Physics – P3

Energy Resources

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Energy Demands

Most of the energy we use today comes from burning fossil fuels, mostly gas, oil, or coal. The electricity for homes and businesses is mainly generated by coal or gas fired power stations. Oil is needed for keeping road vehicles, ships, and planes.

Fossil fuels are extracted from the seabed and then transferred to oil refineries and power stations. However, the use of fossil fuels is causing huge environmental problems, and increasing the levels of greenhouse gases, and fossil fuels are non-renewable, meaning that it will eventually run out

Inside a Power Station

In a coal-fired or oil-fired power station, as well as in most gas-fired power stations, the burning fuel heats water in a boiler. The boiling of the water produces steam. The steam spins a turbine, which drives an electricity generator.

Biofuels

A Biofuel is any fuel taken from a living, or recently living, organism. Biofuels can be used instead of fossil fuels in modified engines and in generators at power stations. A biofuel is both renewable and carbon-neutral, as the source of the biofuel is continually produced (eg animal waste) and the carbon that the living organism has taken in over its life balances the carbon emitted when it is burnt. Biodiesel uses waste vegetable oil and plants, such as rapeseed. Other example of biofuels include:

* Ethanol (fermented sugar cane)
* Straw
* Nutshells
* Woodchips

Nuclear Power

Nuclear fuel uses energy from atoms. Every atom contains a positively charged nucleus, surrounded by negatively charged electrons. The fuel in a nuclear power station is normally uranium or plutonium and is placed in sealed rods in the core of the reactor. The nuclei of radioactive elements (including these fuels) are unstable and can split in two when hit by a neutron.

When this happens, a large amount of energy is releases in the form of heat, as well as more neutrons, which can cause other atoms to split, creating a chain reaction. The heat from the core is carried by a fluid (called a coolant) to a heat exchanger, where the heat boils water, before returning to the core. The steam produced is used to rotate a turbine, generating electricity.

Nuclear vs Fossil Fuels

|  |  |  |
| --- | --- | --- |
|  | Nuclear | Fossil Fuels |
| Fuel | Uranium / Plutonium | Coal, Oil or Gas |
| Energy released per Kg of fuel | 300,000 MJ | 30 MJ |
| Waste | Dangerous radioactive waste which must be stored for many years | Non-radioactive waste |
| Greenhouse gases produced | None – energy is released without burning | Fossil Fuels produce greenhouse gases when they burn. |

Wind and Wave Power

A wind turbine is an electricity generator on top of a narrow tower. The wind rotates the turbine, generating electricity. The power generated increases as the wind speed increases. However, wind turbines are unreliable, as when there is little or no wind, they do not generate electricity.

A wave generator is a floating generator, which is turned by the waves as it moves up and down. A cable connected to the shore delivers the generated electricity. However, these are also unreliable, and need to be built to withstand storms. They also spoil large areas of coastline, and may disrupt the habitat of marine life and birds.

Hydroelectric and Tidal Power

Hydroelectricity can be generated when water that has been collected in a reservoir flows downhill. The flowing water drives turbines and the bottom of the hill which are connected to generators. Some hydroelectric power stations are designed as pumped storage schemes. When power demand is low, water can be pumped to an upper reservoir. When more power is required, the water can be allowed to flow downhill, generating electricity.

A tidal power station traps water from each high tide behind a large barrage. The high tide can then be released back into the sea through turbines, generating electricity. In some costal areas, electricity is generated by the natural tidal flow passing through underwater turbines. These turbines are connected to the mainland through cables, allowing them to transfer the generated electricity.

Solar and Geothermal Energy

Today’s solar cells only convert less than 10% of the energy it receives into electricity. This means that they are only effective in devices which do not require much power, or remote locations. Many solar panels are required to generate enough power to be useful, even so, they can be unreliable in cloudy conditions.

A solar heating panel is a solar panel which has water flowing through it. Instead of generating electricity, it heats water. A solar power tower uses many flat mirrors. The mirrors are controlled by a computer to focus the sun onto the top of a tower. Water is stored there and is heated up by the sun. The hot water creates steam, which is used to generate electricity.

Geothermal energy comes from the heat of the Earth. These power stations are built in volcanic areas, or areas where there are hot rocks below the Earth’s surface. Water is pumped down to these rocks to produce steam. This steam is brought back to the surface, where it generates electricity.

Problems with Fossil Fuels

When fossil fuels such as coal or gas are burnt, greenhouse gases are released. These gases are building up, and most scientists believe that this is speeding up global warming and causing climate change. Burning impure fossil fuels can also produces sulphur, in the form of sulphur dioxide. This can cause acid rain, which damages the environment. This can be prevented by ensuring that the impurities are removed from fuels before they are burnt.

Also, fossil fuels are a non-renewable resource and will eventually run out. By that point we will need to have found reliable renewable sources of energy. Oil and gas supplies could run out in the next 50 years, but coal is expected to last much longer.

Nuclear vs Renewable

Nuclear:

|  |  |
| --- | --- |
| Advantages | Disadvantages |
| No greenhouse gases produced | Used fuel is highly radioactive, and must be stored safely for centuries |
| More energy is transferred compared to fossil fuels | An accident at a nuclear reactor could lead to widespread contamination, affecting the area and residents for many years. |

Renewable Energy:

|  |  |
| --- | --- |
| Advantages | Disadvantages |
| They will never run out as they are replaced by natural processes | Renewable energy cannot currently meet global demand |
| Does not produce greenhouse gases or acid rain | Wind turbines create a whirring noise which can upset those living nearby |
| Does not create dangerous radioactive waste | Tidal barrages can affect the habitats of animals living in river estuaries |
| They can be used in remote locations without connections to the national grid | Hydroelectric schemes require reservoirs of water, which can affect plant and animal life |
|  | Solar cells need to cover large areas of land to generate sufficient power |
|  | Some renewable resources can be unreliable as they only work in certain conditions (eg solar cells require sunlight) |

Supply and Demand

The demand for electricity changes throughout the day, every day. It is also higher in winter due to heating. Power stations cannot start up instantly, and some take longer than others. The demand for electricity is met using:

* Nuclear and Coal-fired power stations to meet the “base” load, which is always the same amount.
* Using Gas-fired power stations to meet daily changes in demand, as well as the extra power required in winter.
* Using renewable energy resources when the demand is high, and when the conditions are suitable
* Using renewable energy resources when demand is low to power pumped storage schemes (see [Hydroelectricity](#Hydroelectric_and_Tidal_Power))

The overall cost of a new energy facility includes the costs to build it, costs for fuel, and costs to decommission it at the end of its life. Here are the costs in £ per kilowatt hour (£/kWH):

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Power Plant type | Coal | Natural Gas | Nuclear | Wind | Solar | Geothermal | Biofuel | Hydroelectric |
| £ per MwH | 93 | 32 | 69 | 53.31 | 75.67 | 27.59 | 68.59 | 69.34 |