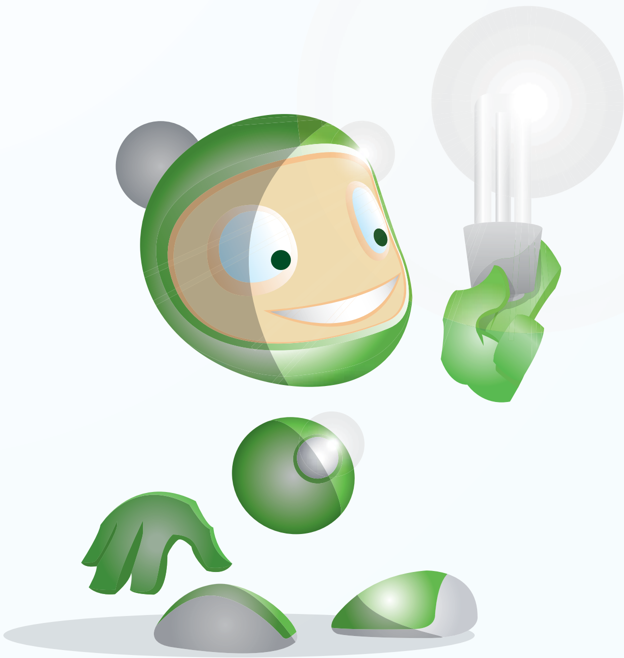
Rewarding Learning

ecoworld

BRIEFING SHEETS: ENERGY



The Consumer Council

Energy Efficiency (background)

Current Usage

The total primary energy requirement in Northern Ireland for 2002 was 41,000 Gigawatt hours (1 Gigawatt = 1,000 Megawatts) equivalent to 3.42 million tonnes of oil[1].

Key Facts

Teacher's note 1.

What is Phantom Load? the phantom load is the electricity consumed by a device when it is turned 'off'. For example, your television consumes electricity as it waits for you to hit the "on" button on your remote; electronic clocks or timers use electricity 24 hours a day, every day. Devices that have a phantom load are sometimes called "vampires." These devices have a hidden energy cost that most people are never even aware of.

Approximate wastage every year in the UK[2]:

- Stereos left on standby waste £383m worth of energy and 1.6m tonnes of CO_2
- VCRs left on standby waste £232m worth of energy and 960,000 tonnes of CO_2
- TVs left on standby waste £116m worth of energy and 480,000 tonnes of CO_2
- Games consoles left on standby waste £93m worth of energy and 390,000 tonnes of CO_2
- Mobile phone chargers unnecessarily left on charge waste £61m worth of energy and 250,000 tonnes of CO_2. If one mobile charger per household is left on standby, the energy wasted is enough to provide the electricity needs of 66,000 homes for one year.
- Computer monitors - £54m worth of energy and 220,000 tonnes of CO_2
- DVD players - £25m worth of energy and 100,000 tonnes of CO_2
- Set top boxes - £15m worth of energy and 60,000 tonnes of CO_2

