RENEWABLE ENERGY RESOURCES

RENEWABLE ENERGY

UNIT 1. What is renewable energy?

The United States currently relies heavily on coal, oil, and natural gas for its energy. Fossil fuels are *nonrenewable,* that is, they draw on finite resources that will eventually dwindle, becoming too expensive or too environmentally damaging to retrieve. In contrast, *renewable energy* resources—such as wind and solar energy—are constantly replenished and will never run out.

Most renewable energy comes either directly or indirectly from the sun. Sunlight, or solar energy, can be used directly for heating and lighting homes and other buildings, for generating electricity, and for hot water heating, solar cooling, and a variety of commercial and industrial uses.

The sun's heat also drives the winds, whose energy is captured with wind turbines. Then, the winds and the sun's heat cause water to evaporate. When this water vapor turns into rain or snow and flows downhill into rivers or streams, its energy can be captured using hydroelectric power.

Along with the rain and snow, sunlight causes plants to grow. The organic matter that makes up those plants is known as biomass. Biomass can be used to produce electricity, transportation fuels, or chemicals. The use of biomass for any of these purposes is called biomass energy.

Hydrogen also can be found in many organic compounds, as well as water. It's the most abundant element on the Earth. But it doesn't occur naturally as a gas. It's always combined with other elements, such as with oxygen to make water. Once separated from another element, hydrogen can be burned as a fuel or converted into electricity.

Not all renewable energy resources come from the sun. Geothermal energy taps the Earth's internal heat for a variety of uses, including electric power production, and the heating and cooling of buildings. And the energy of the ocean's tides comes from the gravitational pull of the moon and the sun upon the Earth.

In fact, ocean energy comes from a number of sources. In addition to tidal energy, there's the energy of the ocean's waves, which are driven by both the tides and the winds. The sun also warms the surface of the ocean more than the ocean depths, creating a temperature difference that can be used as an energy source. All these forms of ocean energy can be used to produce electricity.

Check: Fill in the gaps

Most of the Earth's energy comes from the [?]. Most power stations burn [?] fuels,

releasing [?] energy that was stored long ago.

A [?] energy resource is one that won't run out.

BASICS OF RENEWABLE ENERGY

When you plug an electric appliance into the wall socket? Do you know where your electricity comes from?
Probably the local public utility company. But how does the utility company generate the electricity you use at home? If it is like most power companies, it produces electrical power by burning fossil fuels – coal, natural gas, oil – to make steam, which turns turbines to generate electricity at the power plant.
Fossil fuels are non-renewable fuels , originating from organic matter of the late Paleozoic Era and estimated by most scientists to run out during this century of the new millennium. When coal, natural gas and oil are depleted, how will people see to read at night? What will power their cars, airplanes, buses, and trains? What will provide electricity for their computers and factories? Fortunately, there are renewable, alternative sources of energy for electricity and transportation that have well-developed technology.

Some renewable energy sources are well known and already in wide use. For example, hydroelectric power is generated by water in damns. Other alternative sources of energy are not well known to the public and are still in the developmental stages. The World Energy Council has identified six sources of energy to pursue as alternatives to non-renewable fossil fuels:

- Solar (energy from the sun's rays)
- Wind (energy from moving air)
- Geothermal (energy from heat inside the earth)
- Modern biomass (energy from plant and animal residue)
- Ocean (energy from seawater movement and temperature changes)
- Small hydroelectric (energy from small dams, such as those filled by melting snow)

It is worth pointing out why large hydroelectric(large dams that block rivers) and traditional biomass(firewood and charcoal) were excluded from the council's focus.
These two renewable sources of energy often cause environmental problems and other adverse effects. Large hydroelectric projects usually require long planning and construction, which delays their benefit, and sometimes results in social problems, such as displacement of people near rivers that are damned. Traditional biomass (burning trees) results in air pollution and deforestation. A combination of these six other alternative sources of energy may prove to be our best hope to fill the energy void created as supplies of fossil fuels gradually diminish.

RECENT DEVELOPMENTS

The future is bright if new technologies in alternative fuels are exploited wisely around the world. Every country can meet the challenging energy demands of the future if national and local governments dedicate themselves to building power plants that use these renewable resources. Recent increase in oil prices is likely to turn government leaders more friendly to alternative energy development policies. Moreover, concerns about pollution and global warming have given proponents of alternative energy development added public support.

BENEFITS OF RENEWABLE ENERGY

Social and economic development:

Production of renewable energy, particularly biomass, can provide economic development and employment opportunities, especially in rural areas, which tend to have limited opportunities for economic growth. Renewable energy can thus help reduce poverty in rural areas and reduce pressures for urban migration.

Land restoration

Growing biomass for energy on degraded lands can provide the incentives and financing needed to restore lands rendered nearly useless by previous agricultural or forestry practices. Although lands farmed for energy would not be restored to their original condition, the recovery of these lands for biomass plantations would support rural development, prevent erosion, and provide a better habitat for wildlife than at present.

Reduced air pollution

Renewable energy technologies, such as methanol or hydrogen foe fuel-cell vehicles, produce virtually none of the emissions associated with urban air pollution and acid deposition, without the need for costly additional controls.

Abatement of global warming

Renewable energy use doesn’t produce carbon dioxide and other greenhouse emissions that contribute to global warming. Even the use of biomass fuels will not contribute to global warming: the carbon dioxide released when biomass is burned equals the amount absorbed from the atmosphere by plants as they are grown for biomass fuel.

Fuel supply diversity

There would be substantial interregional energy trade in a renewable-intensive energy future, involving a diversity of energy carriers and suppliers. Energy importers would be able to choose from among more producers and fuel types than they do today and thus would be less vulnerable to monopoly price manipulation or unexpected disruptions of supplies. Such competition would make wide swings in energy prices less likely, leading eventually to stabilization of the world oil price. The growth in world energy trade would also provide new opportunities for energy suppliers. Especially promising are the prospects fro trade in alcohol fuels such as methanol derived from biomass, natural gas (not a renewable fuel but an important complement to renewables) and in the future, hydrogen.

Why is renewable energy important?

Renewable energy is important because of the benefits it provides.

The key benefits are:

Environmental benefits
Renewable energy technologies are clean sources of energy that have a much lower environmental impact than conventional energy technologies.

Energy for our children's children's children
Renewable energy will not run out. Ever. Other sources of energy are finite and will some day be depleted.

Jobs and the economy
Most renewable energy investments are spent on materials and workmanship to build and

maintain the facilities, rather than on costly energy imports. Renewable energy investments are usually spent within the United States, frequently in the same state, and often in the same town. This means your energy dollars stay home to create jobs and fuel local economies, rather than going overseas.

Meanwhile, renewable energy technologies developed and built in the United States are being sold overseas, providing a boost to the U.S. trade deficit.

Energy security
After the oil supply disruptions of the early 1970s, our nation has increased its dependence on foreign oil supplies instead of decreasing it. This increased dependence impacts more than just our national energy policy.

VOCABULARY

Tap for
dwindle
Fossil
Generate electricity
abundant
convert
Evaporate
Retrieve
replenish
Run out
Deforestation
Deplete
Adverse effects
void
diminish
derive
utility company
incentive
charcoal
abatement
contribute to

QUESTIONS

1. How can every country meet the challenging energy demands?
2. What are the major concerns of alternative energy proponents?
3. What social and economic benefits can alternative energy provide (in the city and in the country)?
4. How does biomass help to restore land?
5. What elements are used in fuel-cell vehicles?
6. Why does production of biomass NOT contribute to the global warning?
7. What are the most promising fuels of the future?
8. How can oil prices be controlled?
9. Key benefits of alternative energy?

Unit 2. Fossil Fuels

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

Find out more about how they formed at
www.energyquest.ca.gov/story/chapter08.html

At the time this page was written, fossil fuels provided around 66% of the world's electrical power, and 95% of the world's total energy demands (including heating, transport, electricity generation and other uses).

How it works:

Coal is crushed to a fine dust and burnt.

Oil and gas can be burnt directly.

The steam that has passed through the power station's turbines has to be cooled, to condense it back into water before it can be pumped round again. This is what happens in the huge "cooling towers" seen at power stations.

Find out about Drax Coal-fired power station in Selby, UK

Some power stations are built on the coast, so they can use sea water to cool the steam instead. However, this warms the sea and can affect the environment, although the fish seem to like it.

More:

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.

More details on 'clean coal technology' from BBC News web site...

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.

I ought to point out that some scientists are claiming that oil is not a 'fossil' fuel - that it is not the remains of prehistoric organisms after all. They claim it was made by some other, non-biological process. Currently this is not accepted by the majority of scientists, but you can find out more about the idea at space.com

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.

Find out more at www.eia.doe.gov/emeu/cabs/canada.html

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.
  More details on 'clean coal technology' from BBC News web site...
- 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.

Check: Fill in the gaps

Coal, **[?]** and natural gas (chemical name: **[?]**) are called fossil fuels because they were

formed from the remains of plants or **[?]** long ago.

We **[?]** the fuels in power stations, releasing the stored chemical **[?]**.

The heat turns water into **[?]**, which drives **[?]**, they drive the **[?]**.

Are fossil fuels renewable? (yes/no) **[?]** Do they cause pollution? (yes/no) **[?]**

Match the words to form the idiomatic word combinations:

Prehistoric	effect
Greenhouse	rain
Carbon	gases
Waste	mining
Acid	dioxide
Strip	shale
Power	animals
Bituminous	station
Oil	sands

Unit 3. Biomass - energy from organic materials

About biomass energy

We have used biomass energy or bioenergy— the energy from organic matter— for thousands of years, ever since people started burning wood to cook food or to keep warm. And today, wood is still our largest biomass energy resource. But many other sources of biomass can now be used, including plants, residues from agriculture or forestry, and the organic component of municipal and industrial wastes. Even the fumes from landfills can be used as a biomass energy source.

The use of biomass energy has the potential to greatly reduce our greenhouse gas emissions. Biomass generates about the same amount of carbon dioxide as fossil fuels, but every time a new plant grows, carbon dioxide is actually removed from the atmosphere. The net emission of carbon dioxide will be zero as long as plants continue to be replenished for biomass energy purposes. These energy crops, such as fast-growing trees and grasses, are called *biomass feedstocks.* The use of biomass feedstocks can also help increase profits for the agricultural industry.

NREL performs research to develop and advance technologies for the following biomass energy applications:

Biofuels
Converting biomass into liquid fuels for transportation.

Biopower
Burning biomass directly, or converting it into a gaseous fuel or oil, to generate electricity.

Bioproducts
Converting biomass into chemicals for making products that typically are made from petroleum.

Biomass
Biomass power, derived from the burning of plant matter, raises more serious environmental issues than any other renewable resource except hydropower. Combustion of biomass and biomass-derived fuels produces air pollution; beyond this, there are concerns about the impacts of using land to grow energy crops. How serious these impacts are will depend on how carefully the resource is managed. The picture is further complicated because there is no single biomass technology, but rather a wide variety of production and conversion methods, each with different environmental impacts.

