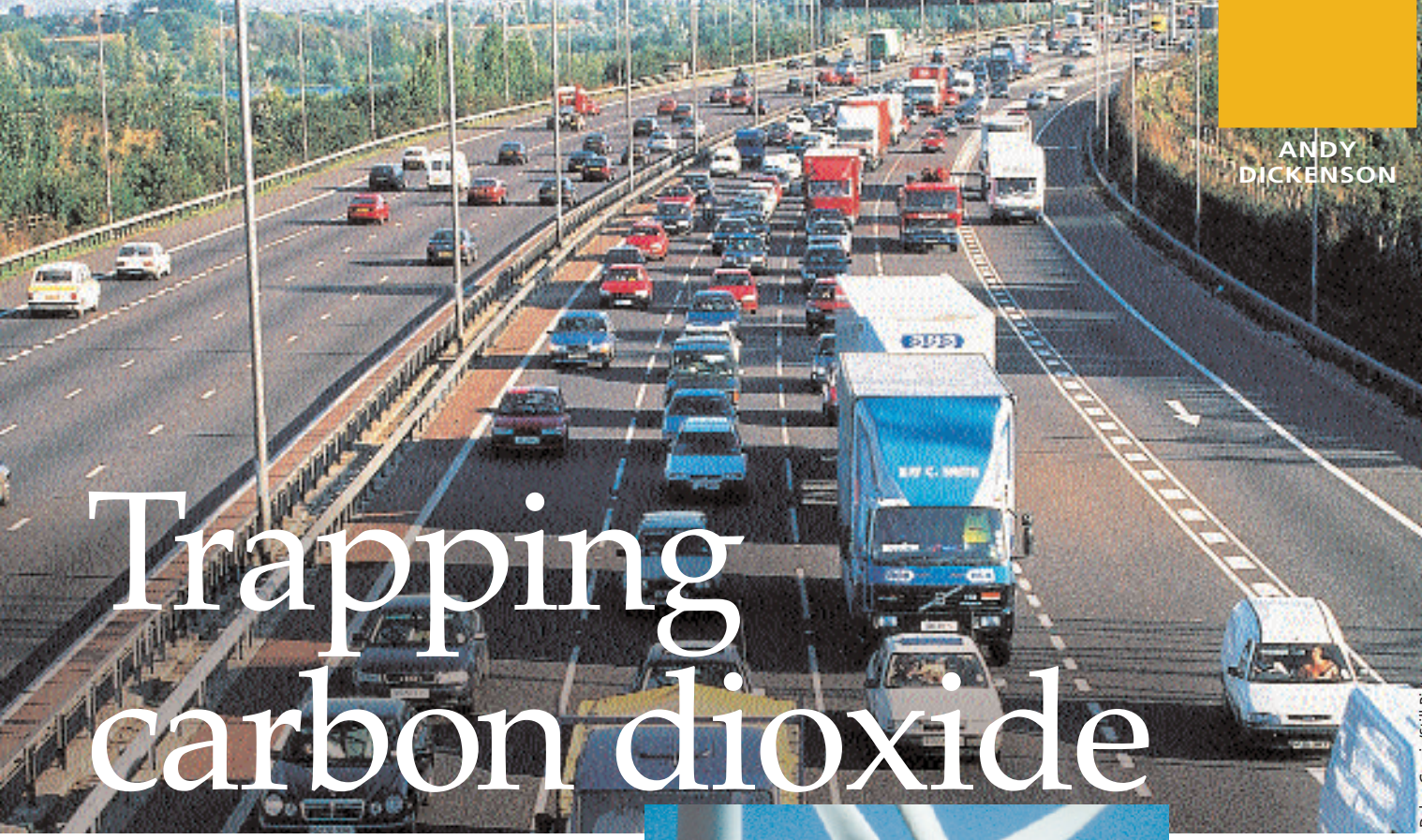
ANDY DICKENSON

Trapping carbon dioxide



Dylan Garcia/Still Pictures

Global warming is being caused by increased levels of carbon dioxide in the atmosphere. This carbon dioxide is released when fossil fuels such as petrol are burnt. Despite concern about global warming, it seems that nobody wants to use their cars less, however expensive fuel becomes. What else can be done to slow the rate of carbon dioxide accumulation in the atmosphere?