Consumer Issues

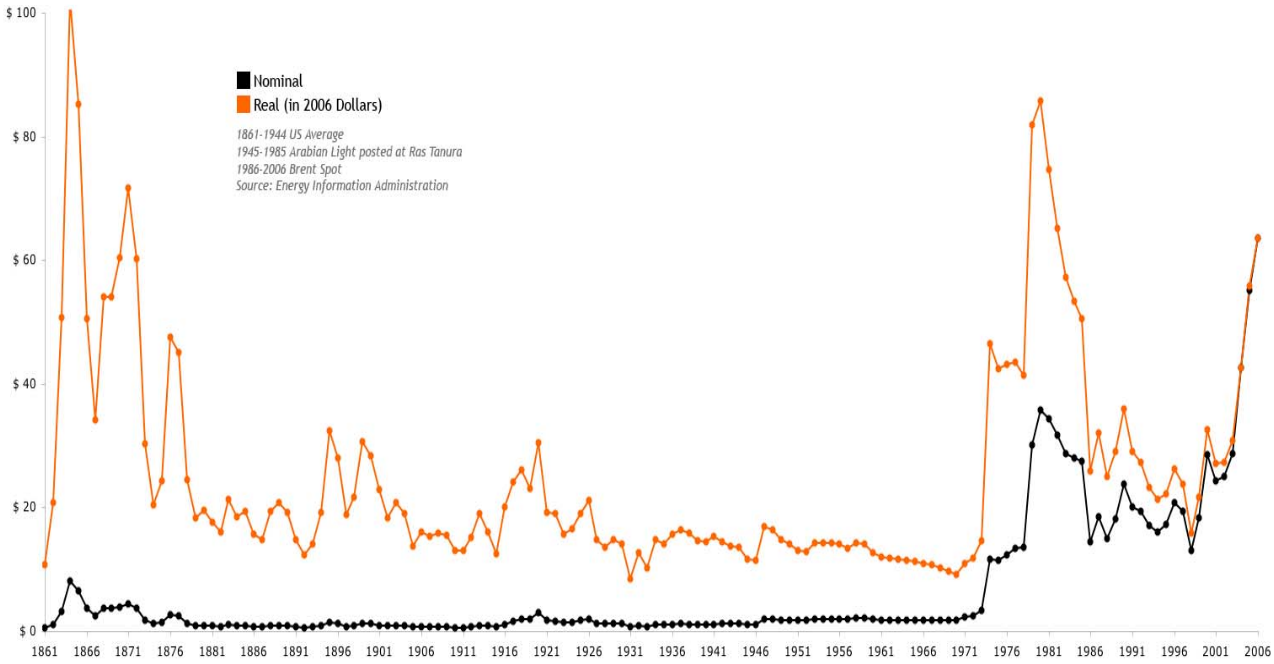
Teacher's notes 2 and 3.

- **Energy Prices**

Long term oil prices 1861 - 2006

[1] http://www.carbontrust.co.uk/Publications/CT-2003-10.pdf

[2] http://msnmoney.est.org.uk/uploads/documents/aboutest/Riseofthemachines.pdf



3

A variety of interlinking factors have been influencing the costs of energy.

- **Increased World demand**.

There are a number of reasons, including strong oil demand growth and tight production and refining capacity which has kept crude oil prices high. Declining OECD oil inventories in the face of rising levels of winter demand, combined with a weakening dollar and geopolitical tensions in key oil producing regions have also contributed to the high price of home heating oil.

Also, energy developments in China and India are having a major influence on the world energy system. China and India are experiencing staggering economic growth, far exceeding other nations. The impact of this on their energy requirements has seen a vast increase in demand[4].

From 1970 to 2005 the global demand for oil increased by 80 per cent. Demand for oil in Asia has risen dramatically: in 1970 one in seven barrels of oil went to the Asian market, in 2005 this has increased to one in three barrels.

The United States has by far the largest demand for oil, consuming around 25per cent of the world's total oil production[5] and 40per cent of the world's gasoline production. Due to depleted domestic reserves and expanding demand each year, approximately 2/3 of the oil and gasoline consumed by the U.S. is being imported from foreign countries. This dependency leaves

[3] From Energy Information Administration
[4] World Energy Outlook, Executive Summary 2007
[5] http://www.marktaw.com/culture_and_media/politics/GlobalOil.html

the U.S. highly vulnerable to any supply disruption and/or moving up of prices. However, due to the US's high dependency on oil there is willingness for the U.S. to pay more for their oil thus further driving up the world figure.

The price of coal has also risen dramatically due to increasing world demand. Coal remains an enormously important fuel and is the largest single source of electricity generation world-wide. In the United States, for example, coal power plants generate 32 per cent[6] of the electricity produced and account for around 35 per cent of Britain's generation.

- **Concerns over future supplies**

There are a number of reasons why oil traders feel that oil supplies might be reduced. One of the most important is growing turbulence in the Middle East, the world's largest oil producing region. The war in Iraq, Iran's nuclear program, and internal instability in Saudi Arabia could all lead to a dramatic fall in the supply of oil.

The table below shows the proven oil reserves (in 1000 million barrels[7]) of the top 15 nations in rank order[8].

