7.1 Energy choices and security

Opposite: Climate change due to energy production is one of the greatest threats to humanity. Here is one solution – the Svartsengi geothermal plant near Keflavik, Iceland

Significant ideas

There is a range of energy sources available to societies that vary in their sustainability, availability, cost, and socio-political implications.

The choice of energy source is controversial and complex. Energy security is an important factor in making energy choices.

Big questions

As you read this section, consider the following big questions:

- What strengths and weaknesses of the systems approach and the use of models have been revealed through this topic?
- To what extent have the solutions emerging from this topic been directed at *preventing* environmental impacts, *limiting* the extent of the environmental impacts, or *restoring* systems in which environmental impacts have already occurred?
- What value systems can you identify at play in the causes and approaches to resolving the issues addressed in this topic?
- How does your own value system compare with others you have encountered in the context of issues raised in this topic?
- How are the issues addressed in this topic of relevance to sustainability or sustainable development?
- In what ways might the solutions explored in this topic alter your predictions for the state of human societies and the biosphere some decades from now?

Knowledge and understanding

- Fossil fuels contribute to the majority of humankind's energy supply and they vary widely in the impacts of their production and their emissions; their use is expected to increase to meet global energy demand.
- Sources of energy with lower carbon dioxide emissions than fossil fuels include renewable energy (solar, biomass, hydropower, wind, wave, tidal, and geothermal) and their use is expected to increase. Nuclear power is a low-carbon, low-emission, non-renewable resource but is controversial due to radioactive waste and the potential scale of any accident.
- Energy security depends on an adequate, reliable and affordable supply of energy that provides a degree of independence. An inequitable availability and uneven distributions of energy sources may lead to conflict.
- The energy choices adopted by a society may be influenced by availability, sustainability, scientific and technological developments, cultural attitudes, and political, economic, and environmental factors. These in turn affect energy security and independence.
- Improvements in energy efficiencies and energy conservation can limit growth in energy demand and contribute to energy security.

Fossil fuels contribute to the majority of humankind's energy supply and they vary widely in the impacts of their production and their emissions; their use is expected to increase to meet global energy demand.

You should be able to evaluate the advantages and disadvantages of different energy sources.

Range of energy resources

Energy can be generated from both non-renewable and renewable resources. Non-renewable energy supplies include fossil fuels (e.g. coal, gas, and oil). These cannot be renewed at the same rate as they are used; this results in depletion of the stock. Nuclear

power can be considered non-renewable because the source of the fission process is uranium, which in a non-renewable form of natural capital.

Renewable energy sources include solar, hydroelectric, geothermal, biomass, and tidal schemes. They can be large scale (e.g. country-wide schemes of energy generation) or small scale (microgeneration) within houses or communities. Renewable energy resources are sustainable because there is no depletion of natural capital.

The majority of the world's fuel comes from non-renewable sources and this is unlikely to change much by 2030 (Figure 7.1).

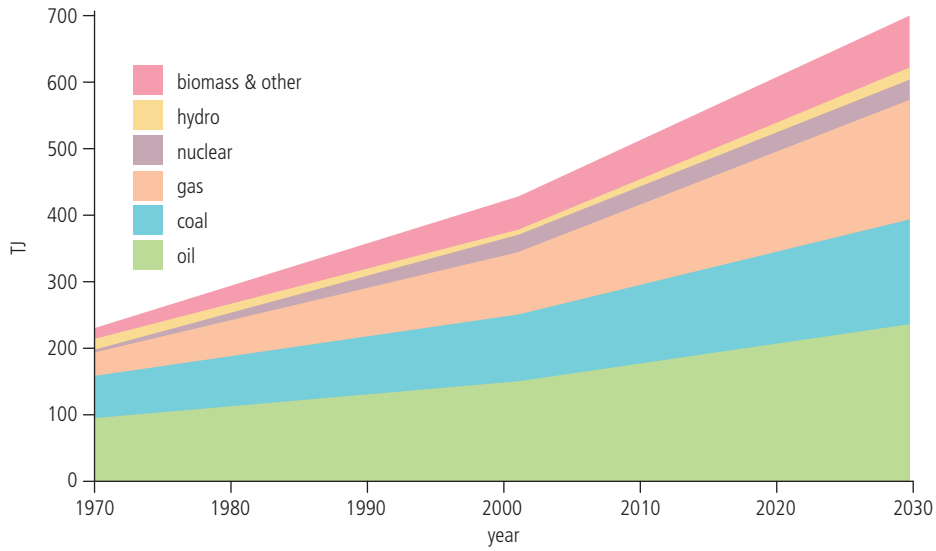


Figure 7.1 The world's fuel sources, 1970–2030

Fossil fuels

To learn about the BP Statistical Review of Energy (updated annually), go to www.pearsonhotlinks.co.uk, enter the book title or ISBN, and click on weblink 7.1.

From the industrial revolution onward, transport and energy generation have been founded on fossil fuel technology. Easily mined sources of coal led to early forms of transport based on this fuel. Processing of fossil fuels to produce petroleum led to the invention of the combustion engine, and this technology has continued to dominate until the present day. The growth of fossil fuel technology has been accompanied by a general unawareness of the effects on the environment. Pollution and global warming were not factors that were considered when fossil fuels were adopted as the primary source of energy generation. More recently, our growing awareness of environmental problems linked to fossil fuel use has put more emphasis on renewable forms of energy.

Energy consumption is much higher in MEDCs than LEDCs. The economies of MEDCs have been based on energy generation built on fossil fuel use, whereas energy demands in LEDCs have traditionally been much lower due to less available technology and reliance on natural resources (wood burning or other biomass sources).

Renewable fuels

Renewable sources of energy have been slow to grow globally. There are several reasons for this. Non-renewable sources of energy (e.g. gas) are generally cheaper than renewables. Gas is cheap because it is relatively plentiful, can be burned directly without the need for refining, and the technology is already in place to access the gas and burn it in existing gas-fired power stations. Renewables such as wind power often require high set-up costs (e.g. the installation of new wind turbines) and may still be unreliable.

In future, the cost of non-renewable energy is likely to be much higher (a possible exception is shale gas, pages 354–356). This is because stocks will become depleted and the easiest and most accessible resources will have already been mined. Only resources which are difficult to access (and therefore more costly to reach) will remain. The increasing scarcity of non-renewable resources will push costs up, and environmental taxes to compensate for global warming will also make fossil fuels more expensive. Therefore, in the future, renewable sources of energy will become more attractive and increased use is likely. Adoption of sustainable energy will have a significant beneficial effect on the planet.

Advantages and disadvantages of fossil fuels

Fossil fuels are formed when dead animals and plants decompose in anoxic conditions (where oxygen is absent), are covered by silt and mud, and are subjected to heat and pressure over tens of thousands of years. The term 'fossil' refers to the fact that the fuels are made from preserved dead organisms. Gas and oil are largely made from oceanic organisms (e.g. plankton) and coal from land plants (mainly from trees growing during the Carboniferous Period – carboniferous means coal-bearing).

All fossil fuels release energy in the same way (Figure 7.2). The original source of energy contained within fossil fuels is the Sun. Photosynthesis traps the energy in plant matter, converting it to chemical energy. This store of energy can remain below ground for millions of years, until humans mine it. Because the fuels are made from dead organisms, they contain much carbon – they lock-up extensive amounts of carbon beneath the ground. Thus, burning fossil fuels releases a great deal of carbon in the form of carbon dioxide.

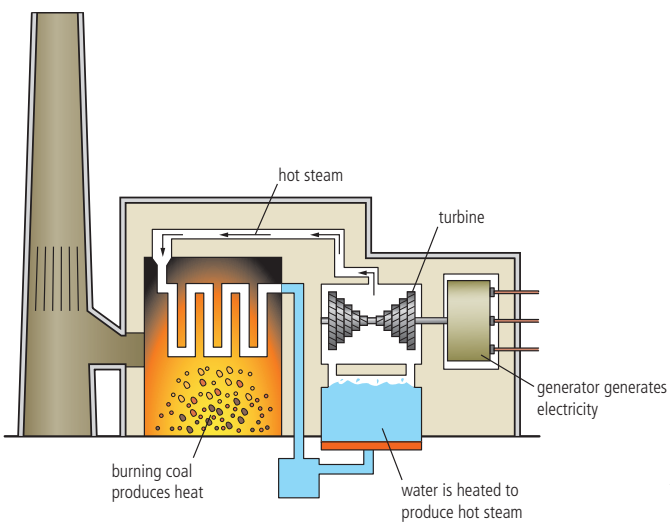


Figure 7.2 Coal and the production of electricity

Coal-fired power stations turn chemical energy in the coal into (about) 40 per cent electricity and 60 per cent waste heat. The clouds emitted from their cooling chimneys are formed by condensed water vapour created by this method of energy generation.