Air Pollution

Inevitably, the combustion of biomass produces air pollutants, including carbon monoxide, nitrogen oxides, and particulates such as soot and ash. The amount of pollution emitted per unit of energy generated varies widely by technology, with wood-burning stoves and fireplaces generally the worst offenders. Modern, enclosed fireplaces and wood stoves pollute much less than traditional, open fireplaces for the simple reason that they are more efficient. Specialized pollution control devices such as electrostatic precipitators (to remove particulates) are available, but without specific regulation to enforce their use it is doubtful they will catch on.
Emissions from conventional biomass-fueled power plants are generally similar to emissions from coal-fired power plants, with the notable difference that biomass facilities produce very little sulfur dioxide or toxic metals (cadmium, mercury, and others). The most serious problem is their particulate emissions, which must be controlled with special devices. More advanced technologies, such as the whole-tree burner (which has three successive combustion stages) and the gasifier/combustion turbine combination, should generate much lower emissions, perhaps comparable to those of power plants fueled by natural gas.
Facilities that burn raw municipal waste present a unique pollution-control problem. This waste often contains toxic metals, chlorinated compounds, and plastics, which generate harmful emissions. Since this problem is much less severe in facilities burning refuse-derived fuel (RDF)-pelletized or shredded paper and other waste with most inorganic material removed-most waste-to-energy plants built in the future are likely to use this fuel. Co-firing RDF in coal-fired power plants may provide an inexpensive way to reduce coal emissions without having to build new power plants.
Using biomass-derived methanol and ethanol as vehicle fuels, instead of conventional gasoline, could substantially reduce some types of pollution from automobiles. Both methanol and ethanol evaporate more slowly than gasoline, thus helping to reduce evaporative emissions of

volatile organic compounds (VOCs), which react with heat and sunlight to generate ground-level ozone (a component of smog). According to Environmental Protection Agency estimates, in cars specifically designed to burn pure methanol or ethanol, VOC emissions from the tailpipe could be reduced 85 to 95 percent, while carbon monoxide emissions could be reduced 30 to 90 percent. However, emissions of nitrogen oxides, a source of acid precipitation, would not change significantly compared to gasoline-powered vehicles.

Some studies have indicated that the use of fuel alcohol increases emissions of formaldehyde and other aldehydes, compounds identified as potential carcinogens. Others counter that these results consider only tailpipe emissions, whereas VOCs, another significant pathway of aldehyde formation, are much lower in alcohol-burning vehicles. On balance, methanol vehicles would therefore decrease ozone levels. Overall, however, alcohol-fueled cars will not solve air pollution problems in dense urban areas, where electric cars or fuel cells represent better solutions.

Greenhouse Gases

A major benefit of substituting biomass for fossil fuels is that, if done in a sustainable fashion, it would greatly reduce emissions of greenhouses gases. The amount of carbon dioxide released when biomass is burned is very nearly the same as the amount required to replenish the plants grown to produce the biomass. Thus, in a sustainable fuel cycle, there would be no net emissions of carbon dioxide, although some fossil-fuel inputs may be required for planting, harvesting, transporting, and processing biomass. Yet, if efficient cultivation and conversion processes are used, the resulting emissions should be small (around 20 percent of the emissions created by fossil fuels alone). And if the energy needed to produce and process biomass came from renewable sources in the first place, the net contribution to global warming would be zero.

Similarly, if biomass wastes such as crop residues or municipal solid wastes are used for energy, there should be few or no net greenhouse gas emissions. There would even be a slight greenhouse benefit in some cases, since, when landfill wastes are not burned, the potent greenhouse gas methane may be released by anaerobic decay.

Implications for Agriculture and Forestry

One surprising side effect of growing trees and other plants for energy is that it could benefit soil quality and farm economies. Energy crops could provide a steady supplemental income for farmers in off-seasons or allow them to work unused land without requiring much additional equipment. Moreover, energy crops could be used to stabilize cropland or rangeland prone to erosion and flooding. Trees would be grown for several years before being harvested, and their roots and leaf litter could help stabilize the soil. The planting of coppicing, or self-regenerating, varieties would minimize the need for disruptive tilling and planting. Perennial grasses harvested like hay could play a similar role; soil losses with a crop such as switchgrass, for example, would be negligible compared to annual crops such as corn.

If improperly managed, however, energy farming could have harmful environmental impacts. Although energy crops could be grown with less pesticide and fertilizer than conventional food crops, large-scale energy farming could nevertheless lead to increases in chemical use simply because more land would be under cultivation. It could also affect biodiversity through the destruction of species habitats, especially if forests are more intensively managed. If agricultural or forestry wastes and residues were used for fuel, then soils could be depleted of organic content and nutrients unless care was taken to leave enough wastes behind. These concerns point up the need for regulation and monitoring of energy crop development and waste use.

Energy farms may present a perfect opportunity to promote low-impact sustainable agriculture, or, as it is sometimes called, organic farming. A relatively new federal effort for food crops emphasizes crop rotation, integrated pest management, and sound soil husbandry to increase profits and improve long-term productivity. These methods could be adapted to energy farming. Nitrogen-fixing crops could be used to provide natural fertilizer, while crop diversity and use of pest parasites and predators could reduce pesticide use. Though such practices may not produce as high a yield as more intensive methods, this penalty could be offset by reduced energy and chemical costs.

Increasing the amount of forest wood harvested for energy could have both positive and negative effects. On one hand, it could provide an incentive for the forest-products industry to manage its resources more efficiently, and thus improve forest health. But it could also provide an excuse, under the "green" mantle, to exploit forests in an unsustainable fashion. Unfortunately, commercial forests have not always been soundly managed, and many people view with alarm the prospect of increased wood cutting. Their concerns can be met by tighter government controls on forestry practices and by following the principles of "excellent" forestry. If such principles are applied, it should be possible to extract energy from forests indefinitely.

Check: Try to fill in the gaps with the given words:

animal carbon dioxide renewable sugar vehicles wood

Biomass means burning **[?]** waste or plant materials such as **[?]** , or **[?]** cane. We can also make biofuels for **[?]**.It's a **[?]** energy resource. It does cause pollution by releasing **[?]** **[?]** when the fuel is burned.

VOCABULARY

Feedstock
Fume
Combustion
Landfill
Soot
Ash
Municipal solid waste
Swtchgrass
Habitat
Species
Husbandry
methanol
Mercury
Husk
Methane
Volatile
Sustainable
Pollutant
Pesticide
Fertilizer
Anaerobic decay

QUESTIONS

1. What is our largest biomass resource?
2. How long have we used biomass energy?
3. What are other sources of biomass?
4. What is the positive effect of bioenergy?
5. What is the result of biomass combustion?
6. Is there a single biomass technology?
7. What chemical elements pollute the air?
8. What does air pollution depend on?
9. What devices can measure the air pollution?
10. What is the difference between biomass and fossil fuels emission?

Introduction

Wood was once our main fuel. We burned it to heat our homes and cook our food. Wood still provides a small percentage of the energy we use, but its importance as an energy source is dwindling.

Sugar cane is grown in some areas, and can be fermented to make alcohol, which can be burned to generate power in the same way as coal.
Alternatively, the cane can be crushed and the pulp (called "bagasse") can be burned, to make steam to drive turbines.

Other solid wastes, can be burned to provide heat, or used to make steam for a power station.
"Bioconversion" uses plant and animal wastes to produce fuels such as methanol, natural gas, and oil.
We can use rubbish, animal manure, woodchips, seaweed, corn stalks and other wastes.

How it works

Burn Fuel → heat water to make steam → steam turns turbines → turbines turn generators → electrical power sent around country

The fuel is burned, which heats water into steam, which turns turbines, which in turn drive generators, just like in a fossil-fuel power station.

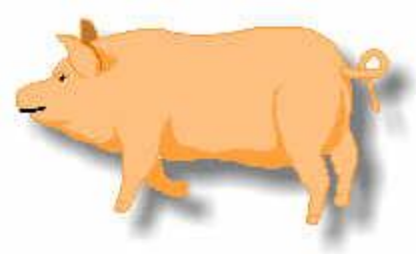
More details :- Sugar cane

Sugar cane is harvested and taken to a mill, where it is crushed to extract the juice. The juice is used to make sugar, whilst the left-over pulp, called "bagasse" can be burned in a power station.

The station usually provides power for the sugar mill, as well as selling electricity to the surrounding area.

Advantages

- It makes sense to use waste materials where we can.
- The fuel tends to be cheap.
- Less demand on the Earth's resources.



Disadvantages

- Collecting the waste in sufficient quantities can be difficult.
- We burn the fuel, so it makes greenhouse gases.
- Some waste materials are not available all year round.

Is it renewable?

Biomass **is** renewable, as we're going to carry on making waste products. We can always plant & grow more sugar cane and more trees, so those are renewable too.

QUESTIONS

1. What does the municipal waste contain?
2. What fuels can be used instead of conventional gasoline?
3. What are theeir advantages?
4. How is ground-level ozone generated?
5. What is RDF, VOC ?
6. What is the major benefit of substituting biomass for fossil fuels?
7. What are the unexpected side-effects of growing trees or plants for energy?
8. What are the harmful environmental effects of energy farming?
9. What is organic farming?
10. What did we use wood for?
11. What is bioconversion?
12. What kinds of waste can be used for energy generation?

Unit 4. Geothermal Energy is energy from heat inside the Earth.

Introduction to geothermal electricity production

Most power plants need steam to generate electricity. The steam rotates a turbine that activates a generator, which produces electricity. Many power plants still use fossil fuels to boil water for steam. Geothermal power plants, however, use steam produced from reservoirs of hot water found a couple of miles or more below the Earth's surface. There are three types of geothermal power plants: *dry steam, flash steam,* and *binary cycle*.

Dry steam power plants draw from underground resources of steam. The steam is piped directly from underground wells to the power plant, where it is directed into a turbine/generator unit. There are only two known underground resources of steam in the United States: The Geysers in northern California and Yellowstone National Park in Wyoming, where there's a well-known geyser called Old Faithful. Since Yellowstone is protected from development, the only dry steam plants in the country are at The Geysers.

Flash steam power plants are the most common. They use geothermal reservoirs of water with temperatures greater than 360°F (182°C). This very hot water flows up through wells in the ground under its own pressure. As it flows upward, the pressure decreases and some of the hot water boils into steam. The steam is then separated from the water and used to power a turbine/generator. Any leftover water and condensed steam are injected back into the reservoir, making this a sustainable resource.

Binary cycle power plants operate on water at lower temperatures of about 225°–360°F (107°–182°C). These plants use the heat from the hot water to boil a *working fluid,* usually an organic compound with a low boiling point. The working fluid is vaporized in a *heat exchanger* and used to turn a turbine. The water is then injected back into the ground to be reheated. The water and the working fluid are kept separated during the whole process, so there are little or no air emissions.

Small-scale geothermal power plants (under 5 megawatts) have the potential for widespread application in rural areas, possibly even as distributed energy resources. Distributed energy resources refer to a variety of small, modular power-generating technologies that can be combined to improve the operation of the electricity delivery system.

In the United States, most geothermal reservoirs are located in the western states, Alaska, and Hawaii.

Introduction

The centre of the Earth is around 6000 degress Celsius - 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.

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".

Check: Fill in the gaps with the given words:

depth drill electricity energy gases hot pump renewable rock sites steam water

Geothermal power means getting **[?]** from **[?]** rocks underground. This is **[?]** so long as we don't take too much energy out and cool the rocks too much.

Hot **[?]** comes up out of the hole we've drilled and usually "flashes" into **[?]**. This can drive turbines and generators, to make **[?]**.At some sites we have to **[?]** water down, at others hot water comes up anyway. Sometimes poisonous **[?]** come up too.

Geothermal power can occasioanally be unreliable, and there are not many suitable**[?]** because there needs to be the right type of **[?]** at a **[?]** we can reach, underneath rock which isn't too hard to **[?]** through.

