Geo Factsheet

www.curriculum-press.co.uk Number 241

GLOBAL WARMING MITIGATION
Part 1: Dealing with Energy Emissions

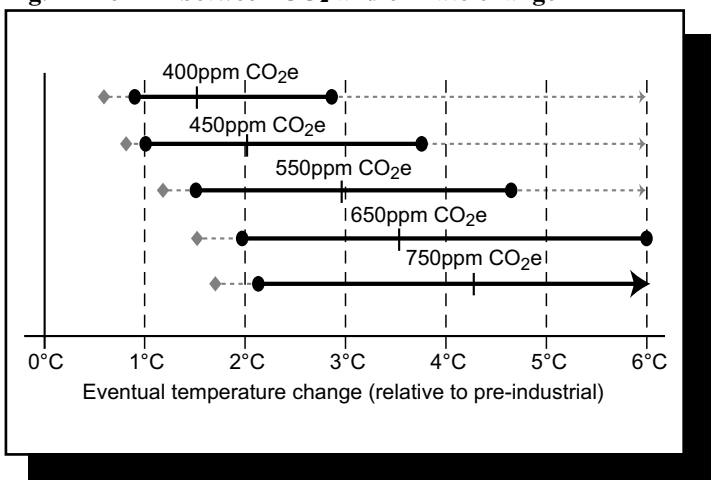
What is Global Warming Mitigation?

The Scientific consensus from IPCC on the cause of recent climate change is that a link exists between the recent increase in atmospheric greenhouse gas concentrations and human activity. While greenhouse gases (carbon dioxide, methane, water vapour and ozone) are naturally occurring and required to provide a warming effect for life to exist on earth, human activity has added to the concentrations of these gases. Levels are considerably higher than at any time during the last 650,000 years, and we have witnessed the introduction of other gases such as nitrous oxide and CFCs which further enhance the warming effect.

Carbon dioxide is the principal greenhouse gas responsible for global warming accounting for 63.7% of the warming effect. Since the start of the industrial revolution in 1750 there has been huge economic growth, largely using fossil fuels, thus resulting in an increase in greenhouse gases – largely CO_2.

Over the last 200 years over 550 gigatonnes of CO_2 have been added to the atmosphere resulting in a present level of 385 parts per million (ppm), one third higher than the pre-industrial level of around 278ppm. If the rate of industrial growth continues to increase unchecked, CO_2 emissions could reach between 855ppm and 1130ppm by the end of the century. As *Fig. 1* shows, such levels could cause a significant rise in global temperatures of between 50c and 60c, leading to significant impacts on the earth's climate, oceans, ecosystems and human population.

Fig. 1 The link between CO_2 and climate change



Source: Adapted from Stern Review 2006.

Global mitigation is a long-term strategy which aims to reduce the output of greenhouse gases in the various sectors of the economy and also increase the size of **carbon sinks** such as forests and by capturing and storing carbon emissions.

Mitigation can operate at all scales from global to local and ideally needs to be combined with **adaptation** a shorter term strategy designed to cope with climate change.

How can Mitigation be achieved?

There are a range of strategies for global warming mitigation which fall into two distinct groups:

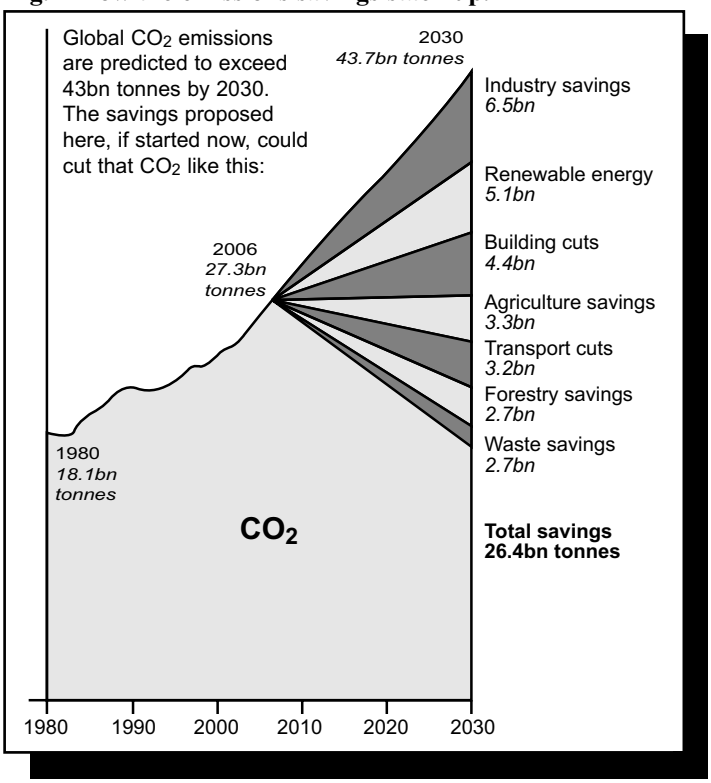
1) Reduce human sources of greenhouse gas emissions by:
   a) Reducing CO_2 levels from power generation and other GHG generating activities *(see Fig. 2)*
   b) Improving efficiency of power use and industrial production
   c) Changing agricultural, land use and waste practices for example to cut down methane emissions.

