

ENERGY OPTIONS

There are many technologies that can be used as a source of energy to power our lives. To help weigh up the options, you should know the level of Greenhouse Gas (GHG) Emissions involved¹, whether the source is renewable (or whether the resource will eventually used up) and what other harmful waste is produced.

¹ GHG Emissions are calculated using CO₂e - carbon dioxide equivalent. Gases other than CO₂ also contribute to global warming, so the combined effect of all the greenhouse emissions of a process together is given by the amount of CO₂ alone required to have the same effect.

² [National Grid ESO article: https://www.nationalgrideso.com/news/britains-electricity-explained-2022-review](https://www.nationalgrideso.com/news/britains-electricity-explained-2022-review)



Fossil Fuels



Wind



Biomass



Solar



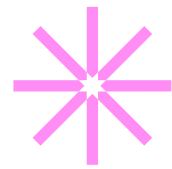
Hydropower



Nuclear

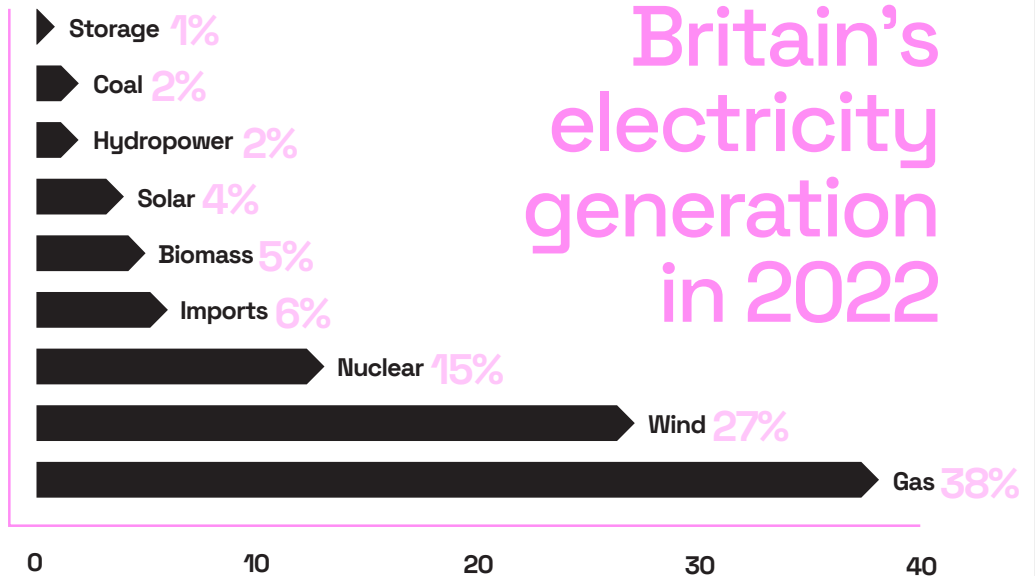


Geothermal









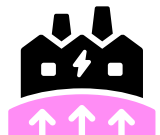

Fusion

Britain's electricity generation in 2022



In Britain, our electricity is mainly generated from burning fossil fuels, with our main renewable source being wind power². We make almost no use of geothermal power, but we do have some storage capacity in the form of batteries. Our biggest electricity imports are from France. In 2022 many French power stations were down for maintenance, so the import percentage is lower than normal. **Let's look at these energy options in more detail...**

² [National Grid ESO article: https://www.nationalgrideso.com/news/britains-electricity-explained-2022-review](https://www.nationalgrideso.com/news/britains-electricity-explained-2022-review)

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|----------------------------|--|--|
| <p>Fossil Fuels</p> |  <p>GHG emissions: Renewable: Harmful waste:</p> | <p>High to very high Non-renewable Particulates*, oil spills</p> |
| <p>Wind</p> |  <p>GHG emissions: Renewable: Harmful waste:</p> | <p>Very low Renewable None</p> |
| <p>Biomass</p> |  <p>GHG emissions: Renewable: Harmful waste:</p> | <p>Medium to high Renewable Particulates</p> |
| <p>Solar</p> |  <p>GHG emissions: Renewable: Harmful waste:</p> | <p>Low Renewable None</p> |
| <p>Hydropower</p> |  <p>GHG emissions: Renewable: Harmful waste:</p> | <p>Very low Renewable None</p> |
| <p>Nuclear</p> |  <p>GHG emissions: Renewable: Harmful waste:</p> | <p>Very low Non-renewable Needs careful disposal</p> |
| <p>Geothermal</p> |  <p>GHG emissions: Renewable: Harmful waste:</p> | <p>Low Renewable Very little</p> |
| <p>Fusion</p> |  <p>GHG emissions: Renewable: Harmful waste:</p> | <p>Very low Renewable Very little</p> |

