish between something charged from the mains as opposed to something that uses batteries that are already recharged. Discuss rechargeable batteries too.

Use PPT slides 3-5 to introduce how electricity is produced in the UK. If time permits, encourage the pupils to identify the overhead National Grid cable lines around the school and community. Note that they may need some guidance on this – not all overhead wires are part of the National Grid. Some pictures of grid lines with pylons will help.

EXTENSION / HOMEWORK IDEA

Ask pupils to find out about how and where electricity is generated in their local region.

STARTER ACTIVITY: MAKING THE NATIONAL GRID

Use PPT slide 6 to introduce this starter activity. It enables pupils to realise that every town and village in the UK can be connected to the national electricity supply network, known as the National Grid.

Resources required

Pupil activity sheets
Making the National Grid - place cards
Making the National Grid - power stations;
Pieces of string cut to 0.5m in length (one for each pupil)
Space for pupils to stand and move around (a classroom/hall or outside space is ideal).

Instructions
Write the name of two local villages/small towns and nearest city on the blank cards and if possible include the population size. Hand out the *Place cards* and *Power Station cards* to different pupils. Ask them pupils to spread themselves around the room and to hold up their cards.

Now give each pupil not holding a card a piece of string and explain that they will act as electricity pylons, with string for their power cables.
Demonstrate that each pupil needs to hold the ends of the string in their hands and all the strings must touch each other for the electricity to flow from one pylon to the next. The aim is for them all to connect to each other, thus representing the National Grid. Start with the pupil holding the Power stations card.

Ask prompt questions such as:

- Why is it a good idea wherever possible, to have more than one connection between a town or a village and the National Grid?
- What might happen if one region needs more electricity than the local power station can produce?

Stress that in the UK, we are lucky as most people have a secure electrical supply. Ask the pupils if they think that everyone in the world has access to electricity. Tell them that in many parts of the world, particularly for people living in rural locations many do not access mains electricity.

To simulate this remove the cables that connect to the towns or villages with a population of less than 10,000 people. Ask the pupils questions such as:

- How would you manage without electricity?
- Is it fair that parts of a country get electricity and others do not?
- What other ways could your village/town generate its own electricity?

PPT slide 7 show some examples of the most common methods of generating electricity when mains access is limited and/or people want to generate electricity from renewable energy sources, including solar energy.

You may like to show pupils our renewable energy poster.
Email us schools@practicalaction.org.uk to request a free copy, or download from practicalaction.org/posters

SOLAR ENERGY

PPT slides 8 - 11 explore the use of solar cells and introduce some investigative activities on making electrical circuits using batteries and solar cells. There are three worksheets to support pupils' investigations on building circuits to explore the use of solar cells.

The materials you need to run these activities with a class of 32 pupils working in groups of four is:

AA batteries (16)
Battery holders (16)
Light bulbs 1.5v (24)
Bulb holders (24)
Round buzzers (8)
Electric motors 1.5 to 4.5v (8)
Blades for motors (8)
Crocodile leads (32)
Solar cell 0.45v (8)

A complete solar kit with all these materials has been compiled for us by TTS and is available to purchase from tts-group.co.uk

TE10025 – Practical Action Solar Kit

1) Getting the power
There are different versions of *Getting the power* sheet for upper primary and lower secondary and/or pupils of different abilities. The purpose of this sheet is to get pupils building and testing circuits, and then exploring how batteries can be replaced by solar cells. It uses equipment that is often available in schools, though the solar cells may need to be acquired. The sheet culminates in pupils being asked to compare and contrast batteries and solar cells; this lays foundations for later work on evaluating the practicality of solar powered appliances.

Note that the solar cells need trying out beforehand. They are very susceptible to varying degrees of light (as would be expected) to the extent that they will often work better in one part of the room than another. Using solar cells also highlights the significantly different requirements of bulbs, motors and buzzers. The latter will often work with one solar cell, whereas bulbs and motors may need two or three solar cells in series.

