

Natural Resources

Introduction

The **Environment** influences an organism's life in many ways. It is everything that surrounds an organism and it includes physical and biological components. The physical components of the environment are soil, water, air, light and temperature. These are termed as **abiotic** components. The biological components are plants and animals, collectively referred to as **biotic** components.

Air, water, soil, minerals, coal, petroleum, animals and plants are referred to as **natural resources**.

The growing human population manipulates these natural resources to satisfy its needs. The destruction of forests for agricultural and commercial reasons has upset the ecological balance.

Types of Natural Resources

There are two types of natural resources.

1. **Inexhaustible Natural Resource**

The inexhaustible natural resources are unlimited in nature, and they are not likely to be exhausted by human activities. Example are solar radiation, air, water, precipitation (rainfall, snow fall, etc.,) and atomic power.

Exhaustible Natural Resource

The exhaustible natural resources are limited in nature and are liable to be degraded in quantity and quality by human activities. Examples are forests, soil, wild animals, minerals, fossil fuels etc.

WATER

About 70-73% of earth is covered by water. Water is available in the form of oceans, seas, rivers, lakes, ponds, pools, polar ice caps and water vapour. The main component of hydrosphere is water. Water exists in all the three forms i.e., solid (snow), liquid (water) and gas (water vapour).

Water is absolutely essential for the maintenance of life. The most important character of water is that its density is similar to that of protoplasm. Water consists of two atoms of hydrogen and one atom of oxygen. It is a universal solvent since it dissolves most of the compounds.

Water is the fundamental natural resource. Human beings depend on water for drinking, cooking, agriculture, transportation, hydropower etc.

Water available in nature is of two types.

Salt Water: It constitutes the oceans and the seas. Nature has comparatively more salt water than fresh water

Fresh Water: Fresh water is an unlimited natural resource. Its quality is often degraded but there is no reduction in quantity.

Sources Of Water

There are three main sources of fresh water.

- Rainwater
- Surface water (surface flow)
- Ground water

Rainwater

India receives about 3 million m³ of water from rainfall (or precipitation), which amounts to 105-117 cm annually. This is a huge quantity and the largest in the world.

Intensity of rainfall in India varies from region to region forming four zones. They are:

Wet Zone: Here annual rainfall is very high (i.e. over 200 cm). West coast of India and northeastern parts of India come under this category.

Intermediate Zone: Rainfall is quite heavy (i.e. 100 to 200 cm). Parts of UP, Karnataka, Maharashtra, Bengal, Orissa, Punjab, Himachal Pradesh and Kerala fall in this zone.

Semi Arid Zone: Annual rainfall is moderate (i.e. between 50-100 cm). Most parts of central India, Southern peninsula and parts of Rajasthan and Gujarat comes under this region.

Arid Zone: In this zone the annual rainfall is very low (i.e., it ranges from 20 to 50 cm). Rajasthan and parts of Gujarat fall under this region.

Surface Water

In India, there are 14 major river systems such as Ganga, Brahmaputra, Godaveri, Krishna and Cauvery. The other sources are ponds, lakes and streams.

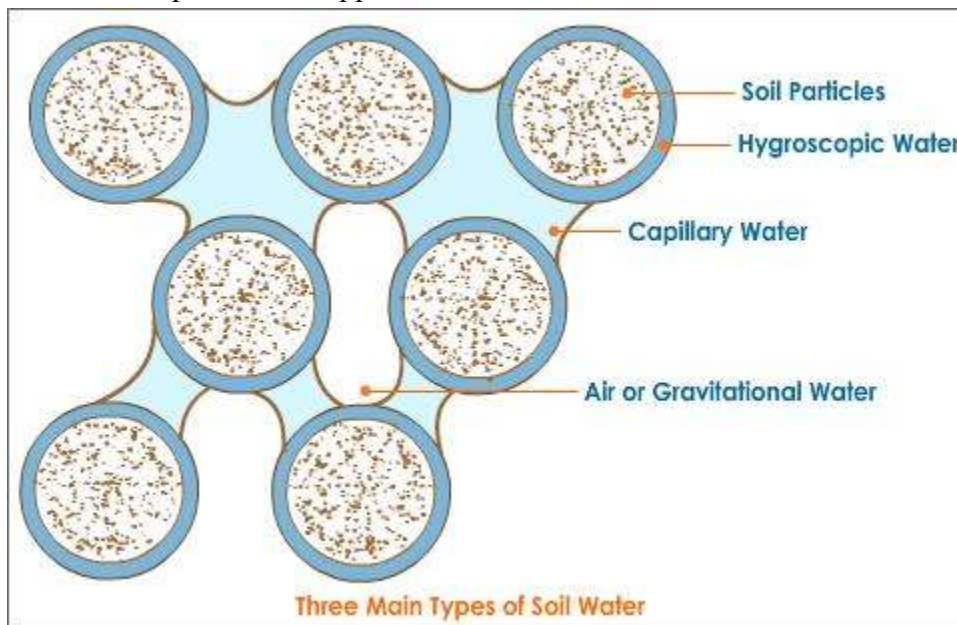
Ground Water

Underground reservoirs of fresh water are called aquifers. They are continuously recharged through infiltration, sewage and evapo transpiration. The total volume of ground water found in the aquifer is estimated to be $42.3 \times 10^{10} \text{m}^3$.

