



The Crown Estate Sustainability Initiative

The engineering design process lesson

Teacher guide

1

OVERVIEW

Thank you for downloading these resources to use with your students. By equipping your students with the knowledge and skills to understand biodiversity, nature recovery, and sustainability, you are empowering them with the tools to take positive action in their own communities, now and in their futures.

This lesson links to the museum at the Wind Power Design Centre in the Offshore Wind Power Challenge. In this lesson, students will:

- Review their understanding of energy
- Develop an appreciation of why the UK has huge capacity to generate wind energy.
- Learn about the engineering design process and the use of biomimicry (basing ideas on nature) for technology.
- Work in teams to design a wind turbine using biomimicry.
- Review the design process.

Throughout the lesson, you will find background information on each topic. **There is also a glossary of key terms at the end.**

To find out more about how to use these resources, watch our teacher video on the website.



OUTCOMES

To understand that wind power is a source of clean energy and be able to design a wind turbine based on an idea from nature.



SKILLS

Teamwork, creative thinking, problem solving, critical thinking.



VOCATIONS

Meteorologist, Offshore wind developer, Turbine expert, Engineer.



RESOURCES

- Presentation slides
- A3 design worksheet per team
- Biomimicry information sheet



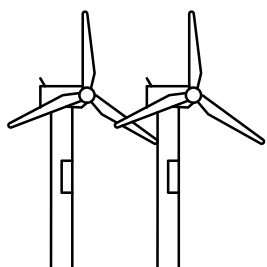
TIMINGS

We have included activities for your class that develop themes from the Minecraft worlds. They are sequenced to build on each other, but we encourage you to pick and choose the ones that will work best for your class and the time available. We have included approximate timings as a guide, but you may wish to spend longer on certain sections.

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Introduction and gameplay	25 minutes	2
Starter activity – Which energy generation statement is false?	5 minutes	3
Teacher input and discussion – Offshore wind	<10 minutes	4
Main activity – Designing a wind turbine	25 minutes	5-7
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Stats quoted in these lesson packs refer to the UK.




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Introduction

 (2 minutes)

- Introduce students to the Offshore Wind Power Challenge world that they are about to explore. Explain that this world will highlight sustainability, renewable energy, and the design process used in green careers.
- In the visit to the museum, students will meet Professor Wynd-Baggs and learn about wind energy and how turbines work.


Minecraft gameplay

 (25 minutes)

- When they launch the world, students will be greeted and then follow a seagull to the Wind Power Design Centre where they will explore the museum as part of this lesson.
- Consider sharing the reflection questions below with your students before they explore the world, so that they can keep them in mind throughout and ahead of class discussion.

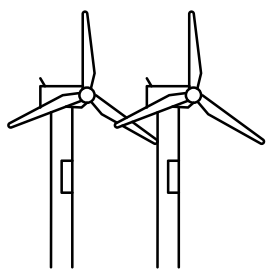


Reflecting on gameplay (Slide 2)

 (5 minutes)

- Facilitate a class discussion about the part of the world they have just explored, encouraging students to reflect on new knowledge gained, anything they found challenging, easy or interesting.
- To steer discussion, you could ask them:
 - Where is the activity based?
 - What has happened so far?
 - Who did you meet? What were their jobs?
 - What did you learn about wind turbines?
 - What can you tell me about renewable energy?





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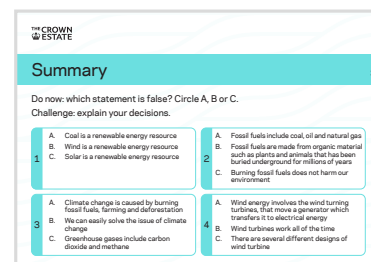
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Starter activity – Which energy generation statement is false? (Slide 3-11) (5 minutes)

This activity will recap some key facts about energy, renewables, fossil fuels and climate change.

- Explain that this activity will recap some key facts about renewable energy, linked to the areas the students have explored in the world.
- Show **slide 3**. Ask pupils to write down answers to the 4 questions. Each contains two correct statements (facts) and one incorrect statement.
- Run through each question (**slides 4-11**). Ask pupils to use a whiteboard or ABC cards to show their answer, before revealing the correct answer.
- Address any misconceptions. To deepen understanding, pupils can be asked to justify their decision. Some may benefit from the glossary to support their understanding of each statement.