2) Remove greenhouse gases from the atmosphere by:
   a) Collecting emissions at point of release
   b) Sequestering CO_2 through geo-engineering
   c) Developing more carbon sinks.

The Stern Review notes that the cost of mitigation to the 550ppm level will cost between 1% and 3.5 % of global GDP per annum until 2050 if engaged in the next decade. This will rise quickly to over 20% if delays occur. The report also notes that the consequences of a lack of mitigation strategies would have incalculable economic impacts for the long-term future.

The danger is that if mitigation policies are not agreed the **tipping point** where irreversible impacts of climate change will occur may take place leading to catastrophic events such as the melting of all Ice Sheets.

Fig. 2 How the emissions savings stack up.



Think mitigation wedges

The idea of stabilisation wedges from Princeton University provides a useful structure to allow a greater understanding of mitigation.

The basic concept is shown in *Fig. 2*. The graph shows the predicted levels to 2030. An increase to 43.7 billion tonnes equates to a carbon dioxide concentration of 450-500ppm – in other words about the level considered by many to be 'dangerous' (unavoidable increase of 2ºC – *see Fig. 1*).

The Princeton 'wedge' game assumes a need to stabilise CO_2 at about 280ppm by 2050 and identifies the task as a 'stabilisation triangle' showing how much carbon dioxide needs to be removed for the system. The triangle is then divided up into a series of 7 wedges, each of which can be achieved by a different reduction strategy such as:

- Efficiency
- Fuel switching
- Ending deforestation
- Carbon Capture and Storage

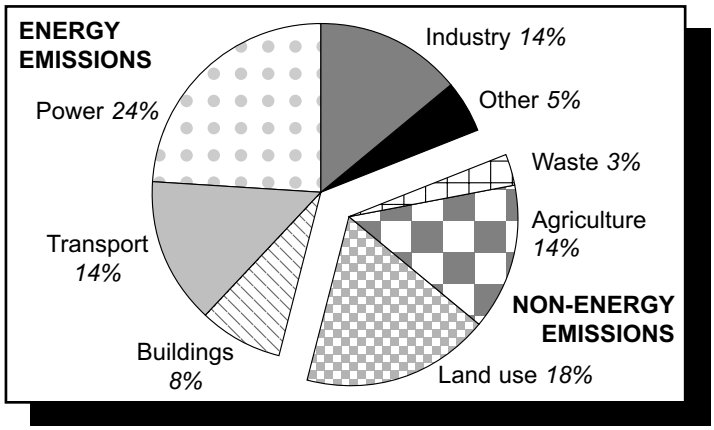
Some of the strategies are suitably controversial (nuclear power) and it is possible for students to come up with their own ideas, i.e. replacing one they dislike with their own strategy.

Further Information:
www.princeton.edu/~cmi/resources/stabwedge.htm
www.princeton.edu/~cmi/resources/CMI_Resources_new_files/CMI_Stab_Wedges_Movie.swf for a flash video introduction.

Reducing human sources of greenhouse gases

Fig. 3 shows a breakdown of greenhouse gases by source. Around two thirds of CO_2 emissions are linked to energy generation and efficiency and this will be the focus of this *Geo Factsheet*.

Fig. 3 Greenhouse gas emissions by source.