GCSE key words
Greenhouse effect
Global warming
Combustion
Photosynthesis

Suppose a car is filled with fuel at a petrol station. The fuel will have a mass of about 25 kg. As you know, when a fuel is burned in sufficient oxygen the products are carbon dioxide and water. Both of these are released as gases; for example, for octane:

$$2C_8H_{18}(l) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(g)$$

What mass of carbon dioxide is released by this fuel when it is burned? Is it more, less or the same as the mass of the fuel? It may surprise you to learn that the mass of carbon dioxide released is a lot more than that of the original fuel. Approximately 77 kg of carbon dioxide will be released from 25 kg of octane.

Multiply this up by the number of cars on the road and you can see that large masses of carbon dioxide are being released every day. Add in the emissions from gas, coal and oil-fired power stations and the total becomes huge. In 1995 each person in the UK contributed 9.3 tonnes of carbon dioxide to the atmosphere. In the US the figure was 20.5 tonnes, while in less industrialised Swaziland it was only 0.5 tonnes per person. These figures are not decreasing.

Chris Knapton/SPL

*Carbon dioxide levels are going up but no-one wants to use their cars less **(above)**. Alternative sources of electricity like wind farms can help **(left)**.*

ENERGY TRAP

This level of emissions is worrying because of the effect carbon dioxide has in the atmosphere. When the Sun shines on the Earth, the Earth warms up. It radiates this energy back into space, at a different

Explain why the mass of the gases released when petrol is burnt is greater than the mass of the fuel. Use the equation in the text to help you, and remember the principle of the conservation of mass.

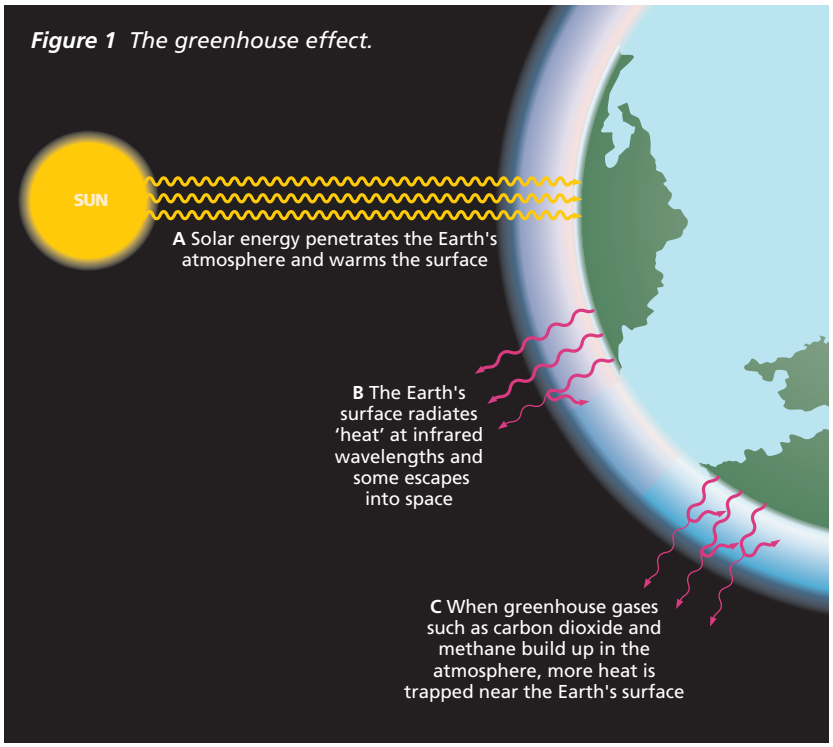
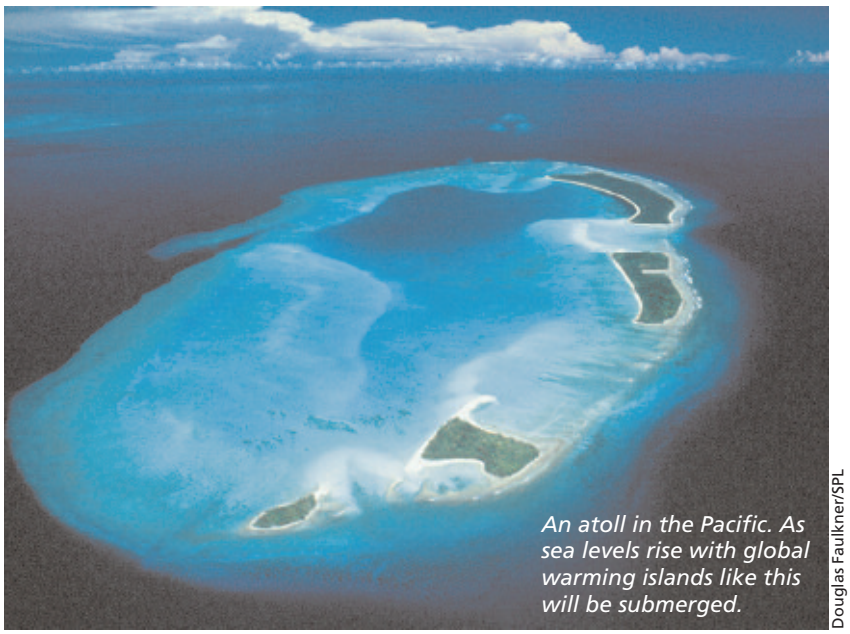