Summary

Do now: which statement is false? Circle A, B or C.
Challenge: explain your decisions.

1	A. Coal is a renewable energy resource B. Wind is a renewable energy resource C. Solar is a renewable energy resource	A. Fossil fuels include coal, oil and natural gas B. Fossil fuels are made from organic material such as plants and animals that have been buried underground for millions of years C. Burning fossil fuels does not harm our environment
2	A. Climate change is caused by burning fossil fuels, burning and deforestation B. We can easily solve the issue of climate change C. Greenhouse gases include carbon dioxide and methane	A. Wind energy involves the wind turning turbines, that move a generator which transfers it to electrical energy B. Wind turbines work all of the time C. There are several different designs of wind turbine

BACKGROUND INFORMATION

Energy in the UK and climate change

Renewable energy comes from sources that won't run out and usually has low or zero emissions. Examples include wind power, solar power, biomass (organic matter burned as a fuel) and hydroelectric power.

Most renewable energy is 'clean' which means no emissions or pollutants are produced when the energy is generated. Wind is an example of 'clean' energy.

Non-renewable energy comes from sources that will run out or will not be replenished in our lifetimes. Most non-renewables are carbon-rich fossil fuels: coal, oil and natural gas. Burning these fuels releases a greenhouse gas (GHG) called carbon dioxide. This gas, along with methane from agriculture/ farming and other GHGs are causing global heating.

As the atmosphere traps increasing amounts of heat, our climate, which has been relatively stable since human civilisation was established, is changing – this is called climate change.

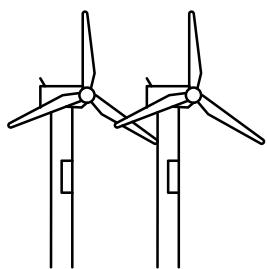
BACKGROUND INFORMATION

The National Grid and energy security

The National Grid is the high-voltage electricity transmission network serving the UK, connecting power stations and major substations. It transports electricity to satisfy demand.

The contributions to the National Grid from the different sources of electrical energy change on an hourly basis. For example, there will be no solar energy at night and there will only be wind energy when it is windy. To match demand, the UK also has to purchase energy from overseas.

You may want to show pupils the sources of electrical energy currently being generated by the National Grid live via <https://grid.iamkate.com/>.



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Teacher input and discussion - Offshore wind (slides 12-13)



(<10 minutes)

This is an opportunity to reinforce some of the information from the world that the students have explored so far and discuss the UK's role in offshore wind.

- Share the information on **slides 12-13** with the students
- Encourage students to discuss some of the concepts in more depth. You may wish to use the following prompts:
 - What is renewable energy? Why is it important for the future and for tackling climate change?
 - What consequences or compromises might need to be considered when planning an offshore wind farm?
- Highlight that consequences and compromise are both concepts that the students will need to consider during the activities in this lesson and when they design and build their own offshore wind farm in the world.



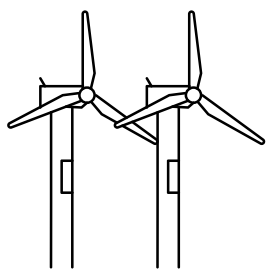
BACKGROUND INFORMATION

The UK wind energy sector

By 2023, the UK had over 11,000 wind turbines.

The UK is a good location for wind energy for several reasons:

- **Location:** The UK is an island nation surrounded by water, which means there are plenty of opportunities for offshore wind farms. The UK's coastline is exposed to strong winds coming in from the Atlantic Ocean.
- **Government support:** The UK government has been generally supportive of renewable energy development and has provided subsidies and incentives to encourage the growth of wind energy, especially offshore. This has helped to drive down the cost of wind energy.
- **Technological advances:** The UK has a strong tradition of engineering and innovation and has been at the forefront of developing new technologies for wind energy. This has helped to improve the efficiency and reliability of wind turbines.



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Main activity - Designing a wind turbine (slides 14-19)

(25 minutes)

In this activity, students will work in teams to design an offshore wind turbine collaboratively. Remind them that so far in their exploration of the world, they will have learnt about wind turbines and how important they are for generating renewable energy.

