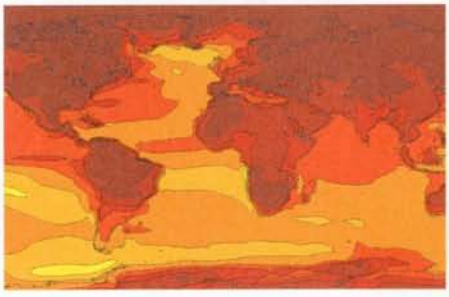
THE Ecologist report
NOVEMBER 2001

# CLIMATE CHANGE

# Time to act

The latest on the problem and the solutions

# THE Ecologist *report* CONTENTS






**Editor** Edward Goldsmith
**Managing Editor** Simon Retallack
**Sub-Editor** Jonathan Bond
**Editor's PA** Rita Kassai
**Design** Jes Stanfield/Lou Tait
**Production Manager** Chris Gregory
**Publisher** Ian McAuliffe

46 The Vineyard, Richmond,
Surrey TW10 6AN.
Tel: +44 (0)20 8332 0295
Fax: +44 (0)20 8948 6787

Publishing handled on behalf of
*The Ecologist* Special Issues by
Think Publishing Ltd, Vigilant House,
120 Wilton Road, London SW1V 1JZ.
Tel: +44 (0)20 7808 7535
Fax: +44 (0)20 7808 7536
Email: watchdog@thinkpublishing.co.uk

*The Ecologist Report* is produced by
*The Ecologist* Special Issues office. If sold separately, this report costs £3.50 plus p+p in the UK, or $5.00 plus p+p in the US.

Ten copies can be bought for £30 plus p+p.
For further bulk discounts, please call
+44 (0)20 8332 0295.

This report, and all *Ecologist* special issues, are free to subscribers of *The Ecologist*:
Unit 18, Chelsea Wharf, 15 Lots Road,
LONDON SW10 0QJ, UK.
Tel: +44 (0)20 7351 3578
Fax: +44 (0)20 7351 3617
Email: sally@theecologist.org
www.theecologist.org.


**DID YOU KNOW?.....EUROPE'S OFF-SHORE WIND POTENTIAL IN WATERS OF 30 METRES DEPTH OR LESS COULD**

# EDITORIAL

The horrific events of 11 September were a grotesque manifestation of the violence that man is capable of inflicting on others. With our sense of security shattered, our attention has focused ever since on how to stamp out the terrorist networks thought to be responsible, so that nothing like it can occur again. But if we are to achieve truly enduring security, we must bring a halt to violence in all its forms – including the violence that we inflict daily on the natural world.

By altering the chemical composition of the atmosphere and disrupting our own climate, we are unleashing a form of violence upon the planet whose nature, scale and consequences are unprecedented and potentially devastating.


COVER IMAGE: AP

As climate change begins to unfold, a picture is emerging of what could lie in store. In response to rising temperatures, the planet's ice cover has begun to melt, coral reefs to die, and record-breaking weather events to strike worldwide – such as the super-cyclone that killed 30,000 people in the Indian state of Orissa in 1999 and the unprecedented floods that hit Britain this time last year.

The climatologists of the UN's Intergovernmental Panel on Climate Change predict that it is going to become a lot worse. They expect average global temperatures to rise by as much as 5.8°C by the end of the century, almost double their previous forecast. And ground-breaking research by the Hadley Centre predicts that temperatures could rise even higher to well over 8°C. The impacts of warming on this scale would be enormous; no one would escape the consequences.

It is virtually undisputed today that we are responsible. The evidence is clear. We have sent $CO_2$ (the main heat-trapping gas) soaring to levels which the planet hasn't seen for 20 million years, by burning coal, oil and gas to generate power for homes, cars and industries, and by destroying forests and soils which absorb carbon emissions.

This means that we can do something about it. There is nothing inevitable about the most extreme climatic scenarios forecast for this century. By using existing technologies and techniques to reduce our demand for energy, switching to renewable sources of power, and protecting the world's natural emission-absorbing sinks, we can phase out the use of fossil fuels and reduce our emissions to avoid the worst.

The problem is that we have very little time to do so – probably no more than 50 years – and the world's governments have got off to a spectacularly slow start. The best they have come up with is the Kyoto Protocol which the US, the world's largest polluter, has pulled out of, and which is now so full of loopholes that it stands only a slim chance of reducing emissions at all. It is a hardly noticeable step that bears virtually no relation to what climatologists deem necessary. What's more, four years after it was conceived, this paltry offering still isn't complete – governments must add the final touches in Marrakech in November and ratify it by September 2002 if it is to come into force. Kyoto is probably better than nothing, but better than nothing is not enough. We need an effort of war-time magnitude. We need action.

As soon as Kyoto is ratified, governments need to adopt a much more appropriate global framework to deal with climate change – one that sets a global limit on greenhouse gas concentrations which all countries should agree, in a fair and rational manner, to abide by. A framework known as 'Contraction and Convergence' would achieve these goals and it should now be negotiated.

Global cooperation on the scale required is possible. We have just seen an unprecedented global alliance being built at break-neck speed to attempt to deal with global terrorism. The same is needed to combat climate change. But that means abandoning the unilateralism that characterised US policy before 11 September.

In doing so, not only would our ecological security be significantly enhanced, so too would our physical security. How? By reducing our dependence on the vast quantities of oil that we import daily from the Middle East, whose supply the West has felt necessary to guarantee militarily – one of the key sources of resentment in which terror has bred. Making the transition away from fossil fuels to renewable energy, therefore, should be seen as a strategic as well as a climatic necessity; a key element in constructing a safer and more sustainable world.

But we can't afford to wait for governments to undertake the task for us – they are too easily influenced by corporate interests determined to preserve the status quo. However, an array of new ideas is emerging to construct leverage over governments and corporations to generate action on climate change – ranging from the mobilisation of the private investment community, the law and the public across all sectors of society. The building of a popular movement both to apply pressure for change and to deliver change in people's daily lives could be especially important. Accessible and viable options exist today to enable each of us to reduce our contribution to climate change dramatically. It is up to us all to take responsibility for the way we live, if life as we know it is to survive in peace on this precious planet.

*Simon Retallack*


Ecologist subscription rates (10 issues per year):

| | |
|---|---|
| **UK and US:** | |
| Individuals and schools | £28 ($45) |
| Institutions and companies | £54 ($86) |
| Concessionary rate | £22 ($35) |
| **Europe:** | |
| Individuals and schools | £33 ($53) |
| Institutions and companies | £59 ($95) |
| Concessionary rate | £27 ($43) |
| **Rest of world:** | |
| Individuals and schools | £40 ($64) |
| Institutions and companies | £66 ($105) |
| Concessions *Unwaged, Students, Retired.* | £34 ($54) |

Subscriptions and back issues: PO Box 326, Sittingbourne, Kent ME9 8FA, UK.
Tel: +44 (0)1795 414963.
Email: theecologist@galleon.co.uk

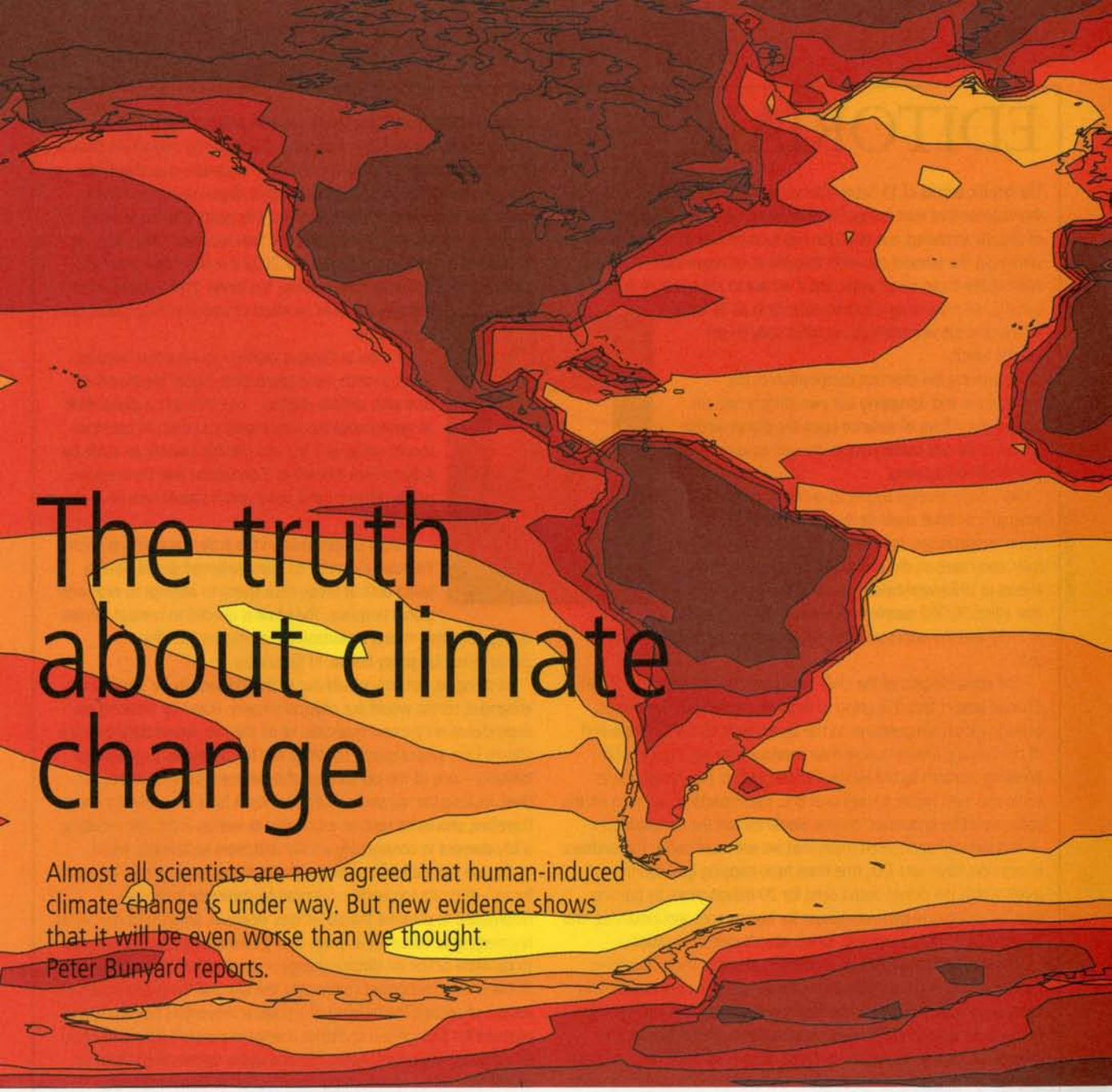
Subscriptions payable to The Ecologist.

Payment by UK£ cheque drawn on UK bank, US$ cheque drawn on US bank, eurocheque in UK£, banker's draft payable through a British bank, postal order, Access, Visa or MasterCard.

ISSN 0261-3131.




SUPPLY ALL OF THE CONTINENT'S POWER.....THERE IS LESS THAN A SIX-MONTH SUPPLY OF OIL IN THE>>



# The truth about climate change

Almost all scientists are now agreed that human-induced climate change is under way. But new evidence shows that it will be even worse than we thought. Peter Bunyard reports.