Water Level and Water Table

• The space between soil particles on the surface of earth is called pore space. This is of two types, micro pores and macro pores. Most of the water is held in the micro pores. These pores are available for plant roots

Surface soil pore spaces are generally filled with air and water. Water that percolates down through pore spaces of rocks is available as ground water. This ground water provides soil moisture for plants and supplements streams and lakes.



The porous rocks are saturated with water at a certain level below the surface that is called zone of saturation. The upper level of zone of saturation is called the water-table. The depth in the soil where all the pore spaces of soil particles are

saturated with water is called water table. The water table reaches the surface of earth in rainy seasons, near rivers, lakes and swamps. It is deeper on hilltops, in dry areas and in areas of low rainfall.

The following factors tend to lower the water at any given place

- Scanty rainfall
- Excessive use of ground water

- Cultivating of trees

SOIL

Soil can be defined as the uppermost crust of earth mixed with organic material and in which animals and microorganisms live, and plants grow. The word soil is derived from a Latin word solum meaning ground. It is a stratified mixture of inorganic and organic materials, both of which are products of decomposition. Formation of soil takes place by interaction between the physical and biological components.

Inorganic or mineral constituents are derived from the soil forming rocks, by fragmentation or weathering. Rocks are affected by the action of rain, wind and temperature. This is physical weathering. Lichens and mosses grow on rocks also causing weathering.

The organic component of the soil is formed either by microbial decomposition of dead remains of plants (litter) or animals, or through metabolic activities of living organism present in the soil.

Components of Soil

- Inorganic material derived from parent (material) rocks
- Organic material derived from dead and decayed materials
- Biological system - such as bacteria, fungi, algae, protozoa and other soil animals such as nematodes, earthworms etc.
- The air and water occupying the pores between the soil particles that are loosely packed
- Aids Food Production

ATMOSPHERE

Atmosphere is the envelop of gases, which surrounds the earth. It is mixture of gases such as nitrogen, oxygen, inert gases, carbon dioxide etc. It is very important for the existence of life on the earth. Atmosphere is divided into different regions on the basis of temperature change, which are

Troposphere

The first zone, 10 to 12 km from the surface of the earth is called troposphere. Oxygen is present here. At higher altitudes, some of us find it difficult to breathe, as the oxygen content is reduced.

In this region of the atmosphere temperature decreases with increasing altitude. All climatic phenomena are possible in this region only.

Stratosphere

Above the troposphere is the stratosphere. This zone is rich in ozone. Hence, it is also called ozonosphere. In ozonosphere, oxygen in the presence of sunlight converts to ozone by photochemical dissolution. The ozonosphere completely absorbs short wave solar radiations, such as ultraviolet (uv) radiations, x-rays, gamma rays etc. Oxygen and ozone of stratosphere provide protection from harmful solar radiation and the bad effects of ultraviolet rays. Stratosphere is free from clouds. Aeroplanes usually fly in this zone.

The effects of ultraviolet radiations are:

- Cataract - eye lens becomes opaque causing blindness
- Inflammatory diseases
- Skin cancer

Mesosphere

It is the third region of the atmosphere from the ground. In this region temperature decreases with increasing height.

Ionosphere

It is the region next to the mesosphere. Generally the gases molecules break into respective ions in this region. This region is very important for the transmission of radio signals to the earth.

MINERALS

Earth's crust is rich in inorganic materials. It includes ores, that are used on a large-scale to yield metals such as iron, aluminium, copper, tin, nickel, silver, gold, platinum etc. These minerals are very useful in industrial and technological growth. Some of the metals are used as catalysts, for e.g., vanadium, tungsten and molybdenum. Some of the non-metallic materials (minerals) such as sand, fluxes, clay, salt, sulphur, phosphorus, diamonds, gems, coal and by-products of petroleum (petrol, kerosene, lubricants) are vital to industrial growth.

The mineral resources are not renewable. Mineral deposits are formed slowly over millions of years and once used, cannot be regenerated. Coal, petroleum, iron, gold, aluminium, copper are

the important natural resources. Petroleum products also called fossil fuels, are widely used in agriculture, transportation and industry.

In the modern technological world, the minerals like iron, steel, aluminium, glass, cement, sand, gravel, bricks etc., are used in the field of medicine and surgery, space technology, agriculture and its allied fields, buildings, transportation and in national defence.

Atomic energy is produced by metals such as uranium and thorium. Thus, mineral resources play a significant role in the economy of a nation.

ENERGY RESOURCES

Fuel wood, agricultural waste and cow dung (gobar), form the major sources of energy for rural India and most of the urban Indian population consumes energy from coal, petroleum, natural gas (CNG), hydel power (hydroelectricity), sun, wind and nuclear power. At present, India produces 97,800 MW of energy from different sources.

Most of the energy, which we use, is derived directly or indirectly from the sun.

Following table gives the different source of power generation in India:

Source	Electricity Production (MW)
Thermal Power (Solar energy)	70,200
Hydel Power	23,800
Nuclear Power	2,700
Wind Power	1,150
Biomass Power	256

Classification of Energy

Non-renewable or Conventional Energy Resources

Resources which are in limited amounts and cannot be renewed are called non-renewable energy resources. Fossil fuels like coal and petroleum are some examples. Petroleum products are energy-rich components of carbon which have undergone anaerobic degradation with the help of sun's energy. Availability of petroleum is limited.