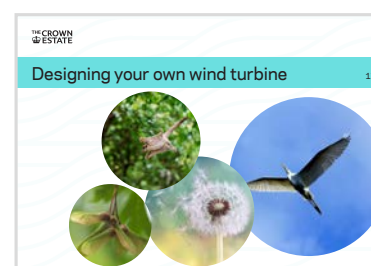
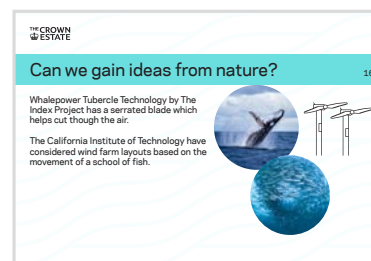
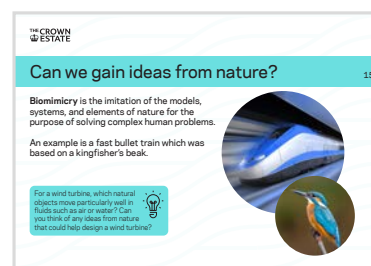
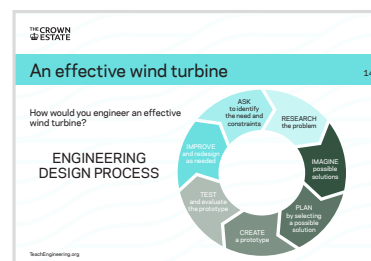
This activity will introduce them to the design process used in real green careers and help them understand the compromises and considerations involved in innovating to develop new solutions to tackle climate change.

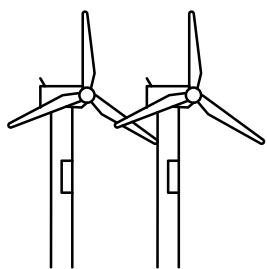
Introduction

- Show **slide 14** to introduce the engineering design process. Talk through each of the steps on the image.
- Show **slide 15** to introduce biomimicry and give the example of the Japanese bullet train, which mimics the streamlined shape of a kingfisher beak.
- Show **slide 16** and the two further examples of how wind turbine and wind farm designs mimic nature (the humpback whale and a school of fish). Reinforce the idea that living organisms have evolved over millions of years, and we can borrow strategies they use to thrive.

The design process

- Show **slide 17**. Tell pupils they will work in teams to **design an offshore wind turbine** including key elements taking inspiration from nature.
- Give each team the **biomimicry information sheet** with ideas from nature for inspiration. Give teams 5 minutes to imagine and discuss different designs using examples from nature. Encourage them to consider all their team's different ideas and weigh up the pros and cons of the different ideas.
- Show **slide 18** and give each team an **A3 Design worksheet**. Tell them you are going to call up one member of each team to explain the first set of instructions, then later will call up other team members for further instructions.
- Emphasise students will need to use communication and teamwork skills as well as creativity.
- Call up the first student from each team and instruct them to work together in teams to plan their final design in box 1, based on the different ideas they discussed, and draw their design in box 2.
- After 5 minutes, call up the second student from each team and tell them to label the diagram with the design specification, including the materials they are going to use and their inspiration from nature. Tell them to give enough information so somebody could use their plans to build a prototype.





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Main activity - Designing a wind turbine (slides 14-19) Cont'd



(25 minutes)

- After 5 minutes, call up the third student from each team. Tell them they need to make design modifications in their team based on requests from the community:
 - To protect some unique ecosystems on the seabed, the turbine needs to have a **floating** design.
 - They also need additional **safety features** to protect the engineers and maintenance staff visiting the offshore turbine.
- If you have time, you can also encourage students to think about any other possible effects their wind turbine design might have. Who else might be impacted? What requests would they have? How can they respond?
- Ask students to have a design meeting to discuss any final improvements they could make in response to these requests and note their modifications in box 3.