Advantages

The advantages of fossil fuels are that they are relatively cheap and plentiful. At the same time, advanced technologies have been developed to allow safe extraction and the technology already exists for their use (e.g. the combustion engine). The technology for controlling pollution from these fuels also exists. At present, no other energy source is close to replacing the amount of energy generated by fossil fuels. Oil and gas have a further advantage in that they can be delivered over long distances by pipeline.

In the US town of Centralia, Pennsylvania, an exposed coal seam caught fire in 1962. It burned for 17 years before a petrol station dealer found the ground temperature was 77.8 °C and other residents found their cellar floors too hot to touch. Smoke began to seep from the ground. The town was abandoned, residents relocated, and buildings bulldozed in 2002. The coal is still burning and may do so for 250 years.

Disadvantages

The two main disadvantages of fossil fuels are their contribution to climate change, and their unsustainability. They are the most important contributor to the build-up of carbon dioxide in the atmosphere and consequently the most important contributor to global warming. Use of fossil fuels is unsustainable because it implies liquidation of a finite stock of the resource: we can extend the lifetime of this resource, through the use of shale gas and tar sands, but it is ultimately unsustainable.

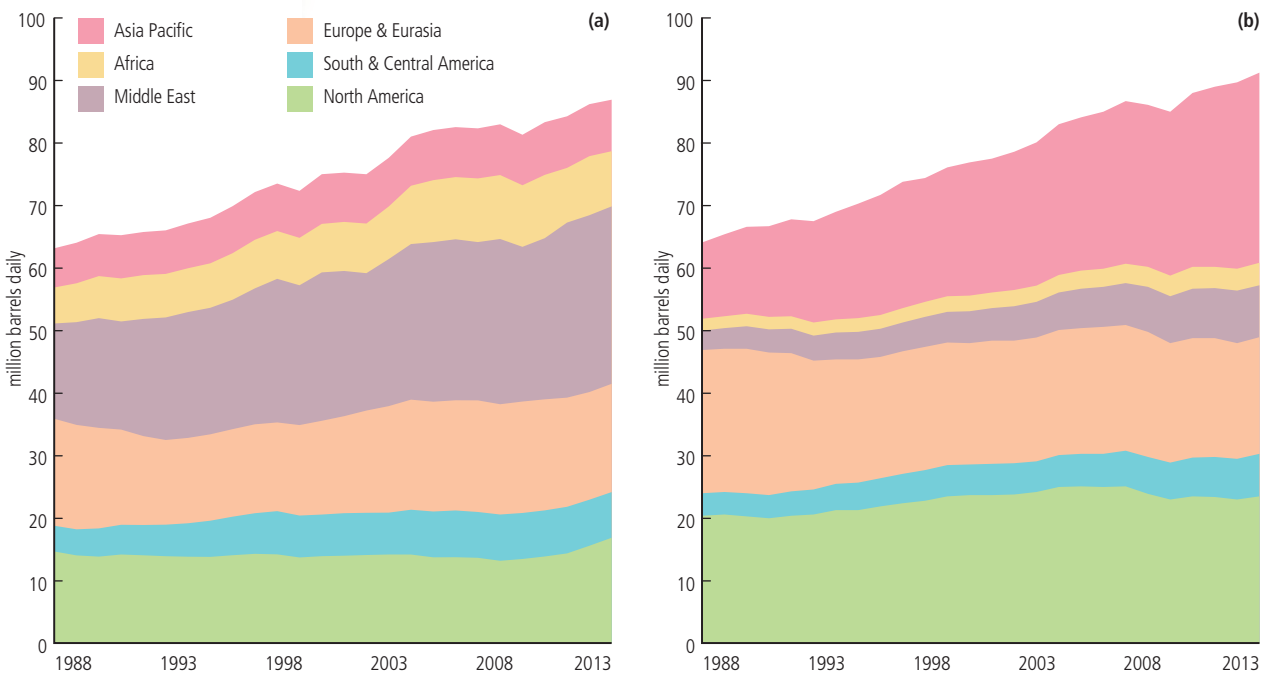
Other disadvantages are that these fuels will become increasingly difficult to extract, and extraction may become more and more potentially dangerous as mines get deeper and oil-rigs are placed further out to sea (e.g. the Deepwater Horizon oil platform in the Gulf of Mexico). Oil spillages from tankers and burst pipelines can severely damage natural ecosystems, and it is very expensive to clear up this sort of pollution. Coal extracted from underground mines causes minimal disturbance at the surface, but open-cast mining clears habitat from the surface and can cause extensive environmental damage.

Fossil fuel consumption and shale gas

Fossil fuel consumption is largest in MEDCs. However, fossil fuel consumption in LEDCs is expected to increase in future because of increasing population, income, and technological development. Coal is not easily transported over long distances, it is mainly consumed where it is locally available. Oil and gas can be consumed far from their source of extraction because they can be piped.

The availability of energy still relies extensively on fossil fuels, which account for around 80 per cent of global energy consumption. Consumption varies country by country, and by region (Figure 7.3). The biggest consumers are the USA, China, and Europe (together accounting for more than half of all fossil fuel consumption).

Figure 7.3 (a) Production and (b) consumption of oil by region



Just as nuclear scientists in the 1950s and 1960s believed that nuclear energy was going to be the answer to the world's energy needs, oil and gas producers believe that gas derived from shale could bring a plentiful supply of low-cost energy. Shale gas could transform the pattern of energy trade in the world. Nevertheless, it has its critics and there may be problems related to the extraction of shale gas.

To watch an excerpt from *The High Cost of Cheap Gas* – a film about the impacts of fracking, go to www.pearsonhotlinks.co.uk, enter the book title or ISBN, and click on weblink 7.2.

Shales are one of the most common forms of sedimentary rocks on Earth. Significant reserves have been found in China, Argentina, USA, and South Africa (Figure 7.4). A new wave of gas producers may emerge. Shale has the potential to change domestic economies. In the USA, President Obama has suggested it could support 600 000 jobs.

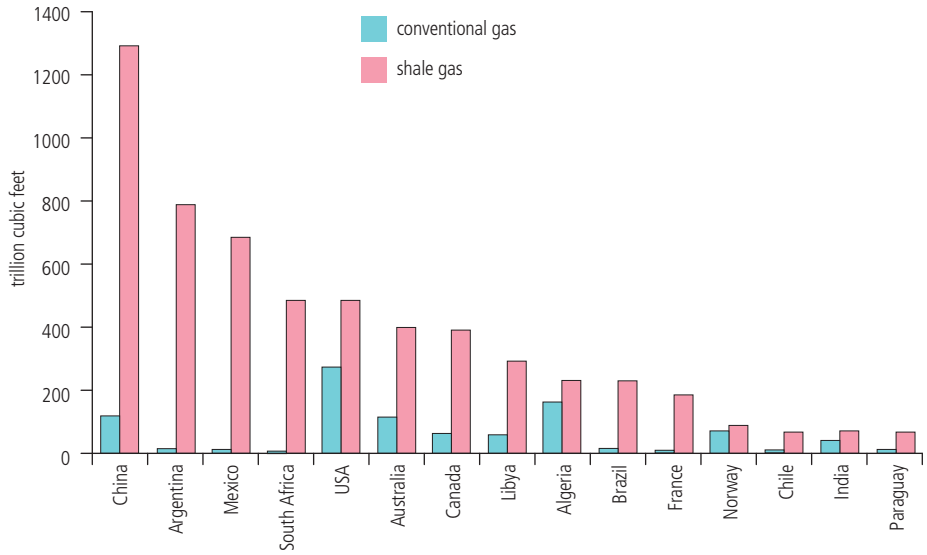


Figure 7.4 Estimated technically recoverable shale gas in relation to conventional supplies, top 15 countries

Shale is also having a geopolitical influence. The world's gas trade has long been dominated by Russia, Qatar, and Algeria. The gas pipelines that link Russia's Siberian gas fields with Europe, and the liquid natural gas (LNG) tankers that carry LNG from the Persian Gulf and South East Asia have created a network of dependency, that may be about to change. For example, Poland and Ukraine have begun investigating their resources, partly to reduce their dependence on Russian sources of natural gas. Russia's domination of the European gas market is no longer assured. China claims to have 25 trillion cubic metres of potentially recoverable shale (about one-fifth of global shale resources), enough to meet consumption for 200 years. If China were to end its reliance on coal and switch to gas, which is cleaner burning, it would have a significant impact on carbon emissions.