Renewable or Non-conventional Energy Resources

Renewable energy resources are solar radiation, wind power, hydel power, biomass and nuclear power. They can be recycled and renewed by nature. These are normally pollution free. In India, unconventional energy resources are harnessed by different methods

Renewable Energy Resources Harnessed by Different Methods

Devices / Methods	Number
Biogas Plants	30,00,000
Solar Cookers	4,90,000
Solar PV Pumps	3,400
Wind Pumps	637

Types of Non-conventional Energy Resources

Solar Energy

Sun is the biggest source of non-conventional energy. Energy is in the form of photons. India receives abundant sunlight for about 250-300 days in a year. Conversion of solar energy to electric energy and thermal energy takes place mainly by photovoltaic cells and through solar thermal pathways.

Applications: solar heaters, solar dryers and solar cells.

Hydel Power

Electricity is obtained from flowing water. Water from the dam is allowed to flow through the tunnels at a high pressure. Turbines convert the potential energy of the water into electrical energy. About 23,800 MW of energy is generated by hydel power in India.

Hydel power requires construction of big dams, which change the ecological balance posing environmental problems. Mini hydel or micro hydel projects can be built on small streams or canals. These are more convenient than mega hydel power projects.

Solar power, that's obvious, but the energy in [coal](#) originally came from the Sun too. Prehistoric plants stored the Sun's energy in their leaves, and when they died and eventually formed coal seams, that energy was still there. So when we burn coal (or any [fossil fuel](#)), we're releasing chemical energy that was stored in plants millions of years ago.

Most power stations burn [coal, oil or natural gas](#) to run the generators. Others use [uranium](#), or the flow of water. Electricity is sent around the country using high-voltage power lines. Nearly all of the power we use comes from large power stations, although some places such as isolated farms, or hospitals, have their own diesel generators.

Coal, oil and gas are called "fossil fuels" because they have been formed from the organic remains of prehistoric plants and animals.

Coal provides around 28% of our energy, and oil provides 40%. Mind you, this figure is bound to have changed since this page was written, so check the figures if you want to quote them.

Burning coal produces sulphur dioxide, an acidic gas that contributes to the formation of acid rain. This can be largely avoided using "flue gas desulphurisation" to clean up the gases before they are released into the atmosphere. This method uses limestone, and produces gypsum for the building industry as a by-product. However, it uses a lot of limestone.

How it works:

Coal is crushed to a fine dust and burnt.

Oil and gas can be burnt directly.



The main bit to remember:



Crude oil (called "petroleum") is easier to get out of the ground than coal, as it can flow along pipes. This also makes it cheaper to transport.

Natural gas provides around 20% of the world's consumption of energy, and as well as being burnt in power stations, is used by many people to heat their homes.

It is easy to transport along pipes, and gas power stations produce comparatively little pollution.

Other fossil fuels are being investigated, such as bituminous sands and oil shale. The difficulty is that they need expensive processing before we can use them; however Canada has large reserves of 'tar sands', which makes it economic for them to produce a great deal of energy this way.

As far as we know, there is still a lot of oil in the ground. But although oil wells are easy to tap when they're almost full, it's much more difficult to get the oil up later on when there's less oil down there. That's one reason why we're increasingly looking at these other fossil fuels.

Advantages

- Very large amounts of electricity can be generated in one place using coal, fairly cheaply.
- Transporting oil and gas to the power stations is easy.
- Gas-fired power stations are very efficient.

- A fossil-fuelled power station can be built almost anywhere, so long as you can get large quantities of fuel to it. Didcot power station, in Oxfordshire, has a dedicated rail link to supply the coal.

Disadvantages

- Basically, the main drawback of fossil fuels is pollution. Burning any fossil fuel produces carbon dioxide, which contributes to the "greenhouse effect", warming the Earth.
- Burning coal produces more carbon dioxide than burning oil or gas. It also produces sulphur dioxide, a gas that contributes to acid rain. We can reduce this before releasing the waste gases into the atmosphere.
- Mining coal can be difficult and dangerous. Strip mining destroys large areas of the landscape.
- Coal-fired power stations need huge amounts of fuel, which means train-loads of coal almost constantly. In order to cope with changing demands for power, the station needs reserves.

This means covering a large area of countryside next to the power station with piles of coal.

Is it renewable?

Fossil fuels are **not** a [renewable](#) energy resource.

Once we've burned them all, there isn't any more, and our consumption of fossil fuels has nearly doubled every 20 years since 1900.

This is a particular problem for oil, because we also use it to make plastics and many other products.

Ok, you could argue that fossil fuels are renewable because more coal seams and oil fields will be formed if we wait long enough. However that means waiting for many millions of years. That's a long time - we'd have to wait around for longer than the time that humans have existed so far! As far as we today are concerned, we're using it up very fast and it hardly gets replaced at all - so by any sensible human definition fossil fuels are not renewable.

Amrapali Institute

Haldwani

Geothermal - heat from underground

Introduction

The centre of the Earth is around 6000 degrees Celsius - easily hot enough to melt rock. Even a few kilometres down, the temperature can be over 250 degrees Celsius.

In general, the temperature rises one degree Celsius for every 36 metres you go down.

In volcanic areas, molten rock can be very close to the surface. Sometimes we can use that heat.