VOCABULARY

Dry steam
Reservoir
Flash steam
Binary cycle
Fluid
Liquid
Condense
Sustainable resource
Heat exchanger
Boiling point
Delivery system
Molten rock
Drill
Poisonous
Hazardous
Assess
Subsidence
Siting
Brine
Scenic
Disposal

QUESTIONS

1. What do we mean under small-scale geothermal power plant?
2. Where are most geothermal reservoirs in the US located?
3. What kind of steam do geothermal power plants use?
4. What are the three types of geothermal power plants?
5. What are the two known underground resources of steam in the US?
6. What is the temperature in the center of the Earth?
7. What for has geothermal energy been used for centuries?
8. What are 3 sources of geothermal energy?
9. What are the environmental concerns of geothermal energy development?
10. What is better for environment: closed-loop or open-loop system? Why?
11. What are the negative impacts of the open-loop system?
12. What gases does geothermal steam contain?
13. What technology produces more CO_2: geothermal or fossil?
14. What does sludge contain?
15. How can the toxic waste be disposed of (2ways)?
16. What is another advantage of back injection?
17. Why is there a water problem in geothermal energy development?
18. How can the issues of natural beauty preservation be solved?

Geothermal Energy

Geothermal energy is heat contained below the earth's surface. The only type of geothermal energy that has been widely developed is hydrothermal energy, which consists of trapped hot water or steam. However, new technologies are being developed to exploit hot dry rock (accessed by drilling deep into rock), geopressured resources (pressurized brine mixed with methane), and magma.

The various geothermal resource types differ in many respects, but they raise a common set of environmental issues. Air and water pollution are two leading concerns, along with the safe disposal of hazardous waste, siting, and land subsidence. Since these resources would be exploited in a highly centralized fashion, reducing their environmental impacts to an acceptable level should be relatively easy. But it will always be difficult to site plants in scenic or otherwise environmentally sensitive areas.

The method used to convert geothermal steam or hot water to electricity directly affects the amount of waste generated. Closed-loop systems are almost totally benign, since gases or fluids removed from the well are not exposed to the atmosphere and are usually injected back into the ground after giving up their heat. Although this technology is more expensive than conventional open-loop systems, in some cases it may reduce scrubber and solid waste disposal costs enough to provide a significant economic advantage.

Open-loop systems, on the other hand, can generate large amounts of solid wastes as well as noxious fumes. Metals, minerals, and gases leach out into the geothermal steam or hot water as it passes through the rocks. The large amounts of chemicals released when geothermal fields are tapped for commercial production can be hazardous or objectionable to people living and working nearby.

At The Geysers, the largest geothermal development, steam vented at the surface contains hydrogen sulfide (H2S)-accounting for the area's "rotten egg" smell-as well as ammonia, methane, and carbon dioxide. At hydrothermal plants carbon dioxide is expected to make up about 10 percent of the gases trapped in geopressured brines. For each kilowatt-hour of electricity generated, however, the amount of carbon dioxide emitted is still only about 5 percent of the amount emitted by a coal- or oil-fired power plant.

Scrubbers reduce air emissions but produce a watery sludge high in sulfur and vanadium, a heavy metal that can be toxic in high concentrations. Additional sludge is generated when hydrothermal steam is condensed, causing the dissolved solids to precipitate out. This sludge is generally high in silica compounds, chlorides, arsenic, mercury, nickel, and other toxic heavy metals. One costly method of waste disposal involves drying it as thoroughly as possible and shipping it to licensed hazardous waste sites. Research under way at Brookhaven National Laboratory in New York points to the possibility of treating these wastes with microbes designed to recover commercially valuable metals while rendering the waste non-toxic.

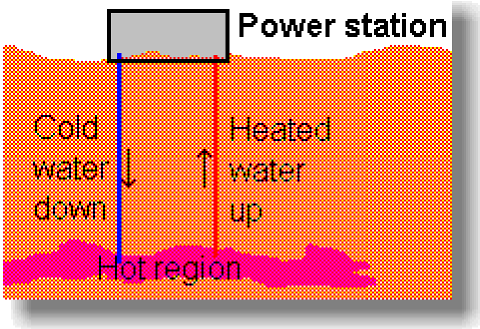
Usually the best disposal method is to inject liquid wastes or redissolved solids back into a porous stratum of a geothermal well. This technique is especially important at geopressured power plants because of the sheer volume of wastes they produce each day. Wastes must be injected well below fresh water aquifers to make certain that there is no communication between the usable water and waste-water strata. Leaks in the well casing at shallow depths must also be prevented.

In addition to providing safe waste disposal, injection may also help prevent land subsidence. At Wairakei, New Zealand, where wastes and condensates were not injected for many years, one area has sunk 7.5 meters since 1958. Land subsidence has not been detected at other hydrothermal plants in long-term operation. Since geopressured brines primarily are found along the Gulf of Mexico coast, where natural land subsidence is already a problem, even slight settling could have major implications for flood control and hurricane damage. So far, however, no settling has been detected at any of the three experimental wells under study.

Most geothermal power plants will require a large amount of water for cooling or other purposes. In places where water is in short supply, this need could raise conflicts with other users for water resources.

The development of hydrothermal energy faces a special problem. Many hydrothermal reservoirs are located in or near wilderness areas of great natural beauty such as Yellowstone National Park and the Cascade Mountains. Proposed developments in such areas have aroused intense opposition. If hydrothermal-electric development is to expand much further in the United States, reasonable compromises will have to be reached between environmental groups and industry.

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 Landrello, 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 Town Hall in Southampton, England, is partly heated this way.

More details

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.

See Also:

Find out more from Mighty River Power, New Zealand

A geothermal project in Hawaii http://www.geothermalhawaii.com/

A diagram showing a geothermal project
http://www.geothermal.marin.org/GEOpresentation/sld037.htm

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.

Compare biomass and geothermal power generation; name three similarities and three differences

Environmental effect	qualities	sources	technologies

VOCABULARY

Expose
Inject
Benign
Conventional scrubber
Noxious
Leach out/ Leak
Objectionable
Vent steam
Ammonia
Precipitate
Porous stratum
Aquifers
Shallow depth
Casing
Wilderness areas
Arouse opposition

Unit 5. Wind power - energy from the air

Introduction to wind energy

We have been harnessing the wind's energy for hundreds of years. From old Holland to farms in the United States, windmills have been used for pumping water or grinding grain. Today, the windmill's modern equivalent— a *wind turbine*— can use the wind's energy to generate electricity.

Wind turbines, like windmills, are mounted on a tower to capture the most energy. At 100 feet (30 meters) or more aboveground, they can take advantage of the faster and less turbulent wind. Turbines catch the wind's energy with their propeller-like blades. Usually, two or three blades are mounted on a shaft to form a *rotor.*

A blade acts much like an airplane wing. When the wind blows, a pocket of low-pressure air forms on the downwind side of the blade. The low-pressure air pocket then pulls the blade toward it, causing the rotor to turn. This is called *lift.* The force of the lift is actually much stronger than the wind's force against the front side of the blade, which is called *drag.* The combination of lift and drag causes the rotor to spin like a propeller, and the turning shaft spins a generator to make electricity.

Wind turbines can be used as stand-alone applications, or they can be connected to a utility power grid or even combined with a photovoltaic (solar cell) system. For utility-scale sources of wind energy, a large number of wind turbines are usually built close together to form a *wind plant*. Several electricity providers today use wind plants to supply power to their customers.

Stand-alone wind turbines are typically used for water pumping or communications. However, homeowners, farmers, and ranchers in windy areas can also use wind turbines as a way to cut their electric bills.

Small wind systems also have potential as distributed energy resources. Distributed energy resources refer to a variety of small, modular power-generating technologies that can be combined to improve the operation of the electricity delivery system.

Wind Energy

It is hard to imagine an energy source more benign to the environment than wind power; it produces no air or water pollution, involves no toxic or hazardous substances (other than those commonly found in large machines), and poses no threat to public safety. And yet a serious obstacle facing the wind industry is public opposition reflecting concern over the visibility and noise of wind turbines, and their impacts on wilderness areas.
One of the most misunderstood aspects of wind power is its use of land. Most studies assume that wind turbines will be spaced a certain distance apart and that all of the land in between should be regarded as occupied. This leads to some quite disturbing estimates of the land area required to produce substantial quantities of wind power. According to one widely circulated report from the 1970s, generating 20 percent of US electricity from windy areas in 1975 would have required siting turbines on 18,000 square miles, or an area about 7 percent the size of Texas.
In reality, however, the wind turbines themselves occupy only a small fraction of this land area, and the rest can be used for other purposes or left in its natural state. For this reason, wind power development is ideally suited to farming areas. In Europe, farmers plant right up to the base of turbine towers, while in California cows can be seen peacefully grazing in their shadow. The leasing of land for wind turbines, far from interfering with farm operations, can

bring substantial benefits to landowners in the form of increased income and land values. Perhaps the greatest potential for wind power development is consequently in the Great Plains, where wind is plentiful and vast stretches of farmland could support hundreds of thousands of wind turbines.

In other settings, however, wind power development can create serious land-use conflicts. In forested areas it may mean clearing trees and cutting roads, a prospect that is sure to generate controversy, except possibly in areas where heavy logging has already occurred. And near populated areas, wind projects often run into stiff opposition from people who regard them as unsightly and noisy, or who fear their presence may reduce property values.

In California, bird deaths from electrocution or collisions with spinning rotors have emerged as a problem at the Altamont Pass wind "farm," where more than 30 threatened golden eagles and 75 other raptors such as red-tailed hawks died or were injured during a three-year period. Studies under way to determine the cause of these deaths and find preventive measures may have an important impact on the public image and rate of growth of the wind industry. In appropriate areas, and with imagination, careful planning, and early contacts between the wind industry, environmental groups, and affected communities, siting and environmental problems should not be insurmountable.

Check: Fill in the gaps with the given words:

Cornwall fuel generators noisy pollution reliable renewable strong Wales

Wind power is **[?]**, does not need any **[?]** and does not produce any **[?]**.
However, you need a lot of **[?]** to make a large amount of power, and you must put them where the winds are **[?]** and **[?]**.
Wind farms can be **[?]** if you live close. Most wind farms in the UK are in **[?]** and **[?]**.

QUESTIONS

1. What for have windmills been used earlier in Holland and the US? And today?
2. How high are they? Why?
3. What do turbines catch wind with?
4. How does a blade act?
5. What is lift? Drag?
6. What are the two ways of using wind turbines?
7. What are the stand alone turbines used for?
8. Why is wind energy benign?
9. What are the three reasons for public opposition?
10. What is the most common misunderstanding about wind power?
11. What are the benefits of landleasing for farmers?
12. What kind of land use conflicts may happen because of wind power?

Introduction

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 were around long before that.

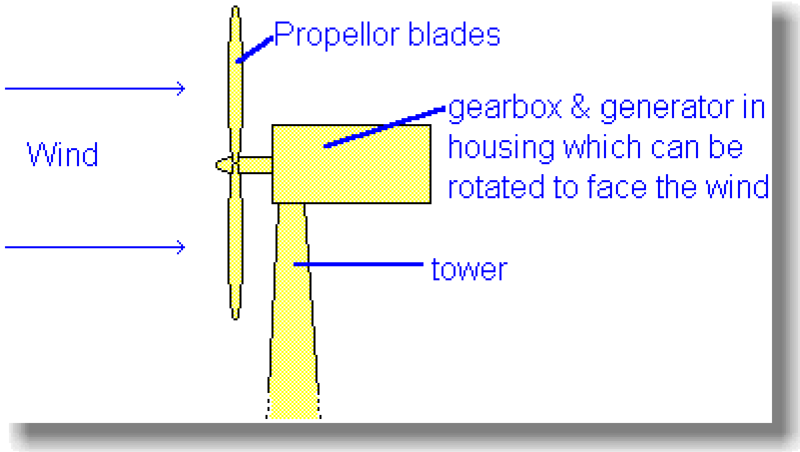
Wind power was used in the Middle Ages, in Europe, to grind corn, which is where the term "windmill" comes from.