Rank	Country	End of 2006	Percentage of global total
1.	Saudi Arabia	264.3	22.00per cent
2.	Iran	137.5	11.4per cent
3.	Iraq	115.0	9.5per cent
4.	Kuwait	101.5	8.4per cent
5.	United Arab Emirates	97.8	8.1per cent
6.	Venezuela	80.0	6.60per cent
7.	Russian Federation	79.5	6.6per cent
8.	Libya	41.5	3.4per cent
9.	Kazakhstan	39.8	3.3per cent
10.	Nigeria	36.2	3.0per cent
11.	USA	29.4	2.5per cent
12.	Canada	17.1	1.4per cent
13.	China	16.3	1.3per cent
14.	Qatar	15.2	1.3per cent
15.	Mexico	12.9	1.1per cent

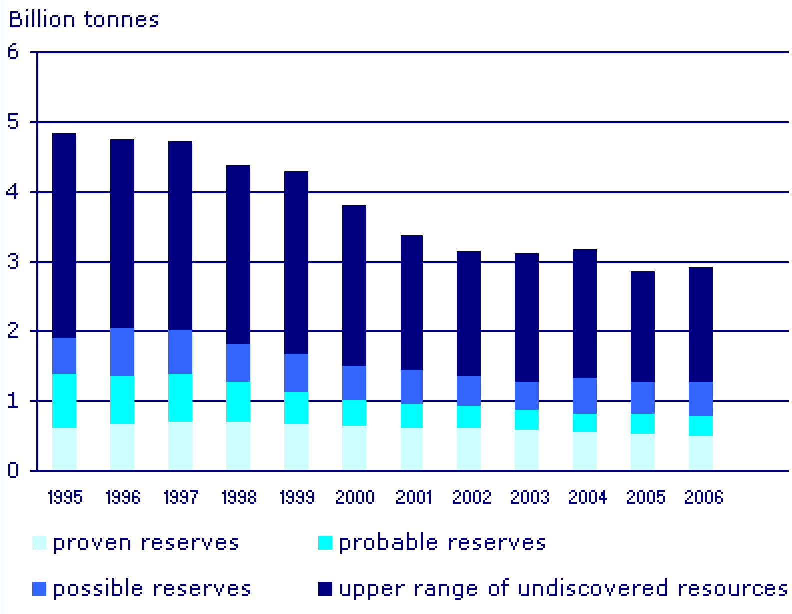
6 http://www.eia.doe.gov/cneaf/electricity/epa/figes2.html
7 a barrel is equal to 159 litres (42 gallons).
8 "Statistical Review of World Energy June 2005", http://www.bp.com/productlanding.do?categoryId=91&contentId=7017990

Natural disasters can also have a huge impact on oil supplies. In late August, 2005, Hurricane Katrina crippled the supply-flow from off-shore rigs in the Gulf of Mexico, the largest source of oil for the domestic U.S. market. Short-term shutdowns because of power outages knocked out two major on-shore pipelines, and at least 10per cent of the nation's refining capacity was not operating in the wake of the storm

World oil supply came in at 84.6 million barrels a day during 2007[9]. This rate has remained constant since. In 2008, the price of crude oil has seen recent highs of over $115 bbl. Increasingly, there is a growing concern that in the future there may be a reduced supply of oil. It is expected that the worlds energy needs will be over 50% more in 2030 than today, attributed mainly to the economic growth of China and India[10].

Even if oil supplies themselves are not reduced, some experts feel the easily accessible sources of crude are almost exhausted and in the future the world will depend on more expensive sources of heavy oil and alternatives.

UK Oil & Gas Reserves



11

Total UK oil reserves were estimated to total of 2.9 billion tonnes at the end of 2006. Of these only 0.5 billion tonnes were proven. The total includes an estimate of between 0.4 and 1.6 billion tonnes of resources which have yet to be discovered, but which may exist in areas of the UK continental shelf.

Levels of oil extraction amounted to 77 million tonnes in 2006, the lowest

[9] http://www.eia.doe.gov/oil_gas/petroleum/info_glance/petroleum.html
[10] www.worldenergyoutlook.org/2007.asp
[11] http://www.statistics.gov.uk/CCI/nugget.asp?ID=129&Pos=4&ColRank=2&Rank=672

recorded. Between 2005 and 2006, the life expectancy of oil reserves increased from 14 to 16 years. However, this is a result of lower extraction rates rather than new discoveries.