However, as with the nuclear dawn, there are potential drawbacks with shale. Hydraulic fracturing (fracking) may pollute groundwater and soil, release methane and trigger earthquakes. For critics such as Josh Fox, maker of the film *Gasland*, the risks are great and the techniques used are contentious. In contrast, a review by the Massachusetts Institute of Technology concluded that with over 20 000 shale wells drilled in the last 10 years, the environmental record of shale gas development has for the most part been 'a good one'.

In 2010, the USA replaced Russia as the world's largest gas producer. This happened because of a combination of large supplies of raw material, a well-developed service industry to drill the wells and provide the equipment, and a network of pipelines to transport the gas. In China, another potential contender, conditions are not so beneficial. Many exploratory projects are in the earthquake-prone Sichuan province. China also lacks the extensive pipeline network needed to get the gas to market.

In addition, large volumes of water are needed in the fracking process – and China faces increasing water shortages. Dozens of wells have been drilled but so far the results have been mixed. Some of China's shale resources are deeply buried in heavily faulted areas. In addition, China's deposits have a higher clay content than the brittle marine shales of the USA, making them more difficult to frack and less productive. Nevertheless, China is the world's biggest energy user, and shale could be the answer to reducing China's growing dependence on imported energy. China has set itself a target of 6.5 billion cubic metres of annual output by 2015, equivalent to 2–3 per cent of its projected gas production, and 60 billion cubic metres by 2020.

USA shale gas exports may well be cheap, as well as plentiful. Canada also has ambitious plans for the export of shale gas. Japan has seen an increased demand for energy imports following the Fukushima nuclear disaster in 2011. As one energy specialist said 'if shale gas proves as plentiful around the world as it is in the USA, it could not only displace coal, wind, and uranium to dominate global electricity generation but also replace oil as the main fuel for transport vehicles.' However, the world is yet to be convinced that hydraulic fracking is completely safe environmentally.

Sources of energy with lower carbon dioxide emissions than fossil fuels include renewable sources and nuclear power.

Renewable and alternative energy sources

The use of renewable sources of energy (solar, biomass, hydropower, wind, wave, tidal, and geothermal) is expected to increase. Nuclear power is a low-carbon, low-emission, non-renewable resource but is controversial due to radioactive waste and potential scale of any accident.

Advantages and disadvantages of renewables

General advantages of renewable sources of energy are that they do not release pollutants such as greenhouse gases or chemicals that contribute to acid rain. Because they are renewable, they will not run out.

There are several restrictions that currently limit large-scale use of renewable energy sources. Fossil fuel resources are still economically cheaper to exploit, and the technologies to harness renewable sources are not available on a large scale. Inertia within cultures (e.g. the USA's car culture) and traditions of both MEDCs and LEDCs means that non-renewable resources are favoured (although certain renewable energy supplies have always been widely used in LEDCs). The locations available for renewable energy sources are often limited by politics – for example, for wind turbines are often not exploited because people living nearby do want their environment 'spoilt' by the presence of wind turbines. All these factors mean that renewable resources are not able to meet current demand.

Hydro-electric power

Hydro-electric power (HEP) uses turbines which can be switched on whenever energy is needed, so it is a reliable form of energy generation (Figure 7.5). Dams are used to block the flow of water so forming large artificial lakes which can be used for leisure purposes, food sources and irrigation as well as electricity generation. Once the construction is completed, HEP schemes are relatively cheap to run. However, there are several disadvantages to HEP. Vast areas may be flooded involving loss of habitats, farmland, and displacement of people, and dams may restrict the flow of sediment thereby affecting ecosystems or farming downstream. They may also lead to increased erosion rates downstream when the flow of natural river systems are disrupted. The cost of building dams is high, and dams may eventually silt-up rendering them unusable.

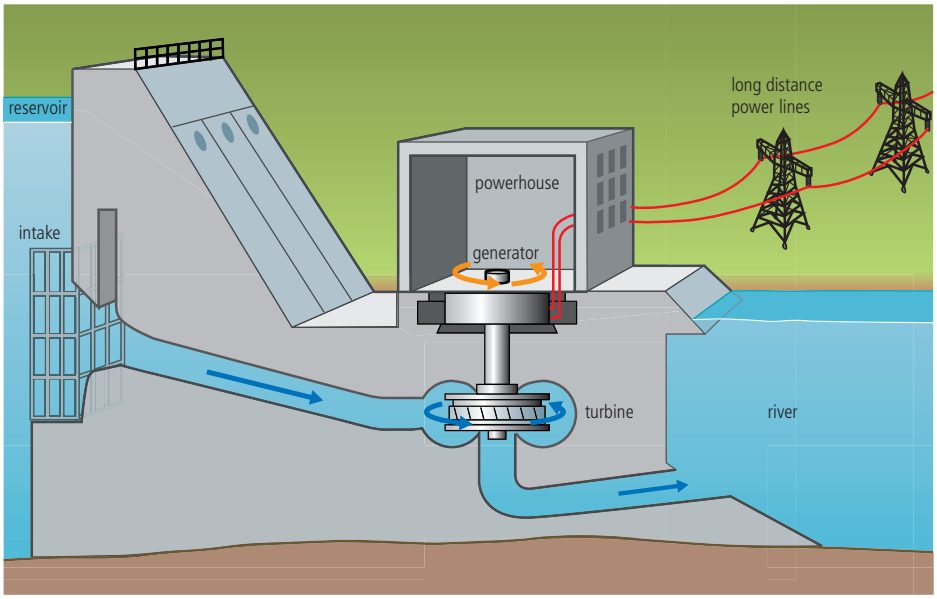


Figure 7.5 Hydroelectric energy is generated when water contained in an artificially made reservoir (created by damming a river) is allowed to flow though a turbine under immense pressure. The water turns the propellers which cause rotation in the turbine shaft, which generates electricity in the turbine's motor.

Case study

The Narmada River Dam Project, India

In India, biomass is a traditional source of energy. A huge proportion of the population relies on local sources of firewood for energy because it is the most readily available source and is inexpensive. Technology such as solar-powered stoves is neither available nor affordable. The Indian government, in a drive to develop economically, has sought to harness other sources of cheap energy to stimulate industrial development. In particular, the government is promoting hydroelectric power, which historically has sometimes been extremely controversial for social and environmental reasons.

The most controversial dam development in India is the Narmada River Dam Project. Plans were initiated in the 1940s by the country's first prime minister Jawaharlal Nehru. Legal and logistical problems delayed the start of the project until 1979. The plan involves the construction of some 3200 dams of varying sizes on the Narmada River (Figure 7.6).

