SECONDARY LEVEL

POWER FOR EVERYONE EVERYWHERE

SLIDE NOTES

Power for Everyone Everywhere is a hands-on enquiry-based workshop that enables pupils to explore the global issues associated with electricity access and the role that engineering plays in electricity distribution.

UK ENGINEERS WITHOUT BORDERS

Last dated update of this document: 09 September 2019.

This document and the accompanying materials are available to download from: http://www.ewb-uk.org/power-for-everyone-everywhere.

Engineers Without Borders UK is a registered charity in England and Wales (No. 1101849) and Scotland (No. SC043537) and is a company limited by guarantee (No. 4856607).
www.ewb-uk.org

OVERVIEW

Power for Everyone Everywhere is a workshop designed to encourage pupils to explore the challenges associated with access to clean and reliable electricity around the world. Pupils learn about the importance of electricity to people's everyday lives and the role that engineering infrastructure plays in the distribution of electricity. Pupils design, build and test their own wind turbine as part of this workshop. This workshop builds on the Sustainable Development Goals and the concept of global citizenship.

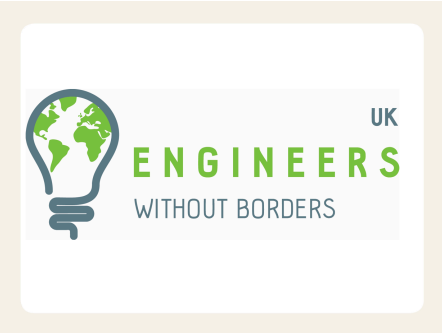
This document is a guide for Engineers Without Borders Ambassadors delivering the presentation. Teachers and youth group leaders can also use it. It should be used in conjunction with the accompanying slides as well as the Facilitator's pack and printouts. Please note that this resource is periodically updated. The date of the last update is on the inside front cover.

If you are not a teacher/youth group leader, please sign up to become an Engineers Without Borders Ambassador to be able to deliver this resource. Find out more and register here on our website. For any queries, please contact Engineers Without Borders UK directly using the email address: outreach@ewb-uk.org.

CONTENTS

INTRODUCTION: HOW WE USE AND RELY ON ELECTRICITY

SLIDE 1: OPENING SLIDE



Display as class enter, if you arrive before them.

SLIDE 2: AMBASSADOR INTRODUCTION

Introduce yourself and anyone else running the session. Each tell the pupils about yourself.
If you are a university student tell the class your:

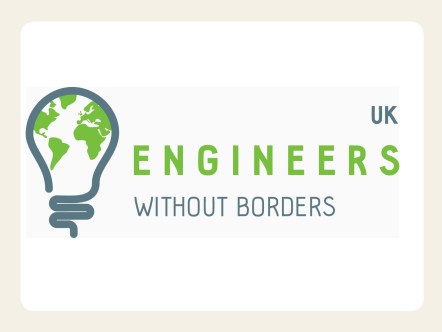
- Name
- University
- Year of study
- Course
- Career plans

If you are not a university student tell the class your:

- Name
- What you studied at university/college
- Profession
- Field of work

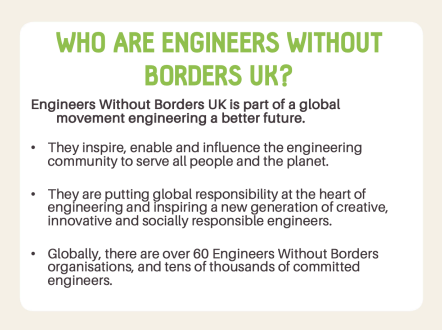
Explain that you are delivering a workshop designed by Engineers Without Borders UK. You could also briefly explain how you got involved with Engineers Without Borders UK.

SLIDE 3: WHO ARE ENGINEERS WITHOUT BORDERS UK?



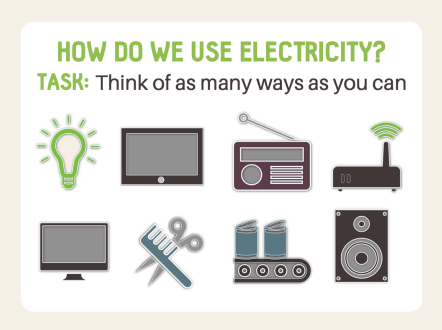
Explain that you are teaching a workshop created by Engineers Without Borders UK.

SLIDE 4: WHO ARE ENGINEERS WITHOUT BORDERS UK?



Introduce Engineers Without Borders UK, a UK based charity engages and galvanises the engineering community to serve all people and our planet better than ever before.

SLIDE 5: HOW DO YOU USE ELECTRICITY?



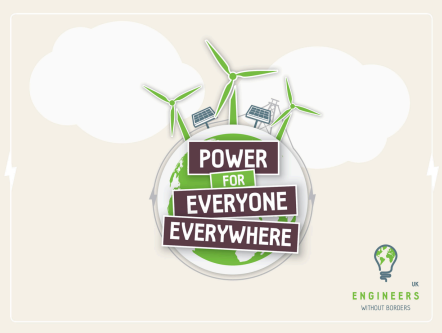
Starter task

- Ask the class to put their hands up with suggestions or prepare A4/A3 paper on tables/use a flipchart.

Summarise the class's response to your question:

- Electricity is used by us to provide lights in our homes and buildings so we can see after dark; for our computers so we can do our homework and do our jobs; it powers our entertainment, from TVs and radios to powering stage lights and sound at music events; businesses use electricity in a variety of ways, hairdressers for example need it for shavers, hairdryers and styling tools, supermarkets need it for lighting up their aisles and powering their fridges and freezers; power is needed to maintain the internet – massive data centers that keep the information require power.

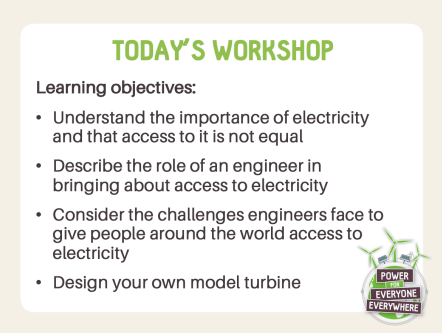
SLIDE 6: INTRODUCTION



Following the starter task:

- Introduce the session as 'Power for Everyone Everywhere'.