Estimates of gas reserves totalled up to 2,016 billion cubic metres at the end of 2006; down 1.2 per cent from 2,041 billion cubic metres in 2005. Proven reserves amounted to 412 billion cubic metres in 2006, 14.3 per cent lower than the 481 billion tonnes recorded a year earlier. The level of gas extraction was 78 billion cubic metres in 2006, the lowest since 1995. The life expectancy of gas reserves showed an increase between 2005 and 2006 from 11 to 13 years. As with oil reserves, this was a result of lower extraction rates rather than significant discoveries of new reserves.

The short term price of oil is partially controlled by OPEC and the oligopoly (a state of limited competition, in which a market is dominated by a small number of producers or sellers) of major oil companies. One other important cause is the United States dollar's slump against the Euro. As oil is traded in dollars, the price must increase for OPEC to maintain purchasing power in Europe.

Oil has a big influence on gas prices in Europe. Continental gas prices are still directly linked to oil prices. This increases UK gas prices as Britain, and in turn Northern Ireland, is connected to the European gas market through the gas interconnector pipeline. Most of our gas still comes from the North Sea, but production has been declining faster than was expected. As a result, the UK has to import some of its gas supplies.

Fuel Poverty

Fuel Poverty is defined as a household which spends more than 10% of its income on fuel. 44 per cent (302,000) of households in Northern Ireland are currently in fuel poverty according to the Northern Ireland House Condition Survey.

Fuel Poverty can have serious implications for the health and well being of vulnerable groups such as the elderly, children and people living with disabilities or chronic illness. Some of the effects include, poor mental health, respiratory disease, heart disease and premature mortality. Asthma can become more common in children and the symptoms of rheumatism and arthritis are worsened for older people.

With a cool, wet climate and mild summers, the likelihood of households in Northern Ireland spending more than ten per cent of their annual income on fuel is increased by the need for year round heating. Many of the elements of Northern Ireland’s social and structural circumstances create the conditions for fuel poverty to develop.

The poor have less money than everyone else and they get less for it. For the fuel poor in Northern Ireland there is the further disadvantage of low incomes and high fuel costs compared to Great Britain. The high cost of fuel, light and power here means that they need to spend more of their money just to keep warm.

Renewables

The total primary energy requirement in NI for 2002 was 41,000 Gigawatt hours (GWh) equivalent to 3.42 million tonnes of oil equivalent available from the following sources:

- Coal 29.4 per cent
- Oil and LPG 26.3 per cent
- Natural Gas 22.4 per cent
- Fuel for Transport 18.9 per cent
- Imports for Electricity 2.8 per cent[12]

The Government's Renewables Obligation policy requires that licensed electricity suppliers source a specified percentage of electricity supply from indigenous renewable sources. The target is to reach 12 per cent by 2012. Currently around 3 per cent of electricity consumed in NI is generated from indigenous renewable sources[13].

Renewable technology exists on both the industrial and domestic scale. It is likely that the future will see large-scale installations, such as wind farms, being supported by other forms of renewable energy including small-scale and building integrated installations.

Inexhaustible sources include harnessing the power of the sun, the wind, the sea, or heat from under the ground. A replaceable source means that it can be replaced as fast as it is used. Replaceable sources include crops grown for the purpose like miscanthus and willow or waste products such as animal slurry and wood waste. This form or renewable energy is called biomass and in terms of carbon dioxide emissions it is "carbon neutral", that is, the amount of carbon it absorbs while growing is the same as the amount it produces when burned.

Ground Source Heat Pumps (GSHP)

GSHPs are an increasingly popular renewable energy but the technology is not new. Heat pumps are commonplace in the form of refrigerators and air conditioning. They simply move heat from one place to another by use of a compressor.

A length of plastic pipe, as a closed loop, is buried in the ground either in horizontal trenches or in a borehole. The pipe is filled with a water/antifreeze mixture. This mixture circulates in the pipe, absorbing heat from the ground and raising the temperature to approximately 40°C.