Figure 1 *The greenhouse effect.*

If you holidayed in Europe last summer you might have noticed that several countries have schemes to reduce rubbish burning by recycling more plastics, metallised containers and compostable waste. What is happening in your area?

wavelength from the original solar radiation. However, in our atmosphere there are a number of **greenhouse gases**, of which carbon dioxide is one. These have the ability to absorb energy of the wavelength that is being radiated by the Earth. They cannot absorb it indefinitely though, and they in their turn release it as radiation — some back towards Earth and some to space.

The overall effect is that the greenhouse gases trap heat energy in the Earth's atmosphere (Figure 1). This is known as the **greenhouse effect**, and is no bad thing for life on Earth. Without this warming effect it is estimated that the average temperature on Earth would be about 30°C colder.



An atoll in the Pacific. As sea levels rise with global warming islands like this will be submerged.

Douglas Faulkner/SPL

GOING UP

The fact that carbon dioxide levels are increasing is not in doubt. Carbon dioxide levels measured at the top of a mountain in Hawaii show a steady rise each year (Figure 2). The saw-tooth shape of the graph indicates an annual decrease due to carbon dioxide removal by **photosynthesis** in the growing season. However, the overall trend is upwards. Most scientists agree that increasing carbon dioxide in the atmosphere is causing **global warming**. Global temperatures have risen by 0.3–0.6°C since 1860 (and the Industrial Revolution), while the mean sea level has risen by 10–25 cm. It is hard to know what would have happened if all the carbon dioxide had not been released, but the United Nations (UN) believes that the changes observed are not due to natural variations.

WHAT CAN BE DONE?

In 1995 politicians from around the world met in Kyoto, Japan, and agreed to limit their countries' emissions of carbon dioxide. There has been progress in the UK towards reducing emissions. New cars are given a carbon dioxide emissions figure, in grammes per kilometre (gCO_2/km) and it is cheaper to tax a car that releases less carbon dioxide. There are plans to generate more of our electricity using wind farms, so that power stations burn less fossil fuels. However, other industrialised countries, notably the US, Australia and Canada, have made little progress in reducing emissions.

IS THIS ENOUGH?

Even if all countries met their reduction targets, we would still be releasing vast quantities of carbon dioxide. The UN predicts that by 2100 mean global temperatures could rise by 2°C, although worst estimates predict 5.5°C. To put this in context, a 1°C rise in temperature this century would be a greater rise than in any century in the past 10 000 years. Clearly 2°C would be extraordinary.

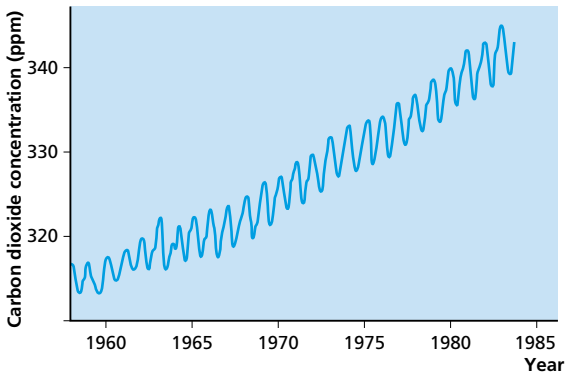


Figure 2 *Levels of atmospheric carbon dioxide measured at Mauna Loa, Hawaii.*

As a result of this, mean sea levels could rise by as much as 50 cm. This will mostly be due to expansion of the water as it warms up, but melting of ice sheets on land, such as those in Antarctica and Greenland, will contribute. It seems that some form of climate change is inevitable and its severity depends on our ability to reduce emissions.