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 propellor on the top.



The wind blows the propellor 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 propellors, the more electricity we can make.

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

More details

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. To be worthwhile, you need an average wind speed of around 25 km/h. Most wind farms in the UK are in Cornwall or Wales.

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.

See Also:

WIND POWER MONTHLY

News, views and analyses from the world's leading independent wind energy magazine, Windpower Monthly, at **http://www.windpower-monthly.com/**

The British Wind Energy Association at **http://www.bwea.com/**

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. Splat!
- Can affect television reception if you live nearby.
- Noisy. A wind generator makes a constant, low, "swooshing" noise day and night, which can drive you nuts. An entire wind farm makes quite a racket! Then again, the small modern wind generators used on boats and caravans make hardly any noise.

Is it renewable?

Wind power **is** renewable. Winds will keep on blowing, it makes sense to use them.

TEXT FOR TRANSLATION

Ветроэлектростанции, они же ветрогенераторы – это специальные устройства, преобразующие энергию ветра в электрическую энергию.

Ветроэлектростанции в последнее время становятся все более популярными. Это связано, в первую очередь с тем, что они используют возобновляемые природные источники энергии, и дополнительного топлива для их работы не требуется. ВЭС, в настоящее время, являются наиболее простыми и удобными в качестве альтернативных источников электроэнергии, используемых в частных целях.

Сегодня, мировая энергетика все больше склоняется к увеличению доли альтернативных способов производства электроэнергии. Показательно, что каждый месяц, в мире устанавливается ветроэлектростанций, суммарной мощностью более 200 Мвт, что сравнимо с высокомощной ГЭС. И это только начало. Благодаря развитию исследований в области композитных материалов, усовершенствовании турбин и генераторов, устанавливаемых на ВЭС, мощность «ветряков», за последние 10 лет, увеличилась более чем в 50 раз. К примеру, если еще 10 лет назад, ветроэлектростанция, вырабатывающая 100 Квт, считалась наиболее мощной, то

сегодня, мощность ветрогенераторов значительно превысила 1 мвт, а в последних моделях достигла 5 Мвт.
Ветроэлектростанции обладают рядом преимуществ, среди которых можно выделить такие как:
– ВЭС полностью независимы от внешних источников электроэнергии.
– энергию, которую вырабатывают ветрогенераторы, можно использовать совместно с другими источниками, такими как, например, дизель-электростанции, или другими, в том числе и альтернативными – например солнечными батареями;
– ВЭС могут быть стационарными, различной мощности. А могут быть и передвижными, и в этом случае, например при использовании в путешествиях, они могут являться незаменимыми источниками дешевой электроэнергии.
– в настоящее время, выпускается огромное количество моделей ветрогенераторов, самой различной мощности, благодаря чему можно легко подобрать наиболее оптимальный вариант для каждого конкретного случая.

Ветроэлектростанции, как правило, состоят из четырех основных узлов. Наиболее технологичным из них, без сомнения, является винт, вращающийся под воздействием силы ветра. Далее в состав ВЭС входят устройство для крепления винта (собственно корпус «ветряка»), генератор и аккумулятор.

Ветроэлектростанции разделяются на стационарные и мобильные.
Мощные, стационарные ВЭС устанавливаются только после проведения ряда исследований, а также подготовительных строительных, и окончательных монтажных работ. Такие электростанции способны полностью обеспечить электроснабжением, например, жилой дом, или небольшое производство. Кроме того, они способны накапливать в аккумуляторных батареях достаточное количество энергии, которая используется в безветренную погоду.

Мобильные электростанции более неприхотливы, просты в обслуживании и установке. Они используются в основном в путешествиях, а также для непосредственного питания электроприборов.

Основные характеристики ветроэлектростанций.
1. Номинальная мощность (Вт), или выходной ток (А). Данная характеристика зависит от типа ВЭС, и определяется мощностью, которую может вырабатывать генератор при определенной скорости ветра. Как правило, это показатель нормируется, при средней скорости ветра в 12 м/сек.
2. Номинальное напряжение (В) – напряжение тока, вырабатываемого генератором (12, 24, 220 В) и т.д.
3. Электрическая мощность генератора, которая напрямую зависит от мощности турбины. Чем больше диаметр турбины, тем она мощнее. Этот показатель прямо влияет на конструкцию мачты, используемой при установке ветрогенератора.

Также необходимо учитывать некоторые характеристики самой ветровой установки:
– количество лопастей;
– частота вращения «ветряка» об/мин;
– пусковая скорость ветра – это та минимальная скорость ветра (м/сек), при которой турбина начнет вращаться;
– максимальная скорость ветра – скорость, при которой турбина работает без повреждений;
– производительность – количество вырабатываемой электроэнергии в год (кВт ч), при среднегодовой скорости ветра, и другие.

Экономисты подсчитали, что все вложения, затрачиваемые на начальном этапе разработки и установки ветроэлектростанции, очень быстро окупаются, и на сегодняшний момент, выгоды от вложений такого рода превосходят все остальные энергетические проекты.

Unit 6. Tidal power - energy from the sea

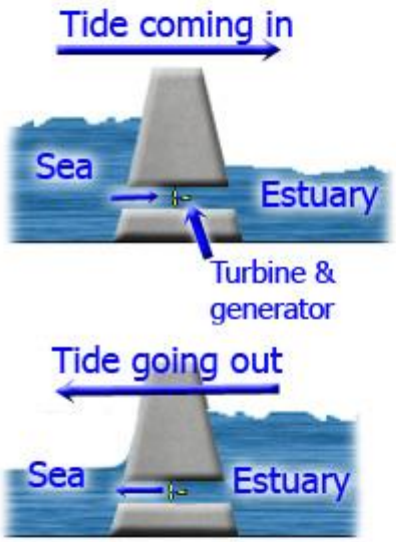
Introduction

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. There have been plans for a "Severn Barrage" from Brean Down in Somerset to Lavernock Point in Wales. Every now and again the idea gets proposed, but nothing has been built yet.

It would cost at least £15 billion to build, but other figures about the project seem to vary depending on where you look. For example, one source says the Severn Barrage would provide over 8,000 Megawatts of power (that's over 12 nuclear power station's worth), another says it would be equivalent to 3 nuclear power stations. The variation in the numbers is because there are several different Severn Barrage projects being proposed, so be careful about which numbers you quote if you're a student researching this topic.

There would be a number of benefits, including protecting a large stretch of coastline against damage from high storm tides, and providing a ready-made road bridge. However, the drastic changes to the currents in the estuary could have huge effects on the ecosystem, and huge numbers of birds that feed on the mud flats in the estuary when the tide goes out would have nowhere to feed.

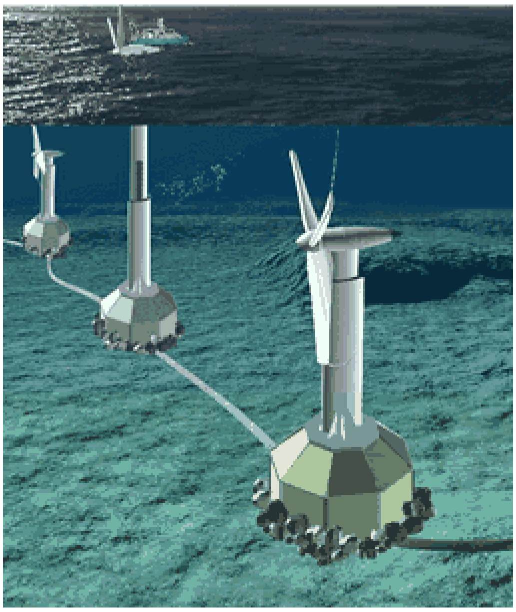
Find out more at: www.bbc.co.uk/insideout/ ; en.wikipedia.org/wiki/Severn_Barrage

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

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.

Find out more at www.marineturbines.com



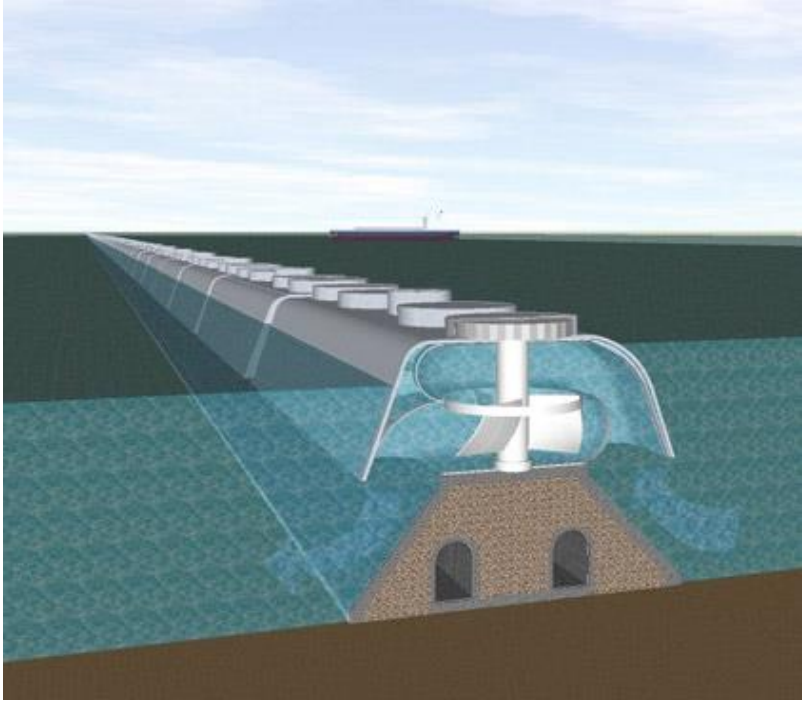
The University of Wales Swansea and partners are also researching techniques to extract electrical energy from flowing water.

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.

Find out more at www.swanturbines.co.uk

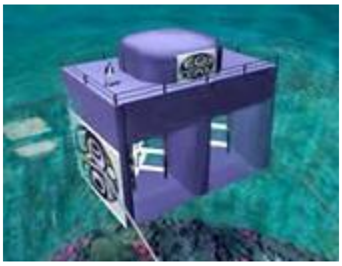
December 2008: A **"Tidal Reef"** across the Severn Estuary is being proposed.

At first glance this looks like a tidal barrage, but this design does not block the water movement as much, so it wouldn't affect the tides as severely and the environmental consequences would be much less. It could be built in sections, so power could start being generated sooner.



Migratory fish could get through, mud flats could still be exposed at low tide, and it would be able to generate power for more hours in the tidal cycle. Sections of it would open to allow shipping through, and it could be used to control tidal levels further upstream, for example preventing storm surges from flooding low-lying land. Tidal barrages have been built before, whereas this idea is untested - so it'll be interesting to see if it gets approve.

vertical-axis turbines:



Find out more from the Canadian company Blue Energy at www.bluenergy.com

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.

Is it renewable?