SLIDE 7: TODAY'S WORKSHOP



Summarise the overall aim of the workshop: to deepen their understanding of what engineers do and the global challenges that engineers are working to address.
Share the learning objectives of the workshop explaining what they will be doing to meet each one:

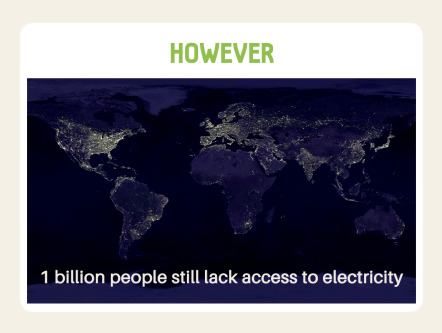
- Understand the importance of electricity and that access to it is not equal - to do this the class will be looking at a mind map of what life is like without electricity and explore a case study on wind power in Malawi.
- Describe the role of an engineer in bringing about access to electricity - throughout the workshop the class will be learning the key role engineers play in the different stages of enabling access to electricity.
- Consider the challenges engineers face around the world - the class will explore the challenges engineers face when supplying electricity to everyone everywhere.
- Design your own model turbine - the class will be showing engineering skills in a practical activity to design, build and test out their turbine.

SLIDE 8: ELECTRICITY IS IMPORTANT

Deduce from the starter activity that hopefully the class can see that power is pretty important for human life.

- Access to electricity enables us to do so many things; it's hard to imagine what life would be like without it.
- In many cases it enables us to do things more quickly and with less manual labor than we would otherwise need. As a result, we have more time for other things like education, earning an income and socialising.
- These things include transport, refrigeration (to make food last longer), entertainment and washing systems like washing machines and dishwashers.

SLIDE 9: HOWEVER



Explain that despite the fact that electricity helps us in so many ways and is an important part of our lives:

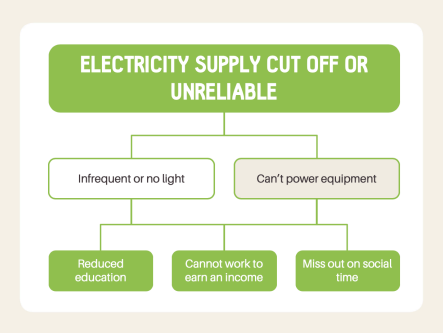
- There are 1 billion people around the world who still lack access to electricity, the equivalent of around 1 in every 8 people.
- This image shows the world at night when all the lights are lit up – highlighting the where people do and don't have access.

Ask pupils if they can identify areas that are the most/lest lit up (take a few responses).

https://www.iea.org/newsroom/news/2018/october/population-without-access-to-electricity-falls-below-1-billion.html
Image:
http://eoimages.gsfc.nasa.gov/images/imagerecords/55000/55167/earth_lights_lrg.jpg

HOW DOES EVERYONE EVERYWHERE GET ACCESS TO ELECTRICITY?

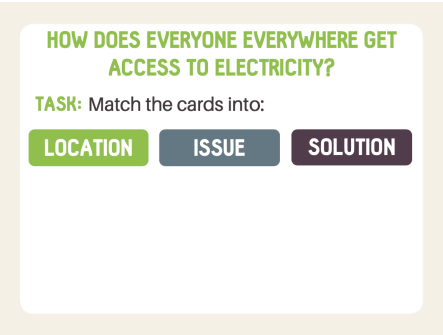
SLIDES 10-19: THE IMPACT OF NOT HAVING ACCESS TO ELECTRICITY



Using the graphic, address the consequences to peoples' lives of not having access to electricity.

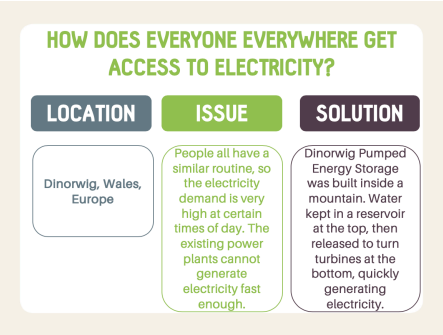
- Explain that when your life is affected in this way, you do not have lighting to see after dark.
- Explain that this limits the time available for educational study.
- This may in turn reduce your future chances of employment.
- It may mean that you don't have as much time to work and earn a living, reducing the amount of money you have to buy food and other items.
- It may also mean you have less time to socialise with your friends.
- Explain that when your life is affected in this way, you do not have the ability to power electrical equipment.
- This limits educational resources, as pupils have no internet access or use of interactive whiteboards.
- This may in turn reduce your future chances of employment.
- It may mean that you don't have as much time to work and earn a living, in turn reducing the amount of money you have to buy food and other items. You may not be able to use electrical equipment that would make your work easier, more efficient or more profitable.
- It may also mean you have less time to socialise with your friends and family.
- For those 1 billion people who lack access at all, these impacts are a daily reality. But even when people have access there are still many issues and challenges associated with access to clean reliable electricity, and the potential impacts of lacking access remain true for everyone.
- Explain that you are going to tell them about four examples from around the world highlighting the local challenges people are facing regarding access to clean reliable electricity and what they are doing to overcome these challenges.

SLIDE 20: CASE STUDIES CARD SORT ACTIVITY



Explain that the class are going to be looking at four case studies that highlight how different communities around the world are addressing issues relating to access to electricity.
The first case study is already solved, as an example. Read through the next few slides, to give the class an idea of what to do for the activity.

SLIDES 21-23: DINORWIG CASE STUDY – CARD SORT ANSWERS



When reading through the example case study, answer any questions from the pupils if they do not understand the matching process.

Note: Coloured blocks appear one after another as you progress through the slides.

SLIDE 24: DINORWIG CASE STUDY

Summarise this case study, highlighting the issue that people tend to use more electricity at certain times (such as when they boil the kettle in the advert break, or cook dinner at the same time) rather than using electricity evenly throughout the day. This means that sometimes power plants aren't needed at all, and sometimes they have to run at full capacity. This isn't very efficient as they have to be 'turned on and off' but using Dinorwig Pumped Energy Storage means that a huge amount of electricity can be generated very quickly and efficiently.

SLIDE 24: DINORWIG - FULL CASE STUDY NOTES

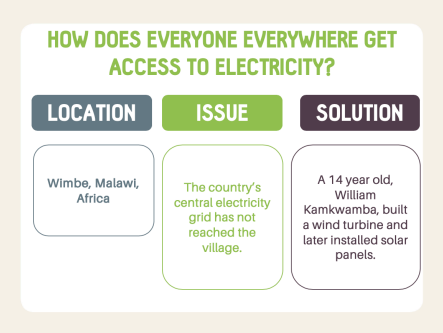
Full case study notes:

This is an example about the electricity challenges facing people in Wales, Europe.

