

Climate change teaching resource – Mitigation & Adaptation

Activity 3: Is the answer blowing in the wind and shining down on us?

Minimum time required: 30 minutes

Learning objectives

- To use information to form an opinion on the benefits and drawbacks of wind and solar PV energy in the UK

Resources needed

- Diamond-9 ranking cards for cutting out
- Wind energy & Solar PV energy diamond-9 ranking worksheets
- Teacher information: Diamond 9 statements for wind and solar energy

Methodology & teacher's notes

This activity provides students with statements about wind and solar energy that are based on factual information, and use the 'diamond-9 ranking' to formulate an opinion about the extent these form of renewable are good ways to mitigate climate change. **NB:** for solar, the focus is on solar photovoltaic (PV) energy, and not solar thermal (see glossary).

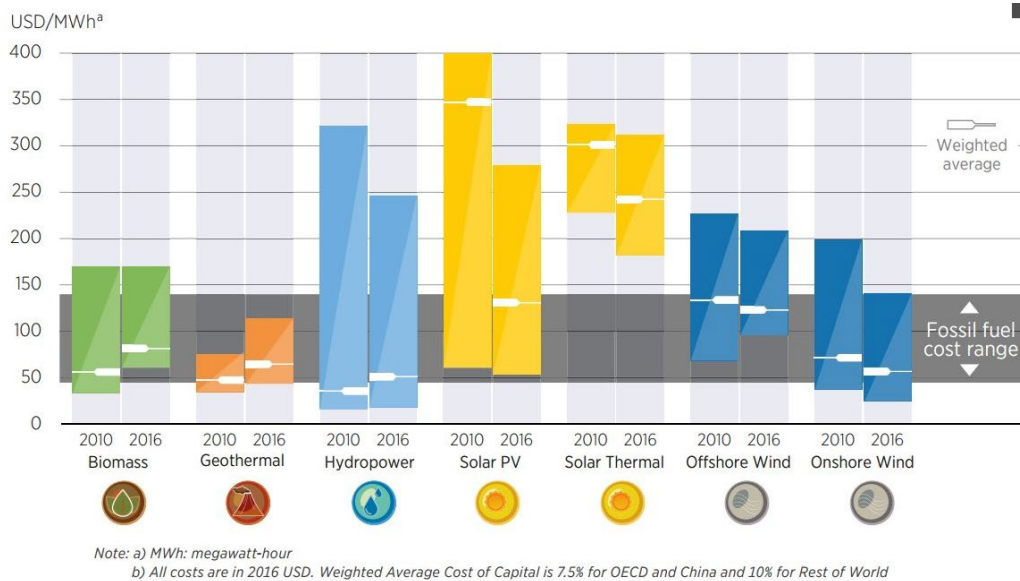
The methodology below assumes an approach where each student themselves evaluate both wind and solar energy. But you can approach this activity in different ways. You could have half the class focus on wind, and the other on solar, then they share there thoughts afterwards in a class discussion. You could also print the resources A3 size and they can work on the diamond-9s in groups.

1. Hand out the 'Diamond-9 ranking cards for cutting out' worksheet to students. Before they cut them out, they can choose two colours to shade in, and/or write a plus (+) or minus (-) on, the statements they feel are 'benefits' and which are 'drawbacks'.
2. Hand out 'Wind energy & Solar PV energy diamond-9 ranking worksheets'. Students to consider the relative importance of each statement using their own opinions. Using the 'Teachers information sheet', you can provide them with further information to support their thinking. It's important that students know that where they place their nine statements on the diamond-9 is up to them and there is no right or wrong answer. Once students are settled with their opinions, they can glue the statements in place and then answer the prompts on the worksheet and think about the statements at the bottom of each page.

- Lead a class discussion using the two statements at the bottom of the worksheet pages. Encourage students to use their diamond-9s to justify their opinions.