These aspects are, of course, key aspects of the learning. The purpose is for pupils to understand that the light needs to be strong and constant to power some devices so finding out that the number and position of the solar cells is important.

2) How much light?
This sheet is designed to challenge pupils to investigate how solar cells respond to different levels of light. The investigation can be set up in different ways, depending upon the age and ability of the pupils and the equipment available.

Varying the light could be done by altering the distance to the light source. Another variation on this could be to find out whether the angle of the solar cell to the direction of light makes a difference (especially if the light is primarily coming from one direction).

Measuring the electricity produced could be done by seeing how bright the bulbs are/how loud the buzzer is/how fast the motor turns. A quantitative measure would be to use a voltmeter (or multimeter on a voltage range) though this is more likely to be an option in a secondary school.

3) Turning up the power

This sheet explores what happens when more power is used in a circuit. This fits well with the KS2 programme of study (England) for Year 6 for example, in which pupils are expected to identify patterns in the behaviour of different circuits. As with the first sheet it starts with using batteries and then develops into using solar cells. Pupils should learn that just as extra batteries provide more power, so do extra solar cells.

To explore this it is likely that groups of pupils will need to share the use of solar cells or that this part of the activity will need to be demonstrated. This isn't necessarily a problem as it enables the teacher to use some astute questioning to draw out key points.

PPT slide 12 clarifies the difference between solar cells which produce electricity and solar panels which are used to heat up water.

Zimbabwe

PPT slides 13-15 introduce the country context for The Solar Challenge and the facts around how many people live without access to mains electricity in Zimbabwe.

EXTENSION/HOMEWORK ACTIVITY

Set pupils the task to find out more about life in Zimbabwe. In particular how people light their homes, cook, etc. in areas without access to mains electricity.

The Sustainable Development Goals

PPT slide 16 introduces the 17 Sustainable Development Goals (SDG's), also known as the Global Goals. The goals each have a set of targets that if acted upon collectively aim to eradicate global poverty by 2030.

The district of Gwanda in Southern Zimbabwe is introduced on PPT slide 17.

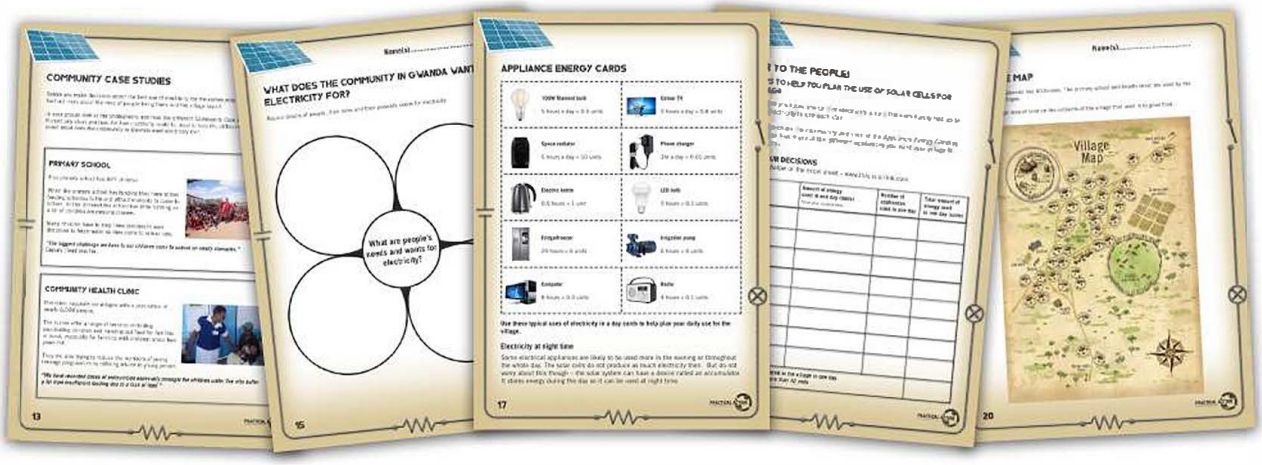
The specific Global Goals that The Solar Challenge will address are presented on PPT slide 18.