* Particulates are tiny particles of solid or liquid in the air (e.g. dust, dirt, soot, smoke, drops of liquid), that can be a serious health hazard



ENERGY TECHNOLOGIES IN DEPTH

Fossil fuels

Coal, oil and natural gas are burned in power plants to heat up water to make steam, which turns turbines to make electricity. They are also used to heat our homes directly, as well as for cooking. Britain's coal use has dropped dramatically in the last few years, but oil and gas are still big players. Britain's coal and gas power stations provided 40% of electricity in 2022. However the vast majority of Britain's gas is burned for heating. Around $\frac{3}{4}$ of the UK's energy required for heating is provided by natural gas, and 94% of cars on UK roads still burn petrol or diesel (from crude oil).

Advantages: most countries have invested a huge amount of money over a number of decades to make this technology cheap and convenient to use in homes, cars, factories, etc. Today, in the short term, it can appear cheaper to continue with old technologies instead of investing in new ones.

Disadvantages: burning fossil fuels is the leading cause of global warming and climate change, because of the increase in the amount of carbon dioxide in the atmosphere (coal is the worst, then oil, with natural gas being slightly less bad again). Without releasing less CO₂,



climate breakdown will continue to get worse. Additionally, fossil fuels release other harmful gases, as well as particulates (very small solid particles or liquid drops) that cause harm by entering the lungs and then the bloodstream.

Fossil fuels are also a non-renewable resource – there is only so much coal oil and gas on planet Earth, and when it's gone, it's gone.

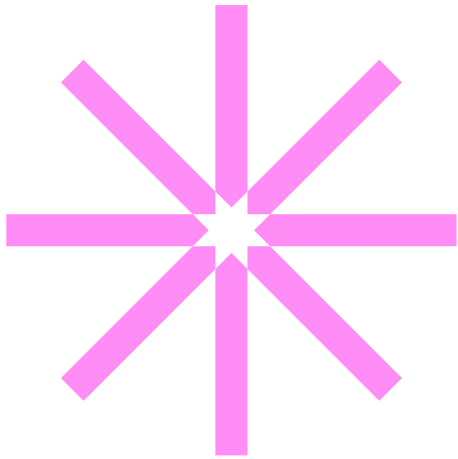
Wind power

Wind turbines turn in the wind, providing electricity that can be used immediately or sometimes stored, much like with solar power. Wind power is Britain's biggest renewable source of electricity, providing 27% of all electricity produced in 2022.

Advantages: wind is freely available, and renewable, as is solar power. During operation, neither emits greenhouse gases nor creates hazardous waste.

Disadvantages: wind turbines on land (known as "on-shore") can be unpopular with people who live nearby, and wind turbines out at sea ("off-shore") can be expensive and challenging to install.





Biomass

Biomass uses biological matter, such as plant material (including wood, crops grown for the purpose, and waste materials from industry and farming) and animal waste. It is either burned directly, or is processed to make a renewable version of fossil fuel natural gas. In 2022, 5% of Britain's electricity came from biomass.

Advantages: Biomass is renewable, since new biomatter can always be generated.

Disadvantages: it still emits quite a lot of greenhouse gases, and even more so if burnt when mixed with coal. If the biomatter is transported long distances to reach the power plant, transport emissions can be substantial. Burning biomass also releases other harmful gases and particulates into the atmosphere.