Further challenge and extension

The relative cost of energy sources has been one of the major drivers of an accelerated shift towards wind and solar PV energy. A very interesting graphic from *Our World In Data* ([‘Relative cost of energy sources’](#)) could be explored by students to see both how much they have changed in just a six-year period, and how these costs compare with fossil fuels. Preparing some questions using this graph would be very good practise at analysing a piece of ‘unfamiliar’ data presentation.



Students can also give a listen to the [BBC’s Digital Planet podcast episode](#) that was broadcasted on 23 June 2020. From 23:43, a segment explores some energy storage solutions that could help support the growing number of solar PV farms coming online. It is only an 8 minute listen, after which students can think about whether this new information about advancing battery technology would change their thinking on the solar PV diamond-9 ranking.

References, sources & credits:

References for this activity can be found on the *‘Teacher information: Diamond 9 statements for wind and solar energy’* sheet.

Teacher information: Diamond 9 statements for wind and solar energy

Wind Energy

Information adapted from '[Advantages and Challenges of Wind Energy](#)' (Office of Energy Efficiency & Renewable Energy, US Government), using various sources.

'Onshore wind is one of the cheapest ways to generate energy and will soon be the cheapest' (benefit)

Wind power is cost-effective. Onshore wind is one of the cheapest energy sources available today in the UK, costing around £63/MWh. This includes all costs through the lifetime of the wind farm, from pre-development to decommissioning. Its fuel is free, and wind energy mitigates the price uncertainty that fuel costs add to traditional sources of energy. Offshore wind is more expensive but is rapidly becoming cheaper.

Info updated using '[Electricity Generation Costs](#)' (BEIS, UK Government 2016)

'Wind energy doesn't pollute the air or generate greenhouse gas emissions while generating electricity' (benefit)

It's a clean fuel source. Wind energy doesn't pollute the air like power plants that rely on combustion of fossil fuels, such as coal or natural gas, which emit particulate matter, nitrogen oxides, and sulphur dioxide—causing human health problems and economic damages. Wind turbines don't produce atmospheric emissions that cause acid rain, smog, or greenhouse gases.

'It helps the UK become more 'energy secure' as it does not have to import fuel and has plenty of wind' (benefit)

Wind is a domestic source of energy. The UK is the windiest country in Europe. Around 40% of the total wind that blows across the continent blows over the UK. Nobody owns the wind and no one can control it, unlike fossil fuels as countries will control the land or area of sea where it is buried. Wind therefore helps with energy independency and security.

Info updated using '[UK Wind Power Potential](#)' (Goudsmit UK)

'Wind is a sustainable, renewable source of energy that will never run out' (benefit)

It's sustainable. Wind is actually a form of solar energy. Winds are caused by the heating of the atmosphere by the sun, the rotation of the Earth, and the Earth's surface irregularities. For as long as the sun shines and the wind blows, the energy produced can be harnessed to send power across the grid.

'Wind turbines can be built in shallow seas or on existing farms. Farmers can still farm around the turbines and earn an income through renting the space.' (benefit)

Wind turbines can be built on existing farms. This greatly benefits the economy in rural areas, where most of the best wind sites are found. Farmers can

continue to work the land because the wind turbines use only a fraction of the land. Wind power plant owners can make rent payments to the farmer for the use of the land, providing landowners with additional income.

'The best places for wind farms are usually in remote locations away from cities where the energy is needed' (drawback)

Good land-based wind sites are often located in remote locations, far from cities where the electricity is needed. Transmission lines must be built to bring the electricity from the wind farm to the city. Costs are even higher for off-shore wind farms as cables need to be laid on the sea bed to sub-stations on land first.

'Enough people believe wind turbines are an eye-sore and noisy to campaign against their construction in their local area' (drawback)

Turbines might cause noise and visual pollution. Although wind power plants have relatively little impact on the environment compared to conventional power plants, concern exists over the noise produced by the turbine blades and visual impacts to the landscape. Most people in the Europe (70–80%) are supportive of wind energy but some may oppose the building of wind farms in their local area. This attitude is called 'NIMBY' (Not In My Back Yard). Opposingly, those who welcome such developments and campaign for them are nicknamed 'PIMBYs' (Please In My Back Yard)!