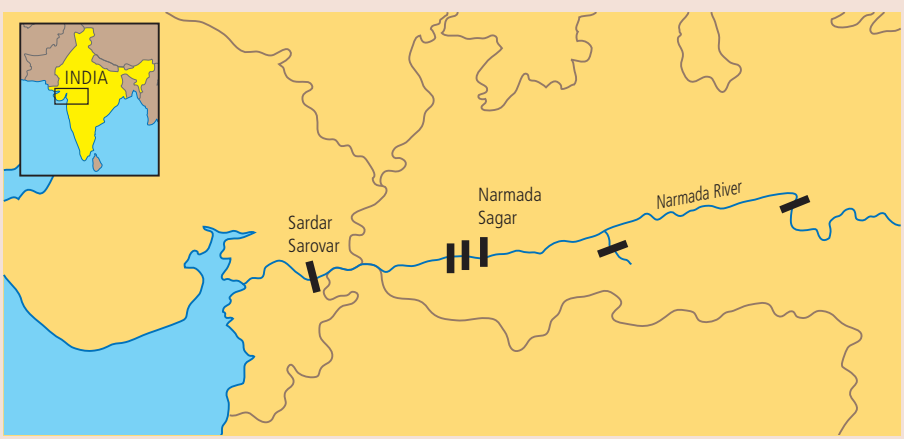


Figure 7.6 The location of dams in the Narmada River, India

The Sardar Sarovar Dam is the biggest dam on the river and its construction has been fiercely opposed. 200 000 people could be displaced by the project, and major damage caused to the ecosystems of the region. Those in favour of the project say that it will supply water to 30 million people and irrigate crops to feed another 20 million people. In October 2000, the Indian Supreme Court gave a go-ahead for the construction of the Sardar Sarovar Dam, saying that the benefits of the project outweigh negative environmental and social impacts. In 2014, the Narmada Control Authority approved a series of changes in the final height from 80 m to 163 m in depth. The project is expected to be completed by 2025.

Tidal power

Tidal power produces energy by using the ebbing or flooding tide to turn turbines which produce energy (Figure 7.7). The major limitations of this method are that a good tidal range is required to generate sufficient energy, together with the right shape of coastline to channel water through the turbines. Such installations may interfere with navigation and can have impact on wildlife. They are expensive to set up.

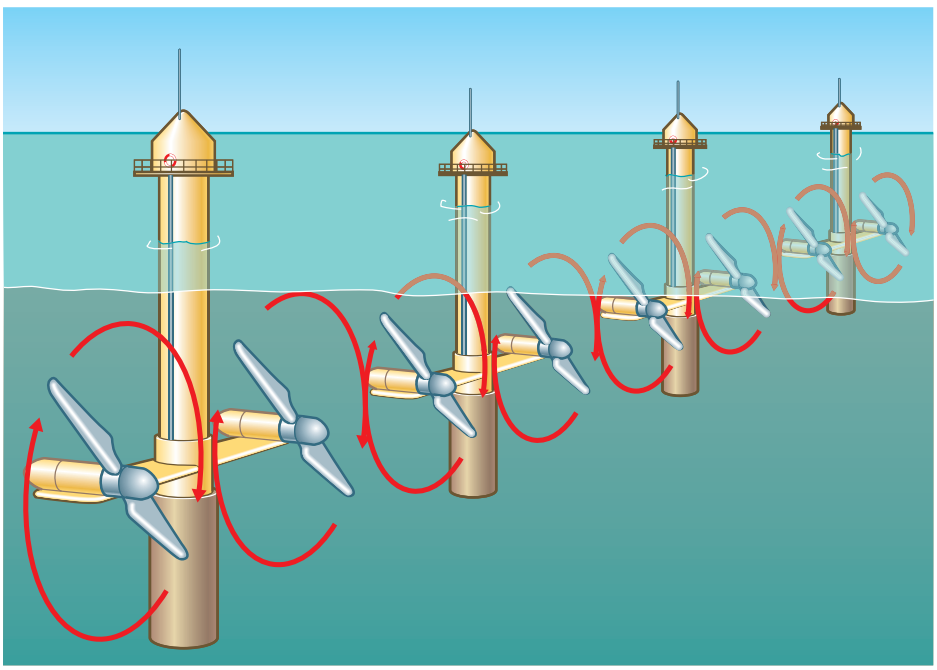


Figure 7.7 The turbines generate power as the tide comes in and again as it goes out

Solar energy

At present, it is very expensive to turn solar energy into high-quality energy needed for manufacturing (compared to using fossil fuels). However, passive solar energy (combined with insulation) is much cheaper for heating homes than fossil fuels. Solar energy has the disadvantage that its usefulness is limited in northern countries during winter months.

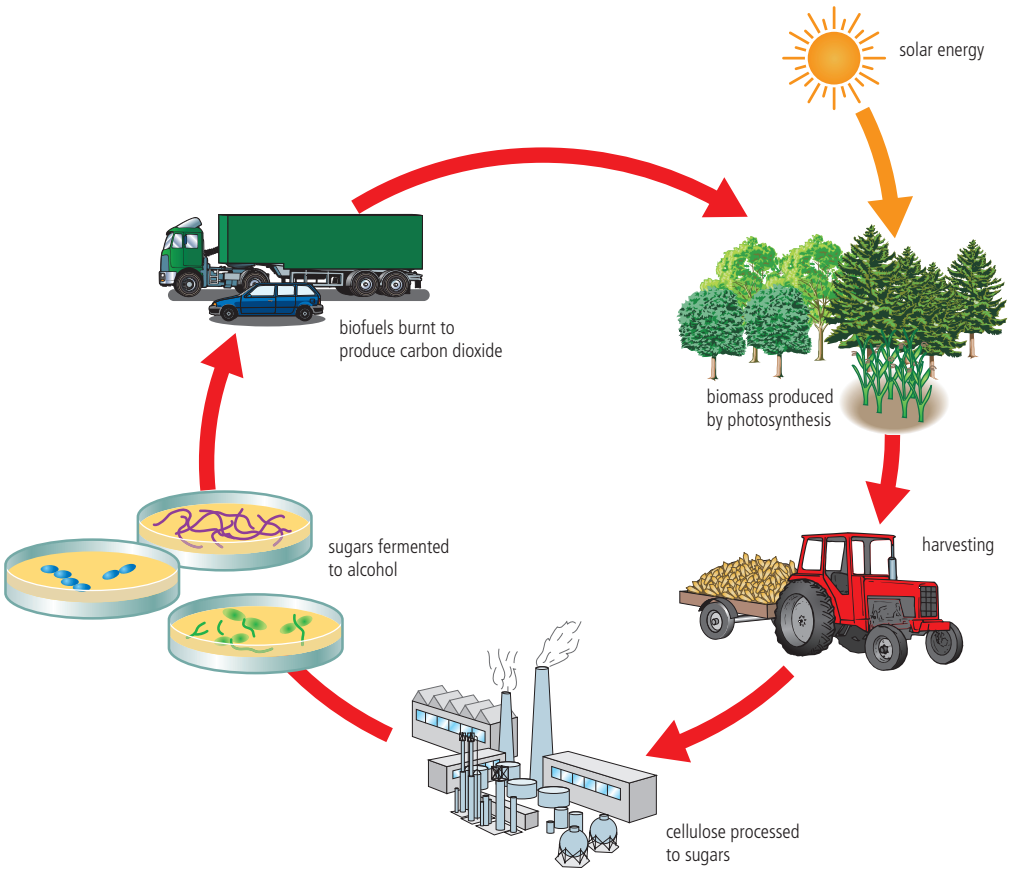
Solar panels are large flat panels made up of many individual solar cells

Wind power

Wind power is produced by wind turbines driven by available wind energy – the wind turns the rotor blades which rotate a metal shaft which transfers the rotational energy into a generator. The generator generates electricity using electromagnetism. The energy is then supplied to an electrical grid. The major limitations of wind turbines are that if there is no wind, no energy is generated. Thus, placement of the turbines is critical: they need to be in areas of consistent high wind.

Biofuel

Biofuel energy is produced by burning plant material to produce heat (Figure 7.8). Other forms of biofuel energy transform plant matter into ethanol which is then used as a fuel, or use methane digestion methods to convert biomass to methane which is then burned to generate electricity. The disadvantages of these techniques are that they produce emissions and require large amounts of land to grow the biofuel crop. Biofuel crops may take up land once used for growing food crops, thus pushing up the price of food, and disadvantaging local people who cannot get enough food to live. Biofuel crops are often planted at the expense of natural ecosystems, where new land clearance to create space for the biofuel crop has destroyed the natural ecosystem.



A wind turbine, Aero Island, Denmark

To learn about the wind farm in the Thames estuary, go to www.pearsonhotlinks.co.uk, enter the book title or ISBN, and click on weblink 7.3.