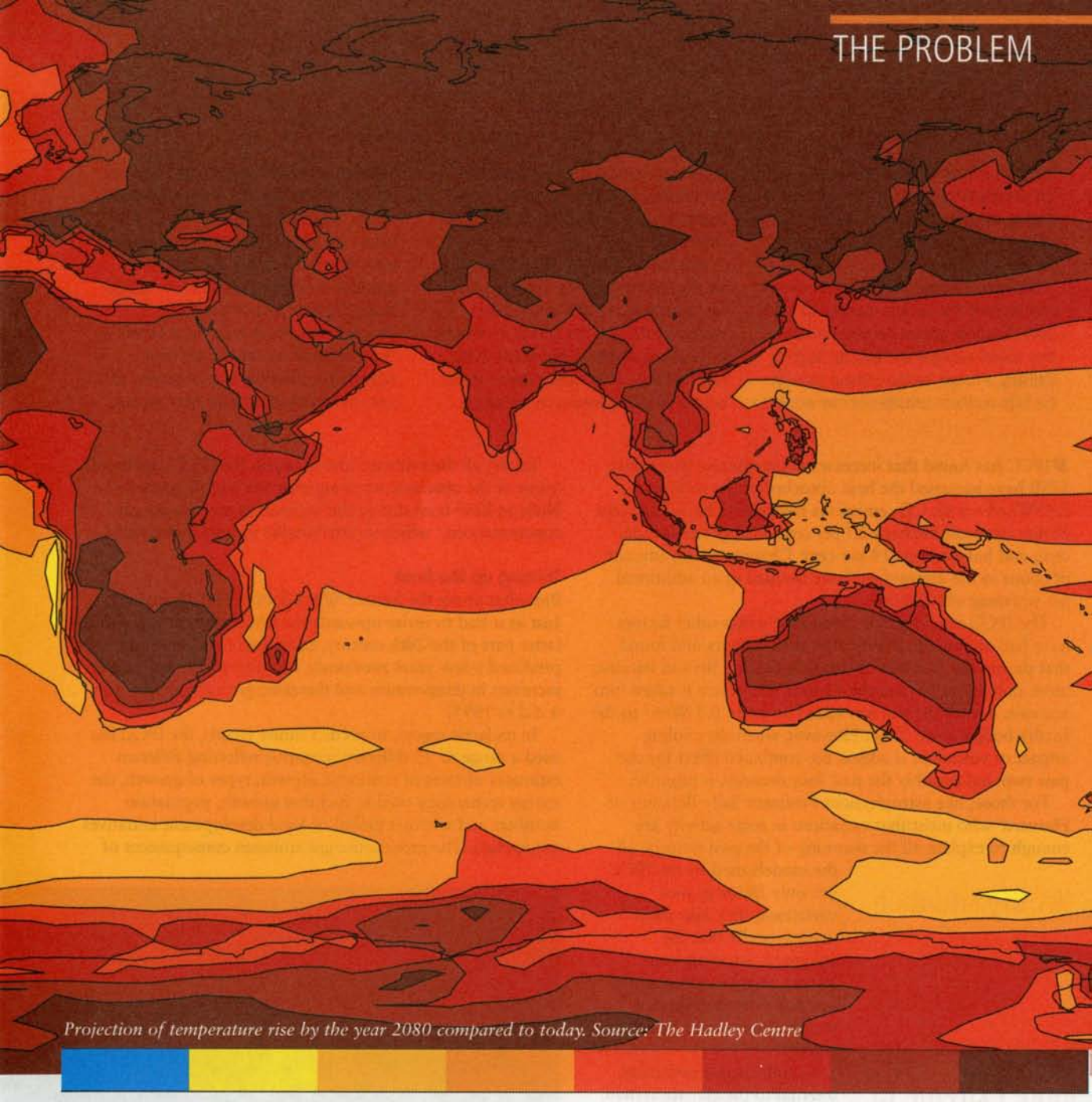
When Britain was awash last winter, in the back of most people's minds was the notion that those seemingly endless torrents of rain had something to do with global warming. Whenever an extreme climatic event happens anywhere in the world, we now often question whether it was entirely 'natural'. Few doubt that the climate is changing, but how certain can we be that humans are to blame with their emissions of greenhouse gases? Are we implicated in what could be the biggest swing in climate for many millions of years?

The Intergovernmental Panel on Climate Change, a body of scientists, economists and policy makers, which the UN first brought together in 1988 to inform governments of the likely causes and consequences of climate change, and solutions to mitigate it, have been deliberating for the past 12 years over the evidence for global warming. In what can only be described as a landmark development, the IPCC confirms in its recently published *Third Assessment Report* not just that global warming is occurring, but that it is largely man-made, has begun to accelerate sharply and will increase far faster than previously thought.[1]

## Global warming is here

Six years ago, in its Second Assessment Report, the IPCC predicted that the overall warming of the planet during the 20th century would be some 0.45°C. Now, in the summary of its latest report, published in March 2001, the IPCC points out that the Earth's surface has warmed by an additional 0.15°C. The 1990s, a run of the warmest years since instrumental records began in 1861, has forced the IPCC to up its assessment of 20th-century temperature rise to 0.6°C. In the northern hemisphere, the IPCC adds, the increase during the 20th century is 'likely to have been the largest of any century during the past 1,000 years'.

Not that global warming just means hotter days in the sun, rather one of the manifestations is an increase in night-



*Projection of temperature rise by the year 2080 compared to today. Source: The Hadley Centre*

+0° +1° +2° +3° +4° +5° +6°

time temperatures. 'On average', states the IPCC, 'between 1950 and 1993, night-time daily minimum air temperatures over land increased by about 0.2°C per decade. This is about twice the rate of increase in daytime daily maximum air temperatures. This has lengthened the freeze-free season in many mid- and high-latitude regions.'

The IPCC also reports that the planet has lost about 10 per cent of its snow cover since the 1960s and that lakes and rivers in the high latitudes of the Northern Hemisphere remain frozen over for two weeks less than they did a century ago. Glaciers in non-polar regions are also retreating, while Arctic sea ice has not only thinned by some 40 per cent since the 1950s, the surface area that it covers during the spring and summer is also down by 10–15 per cent. All in all these figures are extremely significant, revealing that rapid changes are afoot.

## We are responsible

After taking a range of different factors into account, such as sunspot activity, erupting volcanoes and wind-blown dust, the IPCC concludes that: 'There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities.'

The present atmospheric level of carbon dioxide ($CO_2$) – the main heat-trapping or 'greenhouse' gas, generated from the burning of fossil fuels – is now up by 31 per cent from its level in 1750. As the IPCC points out, the present level 'has not been exceeded during the past 420,000 years and likely not during the past 20 million years. The current rate of increase,' continues the IPCC, 'is unprecedented during at least the past 20,000 years.'

On average approximately 240 watts per square metre ($W/m^2$) of the sun's energy reaches the Earth's surface. The

**GLOBAL OIL USE HAS RISEN EIGHT-FOLD – AND THE USE OF NATURAL GAS HAS GROWN 12 TIMES..... ONCE>>**

## Melting ice and changing tree cover could speed up warming

The decline in snow cover and sea ice that has already taken place in high latitudes is altering the reflectivity of the earth's surface – its albedo – thereby increasing the warming trend.

Acting as a mirror, ice and snow reflect back most of the sunlight received by the Earth. But once oceans become ice-free, they absorb sunlight and take up heat. Similarly, a longer period without snow in the high northern latitude summer would accelerate warming because the darker colour of exposed trees, rocks and other vegetation also leads to the absorption of more heat.

That effect could also arise, therefore, if we start planting forests where previously we had arable cropland so as to gain carbon credits from the growth in biomass. In a letter to *Nature* (9 November 2000), Richard Betts of the Hadley Centre spells out the pitfalls of relying on the simple arithmetic of 'carbon offsets' by which one country sells its capacity to grow forests to another so that it can avoid having to reduce its own carbon emissions. Hence, even though the carbon sequestration potential in Eastern Siberia may be as high as 80-120 tonnes of carbon per hectare, according to Betts, that apparent benefit in terms of global cooling is more than swamped by the propensity of conifers to shed snow and absorb heat from the sun.

IPCC has found that increases in greenhouse gases since 1750 have increased the heat absorbed at the surface by 2.43W/m$^2$ – with $CO_2$ emissions responsible for 60 per cent of that increase; methane 20 per cent; nitrous oxide 6 per cent; and halocarbons 14 per cent. Changes to the amount of ozone in the atmosphere have resulted in an additional net warming of 0.2W/m$^2$.

The IPCC also carefully assessed whether other factors have had an impact. It looked at solar activity and found that during the first half of the 20th century the sun became more radiant, and when the 11-year solar cycle is taken into account, overall the sun has added an extra 0.3 W/m$^2$ to the earth's budget since 1750. However, when the cooling impact of volcanoes is added, the combined effect for the past two and possibly the past four decades, is negative.

For those, like astrophysicist Professor Sally Baliunus of Harvard[2] who insist that variations in solar activity are enough to explain all the warming of the past century, all the models used by the IPCC not only factor in such variations, they also show unequivocally that the enhanced warming from human activities swamps the ups and downs in surface temperature caused by solar activity.

'As the situation stands, we are currently embarked on the more extreme of the emissions scenarios, with all the potential for catastrophic climate change.'

Could natural variability, internal to the climate system, be of a sufficient magnitude to have resulted in the global warming that we have experienced over the past few decades? The IPCC realises the vital importance of detecting a real signal of climate change against chance fluctuations and, on the basis of models that factor in the dynamic interactions of the different components of the climate system, it concludes that 'the warming over the past 100 years is very unlikely to be due to internal variability alone'. Again, in the same cautious language, the IPCC points out from reconstructions of climate over the past 1,000 years, that 'this warming is unusual and is unlikely to be entirely natural in origin'.

Taking all the evidence into account, the IPCC concludes, 'most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations,' which is 'attributable to human activities'.

### Turning up the heat

But what about the future? What does the IPCC predict? Just as it had to revise upwards the actual warming of the latter part of the 20th century, compared to what it had predicted a few years previously, is it also predicting greater increases in temperature and therefore greater impacts than it did in 1995?

In its latest report, to predict future trends, the IPCC has used a range of 35 different scenarios reflecting different estimates of rates of economic growth, types of growth, the energy technology used to fuel that growth, population numbers and whether global or local development initiatives are applied. The greenhouse gas emission consequences of

those different scenarios are then fed into climate models that have been calibrated to give equivalent responses in temperature and sea-level rise (following the melting of ice cover and the thermal expansion of sea water). The range of predictions therefore reflects projections for different modes of development. While some of those modes lead to a flattening out of greenhouse gas concentrations in the atmosphere and hence of surface temperatures, others show a steep rise in $CO_2$ emissions and hence in atmospheric levels of the gas.

A scenario in which fossil fuels remain the prime source of energy gives rise to nearly 1,000 parts per million by volume (ppmv) of $CO_2$ in the atmosphere by 2100, even with some energy conservation (compared with the 280ppmv of the pre-industrial era and the 370ppmv of today). A scenario in which energy conservation and recourse to alternative energy systems is aggressively followed will lead to a state in which the $CO_2$ content of the atmosphere is stabilised at 540ppmv, double that of pre-industrial times.

The high-emission scenario indicates an increase in temperature of 5.8°C over 1992 levels by 2100. The scenario in which we use less energy shows a rise of 1.4°C by 2100. We also see a similar range in sea level rise, with the upper range scenarios leading to a projected 0.09m rise by 2100, and the lower range, about 0.01m.

As the situation stands, we are currently embarked on the more extreme scenario, with all its potential for catastrophic climate change. That makes it all the more critical that we take action now to curb emissions – without question we would gain immeasurably just from stabilising climate at a point close to current values.

The new emissions scenarios and their consequences reveal a substantially greater warming compared with that of the IPCC's 1995 Second Assessment Report, which projected a temperature increase in the range of 1–3.5°C.