Tidal energy **is** renewable. The tides will continue to ebb and flow, and the energy is there for the taking.

Check: Fill in the gaps with the given words:

barrage estuary expensive France fuel in large out pollution renewable Severn turbines

There is a great deal of energy in tides. To use it, we can build a large dam, called a tidal **[?]**, across an **[?]** where the tides are strong. There are proposals to build one across the river **[?]** in the UK. Tidal energy is **[?]**, needs no **[?]** and produces no **[?]**. However, such a huge am is very **[?]** to build and will affect the environment over a **[?]** area. The largest one in the world so far is in the Rance estuary, in **[?]**.
An alternative is 'offshore **[?]**', like an underwater wind farm. This will not have such a dramatic effect on the surrounding area. It will only generate power when the tide is going **[?]** or **[?]**, but we know when this will be so we can easily plan for it.

QUESTIONS:

1. How many sites in the world have been identified as possible tidal power stations?
2. What is a barrage?
3. If you were a bird, what problem/s would you have with tidal power stations?
4. What is the major drawback of a tidal power station?
5. What are the benefits of the tidal power generation?
6. What is the advantage of the offshore turbines?
7. How is the Swansea design different from other devices?
8. What is the gravity base?
9. What could be the effects of the tidal reef?

Unit 7. Solar Power is energy from the Sun

About solar energy

Solar Energy

Ultimately, almost all energy comes from the sun. the energy stored in coal, oil, and natural gas is the result of photosynthesis carried out by plants that lived hundreds of millions of years ago. Wind energy is actually the movement of the atmosphere driven by the heat from the sun. Currently solar energy is used two ways: for heat (thermal) and to generate electricity (photovoltaic). Solar rays can be directly thermal in two ways: actively as can be seen in the thousands of rooftop water heaters throughout Europe, and passively with proper design of homes and buildings. Improvements in photovoltaic (or solar electric) panels continue to make this technology more applicable, especially for developing countries without widely established power grids that transport electricity generated at large public utilities. Increased efficiency of converting sunlight into electricity, using thin film silicon panels or copper indium thin film, has been an ongoing goal of several manufacturers of solar energy technology.

As technology has improved, the cost of using solar energy has dropped. However, one concern about widespread use of solar panels to generate the large amount of electricity needed for industries and cities is the environmental impact – they take up a lot of space and are highly visible. But this is an acceptable trade-off because solar energy is totally clean and panels have a long life span. Panels are also easy to maintain for there are no moving parts, only moving electrons!

A more serious concern for widespread use is that solar energy is an intermittent energy source as are wind and tides. Therefore, storage of excess energy or backup sources of energy are needed for times when there is not adequate sunshine for the panels to function efficiently. Improved battery technology has made use of photovoltaic panels easier for users in remote areas who live "off the grid" of the public utility company and need to store excess power. In some areas, users of solar panels who are connected to the grid may sell back any surplus power to the public utility company. Development of thin film technology has made solar power viable for use in some forms of transportation. For all its advantages, however solar power remains the least used of the main alternative energy sources.

There are a variety of technologies that have been developed to take advantage of solar energy. NREL performs research to develop and advance all of these technologies. These include:

Photovoltaic (solar cell) systems- Producing electricity directly from sunlight.

Concentrating solar systems- Using the sun's heat to produce electricity.

Passive solar heating and daylighting- Using solar energy to heat and light buildings.

Solar hot water- Heating water with solar energy.

Solar process heat and space heating and cooling- Industrial and commercial uses of the sun's heat.

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.

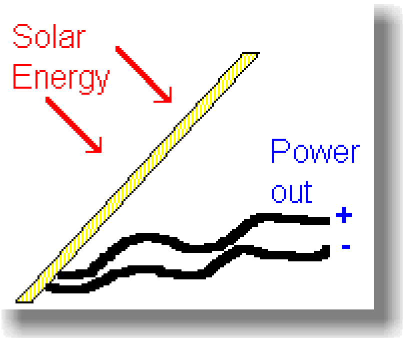
In fact, every minute, enough energy arrives at the Earth to meet our demands for a whole year - if only we could harness it properly.

How it works

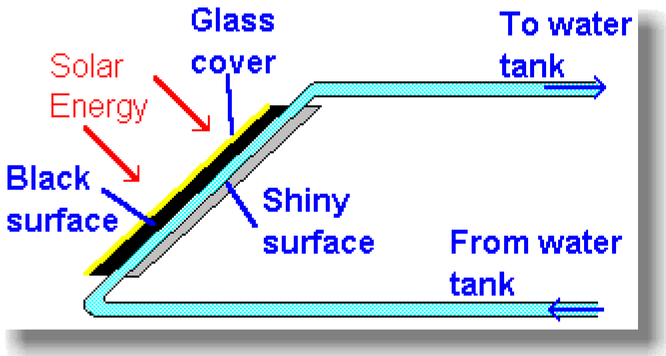
There are three main ways that we use the Sun's energy:-

1. Solar Cells (really called "photovoltaic" or "photoelectric" cells) that convert light directly into electricity.

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.



2 Solar water heating, where heat from the Sun is used to heat water in glass panels on your roof.
This means you don't need to use so much gas or electricity to heat your water at home.

QUESTIONS

1. What are the ways to use solar energy?
2. What are the two ways to use solar rays?
3. What is the goal of solar energy manufacturers?

4. What is the man concern about solar panels?
5. Why are the panels easy to maintain?
6. What does it mean that solar energy is *intermittent?*

Water is pumped through pipes in the panel. The pipes are painted black, so they get hot when the Sun shines on them.

This helps out your central heating system, and cuts your fuel bills. However, in the UK you must remember to drain the water out to stop the panels freezing in the winter.

Solar heating is worthwhile in places like California and Australia, where you get lots of sunshine.

3 Solar Furnaces

use a huge array of mirrors to concentrate the Sun's energy into a small space and produce very high temperatures.

There's one at Odellio, in France, used for scientific experiments.
It can achieve temperatures up to 33,000 degrees Celsius.

More details

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

In California, the **Solar One** power station uses the Sun's heat to make steam, and drive a generator to make electricity. The station looks a little like the Odellio solar furnace (see picture above), except that the mirrors are arranged in semi-circles around the "power tower".
As the Sun moves across the sky, the mirrors turn to keep the rays focussed on the tower, where oil is heated to 3,000 degress Celsius, The heat from the oil is used to generate steam, which then drives a turbine, which in turn drives a generator capable of providing 10kW of electrical power.

Solar One was very expensive to build, but as fossil fuels run out and become more expensive, solar power stations may become a better option.

One idea that is being considered is to build **solar towers**.

The idea is very simple - you build a big greenhouse, which is warmed by the Sun. In the middle of the greenhouse you put a very tall tower. The hot air from the greenhouse will rise up this tower, fast - and can drive turbines along the way. this could generate significant amounts of power.

See www.enviromission.com.au/intro.htm to find out more.

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

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 except for low-power applications, as you need a very large area of solar panels to get a decent amount of power.

Is it renewable?

Solar power **is** renewable. The Sun will keep on shining anyway, so it makes sense to use it.

TRANSLATION TEST

1. В настоящее время существует три схемы производства электроэнергии с использованием гидротермальных ресурсов: прямая с использованием сухого пара, непрямая с использованием водяного пара и смешанная схема производства (бинарный цикл).
2. Паровые электростанции работают преимущественно на гидротермальном пару. Пар поступает непосредственно в турбину, которая питает генератор, производящий электроэнергию. Использование пара позволяет отказаться от

сжигания ископаемого топлива (также отпадает необходимость в транспортировке и хранении топлива)

3. Большинство геотермальных районов содержат воду умеренных температур (ниже 200 0С). На электростанциях с бинарным циклом производства эта вода используется для получения энергии. Горячая геотермальные вода и вторая, дополнительная жидкость с более низкой точкой кипения, чем у воды, пропускаются через теплообменник. Тепло геотермальной воды выпаривает вторую жидкость, пары которой приводят в действие турбины. Так как это замкнутая система, выбросы в атмосферу практически отсутствуют.
4. "DIZELEK" предлагает вертикальные ветрогенераторы бесшумные, инерционные, вертикально-ориентированные. На сегодняшний день данная модель ветрогенератора является одной из самых эффективных.
5. Использование возобновляемых источников электроснабжения предусматривает обязательный детальный учет географического места размещения комплекса. Предварительное обследование площадки специалистами и анализ условий эксплуатации (высоты объекта, удаленности от терминала управления, диапазона температур окружающего воздуха, среднегодовой и среднемесячной скорости ветра, интенсивности поступления солнечной энергии и потенциала водных ресурсов для мини–ГЭС) позволят сформулировать оптимальное техническое задание на конфигурацию комплекса
6. Солнечные электростанции с аккумуляторами идеально подходят для производства и хранения электроэнергии в местах с отсутствием энергоснабжения. Способность производить, накапливать и хранить электроэнергию делает такие солнечные электростанции надежным источником энергии в любое время, независимо от погодных условий и времени суток.Солнечные электростанции с аккумуляторами проектируются для снабжения электричеством как постоянного, так и переменного токов.
7. Прили́вная электроста́нция (ПЭС) — особый вид гидроэлектростанции, использующий энергию приливов, а фактически кинетическую энергию вращения Земли. Приливные электростанции строят на берегах морей, где гравитационные силы Луны и Солнца дважды в сутки изменяют уровень воды. Колебания уровня воды у берега могут достигать 13 метров.
8. Для получения энергии залив или устье реки перекрывают плотиной, в которой установлены гидроагрегаты, которые могут работать как в режиме генератора, так и в режиме насоса (для перекачки воды в водохранилище для последующей работы в отсутствие приливов и отливов
9. Преимуществами ПЭС является экологичность и низкая себестоимость производства энергии. Недостатками — высокая стоимость строительства и изменяющаяся в течение суток мощность, из-за чего ПЭС может работать только в составе энергосистемы, располагающей достаточной мощностью электростанций других типов .
10. Все люди за возобновляемые источники энергии, но некоторые люди отчаянно выказывают недовольство, когда строительство ветровых турбин предполагается в их районе. Видимо, все хотят пожинать плоды энергии ветра, но никто не хочет смотреть на ветротурбины.
11. Вертикальные ветрогенераторы в настоящее время имеют ряд существенных преимуществ и несколько недостатков по сравнению с горизонтальными ветрогенераторами.Преимущества вертикальных ветрогенераторов:

- Генератор может быть размещен на земле, что делает проще ремонт
- Коробка передач могут быть расположена на земле, что делает проще ремонт
- Всенаправленость (не требуются механизмы для контроля направления ветра и поворота)
-
- Одним из недостатков вертикальных ветрогенераторов есть то, что они (как правило) устанавливаются у земли (что означает, что они не могут воспользоваться преимуществами высокой скорости ветра на больших высотах над уровнем земли).

Unit 8. Hydro-electric power is generated from falling water

Hydropower

The development of hydropower has become increasingly problematic in the United States. The construction of large dams has virtually ceased because most suitable undeveloped sites are under federal environmental protection. To some extent, the slack has been taken up by a revival of small-scale development. But small-scale hydro development has not met early expectations. As of 1988, small hydropower plants made up only one-tenth of total hydropower capacity.

Declining fossil-fuel prices and reductions in renewable energy tax credits are only partly responsible for the slowdown in hydropower development. Just as significant have been public opposition to new development and environmental regulations.