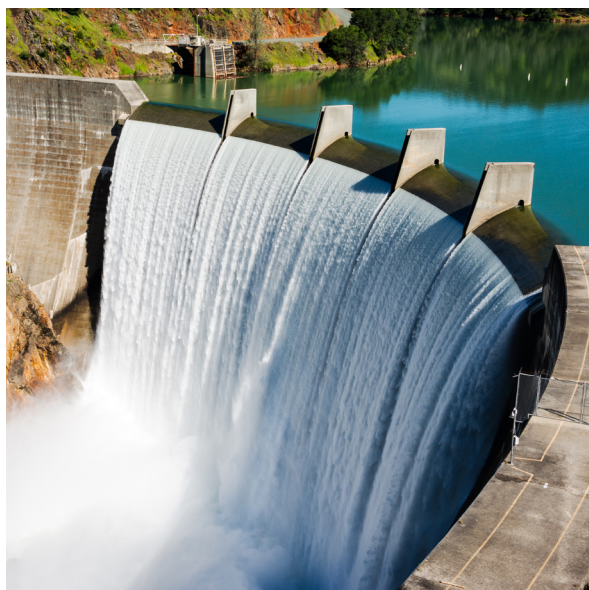
Solar power

Solar panels contain many photovoltaic cells, made of materials that produce electric current when exposed to sunlight. The panels provide electricity, which is either used immediately, or transferred to battery storage for use later. Solar power provided just over 4% of Britain's electricity in 2022.

Advantages: Sunlight is freely available, and renewable (sunlight continually hits the Earth and cannot be used up). The amount of energy transferred from the sun to the Earth every second is huge – much much greater than the needs of humankind (but currently only a tiny fraction is transferred in useful ways). During operation, solar power emits no greenhouse gases and creates no hazardous waste.

Disadvantages: the technology required to convert sunlight to electricity or useful heating is still quite expensive for individual households. Solar farms often cover large areas of land that people wish to use for other purposes. Solar panels release no CO₂ while they operate, but manufacturing them still releases some emissions.





Hydroelectric power

In conventional hydroelectric power, damming a river means that the flow of water downstream can be controlled and directed through a turbine. Other methods use the natural flow of a river downstream or motion of the tides. Britain's 2022 hydroelectric power made up less than 2% of electricity generated, but worldwide it is the most used renewable source of electricity¹.

Advantages: no carbon emissions whilst operating, and water is a fully renewable resource. No harmful waste is produced during operation either.

Disadvantages: dams need to be built to flood the area upstream of the turbine, disrupting the ecosystem. Ecological impact is smaller if we consider wave power or tidal power on the coast.



Nuclear power (fission)

Nuclear power takes radioactive material dug from the ground and processes it into a nuclear fuel. The process of fission heats up steam to turn a turbine and generates electricity. In Britain, nuclear power produced 15.5% of electricity in 2022, whereas for Germany it's only 6%, but compare this to say France, where in a typical year it is 70%².

Advantages: a small amount of fuel can generate a very large quantity of electricity. In theory, one kilogram of nuclear material can transfer 1.5 million times as much energy as one kilogram of coal. No greenhouse gases are emitted during operation.

Disadvantage: like fossil fuels, the raw materials needed for nuclear fission are non-renewable. Safely disposing of nuclear waste is still a challenge. Some people don't like the idea of nuclear power because they remember the history of nuclear weapons, and nuclear power plant disasters in the past.

¹ International Energy Agency Hydropower Special Market Report June 2021

<https://www.iea.org/reports/hydropower-special-market-report/executive-summary>

² <https://www.eia.gov/todayinenergy/detail.php?id=55259#:~:text=Nuclear%20power%20plants%20in%20France,generation%20share%20in%20the%20world>.



Geothermal

In some places, hot fluids naturally occur beneath the Earth's surface. These fluids can be pumped to the surface to create steam, driving a turbine. Either the fluid itself is transformed into steam, or it is used to heat up a second system of water that then turns to steam. Geothermal is heavily utilised in places like Iceland for both domestic heating and electricity, but Britain uses this source very little.

Advantages: Geothermal is potentially a huge power source that is renewable, doesn't involve burning fossil fuels, and creates only a small amount of hazardous waste.

Disadvantages: Geothermal plants can only be built in certain locations on Earth. Geothermal plants release some CO₂ while they are built, and during their operation.



Fusion Power

Fusion power is still experimental. Fusion is another nuclear process, but fusion power uses the opposite process to nuclear fission. In fusion, small atoms are combined to make larger atoms – the same process that powers the sun. The energy could then be transferred to heat up steam to drive turbines and make electricity.

Advantages: in theory, fusion power plants could produce huge amounts of electricity, without being dependent on the weather or the seasons. The raw materials are mostly recyclable, and those that aren't are needed in much smaller amounts than for other uses. This means fusion power is almost entirely renewable, as well as emitting no CO₂ whilst operating. The waste from fusion power is also much less of a problem than traditional nuclear (fission) plants – both in quantity and the level of danger posed.

Disadvantages: fusion machines need more work before they are ready to supply electricity full time – this will take time and money. Fusion needs electricity to run, and fusion machines need to be perfected further before enough electricity is generated to make it worthwhile.