[12] Northern Ireland Energy Study 2002 – The Carbon Trust
[13] Further information on the Renewables Obligation can be found at www.detini.gov.uk

For every unit of electricity used to pump the heat around the system 3-4 units of heat are produced measured in kilowatt therms (kWth).

Current installed capacity for GSHP in NI equals 3604.55 kW[14].

Hydro Electric Schemes

With the development of the National Grid in the 1950s the historically small -scale hydro schemes gave way to the larger-scale schemes and other forms of generation. Current trends in renewable energy generation have seen a shift away from larger-scale and a re-emergence of small-scale hydro plants.

Costs for hydro works can be high depending on the amount of civil works that need to be undertaken. For small scale schemes the costs per kW of installed capacity is typically high in comparison to other renewable technologies.

Current installed capacity for Hydro Electric schemes in NI equals 2250.6 kW[15]

Solar Photovoltaics (PV)

The amount of electricity generated is related to the number of cells and the intensity of the light. However, modern PV cells do not require direct sunlight with normal daylight being sufficient to produce electricity[16].

PV systems can be integrated into the building. Typically, an array covering $10m^2$ generates 1.5 kilowatt peak (kWp) and will meet 30 per cent of a household's annual electricity needs.

As technologies have advanced the costs of installing PV panels have reduced, but vary depending on factors such as the size of the system, the type of PV cell used and installation considerations.

Current installed capacity for PV in NI equals 2091.6 kW[17].

Solar Water Heating (SWH)

SWH systems are usually integrated with existing water heating systems to ensure year round hot water. SWH systems can provide around 60 per cent of domestic hot water NI.

Typically an installation will need 3 to $4m^2$ of panelling on the roof. It operates best without shadow from trees or other buildings[18].

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[14] Figures have been provided by Action Renewables
[15] Figures have been provided by Action Renewables
[16] The average annual solar radiation in NI is approximately 2.5 kWh per m^2 per day.
[17] Figures have been provided by Action Renewables
[18] http://www.actionrenewables.org/uploads_documents/SWH.pdf

A fully installed domestic system currently costs approximately £2,500 and will save up to £150 per year on fuel costs depending on lifestyle[19]. As with all renewables these savings will increase as traditional fossil fuel costs rise. The pump costs around £12 per year to operate.

Current installed capacity for SWH in NI equals 4767.7 kW[20].

Biomass and Anaerbic Digestion

Wet wastes such as farm slurries can be digested to produce biogas, which can then be burnt as fuel. Dry fuels can be burned to produce heat and/or power. Where organic material is burned or digested the fuel forms part of an ongoing cycle so that the growing of more fuel sequesters gas released during the process. The process can become self-sustaining having no net impact on greenhouse gases produced.

An excellent example of the potential of biomass is the Balcas plant outside Enniskillen that produces a wood pellet by burning sawdust and woodchips. The plant produces 50,000 tonnes of fuel pellets a year. This is enough to meet the company's own energy requirements and power 10,000 homes. Other benefits include the elimination of an estimated 10,000 heavy truck journey's from NI roads due to on-site processing and the employment of around 1000 people including harvesting and processing the output from the renewable forests.

Wood provides about 1% of Ireland's energy needs. It is regarded as a 'carbon neutral' fuel and takes just 5-20 years to grow, unlike fossil fuels which forms over thousands of years[21].

Current installed capacity for Biomass (dry) in NI equals 19857.9 kW[22]

Wind

Teacher's note 4.

Wind turbines vary in size and power output from small (less than 100 watts) to several MW for wind farms. The size of the wind turbine determines the total amount of energy generated.

NI has one of the best wind resources in Europe and is therefore well suited to wind development. These range from large wind farms across the province to small single turbines, suitable for households,

Costs for household and other small-scale applications would typically vary between £5,000-£45,000 including installation. The potential demand and installation rate for the new 1kW non-grid connected system is at present unknown.