- The National Grid experiences high demand at certain times. The country can produce the amount of electricity required but not very quickly if only conventional power stations are used. So, they decided to construct Dinorwig Pumped Energy Storage.
- The power station was built inside the mountain, as the interior had already been excavated when it was the site of a mine. This also meant that the natural beauty of the area was preserved.
- Water is pumped to reservoir the top of the mountain over 7 hours, which is done when electricity demand in the country is low.
- When electricity is suddenly required, the water is released, which turns turbines as it falls under gravity, producing electricity. This returns the water to the reservoir at the base of the mountain.
- The power station can generate 6 x 400 MW over 5 hours, starting 12 seconds after the water is released.

https://www.electricmountain.co.uk/Dinorwig-Power-Station
https://www.electricmountain.co.uk/About
https://www.electricmountain.co.uk/History

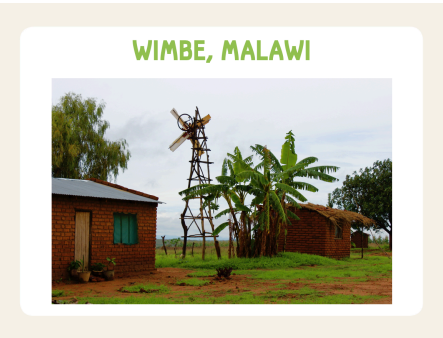
SLIDES 25-27: WIMBE CASE STUDY – CARD SORT ANSWERS



Use these slides to go over correct card matching, getting groups to feedback on what they think the next card should be.

Note: Coloured blocks appear one after another as you progress through the slides.

SLIDE 28: WIMBE CASE STUDY



Summarise this case study, highlighting the impact that one hard working individual (even at age 14) can make and discuss what the turbine in the picture looks like.

SLIDE 28: WIMBE - FULL CASE STUDY NOTES

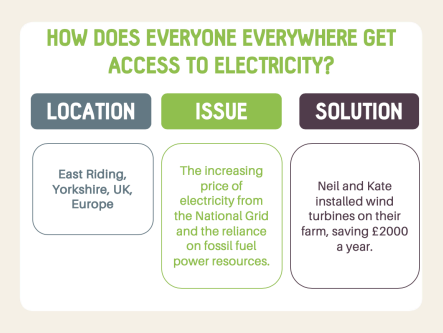
Full case study notes:

This is an example about the electricity challenges facing people in Wimbe, in Malawi, Southeastern Africa.

- The country's central electricity grid has not reached the village, so the residents are unable to power electrical devices such as lighting. This means that when it gets dark, they cannot see to read, socialise or make a living.
- 14-year-old William Kamkwamba studied in the local library and found out about harnessing the wind for power.
- He decided to build a wind turbine and as a result successfully powered electrical devices in his family home.
- He also managed to bring light into six other homes nearby through solar power and has since gone onto develop other technologies [1].

[1] http://williamkamkwamba.typepad.com/about.html
Image: http://www.theforesightinitiative.com/innovationandprogress/

SLIDES 29-31: EAST RIDING CASE STUDY- CARD SORT ANSWERS



Use these slides to go over correct card matching, getting groups to feedback on what they think the next card should be.

Note: Coloured blocks appear one after another as you progress through the slides.

SLIDE 32: EAST RIDING CASE STUDY

Summarise this case study, highlighting the issues/ solutions for rural England. Compare what the turbine in the picture looks like.

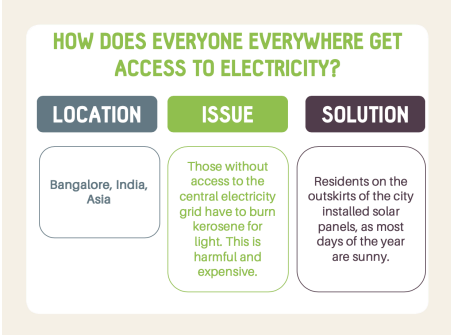
SLIDE 32: EAST RIDING - FULL CASE STUDY NOTES

Full case study notes:
This is an example is about East Riding in Yorkshire, UK.

- In the UK, the price of electricity from the National Grid has been increasing and there are regular reports of the fossil fuels upon which the national grid relies suffering from shortages [1]
- Neil and Katie May run a 250-acre farm in East Riding, Yorkshire.
- They decided to address their rising electricity bills and reduce their reliance on electricity from the National Grid by installing a wind turbine on their farm.
- They save around £2000 a year on their electricity bills and are finding that other people are really interested in doing the same.
- They have also found that people are keen to buy their farm's produce as it comes from a farm using renewable electricity. [2]

[1] http://cleantechnica.com/2014/05/18/eu-facing-severe-fossil-fuel-natural-resource-shortages-near-future-report-warns/
[2] http://www.renewableuk.com/download.cfm/docid/F89DF9C7-7912-4B9C-8CEA59E08BC3B2F3
Image: http://www.sunwindenergy.com/wind-energy/buying-trip

SLIDES 33-35: BANGALORE CASE STUDY- CARD SORT ANSWERS



Use these slides to go over correct card matching, getting groups to feedback on what they think the next card should be.

Note: Coloured blocks appear one after another as you progress through the slides.

SLIDE 36: BANGALORE CASE STUDY

Summarise this case study, highlighting that issues are wide spread from rural to urban areas. Mention the need for governments to recognise power issues and address them in a globally responsible way.

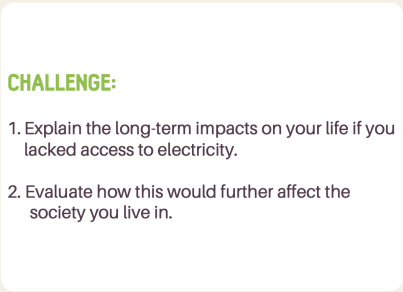
SLIDE 36: BANGALORE - FULL CASE STUDY NOTES

Full case study notes:
This example is about Bangalore, a city in India.

- Not everyone in the city has access to the central electricity grid, so lighting is an issue.
- To combat this, the Indian government subsidises kerosene, which generates a flame to bring light into people's homes. However, kerosene creates a smoke that is harmful when inhaled and is still an expensive resource.
- Instead, residents of Ashraya Nagar, an informal settlement on the outskirts of Bangalore, have started installing solar panels on their homes. [1]
- With around 300 clear sunny days a year, this solar power is a cheaper, healthier way to bring light into their homes so that they can read and socialise after dark.

[1] http://www.eenews.net/stories/1059992166
Image: SELCO

SLIDE 37: CHALLENGE



Ask the pupils to reflect on what they have learned about how not having access to electricity can affect people's lives, and think about how it would affect them, and their lives. Ask them to think more broadly about how a lack of access to electricity could affect society.

SLIDE 38: THE SUSTAINABLE DEVELOPMENT GOALS

Introduce that alongside local action, global leaders are also taking the issue of access to clean, reliable electricity seriously.

- In 2015, global leaders from countries all over the world made a commitment to take 17 global challenges seriously and aim to address them all over 15 years (up to 2030).

https://www.un.org/sustainabledevelopment/sustainable-development-goals/
Image: http://www.globalopportunitynetwork.org/sustainable-development-goals-reconnecting-businesses-with-society/#.VkCT-67hDMU

SLIDE 39: THE SUSTAINABLE DEVELOPMENT GOALS

The world leaders recognise that ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth – all while tackling climate change and working to preserve our oceans and forests.
The 7th Sustainable Development Goal is related to giving people access to electricity.

