Farming the wind – through onshore and offshore windfarms
A discussion on the local and national potential of developing wind energy sources

Windfarm at Lillgrund, offshore of Malmö, Sweden *(by Jorchr, CC BY-SA 3.0).*

Wind as a power source
Wind speeds vary but the higher you are, the stronger the wind. But importantly, the flatter the area is, the stronger and more consistent the wind speed, because there is little to slow the wind down or to cause turbulence. This is one of the reasons why the main focus in many parts of the world today, is offshore wind farms – since the sea is flat.

Since wind speed increases with height above the surface, wind turbines need to be high – 100m or more at sea, but higher in more turbulent inland areas.

While wind speeds vary from minute to minute, they are fairly predictable over periods of a few days, more predictable than, for example, sunshine (changes due to cloud cover) but not as predictable as tides.

Wind turbines begin generating power at wind speeds of around 4 m s^{-1} (15 km/h or 10 mph), are most efficient at between 17 and 25 m s^{-1}, but must be shut down above 25 m s^{-1} (about 94 km/h or 58 mph) to avoid damage.

The potential for developing offshore wind resources globally is shown on the map in the 'Context' section.

Wind turbine technology
The power generated by a single turbine is linked to the cube of the wind speed, so the stronger the wind, the much greater the power generated. The power is also linked to the size of blades – the longer the blade, the more power generated. This explains why larger and larger turbines with longer and longer blades are being built. Early turbines had 20m long blades but modern blades are 150m long and greater lengths are planned. Such big turbines with such long blades are very difficult to install on land because of transport issues – another reason for the strong development of offshore wind farms.

During rotation, blade tips move at up to 100m s^{-1} (260 kph/ 220mph) and travel around 50 million km (30 M ml) over a blade's lifetime, so erosion of blades by rain, hail and dust is a major issue. Currently blades are repaired by people on ropes, but robots are being developed to both monitor and repair blades.

Most offshore wind turbines are built directly on the sea bed, but, in deeper water, some float using strong anchors. Remarkably, it is possible for a single specially-built installation ship to erect one new offshore turbine per day.

Wind generation costs and benefits
The costs of wind generation have reduced by two thirds in the past 10 – 15 years to become one of the cheapest forms of large-scale generation. This reduction is due to increased sizes of turbines and wind farms and to increasingly efficient installation, operation and maintenance methods. The major issue with wind farms remains the unsteady supply, which is why research into how excess energy can be stored remains so important.

The building and operation of wind farms releases less greenhouse gas into the atmosphere than all other major energy sources and their running costs are also lower. When the numbers of deaths caused by developing and operating different power sources are compared, wind power has much lower figures than most of the others.

Beautiful or not?
Some people see wind turbines and wind farms as things of great beauty. Others see them as eyesores.

So, the question for discussion in your region is: 'Could a wind farm be constructed in your area?' If it could – should it be constructed there? This question will need discussion between industry, government and the local community.

A 50 metre-long wind turbine blade. Blades three times this size are currently being manufactured; blades five times larger (250m length) are in prospect *(by Z22 CC BY-SA 3.0).*

The back up

Title: Farming the wind – through onshore and offshore windfarms.

Subtitle: A discussion on the local and national potential of developing wind energy sources.

Topic: Data and perspectives on electricity generation by wind farms are provided to support a debate on their local and national potential.