Source: Stern Review

Energy Production

Nearly a quarter of all greenhouse gases come from power stations. Together with industrial power production it makes up around 38% of emissions and is the first area to be targeted by mitigation driven by international agreement. In 1997 many developing countries signed up to the Kyoto Protocol binding them to a carbon trading system. Emission quotas were agreed by each participating country, with the intention of reducing their overall emissions by 5.2% of their 1990 levels by the end of 2012. Under the treaty, for the period from 2008 until 2012, countries that emit less than their quota are able to sell emission credits to nations that exceed their quota or to sponsor projects that reduce greenhouse gas emissions in less developed countries, as a way of generating extra tradable carbon credits called the Clean Development Mechanism (CDM). Some countries such as Australia only signed Kyoto recently, and the USA may only finally sign with the arrival of President Obama.

Example: European Union Emission Trading Scheme (EU ETS)
This is the largest multi-national, greenhouse gas emissions trading scheme in the world and was created in conjunction with the Kyoto Protocol.

Phase 1 (2005 - 2007): All member states capped the amount of carbon dioxide that could be emitted from large installations such as power plants and factories. Participants also traded credits amongst themselves under the Clean Development Mechanism.

This phase received criticism due to countries setting their own allowances based on their historic emissions. These were not stringent enough and the scheme was dogged by problems of complexity, monitoring and enforcement. However, some member states such as the UK gave fewer allowances to the power generation sector than they were expected to need as a deliberate cutback to encourage the focus on cleaner technologies.

Achieving these reductions in CO_2 emissions involves changes in the methods of electricity generation.

Cleaner fossil fuels

Table 1 shows that switching from one type of fossil fuel to another can be one effective strategy.

Coal emits around 15% of its emissions as CO_2 compared to 14% for oil and 10% for gas. Conversion costs for many power stations are relatively low but declining oil and gas reserves have lead to rises in prices. Coal-rich countries are seeing new export opportunities which undermine the potential long-term environmental benefits of switching to gas for current short-term economic benefits as new coal fuel power stations are proposed. Unfortunately the mechanism needed carbon so the station is unlikely to be operational until 2030!

Table 1 CO_2 emissions for various energy sources.

Energy Source	CO_2 in g per kWh
Coal	950
Oil	900
Gas	600
Nuclear	3-5
Renewable source average	11

Nuclear fuel

Globally, nuclear fuel accounts for around 14% of electricity generated. Nuclear power stations have often been controversial. High set-up costs, long term hazardous waste storage issues, an expensive and lengthy decommission process and the risk of radioactive leaks or reactor fires have all being given as a reason against the use of nuclear fuel. As a result many counties have decided to phase out nuclear power for environmental, economic and social reasons. However, counties such as France have totally switched over to nuclear power and the UK is giving serious consideration to a more wide scale program.

This resurgence of interest is partially connected with the fight to reduce carbon dioxide emissions. Unlike many renewable energy sources which rely on appropriate environmental conditions, nuclear offers a consistent and controllable source of electricity which has one of the lowest CO_2 emissions *(see Table 1)*. In fact, the bulk of the CO_2 emissions from nuclear production are generated when electricity from fossil fuel is used in the Uranium enrichment process.

Renewable Energy Sources

Renewable energy makes up around 18% of global energy supply but as *Table 2* shows The International Energy Agencies (IEA) research indicates the potential to supply considerably more power at out current technology levels and significantly help to reduce CO_2 by 50% by 2050. The European Union has been one of the first to take up this call and in 2007 agreed to produce 20% of their nations energy through renewable by 2020. Wind power is a major area of future growth with realistic costs and generation potential.

Table 2 Worldwide energy generation.

Energy Source	Current Global Share %	Cost per kWh	Potential future increases
Hydropower	2.70	1-6p	400
Wind	0.01	2-5p	600
Solar	0.01	16-106p	1500
Biomass	14.90	1-7p	500
Geothermal	0.06	0.5-3p	-
Nuclear	14.00	2p	-
Fossil Fuels	68.00	2p (average)	-

Case Study 1: Wind Power

Wind power is one of the most environmentally friendly sources of renewable energy occupying less land area per kilowatt-hour of electricity than any other energy system, while still allowing other land uses such as agriculture. Turbines can recover constructed energy costs in 3 months and operate for 25 years before replacement and leaving no trace of their presence on removal. Carbon dioxide production is near zero coming only from energy used during construction.