[1] https://sustainabledevelopment.un.org/?menu=1300
Image: http://www.globalopportunitynetwork.org/sustainable-development-goals-reconnecting-businesses-with-society/#.VkCT-67hDMU

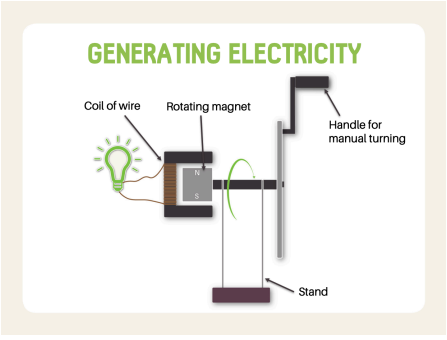
SLIDE 40: THE SUSTAINABLE DEVELOPMENT GOALS

The aim of the 7th Sustainable Development Goal is to give everyone everywhere access to affordable, reliable, sustainable and modern energy, by 2030.

https://sustainabledevelopment.un.org/?menu=1300

REFLECTION ACTIVITY: ELECTRICITY ACCESS ISSUES

SLIDE 41: GENERATING ELECTRICITY

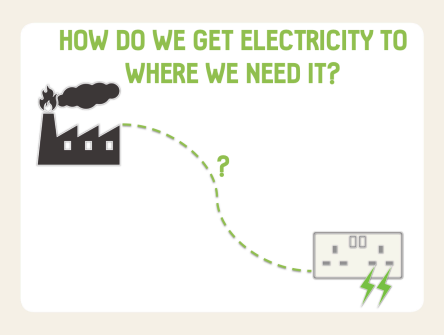


Explain to the class that the first thing they need to understand is that electricity needs to be generated – it can't be found in nature.
Ask the class if they have studied the generation of electricity, possibly in a power station. If they can get them to name key parts (turbine and generator).
If the class has not yet covered this in science lessons, don't worry, use this simple explanation and assure them that they will learn about it some other time.

- The basic principle is that if a magnet moves near a wire an electrical charge is induced.
- Most of the time, the movement we use is a rotational movement. The magnet can be rotated close to a coil of wire, if we were doing this by hand it might look something like this hand operated torch – as you move the handle the magnet moves around near the coil, generating electricity and powering the light inside the torch.

We don't want to be sitting around all day moving magnets over wires. Therefore, you need a power resource to transfer energy into kinetic energy, to provide the rotational movement.

SLIDE 42: HOW DO WE GET ELECTRICITY TO WHERE WE NEED IT?



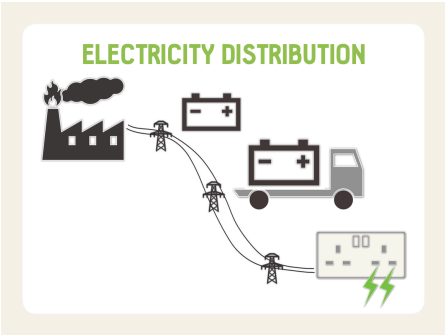
Explain that once we've managed to find the power resource and use it to generate electricity, the next thing an engineer needs to do is get the electricity to where we want to use it. Mention that in some cases the electricity is generated a long way from where we want to use it. So, ask the class to answer this question:

- How do you think that electricity is taken from where we generate it to where it needs to be used?

You could either have pupils shout out answers and then you reiterate them or, you could use a white board / flip chart to list them down for all to see. Alternatively, you can run through this yourself, especially if you are running behind schedule.

Note: next slide is a summary of the answers, so get a few contributions first before moving to the next slide

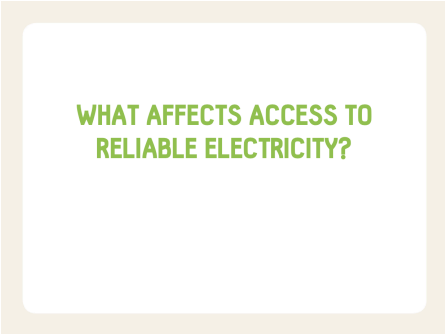
SLIDE 43: ELECTRICITY DISTRIBUTION



Summarise the class's response to your question with this slide/run through these yourself without asking the class.

- You can go and charge a battery yourself and bring it back to where you need to use the electricity.
- You could charge up lots of batteries and then transport them using a truck.
- You can connect the point of generation up with the point of use using cables either buried in the ground or across the land using electricity tower (this is generally how we get most of our electricity in the UK).

SLIDE 44: WHAT AFFECTS ACCESS TO RELIABLE ELECTRICITY?



Explain that we have looked at how engineering brings clean, reliable electricity to you to use. However, it is not always an easy exercise and that is what makes it a challenge.

SLIDE 44: OPTIONAL ACTIVITY

Optional Activity:
Explain that we are now going to do a small activity to reflect on the impact of electricity and explore what factors affect access to clean, reliable electricity.

- Give each group a scenario card and tell them that they need to explain the impacts of the situation and identify factors they must consider and further information they would need, to better understand the context of the issue before thinking about an appropriate solution.
- Give the class 2 minutes to read the scenario, 5 minutes to share ideas that they will present. Reassure groups that there is no right answer and that this would be an initial step in attempting to solve different challenges.
- You can challenge groups to further suggest what suitable solution ideas they initially have to help address the issue.

Notes: Use the information to support groups in thinking of solutions.

Scenario 1: challenges of getting access in the first place

- You could physically move the population group so that they are visibly far away from everyone else, this will help you to highlight that they may not be connected because it's too difficult due to the terrain or distance. It could be too expensive and the money isn't available, it could be that there currently aren't enough materials available to put the cables in place or that there aren't currently enough people who know how to put the cables in place available to come and build it for them – installing electrical cables can be dangerous and requires technical knowhow about how it all works, if they need help with this suggest they think about a time something has broken at home and how long it has taken for someone with the right skills to come and fix it.

Scenario 2: challenges of a Technical failure

- Even once you have access to electricity, there are factors that could mean this access is affected.
- A technical failure/breakdown of the electricity distribution system could mean that you no longer have access to electricity. This could be due to not maintaining the system, or something breaking the cable affecting the reliability of the system.
- Highlight that the groups downstream now face similar issues to the first population groups you highlighted that weren't connected to the power resources.

Scenario 3: challenges of Demand changes

- When the population increases but the existing system was only able to support the previous population size. Now that there are more people demanding electricity in the same place there isn't as much electricity for each person as there was before.
- Suggest that the people living here might need to change their day to day use accordingly otherwise there won't be enough for everyone. If there's enough money, materials and skills then a bigger system can be built to provide more electricity, but this will take time.
- The same problem would occur if the existing population had changed their lifestyles to demand more electricity. Conclude by saying that another factor affecting access to clean, reliable electricity is the balance between available supply and the human demand.