If you choose to extend the pupils understanding of the Global Goals, a range of activities and classroom display materials can be found at practicalaction.org/global-goals.

The Solar Challenge
By now, your pupils should have a good understanding of solar energy and of the context of Zimbabwe. This should provide a great foundation for their Solar Challenge activities.

Divide the class into small teams of up to 4 pupils then introduce the challenge with PPT slide 19. Now hand out one copy of the following activity sheets per team:

- *Your Solar Challenge*
- *Community case studies*
- *What does the community in Gwanda need electricity for?*
- *Village map*
- *Team feedback*
- *How much electricity do appliances use?*
- *Appliance energy cards*
- *Power to the people! - Printed or excel spreadsheet*



Depending on the age and ability of your pupils, you might choose to work through the activities with them on PPT slides 20-21 or talk them through the steps for them to work though The Solar Challenge more independently.

Essentially the pupils are tasked with deciding how to use **10 solar cells** to best meet the needs of the community based in a village in Gwanda. They need to combine their research findings from the needs of the community with how much electricity different appliances use and how long they need to be on for in one day to work out the best use of **limited** solar cells.

Pupils can use either the *Power to the People!* sheet or excel spreadsheet to calculate and record their decisions on choice and number of appliances. The spreadsheets can be found here https://practicalaction.org/power-primary and https://practicalaction.org/power-secondary.

Once they have decided on their use of the units, pupils can plot where they would install the solar cells on to the *Village map*. You might want to have a discussion about which direction and where solar cells are best positioned.

We suggest that the pupils give a short presentation to present their ideas. You might want the rest of the class to give each team feedback. In which case, *Team feedback* sheets are provided.

Pupils are asked to comment on:
Teamwork - Did they assign roles well and work together as a team?
Research - Did they use their research to make decisions on recommendation for the use of the solar cells?
Developing and finalising ideas - Did they develop ideas that met the needs of the community?
Village map and/or model - How clearly did they annotate the map or model?
Presentation - How well did the team communicate about their Solar Challenge?

PROMPT QUESTION

It might be interesting to ask the pupils, if there was more funding available for solar cells, what further uses for the community would they suggest?

SUNNY SOLUTIONS IN ZIMBABWE

To round off the challenge, show the pupils PPT slides 22-23 with a story of how the use of solar cells has transformed the lives of people living in another district in Gwanda.

It is important to tell the pupils that the real community in Gwanda decided to use their entire allocation of solar cells to install a solar irrigation system. They felt this would bring about the greatest benefit to all of the community, as families would be able to grow enough food to feed themselves and prevent malnutrition especially amongst children. Any additional foods can be sold at markets bringing additional income for women.

So overall the installation of the solar cells has helped a community to reach a number of the Sustainable Development Goals. These include Goal 2 - Zero hunger, Goal 3 - Improved health and well being, Goal 4 - Quality education and goal 5 - Gender equality.

For further case studies on solar energy, visit Practical Action's website practicalaction.org/plantingforprogress.

CELEBRATING SUCCESS

Certificates are available to congratulate the pupils for taking part in The Solar Challenge and/or to award the team(s) that you and/or the class feel have best met the challenge requirements (and scored thehighest in the *Team feedback* sheets).

CREST AWARDS

Taking part in The Solar challenge is a great way for pupils to gain a CREST Award. The challenge is particularly aligned to the CREST Super Star and Discovery Award, but can equally be used as a context for a Bronze, Silver or Gold Award.

CREST Super Star Award is designed for 7 – 11 year olds. Any of the Building circuits to explore the use of solar cells activities can be condensed into an hour and would enable the pupils to gain one star to add to their Super Star passports.