[19] Figures from Action Renewables and Zen EAGA Solar
[20] Figures have been provided by Action Renewables
[21] http://www.actionrenewables.org/uploads_documents/WoodHeating.pdf
[22] Figures have been provided by Action Renewables

Current installed capacity for Wind in NI equals 231,559.7 kW[23].

The advantages

- Wind power enables electricity to be produced in an environmentally friendly way – the turbines don't produce chemical or radioactive emissions.
- The ground on which the turbines are positioned can still be used for agricultural purposes – such as sheep grazing.
- If the turbines need to be taken down, there is no damage to the environment and no residues are left behind.
- Advances in technology will allow turbines to be positioned further out to sea.

The disadvantages

- There are concerns from some people who are worried about wind farms being positioned in their area. The main worries are that they ruin the landscape – because they generally have to be positioned on hills to get the maximum benefits of the wind.
- Wind farms also take up much more space to produce the same amount of energy as other methods such coal-fire powered stations.
- Wind farms can be costly to maintain and electricity produced by this method is more expensive than that produced by other means. There are arguments that the money would be better put into energy conservation.
- The noise generated from wind turbines has been criticised by some people who live very close to the wind farms.

Marine Energy

Teacher's note 5.

- **Tidal energy** occurs due to large movements of water in the sea. As tides come in and out (flow and ebb), water near the coast is raised and lowered and the potential energy of this tidal range can be used. It is also possible to harness the kinetic energy of the moving water in the tidal stream itself.
- **Wave energy** occurs due to movements of water near the surface of the sea. Waves are formed by winds blowing over the water surface, which make the water particles adopt circular motions. This motion carries kinetic energy, the amount of which is determined by the speed and duration of the wind, the length of sea it blows over, the water depth, sea bed conditions and also interactions with the tides.

Wave-based devices generate electricity from movements of the sea surface, whereas tidal stream installations sit on the sea floor and use the movement of the tides as they come in and out.

[23] Figures have been provided by Action Renewables

A 2003 report[24] assessed the potential for generating power from marine currents in and around NI. The main results were

- Strangford Narrows – up to 30MW
- Copeland Islands – 27MW possibly increasing to 45MW;
- North East coast on NI (from Fair Head, past Toor Head to Runabay Head) – potential for 67MW.

SeaGen- Tidal energy

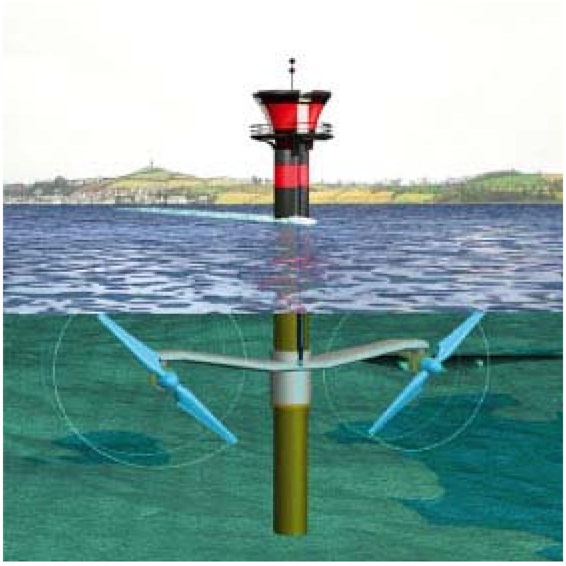
The world's first deep-water device to generate electricity from the tides on a commercial scale has just been installed in Strangford Lough. The SeaGen Tidal System at Strangford Lough in Co Down, Northern Ireland, is designed to produce enough electricity to supply 1,000 homes. Strangford Lough is one of the best locations to put the tidal system into due to the speed and power of the tidal system there.

A seagoing crane barge lowered the 1,000-tonne double turbine into place and it was fixed into the seabed with 12 metre (40 ft) pins.

The system, made by Marine Current Turbines (MCT) and assembled at the Harland and Wolff dockyard in Belfast, has two 16m blades which will be turned by the water streaming in and out of Strangford Lough at a speed up to 8 knots.

The Sea gen is a revolutionary new device and will be closely monitored over the course of time to see its success and the effects it has on the surrounding Lough.