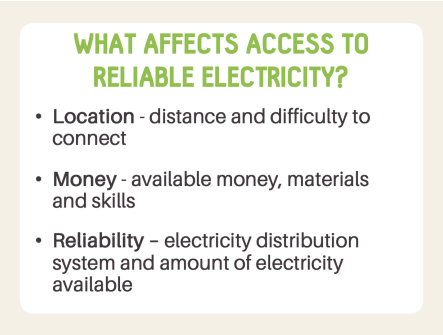
Scenario 4: challenges of Supply issues

- A significant reduction/no wind this year and therefore no wind power was available to generate electricity.
- Conclude by highlighting that the availability of power resources fluctuates, the wind doesn't always blow, the sun doesn't always shine, fossil fuels may become too expensive. Therefore, availability of the power resources is a significant factor affecting access to electricity.

Scenario 5: challenges of Climate change

- Explain that governments have decided that they need to take drastic action and significantly reduce the amount of fossil fuels used to supply our electricity. Disconnect the coal-fired power station.
- Again, ask the affected population groups to identify themselves.
- Explain that climate change is not something we can ignore so we need to do something about our reliance on fossil fuels. Maintaining access to electricity whilst trying to avoid further contributing to climate change is a huge challenge that engineers are working to overcome.

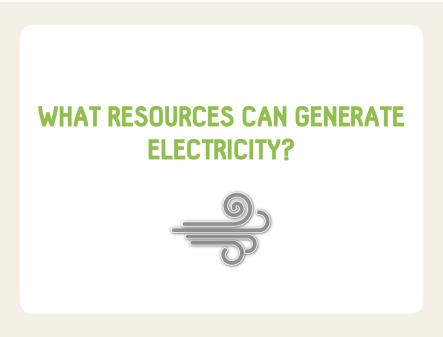
SLIDE 45: WHAT AFFECTS ACCESS TO RELIABLE ELECTRICITY?



- Thank the volunteers that participated in the activity and invite everyone to sit back in their seats.
- Use this slide to summarise the key factors that affect access to clean, reliable electricity by referring to the bullets on the slide.
- Conclude the activity by highlighting how difficult it is to get access to clean, reliable electricity and therefore we need engineers to give everyone everywhere access to electricity.

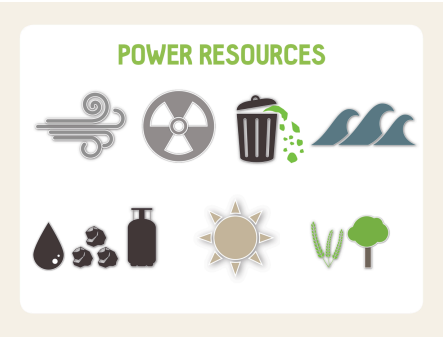
THE ROLE OF ENGINEERING

SLIDE 46: WHAT RESOURCES CAN GENERATE ELECTRICITY?



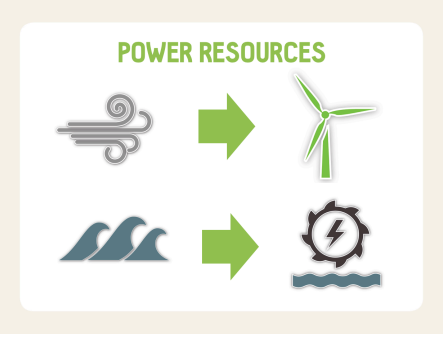
Explain that there are many other power resources that can generate electricity. Ask the class to come up with suggestions of power resources, such as the one shown on the slide (wind) which can be used to generate electricity from kinetic energy.

SLIDE 47: POWER RESOURCES



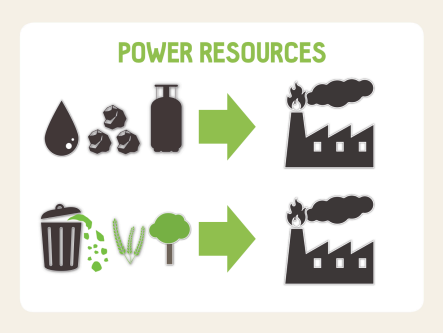
Ask the class to put their hands up to name the power resources they can see on the board, that have not been previously suggested.

SLIDE 48: POWER RESOURCES



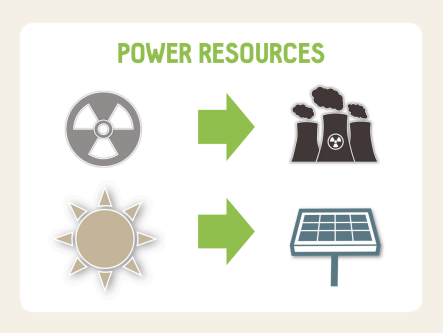
Things that themselves can move/push the generator around, like the wind and moving water for example in a river or a waterfall or in the sea. Here you can see that these resources are harnessed using turbines, as the wind or water flows through the turbine, the blades are specially shaped to capture this flow motion and turn it into a rotational movement.

SLIDE 49: POWER RESOURCES



Things that generate heat which makes steam. The pressure of the steam is then used to push the generator around. These things can be harnessed by burning things like coal, oil, gas, our rubbish, and wood.

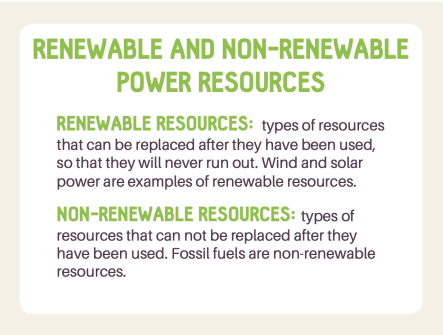
SLIDE 50: POWER RESOURCES



Nuclear radiation can also be used to generate heat to make steam, which is used to push the generator around.
Explain to the class that there is another valuable resource that generates electricity, but in a different way to moving wire and magnets.

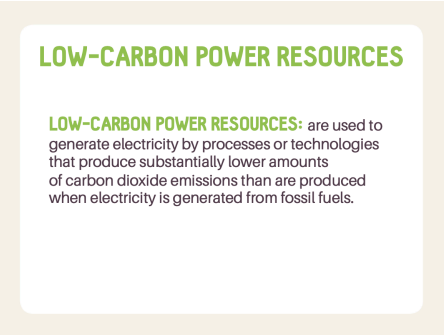
- Solar panels can be made of a special material that generates electricity when it is exposed to sunlight. This type of solar panel is called photovoltaic. So, the sun is another valuable resource that can be used to generate electricity.
- (The other type of solar panels are thermal, and they get very hot and are used to heat water for people to use in their homes.)