CREST Discovery Award is generally undertaken by 10 – 14 year olds. It offers a great opportunity for project work as it can be achieved in between three to five hours. The Solar Challenge therefore makes for an ideal project for the Discovery Award.

CREST Bronze and Silver Awards are designed secondary aged pupils. To achieve these awards pupils need to complete 10+ hours (for Bronze) and 30+ (for Silver) of project work. The Solar Challenge makes a good starting point for pupils to identify an independent project based around renewable energy. Further ideas here https://practicalaction.org/global-project-ideas.

For more information on CREST Awards and how to enter your pupils visit the CREST Awards site www.crestawards.org

BIG BANG COMPETITION

Pupils who have taken part in The Solar Challenge can enter their work into the Big Bang Competition.

The Big Bang Competition recognises and rewards young people's achievements in all areas of science, technology, engineering and maths (STEM), whilst providing them with the opportunity to build their skills and confidence in project-based work.

The competition is open to all UK residents in full-time education or training (year group 7-13 and Scottish/NI equivalent), and students can enter online and via regional heats.

The UK Finals take place at The Big Bang Fair in March each year.

Finalists compete for over £20,000 worth of amazing prizes, including top and runner-up prizes in the Junior, Intermediate and Senior categories for science and engineering, as well as the coveted titles of GSK UK Young Engineer of the Year and GSK UK Young Scientist.

For more information go to competitions@BigBangfair.co.uk

OFF-GRID!

Running until June 2019, our Off-Grid! Design Competition is an exciting opportunity for young people aged 8-14 years to extend their work on The Solar Challenge.

Eligibility: Schools and pupils in the UK are welcome to enter. We are happy to accept entries from children who are not in a formal school setting and from children taking part in youth groups.

Age categories: There are two age categories. Primary pupils (aged 8-11years) and secondary pupils (aged 11-14 years). Pupils can enter individually or in a teams of up to four pupils. Please note that due to GDPR we cannot store pupils' names so pupils should enter using a team name or a pseudonym.

Prizes: Practical Action will award the winning primary school and secondary school a £100 worth of STEM kit from TTS. Each pupil(s) in the winning team will receive a £10 voucher and a STEM book.

OFF-GRID!
DESIGN BRIEF

This information is available to share with your pupils on The Solar Challenge PPT slides (25-27).

We would like them to address one of the following problems.

- Lack of refrigeration to keep vaccines cold at rural health clinics
- Lack of water for farmers to irrigate their crops when they live far from water
- No lighting at night time for farmers who want to check on their animals at night time
- No outside lighting in school to enable children to go to the toilet safely at night time.

They can also have free choice – to develop a solar powered solution to a problem identified through The Solar Challenge.

JUDGING CRITERIA

Each activity below will be awarded up to 10 marks (where 10 is the highest).

Background research (10 marks) - include:

- Reading of Community case studies of people from Gwanda
- Solar products that already exist

Initial ideas (10 marks) - Annotate ideas with how they meet the design criteria including:

- Suitability for the user
- Cost
- Sustainability (think about the use of materials and whether they can be easily maintained and repaired)
- Creativity

Final design idea (10 marks) - include:

- How well does your design idea fit the purpose for which it was designed?
- Justify your final idea with comments about how it meets the design criteria.

To support your pupils to enter the Off Grid! Design Challenge – please:

1. Download the Off-Grid! Design competition Research and design sheets from **practicalaction.org/solar-challenge-off-grid**

2. Complete the registration form with school contact details.

3. Send your entries to Off-Grid! **Education Unit, Practical Action, Robbins Building, 25 Albert Street, Rugby, Warwickshire, CV21 2SD**

   Or email your scanned entries to: **schools@practicalaction.org.uk**

All entries must be received by post or email by midday on the 14th June 2019.

We look forward to receiving your entries. For any enquiries about the competition please email: schools@practicalaction.org.uk