[24] "The Potential for the use of Marine Current Energy in Northern Ireland" report commissioned by DTI, DETI and NIE



Domestic combined heat and power (d-CHP)

In existing domestic gas boilers, about a third of the heat produced is wasted but with d-CHP technology, the extra heat is used to drive a small generator to produce electricity.

Two units were installed in a demonstration project commenced in March 2004 in two homes in Bangor and Newtownards. The dwellings were monitored to evaluate the performance and effect of the technology in reducing energy consumption. Reports indicate that annual savings were approximately £150[25]. Owing to the success of the first two d-CHP units in Northern Ireland, a further 50 units are going to be installed. Further installations may be affected by the prohibitive cost of the units.

Connection to the Grid?

An off-grid or stand-alone system for power generation requires battery storage to store the electricity generated. Excess power can be re-directed and used for space heating or pre-heating domestic hot water. Systems can also be grid-connected and export any excess electricity back to the grid. NIE will offer a credit for electricity that is generated but not used. The amount offered varies between technologies. The current export prices are 4.5p per kWh for wind, hydro and d-CHP.

Nuclear energy & security of supply

Teacher's note 6.

Calder Hall, Cumbria, was the world's first nuclear power station to produce electricity. It opened in 1956. There have been a few serious incidents at nuclear power plants worldwide. The most well known happened in 1986 when a reactor exploded in Chernobyl, Ukraine.

How nuclear power works

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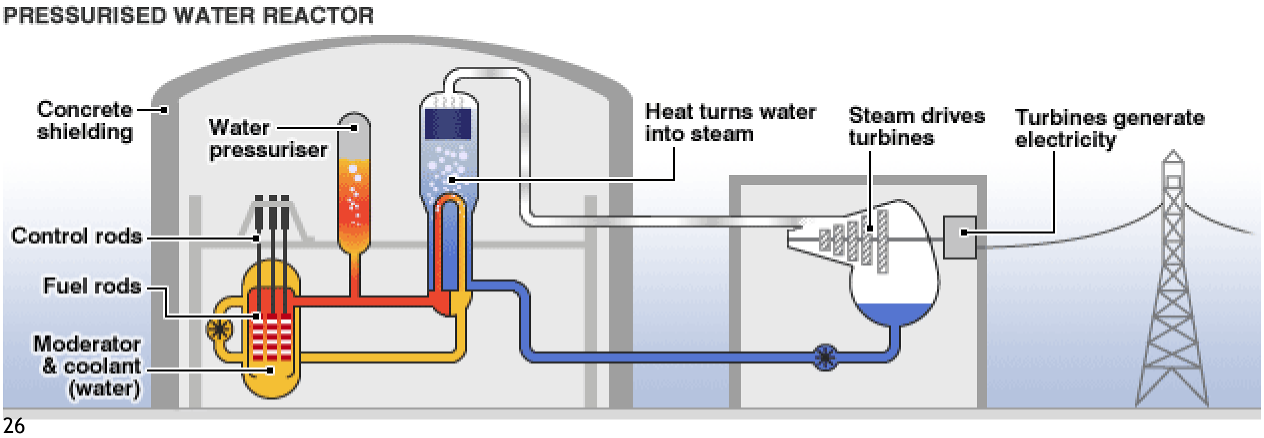
[25] NIE d-CHP report December 2005



26

A nuclear power station uses the atomic energy released during the nuclear fission process. Nuclear fission occurs when an atom splits releasing a large amount of energy.

Only certain types of atom are fissionable. The naturally occurring metal uranium (a heavy, unstable element) is most commonly used.

There are several different types - or isotopes - of uranium. Uranium-235 is the most easily fissionable, but only seven atoms in every 1,000 of naturally occurring uranium are U-235.

A uranium-235 atom not only splits when bombarded with a neutron or other sub-atomic particle, but also releases two or three more neutrons which go on to strike other U-235 atoms, triggering what is known as a chain reaction.

A nuclear power station facilitates this chain reaction under controlled conditions while harnessing the energy to generate electricity.

Rods of nuclear fuel - usually uranium with an enriched concentration of U-235 atoms - are positioned in the reactor core.