## The full impact of our emissions is not felt for 20 years

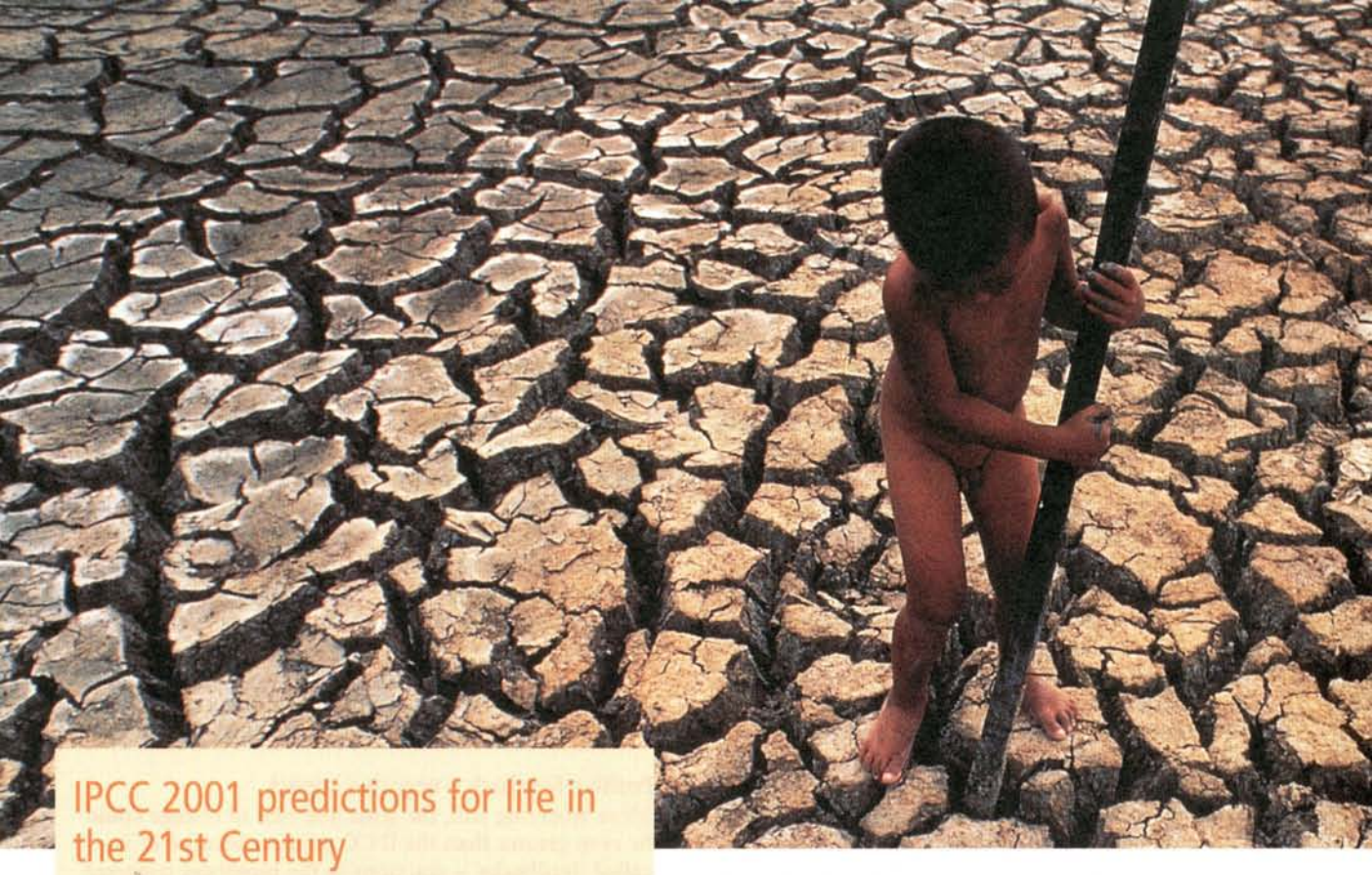
Recent evidence shows that a significant proportion of the sun's heat arriving at the earth's surface is absorbed by the oceans before passing back into the atmosphere about 20 years later, an effect which to date has not been properly included in climate models.[6]

This means that as we pump greenhouse gases into the atmosphere today, we are committing ourselves to warming which will only fully be felt in two decades time. Even if the Earth's overall energy budget was held at current levels, the global mean surface air temperature would still rise an extra 1°C. It is estimated that by 2060, the warming commitment will have doubled to 2°C, thereby adding to the surface heat that we will already be experiencing.[7]

### Positive feedback – negative impact

More worrying still, the scale and rate of change could be even greater than the IPCC predicts because of so-called 'feedbacks' – reactions in the biosphere triggered by a changing climate. These feedbacks could go both ways. As temperatures rise and precipitation changes, living organisms could respond by releasing carbon from soils and biomass – thus adding to the warming effect. On the other hand, in some instances, organisms could take up carbon – through the spread of boreal forests to higher latitudes, for example.





STILL PICTURES

## IPCC 2001 predictions for life in the 21st Century

- A general reduction in potential crop yields in most tropical and sub-tropical regions for most projected increases in temperature.
- A general reduction, with some variation, in potential crop yields in most regions in mid-latitudes for increases in annual average temperature of more than a few degrees.
- Decreased water availability for populations in many water-scarce regions, particularly in the sub-tropics.
- An increase in the number of people exposed to vector-borne disease such as malaria, and water-borne diseases such as cholera, and an increase in heat-stress mortality.
- A widespread increase in the flooding of many human settlements (tens of millions of inhabitants in settlements studied) from both increased heavy precipitation events and sea-level rise.

As the IPCC says: 'More people are projected to be harmed than benefited by climate change, even for global mean temperature increases of less than a few degrees centigrade.'

The IPCC's scenarios include feedbacks between the land and the ocean, but still neglect potential feedbacks between terrestrial vegetation and soil micro-organisms and climate. Even so, the models suggest that even after several centuries, approximately one quarter of the increase in $CO_2$ concentration caused by our emissions will still be present. But how much $CO_2$ gets drawn down out of the atmosphere or released depends crucially on the biosphere – which the IPCC pays little attention to. Forest die-back and permafrost melting – resulting from higher temperatures – have the potential to release at least as much carbon into the atmosphere, in the form of $CO_2$ and methane, as is currently there, doubling the atmospheric concentration in one stroke.

And those same feedbacks, by causing additional warming, are likely to cause less carbon uptake overall compared with today. Therefore, as our emissions increase, proportionately more $CO_2$ will accumulate in the atmosphere and take longer to leave. A warmer ocean holds less $CO_2$ compared with a cooler one, and warmer soils will have more respiratory activity, so 'burning up' carbon (instead of storing it) as soon as it accumulates.

The IPCC has tried to encompass that which it cannot yet measure with any certainty by assuming that at best the biosphere will reduce atmospheric levels of $CO_2$ by 10 per cent, and at worst cause levels to rise by 30 per cent. Consequently, atmospheric $CO_2$ could vary from 490ppmv for curbed emissions at the bottom range to 1,260ppmv for unrestrained emissions at the upper range (four times pre-industrial levels).

According to Jerry Mahlman, director of the Geophysical Fluid Dynamics Laboratory, the consequences of the unrestrained emissions scenario could be a temperature rise of 10–14°C compared with today. Such an increase in greenhouse gases would generate untold changes to global climate. It would lead to droughts on an unprecedented scale, damaging torrential rain, longer lasting heat waves, the wide-scale spread of pests and disease to over-stressed systems, and devastating storm surges and cyclones in low-lying delta regions such as in Bangladesh. Against that background of destabilised climate, we would somehow be seeking to feed a population at least double today's.

As *The Ecologist* stated in its special issue on climate change of 1999 (Vol 29/2), the response of the biosphere to global warming is clearly critical to any analysis. Any models need to reflect the interactions between all the factors that impinge on climate. To some degree, the IPCC admits to its current ignorance. It therefore sees the projected climate changes during the 21st century as having: 'the potential to lead to future large-scale and possibly irreversible changes in Earth systems resulting in impacts at continental and global scales.' Among these changes it cites

## Will we lose the Gulf Stream?

Most climate models indicate that the flow of warm Gulf Stream water (or thermohaline circulation) up past Northern Europe will weaken as a result of global warming. According to the IPCC: 'Beyond 2100, the thermohaline circulation could completely and possibly irreversibly shut down.'

However, the IPCC claims that the loss of heat in Northern Europe brought about by a partial shutdown of the Gulf Stream during the course of this century will be more than made up by greenhouse gas-induced warming. However, this ignores the potential impact of the collapse of the Amazon rainforest (made more likely by Brazil's plans for developing up to 50 per cent of its share of the Amazon), which would lead to much less energy being transferred into the air circulation system in the equatorial region. The combination of a faltering Gulf Stream and the loss of the rainforest is therefore likely to lead to polar air from the Arctic pushing further south. Were that to occur, temperatures will undoubtedly be lower, especially in the winter months, and Britain would experience a significant drop in rainfall.

'significant slowing of the ocean circulation that transports warm water to the North Atlantic, large reductions in the Greenland and West Antarctic ice sheets, accelerated global warming due to carbon cycle feedbacks in the terrestrial biosphere, and releases of terrestrial carbon from permafrost regions and methane from hydrates in coastal sediments'.

However, the IPCC then states, 'these possibilities are very climate scenario-dependent and a full range of plausible scenarios has not been evaluated,' and concludes, 'the likelihood of many of these changes in Earth systems is not well-known, but is probably very low'.

### Hadley Centre forecasts a more troubled future

Since life is so heavily implicated in what goes on in the atmosphere, (both in generating it in its current form and, through the hydrological cycle, playing a powerful role in the transfer of energy from the equator to the poles), it would seem that the IPCC is flying in the face of reason in its downplaying of the feedbacks involving the biosphere.

However, recent climate models developed at the Hadley Centre of the UK Met Office, one of the world's leading centres on climate research, indicate that feedbacks involving the biosphere play a truly significant role in creating climate and could lead to temperature rises by 2100 that are significantly higher than those projected by the IPCC.[3]

Peter Cox and his colleagues at the Hadley Centre find that feedbacks between terrestrial vegetation and climate are likely to accelerate global warming. As they pointed out in *Nature* (9 November, 2000): 'General circulation models have generally excluded the feedback between climate and biosphere, using static vegetation distributions and $CO_2$ concentrations from simple carbon-cycle models that do not include climate change.' In contrast, the Hadley Centre's 'fully coupled, three-dimensional carbon-climate model... indicates that under a 'business-as-usual' scenario, the terrestrial biosphere acts as an overall carbon sink until about 2050, but turns into a source thereafter'.[4]

The Hadley Centre's coupled carbon-climate model indicates an atmospheric concentration of $CO_2$ for the present that differs little from the IPCC's standard upper-range projection. But as feedbacks kick in, the two models begin to diverge. Twenty years from now, even without any cutting down of the rainforest, the Amazon forest begins to die-back as Amazonia begins to warm and dry out. The net result is that South America as a whole begins to lose carbon to the atmosphere. Then, after 2050, the land

## On the cusp of a climate flip?

More than 100 million years ago, Wyoming was covered in rainforest. Today its 'badlands' show a devastated landscape of eroded hills devoid of soil and vegetation. A historical study of the climate indicates a sudden drastic drop in rainfall coinciding with a sharp rise in temperature. Wyoming's badlands never recovered.

The Amazon Basin could now suffer a similar fate. Precipitated by the inexorable rise in man-made emissions of greenhouse gases (causing rainfall to falter and fail in a succession of drier and drier years), and deforestation, the Amazon could become not just the 'badlands' of our generation, but worse still, could trigger runaway global warming.[8]

We now know that the Amazon rainforest (which currently absorbs as much as one-tenth each year of the total carbon we emit) has collapsed before, liberating billions of tonnes of accumulated carbon back into the atmosphere. According to the models of Peter Cox and his colleagues at the Hadley Centre, we are little more than half a century away from such a scenario if current trends of greenhouse gas emissions remain unchanged. A temperature rise of only 2°C is all that is required to turn rainfall patterns upside down, leaving the Amazon dry, and prone to all-consuming fires that will sweep across thousands of kilometres.

But that's not all. Over thousands, if not millions of years, organic carbon run-off from terrestrial vegetation gets washed into the oceans, settling out over continental shelves where bacteria convert that organic carbon into methane (a greenhouse gas many times more powerful than $CO_2$). Because of high water pressure and low temperatures, much of that methane, about 10,000 billion tonnes of it, remains trapped as methane hydrate (a form of crystal), unless temperatures around it rise enough for it to become unstable, whereupon it bubbles out: a potential climate bombshell.

The discovery of jagged temperature peaks in the climate record (from sediment core data) over the past 100 million years, mirrored in extraordinary fashion by flushes of methane and $CO_2$, give us a glimpse into what could happen now. In a few decades, surface temperatures could soar by 10°C or more.

According to the geologist, Euan Nisbet, we are already beginning to see methane emissions from the oceans (and also from permafrost and peat bogs – in the UK carbon emissions from peat have gone up by 65 per cent in just over a decade).[9] We could be just at the beginning of runaway carbon releases – a fact that does not feature in the IPCC's predictions. It is clear, therefore, that we have no choice, if we want to survive, but to keep those emissions down and do all in our power to protect those life-saving tropical forests.

**TROPICAL FORESTS OF THE AMAZON WILL DIE BACK AND DISAPPEAR BY 2050 BECAUSE OF WARMING AND>>**

biosphere as a whole switches from being a weak sink for $CO_2$ to becoming a strong source. Even though increased concentrations of $CO_2$ in the atmosphere stimulate photosynthesis, particularly in temperate regions, any such gains are more than offset by increased respiration from soil organisms and from vegetation owing to the maintenance costs of resisting higher temperatures.