Geothermal energy has been used for thousands of years in some countries for cooking and heating.

The name "geothermal" comes from two Greek words: "geo" means "Earth" and "thermal" means "heat".

How it works

Hot rocks underground heat water to produce steam.

We drill holes down to the hot region, steam comes up, is purified and used to drive turbines, which drive electric generators.

There may be natural "groundwater" in the hot rocks anyway, or we may need to drill more holes and pump water down to them.

The first geothermal power station was built at Larderello, in Italy, and the second was at Wairekei in New Zealand. Others are in Iceland, Japan, the Philippines and the United States.

In Iceland, geothermal heat is used to heat houses as well as for generating electricity.

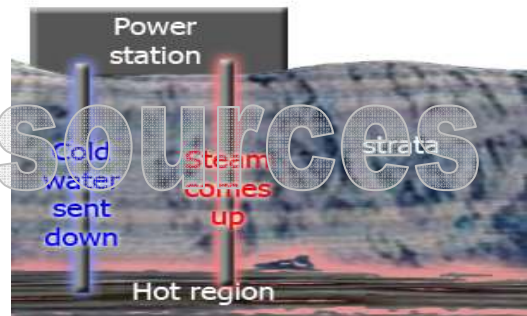
If the rocks aren't hot enough to produce steam we can sometimes still use the energy - the Civic Centre in Southampton, England, is partly heated this way as part of a district heating scheme with thousands of customers

Geothermal energy is an important resource in volcanically active places such as Iceland and New Zealand.

How useful it is depends on how hot the water gets. This depends on how hot the rocks were to start with, and how much water we pump down to them.

Water is pumped down an "injection well", filters through the cracks in the rocks in the hot region, and comes back up the "recovery well" under pressure. It "flashes" into steam when it reaches the surface.

The steam may be used to drive a turbogenerator, or passed through a heat exchanger to heat water to warm houses. A town in Iceland is heated this way.



The steam must be purified before it is used to drive a turbine, or the turbine blades will get "furred up" like your kettle and be ruined.

Advantages

- Geothermal energy does not produce any pollution, and does not contribute to the greenhouse effect.
- The power stations do not take up much room, so there is not much impact on the environment.
- No fuel is needed.
- Once you've built a geothermal power station, the energy is almost free.
It may need a little energy to run a pump, but this can be taken from the energy being generated.

Disadvantages

- The big problem is that there are not many places where you can build a geothermal power station.
You need hot rocks of a suitable type, at a depth where we can drill down to them. The type of rock above is also important. It must be of a type that we can easily drill through.
- Sometimes a geothermal site may "run out of steam", perhaps for decades.
- Hazardous gases and minerals may come up from underground, and can be difficult to safely dispose of.

Is it renewable?

Geothermal energy is [renewable](#).

The energy keeps on coming, as long as we don't pump too much cold water down and cool the rocks too much.

Hydroelectric power

Introduction

We have used running water as an energy source for thousands of years, mainly to grind corn. The first house in the world to be lit by hydroelectricity was [Cragside House, in Northumberland, England, in 1878](#).

In 1882 on the Fox river, in the USA, hydroelectricity produced enough power to light two paper mills and a house.

Nowadays there are many hydro-electric power stations, providing around 20% of the world's electricity. The name comes from "hydro", the Greek word for water.

How it works

A dam is built to trap water, usually in a valley where there is an existing lake.

Water is allowed to flow through tunnels in the dam, to turn [turbines](#) and thus drive generators.

Notice that the dam is much thicker at the bottom than at the top, because the pressure of the water increases with depth.

Hydro-electric power stations can produce a great deal of power very cheaply.

When it was first built, the huge "Hoover Dam", on the Colorado river, supplied much of the electricity for the city of Las Vegas; however now Las Vegas has grown so much, the city gets most of its energy from other sources.

Although there are many suitable sites around the world, hydro-electric dams are very expensive to build. However, once the station is built, the water comes free of charge, and there is no waste or pollution.

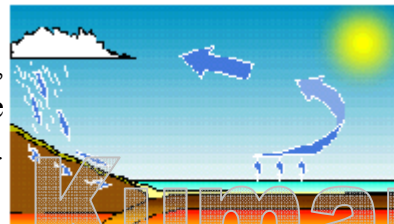
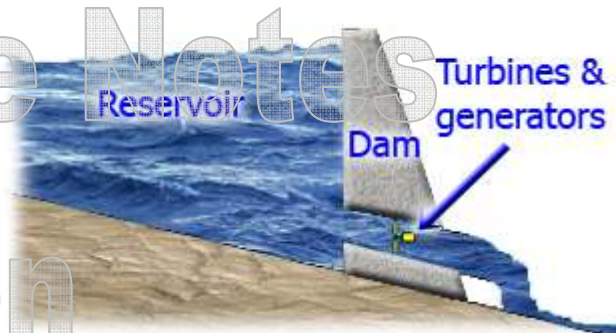
The Sun evaporates water from the sea and lakes, which forms clouds and falls as rain in the mountains, keeping the dam supplied with water. For free.

