Climate Change

SCIENCE AND TECHNOLOGY IN ACTION FOURTH EDITION

Introduction

In order to *mitigate* the effects of climate change governments and major international agencies throughout the world are prioritising steps to address aspects of the problem. These steps include:

- reducing our use of fossil fuels
- reducing or limiting global greenhouse gas emissions
- developing alternative energy sources
- making more efficient use of energy and reducing energy loss

Fig. 1 Planet Earth

Predicted effects of climate change, such as greater risk of flooding in low-lying areas, can be reduced by taking appropriate preventive measures.

These strategies are all interrelated.

Reducing the use of fossil fuels

Certain gases in the atmosphere absorb infrared radiation emitted by the surface of the Earth. This warms the planet by about 30 °C; without this *greenhouse effect* the average global temperature would be an inhospitable -15 °C.

Since the industrial revolution the use of fossil fuels has risen dramatically. There has also been a rise in the average global temperature; this is known as the *enhanced greenhouse effect*. When coal, oil and gas are burned the main *products* are carbon dioxide and water – both greenhouse gases. Over the last two hundred years the average concentration of *water vapour* in the atmosphere has remained relatively constant while the concentration of carbon dioxide has risen from 280 *ppm* to about 360 ppm, contributing significantly to the enhanced greenhouse effect. Other gases are also significant, especially *nitrous oxide* (N_2O) and *methane* (CH_4); these have a greater greenhouse effect but are present in lower concentrations than CO_2.

Reducing or limiting our production of greenhouse gases can be achieved in a number of ways:

- reducing the consumption of fossil fuels
- substituting renewable fuels, such as wood or other *biomass*, for fossil fuels

Reducing greenhouse emissions

Emissions of carbon dioxide can obviously be reduced by reducing the combustion of fossil fuels. Other strategies involve '*carbon capture*' – the removal of carbon dioxide from the exhaust gases of large power plants, factories etc. for later storage.

Several techniques are being tried but they are not energy neutral; extra energy must be expended to remove, compress and store the CO_2.

Carbon dioxide can be removed from *flue gas* by cooling it and then reacting it with *sodium carbonate* (Na_2CO_3) to form *sodium bicarbonate* ($NaHCO_3$).

$Na_2CO_3 + CO_2 + H_2O \Leftrightarrow 2\ NaHCO_3 + 136\ kJ/mol$ (of CO_2)

So for every 12 g of carbon burned about 136 kJ of energy must be added to capture the CO_2; this is equivalent to over 11 MJ per kg of carbon burned or about one third of the energy produced by burning coal (33 MJ/kg). In reality some of the energy released when the CO_2 is absorbed can be used to decompose the sodium bicarbonate and regenerate the *absorbent* sodium carbonate. Other processes of this kind are currently being evaluated.

Storage of 'sequestered' CO_2

There are several proposed methods for storing carbon dioxide and some of them are already being used:

- conversion to a solid mineral form
- storage in ocean depths
- storage in deep geological formations including oil wells.

Carbon dioxide reacts with many metal oxides to form relatively stable *carbonates* such as *calcium carbonate* and magnesium carbonate. However, the metal oxides are mainly produced by displacing carbon dioxide from the corresponding carbonates – a process that requires a considerable energy input.

If carbon dioxide is pumped to ocean depths of more than 3000 m it remains a liquid and being denser than water it sinks to the bottom. In conditions of such high pressure carbon dioxide can react with water to form a relatively stable ice-like solid *hydrate*.

Alternative energy sources

Wind and water powered devices have been in use for thousands of years to drive mills, irrigation pumps and ventilation systems. In the twentieth century thousands of *hydro-electric* power plants were constructed and for many countries they are the primary source of electricity – about 99% in the case of Norway and about 66% in Egypt.

Fig. 2 Wind Turbine

In recent decades there has been considerable progress in the development of other alternatives to *fossil fuels*. Of these wind powered electricity generators are so far the most promising and the most widely used. Although wind power accounts for only about 1% of global energy production it represents about 19% of the national demand in Denmark, 9% in Spain and 6% in Ireland.

Tidal water flow is also used to drive electricity generators but few places are ideally suited to this technology.

Commercial wave powered generators are being constructed at present but the technology is not very efficient. Wave energy and direction are variable and, of their nature, *intermittent* while conventional electricity generators work best with more even energy inputs. Wave power generators must be capable of withstanding storms and large installations can interfere with shipping. Bringing the electricity ashore in a safe and reliable way is also problematic.

Sunlight is the main energy source for the planet. The average *solar radiation* at the Earth's surface is about 340 W/m² or about 40,000,000 GW globally. Global energy use in 2005 was about 30,000 *GW* – less than one thousandth of the incoming solar radiation. Improving our use of this constant resource is an increasingly attractive objective.

Converting light into electricity requires relatively expensive *photovoltaic cells* and is most useful in places with high sunshine levels. It is about 12% efficient in ideal conditions and considerably less efficient on average.

Fig. 3 Solar Panels

In developed countries up to 70% of energy use in the home is for space heating and water heating. Solar power is particularly useful for heating water and modern vacuum tube heating panels are reputed to be up to 80% efficient. At our latitude (ca. 55 °N) they can capture about 5 kWh per day in summer and about one tenth of that in winter.