Age range of pupils: 14 years upwards

Time needed to complete activity: 20 minutes

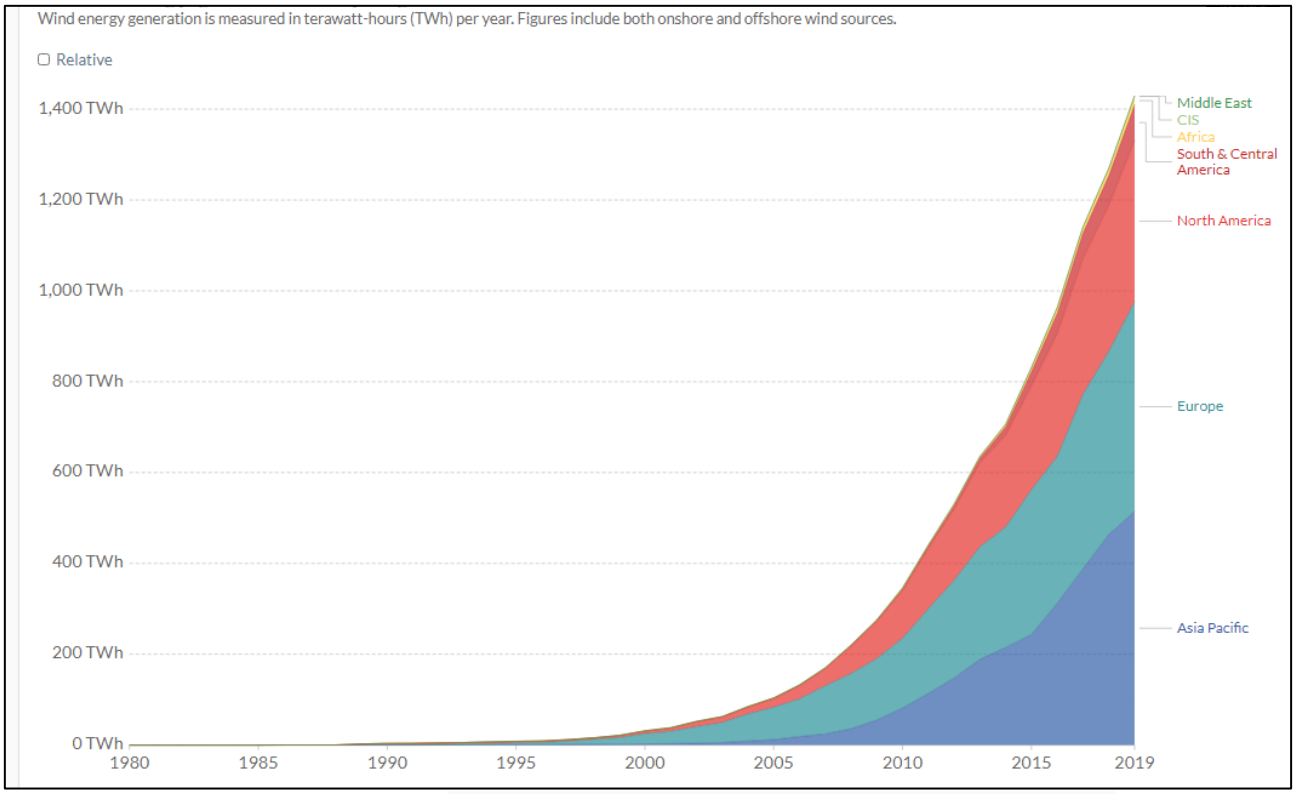
Pupil learning outcomes: Pupils can:

- explain how wind can be used to drive turbines;
- explain issues of siting and running turbines;
- discuss the pros and cons of wind power;
- discuss the potential for wind power generation locally and nationally.

Context:
Government 'net-zero' targets will affect many areas across the world. This Earthlearningidea explores the potential contribution of wind turbine technology.

Wind has been used to drive machines like grain mills and water pumps for more than a thousand years. The first wind turbines to generate electricity were built in Scotland by James Blyth in 1887 and in the USA by Charles Brush around the same time. Modern-style wind turbines began to be developed in the 1940s. Their development continues.

The increasing rate of wind energy generation is shown in the graph below, whilst the map on page 3 shows global potential for wind technology development.



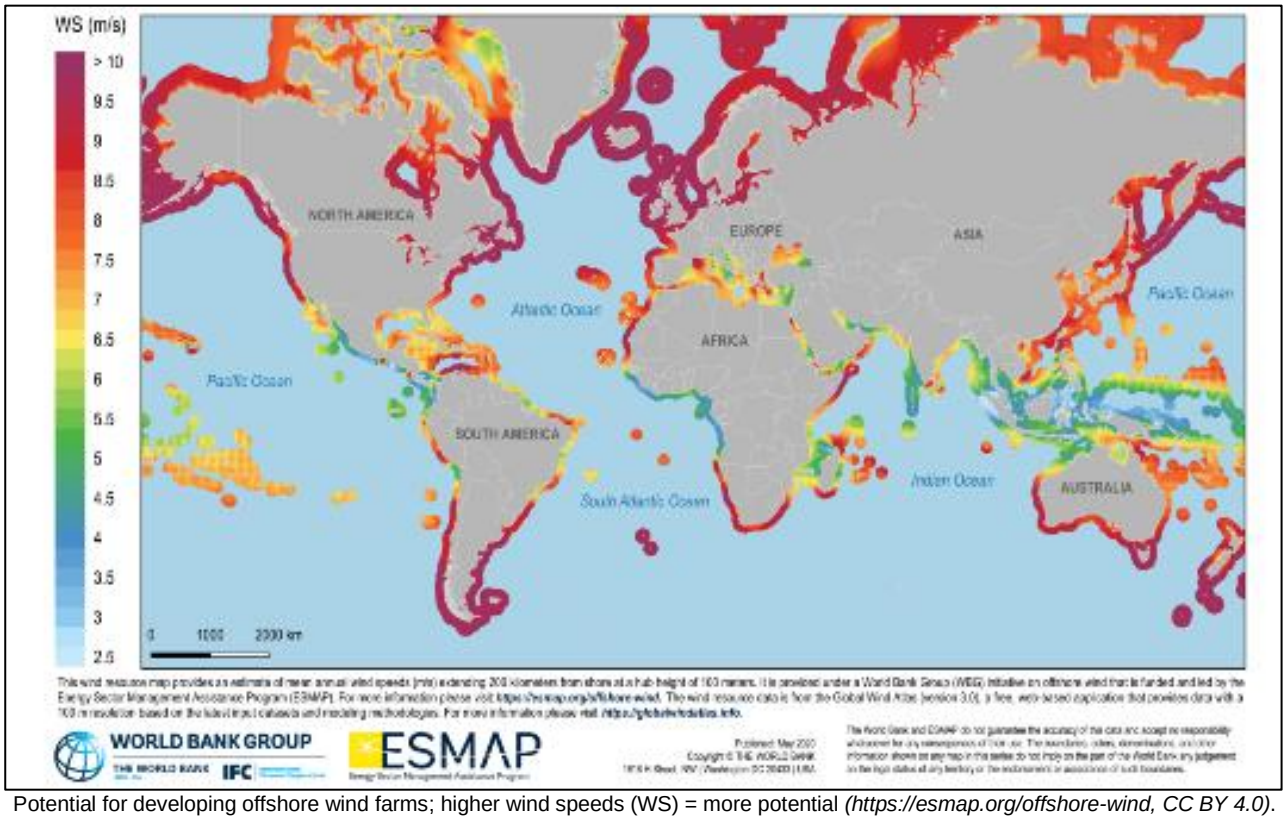
Wind energy development by region *(https://ourworldindata.org/grapher/wind-energy-consumption-by-region, CC BY 3.0).*