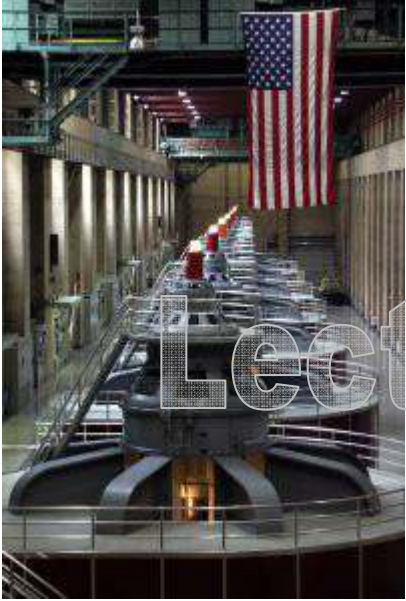
Gravitational potential energy is stored in the water above the dam.

Because of the great height of the water, it will arrive at the [turbines](#) at high pressure, which means that we can extract a great deal of energy from it. The water then flows away downriver as normal.

In mountainous countries such as Switzerland and New Zealand, hydro-electric power provides more than half of the country's energy needs.

An alternative is to build the station next to a fast-flowing river. However with this arrangement the flow of the water cannot be controlled, and water cannot be stored for later use.





Advantages

- Once the dam is built, the energy is virtually free.
- No waste or pollution produced.
- Much more reliable than wind, solar or wave power.
- Water can be stored above the dam ready to cope with peaks in demand.
- Hydro-electric power stations can increase to full power very quickly, unlike other power stations.
- Electricity can be generated constantly.

Disadvantages

- The dams are very expensive to build. However, many dams are also used for flood control or irrigation, so building costs can be shared.
- Building a large dam will flood a very large area upstream, causing problems for animals that used to live there.
- Finding a suitable site can be difficult - the impact on residents and the environment may be unacceptable.
- Water quality and quantity downstream can be affected, which can have an impact on plant life.

Is it renewable?

Hydro-electric power is [renewable](#).

The Sun provides the water by evaporation from the sea, and will keep on doing so.

Nuclear Power - energy from splitting Uranium atoms

Introduction

Nuclear power is generated using Uranium, which is a metal mined in various parts of the world.

The first large-scale nuclear power station opened at Calder Hall in Cumbria, England, in 1956.

Some military ships and submarines have nuclear power plants for engines.

Nuclear power produces around 11% of the world's energy needs, and produces huge amounts of energy from small amounts of fuel, without the pollution that you'd get from burning fossil fuels.

How it works:

The main bit to remember:



Nuclear power stations work in pretty much the same way as fossil fuel-burning stations, except that a "chain reaction" inside a nuclear reactor makes the heat instead.

The reactor uses Uranium rods as fuel, and the heat is generated by **nuclear fission**: neutrons smash into the nucleus of the uranium atoms, which split roughly in half and release energy in the form of heat.

Carbon dioxide gas or water is pumped through the reactor to take the heat away, this then heats water to make steam.

The steam drives [turbines](#) which drive generators.

Modern nuclear power stations use the same type of [turbines](#) and generators as conventional power stations.

In Britain, nuclear power stations are often built on the coast, and use sea water for cooling the steam ready to be pumped round again. This means that they don't have the huge "cooling towers" seen at other power stations.

The reactor is controlled with "control rods", made of boron, which absorb neutrons. When the rods are lowered into the reactor, they absorb more neutrons and the fission process slows down.

To generate more power, the rods are raised and more neutrons can crash into uranium atoms.

More:

Natural uranium is only 0.7% "uranium-235", which is the type of uranium that undergoes fission in this type of reactor.

The rest is U-238, which just sits there getting in the way. Modern reactors use "enriched" uranium fuel, which has a higher proportion of U-235.

The fuel arrives encased in metal tubes, which are lowered into the reactor whilst it's running, using a special crane sealed onto the top of the reactor.

With an AGR or Magnox station, carbon dioxide gas is blown through the reactor to carry the heat away. Carbon dioxide is chosen because it is a very good coolant, able to carry a great deal of heat energy. It also helps to reduce any fire risk in the reactor (it's around 600 degrees Celsius in there) and it doesn't turn into anything nasty (well, nothing long-lived and nasty) when it's bombarded with neutrons

You have to be very careful about the materials you use to build reactors - some materials will turn into horrible things in that environment. If a piece of metal in the reactor pressure vessel turns brittle and snaps, you're probably in trouble - once the reactor has been built and started you can't go in there to fix anything.

Uranium itself isn't particularly radioactive, so when the fuel rods arrive at the power station they can be handled using thin plastic gloves. A rod can last for several years before it needs replacing.

It's when the "spent" fuel rods are taken out of the reactor that you need the full remote-control robot arms and Homer Simpson equipment.

Should I worry about nuclear power?

Nuclear power stations are not atomic bombs waiting to go off, and are not prone to "meltdowns".

There is a lot of U-238 in there slowing things down - you need a high concentration of U-235 to make a bomb.

If the reactor gets too hot, the control rods are lowered in and it cools down. If that doesn't work, there are sets of emergency control rods that automatically drop in and shut the reactor down completely.

With reactors in the UK, the computers will shut the reactor down automatically if things get out of hand (unless engineers intervene within a set time). At Chernobyl, in Ukraine, they did not have such a sophisticated system, indeed they over-rode the automatic systems they did have.

When they got it wrong, the reactor overheated, melted and the excessive pressure blew out the containment system before they could stop it. Then, with the coolant gone, there was a serious fire. Many people lost their lives trying to sort out the mess. A quick web search will tell you more about this, including companies who operate tours of the site.