SLIDE 51: RENEWABLE AND NON-RENEWABLE POWER RESOURCES



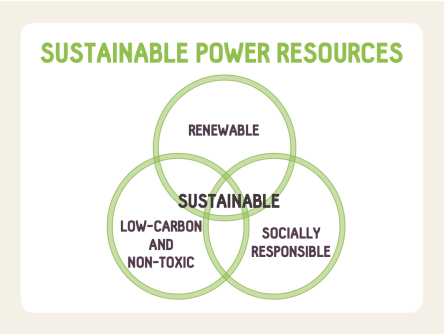
Now tell the class that you are moving onto ways we can classify different types of power resources.
Ask if the class knows the difference between renewable and non-renewable power resources. If they have already learned about this in school, then you can cover this slide with a quick recap. if not then make sure you explain the difference between the types of power resources and ask the class to give additional examples of each.

SLIDE 52: LOW-CARBON POWER RESOURCES



Explain what low-carbon power resources are. Ask the class to suggest what a examples of low-carbon power resources might be.

SLIDE 53: SUSTAINABLE POWER RESOURCES



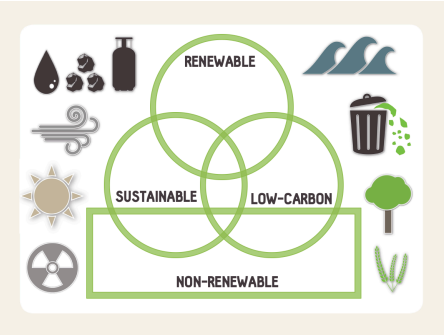
Explain that for a power resource to be sustainable, it must meet the three criteria in the Venn diagram, not just one or two of them. Essentially, it must be renewable, low-carbon and not damaging to the quality of life of humans.

Chapter 1 in the Energy Systems and Sustainability book (ISBN: 9780199593743)

SLIDE 54: POWER RESOURCES

Give the class a couple of minutes to decide in pairs or small groups which criteria they would use to group the resources. Take feedback from a couple of groups. Build on these categories on the next slide.

SLIDE 55: DEFINING POWER RESOURCES



- With the class, go through each power resource and decide where in the Venn diagram it belongs.
- Explain that these are considerations engineers must take into account when choosing a power resource.
- Highlight that even between renewable resources the reliability will differ depending on availability (i.e. days of sunshine for solar power).

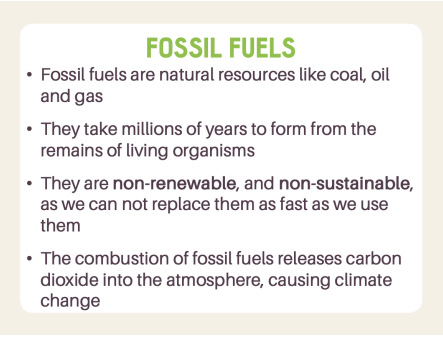
SLIDE 56: WE NEED TO BE AWARE

Remind the class about one of the issues you raised at the beginning and in the power resources activity:

- That electricity production sometimes uses fossil fuels and these produce pollutants which are contributing to climate change.
- Climate change will detrimentally affect the lives of many people on the planet through more frequent and more severe weather events such as hurricanes, flooding, extreme heat and extreme cold.
- Oil, coal and gas are all forms of fossil fuel. In the UK they currently account for around 60% of our electricity production and the same is true for much of the rest of the world. [1]
- Whilst we would like to stop using them to prevent further contributing towards climate change, we are currently very reliant on them and have not yet found an alternative that will fill the gap that would be created if we stop using them.
- Electricity is incredibly important to our everyday lives, so it is difficult for us to think about not using it. Instead we need to think of ways to reduce our electricity consumption and move towards using low carbon or renewable power resources

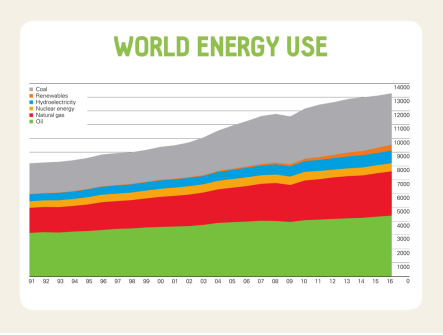
[1] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/450302/DUKES_2015.pdf

SLIDE 57: FOSSIL FUELS



Recap the negative aspects of using fossil fuels as a power resource. Explain that, despite this increased electricity demand is meaning that even more fossil fuels are being burnt.

SLIDE 58: WORLD ENERGY USE



Talk to the class about what the graph of world energy use shows and point out that all the power resources used are fossil fuels with the exception of the orange, blue and yellow band. However, use of renewables is clearly increasing. It also shows that global energy demand has been increasing, other than the recession in 2009, where there is a dip in the graph.
The graph is time in years (from 1991 to 2016) against energy in units Mtoe.

https://www.bp.com/content/dam/bp/en/corporate/powerpoint/energy-economics/statistical-review-2017/bp-statistical-review-of-world-energy-2017-full-slidepack.pptx

SLIDE 59: GLOBAL POPULATION INCREASE

GLOBAL POPULATION INCREASE

ISSUE: World population will continue to increase until 2100. This means that we will need to generate and conserve more electricity, so that everyone everywhere can have access to electricity.

	POPULATION (BILLIONS)			
YEAR	2015	2030	2050	2100
WORLD	7.3	8.5	9.7	11.2

Explain that as population increases, we must try harder to conserve electricity, so that there is enough for everyone without further increasing the ongoing damage to the planet.

United Nations, Department of Economic and Social Affairs, Population Division (2015). World Population Prospects: The 2015 Revision, Key Findings and Advance Tables. Working Paper No. ESA/P/WP.241.

THE ROLE OF ENGINEERING

SLIDE 60: WIND TURBINES

WIND TURBINES

Electricity generated from wind turbines is low-carbon and becoming less expensive. Great Britain has a significant wind resource, especially offshore, and wind produced 15% of our electricity in 2017.

Explain that we can use less fossil fuels by generating more of our power from renewable resources.
Introduce wind turbines to the class as more of a focus than the other types of energy technology. Explain that we will be learning more about them and building our own to test.

SLIDE 61: WIND TURBINES - ADVANTAGES

WIND TURBINES

ADVANTAGES:

- Electricity is generated without polluting the air at the site
- It can be used wherever there is a wind resource
- It can be generated where it is needed
- It is useful for remote or island communities
- Many turbines can be used, so electricity can still be generated if one has a technical failure

Talk to the class about the advantages of using wind turbines to generate electricity.