Following up the activity:
Discuss this question with your class: 'If you were an environmental scientist asked to research the impact of a wind farm on the local environment, which aspects would you investigate by observation and measurement?'

Issues they may suggest include: monitor noise; observe behaviours of animals including fish; observe differences in local plant cover on land or seabed; record deaths by bird or insect strikes; investigate local microclimate/sea flow changes; investigate what the effects of disposal of worn out wind turbines might be.

Underlying principles:

- Wind turbines generate electricity from wind power.
- Although wind is variable, it is most consistent as an energy source at high altitude and in flat regions, like seas.
- Large wind turbines are more efficient at harvesting wind power than smaller ones.
- Wind has become a major contributor to global electricity generation supplies in the past 15 years and its contribution is increasing.
- Wind generation, including construction, operating and maintenance, has a very low carbon footprint and a strong safety record.
- The pros and cons of developing wind farms in local onshore or offshore areas provoke interesting discussions.



Potential for developing offshore wind farms; higher wind speeds (WS) = more potential *(https://esmap.org/offshore-wind, CC BY 4.0)*.

Thinking skill development:
In order to discuss the potential of wind power generation in a local or national area you have to construct your own picture of the operation of wind turbines. As discussions develop, cognitive conflict and metacognition will be involved. Understanding has to be bridged to local and national scenarios.

Resource list:

- optional: maps of the local area

Useful links:
Visit the Earthlearningidea website to find other activities relating to climate change mitigation or adaptation. Search for 'net-zero'.

Put 'wind farm' into a search engine like Google™ and click 'images' to see a wide range of different windfarm situations from different perspectives, to aid discussion.

Source: Chris King of the Earthlearningidea Team based on information supplied by Jim Gilbert of Hull University. Jim kindly acted as our 'expert checker' too.

The ‘How will the ‘net-zero’ target affect your local area?’ series of Earthlearningideas

Topic			Earthlearningidea title
Introduction			How will the ‘net-zero’ target affect your local area?
Possible mitigation measures	Use alternative energy sources	Solar	Harnessing the power of the Sun
		Wave	Harnessing the power of waves
		Wind	Farming the wind: through onshore and offshore windfarms
		Tidal	Tidal energy
		Nuclear	Nuclear power - harnessing the energy of the atom
		Nuclear waste	Nuclear waste disposal
		Biofuel	Liquid biofuels: keeping our wheels turning into the future
		‘Blue’ hydrogen	Blue hydrogen: the fuel of the future? *Also:* Hydrogen of many colours
		Geothermal – hot rocks	Deep geothermal power from ‘hot dry rocks’: an option in your area?
		Geothermal – flooded mines	A new use for old coal mines
		Hydro – small scale	Small-scale hydroelectric power schemes
		Heat pumps	Heat from the Earth
		Waste – incineration	Energy from burning waste
		Waste – methane	Energy from buried waste
	Stop fuels releasing greenhouse gases	Carbon capture	Capturing carbon?
	Store energy from sources that give irregular energy supplies	Batteries	Nuclear batteries: the future?
		‘Green’ hydrogen	Green hydrogen used to even out renewable energy supplies? *Also* Hydrogen of many colours
		Hydro – storage	Matching supply and demand using stored water
		Compressed gas	Storing gas underground: What can we store? How can we do it? How will it help?
	Provide raw materials for new technologies	Electric vehicles	Electric vehicles: the way to go?
		Insulation	How do I choose the best insulation?
	Remove carbon form the atmosphere	Enhanced weathering	Speeding up nature to trap carbon dioxide
		Tree planting	Let’s plant some trees
Possible adaptation measures		Coastal flooding	How will rising sea level affect our coastlines?
		Inland flooding	Inland flooding: a Sheffield case study
		Landslides	Landslide danger
		Agriculture	The future for global agriculture