Environmental regulations affect existing projects as well as new ones. For example, a series of large facilities on the Columbia River in Washington will probably be forced to reduce their peak output by 1,000 MW to save an endangered species of salmon. Salmon numbers have declined rapidly because the young are forced to make a long and arduous trip downstream through several power plants, risking death from turbine blades at each stage. To ease this trip, hydropower plants may be required to divert water around their turbines at those times of the year when the fish attempt the trip. And in New England and the Northwest, there is a growing popular movement to dismantle small hydropower plants in an attempt to restore native trout and salmon populations.

That environmental concerns would constrain hydropower development in the United States is perhaps ironic, since these plants produce no air pollution or greenhouse gases. Yet, as the salmon example makes clear, they affect the environment. The impact of very large dams is so great that there is almost no chance that any more will be built in the United States, although large projects continue to be pursued in Canada (the largest at James Bay in Quebec) and in many developing countries. The reservoirs created by such projects frequently inundate large areas of forest, farmland, wildlife habitats, scenic areas, and even towns. In addition, the dams can cause radical changes in river ecosystems both upstream and downstream.

Small hydropower plants using reservoirs can cause similar types of damage, though obviously on a smaller scale. Some of the impacts on fish can be mitigated by installing "ladders" or other devices to allow fish to migrate over dams, and by maintaining minimum river-flow rates; screens can also be installed to keep fish away from turbine blades. In one case, flashing underwater lights placed in the Susquehanna River in Pennsylvania direct night-migrating American shad around turbines at a hydroelectric station. As environmental regulations have become more stringent, developing cost-effective mitigation measures such as these is essential.

Despite these efforts, however, hydropower is almost certainly approaching the limit of its potential in the United States. Although existing hydro facilities can be upgraded with more efficient turbines, other plants can be refurbished, and some new small plants can be added, the total capacity and annual generation from hydro will probably not increase by more than 10 to 20 percent and may decline over the long term because of increased demand on water resources for agriculture and drinking water, declining rainfall (perhaps caused by global warming), and efforts to protect or restore endangered fish and wildlife.

QUESTIONS

1. What is the present situation with hydropower in the US?
2. Why has the construction of dams ceased?
3. What are the two reasons for the slowdown in hydropower development?
4. Why have salmon numbers decreased?
5. What can hydropower plants do to help?
6. What is the environmental impact of large dams?
7. What devices allow fish to migrate over dams?

Introduction

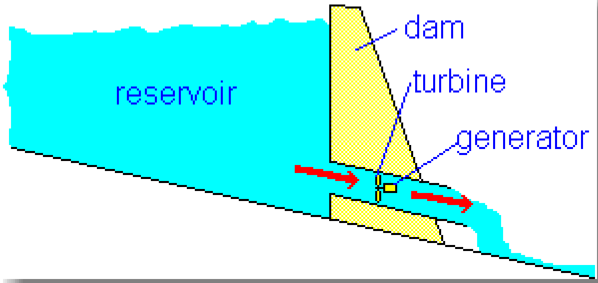
We have used running water as an energy source for thousands of years, mainly to grind corn.

The first use of water to generate electricity was in 1882 on the Fox river, in the USA, which 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.

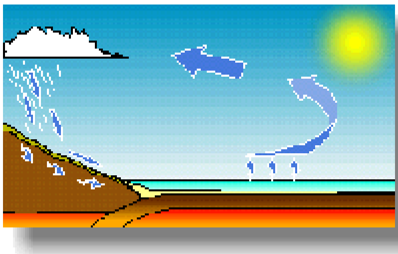
Hydro-electric power stations can produce a great deal of power very cheaply. The huge "Hoover Dam", on the Colorado river, supplies much of the electricity for the city of Las Vegas.

There's a good explanation of how hydro power works at http://www.fwee.org/Tours.html.

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.



More details

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.

Unit 9. Wave Power

Introduction

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

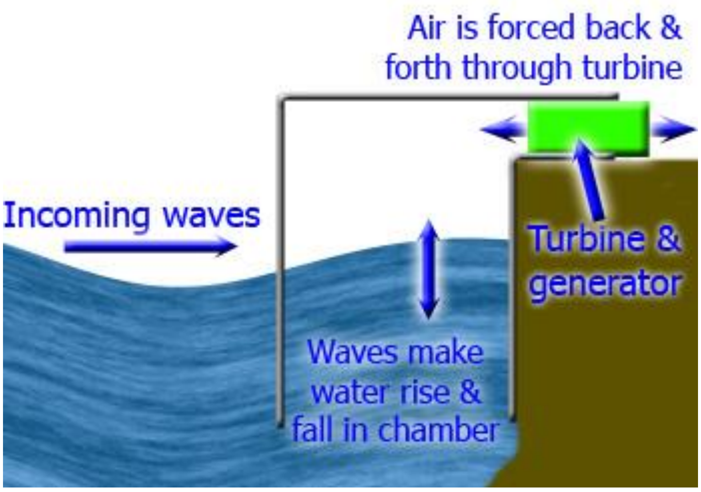
The problem is that it's not easy to harness this energy and convert it into electricity in large amounts. Thus, wave power stations are rare.

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.

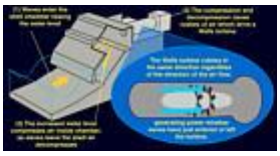
At a wave power station, the waves arriving cause the water in the chamber to rise and fall, which means that air is forced in and out of the hole in the top of the chamber.



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.

Example:
A company called Wavegen operate a commercial wave power station called "**Limpet**" on the Scottish island of Islay.
Find out more at www.wavegen.co.uk...

View an animation about how "Limpet" works from the Greenpeace website.



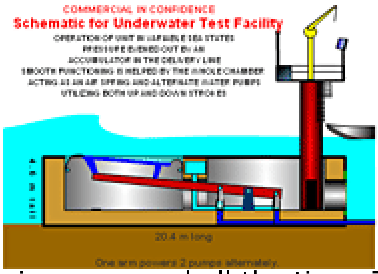
Example:

A company called Ocean Power Delivery are developing a method of offshore wave energy collection, using a floating tube called "**Pelamis**".

This long, hinged tube (about the size of 5 railway carriages) bobs up and down in the waves, as the hinges bend they pump hydraulic fluid which drives generators.

Find out more, including an interactive model, videos and technical details at www.oceanpd.com...

Example: Another company is called **Renewable Energy Holdings**. Their idea for generating wave power (called "**CETO**") uses underwater equipment on the sea bed near the coast. Waves passing across the top of the unit make a piston move, which pumps seawater to drive generators on land.
They're also involved with wind power and biofuel.



More

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.

Check: Fill in the gaps with the given words:

air calm fuel movement reliable renewable storms strong turbine water waves

Wave power is a **[?]** energy resource, needs no **[?]** and produces no pollution. There are several ways to get energy from waves. One is to use the waves to make **[?]** bob up and down in a chamber, allowing **[?]** to be blown in and out of the top which can drive a **[?]** and a generator. Another is to tether objects where the **[?]** can move them up and down or back and forth, and use this **[?]** to drive generators.A wave power station must be built where waves are **[?]** and **[?]**, must be able to generate during **[?]** weather and yet withstand violent **[?].**

Unit 10. 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.

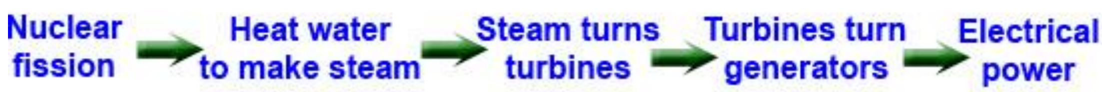
The first large-scale nuclear power station opened at Calder Hall in Cumbria, England, in 1956.

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.

Actually, it's not that simple - we can use "fast breeder" reactors to convert uranium into other nuclear fuels whilst also getting the energy from it. There are two types of breeder reactors - ones that make weapons-grade plutonium and ones that are for energy production.

Check: Fill in the gaps with the given words:

burn chain dangerous electricity energy no Nuclear reactor robot rods shielding uranium waste water

Is nuclear power renewable? (yes/no) **[?]** Nuclear power stations use **[?]** as fuel. The need very little fuel compared to a fossil-fuel power station, because there is much more **[?]** in nuclear fuel.The **[?]** reaction inside the **[?]** vessel creates heat, which turns **[?]** into steam to drive turbines, which drive generators to make **[?]**.The fuel **[?]** are safe to handle before they go into the reactor, it's only when they come out that you need **[?]** arms and heavy **[?]**. **[?]** power stations do not create atmospheric pollution because they do not **[?]** anything. However the small amount of **[?]** they do produce is very **[?]**.

Unit 11. Low-Impact, Renewable Energy

One way that electricity companies can reduce their greenhouse gas (GHG) emissions is to incorporate low-impact, renewable energy in their systems, while encouraging its use by their customers. Renewable energy provides heat and electricity from natural resources that are not depleted over time. Canada has extensive renewable energy resources, which include wind, solar radiation, water power, earth energy, and biomass. These resources can be used without an impact on climate. By contrast, non-renewable, fossil fuel energy sources, such as coal, oil and natural gas, are the key contributors to global climate change.

However, not all uses of renewable energy make sense for the climate, the environment or a sustainable society. For example, water reservoirs penned up behind dams can have negative environmental impacts on rivers, fish, and surrounding land. They can also produce GHG emissions. As well, using energy from trees or other biomass sources that are being harvested too quickly without allowing enough time for regeneration does not help solve the climate change issue. Without sustainable harvesting practices GHG emissions produced when the wood or biomass is burned are not adequately offset by new growth.

As a result, we need to significantly increase our use of "low-impact, renewable energy" both to protect the climate and move to a more sustainable energy system. Unfortunately, Canada is rapidly falling behind other countries in the deployment of such technologies. Some examples of low-impact renewable energy technologies for electricity generation include:

- Wind power;
- Photovoltaic solar energy;
- Run-of-river hydroelectricity;
- Co-generation of heat and power from geothermal steam;
- Sustainable use of wood or other biomass, for example fire-killed timber, waste wood from forestry operations, or agricultural wastes; and
- Water velocity turbines - used in rivers or to capture the tidal power of the oceans.

Using renewable energy indirectly reduces GHG emissions of an electricity company by reducing their need to generate power from fossil fuels or other GHG-emitting sources. Electric utilities can also use renewable energy for a variety of applications in their day-to-day operations, and build new generating capacity from renewable sources. Finally, electricity companies can play a significant role in encouraging their customers to use renewable energy. In fact, without the support of their energy company, it is very difficult for individuals and families to adopt low-impact, renewable energy into their lives. Electricity companies can undertake several kinds of measures to support low-impact renewable energy:

- Installing renewable energy technologies for use in their own operations - such as buildings, transformer stations or remote applications. For example, one electricity company installed photovoltaic solar panels to power utility buildings.
- Investing in cost-effective renewable energy applications to provide power to the grid or remote applications - this is often possible in remote jurisdictions where electricity is normally supplied by diesel generators, and where renewable energy resources are abundant.
- Purchasing some power from renewable energy sources, while sharing the costs among all customers, and/or the company's shareholder(s).
- Establishing a green power marketing program that offers customers an opportunity to purchase low-impact, renewable energy. Such programs can take the place of the company's regular power, and individual customers can be charged for any differential in price. Governments at all levels, and indeed, organizations in any sector can support green power marketing by purchasing green power and establishing green power procurement policies. li>Establishing a net metering program to allow customers to generate their own power from low impact, renewable

energy sources. Customers typically receive credit for any excess power they produce that is fed into the grid.