SLIDE 62: WIND TURBINES - DISADVANTAGES

WIND TURBINES

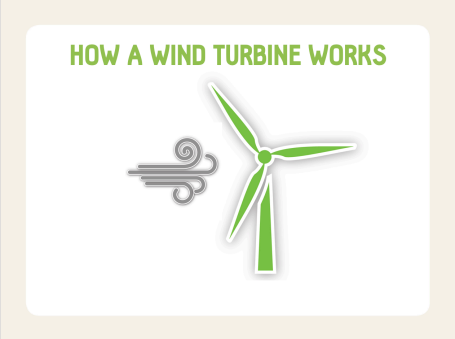
DISADVANTAGES:

- The strongest wind is not necessarily near where electricity is needed
- Public acceptance - people sometimes think that wind turbines are ugly
- Large area wind farms are needed to generate a significant amount of electricity
- The wind strength changes, so the electricity generated is not constant and other methods of electricity generation must also be used

Talk to the class about the disadvantages of using wind turbines to generate electricity.

BUILD ACTIVITY: BUILD A WIND TURBINE

SLIDE 63: HOW A WIND TURBINE WORKS



Explain that we are now going to look at one renewable power resource, wind, and how we use it to generate electricity using a wind turbine.

- Refer to the diagram on the slide to highlight that as the wind blows it flows over the blades of the wind turbine.
- The blades are shaped so that when the wind hits the blade, the blade experiences a force which causes the blade to move.
- As an example, ask the class to think of what happens when you put your hand out of the window in a moving car. As you change the angle that your hand meets the wind, the force on your hand changes and it gets pushed away.
- Because the turbine blades are fixed at one end to the wind turbine, the resultant movement of the turbine blades is in a circle.
- The bigger the turbine blade, the more surface area there is for the wind to push a force on, so you end up with more power. To deal with this greater power the turbine blades need to be much stronger otherwise they will break.
- However, the downside of being both bigger and stronger often means that the blades are heavier. The blades then require stronger wind to get moving – which isn't always available.
- So, when you're designing a wind turbine you have to make a compromise between the blades being big enough to make the most power from the wind, but not so big that if the wind is weaker for most of the time the wind turbine can't move at all.

SLIDE 64: BUILDING A WIND TURBINE

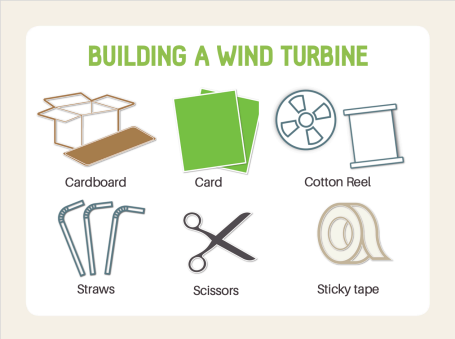
Use this slide to explain the activity to the class. Tell them, that in groups, they will be designing and making the blades and can use the images of different turbines as inspiration. You will need to decide how to define the groups, this could be in their tables. Explain to the pupils that you will be testing their turbines afterwards to see which of them spins.

- Each group should have a worksheet to fill in.
- They should first design the turbine and fill out their worksheet in their groups, then build it when everyone has finished their sketch. **Don't hand out the building materials until the designs are finished!** This highlights the importance of planning.
- If you are behind schedule, give a strict time limit for planning to ensure adequate building time.
- During the plan and build task highlight the engineer skills pupils are displaying- planning, creativity, problem solving, team work, evaluative.

Signal to the class the end of planning time and start of building time.

- Each group should have enough of the materials to make their turbine.
- Ask them to bring their turbines to a table at the front when they are finished, to be tested when everyone is ready.
- Remind the pupils of the principle of how the turbines spin, however, encourage them to work out their designs on their own.
- **Note:** The cotton reel will have the blades attached to it so should be in the center of their design and the central cotton reel hole should be clear/free from obstruction.

SLIDE 65: BUILDING A WIND TURBINE

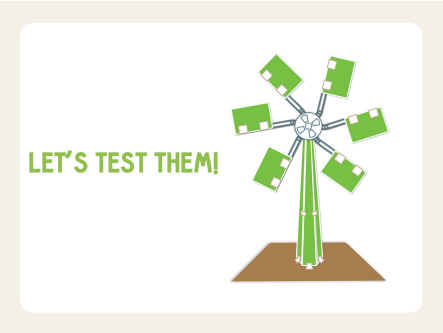


Use this slide to show the class the materials that they have available. Display this slide during the planning stage.

- Each group should have enough a cotton reel each; this will be used to connect the wind turbine blades to our wind turbine tower for the test at the end of the activity. The cotton reel should be in the center of their design and the central cotton reel hole should be clear/free from obstruction.
- Each group should have some cardboard, card, straws, sticky tape and scissors. Tell them they need to be extremely careful with the scissors so that they don't hurt themselves.
- Explain to the pupils that you will be testing their wind turbines afterwards using a hair dryer.
- Tell them they have 10-15 minutes to complete the planning and building and invite them to bring up their completed worksheets and wind turbines to the front desk when ready.

Remind the pupils of the turbine blade principle, to be at the right angle and big enough to capture the power of the wind, but not so heavy that they are too heavy for the wind to move the turbine.

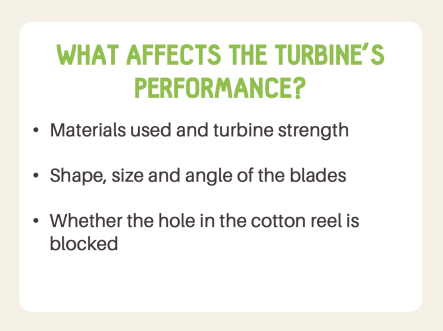
SLIDE 66: LET'S TEST THEM!



When the time is up, get testing!

- One at a time, attach each group's wind turbine blades to the wind turbine tower, by placing the cotton reel onto the rod/pencil.
- Point the hair dryer at the turbine blades and turn it on to see if the turbine blades will move. Start gently then increase the power if need be. Do this for all the wind turbines to compare their performances.
- As you're going, if any are particularly good, or particularly bad, ask the pupils why they think this might be. Is this because the turbine blades aren't strong enough/big enough? Is it because of the angle at which the wind from the hair dryer hits the blades?
- Manage pupils' expectations about the performance of their blades by informing them that in the real world, wind turbine blades take a very long time to design and get right, with months of testing and redesigning until a final design is decided upon.

SLIDE 67: WHAT AFFECTS THE TURBINE'S PERFORMANCE?