Geothermal heating has become more attractive as the price fuel has risen. It is relatively expensive to install but has low running costs. There has also been a revival of interest in nuclear power. Although disposal of spent nuclear fuel is problematic this energy source is readily available and when up and running it does not add to greenhouse gases.

Reducing energy loss in the home

In temperate latitudes electricity demand is 40% higher in winter than in summer due to the higher use of electric heating. Heat is lost from a house (as *infrared radiation*) through the walls, windows, floor and roof. Good *thermal insulation* can reduce the loss and cut heating costs by up to 50%. Draught exclusion is the most cost-effective way of improving energy efficiency in the home, it is relatively inexpensive and may reduce heating costs by 30%.

Fig. 4 Heat losses from a house

Adapting to climate change

There are many ways in which we can reduce our energy requirement, avoid waste and reduce our impact on the environment. Some require action at a domestic level while others require national and international cooperative action.

The Environmental Protection Agency (EPA) is an independent public body established under the Environmental Protection Agency Act, 1992. The EPA regulates and polices activities that might otherwise cause pollution. It ensures there is solid information on environmental trends so that necessary actions are taken. The EPA's priorities are protecting the Irish environment and ensuring that development is sustainable. It employs over 340 people who work in ten locations throughout the country.

The other main instruments from which it derives its mandate are the Waste Management Act, 1996, and the Protection of the Environment Act, 2003. The EPA has a wide range of functions to protect the environment. Its primary activities include:

- environmental licensing
- enforcement of environmental law
- environmental planning and guidance
- monitoring and reporting on the environmental status of air, water, waste, noise, sand and soil and
- environmental research and development.

The EPA's function is to protect and improve the natural environment for present and future generations, taking into account the environmental, social and economic principles of sustainable development.

The EPA's Climate Change Programme encompasses responsibilities for Emissions Trading (National Allocation Plans, Permitting and National Emissions Trading Registry), Kyoto Project Mechanisms, GHG Emission Inventories and Projections, Scientific Advice, and Climate Change Research.

The EPA's 2020 Vision strategy (Protecting and Improving Ireland's Environment) and the National Climate Change Strategy, 2007, have strengthened the EPA's position on climate change and envisages new roles for the EPA in this area. The EPA's climate change programme, which provides a basis for addressing these developments, is available on the EPA website at **www.epa.ie/whatwedo/climate**.

Find out more on the work of the Environmental Protection Agency on **www.epa.ie**

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Syllabus References

Leaving Certificate Biology

Syllabus Aims

- Biology is the study of life…Through the study they (students) become aware of the use by humans of other living organisms and their products to enhance human health and the human environment and make informed evaluations about **contemporary biological issues**.
- to create an awareness of the **application of biological knowledge to modern society** in personal, social, economic, environmental, industrial, agricultural, medical, waste management and other technological contexts

Leaving Certificate Geography

4.5 Environmental impact Statement: Economic activities have an environmental impact.

Students should study

- the use of **renewable and non-renewable resources** in the economy
- the impact of the burning of fossil fuels and the use of **alternative energy** sources
- environmental pollution at a local/national and global scale
- sustainable economic development so as to control its environmental impact. Students should examine past experiences, future prospects and the necessity for **environmental impact** studies
- conflicts that may develop between local and global economic interests and environmental interests. **Students should be familiar with the issues** relating to at least two examples.

Leaving Certificate Physics

- Work, Energy, Power (p.27)
- Heat, Heat Capacity and Heat Transfer (p.29)
- Option 1: Modern Physics (pp. 40–43)

Learning Outcomes

On completing this section, the student will:

- Understand that reducing the use of fossil fuels will help to reduce the emission of greenhouse gases
- Realise the importance of the greenhouse effect for life on Earth
- Recognise the consequences of using up the Earths' non-renewable resources
- Be aware of the different ways to reduce greenhouse gas emissions such as CO_2 capture and storage
- Know about the different alternative energy sources and how energy loss in the home can be reduced
- Be aware of some methods of reducing the output of CO_2 to the environment
- Understand that 'carbon capture' has an energy cost
- Be aware that their own personal decisions can have a beneficial impact on the environment.

General Learning Points

- Non-renewable resources such as fossil fuels are limited, so we must reduce our dependence on their supply.
- Reducing the use of fossil fuels will help reduce the emission of greenhouse gases.
- The burning of fossil fuels generally releases carbon particulates (soot); this contributes to air pollution.
- Emission of greenhouse gases can be reduced by carbon capture.
- Wind energy, tidal water flow, solar power and wave energy are all examples or renewable energy sources that are being utilised by many countries.
- The developed countries consume a disproportionately large share of the Earth's non-renewable resources.
- Draught exclusion in the home can reduce heating costs by up to 50% and good insulation can reduce heating costs by 30%.

Student Activities

- Calculate how much energy (in the form of oil) is consumed by your school/house each year.
- Convert this to carbon emissions. Suggest ways in which your school might reduce 'carbon' emissions.
- List renewable energy resources that could be used as alternatives to fossil fuels.