Even though land as a whole may have accumulated some 75 billion tonnes of carbon (GtC) between 1860 and 2000, during this century, as much as 170 GtC may be vented back into the atmosphere. As a result, the modelled $CO_2$ concentration approaches 1,000ppmv by 2100 which is 250ppmv higher than that predicted in the 'business-as-usual' scenario of the IPCC. The carbon cycle model also results in higher global average temperatures, over 8°C up on 1860 by 2100, compared to the 5.8°C of the IPCC.[5]

### Climate change could be worse still

This latest work is a salutary reminder of the limitations of climate models that do not include life in the dynamics of energy transfers across the planet. Yet, for all that Cox and Betts and their colleagues have now begun to include life, and are obtaining such important results, it must be appreciated that they can include only those factors that can be quantified with the current state of knowledge.

Uncertainties, such as the venting of methane from permafrost as it melts or from oceanic deposits of methane hydrates as they warm are not yet incorporated into the

## Back to the Future:

### what ice and sediment cores tell us about climate change today

One way to view the future is to obtain data from the distant past, for if we continue to burn fossil fuels and deforest at the current rate, within a century we might find ourselves with greenhouse gas concentrations in the atmosphere and surface temperatures similar to those of that ancient past.

Fifty million years ago, the planet had little ice, yet global temperatures were on average no more than 5°C warmer than today – slightly less than the upper bound of temperature rise that the UN Intergovernmental Panel on Climate Change (IPCC) projects for 2100. Equally relevant, $CO_2$ levels in the atmosphere were probably no higher then than the IPCC has projected as a strong possibility for 2100.

For those still unconvinced about the severity of the problems we would encounter if temperatures and $CO_2$ levels rise in this way, it is worth remembering that 50 million years ago sea-levels were several hundred feet higher than they are today. Most of that water is now ice in Antarctica and Greenland – 6 metres of sea level equivalent is currently locked away in the Greenland ice sheet, 6 metres in the relatively small and unstable West Antarctic ice sheet, and 60 metres in the huge East Antarctic ice sheet.

Were these ice sheets to melt, vast areas of the planet – including Denmark and large parts of eastern Britain and Holland – would vanish in their entirety. It would be a world in which we would have considerable difficulty surviving, not least because of extreme weather conditions, which, combined with the loss of huge areas of cropland, would play havoc with food production.

But, given that we only have records of surface temperatures and precipitation patterns going back a few centuries at best, how can we know what the Earth's climate was like hundreds of thousands, if not millions of years ago?

That is where the Antarctic comes in, not only because of its 2,400-metre-thick cap of ice, which covers 14 million sq km, but also because of sediments off the land mass at Cape Roberts in the Ross Sea. The ice, like that drilled at the Russian Base, Vostok, yields information going back 400,000 years on temperature, $CO_2$ content and sea-level. One of the revelations about those 400 millennia from the analysis of gas bubbles in these ice cores is that throughout this period there is a strong association between temperature and $CO_2$ levels – they rise and fall together – confirming that the 'greenhouse effect' of rising levels of heat-trapping gases causing temperatures to climb is not just theory.

Analysis of Antarctic sediments allow us to look even further back into the past. The sediments overlying Beacon sandstone of the Devonian age are 1,500m thick and date from 34–17 million years ago until the present. Drilling 100m into the underlying sandstone, meanwhile, takes one back still further, to beyond 100 million years ago.

Peter Barrett, from New Zealand's Antarctic Research Centre at Victoria University, has been part of a team of some 55 scientists from Australia, Britain, Germany, Italy, Netherlands, New Zealand and the US, who investigated the sediments. As he points out in *New Zealand Science Review*, sediments are important because ice-core records can take you back only so far, and nothing in the ice-core history shows $CO_2$ levels in the atmosphere as high as we are likely to reach in a few decades. 'Global climate, even in 50 years' time,' he says, 'may be warmer than the Earth has experienced in the past 12 million years.'

From fossils in sediments, as revealed by tree stumps, leaves and coal seams, we know that 200 million years ago Antarctica was covered in forests and swamps. Antarctic temperatures then were at least 15°C warmer than today and, consistent with that, average global temperatures were some 7–8°C warmer than now.

Two distinct factors may have been responsible, then, for a warmer, vegetation-covered Antarctica. During the Cretaceous and Early Cenozoic periods, between 136 and 54 million years ago, we know that atmospheric levels of $CO_2$ were high, and certainly responsible for part of the warming. Also, at that time, Antarctica was still part of the supercontinent of Gondwanaland. Once that continent began to break up, Antarctica became increasingly cut off by a strong polar air circulation system and consequently a cold circumpolar ocean current.

As a result, the first ice-sheets formed over Antarctica 34 million years ago, and then, as the Earth cooled still more, some 2.5 million years ago, the ice-sheet formed for the first time over Greenland in the northern hemisphere. From then on, we have had ice ages affecting both poles.

Since the Arctic has never been as isolated as Antarctica, greenhouse gas concentration was probably a critical factor in its

>>>DRYING UNLESS EMISSIONS ARE REDUCED.....THE ARCTIC PERMAFROST (WHICH CONTAINS ABOUT 14

models. These are significant omissions as they comprise large potential sources of carbon, more than enough, in fact, to double or triple atmospheric concentrations.

Other omissions include the impact on climate of human-induced land-use changes, such as deforestation and the displacement of people onto marginal lands through the machinations of agribusiness. Brazil's aid-assisted plan, Avança Brazil, for example, aims to convert half of its share of the Amazon into industrialised agriculture, taking no account of the dynamics of the Amazon Basin in which the forest is a self-sustaining system surviving through recycled rain from evapo-transpiration. As of now, we do not know the critical point of collapse. Even were Brazil to stick absolutely to its plan, that degree of forest destruction may be more than enough to bring about the forest's total collapse. Such a possibility, however, is not included in any climate model.

Nevertheless, the Hadley Centre's findings are of crucial importance: they tell us that a climate model that does not integrate the impact of life on the processes of energy exchange between the atmosphere and the earth's surface is inadequate. Over and above that, their findings provide us with a stark warning about the consequences that will befall us if our behaviour remains unchanged, leaving us with only one sensible strategy: to act now to minimise those runaway impacts that could make our planet uninhabitable.

*Peter Bunyard is science editor of* The Ecologist. References on page 50.

impact on surface temperature. An additional factor was the degree to which the warm waters of the Gulf Stream penetrated into the Arctic Circle. At the other pole, in all probability, the cold circumpolar current contributed most to the chilling of Antarctica, in which case it might take more than elevated $CO_2$ levels to bring about a complete melting of the Antarctic ice-sheet.

Yet, as the ice-core data shows, the expansion and retreat of the ice-sheet during the glacial and inter-glacial periods have always been associated with swings in temperature that themselves correlate closely with levels of $CO_2$ in the atmosphere, and changes in sea-level. Some 18,000 years ago, when the last ice age was at its most intense, $CO_2$ levels were 30 per cent below 1900 levels and sea-level was 120m below present sea-level. That should warn us that whatever regulates greenhouse gas concentrations in the atmosphere could have profound effects on climate.

In fact, we do not know which triggered which in the past: whether higher $CO_2$ concentrations in the atmosphere triggered temperature rise or whether temperature rise triggered higher $CO_2$ concentrations. In all likelihood, one affected the other. But we do know that the initial cause of changes in temperature and greenhouse gas concentrations in the past was almost certainly the changing obliquity and eccentricity of the Earth's orbit and the movement of the Earth from side to side (known as the Malenkovitch Wobble) which together determine changes in the pattern of solar energy reaching the Earth.

The Antarctica data are the best record we have showing correspondence between the retreat and then re-establishment of the ice sheet in relation to the Earth's orbit around the sun. Until 800,000 years ago, the glacial cycle lasted some 40,000 years, but then lengthened into the current 100,000 cycle. The two periodicities, 40,000 years and then 100,000 years happen to conform respectively to orbital changes.

But orbital changes take place over millennia and cannot explain the sudden changes in climate we are now experiencing in one century. Today, it is human activity – with the burning of fossil fuels and the destruction of carbon-absorbing soils and forests – which is filling the atmosphere with greenhouse gases and causing temperatures to rise and the climate to change. As Peter Barrett says: 'Changes in Earth's climate of this speed and magnitude are unprecedented to our knowledge, aside from large meteorite impacts.'

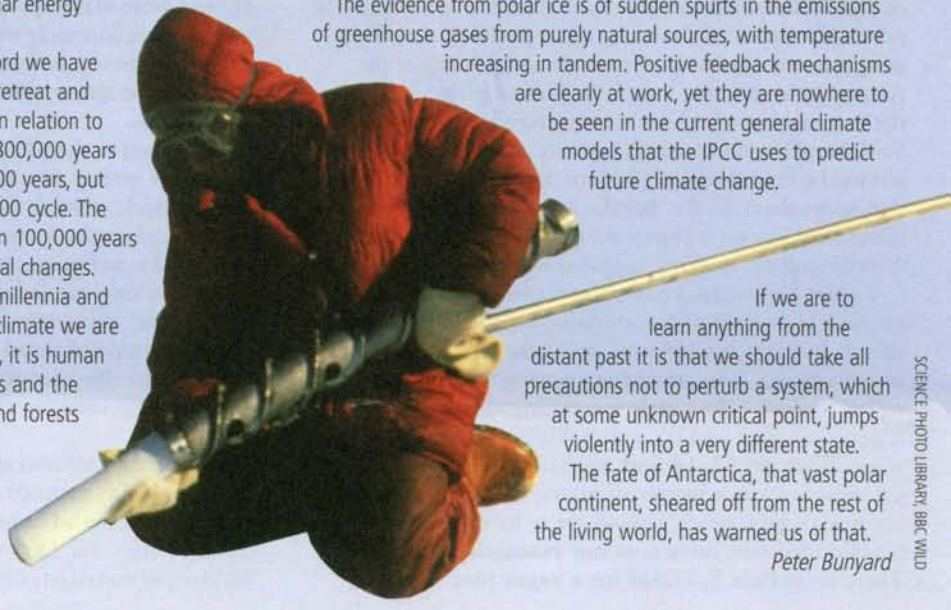
Nevertheless, the impact of orbital changes in the past are still relevant because of how ice-core records tell us life responded to them. In the past, life seems to have taken advantage of the changing conditions, either embarking on a spate of photosynthetic activity, which deposits organic carbon, or, suddenly embarking on a feverish burning up of the surplus carbon store. These clues from the past suggest that we should expect even more dramatic changes in climate than suggested by the forecasts of the IPCC.

Of particular importance is the climate-modulating role of certain plankton – namely coccolithophores – which contribute significantly to the cooling of the Earth's surface, especially over the oceans, by forming clouds which reflect sunlight and by drawing down $CO_2$ in photosynthesis, depositing it as calcium carbonate on the ocean floor.

As the ice-core record shows us, the periods when plankton are thriving correlate with the occurrence of ice ages and with falls in atmospheric $CO_2$ concentrations. When phytoplankton activity is depressed, which appears to be correlated with warm inter-glacial periods, then $CO_2$ levels rise.

The lessons for us now are instructive. If, as ice core records reveal, plankton activity is at a peak when the climate is colder, we can expect rising temperatures today to trigger a decline in phytoplankton activity, causing temperatures to rise still further.

The evidence from polar ice is of sudden spurts in the emissions of greenhouse gases from purely natural sources, with temperature increasing in tandem. Positive feedback mechanisms are clearly at work, yet they are nowhere to be seen in the current general climate models that the IPCC uses to predict future climate change.