Europe is already a leader in wind power. Denmark uses it to produce 18% of its energy needs, Germany 7% and Spain 9%. The UK government is set to build the world's largest offshore wind farm, in the Thames estuary. The London Array will consist of 341 turbines, over an area of 230km² producing 1000 MW a year - enough to power one-third of London's homes. It will save 1.9 million tones of CO_2 emissions a year and make up to 10% of the Government's role in the 2020 European renewable energy target.

Like most renewable projects, success will depend on finding investors during the construction phase and to date this project has been dogged by a changing energy market and worldwide recession which may cause delays and reduce its mitigation potential. See Geo Fact Sheet 232.

Energy Efficiency

As *Fig. 3* shows, residential and commercial buildings, industry and transport of people and goods are also part of the problem. A lack of energy efficiency in these sectors contributes around one third of the global CO_2 production and improvements in energy use could help to reduce emissions significantly. However, dealing with energy efficiency is a much more complex task.

Unlike power generation there is a much larger number of groups involved, including businesses of all sizes, communities, and individuals. Each group has own specific needs for the way it uses energy and will need personalised solutions to improve their efficiency and cut carbon emissions. *Table 3* shows a range of strategies for the different sectors at different scales.

Table 3 A selection of Energy Efficiency strategies for different sectors.

	Local	National	International
Industry	**Beaufort Court,** Hertfordshire is a converted egg farm and the home of Renewable Energy Systems (RES). RES uses a wind turbine, solar and its own biomass crop for heating. It uses water as a heat store and a ground water cooling system alongside sympathetic passive solar architecture.	The **Climate Change Levy** is a tax on non-renewable energy to commercial users. It is an incentive to increase energy efficiency and to cut UK emissions by 2.5 million tones annually by 2010 as part of the UK's Climate Change Programme. Part of the revenue is used to fund a number of energy efficiency initiatives, including The Carbon Trust.	Carbon offset through the **Kyoto Clean Development Mechanism** has lead to investment in energy projects in countries such as China, Mexico, India and Brazil. The investment from companies, across the developing world has encourage a range of 'clean' solutions some of which are controversial including the development of Biofuels based on local crops.
Transport	The **Velib Cycle Scheme** in Paris uses 20000 bicycles in 750 racks around the city. Users swipe their travel card and pedal to another rack near their destination. One year in, there are over 20,000 regular users, making an average of over 60,000 trips a day, reducing an estimated 50,000 tons of CO_2 a year.	Since 1998 UK **Vehicle Excise Duty** has been linked to engine size and CO_2 emissions to penalise heavy polluters and reduce costs for the more 'cleaner' cars. From 2010 an additional showroom tax will be introduced to further tax the highest polluters who will have to pay nearly £1000 extra on purchase. This is in addition to nearly £500 a year on road tax.	Approximately 90% of cargo worldwide moves by containers stacked on transport ships and around 18 million containers make over 200 million trips per year on around 100,000 ships. **Sky Sails** uses a large kite and an electronic control system to cut a ship's average annual fuel costs by 10%. Retrofitting sky sails throughout the world, would to save over 150 million tons of CO_2 emissions a year.
Buildings	A **Quiet Revolution** wind turbine is a vertical axis helical design which functions 20-40% more efficiently in urban roof top locations than traditional designs. A single quiet turbine producing around 10,000 kW a year and can make a small commercial building virtually self-sustaining in power. Users include Sainsbury's in Dartmouth and King's College School, Wimbledon.	Germany is investing over €1billion a year in its **Passiv Haus** buildings, a world leading low energy, low carbon design. These buildings use insulation, passive solar architecture, appliance heat recovery, computer-controlled ventilation and solar panels resulting in 90% less energy for heating than average building stock.	The EU will **phase out high-energy filament bulbs** by 2010 to improve energy efficiency by 60% and help to meet climate change targets by cutting 30 million tonnes of CO_2 a year. The switchover will affect all of the European Union's 500 million citizens.

Individuals

The need for a raft of societal mitigation strategies can be clearly seen in the figures and tables, with 40% of the UK's **carbon footprint** coming as a direct result of individual behaviour (driving, flying, home energy use). As a result government strategies such as 'Act on CO_2', energy businesses such as EON and British Gas and non-governmental organisations such as Greenpeace and Oxfam have taken to provide grants, support and information to individuals about how to reduce their CO_2 emissions on a voluntary basis. Common energy efficiency recommendations include turning down the thermostat by one degree, improving insulation, installing low energy light bulbs, and cutting down on car use and flights. However as *Table 3* shows, national strategies such as car tax in the UK and international agreements such as light bulb regulations in the EU are being used as catalysts for change.