Fission is most likely to occur if the free neutrons are moving relatively slowly, so the rods are surrounded by a substance called a moderator which slows the neutrons.

In the most common type of modern reactor, the pressurised water reactor (above), water is used both as a moderator and also as a coolant.

As well as slowing the neutrons, the water carries the energy away from the reactor core, using the heat to generate steam which then turns turbines to generate electricity.

To maintain the reaction at a constant rate, for every atom that splits, only one neutron should be allowed to go on to strike another atom.

[26] http://news.bbc.co.uk/1/shared/spl/hi/guides/456900/456932/html/nn2page1.stm

This is controlled using rods made of materials such as cadmium and boron, which absorb some of the neutrons released during the fission process. The control rods can be raised or lowered if more or less absorption is needed.

The reactor is surrounded by a heavy concrete shield which blocks radiation from escaping into the environment.

Teacher's note 7.

The greatest concern is the small proportion of nuclear waste that is "high-level waste" - waste so radioactive that it generates heat and corrodes all containers, and would cause death within a few days to anyone directly exposed to it. In countries where reprocessing takes place, high-level radioactive waste is the waste left behind after the uranium and plutonium have been extracted. In the UK, this is treated as shown above.

In the UK this accounts for less than 0.3per cent of the total volume of nuclear waste but accounts for about half the total radioactivity[27].

No man-made container could survive the tens of thousands of years it will take for high-level waste to decay to safe levels.

No country has yet implemented a long-term solution to this problem, although Finland and the US have plans to build repositories deep underground in areas identified for their geological stability. This solution is one of those under consideration in the UK.

In these countries, spent fuel, uranium and plutonium are not currently categorised as wastes (because they can be used), although they must be stored like radioactive wastes - and there is the added security concern that plutonium can be used to make nuclear bombs.

Intermediate level wastes are mixed with concrete and stored in tanks, drums and vaults at the sites where they are created.

If the UK's reactors all operate to their current shutdown dates and no more are built, there will be an estimated 36,590 cubic metres - enough to fill 14 Olympic-sized swimming pools - of intermediate and high level waste in the UK[28].

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[27] http://news.bbc.co.uk/1/shared/spl/hi/guides/456900/456932/html/nn3page1.stm
[28] http://news.bbc.co.uk/1/shared/spl/hi/guides/456900/456932/html/nn3page1.stm

Teacher's note 8.

HOW TO CALCULATE APPLIANCE RUNNING COSTS

Appliance usage is measured in UNITS or KILOWATT-HOURS
1 KILOWATT- HOUR (kWh) = 1 UNIT
This is the same for any appliance, and any fuel e.g. electricity, gas.
To work out how much an appliance uses you must have three values:
· The power rating or wattage of the appliance. This is found on the appliance.
· The time the appliance is on for.
· The cost per unit.

APPLIANCE WATTAGE ÷ 1000 = KILOWATTS
KILOWATTS × (TIME APPLIANCE IS ON FOR IN MINUTES ÷ 60) = kWh's
kWh's x COST PER UNIT = TOTAL RUNNING COST OF AN APPLIANCE FOR THE TIME IT WAS ON FOR

Calculations below are based on the Home Energy Tariff, with cost per unit of electricity = 15.03p
VAT = 5per cent

EXAMPLE: 100 watt light bulb on for 24 hours
(100 ÷ 1000) × (1440 mins ÷ 60) = 2.4 kWh or units used
(2.4 kWh × 15.03p) = **36.07p + VAT = 37.87p**
This means that it costs 37.87p to use a 100 Watt light bulb for 24 hours.

EXAMPLE: Equivalent energy saving light bulb (20 Watts) for 24 hours
(20 ÷ 1000) × (1440 mins ÷ 60) = 0.48 kWh or units used
(0.48 kWh × 15.03p) = **7.21p + VAT = 7.57p**
This means that it costs just 7.57p to use an equivalent low energy light bulb for 24 hours.

As you can see using a low energy saving light bulb in place of an ordinary light bulb will save you 30 pence every 24 hour period your light is on.

You can calculate all appliances in your home using this formula[29].

[29] From Energy Savings Trust