'Turbines are a risk to birds and bats, and have been killed by spinning blades' (drawback)

Wind farms can impact local wildlife. Birds and bats have been killed by flying into spinning turbine blades. Most of these problems have been resolved or greatly reduced through technology development or by properly siting wind farms. Research from the London School of Economics (LSE) estimated in 2014 that by 2020 there could be anywhere between 9,600 and 106,000 bird deaths a year from wind energy in the UK. While this shows uncertainty, for comparison, an estimated 55 million birds killed by domestic cats in the UK each year.

Info updated using ['Putin: Is he right about wind turbines and bird deaths?'](#) (BBC News, July 2019)

'The production of wind energy varies on all time scales, not as much is produced on calmer days than on windier days' (drawback)

When the UK has high pressure conditions, with calm conditions, far less energy will be produced than during times of unsettled weather. Also, of average less wind energy is produced in the summer as conditions on average are calmer. However, much collaborative work has been done by the energy and meteorology sectors to greatly improve 'power forecasting' to help monitor energy supply and demand in order to 'keep the lights on'. Also, large scale energy storage for renewables may not be too far away.

Solar PV Energy

Information adapted from '[11 Prevailing Solar Farms Pros and Cons](#)' (Vitanna), using various sources.

'The sun is a sustainable, renewable source of energy that will never run out'
(benefit)

The sun likely has several billion years of life left. That means we do not need to worry about running out of solar energy, like we do with fossil fuels. Solar energy is the one form of abundant energy that we can use right now. Enough sunlight hits the planet every day to fuel the world's energy needs, at current consumption levels, for an entire year.

'Solar farms require very little maintenance, which is mostly to keep the panels clean'
(benefit)

Once installed, the photovoltaic panels at a solar farm are very easy to maintain. Some farms may use moving parts to maximize sunlight exposure throughout the day and these components may require additional maintenance. The main issue is 'soiling' (the panels getting dirty) and so the occasional cleaning is all that is required to maintain high levels of productivity.

'Solar energy doesn't pollute the air or generate greenhouse gas emissions while generating electricity' (benefit)

While fossil fuels are often used to create the photovoltaic panels, and so emissions are released during the processing of the panel, they create a net savings in emissions when compared to other energy resources. They only consume the fossil fuel products once, which means there is one emissions price to pay. If you continually combust coal or oil for energy, on the other hand, you're paying an emissions price with every energy generation effort.

'Solar power allows individuals, communities and countries to become energy independent and secure' (benefit)

Many rooftops are suitable for panels, and those which aren't (e.g. have little space, or don't face southwards) could benefit from community schemes where those with panels connected together and share the energy. Like wind, no-one controls the sun and so countries that build solar farms will be less reliant on imported fossil fuels for energy.

'Solar panels can be installed on existing rooftops and over existing infrastructure'
(benefits)

People who install solar PV panels for their own consumption, but send the surplus energy generated into the National Grid are called 'prosumers'. It is estimated that 825,000 residential 'prosumers' in the UK. Solar panels can be

installed on existing infrastructure such as floating panels on reservoirs or as canopies over car parks.

Information collated from [Study on 'Residential Prosumers in the European Energy Union'](#) (European Commission, 2017), [Solar carport takes Norwich office off the grid](#) (Aviva, 2019) and [World's biggest floating solar farm powers up outside London](#) (The Guardian, July 2016)

'For solar farms to generate large amounts of energy they need to take up a lot of space' (drawback)

Solar farms are usually developed in rural areas because of the amount of space that is required for them. To generate 1 megawatt, a solar farm would require about 2.5 acres. Most solar farms are 100 acres or less in size. The facility in Kamuthi, Tamil Nadu, has a capacity of 648 megawatts and covers 10 square kilometers. In May 2020, the UK government gave the go-ahead for the biggest solar farm to date to be built in Kent. It could supply around 91,000 homes but will require 25 acres of land.