If something does go wrong in a really big way, much of the world could be affected - some radioactive dust (called "fallout") from the Chernobyl accident landed in the UK. That's travelled a long way.

With AGR reactors (the most common type in Britain) there are additional safety systems, such as flooding the reactor with nitrogen and/or water to absorb all the neutrons - although the water option means that reactor can never be restarted.

So should I worry? I think the answer is "so long as things are being done properly, I don't need to worry too much. The bit that does worry me is the small amount of high-level nuclear waste from power stations. Although there's not much of it, it's very, very dangerous and we have no way to deal with it apart from bury it and wait for a few thousand years..."

There are many different opinions about nuclear power, and it strikes me that most of the people who protest about it don't have any idea what they're talking about. But please **make up your own mind**, find out as much as you can, and if someone tries to get you to believe their opinion ask yourself "what's in it for them?"

Advantages

- Nuclear power costs about the same as coal, so it's not expensive to make.

- Does not produce smoke or carbon dioxide, so it does not contribute to the greenhouse effect.
- Produces huge amounts of energy from small amounts of fuel.
- Produces small amounts of waste.
- Nuclear power is reliable.

Disadvantages

- Although not much waste is produced, it is very, very dangerous. It must be sealed up and buried for many thousands of years to allow the radioactivity to die away. For all that time it must be kept safe from earthquakes, flooding, terrorists and everything else. This is difficult.
- Nuclear power is reliable, but a lot of money has to be spent on safety - if it **does** go wrong, a nuclear accident can be a major disaster. People are increasingly concerned about this - in the 1990's nuclear power was the fastest-growing source of power in much of the world. In 2005 it was the second slowest-growing.

Is it renewable?

Nuclear energy from Uranium is **not** [renewable](#). Once we've dug up all the Earth's uranium and used it, there isn't any more.

Pumped Storage Reservoirs - storing energy to cope with big demands

Introduction

Pumped storage reservoirs aren't really a means of **generating** electrical power. They're a way of **storing** energy so that we can release it quickly when we need it.

Demand for electrical power changes throughout the day. For example, when a popular TV programme finishes, a huge number of people go out to the kitchen to put the kettle on, causing a sudden peak in demand.

If power stations don't generate more power immediately, there'll be power cuts around the country - traffic lights will go out, causing accidents, and all sorts of other trouble will occur.



The problem is that most of our power is generated by fossil fuel power stations, which take half an hour or so to crank themselves up to full power. Nuclear power stations take much longer. We need something that can go from nothing to full power immediately, and keep us supplied for around half an hour or so until the other power stations catch up. Pumped storage reservoirs are the answer we've chosen.

The UK has one in North Wales, at Dinorwig. There's an older one at Ffestiniog, also in North Wales.

How it works

Between 1976 and 1982 at Dinorwig, in North Wales, a huge project was built. Yet there's little to see as you drive past, as most of it is deep inside a mountain.

Water is pumped up to the top reservoir at night, when demand for power across the country is low.

When there's a **sudden demand for power**, the "headgates" (huge taps) are opened, and water rushes down the tunnels to drive the [turbines](#), which drive the powerful generators.

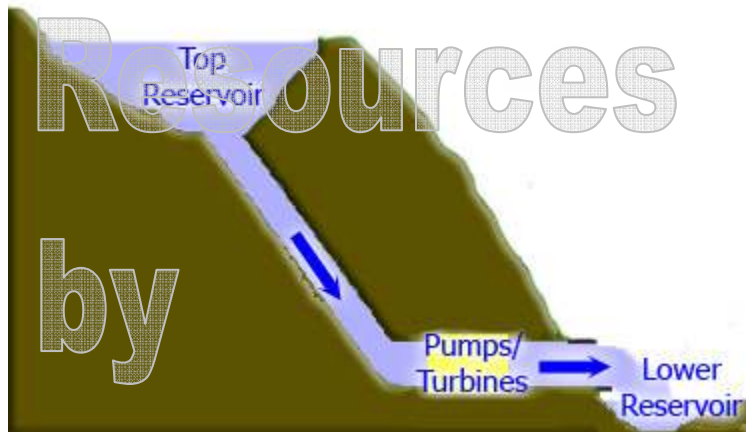
The water then collects in the bottom reservoir, ready to be pumped back up later.

Dinorwig has the fastest "response time" of any pumped storage plant in the world - it can provide 1320 MegaWatts in 12 seconds. That's a lot of cups of tea!

More about Dinorwig

When water is pumped up to the top reservoir (called "Marchlyn Mawr") we are storing gravitational potential energy in it. The greater the height, the more energy is stored.

This is one of the reasons that the Dinorwig site was chosen - there was a big height difference between two existing lakes, so less work was needed to build the station.



The water falls 600 metres on its way to the [turbines](#), so it's under a great deal of pressure when it arrives. For this reason, the tunnels are lined with steel at the bottom end.



Each of the six generators is capable of producing 288 MegaWatts of power at 18,000 Volts, which is stepped up to 400,000 Volts by transformers and sent along underground cables to be fed into the "supergrid", which is the long-distance network of the National Grid.

Dinorwig has "pump/turbines", which can be used both as pumps for getting water from the lower to the upper reservoirs, and as [turbines](#) for generating electrical power.