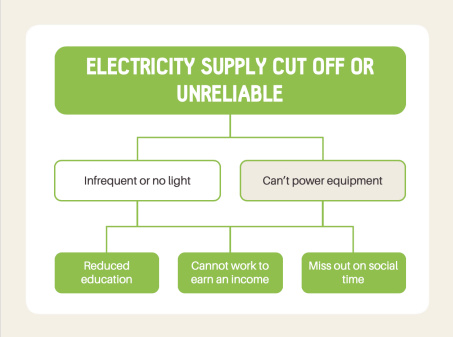
You should have discussed some of these things whilst testing the wind turbines but use this slide to summarise the factors that affect the turbine's performance and conclude the activity.

- The surface area of the turbine blades
- The angle of the turbine blades
- The sturdiness of the turbine blades
- The weight of the turbine blades

Highlight that these might be things you would reconsider if you were to do the activity again to improve the turbine's performance and optimise the design.

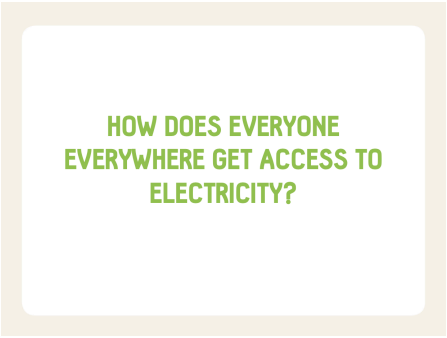
After testing instruct the group to evaluate their turbine's performance on the worksheet if they have not done so already.

SLIDE 68: REITERATING THE IMPORTANCE OF ELECTRICITY



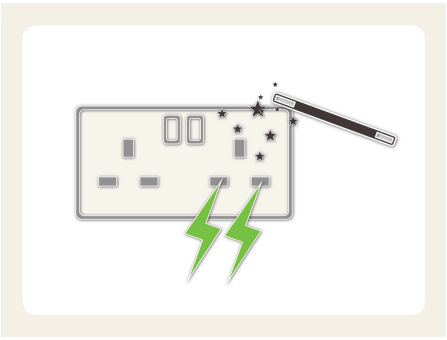
- Use this slide to do a quick recap on how important electricity is to us, and what can happen when we lack access to clean, reliable electricity.
- We should all be careful to conserve electricity as best we can – e.g. we should not be wasteful with it.

SLIDE 69: HOW DOES EVERYONE EVERYWHERE GET ACCESS TO ELECTRICITY?



- Conclude the first part of the session by summarising the key points culminating in this question.
- Highlight that electricity is important to human life. But, unfortunately not everyone has equal access to this vital resource.
- All around the world, people are addressing this issue and recently there has been a commitment made amongst global leaders to ensure access to clean affordable energy for everyone, everywhere by 2030 through the Sustainable Development Goals.
- So, we have to ask the question – how can this happen? How does everyone, everywhere get access to clean affordable energy, in particular electricity?

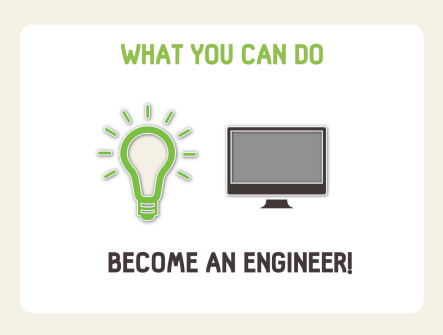
SLIDE 70: THE MAGIC OF ENGINEERING



Through the magic of engineering, everyone everywhere will one day have access to affordable, reliable, sustainable and modern energy.

But, what can you do to help this happen?

SLIDE 71: WHAT YOU CAN DO



Use this slide to explain to the class that here are some ideas for how you can individually conserve electricity.

- This means doing things like turning off the lights when you're not using them, turning off equipment like TVs, computers and not leaving them on stand-by – ask the pupils for more suggestions of how they can conserve electricity.
- Explain that whilst you might think doing these things won't make a lot of difference, in fact when you consider the total population, for example the UK population is 68 million people, and imagine if everyone did these things, we'd save a huge amount of electricity.
- As we have seen, it is also important to use less fossil fuels, and so they should try to use green electricity when they can.

Explain, that these are examples of things pupils can do in their everyday lives, but also you hope that the workshop has inspired them to consider how they could play a major role in tackling issues to do with electricity access, by becoming engineers themselves!

Engineers:

- Generate electricity.
- Transport electricity to where it is needed.
- Innovate new technologies to improve the efficiency of generating renewable electricity.
- Make processes less energy intensive, to conserve electricity.

SLIDE 72: WE NEED TO BE AWARE

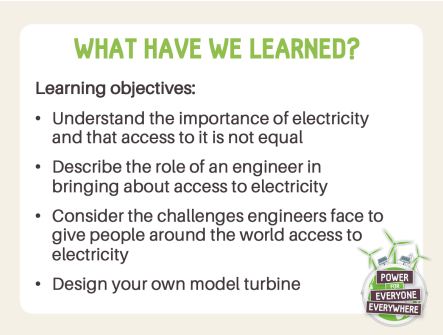
Remind the class about one of the issues you raised at the beginning and in the power resources activity:

- That electricity production sometimes uses fossil fuels and these produce pollutants which are contributing to climate change.
- We need to change the way we generate electricity, so that we can preserve our planet's delicate ecosystem.

[1] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/450302/DUKES_2015.pdf

WHAT YOU CAN DO & REFLECTIONS ON LEARNING

SLIDE 73: WHAT HAVE WE LEARNED?



Summarise the overall aim of the workshop: to deepen their understanding of what engineers do and the global challenges that engineers are working to address.
To test the knowledge of the class, ask each table, or even more pupils, a question about a topic covered in the workshop, such as:

- What is something we use electricity for
- What are the consequences if you do not have access to electricity
- Give an example of a power resource
- Give an example of a way we generate electricity from a power resource
- What might stop someone having access to electricity
- Give an example of a renewable/non-renewable/sustainable/low-carbon/fossil fuel power resource
- How can we conserve electricity by changing our habits etc.

Pupil feedback is vital to measure the success of the workshop.
Hand out sticky notes and encourage the pupils to fill them out with:
Score of 1-10 for how much they enjoyed the workshop
Something that they enjoyed about the workshop
Something that they did not enjoy about the workshop
Something new that they have learned from the workshop
Take a photograph of the sticky notes, or take them with you, so that you have a record of how well the workshop was received.

SLIDE 74: THANK YOU!

- Thank the class for listening and participating in the workshop.
- Thank the teacher for having you.
- Highlight to the class that if they've enjoyed the process we've gone through today that they might like to find out more about engineering and what engineers do. There are lots of other things that engineers do, not just giving people access to electricity.

SLIDE 75: QUESTIONS?

- Encourage the pupils to ask you about any relevant topic. When talking about your university experience, remember to make it clear that you can only speak for yourself and other people have different answers to you. All ambassadors should answer the questions, to get a better range of answers.
- Clear up, don't leave a mess, and safe travels home!