True/False Questions

a) Reducing the use of fossil fuels will help reduce the emission of greenhouse gases. **T F**

b) Due to the greenhouse effect the average global temperature will become -15 °C. **T F**

c) The use of alternative energy sources has in itself no effect on energy demand. **T F**

d) Fossil fuels are a renewable resource. **T F**

e) CO_2 storage is a way of reducing the levels of CO_2 in the atmosphere. **T F**

f) Hydro-electric power uses the wind to produce energy. **T F**

g) When hydrocarbons are burned the main products are carbon dioxide and water. **T F**

h) The concentration of carbon dioxide in the atmosphere is now more than 1 %. **T F**

i) Most of the heat loss in houses occurs through windows and doors. **T F**

j) 'Carbon capture' is a way of saving energy. **T F**

Check your answers to these questions on www.sta.ie

Examination Questions

2007 Leaving Certificate Chemistry Higher Level

Environmentalists are concerned about the increasing abundance of carbon dioxide in the atmosphere.

(i) State one important way carbon dioxide is constantly added to the atmosphere.

(ii) Carbon dioxide is a greenhouse gas. It has been assigned a greenhouse factor of 1.

(iii) What use is made of the *"greenhouse factor"* of a gas?

(iv) Name two other greenhouse gases.

(v) Carbon dioxide is removed from the atmosphere when it dissolves in rainwater, seas, lakes, etc. What three chemical species arise in water as a result of carbon dioxide gas dissolving in it?

2004 Leaving Certificate Chemistry Higher Level

The *greenhouse effect* is a natural phenomenon but its effects have been enhanced by human activity over the past 200 years.

(i) Explain the term greenhouse effect.

(ii) Identify one gas in the atmosphere which makes a significant contribution to the greenhouse effect.

(iii) In relation to the gas you have identified in (ii), mention a type of human activity which has been a major contributor to the increased levels of this gas in the atmosphere.

(iv) Identify one gas, found in the atmosphere, which is not a greenhouse gas.

(v) State three probable consequences of an increased greenhouse effect which have been suggested by environmental scientists.

Did You Know?

- Between the years of 1990-1995 Central America lost almost 19% of its forest, this was the fastest rate of deforestation in the world.
- The Kyoto Protocol is an international agreement set up by the United Nations Framework Convention on Climate Change. Its major feature is to legally bind 38 parties to reduce their greenhouse gas (GHG) emissions and to encourage a further 150 parties along this path.
- Ireland is required to meet its emissions limit which is set at 13% above its 1990 levels.
- The United Stated has not yet ratified the Kyoto Protocol .
- Between the years of 1990-2004, GHG emissions of India and China rose by 55% and 47%, respectively. Both countries have signed the Kyoto Protocol but as developing countries have no GHG reduction obligations – they are participating in the Clean Development Mechanism.
- Present renewable energy sources supply 18% of current global energy use but there is much more potential that can be exploited.
- Brazil has one of the largest renewable energy programmes in the world's, involving productions of ethanol fuel from sugar cane. Ethanol now provides 18% of the country's automotive fuel.
- The worlds largest wind turbines deliver up to 6MW and have a height of 186m.
- For simplicity, energy consumption is often expressed as tonnes of oil equivalent (toe). One toe is the amount of energy released by burning one tonne of crude oil and is approximately 42 GJ.

Biographical Notes

Dr. Akhtar Hameed Khan (1914-1999)

Khan pioneered microcredit (small loans to the unemployed or those not considered bankable) and microfinace initiatives, farmer's cooperatives and training programmes in developing countries. His development programmes included the Comilla Model in 1959 and the Orangi Pilot Project in 1980. These projects earned him the Magsaysay award from the Philippines and an honorary Doctorate of Law from Michigan State University.

Gro Harlem Brundtland (1939)

The former Norwegian Prime Minister is an international leader in sustainable development and public health. She once served as the Director General of the World Health Organisation and as Chair of the World Commission on Environment and Development (WCED). She developed a broad political concept of sustainable development and published the article titled 'Our Future' in 1987. As chair of the WCED or Brundtland commission as it is called, she was a major driving force behind Agenda 21, a programme related to sustainable development. It is a plan of action to be taken globally, nationally and locally by organisations of the UN, governments and major groups in every area in which humans impact the environment. Some of the main features to be tackled by Agenda 21 include: combating poverty, changing consumption patterns, promoting sustainable settlement patterns and integrating environment and development into decision making.

Revise the Terms

Can you recall the meaning of the following terms? Reviewing the terminology is a powerful aid for recall and retention.

absorbent, biomass, calcium carbonate, carbon capture, carbonates, enhanced greenhouse effect, flue gas, Geothermal heating, greenhouse effect, GW, hydrate, hydro-electric, infrared radiation, intermittent, kWh, methane, mitigate, nitrous oxide, nuclear power, photovoltaic cells, sodium bicarbonate, sodium carbonate, solar radiation, thermal insulation, tidal water flow, W/m^2, water.

Check the Glossary of Terms for this lesson at www.sta.ie