Businesses

A similar approach is being attempted with commercial organisations in the UK. The Carbon Trust was set up to offer support and advice to move companies forward in terms of carbon reduction. Its funding comes from the taxation of energy levied at the same companies. On an international scale, carbon production limits have been used in a limited way with large industries to force change. With the arrival of the second phase of the EU **carbon trading** scheme being more stringent and further developments from the Kyoto protocol it is possible that carbon trading may become an important part of the future economy. Some companies however, have seen opportunities in developing technology to improve efficiency and like Sky Sails or Passiv Haus may make a substantial difference to other businesses carbon emissions *(see Table 3)*. Most TNCs such as General Electric or Walmart have **'green growth'** strategies in which energy efficiency is a cornerstone.

Communities

Collective responsibility for 'green issues' has long been the call of environmental groups, but recently this idea has begun to move into the mainstream. Following the Climate Change march in London in 2005 a new movement called Carbon-Rationing Action Groups (CRAGs) has formed both in the UK and abroad. These groups communicate regularly to account for and reduce their collective carbon emissions, setting ambitious reduction targets and swapping ideas on the processes to achieve this such as, buying local to reduce food-miles, reusing items to reduce energy production and supporting local community efforts.

However, collective responsibility has gone beyond this in some locations with the creation of so-called Transitions Initiatives *(see Case Study 2)*. These are cities, towns, regions or even islands in the process of imagining and creating a future to addresses the challenges of diminishing fossil fuel supplies and climate change, while creating a strong sense of community.

Conclusion

Changing energy generation and energy efficiency is an important part of global warming mitigation as these sectors contribute around two thirds of the gas emissions. However, non-energy based production makes up the remaining third and is an important if often overlooked area for further mitigations strategies. The next global warming mitigation Geo Factsheet will examine possible solutions as well as exploring on the other side of mitigation strategies- direct capture and removal of CO_2 from the atmosphere, increasing carbon sinks and geo engineering.

Useful websites

- *www.ncdc.noaa.gov/oa/climate*
- *www.ipcc.ch1* – IPCC site
- *www.hm-treasuring.gov.uk* – for Stern Review
- *www.stabilisation2005.com* – avoiding dangerous climate change

Case Study 2: Totnes Transition Town

Totnes was the UK's first Transition Town, where residents, business, public bodies, community organisations and schools work together to formulate innovative, effective, practical ideas to fulfil the mission statement:

- *To explore and follow practical actions to reduce carbon emissions and dependence on fossil fuels.*
- *To become more self reliant and resilient in areas such as food, energy, health care, jobs and economics.*

There are around 20 different projects running, each concentrating on different aspects of sustainability including education, housing and energy. One example includes a community energy efficiency scheme where the collective purchasing power of town members has allowed them to negotiate a lower price for the purchase of solar water-heating units for all. In addition several residents have become qualified fitters, pushing costs down even further as well as reducing the towns dependence on fossil fuels and associated production of CO_2.

Even more innovative is the town's own currency, the Totnes Pound. Around 80 businesses take the currency; many offering discounts on purchases using the local currency made on locally sourced goods and services. This economic localisation is a key aspect of the transition process, and provides the opportunity to strengthen the local economy through the multiplier effect. One benefit of this process is in reducing food and trade miles for the community and the associated carbon emissions. Further to this, at a later stage benefits could include supporting the start up of new social, ethical and environmental businesses all adding to the movement away from fossil fuels and towards a zero carbon economy.

Acknowledgements

This Factsheet was researched by Ron Burn who is Head of Geography at Newstead Wood School. ***Curriculum Press, Bank House, 105 King Street, Wellington, TF1 1NU. Tel. 01952 271318.*** *Geopress Factsheets may be copied free of charge by teaching staff or students, provided that their school is a registered subscriber. No part of these Factsheets may be reproduced, stored in a retrieval system, or transmitted, in any other form or by any other means, without the prior permission of the publisher.* ***ISSN 1351-5136***