Extracting an ice-core sample in Antarctica

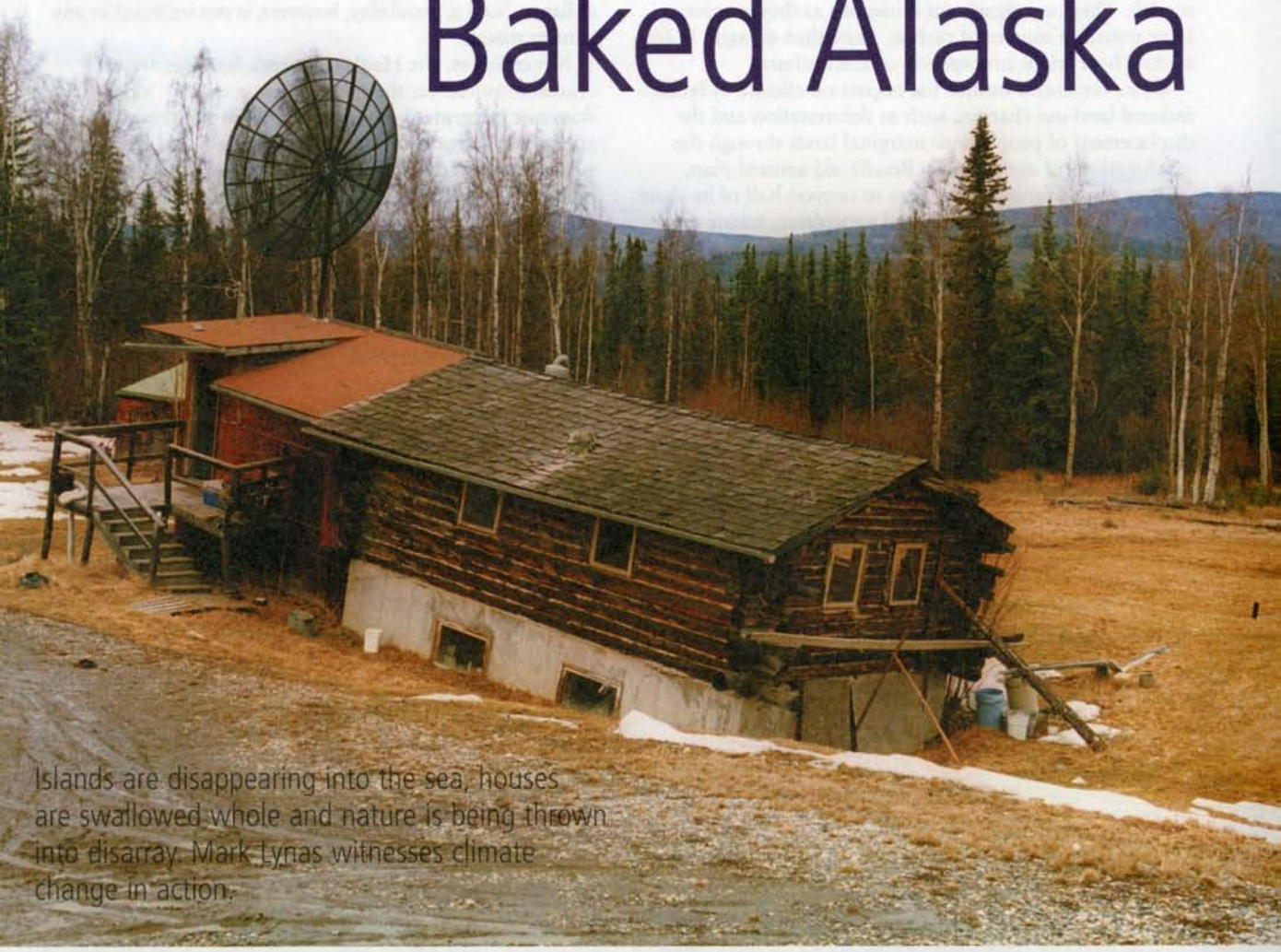
SCIENCE PHOTO LIBRARY, BBC WILD

If we are to learn anything from the distant past it is that we should take all precautions not to perturb a system, which at some unknown critical point, jumps violently into a very different state. The fate of Antarctica, that vast polar continent, sheared off from the rest of the living world, has warned us of that.

*Peter Bunyard*

PER CENT OF THE CARBON STORED IN THE WORLD'S SOILS), AND WHICH USED TO STAY FROZEN ALL YEAR>>>

# Baked Alaska



Islands are disappearing into the sea, houses are swallowed whole and nature is being thrown into disarray. Mark Lynas witnesses climate change in action.

Robert Iyatunguk taps gently at the base of the cliff with his foot. Icy soil crumbles away. 'You see that,' he says. 'We're living on a timebomb. This island is nothing but an iceberg covered in sand.' The 600 residents of Shishmaref – almost all Inupiat Eskimos – live on a half-mile-wide spit of land sticking out into the ocean off the west coast of Alaska. It's a mere 20 miles south of the Arctic Circle and only a short hop away from Siberia. In the autumn, strong storms roar in from the Bering Sea and Shishmaref's residents sleep uneasily as the northwest wind scours the tundra outside. It's not just the noise of the sea that keeps them awake, but the knowledge that the very island they live on is slowly disappearing beneath them. And the culprit, it seems, is global warming.

Robert Iyatunguk knows the problems better than anyone. He's erosion co-ordinator for the village, and spends his days tracking the speed the island is disintegrating. 'The storms are getting more frequent,' warns Robert. 'The winds are getting stronger, the water is getting higher and it's noticeable to everybody in town. If we get 12–14 foot waves this place is going to get wiped out in a matter of hours. We're in panic mode because of how much ground we're losing. If our airstrip gets flooded out, there goes our evacuation by plane.' There is no Plan B, except for a vague idea to get everyone out of their houses and into the church, the village's highest building. There, they'll just have to wait and hope. It nearly happened back in 1997, when a storm struck the island with such ferocity that fifty feet of land were washed away literally overnight. Three houses were lost over the edge of the cliff, and nine more had to be moved further away from the edge – one at the height of the storm, whilst freezing 50mph winds lashed the rescuers.

According to the villagers, the problem isn't only that storms are getting stronger and more regular, but that the sea ice which protects the island during the winter months is forming later in the year. Clifford Weyiouanna, a life-long Shishmaref resident and an expert hunter, has spent weeks at a time out living on the ice, and knows the wind and weather intimately. 'The currents have changed, the ice conditions have changed, and the freeze-up of the sea has got later too. We used to freeze up by the last part of October. This last year we didn't freeze up until Christmas.'

The changes are also affecting the village's food supply. The community depends on the 'subsistence' food that hunters like Clifford bring in – seals, fish and walrus are dietary staples. But the animals are changing too. 'Last year we covered thousands of miles by boat to get walrus,' recalls

ALL PICS: KAREN ROBINSON

>> ROUND, IS ALREADY BEGINNING TO RELEASE CARBON AS IT THAWS.....THE WORLD'S CORAL REEFS ARE

Clifford. 'But only one boat was successful – otherwise we got nothing.' Even the ice they hunt on in winter is no longer safe. 'Years ago we used to get big icebergs from the north, but not anymore – it's all young stuff, young ice we call it. It's only about a foot thick, whereas that ocean out there should be at least four foot thick right now.'

For Professor Gunter Weller, at the Center for Global Change and Arctic Systems Research in the Alaskan interior town of Fairbanks, all this is evidence of a rapidly changing climate. He points out that average temperatures statewide have risen by 3°C since the 1960 and 4.5°C in winter – a rate of warming that's 10 times greater than the rest of the world.

It's even happening on his own doorstep in Fairbanks, where the number of days with winter temperatures reaching –40°C has been reduced by half since the 1950s.

'We've seen great changes in temperature, but also in the physical environment,' he says. 'Glaciers are melting, permafrost thawing and the sea ice is reduced. We've seen a slow encroachment of the boreal forests northwards – so tundra is being slowly overtaken by forests. There are changes in the ocean – fish species get displaced, new fish species get introduced. We see changes everywhere.' He has also seen how climate change is affecting Alaska's native peoples: 'In some of the villages they are really concerned about these changes because their regular subsistence lifestyles have been affected.'

One such village is Huslia, where the local Athabascan Indian residents report drastic effects on the neighbouring wildlife and topography. Inside Cesa Sam's house, which also doubles as the village's video store, Tribal Administrator Lorraine Vent discusses the changes around the kitchen table. 'Two lakes outside town have dried up, whilst in the other lakes there are less fish,' she reports, whilst Cesa nods in agreement. The two women discuss the 'big change' the weather has gone through. 'I remember it used to be cold. Now we have really mild winters,' says Lorraine. 'There's only been one cold winter since '94,' adds Cesa. 'Last winter it only got down to 30 below a couple of times – and that's warm for us.' Lorraine laughs: 'It was even raining in December. The kids were so confused they didn't know what clothes to wear.'

Across the yard Cesa's parents, Wilson and Eleanor Sam are plucking geese, plunging them first into boiling water to make the feathers easier to remove. After many decades as a hunter Wilson has been spotting changes too. 'One guy shot a bear this spring and it was really skinny,' he says. 'There was no blueberries last summer – it was too dry.

## To drill or not to drill?

### Native peoples are divided over oil exploration in the Arctic National Wildlife Refuge

Almost every politician in Alaska wants to open up the Arctic National Wildlife Refuge (ANWR) to oil drilling. Now, with an oil-industry sponsored president in the White House, they are assured of a sympathetic audience in Washington. Indeed the state's top oil lobbyist, Cam Toohey, was recently appointed Interior Secretary Gale Norton's 'Special Assistant' in the state. Toohey's previous post was heading Arctic Power, the lobbying group which campaigns vociferously for opening up the ANWR. Although Arctic Power makes great play of the fact that it is predominantly funded by the State of Alaska, BP has also been pumping in cash. BP is the largest operator at the giant Prudhoe Bay oilfield on Alaska's North Slope, a source of state revenue so lucrative that every Alaskan resident receives a yearly dividend cheque totalling $2,000. According to Cam Toohey, 80 per cent of the state's revenues come from oil and gas exploitation.

Prudhoe Bay is now in decline – and BP has its eyes on ANWR's fragile coastal area, which is claimed by the industry to hold between 5.7 and 16 billion barrels of oil. It's a proposition which is supported by the Eskimo residents of the only village actually inside the reserve, the windswept coastal settlement of Kaktovik. Vice-mayor Nora Jane Burns is unequivocal: 'I'm for opening ANWR because it will offer jobs for our people and we'll have more school funding, instead of being cut. We'll have money for the children to have a better education.'

But on the southern side of the refuge, the Gwich'in Indians of Arctic Village don't agree. They fear that bringing drilling rigs onto ANWR's coastal plain will destroy the calving grounds of the porcupine caribou herd, on which they depend for meat, furs, and cultural survival. But it's not just the caribou they feel to be under threat. Indeed, the Gwich'in are some of the first Alaskans to link oil industry expansion with global warming. 'We're already going through extreme changes because of climate change,' declares spokeswoman Sarah James. Sometimes we get too much rain, sometimes no rain at all. A couple of years back we had a heatwave, and all the fish in a lake died from heat exposure.'

Back in 1988, the tribal elders called the whole Gwich'in nation together for an unprecedented meeting – people came from villages as far away as Canada, and agreed to oppose oil development. 'This is an emergency because of pressure from the Bush administration,' says Sarah James. 'The young people know it is their future.' And the young people are acting. During June they organised a Gwich'in Gathering, where again people from the whole tribe met to plan out the next stages in the battle against the fossil fuel corporations. But they also demonstrated the alternatives. In perhaps the first ceremony of its kind, there was a religious inauguration of the village's new solar panels. As the elders gathered solemnly round, the panels were spiritually dedicated to the village youth – a new technology for a new generation.

There are less geese too, and some of the good geese hunting spots, they're not good no more because all these lakes just dried up.'

The same problem is troubling Harold Vent, who is willing to give visitors an impromptu snowmachine tour to point out the most drastic changes. Standing in the middle of what used to be a lake, he points to the ground. 'All these lakes are drying out now. It's just grass left. My mum's got a summer camp down here – we used to paddle out to it on canoes, but now we've got to carry them the whole way.' The changes have affected the hunting too: 'We used to shoot muskrat off the bank here,' he explains. 'But everything is dry now so we can't get nothing. With beaver it's the same thing. There used to be a beaver house just over there, but it's all dried up now.' Farmer shakes his head. 'It's just getting harder and harder to live up here.'

It's not just native Alaskans who are noticing the 'big change'. Outside the hostel he runs in Fairbanks, Dale Curtis tends the first barbecue of the summer season. It's been another strange winter. 'Yeah, the weather patterns have been real different from when I was growing up as a boy,' he says. 'Now the animals don't know what to do. The moose take longer to go into their rutting season, the bear is coming out a lot earlier – it's real strange. Last year the bears were out early – they don't seem to know whether to go into hibernation or not. I was really struck this winter watching ducks swimming in the Chena river, in the dead of winter when they're supposed to be way down south already.' He turns over a rib and dabs it with barbecue sauce. 'You know a couple of years ago at Christmas it rained and melted all the snow away – it ain't right, you know.'

Drive around Fairbanks itself, and every couple of miles the road undulates up and down. Big cracks are opening up in the tarmac. Under the road the permafrost, a layer of icy ground tens of metres thick, is melting under the combined assaults of human disturbance and climate change. The collapsing highways are costing money – the state now spends about $30 million a year in permafrost-related road repairs. Buildings are suffering too.