Figure 7.8 Biofuels are seen as a green form of power generation because, although they produce carbon dioxide, the gas is recycled (biofuel crops absorb carbon dioxide when they photosynthesize).

Wastes

Energy can be obtained from wastes. Organic waste decomposes and gives off methane gas which can be burned. Waste can also be burned directly to generate energy, for example burning straw. Advantages are that the resource used is readily available and its use does not deplete natural capital. At the same time, a useful purpose is being served by waste that would otherwise have to be disposed of in some other way. Disadvantages are that the burning adds to global warming gases in the atmosphere (although it could be argued that decomposition of the waste would do this in any case).

Geothermal energy

Energy can be obtained from residual heat in the ground. Water is pumped into pipes beneath the ground and the geothermal heat from the ground heats the water which can then be used to heat buildings. The pipes do not have be buried at great depth to

be effective, although deeper burial allows greater heat capture. This method of heat transfer is low impact and does not release any form of pollution. The pipes can be arranged in various formations (Figure 7.9).

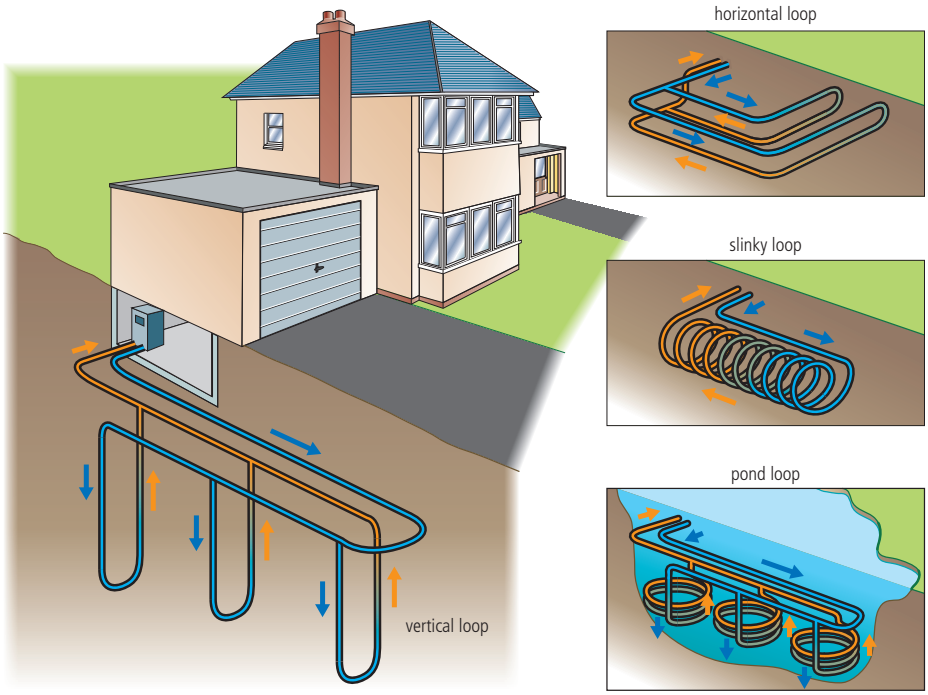
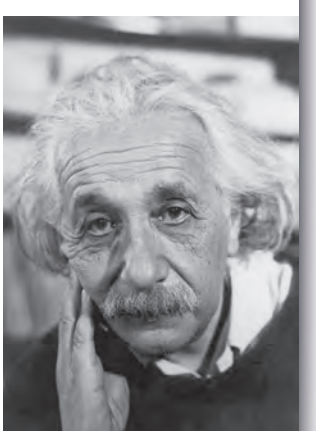


Figure 7.9 Designs for pipe layout to supply geothermal energy to the home

CONCEPTS: Sustainability

In *Renewable Energy – A Global Perspective*, Mohamed El-Ashry (Senior Fellow, UN Foundation) argues that 2008, seemingly the peak of the global financial crisis, was the best year for renewables. In just 1 year, all forms of grid-connected solar power grew by 70 per cent. Wind power grew by 29 per cent, and solar hot water increased by 15 per cent. According to the *Financial Times*, more than 50 per cent of total added power capacity in 2008 in both the USA and Europe was renewable – more than new capacity for oil, gas, coal, and nuclear combined.

National investments in renewable energy also changed. In 2006, Germany and China were the global leaders in new capacity investment, with the USA far behind. But a massive increase in wind power investment in the USA allowed it to become the global leader in 2008. Spain, China, and Germany were not far behind. Spain moved up to second place thanks to its large investments in solar power. Brazil was fifth, due to large investments in biofuels. The global recession might turn out to be a blessing in disguise for renewable energy, because governments of the world's largest economies have, for the first time, provided direct financial support. Governments did not invest just for energy security and climate change. They recognized the economic benefits of clean energy. At the end of 2008 and in early 2009, a number of national governments announced plans to greatly increase public finance of renewables and other low-carbon technologies. Many of these announcements were directed at economic stimulus and job creation, with millions of new 'green jobs' targeted.



Einstein's equation $E = mc^2$ related energy and matter, where the amount of energy in matter (E) was calculated by multiplying mass (m) by the speed of light squared (c^2), generating enormous numbers for E from even small quantities of matter.

Advantages and disadvantages of nuclear power

The equations of Albert Einstein first alerted scientists to the possibility of generating huge amounts of energy from splitting atoms. Fission technology was first developed in 1945 and used in atomic bombs at the end of the Second World War. It was then used in generating atomic energy (Figure 7.10). When enough fissionable material (e.g. uranium or plutonium) is brought together, and the process initiated, a chain reaction occurs that splits atoms releasing a tremendous amount of energy.

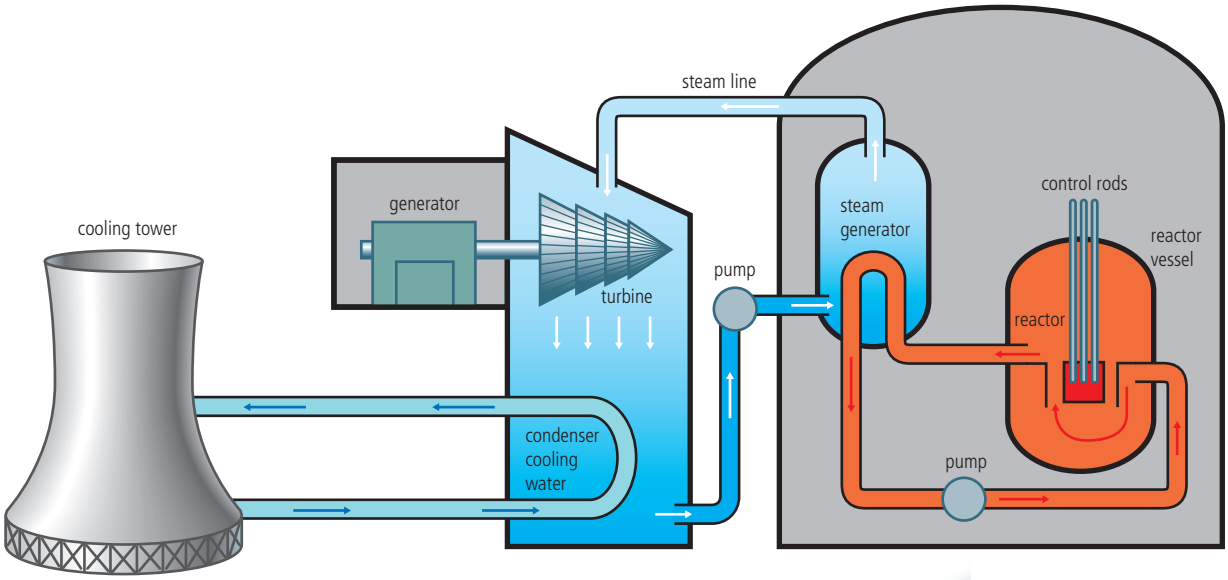


Figure 7.10 When a fission reaction takes place, a large amount of heat is given off. This heats water around the nuclear core and turns it to steam. The steam passes over the turbine causing it to spin, which turns a large generator, creating electricity. The steam is then cooled by cold water from the cooling tower travelling through the condenser below the turbine. The drop in temperature condenses the steam back into water, which is pumped back to the reactor to be reheated and continue the process.