There is a complex system of gutters in the roof of the caves, to collect water that drips down through the rock. Carol Vordeman worked on this part of the station - helping to design this was one of her first engineering jobs before she moved into television.

Solar power - energy from the Sun

Introduction

We've used the Sun for drying clothes and food for thousands of years, but only recently have we been able to use it for generating power.

The Sun is 150 million kilometres away, and amazingly powerful.

Just the tiny fraction of the Sun's energy that hits the Earth (around a hundredth of a millionth of a percent) is enough to meet all our power needs many times over.

In fact, every minute, enough energy arrives at the Earth to meet our demands for a whole year - if only we could harness it properly.

Currently in the UK there are grants available to help you install solar power in your home.

here are three main ways that we use the Sun's energy

In a sunny climate, you can get enough power to run a 100W light bulb from just one square metre of solar panel.

This was originally developed in order to provide electricity for satellites, but these days many of us own calculators



powered by solar cells.



Solar cells provide the energy to run satellites that orbit the Earth. These give us satellite TV, telephones, navigation, weather forecasting, the internet and all manner of other facilities.

The graphic shows a GPS satellite. A satellite navigation receiver in a car gets signals from a whole host of these and works out its own position.

Advantages

- Solar energy is free - it needs no fuel and produces no waste or pollution.
- In sunny countries, solar power can be used where there is no easy way to get electricity to a remote place.
- Handy for low-power uses such as solar powered garden lights and battery chargers, or for helping your home energy bills.

Disadvantages

- Doesn't work at night.
- Very expensive to build solar power stations.
Solar cells cost a great deal compared to the amount of electricity they'll produce in their lifetime.
- Can be unreliable unless you're in a very sunny climate. In the United Kingdom, solar power isn't much use for high-power applications, as you need a large area of solar panels to get a decent amount of power. However, technology has now reached the point where it can make a big difference to your home fuel bills..

Is it renewable?

Solar power is [renewable](#). The Sun will keep on shining anyway, so it makes sense to use it

Tidal power - energy from the sea

Introduction

Haldwani

The tide moves a huge amount of water twice each day, and harnessing it could provide a great deal of energy - around 20% of Britain's needs.

Although the energy supply is reliable and plentiful, converting it into useful electrical power is not easy.

There are eight main sites around Britain where tidal power stations could usefully be built, including the Severn, Dee, Solway and Humber estuaries. Only around 20 sites in the world have been identified as possible tidal power stations.

A few years ago, "tidal power" meant "tidal barrage".

But these days there are other options as well.

How it works: Tidal Barrages

These work rather like a [hydro-electric](#) scheme, except that the dam is **much** bigger.

A huge dam (called a "barrage") is built across a river estuary. When the tide goes in and out, the water flows through tunnels in the dam.

The ebb and flow of the tides can be used to turn a [turbine](#), or it can be used to push air through a pipe, which then turns a [turbine](#). Large lock gates, like the ones used on canals, allow ships to pass.

If one was built across the Severn Estuary, the tides at Weston-super-Mare would not go out nearly as far - there'd be water to play in for most of the time.

But the Severn Estuary carries sewage and other wastes from many places (e.g. Bristol & Gloucester) out to sea. A tidal barrage would mean that this stuff would hang around Weston-super-Mare an awful lot longer!

Also, if you're one of the 80,000+ birds that feeds on the exposed mud flats when the tide goes out, then you have a problem, because the tide won't be going out properly any more.

More: The largest tidal power station in the world (and the only one in Europe) is in the Rance



estuary in northern France, near St. Malo. It was built in 1966. A major drawback of tidal power stations is that they can only generate when the tide is flowing in or out - in other words, only for 10 hours each day. However, tides are totally predictable, so we can plan to have other power stations generating at those times when the tidal station is out of action.

Another option is to use **offshore turbines**, rather like an underwater wind

farm.

Amrapali Institute
Haldwani



This has the advantage of being much cheaper to build, and does not have the environmental problems that a tidal barrage would bring.

There are also many more suitable sites.

The University of Wales Swansea and partners are also researching techniques to extract electrical energy from flowing water.

The "Swanturbines" design is different to other devices in a number of ways. The most

significant is that it is direct drive, where the blades are connected directly to the electrical generator without a gearbox between. This is more efficient and there is no gearbox to go wrong. Another difference is that it uses a "gravity base", a large concrete block to hold it to the seabed, rather than drilling into the seabed. Finally, the blades are fixed pitch, rather than actively controlled, this is again to design out components that could be unreliable.

Advantages

- Once you've built it, tidal power is free.
- It produces no greenhouse gases or other waste.
- It needs no fuel.
- It produces electricity reliably.
- Not expensive to maintain.
- Tides are totally predictable.
- Offshore turbines and vertical-axis turbines are not ruinously expensive to build and do not have a large environmental impact.

Disadvantages

- A barrage across an estuary is very expensive to build, and affects a very wide area - the environment is changed for many miles upstream and downstream. Many birds rely on the tide uncovering the mud flats so that they can feed. There are few suitable sites for tidal barrages.
- Only provides power for around 10 hours each day, when the tide is actually moving in or out.

Tidal energy is [renewable](#). The tides will continue to ebb and flow, and the energy is there for the taking.

Wave power

Introduction

Ocean waves are caused by the wind as it blows across the sea. Waves are a powerful source of energy.