- Helping energy users purchase cost-effective, renewable energy technologies that provide heating and cooling can also have the effect of reducing electricity use.

Conclusion

So, no single solution can meet our society's future energy needs. The solution instead will come from the family of diverse energy technologies that do not deplete our natural resources or destroy our environment. That's the final decision that the nature imposes. Today mankind's survival directly depends upon how quickly we can renew the polluting fuel an energy complex we have now with sound and environmentally friendly technologies.

Certainly, alternative sources of energy have their own drawbacks, just like everything in the world, but, in fact, they seem minor in comparison with the hazards posed by conventional sources. Moreover, if talking about the dangers posed by new energy technologies, there is a trend of localization. Really, these have almost no negative global effect, such as air pollution.

Moreover, even the minor effects posed by geothermal plants or solar cells can be overseen and prevented if the appropriate measures are taken. So, when using alternatives, we operate a universal tool that can be tuned to suit every purpose. They reduce the terrible impact the human being has had on the environment for the years of his existense, thus drawing nature and technology closer than ever before for the last 2 centuries.

Final check

1. Choose the correct variant:

1. Hydroelectric power is

A. ? non-renewable

B. ? renewable

2. Biomass and biofuels are

A. ? renewable

B. ? non-renewable

3. Tidal power is

A. ? non-renewable

B. ? renewable

4. Wave power is

A. ? non-renewable

B. ? renewable

5. Nuclear power is

A. ? non-renewable

B. ? renewable

6. Geothermal power is

A. ? renewable

B. ? non-renewable

7. Solar power is

A. ? renewable

B. ? non-renewable

8. Wind power is

A. ? renewable

B. ? non-renewable

9. Fossil fuels are

A. ? non-renewable

B. ? renewable

2. Find the matching part of the sentence

I.

Powered by movements of water in an estuary
Coal, oil and natural gas are called...
The chemical name for natural gas
Powered by hot rocks underground
Convert the Sun's energy directly into electricity
Energy from waste plant or animal material
Uranium is the fuel
Where the Earth gets most of its energy from
Formed from ancient dead plants
Powered by natural air movements
Formed from ancient dead animals

II.

Oil
Nuclear power
Tidal power
Methane
Coal
Fossil fuels
Wind power
Biomass
Geothermal power
Photovoltaic cells
Sun

3. Choose the correct variant:

1. Wind power

A. ? does not depend on the Sun at all

B. ? depends indirectly on the Sun

C. ? depends directly on the Sun

2. Hydroelectric power

A. ? depends indirectly on the Sun

B. ? does not depend on the Sun at all

C. ? depends directly on the Sun

3. Wave power

A. ? depends directly on the Sun

B. ? does not depend on the Sun at all

C. ? depends indirectly on the Sun

4. Geothermal power

A. ? depends directly on the Sun

B. ? depends indirectly on the Sun

C. ? does not depend on the Sun at all

5. Solar power

A. ? depends indirectly on the Sun

B. ? depends directly on the Sun

C. ? does not depend on the Sun at all

6. Nuclear power

A. ? depends indirectly on the Sun

B. ? does not depend on the Sun at all

C. ? depends directly on the Sun

7. Fossil fuels

A. ? do not depend on the Sun at all

B. ? depend directly on the Sun

C. ? depend indirectly on the Sun

8. Biomass

A. ? depends directly on the Sun

B. ? depends indirectly on the Sun

C. ? does not depend on the Sun at all

Exam questions

1. Name 2 fossil fuels

______________________? ______________________? *(2 marks)*

2. Name a non-renewable energy resource that is not a fossil fuel

_____________________? *(1 mark)*

3. Describe how a gas-fired power station works

____

____ *(3 marks)*

4. Name two advantages of generating electricity using nuclear power

____?

____? *(2 marks)*

5. Which uranium isotope is only 0.7% of natural uranium, and is the "fissile" part?
(Hint: the answer is a number, "Uranium-23something") __________________________? *(1 mark)*

6. Describe two methods for getting energy from sunlight

1.____?

2. ____? *(2 marks)*

7. Describe three disadvantages of wind power

1. ____?

2. ____?

3. ____**?** *(3 marks)*

8. What is a Tidal Barrage? Describe where one could be built.
Name one advantage and one disadvantage of this method of generating power.

____

____

____

____ *(4 marks)*

9. Why does New Zealand make more use of hydroelectric power than the UK?

____ *(1 mark)*

10. Why does Switzerland not use tidal barrages?

____ *(1 mark)*

11. What is a Pumped Storage Reservoir and why do we need them?

____

____

____ *(3 marks)*

12. <u>Name</u> the energy resource that involves extracting heat from rocks

____ *(1 mark)*

13. <u>Name</u> two materials that we can burn in order to get energy from “Biomass”

____

____ *(2 marks)*

(Total 26 marks)

Name ______________________________ Date ____/____/_______

	How it works; advantages/disadvantages	Your Quiz score (%)
Fossil Fuels (Coal, Oil, Gas)		
Solar Power		

Wind Power		
Tidal Power		
Hydro-electric Power		

Wave Power		
Geothermal Power		
Biomass		

TEXTS FOR LISTENING

1. Progress.

It is said to be ______________that marches on but in our quest to _______ and _____________, this ______ hasn't always followed the most _______________ conscious path. Today __________ awareness guides us to ____ rather then plunder, considering the ____ of ______ along with our _____.

We're a _______ dependent on _________l ____. ______ experts calculate that by ____ global oil ____ will peak and _______ and irreversibly ____ making the need to ______ an ________ fuel source even more _____. _________ make up ____ of the world's _________and they __________ about ____ of the world's ___________. At their current rate we will be __________ of fossil fuels by the year ______. Because we are ________ our _______ at such a brisk rate, _________ are looking at ________ sources of _______ such as _________, renewable _______ matter. Biomass _______ is stored _______ energy which can be _________ to ________ or heat. There is about a ______mln. dry ____ of crop residue a ____ to be used as __________ and these __________ will not be depleted and will be ________ for a long _____. Because __________ is a ___________ resource, ______ have _______________ to incorporate it as a ____________ for current _________. For instance, __________ with Bixby _________ Systems have been _____ at a revolutionary biomass ______system. This hi-tech_______ is designed to be a ______ burner in an effort to _______ economically and ________-friendly ________.

Biomass is a very ______ material to _____. _______ is a 100% ________ why anything burns, but only _____ of the air we ______. So it is _________ to develop a ______ of burning that would _____ us to _______ the _______ of the burner. ____________provides a _____ combustion ratio which _______ you to get the ________ amount of _______ out of the ____ which we are using. The ____ difference ________ Bixby's ________ and other __________ fuel _______ is addition to ______ dry-shelled _____ and ____ pellets. Specially ______ fuel pellets ____ from ______ waste______ can also be used to ______ the patented _____. Biomass _____ are made from _____ thousands of _____ kinds of _______ and are _______ in a recipe ________ into a form that ______ for easy ________. This biomass can _____ more c______ energy up to ____ more per 1 $ than propane or fuel, ______. Energy _____ have long felt the _______ industry would ______ an advantage with_______ because of its ______ to produce ______ methods of e______ delivery. But _______ at Bixby have ______ to level that plain ______ as well. We have a ______ system that allows us to ____ the trucks to the ______, blow it into the ___, using a ____, into a _______ system, whereby the _______ can drove off that fuel.

My ____ and I bought this _____unit about a ____ago and it had done a lot ____ than some of the other ____ that we'd ____ had. It is a lot ____ and we got a lot more ____ out of it than of the ones we had ____. We heat our ____ house with it _____ of just a basement.

Our ____ resources will not be ____ for ever and an ______ practical _____ to our energy _____ may be _________ worth further _______ exploration.

Some great _____ and _____. We are _____ you can ____ us here on the _____ Series. Be sure to ____ us again ____ time for ____ stories of ______. Lou Gossett Junior.

2.WHAT IS BIOMASS?

Hi! What is _____________? Biomass refers to __________ and recently dead ____________________ that can be used as fuel for ______________. Most commonly biomass refers to _________ matter grown for use as _________. It also includes plant or _________ matter used for __________ of fibers, ________ or heat. Biomass can also include biodegradeable _______ that can be burnt as _____. It excludes ______ material which is being transformed by __________ processes into ________ such as coal or ________. Biomass is grown for ______ and ________ production from several _____ including myscanthus, switch grass, hemp, corn, poplar, willow, sugar cane and oil palm. The particular ____ used is usually not very _______ to the end ______ but it does affect the processing of the raw _____. Production of biomass is a _______ industry, as ______ in sustainable fuel ______ is growing. Although _________ have their origin in ancient _______, they are not considered to be biomass by the ________ accepted _______ because they contain ________ that has been out of ______ cycle for a very long _____. Their ______ disturbs the _________ content in the __________. Its intensive use is thought to be causing the ___________ effect which in turn is causing ______ change and ____________. Demand for biomass _________ for refining as _____ or as ________ for power end is growing and will _______ to do so. One big concern is that this ______ in demand will actually compete with producing _____. This will be very unfortunate if it does, as it will _____ the cost of food for the _____ of the _____. There are many ways, nevertheless, that ______ can actually be harvested and ______ biomass ______ can be utilized. In 2004, 11 % of all the maize _______ in the US was converted to ________ supplying 1.7% of their fuel _______. The US target for ______ is to satisfy ____% of its _____ need via biomass route. However, even if all the _______ maize in the US was to be ______, it would meet only _____ of the target. Other _____ of biomass will be needed to ____ safeguard fuel ______. _____ is in the similar ______ and in the UK the _______ target under renewable fuels obligation is to replace ___% of road fuels with ________ fuels by ______. As we have described earlier, there are many ________ sources of biomass. And these will _______ need to be ________ to meet targets without jeopardizing ______ production. We won't stop using existing ________ of biomass and _______ and wood industry have always been an ______ source. There are new ____ of using wood. There is much more scope to use ______ wood which would otherwise go to ________ and this scope is to use a lot more chipped _______ made from poor _____ wood. And, indeed, when ______ down ______ quality wood, additional ______ – twigs and branches – can actually be _______ and the biomass used after ______ the materials, for example.

I hope you now _______ a lot more _____ is biomass. Biomass will need to be used a lot more than it is at _______. This is because of the ______ cost of _________ and in time ________ scarcity of fossil fuels. What we don't ______ is the extent to which ______ can ever replace ________. We have a long _______ to travel before that could ever be a case. Do visit our ______ to find out more about how biomass can be used as a ______ source of energy. If you have _____, we'd love to hear them. Join our _____, tell us all about you. Make sure you visit www.anaerobic – digestion.com.

3. **FOSSIL FUEL POWER STATION. HOW IT WORKS**

The huge ______________ you see behind me is one of Ontario power generation ___________ ____________ generating stations. This one uses ____________. Other fossil fuel generating stations use oil and natural gas to make ___________. In essence, it is a factory that converts the ___________ of the burning coal into a flow of ____________ or what is commonly called electricity, the electricity that powers the province. Coal is shipped to the ____________ by freighter or train, and then transferred to the coal yard. There large ___________ called tractor-scrapers arrange the coal into the storage piles. A series of conveyors ____________ the coal into the plant where it passes through enormous powderizers that grind coal into a fine powder prior to __________. The powderized coal is fed into a large ___________ furnace that is surrounded by boiler tubes filled with ________. The intense heat from the burning coal heats the water in the boiler tubes and turns it into ______. The steam is transferred under __________ at high speed through large pipes to _________ like these. Then this pressurized flow _________ the blades of the turbine causing it to spin. The turbine is connected to a ________ that contains a rotor. Large electromagnets are attached to the rotor that is located within coils of copper wire called the ________. As the generator rotor spins, a flow of electrons is created in the stator. This produces _________ that could be stepped up in voltage through the station

____________ and sent from the station across transmission lines. The steam from the turbine is condensed back to ______ using cooling water from the lake and comes back to the _______ where it is reheated to continue the process.