BACKGROUND INFORMATION

Biomimicry and wind turbines

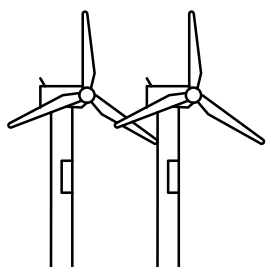
Biomimicry is an approach to design and innovation that seeks to solve human problems by emulating nature's time-tested patterns and strategies. It involves observing and studying the ways in which plants, animals, and other organisms have adapted and evolved to thrive in their environments, and then applying these principles to create efficient solutions to human challenges.

To develop a wind turbine using biomimicry, pupils could look at natural examples of how wind is harnessed and converted into energy in the animal and plant kingdom (examples on **biomimicry information sheet**).

One example of biomimicry in wind turbine design is the whale-inspired turbine. Humpback whales have bumpy flippers that allow them to swim more efficiently through the water. Researchers have created a wind turbine design with similar bumps on the blades, designed to allow the turbine to operate more quietly and with greater efficiency.

In addition, pupils can also consider the broader principles of nature's design. For example, trees can withstand strong winds because they are flexible and able to sway.

Could this inspire a wind turbine design that is able to move and adjust to changing wind patterns, rather than being rigid and inflexible?



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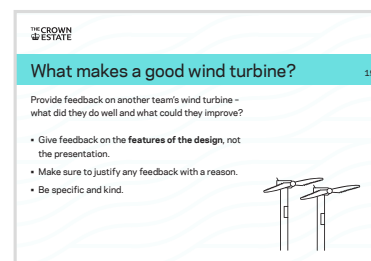
Main activity - Designing a wind turbine (slides 14-19) Cont'd



(25 minutes)

Peer critique and feedback

- Show **slide 19**. Tell students it's now time for a design review to get some fresh ideas from the other students to improve their design. Explain that in real green careers, hearing other perspectives is a key way we can improve designs and create better products.
- Ask students to display their turbine designs around the room. When all designs are displayed, instruct teams to rotate around the room and explore other teams' designs.
- Tell students to add feedback on **what is good** and **what could be even better** to at least one other team's design, using box 4.
- Thank students and tell them to return to their teams to review the feedback they have received. Congratulate teams on their designs.



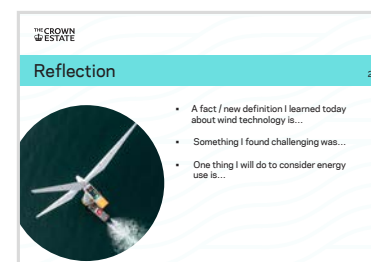
Reflection (Slide 20)

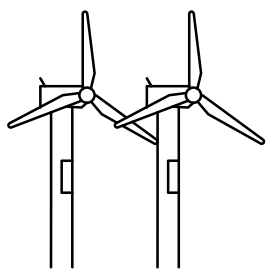


(5 minutes)

Before finishing the lesson, encourage your students to reflect on their learning.

- Display **slide 20** and ask your students to use the following sentence starters to reflect:
 - A fact / new definition I learned today about wind technology is...
 - Something I found challenging was...
 - One thing I will do to consider energy use is...
- Depending on your class, you may wish to do this one by one or invite volunteers to take turns.





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Optional extension activity – Design and skills review (slide 21)

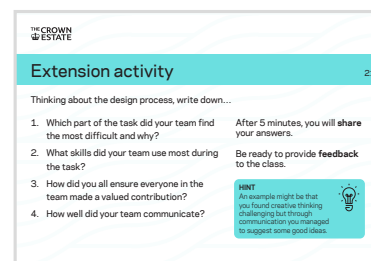


(10 minutes)

If you would like to extend the learning from this lesson a bit further, you can try the following activity.

This activity will help students to reflect on the skills they have learned and what good collaboration looks like.

- Show **slide 21** and ask students to reflect on the design process. Ask them to use paper or whiteboards to write their ideas about the questions on the screen:
 - Which part of the design task did you find the most difficult and why?
 - Which skills did your team use most during the task?
 - How did you all ensure everyone in the team made a valued contribution?
 - How well did your team communicate?
- After 5 minutes, ask students to pass their notes to the person on their left and receive notes from the person on their right, to share their reflections.
- Select students from each team to share what they learned with the class.