TRAPPING CARBON DIOXIDE

Scientists at the University of Sheffield and the British Geological Survey (both funded by the Natural Environment Research Council) are looking at ways of removing carbon dioxide from the atmosphere. The most obvious process to look at is photosynthesis. Is it possible to plant enough trees to absorb the carbon dioxide being produced? The conclusion from scientists at the University of Sheffield is simple — planting more vegetation will not combat rising carbon dioxide levels. To absorb the carbon dioxide from just one large power station would need a forest the size of central England!

Scientists from the British Geological Survey (BGS) are focusing on an alternative way of storing carbon dioxide for a long time. They have discovered that it is possible to store it underground in porous rock. The gas is pumped underground where the pressure puts it into a supercritical state. The gas molecules are much closer together than they would normally be, and so the gas takes up less space.

The scientists have found that porous rock filled with salt water is the best place to store carbon dioxide. The water has been locked up for thousands of years and so it is very stable, and so salty it is unlikely to be of use. In the rock below the North Sea alone there is space for 800 billion tonnes of carbon dioxide, which is sufficient for all the carbon dioxide from Europe's power stations for 800 years.

STATOIL

The oil company Statoil has already begun storage of carbon dioxide by this method. The gas it extracts from the North Sea for use as fuel contains about 9% carbon dioxide. This has to be reduced to about 2.5% before it can be sold. In the past, the carbon dioxide removed from the gas would have been released into the atmosphere. Now it is injected back 800 m under the sea bed (Figure 3). One million tonnes of carbon dioxide per year have been injected since 1996. The BGS scientists are monitoring the long-term safety of this project.

Storage in disused oil and gas fields is an appealing way of dealing with carbon dioxide. Oil is, of course, formed underground. If we can extract it, use the energy and return the damaging emissions safely back underground then we will really be on the road to meeting our energy requirements while limiting the environmental impact.

Storage in disused oil and gas fields is one way of dealing with carbon dioxide. The inset shows the Sleipner platform and the bridge connecting it to the treatment platform where carbon dioxide is removed and compressed for injection.

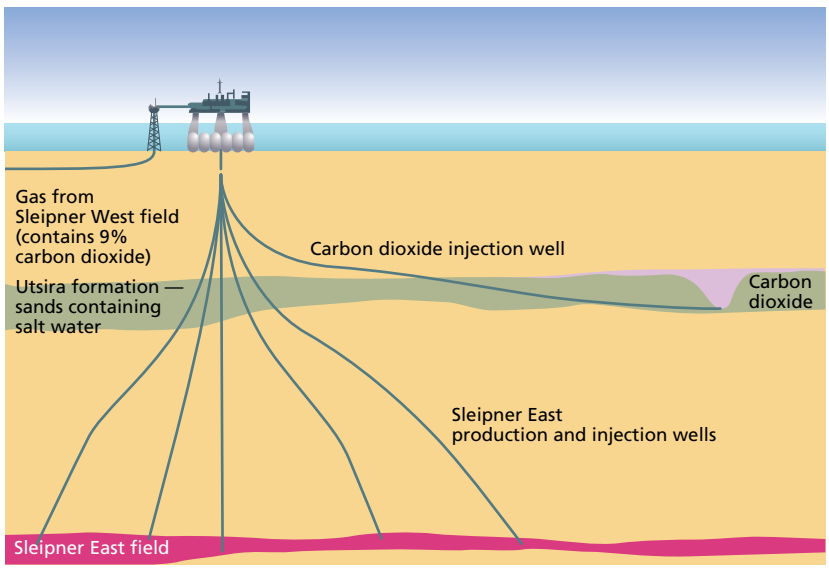


Figure 3 *Storage of carbon dioxide in the Sleipner oil field.*

You should know that plants take up carbon dioxide from the atmosphere and, with water and light energy, produce sugars, in the process of photosynthesis.

WEBSITES

- Find out more about the oilfield where carbon dioxide is being pumped underground at **http://www.ieagreen.org.uk/sacs2.htm**
- Calculate your carbon dioxide emissions at **http://www.facefoundation.nl/Eng/frameset1dE.html**

Andy Dickenson teaches science at King Charles I School, Kidderminster.