4. GEOTHERMAL ENERGY

Geothermal_______gives us a steady_________ of electrical________ with minimal ________ impact. Here is the basic ______. Water in _______ reservoirs is heated to high ____________ by magma. _________ well is drilled up to __________ ft below the earth __________ tapped into its hot fluid. Under its own _________, the fluid ______s through the wells towards the _______. As it travels, the ________ lessens, causing a ______ amount to become _____. Together the hot _____ and _____ move through a ________ pipeline to the well head _________ where the ________ is reduced. Any ______, not flashed into ______, moves to a ________ pressure __________ to produce _______pressured steam. ______ is then flashed at a _____ pressure to ____ low _______ steam. All steam ______ at the _____ is sent to a _____ on site. The _____ of the _____spins the turbine's ______ which turn a shaft ______ to an electrical ________. An _______ charge is ________ and directed to a _________ where the _______ is _________ and sent down the _______lines. Any fluids not _____ into steam, return to the ________ reservoir where in ____ they will be ________and _______. Geothermal ______, a simple ____ and _____ energy _________.

5. HYDROELECTRIC POWER. HOW IT WORKS

……………….of water flow past here every………at almost………..hour. That is enough water to fill about a ………Olympic swimming …………..every day. Standing here, you can actually feel the ….. of the water. Harnessing that power is what ……………………power stations have been ………. to do for over a ……………….years in Ontario. In essence, they are …………that convert the

…………of the falling …… into the flow of ……….or what is commonly called……………, electricity that powers the province. Most hydroelectric stations use either ………diverted around the ………………drop of the ………….. such as …………………… or rapids or a dam is built across a …………………to raise the water level and provide the ………..needed to create a driving……..Water at the higher …………is collected in the forebay. It flows through the plant's intake into the ……… called the pinstock which carries it …….to a ……water wheel at a lower …. ……………the water pressure ……………..as it flows down the ………….. It is this pressurized flow that drives the ………. That is connected to the ……………… In side the …………………… is the ………. That is spun by the …………… Large …………….. are attached to the……….located within coils of carbon wire called the ………………… As the generator……………. Spins the ……………….., a flow of electrons is created in the coils of the ……………… This produces electricity that can be stepped up in ………………….. through the station ………………………… and set across transmission ……………… The falling water, having served this purpose, exits the…………… to the tailrace or it rejoins the mainstream of the ……………… to continue the ……….. of creating clean …………. energy for Ontario.

6. Supercar, supercar.

With ……. and ……, as …….. as can be, watch it …….. through the air. It travels in …….. or under the …. and it can journey …... Most of us have given up on the …… of getting our fine car ………. What will the ……… of the ……… look like? Will they be ……… cars, ………. cars? Will they steer …………, will they look like this, or this, or this? Or maybe like this? This is the Chevy Volt. Probably the most …… and …… car design since the Model T. Its …….. or ……… may well show us whether the US ….. will flourish or …… . It's a hybrid ….. , part of a new …….. called Series Hybrids. The Voltron runs on

……… power for about ….. miles, after that a small …….. engine takes over to ……. the battery, giving it a …….. range of more than …… miles.The battery can then be …….. overnight by plugging it into an ….. . If you are like most …… who commute …. miles or less a day, you'll be able to ….. gas free for most of your daily driving. Ironically, …. years ago, General Motors was on the …… of electric car technology with the EVI. But GM cancelled that …. and gave up …… in this key technology. Now the world has got up. Look out! GM has ….. . Nissan has set on belts a new all-electric ……. next year, while Honda will rule out gas-electric ……. .Perhaps the most critical ………. has been in the world's ……… auto market. As seen at a recent Shan Hai …….. , every major ……… car company seems to have one. Geely's EK2, Cherry's Rich M1, LYD – E6. Models of ……. cars are claiming to be ………, safer, better in competition.Behind in the race to build a ………. petrol car vehicles, Chinese ………. are trying to get a ……… on the future. As oil …….. climb, and concern about ……….. increases, the coming decades will almost certainly be ……….. by electric vehicles. But some ………….. ask: in going this realm, are we ………… one form of pollution for another? Are we merely ………… the tailpipe for the smoke stack? Will we have to build a new generation of …………… power plants to power our electric cars?This is where the story gets really …………. If you are an electric ……….., this is your problem to solve each day. This is a 24-hour graph of electrical …………. Typically they show low demand in early …………. hours and high peaks in the late …………. and evening. Each of these periods is a significant ……………. for the power system. In the early morning, ………….. is low but the giant power …………. used to provide base load power, usually coal-fired and ……….., cannot be shut down to economize on a daily basis. They continue to be run , burning fuel or ………….. atoms even though demand is low. It's called "spinning reserve" and it's a ……………. cost to e-payers. In the afternoon peaks, many utilities find it ……………. to meet demand with only their base load units, so they rely on a ………. of smaller power plants, many of which are only in use for a few hours each day and …………… only a few days out of every year during the very hottest ………. and months. It's an extremely …………….. way to produce ………. and e-payers again take ahead. What will ………….. on this curve be if millions of new electric cars begin to take the road? Will our existing fleet of ………….. be able to meet demand? Experts tell us that since most cars will be …………… at night the spinning reserve from ………. power plants will be more than enough to meet demand. In fact, the study from the US Department of Energy has shown that for the United States as a whole, ……..% of US cars, pickup trucks and SUVs could be supported by the existing …………….. For utilities this means they can sell more ……………… without building expensive new power plants. For e-payers this means they can run cars on cheap electricity instead of …………… gas or allowing electric rates to be stable or actually drop, but that's only one part of the story. What about addressing these expensive ………….. peaks?There is another emerging piece of the ………… I could while away the time with… Electrical grids all over the ………… are being rebuilt to carry vastly more ………………. and behave more like the ……………. or make the way we distribute electricity more efficiently simply by making it more ………… A key piece of the new grid will be the smart Internet-………….. electric meter in homes and businesses. So, my summer pay ……… are talking to my house, are talking to my car, are talking to my house… The way this will work on that hot summer ………………. when demand peaks, is that a ……………… in the grid will talk to your electric meter and say: I see you have an electric car …………… in your system and it looks all …………………… up. May I …………….. some electrons? And your meter might answer: Well,yes! I'm authorized to ………… some electrons with you. And …………….. from millions of powerful car …………… the electrical grid will share at the top of the power peak without turning on more expensive …………….. power plants. This system has a number of advantages. Most cars are parked and could be available ……… out of 24 hours. A fleet of electric cars would be equal to ……… to ……..times US electric grid capacity. And the service car owners provide is so valueable you may have your electric bill credited ….. to …. thousand dollars a year just to have your car plugged in when you are not using it. The details of how this will eventually work are not yet ………. It may be that most cars will rely on charging stations at home or at work, or one ………….. is that car owners will not own the car batteries. Instead of gas stations we may build a network of ……….. replacement stations where used batteries are quickly swapped out for fresh ones. This model has alrteady been demonstrated in ………….. and ………. Another advantage of smart grids is the ability to ……… existing sources of energy as well as integrate and even store new ……….. sources like wind and solar. Danes are today the world leaders on the wind side.

7. CRUDE OIL

Crude oil is a ____________________ found ______ in the Earth crust. It's a ____________of different __________________, molecules made of _______________ and ____________. Some of __________________ in the mixture are very small – just a few ____________ joined together. Others are far more _____________ with many __________ forming long chain ________________. But as a mixture it's ______________. The different______________ need __________. The technique used is ______________. This simple _______________ is set up in a fume cupboard. _____________ wool stops the ___________ spitting when it's ___________. ____________ is dropped into the ______________ of the tube. A collecting ___________ is put in place. And the _______________ leveled with the side arm ____________ temperature. The ____________ step is to gently heat the ____________ by immersing the ___________ into a hot ____________ bath. The ____________ with a lower ___________ point begin to ______________ immediately. They're _____________. So it's safer not to __________ with a naked __________. As the vapor __________, it enters the side arm where it _________ and _________. This happens at about ____________. The ____________ which boil at this ____________ drip ____________ the side arm and form our first ____________. It's a colorless ____________. The ______________ stays at around ____ until all the ___________ with this ____________point _______________. The hydrocarbons left ___________ aren't _____ enough to __________. Their ________ point must be ________. Once the first __________ has been _________, it's safe to ______ heating with a Bunsen. As the _______________ rises, other _______________ begin to boil. A new __________ is collected at about _____ Celsius. It's slightly _________ in color. And so the __________ continues. By carefully___________ the oil and collecting the _________ which _________ at a number of different _____________, the many _________________ hydrocarbons in ___________ can be __________. This is known as ______________ distillation. On a larger scale, a ___________ column is used. The oil is ___________ with an ______________ heater for

_______. The vapor is ________ by a Liebig ________ and is _________ in a conical flask. Hot ________ rises up the ____________ column. It's a long _____ to _____, and the _________ from the ________ source, the _______ it gets. Most of the vapor __________ on the glass _________ inside the ________ and drips back into the _________. Only the ______________ which are still ________ at the very ______ of the ________ enter the side arm and ________ to liquid. _________ uses the same _________ but on a mammoth scale in _______ fractional ___________ columns. The hot _____ enters near the _________ at a __________ 330 Celsius. The column becomes ________ towards the top. ___________ which remain as _________ at 85 Celsius go _______ to the top and are piped _______. Different ________ condense at different ____________ running off at __________ levels. Those with __________boiling points are __________ at the ______. Those with ________ boiling ______ run off near the __________. The _________ the molecules the ________ the boiling _______. __________ distillation ________ crude oil into ________ fractions each containing _________ of similar size.

8.GEOTHERMAL POWER. IT'S HOT

Not far below the Earth's ___________ there is a great________boiler. The boiler or _______ is the planet, the heat source is the ________, and the fuel is ________ in the sand-stone layer that the magma changes from _______ into superheated dry _____. Dry steam in the subterranean cauldron is collected in _____ to drive _____ to create ________. This clean free energy ______ in the form of steam comes up to steam _____ and passes through ducts to a steam ______ designed to handle gas at _____ degrees Fahrenheit at ____ pounds per square inch _______. The steam turbine powers electrical _______. Spent steam passes through a _______ where non-condensable ______ like ________ sulfide, arrive at a few scrubbers and are ______. The surface condenser also cools the steam and turns it _____ into water. The water then goes to ______ tower where about ____% is evaporated as part of ________ process and _____ % is injected back into the steam ________. Other gases that are not condensable are _______, nitrogen ______ monoxide, carbon ______, ammonia, _____, arsenic and radon. Theses gases are sent to _______ and cleaned to the point when they can be _____ reinjected into the Earth. The mercury is taken to a _______ hazardous waste ____ facility and the ____ is collected and sold for use and making ______ for soil ______ and to fight mold on _____ leaves. In the future, ______ may be stored for use in _____cells. Geothermal power _____ are highly ______ and can operate ____ hours a day more than ___% of the time. ______ energy offers a large source of secure _______ energy. In ________, sales of geothermal ________ enhance US trade and ________ the environment.