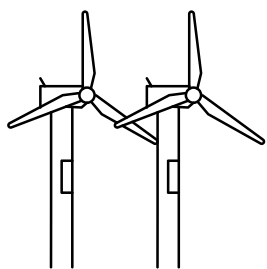
BACKGROUND INFORMATION

Skills needed for engineering

The engineering design process involves a series of steps that engineers use to develop and refine solutions to complex problems. Some of the skills that are important in this process include:

- **Problem-solving:** Engineers must be able to identify problems, analyse data, and develop creative solutions to complex challenges.
- **Critical thinking:** Engineers must be able to evaluate information, weigh the pros and cons of different options, and make informed decisions.
- **Creativity:** Engineers must be able to think outside the box and come up with innovative solutions to problems.
- **Communication:** Engineers must be able to explain their ideas and designs clearly and effectively, both in writing and through verbal communication.
- **Collaboration:** Engineers often work in teams, so the ability to collaborate with others and work effectively in a group is essential.
- **Technical skills:** Engineers must have a solid foundation in mathematics, science, and technology, as well as a deep understanding of the principles and concepts relevant to their field.
- **Attention to detail:** Engineers must be meticulous in their work, paying close attention to even the smallest details to ensure that their designs are safe, effective, and efficient.

By cultivating these skills, engineers can develop effective, sustainable, and innovative solutions to complex challenges, and help to shape a better future for all.



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Real world action

Building student agency with real world action

By taking part in this lesson, students have developed their:

- knowledge of a key sustainability topic
- understanding of why it is important
- practical toolkit, and articulation, of their own green skills

These are the ingredients that enhance students' agency and power to take real world action.

There are a number of ways you can support them to take their learning forward and continue this process beyond the classroom.

- Research project investigating the materials turbines are made from such as composites and concrete which have their own environmental impact and how wind turbine blades can be repurposed (e.g., bike shelters).
- Research project on sea levels rising as a result of climate change and the effects of increasing frequency and severity of storms on wind farms.

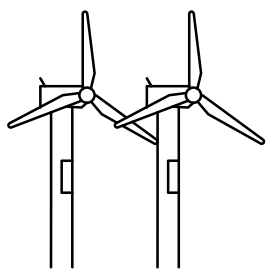


Building on these lessons – Taking action toolkit

For more ideas on safe and manageable ways to harness the enthusiasm your students may have for this or other biodiversity topics, we have created a **Taking Action Toolkit**.

It features accessible principles to empower students to identify key issues that they care about, affecting their school/local community, and begin creating meaningful solutions for nature recovery with their peers.





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Glossary

- **Offshore:** Refers to activities or infrastructure that are located in the sea or ocean, away from the shore.
- **Renewable energy:** Energy sources that are replenished naturally and can be used over and over again, such as solar, wind, and hydropower.
- **Non-renewable energy:** Energy sources that are finite and will eventually run out, such as fossil fuels like coal, oil, and natural gas.
- **Fossil fuel:** Refers to natural resources, such as coal, oil, and natural gas, that were formed from the remains of ancient plants and animals. They are considered non-renewable because they take millions of years to form and are being depleted much faster than they are being replenished.
- **Greenhouse effect:** The process by which greenhouse gases, such as carbon dioxide, trap heat in the Earth's atmosphere and cause the planet to warm.
- **Global warming:** The gradual increase in the Earth's average surface temperature, primarily caused by the increase in greenhouse gas emissions from human activities.
- **Climate change:** The long-term changes in the Earth's climate, including changes in temperature, precipitation, and extreme weather events, that are primarily caused by human activities.
- **Turbine:** A machine that converts the energy from a fluid or gas into mechanical energy, typically used to generate electricity.
- **Wind:** The natural movement of air caused by differences in air pressure, often harnessed to generate electricity through wind turbines.
- **Engineering design cycle:** A problem-solving framework used by engineers to design and develop new products, systems, or processes. It typically involves several stages, including research, ideation, prototyping, testing, and refinement.
- **Biomimicry:** The practice of looking to nature for inspiration in design and innovation. Biomimicry involves studying natural systems, processes, and materials and applying them to human-made products and technologies.
- **Ecology:** The scientific study of how living organisms interact with each other and their physical environment.