On one residential street homes on both sides of the road are sagging as the ground beneath them sinks. In one of the worst-affected houses Vicki Heiker and her daughter Jessica have just about learned to live with wonky stairs, doors which no longer shut, and floors which are so steeply sloping a carelessly-placed tennis ball rolls down and bounces off the far wall. 'In my room all the furniture has to go at one end or it'll fall down,' says Vicki. She points around the living room: 'The bookshelf over there is supported by the couch. See those glass ornaments? One leg of the table is supported by a book, the other by some wood, the other two are on the floor. If it wasn't like that they'd all crash off.' Further up the road one wooden cabin has tipped so completely into a hole that it's no longer habitable. When most houses become this bad, the owners have no choice but to tear them down and start again.

At the nearby University of Alaska-Fairbanks, Russian-born scientist Vladimir Romanovsky is a world expert on permafrost and 'thermokarsts' – the dips which appear in the ground as the ice melts out underneath. When a huge hole opened up at the end of his mother-in-law's garden, Romanovsky immediately recognised it as a 'very nice' thermokarst. Workmen filled it in with ten truckloads of sand, but already this new material is sinking as if into a giant funnel.

'Permafrost thawing is definitely not a local process,' Vladimir says. 'It's right across Alaska, and we have evidence of the same thing happening in Siberia.' Around a nearby lake, trees lean over at crazy angles as the ground around them gives way. Even in the depths of the undisturbed forest, hundreds of trees have fallen over so far that they are knitted into one another – locked together in an embrace of death.

'"You know a couple of years ago at Christmas it rained and melted all the snow away – it ain't right, you know."'

Vladimir is unsure about the causes of these changes. But in the next-door building at the university, his colleague Gunter Weller entertains no such doubts. Gunter is probably the only town resident who drives a jeep with a sticker on the back window declaring: 'I'm changing the climate – ask me how'. 'Since I drive an SUV my wife made me put up the sticker,' he admits guiltily. But climate change itself is no joking matter: 'Yes, I think we should take this very seriously,' he says. 'We've seen signals that indicate that the climate is warming tremendously. Unless we do something about fossil fuel use then the climate impacts will become worse and worse.'

The official changes forecast for Alaska are dramatic. By 2100, temperature is projected to climb by up to 10°C; much of the tundra will disappear; Arctic sea ice will continue to decline, and could even disappear completely during the summer months. The polar bears, walruses, seals and sea mammals which live on the ice during the Arctic summer will be threatened with extinction. And coastal communities faced with increasing storm surges and erosion will lose their homes and have to relocate.[1]

As the storms roll in from the Chukchi Sea, Shishmaref's Robert Iyatunguk worries about the 'big one'. 'I'd hate to be here when it hits,' he says. 'But if my kids are here I'm going to be forced to stay.'

*Mark Lynas is a journalist and writer specialising in environmental issues. He is currently writing a book about the impacts of climate change on people around the world. Email: marklynas@zetnet.co.uk.* References on page 50.

>>>ON GROWING CROPS USING INDUSTRIALISED HIGH-INPUT SYSTEMS COMPARED WITH A SUSTAINABLE

# Is it too late to make a difference?

Peter Bunyard explores what it would take to put a brake on climate change.

PHOTODISC

The reaction of many to predictions for the coming century about climate change and its impacts is to feel overwhelmed by the sheer magnitude of the problem. They shrug their shoulders and say, 'it seems more or less inevitable now whatever we do'.

But is that the reality? Can we still make a significant difference to the extent of climate change if we summon the will to act to reduce the emissions that are responsible?

## Doing nothing

The worst of the impacts predicted by the UN Intergovernmental Panel on Climate Change (IPCC) and others will only take place if we fail to curb our greenhouse gas emissions and break the spiral of fossil fuel-based energy consumption within which we are now caught.

If we allow worldwide emissions to continue to double every 30 years, in line with energy usage, as astrophysicist Alberto di Fazio reports is now happening, we will exceed 1,000 parts per million by volume (ppmv) of $CO_2$ in the atmosphere by the end of the century – nearly four times pre-industrial levels, and nearly three times higher than levels are today.[1]

According to the UK's Hadley Centre, the average temperature increase across the planet would be more than 8°C compared with 1990, and double that in the polar regions. Temperatures would be as high as they were 40 million years ago, before Antarctica had a permanent ice-sheet.[2]

Clearly, such a future would be catastrophic. Sea-level rise by 2100 due to the thermal expansion of water and from melting glaciers and ice-caps would be nearly 1m higher than today, according to the IPCC's Third Assessment Report. A lot would be at risk given that the majority of the world's population lives along the flanks of oceans and some 30 per cent of the world's best croplands are in coastal plains.

Cyclones, storm surges, hurricanes and a sea with waves generally higher than they were 30 years ago would cause havoc to coastal areas, decimating cities, settlements and agriculture. The potential damage could amount to tens of billions of dollars a year for vulnerable countries such as Egypt, Vietnam, Bangladesh and Poland.

Heat waves and drought would also have a heavy toll. One-third of the world's population currently live in countries that are water-stressed. 'This number is projected to increase to around 5 billion by 2025, depending on the rate of population growth,' states the IPCC.

Meanwhile, over 4 million sq km of vegetation would die back within 100 years – practically equivalent to the whole of the Brazilian Amazon – leading to a massive venting of carbon into the atmosphere – as much as 1 billion tonnes of carbon within a century. This would also mean that net uptake from the atmosphere would decrease by a significant amount, hence adding to the total remaining behind, further accentuating global warming.[3]

This could all happen within a century from now – if we do next to nothing to curb our growing emissions.

## Partial curbs

The extent and severity of the impacts would be lessened somewhat if we were to stabilise concentration levels of

FARMING SYSTEM..... HAD ALL THE INDUSTRIALISED COUNTRIES AGREED TO ABIDE RIGOROUSLY TO >

$CO_2$ in the atmosphere at 750ppmv – twice the level they are today. To achieve that, the UK's Hadley Centre says we would need to reduce global emissions by half from where they are now by 2270.

At that level, the temperature increase would be just over 3°C and the sea would have risen 40cm in a century's time. The IPCC points out that that would cause 200 million people a year to suffer from flooding, up from 75 million a year today. Moreover, sea-levels would keep on rising over the next 900 years to 1.5m higher than today, as water in the oceans would carry on warming and expanding.

'The higher the concentration targets we accept, the larger and faster the rises in temperature and sea-level will be, with much greater consequences for life.'

Stabilisation at 750ppmv would also cause as much as 3 million sq km of vegetation to die back over 200 years. We would therefore undoubtedly suffer similar consequences as in an unmitigated emissions scenario, but to a slightly lesser degree.[4]

The impacts would be lessened slightly further if we were to stabilise levels of $CO_2$ in the atmosphere at 550ppmv – one-and-a-half times the level they are today – which would require reducing global emissions by about 80 per cent by 2100. That is the level which the UK's Royal Commission on Environmental Pollution in its report, *Energy – The Changing Climate*, believes 'should be regarded as an upper limit that should not be exceeded'.[5]

According to the UK Met Office, stabilisation at 550ppmv will lead to a committed warming of 2°C over the next 150 years, leaving us with a temperature that still would not have been exceeded for 38 million years. Sea-level would still rise on average by 40cm over the next century and the Gulf Stream circulation (which keeps Northern Europe warmer than it otherwise would be) would become weaker over the next 50 years, but would rebound back to its original strength from then on. The models also indicate that stabilisation at 550ppmv would prevent the Amazon Basin drying out to the point of die-back, but would still lead to about 1 million sq km of global vegetational die-back over 250 years.

Moreover, the latest climate models which incorporate some of the dynamics between life and climate change, indicate that previous models (such as the IPCC's) underestimate the temperature increase and the impacts that would follow. The perturbations resulting from stabilising $CO_2$ levels at even 550ppmv, therefore, could be far greater than is evident now.

## Radical cuts

Given such a prospect, the most sensible strategy would seem to be to curb our emissions of greenhouse gases as rapidly and radically as we can, with the aim of keeping atmospheric $CO_2$ concentrations as close to current levels (of 370ppmv) as possible.

That would require cuts in $CO_2$ emissions of 80–90 per cent within 50 years. It would necessitate a Herculean effort to improve energy efficiencies, reduce overall energy use, install alternative technologies for electricity generation and transport and move away from industrialised agriculture, which damages soils and releases carbon.

In return, further temperature rise, and hence damage to human communities and wildlife, would be minimised. So too would the risk of triggering feedbacks, which could dramatically increase global warming and cause climate change to spiral out of control, or, in the case of the UK and northern Europe, lead to the collapse of the Gulf Stream (the ocean current that normally brings warmth to our shores) and hence bring about a sudden freezing.[6]

But because it would still mean stabilising $CO_2$ concentrations in the atmosphere at about 30 per cent above pre-industrial levels, some climate change would still take place. At today's levels, we are already experiencing turbulence to the global climate system. Storms in the North Atlantic are getting fiercer, winds stronger, waves bigger. Unprecedented floods – like those that afflicted Orissa during India's 2001 monsoon and the UK during the winter of 2000–2001 – are becoming increasingly common. According to the Red Cross, floods, storms, landslides and droughts have doubled from their 200–a–year tally before 1996. The cost of natural disasters in 1999 (85 per cent of which were weather-related) amounted to $70 billion. Recent evidence has shown too that the Gulf Stream is already weaker and less steady than it was. Over the past 30 years, scientists have measured a 20 per cent fall in the cold, dense water flowing across the Faroe Bank Channel.[7]

Also, because of the lag in the climate system, our emissions of the past have yet to make themselves fully felt, so even if we suddenly experienced a massive collapse of the global economy and emissions stopped tomorrow, we could expect at least a 1°C rise over the century as the oceans gradually release the heat they have accumulated. Sea levels would also still rise by about 1 metre over hundreds of years.

But clearly, stabilising concentrations as close to today's levels as possible would ensure that climatic changes happened over a much longer period of time than would otherwise be the case, providing human and wildlife communities with a much greater opportunity to adapt.

## All to play for

Therefore, we do have a choice. The higher the concentration targets we accept, the larger and faster the rises in temperature and sea-level will be, with much greater consequences for life. What will actually happen is up to us. But if we allow the inadequate nature of the political response to the challenge of climate change to remain as it is, and if the paltry emissions reduction targets agreed under the Kyoto Protocol (which would effectively require no cuts below 1990 levels at all) remain unrevised, the chances of keeping levels close to current concentrations seem minimal, given the radical changes that would be required.

Bert Metz, co-chairman of the mitigation group of the IPCC, believes the best we can hope for is to stabilise carbon dioxide levels in the atmosphere at 450ppmv. 'Even 450ppmv is not safe,' he says, 'but if we do not take action,

>>THE ORIGINAL TARGETS OF THE KYOTO PROTOCOL, THE OVERALL DIFFERENCE IN PROJECTED GLOBAL

it will go higher and higher, up to 1,000ppmv in some estimates. That would be very, very dangerous for the human race.'[8]

The stakes could not be higher. We have no more time to fritter away in talk. In the words of Bert Metz: 'Five to 10 years' delay in cutting greenhouse gas emissions could put the job of stabilising the atmosphere beyond reach.'

If that were to happen, the planet would be well on its way to becoming a human-free zone.

*Peter Bunyard is science editor of* The Ecologist. References on page 50.

## Ask the experts: *at what level should we stabilise atmospheric $CO_2$?*

The task of identifying a target level at which we should aim to stabilise atmospheric concentrations of $CO_2$ is of growing urgency to those concerned with climate change. As Michael Zammit Cutajar, Executive Secretary of the United Nations' Framework Convention on Climate Change (UNFCCC), said before July's COP6 climate change talks in Bonn: 'I believe that the political process on climate change would be greatly assisted by agreement on a target for atmospheric concentrations, at least an intermediate target. This would give a sense of where the whole international community should be heading and a basis for apportioning responsibility for getting there.'[1]

*Ecologist Report* contributor Matilda Lee asked three of the world's leading climatologists to give their opinions on what level they thought we should aim to stabilise atmospheric concentrations of $CO_2$ and why.

**Peter Cox, Climate/Carbon Cycle Modeller, Climate Research Department, Hadley Centre, UK MET Office:**

'I think we should certainly avoid exceeding 550ppmv (about double pre-industrial levels). This is the point, in our model, at which the land biosphere stops slowing climate change and starts to accelerate it (by becoming a source rather than a sink for $CO_2$). The main reasons for this occurring in our model are: (a) a climate change-driven die-back of the Amazon rainforest, (b) release of soil carbon due to accelerated breakdown of soil organic matter at high temperatures. Although both of these processes are uncertain, based on our current knowledge I would advise against gambling with such a potentially strong positive feedback.'