Nuclear power plants produce radioactive wastes, including some that can remain dangerous for tens of thousands of years. Radioactivity is the result of nuclear changes in which unstable (radioactive) isotopes emit particles and energy continuously until the original isotope is changed into a stable one. When people are exposed to such radiation, the DNA in their cells can be damaged by mutation. If mutation occurs in body (somatic) cells, cancers, miscarriages, and burns can be caused. If the mutation occurs in reproductive cells (eggs and sperm), genetic defects can appear in subsequent generations.

The advantages of nuclear power generation are as follows.

- It does not emit carbon dioxide and so does not contribute to global warming.
- The technology is readily available.
- A large amount of electrical energy is generated in a single plant.
- It is very efficient, especially in comparison to fossil fuels: 1 kg uranium contains 20 000 times more energy than 1 kg coal.

Nuclear power generation has the following disadvantages.

- The waste from nuclear power stations is extremely dangerous and remains so for thousands of years. How best to dispose of this is still an unresolved problem.
- The associated risks are high. It is impossible to build a plant with 100 per cent reliability, and there will always be a small probability of failure (e.g. the Chernobyl and Fukushima-Daiichi disasters). The more nuclear power plants (and nuclear waste storage shelters) are built, the higher is the probability of a disastrous failure somewhere in the world. The potential of nuclear power plants to become targets for terrorist attack has been pointed out by opponents of this type of energy generation.
- The energy source for nuclear power is uranium, which is a scarce and non-renewable resource. Its supply is estimated to last for only the next 30–60 years depending on actual demand.
- The time frame needed to plan and build a new nuclear power plant is 20–30 years: uptake of nuclear power will therefore take time.

Energy security depends on adequate, reliable, and affordable supply of energy that provides a degree of independence.

Energy security

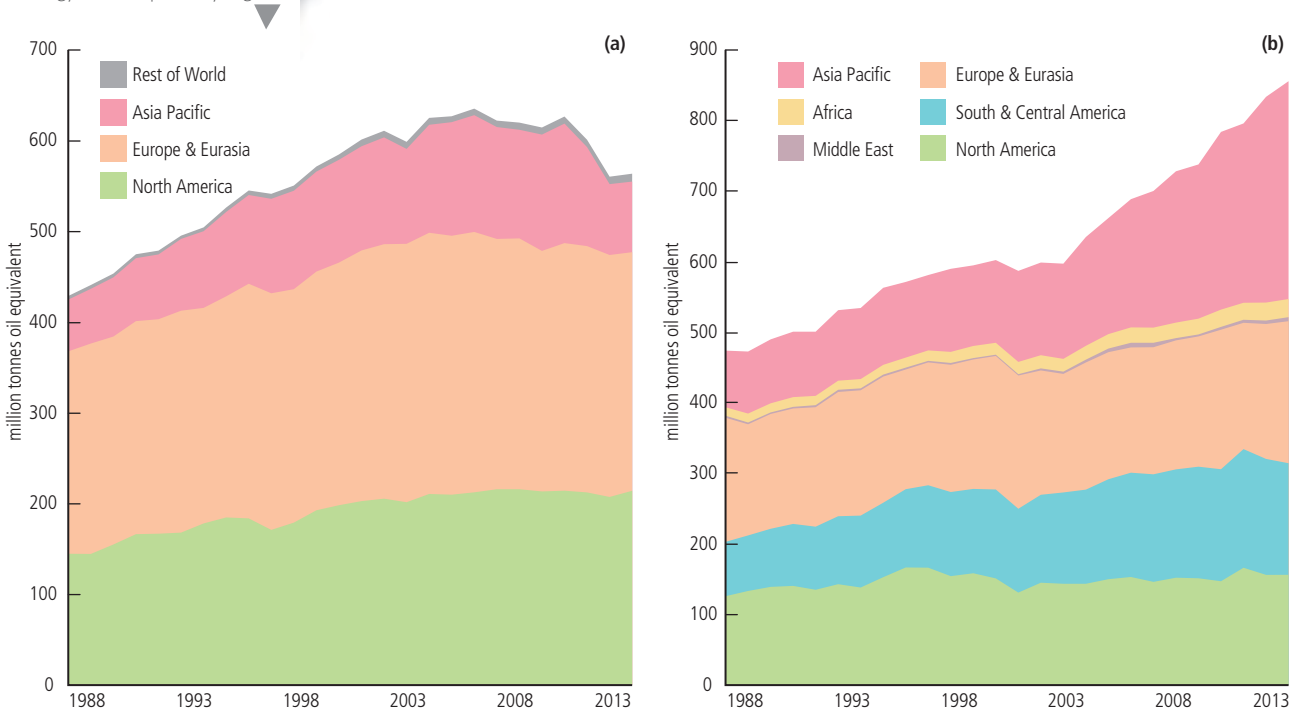
Energy security refers to a country's ability to secure all its energy needs, whereas energy insecurity refers to a lack of security over energy sources. Inequitable availability and uneven distribution of energy sources may lead to conflict (Figure 7.11).

According to the analyst Chris Ruppel (2006), the period from 1985 to 2003 was an era of energy security, and since 2004 there has been an era of energy insecurity. He claims that following the energy crisis of 1973 and the Iraq War (1990–91), there was a period of low oil prices and energy security. However, insecurity has since arisen for a number of reasons, including:

- increased demand, especially by NICs
- decreased reserves as supplies are used up
- geopolitical development: countries such as Venezuela, Iran, and Russia have 'flexed their economic muscle' in response to their oil resources and the decreasing resources in the Middle East and North Sea
- global warming and natural disasters such as Hurricane Katrina, which have increased awareness about the misuse of energy resources
- terrorist activity (e.g. in Nigeria and Iraq)
- the conflict between Russia and the Ukraine.

Energy insecurity can cause and be the result of geopolitical tension. For most consumers, a diversified energy mix is the best policy, rather than depending on a single supplier.

Figure 7.11 (a) Nuclear energy consumption and (b) hydro-energy consumption by region



The potential for conflict

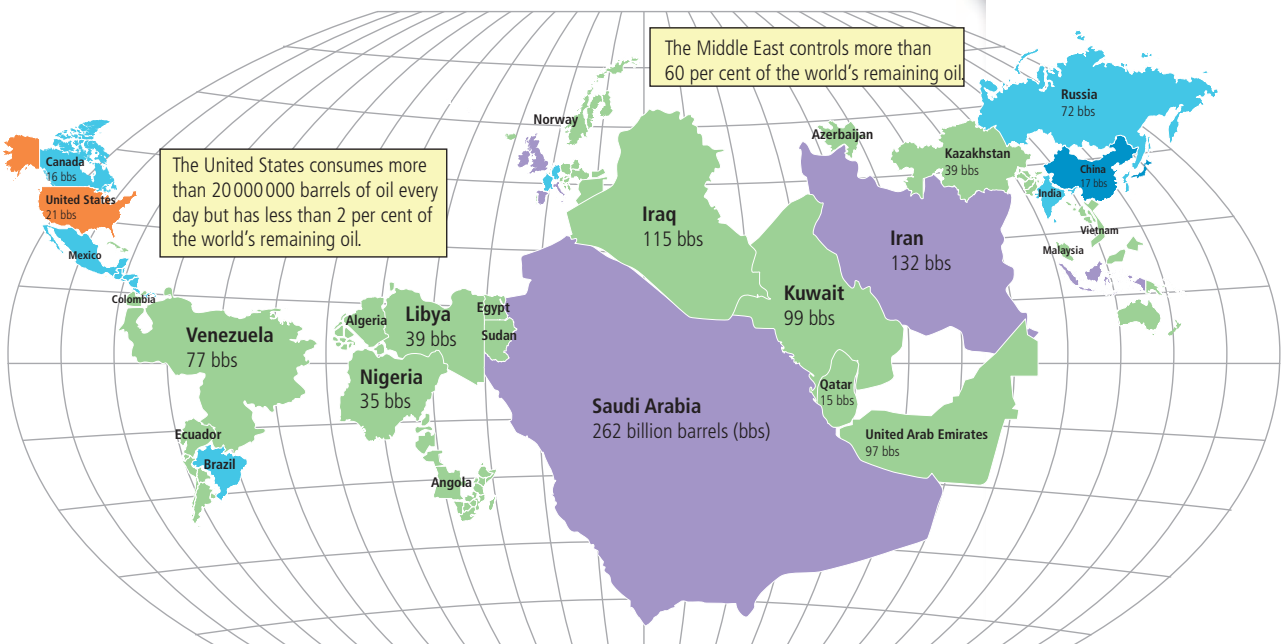
The Middle East controls about 60 per cent of the world's remaining oil reserves. Saudi Arabia alone controls over 20 per cent (Figure 7.12). On the other hand, the USA possesses less than 2 per cent of the world's oil reserves yet consumes over 200 million barrels of oil per day. This means that the USA has to source much of its oil from overseas, notably the Middle East. This gives the Middle East an economic and political advantage – countries that want oil have to stay on friendly terms with those that supply it. (There are obvious exceptions such as the US–British invasion of Iraq, and the Iraqi invasion of Kuwait.)