Info updated using [Biggest UK solar plant approved](#) (BBC News, May 2020)

'Weather and climate limit how much solar energy a place can produce. There is no sun during the night, and less of it in winter.' (drawback)

Cloud cover can obscure sunlight, and reduce the energy produced. Facilities that have excess shade levels are also impacted in a negative way. In the UK, far less solar energy is received in the winter than is in the summer due to latitude. The only way to use solar energy at night-time, is to store what you produce during the day, e.g. in batteries, and they add extra cost to an installation.

'Solar panels are relatively inefficient at converting the sun's energy into electricity' (drawback)

Although the technology is improving all the time, solar cells are one of the least efficient ways of generating electricity, typically converting only 15-20% radiative energy from the sun to electrical energy. Wind and gas turbines are at least twice as efficient, while water turbines from hydro-plants can be up to 90% efficient.

Info from [Energy conversion efficiency](#) (Wikipedia, accessed July 2020)


'The cost of installing solar PV panels or building large solar farms is still relatively high' (drawback)

Although the price per unit of energy is relatively cheap (around £67/MWh) and is continuing to fall rapidly, the cost of installing a solar PV system on a residential roof top, or constructing a large solar farm (and purchasing or renting the land for it) is still pricy.

Info from ['Electricity Generation Costs'](#) (BEIS, UK Government 2016)

Learning materials: Diamond-9 ranking cards for cutting out

Wind Energy



Wind is a sustainable, renewable source of energy that will never run out

Onshore wind is one of the cheapest ways to generate energy and will soon be the cheapest

The production of wind energy varies on all time scales, not as much is produced on calmer days than on windier days

Wind energy doesn't pollute the air or generate greenhouse gas emissions while generating electricity

It helps the UK become more 'energy secure' as it does not have to import fuel and has plenty of wind


Turbines are a risk to birds and bats, and have been killed by spinning blades

Turbines can be built in shallow seas or on existing farms. Farmers can still farm around the turbines and earn an income through rent.

The best places for wind farms are usually in remote locations away from cities where the energy is needed

Enough people believe wind turbines are an eye-sore and noisy to campaign against their construction in their local area

Solar Energy



Solar energy doesn't pollute the air or generate greenhouse gas emissions while generating electricity

The sun is a sustainable, renewable source of energy that will never run out

Solar panels are relatively inefficient at converting the sun's energy into electricity

Solar farms require very little maintenance, which is mostly to keep the panels clean