The problem is that it's not easy to harness this energy and convert it into electricity in large amounts. Thus, wave power stations are rare

How it works

There are **several methods** of getting energy from waves. One of them works like a swimming pool wave machine in reverse.

At a swimming pool, air is blown in and out of a chamber beside the pool, which makes the water outside bob up and down, causing waves.

At a wave power station, the waves arriving cause the water in the chamber to rise and fall, which means that air is forced in and out of the hole in the top of the chamber.

We place a [turbine](#) in this hole, which is turned by the air rushing in and out.

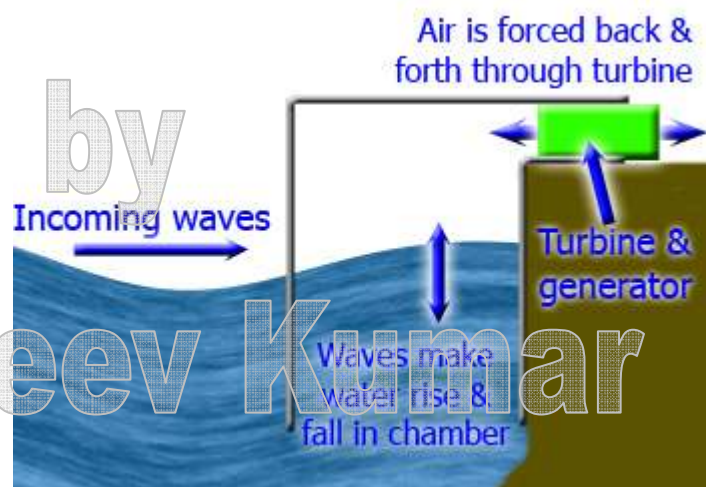
The [turbine](#) turns a generator.

A problem with this design is that the rushing air can be very noisy, unless a silencer is fitted to the turbine. The noise is not a huge problem anyway, as the waves make quite a bit of noise themselves.

More ideas about how to extract energy from waves are being proposed all the time. This page only shows three examples.

Once you've built a wave power station, the energy is free, needs no fuel and produces no waste or pollution.

One big problem is that of building and anchoring something that can withstand the roughest conditions at sea, yet can generate a reasonable amount of power from small waves. It's not much use if it only works during storms!



Advantages

- The energy is free - no fuel needed, no waste produced.
- Not expensive to operate and maintain.
- Can produce a great deal of energy.

Disadvantages

- Depends on the waves - sometimes you'll get loads of energy, sometimes almost nothing.
- Needs a suitable site, where waves are consistently strong.
- Some designs are noisy. But then again, so are waves, so any noise is unlikely to be a problem.
- Must be able to withstand very rough weather.

Is it renewable?

Wave power is [renewable](#).

Wind power



We've used the wind as an energy source for a long time.

The Babylonians and Chinese were using wind power to pump water for irrigating crops 4,000 years ago, and sailing boats went around long before that.

Wind power was used in the Middle Ages, in Europe, to grind grain, which is where the term "windmill" comes from.

How it works

The Sun heats our atmosphere unevenly, so some patches become warmer than others.

These warm patches of air rise, other air blows in to replace them, and we feel a wind blowing.

We can use the energy in the wind by building a tall tower, with a large propeller on the top.

The wind blows the propeller round, which turns a generator to produce electricity. We tend to build many of these towers together, to make a "**wind farm**" and produce more electricity.

The more towers, the more wind, and the larger the propellers, the more electricity we can make.

It's only worth building wind farms in places that have strong, steady winds, although boats and caravans to help keep their batteries charged.

The best places for wind farms are in coastal areas, at the tops of rounded hills, open plains and gaps in mountains - places where the wind is strong and reliable. Some are offshore.

To be worthwhile, you need an average wind speed of around 25 km/h. Most wind farms in the UK are in isolated places such as farms may have their own wind generators. In California, several "wind farms" supply electricity to homes around Los Angeles.

The propellers are large, to extract energy from the largest possible volume of air. The blades can be angled to "fine" or "coarse" pitch, to cope with varying wind speeds, and the generator and propeller can turn to face the wind wherever it comes from. Some designs use vertical turbines, which don't need to be turned to face the wind.

The towers are tall, to get the propellers as high as possible, up to where the wind is stronger. This means that the land beneath can still be used for farming.

Advantages

- Wind is free, wind farms need no fuel.
- Produces no waste or greenhouse gases.
- The land beneath can usually still be used for farming.
- Wind farms can be tourist attractions.
- A good method of supplying energy to remote areas.

Disadvantages

- The wind is not always predictable - some days have no wind.
- Suitable areas for wind farms are often near the coast, where land is expensive.
- Some people feel that covering the landscape with these towers is unsightly.
- Can kill birds - migrating flocks tend to like strong winds.
However, this is rare, and we tend not to build wind farms on migratory routes anyway.
- Can affect television reception if you live nearby.
- Can be noisy. Wind generators have a reputation for making a constant, low, "swooshing" noise day and night, which can drive you nuts.
Having said that, as aerodynamic designs have improved modern wind farms are much quieter. A lot quieter than, say, a fossil fuel power station; and wind farms tend not to be close to residential areas anyway. The small modern wind generators used on boats and caravans make hardly any sound at all.

Is it renewable?

Wind power is [renewable](#). Winds will keep on blowing, it makes sense to use them.