**Mike Hulme, Executive Director, Tyndall Centre for Climate Change Research, University of East Anglia, UK:**

'I do not believe we have any sure basis for establishing what a 'non-dangerous' level should be. This is because what 'dangerous' is depends on what measures are taken to adapt to climate change. In one assumed future world 550ppmv may be 'safe', but 'dangerous' in another. The basis for establishing 'danger' is contested. One could argue that 'dangerous' climate change is change in climate that leads to the death of just one person; or argue that some cost/benefit ratio should be used; or argue that if a sovereign state is extinguished (eg a pacific atoll nation) then that is the definition of 'dangerous'. I do not believe we can arbitrarily choose 550ppmv or 650ppmv, as done in many scientific pronouncements, and claim that is our target. This can only be done by using the instruments of social and political discourse on an international scale. What we can say is that the higher the concentration of $CO_2$ reached, the greater the likely risks associated with that concentration will be. But this is a relative argument, not an absolute one.'

**Robert T Watson, Chairman, Intergovernmental Panel on Climate Change:**

'Unfortunately I will not be able to respond to your request. Establishing the appropriate level to stabilise the atmospheric concentration of $CO_2$ is not a scientific issue alone. The level must be established through a socio-political process, informed by scientific, technical and economic information. The IPCC has consistently taken the position that it will not and must not specify a specific stabilisation target for $CO_2$ (which will vary depending upon the stabilisation level of the other greenhouse gases.) This is because what is considered dangerous by one group of people may not be considered dangerous by a different set of people. My view is that the scientific community must inform policy-makers as to the implications of different stabilisation levels locally, regionally, and sectorally. Also it is important to assess the adaptive capacity, locally, regionally and sectorally.

But the biggest problem is that the stabilisation level is not a well-defined parameter. What society cares about is, for example, changes in food production, water availability, human health, sea-level rise, and the goods and services from ecological systems. These do not respond directly to changes in greenhouse gas concentrations, but to changes in climatic parameters, temperature, precipitation and extreme [weather] events. Unfortunately, there is a factor-of-three uncertainty in the climate sensitivity factor. Therefore, a projected change in temperature can arise from a stabilisation level of 450ppmv (if climate sensitivity is high) or 1,000ppmv (if climate sensitivity is low). So we must evaluate 'acceptable' changes in climatic parameters and decide how to apply the precautionary principle given uncertainty in the climate sensitivity factor.'

*References on page 50.*

**Note:** The level of $CO_2$ in the atmosphere today is approximately 367ppmv, an increase of almost 30 per cent from pre-industrial levels (approximately 280ppmv).[2] 'The ultimate objective,' of the UNFCCC is, 'to achieve… stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.'[3]

TEMPERATURES IN 50 YEARS' TIME WOULD HAVE BEEN A MERE 0.07°C LOWER THAN THE ANTICIPATED >>



Kyoto photo-call: all smiles as Bonn conference chairman Jan Pronk hugs Michael Zammit Cutajar, Executive Secretary of the UNFCCC (above, top) and other delegates join in the celebrations (right, top right)

# We've saved Kyoto!
## (Shame about the world's climate)

Just as the Kyoto Protocol appeared to be knocking at death's door, governments claim to have resurrected it. But what exactly has been saved, and what action if any will emerge? Simon Retallack reports.

Following the jubilation that greeted the outcome of the UN climate negotiations in Bonn in July, anyone would be forgiven for assuming that climate change had been licked. 'It's a brilliant day for the environment,' gushed the British Environment Minister, Michael Meacher. 'We have delivered probably the most comprehensive and difficult agreement in human history,' said New Zealand delegate Peter Hodgson. 'We can go home and look our children in the eye and feel proud of what we have done,' proclaimed EU Environment Commissioner Margot Wallstrom. The cause of this euphoria? The rather arcane pleasure of completing the operating rules for the Kyoto Protocol. For the world's environment ministers – who had spent four years trying but failing to finish the job, and an even longer ten years talking about climate change but achieving little – this was reason to celebrate. In the cold light of day, however, what does this deal mean? What will it actually deliver?

The answer is, far less than the environment ministers meeting in Bonn would have us believe. The Kyoto

>>RISE.....WARMER OCEANS CAN ACTUALLY RELEASE CO2 INSTEAD OF STORING IT. THIS IS IMPORTANT AS

Protocol, as it was originally conceived in 1997, was never going to solve climate change, but it was a start. Its most important innovation was that it required industrialised countries to accept legally-binding targets to reduce their greenhouse gas emissions. The total reduction required, however, was of only 5.2 per cent below 1990 levels by 2012 – far less than the immediate cut of over 60 per cent that climatologists say would be necessary to keep greenhouse gases at safe levels. Now, though, even this modest target has been significantly weakened.

### The US lands the first hit

The single largest blow to the Kyoto Protocol has been the decision of President George W Bush earlier this year to pull the US out altogether. This means that Kyoto has lost from its ambit the world's largest emitter of greenhouse gases, which, as a result, is no longer legally bound to reduce its contribution to climate change.

The new Bush administration justified this decision on the grounds that the Protocol was 'fatally flawed' and 'unfair' because 'It exempts developing nations and is not in the United States' economic best interests.'

These arguments are bogus. The US, with just five per cent of the world's population, produces a quarter of the world's carbon emissions, more than any other country: 11 times more per head of population than China, 20 times more than India, and 300 times more than Mozambique. The US and other industrialised countries are responsible, without a shadow of a doubt, for the vast majority of the historic increase in greenhouse gases in the atmosphere that is causing climate change and which already is wreaking destruction upon developing countries. It is, therefore, only right that the US and other industrialised countries should act first to reduce their emissions.

IISD/PA

In any case, in raw geo-political terms, there is no alternative. Developing country governments would reject outright any demand that they should cut their much lower emissions as a precondition of US action.

The claim that Kyoto would damage US economic interests is misplaced too. If US companies lose any economic advantage it will be because the US does *not* reduce its emissions as agreed in Kyoto. In the wake of the OPEC oil price hikes in the 1970s, US car manufacturers lost market share to foreign competitors producing more fuel-efficient cars. The same dynamic could play itself out again now in the vehicle and clean energy sectors, with European and Japanese manufacturers taking the lead in developing the technologies of the future.

From a climatic perspective too, it is clearly inaction to reduce greenhouse gas emissions that will cause the greatest economic damage. Already, insurance companies estimate that the bill for severe weather in the 1990s worldwide was $480 billion, with economic and insured losses over that period increasing by a factor of 8 and 15 respectively. If these rates are projected into the future in comparison to a standard growth in GDP of 3 per cent a year, by 2065, the world would become bankrupt, as damages would outstrip global earnings.

But such reasoning cuts little ice with the Bush administration. Bush is acting, it is strongly suspected, to protect the short-term financial interests of polluting fossil fuel companies, with which he and his cabinet have very close ties. Oil, gas, coal and utility companies donated about $50 million to the Republican party's election campaign in 2000. Moreover, the President, Vice President, Commerce Secretary, and National Security Advisor, all either owned, ran, or worked for oil companies. The White House Chief of Staff, Andrew Card, meanwhile, worked as the chief lobbyist for the largest car makers in the US, and at least 15 other officials who have been appointed or nominated have ties to the energy and auto industries. Clearly, fossil fuel interests now no longer need to lobby the US government; they are the government.

It is probably no coincidence, then, that the Bush Administration has withdrawn the US from Kyoto, nor that it has refused to accept a cap on US $CO_2$ emissions, pledged a massive expansion in fossil fuel production and proposed cuts to renewables and energy efficiency programmes (see box on page 21).

The climatic consequences of all of these decisions will be appalling, as US emissions soar. This has not only rendered Kyoto much less effective as a means of reducing industrialised country emissions – of which the US is responsible for over one-third – but it has opened the door for the Kyoto Protocol to be weakened yet further.

### Opening the door to ransom

For the Protocol to come into force and become legally binding, it needs to be ratified, by early September 2002, by the parliaments or legislatures of at least 55 countries, including those industrialised countries which contributed at least 55 per cent of global greenhouse gas emissions in 1990.

So far, of the major emitters, only European governments have publicly pledged to ratify. If the Kyoto Protocol is to survive without the US though, it also requires ratification by Canada, Australia, Russia, or Japan, all close US allies throughout the negotiations who, as some of the world's largest exporters, or, in the case of Japan, importers of fossil fuels, have always sought to keep obligations to reduce emissions to a minimum.

As soon as the US withdrew, the governments of these countries refused to clarify whether or not they would follow the US lead and pull out too. They then proceeded to exploit their new-found leverage by demanding large concessions that would water down the whole agreement.

The situation came to a head as the world's environment ministers gathered in Bonn on 19 July to try to finalise Kyoto's operating rules. This was a crucial meeting. If it

## Instead of blowing $60 billion on Star Wars...

The Bush administration is planning to spend at least $60 billion over 15 years on an anti-missile defence system which would have done nothing to prevent the attacks on 11 September. If this sum was diverted to support renewable energy...

- The electricity needs of 40 million average US households could be supplied from wind energy, displacing 350 million metric tonnes of $CO_2$ annually, and offsetting around a third of US residential sector emissions;
- 1.5 billion families in the developing world could receive solar cookers, dramatically reducing the use of wood as a cooking fuel.

OCEANS CONTAIN ABOUT 60 TIMES AS MUCH CO2 AS THE ATMOSPHERE.....GLOBAL WARMING IS PROJECTED TO>>

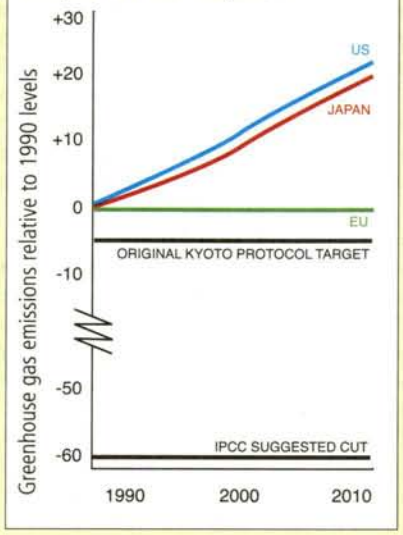
## How most countries' emissions are rising

At Rio in 1992, industrialised countries pledged to stabilise their emissions at 1990 levels by the year 2000. Most have failed to do so. US greenhouse gas emissions are now 11.2 per cent over 1990 levels; Japan's are 9.7 per cent over; Canada's are 13.2 per cent over; and Australia's 14.5 per cent over.

Only the emissions of the European Union were at 1990 levels in 2000, and that had very little to do with the introduction of measures designed to mitigate climate change, but rather one-off, coincidental events that produced emission reductions in the EU's two largest emitters – Germany (after re-unification) and in the UK (following the 'dash to gas,' and the closure of coal-fired power plants). In almost every other EU country, emissions have risen since 1990, and even in Britain and Germany, emission began to rise again in 2000 because of increased use of coal.

Unsurprisingly therefore, very few countries are on track to meet the formal targets they agreed at Kyoto to reduce their greenhouse gas emissions below 1990 levels by 2008-2012. Instead of reducing its emissions by 7 per cent below 1990 levels, under current policies, the US is projected to increase them by 23 per cent by 2010. Instead of a 6 per cent cut, Japan is heading for a 20 per cent increase and Canada, an 18 per cent increase. And the European Commission estimates that member states' existing policies and measures would at best reduce the EU's overall greenhouse gas emissions in 2010 to 1.4 per cent below 1990 levels, not the 8 per cent required by Kyoto.

**National greenhouse gas emissions compared to cuts required**




failed, the most recalcitrant countries would be able to claim that they didn't have enough time to cut their greenhouse gas emissions by the targets they agreed in Kyoto, and the Protocol would collapse by default. After having failed to complete the task the previous November in the Hague and desperate to salvage his reputation, the chairman of the talks, Jan Pronk, the Dutch Environment and Development minister, was determined to do everything possible to ensure a deal.

In a bid to persuade enough countries to ratify the Protocol, Pronk produced a negotiating text – on a take-it-or-leave-it basis – which recognised almost all the demands for concessions made by Japan, Canada, Australia and Russia. Convinced that these countries might walk away unless they were given what they wanted, and anxious to avoid being blamed for bringing the talks down themselves, the ministers of the European Union conceded almost all of their long-standing concerns and agreed to a text shot through with loopholes.