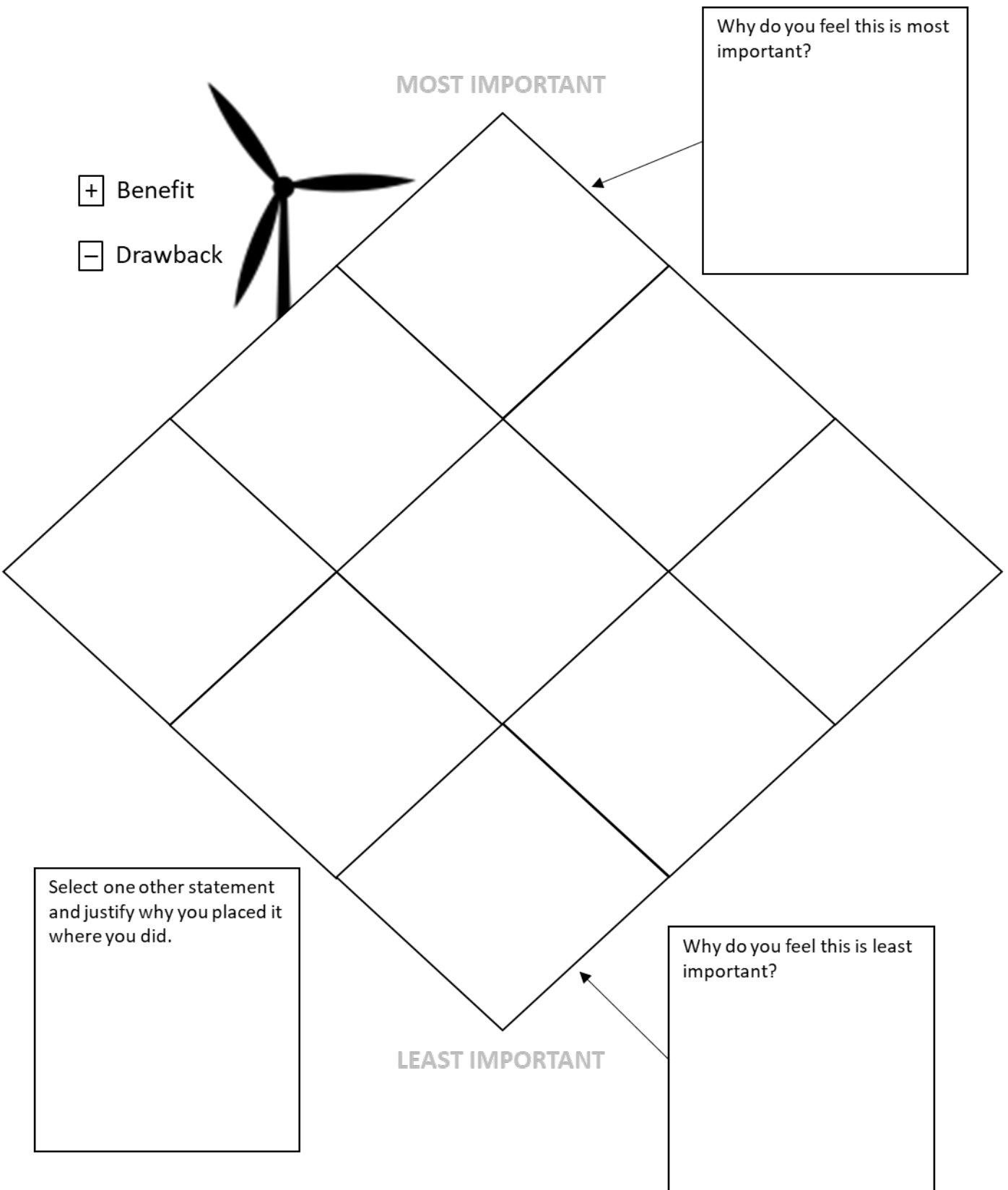
Weather and climate limit how much solar energy a place can produce. There is no sun during the night, and less of it in winter.

Solar panels can be installed on existing rooftops and over existing infrastructure

The cost of installing solar PV panels or building large solar farms is still relatively high

Solar power allows individuals, communities and countries to become energy independent and secure

Learning materials: Wind energy diamond-9 ranking worksheet



MOST IMPORTANT

Why do you feel this is most important?

Benefit

Drawback

LEAST IMPORTANT

Why do you feel this is least important?

Select one other statement and justify why you placed it where you did.

"The UK should not just continue to develop wind energy, but should be doing even more." To what extent do you agree or disagree with this statement? Use your diamond-9 ranking to justify your reasons.


Learning materials: Solar PV energy diamond-9 ranking worksheet

MOST IMPORTANT

Why do you feel this is most important?

Benefit

Drawback



Select one other statement and justify why you placed it where you did.

LEAST IMPORTANT

Why do you feel this is least important?

The diagram features a large diamond shape divided into nine smaller diamond-shaped cells. The top vertex is labeled 'MOST IMPORTANT' and the bottom vertex is labeled 'LEAST IMPORTANT'. A box at the top right asks 'Why do you feel this is most important?' with an arrow pointing to the top cell. A box at the bottom right asks 'Why do you feel this is least important?' with an arrow pointing to the bottom cell. A box on the left side asks 'Select one other statement and justify why you placed it where you did.' with an arrow pointing to the middle-left cell. To the left of the diamond, there is a legend with a plus sign in a box labeled 'Benefit' and a minus sign in a box labeled 'Drawback'. Below the legend is an icon of a solar panel with a sun behind it.

"Solar power is not suitable for a country like the UK." To what extent do you agree or disagree with this statement? Use your diamond-9 ranking to justify your reasons.