Countries that depend on the Middle East for their oil need to:

- help ensure political stability in the Middle East
- maintain good political links with the Middle East
- involve the Middle East in economic cooperation.

On the other hand, the situation is also an incentive for rich countries to increase energy conservation or develop alternative forms of energy. There is a need to reassess other energy sources such as coal, nuclear power and renewables, and use energy less wastefully.

Figure 7.12 Oil reserves (the area of each country is shown in proportion to its percentage of world oil reserves)



Oil consumption
(thousands of barrels per day)

- 6000+
- 3000–5999
- 2000–2,999
- 1000–1999
- 0–999

Oil reserves

	Billions of barrels (bbs)	Percentage of world reserves		Billions of barrels (bbs)	Percentage of world reserves
Saudi Arabia	262.73	22.3%	Kazakhstan	39.62	3.4%
Iran	132.46	11.2%	Libya	39.12	3.3%
Iraq	115.00	9.7%	Nigeria	35.25	3.0%
Kuwait	99.00	8.4%	United States	21.37	1.8%
United Arab Emirates	97.80	8.3%	China	17.07	1.4%
Venezuela	77.22	6.5%	Canada	16.80	1.4%
Russia	72.27	6.1%	Qatar	15.20	1.3%

The scramble for the Arctic

Case study

Another potential conflict is over the oil and gas reserves in the Arctic Ocean (Figure 7.13). Scientists believe rising temperatures could leave most of the Arctic ice free in summer months in a few decades' time. This would improve drilling access.

Denmark is trying to prove that a detached part of the underwater Lomonosov Ridge is an extension of Greenland, which is Danish territory. Russia has staked a claim by sending a submarine to plant a flag some 4 km below the North Pole. In 2008 Canada, Denmark, Norway, Russia, and the United States met in Greenland to discuss how to divide up the resources of the Arctic Ocean.

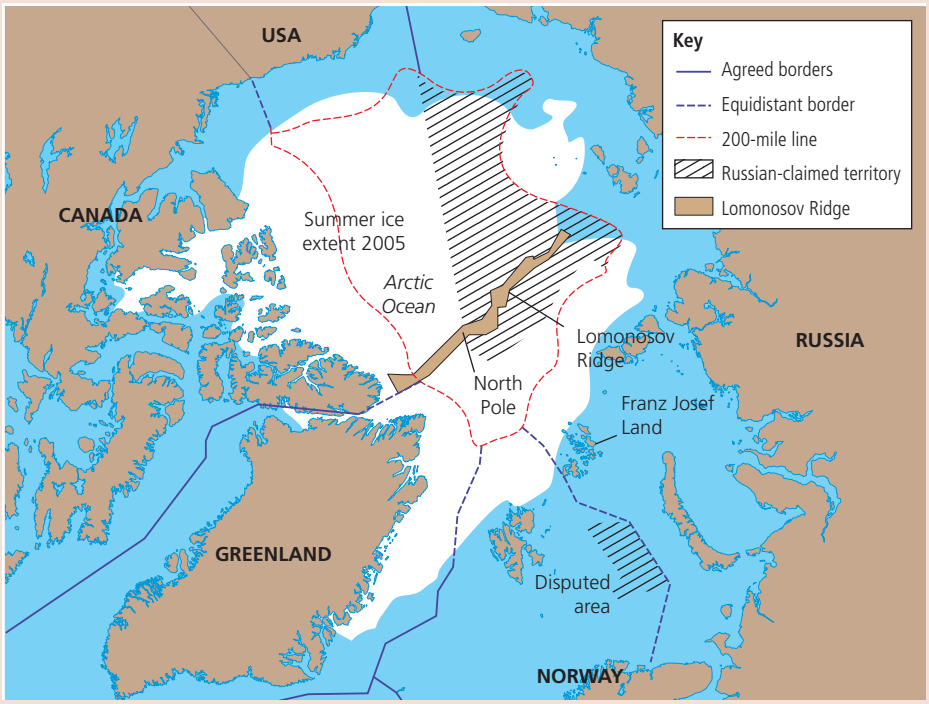


Figure 7.13 Territorial claims over the Arctic

According to the US Geographical Survey, the Arctic could hold a quarter of the world's undiscovered gas and oil reserves. This amounts to 90 billion barrels of oil and vast amounts of natural gas. Nearly 85 per cent of these deposits, they believe, are offshore. The five countries are racing to establish the limits of their territory, stretching far beyond their land borders.

Environmental groups have criticized the scramble for the Arctic, saying it will damage unique animal habitats, and have called for a treaty similar to that regulating the Antarctic, which bans military activity and mineral mining.

Under the 1982 UN Law of the Sea Convention, coastal states own the seabed beyond existing 370 km zones if it is part of a continental shelf of shallower waters. While the rules aim to fix shelves' outer limits on a clear geological basis, they have created a tangle of overlapping Arctic claims.

Factors which affect the choice of energy generation

The energy choices adopted by a society may be influenced by factors such as the availability and sustainability of resources, scientific and technological developments, cultural attitudes, and political, economic, and environmental factors. These in turn affect energy security and independence.

There are many important factors to consider in the choice of energy resources by societies. These include the following:

- The availability and reliability of supply – the UK used to have coal, then it had oil, but it has limited potential for solar or geothermal energy.
- Sustainability of supply – there are perhaps 40 years' worth of oil, 140 years' worth of coal, but an infinite supply of solar and geothermal energy in the world.
- Scientific and technological development – LEDCs use less energy and more basic energy (e.g. fuelwood) whereas MEDCs use more energy and more expensive forms (e.g. nuclear and oil).
- Political factors – in 1973 the Organization of Petroleum Exporting Countries (OPEC) raised the price of oil, causing other countries to develop their own cheaper resources.
- Economic factors such as cost of production, distribution, and use mean that nuclear power or tidal energy may be too expensive for many countries.

- Cultural attitudes – increased awareness of the problems of global warming or the risks associated with nuclear power may cause nations to change their energy choices.
- Environmental factors – certain climates allow for the use of certain types of energy such as solar or wind power; colder climates require more heating, warmer climates more air-conditioning.

The choice of energy sources adopted by different countries often has an historical basis. Large oil, coal, and gas reserves in certain countries (e.g. the UK) made fossil fuels an obvious choice for exploitation in those countries. Energy generation may also depend on economic, cultural, environmental, and technological factors.

Oil use in MEDCs is almost 50 per cent greater than in LEDCs, and fossil fuels in MEDCs account for 85 per cent of energy use as opposed to 58 per cent in LEDCs. The use of nuclear power is five times more important in MEDCs than in LEDCs. Biomass use in LEDCs is more than 10 times that in MEDCs. In some instances, both LEDCs and MEDCs have similar levels of use of a resource; examples are coal (25 per cent), HEP, geothermal, and solar power (6 per cent in LEDCs and 7 per cent in MEDCs) (Figure 7.14).

There are various explanations for these observed patterns. Oil is used extensively to produce petroleum products, and difference in oil use between LEDCs and MEDCs can be explained by the more prevalent use of cars in MEDCs. Biomass is very important in LEDCs as fuel for cooking, whereas MEDCs use gas or electricity (i.e. fossil fuels). The relatively small contribution of nuclear power may be due to the problems of disposing of nuclear fuel and the cost of nuclear technology. The relatively small proportion of nuclear power generation in MEDCs may also be affected by the general distrust of the industry in certain countries. Cultural fears, based on perception of nuclear accidents and waste, have made this a politically unpopular choice in many countries.

There are various factors are currently restricting the use of renewable energy sources. Fossil fuel resources are still economically cheaper to exploit, and the technology to harness renewable sources is currently not available on a large scale. Culture and tradition means that non-renewable resources are favoured, and the locations for renewable energy sources are often limited by available sites and local political issues. The low uptake of renewable energy globally means that renewables are not able to meet current demand. However, recession can change things.

You should be able to discuss the factors that affect the choice of energy resources of two different societies. These could be two types of country (MEDC/LEDC) or could be two different societies within the same country (e.g. indigenous population and advanced-urban population in Brazil or Australia).

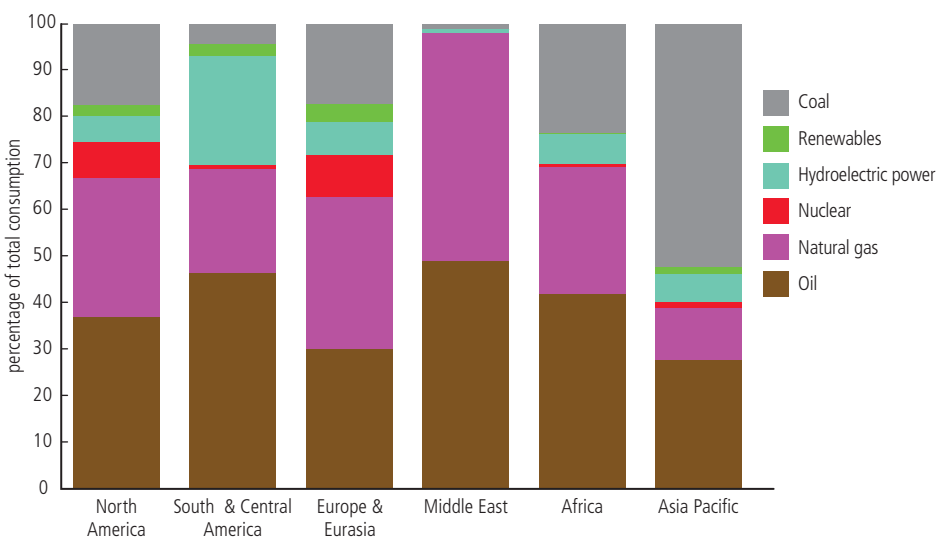


Figure 7.14 Relative contributions of different sources of commercial energy by world region

TOK

Nodding donkey, Brunei oilfield

Peak oil production refers to the year in which the world or an individual oil-producing country reaches its highest level of production, with production declining thereafter (Figure 7.15).

We depend on oil for many things: we use it for fuel, transport and heating, as a raw material in the plastics industry, and for fertilizer in food production. As oil production decreases after peak oil, so will all of these, unless we can find new materials and alternatives.

Peak oil varies country by country. The peak of oil discovery occurred in the 1960s, and by the 1980s the world was using more oil than was being discovered. Since then the gap between use and discovery has been increasing, and many countries have passed their peak oil production. However, reliable data is hard to come by, and some data is jealously guarded.

The International Energy Agency suggests that global peak oil will occur between 2013 and 2037. In contrast, the US Geological Survey suggests it will not occur until 2059. M King Hubbert, who popularized the theory of peak oil, predicted that it would occur in 1995 'if there were no changes in contemporary trends'. The Association for the Study of Peak Oil (ASPO) suggests it will be 2011. They claim that in 1950 the world consumed 4 billion barrels of oil per annum and the average discovery was 30 billion barrels per annum. Now, they say, the figures are reversed: new discoveries are around 4 billion barrels per year compared with consumption of 30 billion barrels.

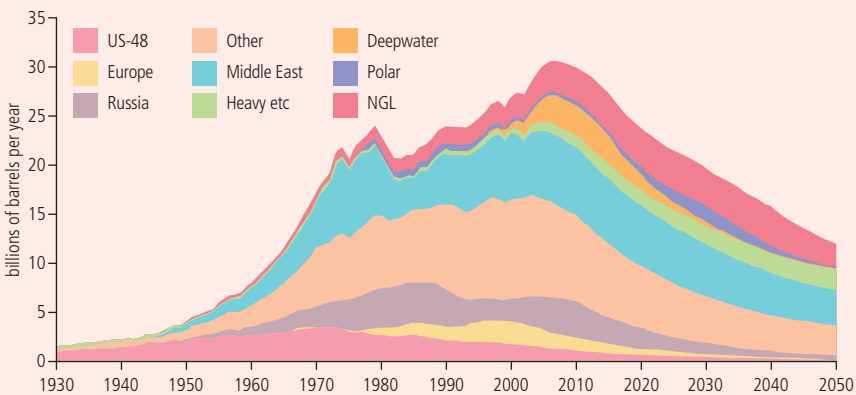


Figure 7.15 Peak oil

CONCEPTS: Environmental value systems

Environmental value systems are important in determining energy usage. A technocentric worldview may lead to continued use of fossil fuels in the belief that pollution can be minimized through technological solutions. A more ecocentric philosophy would see humanity living more within its means, and making better use of renewable sources of energy.

Changes in methods of energy generation employed can result from changing costs of production and from changes in social perspectives on established fuel supplies, which in turn may lead to shifts in environmental philosophy. In countries that rely on fossil fuels, the costs of exploitation have increased as the most easily accessible reserves have been used up, thus alternative sources been sought. The increasing cost of fossil fuels will change peoples' views of them.

At the same time, changing awareness of the environmental implications of fossil fuel exploitation (e.g. global warming) has led to a shift in attitude towards renewable energy sources (e.g. wind power), despite aesthetic and environmental implications, and increased demand for renewable, non-polluting sources. This has led to greater investment and research into alternatives (e.g. wind and tidal power).

Energy conservation

There are a number of possibilities for greater energy conservation. These include greater efficiency and the use of alternatives. Greater efficiency could be achieved through:

- smart meters
- enhanced environmental standards.

Improved building design could include:

- reduced energy use and emissions of carbon dioxide
- reduction of waste
- improved thermal efficiency of walls and windows
- reduction of heat loss between inner and outer walls
- energy-efficient domestic appliances
- improved daylighting by larger windows.

Energy saving is the quickest, most effective and cost-effective way of reducing greenhouse gas emissions. It also reduces the use of scarce resources.

Improvements in energy efficiencies and energy conservation can limit growth in energy demand and contribute to energy security.

Case study

Beddington Zero Energy Development (BedZED)

Beddington Zero Energy Development (BedZED) is an environmentally friendly housing development near Wallington, in the London Borough of Sutton. The 99 homes, and 1405 m^2 of work space were built in 2000–02.

Because of BedZED's low energy-emission concept, cars are discouraged; the project encourages public transport, cycling, and walking, and has limited parking space. It Is close to the tramline that runs between Croydon and Wimbledon.

Monitoring conducted in 2003 found that BedZED had achieved these reductions in comparison to UK averages:

- heating requirements were 88 per cent less
- hot-water consumption was by 57 per cent less
- electric power usage was 25 per cent less (and 11 per cent of the power used was produced by solar panels)
- car mileage of residents was 65 per cent less.

BedZED has achieved this through a combination of:

- a zero energy import policy – renewable energy is generated on site by 777 m^2 of solar panels; tree waste is also used
- energy efficiency – houses face south, are triple glazed, and have high thermal insulation
- water efficiency – most rain water falling on the site is collected and reused
- low-impact materials – building materials were selected from renewable or recycled sources within 35 miles of the site, to minimize the energy required for transportation
- waste recycling
- encouraging eco-friendly transport – public transport, car-sharing, cycling.

BedZED

Exercises

1. Outline the range of energy resources available to society.
2. Evaluate the advantages and disadvantages of two contrasting energy sources.
3. Discuss the factors that affect the choice of energy sources adopted by different societies.