### Loopholes triumph

Under the terms of the deal agreed in Bonn, countries are faced with no requirement to achieve the majority of their reduction targets by taking measures to reduce emissions (from cars, homes, and industry) domestically. Such action, the agreement says, shall constitute simply 'a significant element' of the effort made. Unrestricted use may therefore be made of so-called 'flexible' trading mechanisms to achieve target cuts, with countries free to buy the excess quotas of countries which live below their limit, or to pay other countries to undertake emission-reducing activities for them and use the credits generated (as under the Clean Development Mechanism).

Particularly hazardous climatically is the lack of any restriction in the Bonn agreement on the amount of carbon credits that can be sold from countries like Russia and Ukraine, whose industrial collapse has left them with vast surpluses, quite by accident. By being traded, that carbon or 'hot air' will simply end up back in the atmosphere, taking levels higher than they would otherwise have been.

Perhaps even more damagingly, the agreement allows for the substantial use of so-called 'sinks' as a means of meeting emission targets. As part of their emission reduction effort, countries can include carbon supposedly absorbed by the planting of new trees, as well from changes undertaken since 1990 in the 'management' of forests, croplands and grasslands, and through re-vegetation.

The only one of these activities whose use as a means of emission reduction is capped under the Bonn accord is forest management, and even then, the cap applies on a country-by-country basis, with very generous allocations awarded to some of the largest emitters. Japan, for example, is allowed to use forest management to write-off 13 million tonnes of carbon from its total emissions. So by using this technique alone, instead of making an emissions cut of 6 per cent below 1990 levels as originally agreed, Japan will only have to make a cut of 2 per cent. Canada's allocation is even greater, allowing it to increase its emissions by 4 per cent instead of cutting them by 6 per cent.

To make matters worse, most of these sink activities have also been included in the Clean Development Mechanism (CDM), enabling industrialised countries to earn carbon credits by paying industrialising ones to undertake sink-related projects.

The use of sinks in any of these ways is hugely problematic. Their presence in the CDM could lead to the spread of large plantations that threaten biodiversity and indigenous communities. More worryingly in climatic terms, carbon sequestration by trees, plants and soils is still a very uncertain and unreliable science, as absorption is hard to measure and because trees fall victim to fire and rot as temperatures rise, releasing carbon dioxide back into the atmosphere in the process. Moreover, forest and farm land management practices are allowed under the Bonn agreement that have already taken place since 1990 and would therefore be likely to continue regardless of the Kyoto Protocol, generating no real emission reductions.

The combined effect of these loopholes and the US

withdrawal is devastating to the ability of the Kyoto Protocol to reduce the emissions of industrialised countries as originally intended. According to an analysis by Greenpeace International, existing loopholes and the use of sinks could transform a 5 per cent cut into an increase in emissions of 0.3 per cent over 1990 levels. Add in unrestricted use of Russian 'hot air' and the figure rises to between 5.6 and 8.4 per cent.

This is still somewhat lower than where the emissions of industrialised countries would be in 2012 on a business-as-usual basis, so some effort would still need to be made to reduce emissions. However, without US participation, Russian 'hot air' (which the US almost certainly would have bought had it ratified Kyoto) would now be available to be purchased by other industrialised countries. Consequently, in the words of Greenpeace, 'the targets for emission reductions by Annex B [ie industrialised] countries could be effectively nullified.' In fact, it would allow 'an increase of greenhouse gas emissions beyond that which would otherwise occur'.

### What is there to celebrate?

Yet, the outcome of the meeting in Bonn was celebrated not just by government ministers, but by most environmental organisations. Jennifer Morgan, Director of WWF's Climate Change Campaign, for example, described the agreement as 'a geopolitical earthquake,' and 'a giant leap for humanity'.

Were they all on a different planet, a realm of make-believe? Their rhetoric was certainly overblown; most likely the product of seeing something they had all worked on tirelessly for years, and become so close to, saved from the dead. Delight at having isolated the US played a role too, with the Iranian Ambassador to the UN, Bagher Asadi, for example, proclaiming the deal 'a triumph over unilateralism.'

But prod beyond that, and most green non-governmental organisations (NGOs) and European environment ministers recognise that the deal is much weaker than they had hoped. As Olivier Deleuze, the EU's chief negotiator at the talks and Belgium's Energy Minister conceded: 'We know it is not enough. It is a very prudent first step.' But, he added, 'I prefer an imperfect agreement than none at all.' Kate Hampton, of Friends of the Earth, concurs. 'This, obviously, is totally inadequate. However, given the political realities, I think it is probably all that we could have achieved.'

NGOs, nonetheless, are optimistic that the Bonn agreement will still force countries to reduce their emissions below business-as-usual levels, because they think it unlikely that all the loopholes will be used. They predict that Russia will not put all of its surplus carbon on the global market because that would undermine its value and hence their earnings. They also expect the Russian government to adopt a Green Investment Scheme to ring fence 'hot air' revenues for investment in emissions reduction projects. Climate groups are also pledging to campaign to pressure governments to publicly forgo the use of loopholes such as 'hot air' and sinks. That may be a forlorn hope with countries such as Australia and Canada who may still not even ratify the Kyoto Protocol, but the EU may be susceptible to such pressure.

Most importantly perhaps, the revellers in Bonn believe that the deal agreed there provides a 'sound legal

## The Bush energy plan: a fossil fuel bonanza

President George W Bush's National Energy Policy calls for a massive boost in the use of fossil fuels that will increase US emissions by an estimated 35 per cent. The plan states that, over 20 years, 'America must have in place between 1,300 and 1,900 new electric plants,' most of which will be fuelled by natural gas.

The plan also recommends 'easing' regulations which slow the siting and licensing of power plants and gas refineries. In particular, it calls for a review of regulations for coal-fired power plants which impose strict air emissions limits.

President Bush has also said: 'We need more oil, and we should produce more of it at home.' His energy plan therefore proposes opening parts of the Arctic National Wildlife Refuge (ANWR) to oil and gas exploration, along with other federal lands, including parts of the Rocky Mountains.

Even more perversely, the Bush energy plan actually cuts resources for renewable alternatives to fossil fuels by 27 per cent. While pledging an 813 per cent increase in funding for research into coal technology, funding for solar research is slated to be slashed by 53.7 per cent and fuel cell research by 14.3 per cent. Investment in actual wind and solar projects, meanwhile, would decline by 49 per cent.

The Bush Administration also pledges to cut federal investment in energy efficiency by 7 per cent. According to the Vice President, 'Conservation may be a sign of personal virtue, but it is not a sufficient basis for a sound, comprehensive energy policy.'

Following pressure from the US fossil fuel industry and several large unions, the House of Representatives has already passed Bush's energy plan, allocating it a budget of $33 billion. The chances of the Senate following suit are growing, as the terrorist attacks on the US are being used by figures such as Senator Frank Murkowski, a Republican from Alaska, to call for increased domestic fossil fuel production as a means of becoming 'less dependent on unstable foreign sources of energy.'


RISE, LOCUST SWARMS MAY BECOME COMMON IN SOUTHERN EUROPE AND ANIMAL DISEASES SUCH AS >>

## What is the UK doing to reduce emissions?

The Blair government in the UK has set itself targets for reducing $CO_2$ emissions by 23 per cent below 1990 levels and for producing 10 per cent of electricity from renewable sources by 2010. However, neither of these goals may be reached.

Spending on research and development in renewable energy has fallen by 81 per cent from 1987–1998, and since the Blair Government took office in 1997, public spending on renewables has declined by 57 per cent, to a total of £58.5 million, leaving renewables' contribution to electricity generation at just 0.4 per cent. The Government has pledged to spend £260 million on renewables from 2001–2003, but that is still only a third of what was spent to build the Millennium Dome, and just 0.07 per cent of total government expenditure.

A Royal Society report on renewable energy finds that in relation to offshore wind, tidal, wave and solar energy, 'none of these is currently being exploited to a significant extent.' Solar photovoltaic cells, for example, can be found on the roofs of just 166 buildings in the UK.

In Britain, as in many other countries, the electricity market is distorted in a way that makes it harder for renewable technologies to compete. Complicated and costly grid connection and permit requirements have to be met, discriminatory planning application rules overcome, and tariff systems put up with that pay less for renewable energy being supplied to the grid than utilities may charge for their electricity. There is also a lack of sufficient grants or low-interest loans for the purchase and installation of renewable energy systems, such as solar PV for buildings.

The Government has introduced a tax on energy use in industry, the Climate Change Levy, to promote the conservation of energy, but it has allowed companies with high energy use to claim 80 per cent discounts in exchange for voluntary targets. The tax also exempts household electricity consumption – responsible for a quarter of UK $CO_2$ emissions. And in the transport sector, the government has dropped its tax escalator on petrol and has so far spent 37 per cent more on roads than on railways (while pledging to spend £60 billion on roads and rail each, over 10 years).

That, together with a decade of little progress in the fuel efficiency of cars, has meant that road traffic remains the UK's fastest growing source of $CO_2$. Traffic levels increased by 12 per cent between 1990 and 1998. They are forecast to grow by another 17 per cent by 2010, and 48 per cent by 2026.

Moreover, the imperative to mitigate climate change has not dissuaded the Government from continuing to provide £17 million a year in subsidies to fossil fuel companies, grant nine new licenses for off-shore oil drilling in the North Sea, or provide £3 billion in annual subsidies to industrial agriculture while setting aside just 0.7 per cent of that figure to develop more 'climate-friendly' organic farming.

The maintenance of such damaging inconsistencies is still all too common among governments worldwide.

REUTERS

## Success stories

With political will, success has been proved possible. China has reduced its $CO_2$ emissions by between 8.5 and 17 per cent between 1997 and 1999, despite economic growth estimated at 36 per cent over the same period. These reductions were achieved by promoting energy conservation and efficiency, tax reforms and reducing coal subsidies. The upper estimate is equal to the 400 million tonnes of carbon that the entire US transportation sector emitted in 2000.

The goals of two other countries also clearly demonstrate that far-reaching change is deemed possible. The government of Iceland has pledged to use hydrogen fuel-cell technology to replace fossil fuels entirely by 2030, and Denmark plans to use wind to generate half of the country's electricity by 2030.

architecture,' in the words of WWF, upon which to build future global action to reduce emissions, or, as Bill Hare of Greenpeace describes it, an 'essential ladder,' in which 'the Kyoto Protocol and the Bonn rules to implement it are the first step on what has to be a long climb.' For them, the very fact that an agreement was reached, that the Kyoto Protocol has survived sends an invaluable signal to industry. It tells it, rightly or not, that we have entered a carbon-constrained world in which the cost of fossil fuel-based energy will rise, and that they need to begin investing in clean and efficient technologies that will reduce the threat of climate change. We can only hope that the campaigners are right.

### What history will say

Once the final technical details of the agreement are hammered out in Marrakech in early November, the deal reached in Bonn does make it likely that Japan and Russia will now ratify the Kyoto Protocol, ensuring enough support for it to come into force by 2002. But it still falls far, far short of what is required if we're to have a hope of successfully mitigating climate change. Its loopholes render its already inadequate reduction targets potentially non-existent, and it still exempts the world's largest emitter.

It is now highly unlikely that the US will rejoin the Protocol under George W Bush. The best that can be hoped for in the US over the next four to eight years is the introduction of domestic measures designed to cap US emissions. Before the terrorist attacks of 11 September, some momentum was building in Congress for such initiatives, but now, legislative priorities clearly lie elsewhere, and may even lead to an increase in US emissions (see box on page 21).

The verdict of future historians on the wisdom of the current generation of political stewards is likely to be harsh. Of the meeting in Bonn in July 2001 they are likely to record that a Protocol named after the Japanese city of Kyoto may have been rescued, but the world's climate was not.

Kyoto may help change behaviour, particularly among investors. But its greatest value may well be this: to teach us that we can't rely on governments to solve even the most grave of our problems.

In the end, it's probably down to us.

*Simon Retallack is managing editor of* **The Ecologist** *special issues and is co-director of the Climate Initiatives Fund.*

**References on page 50.**

# Who's in the red now?

**Poor countries have traditionally been seen as the world's debtors. But climate change is turning the tables, says Andrew Simms, and it is now the rich who are living on borrowed time.**

The debate around international debt is about to change dramatically. To date, the focus of attention has been on Third World debt. But when people realise the scale and threat of ecological debt, no one again will have the audacity to demand that countries like Mozambique or Niger send a penny more debt service back to their creditors.

If you use more than your fair share of natural resources in a delicately balanced ecosystem you run-up an ecological debt. It's a one-way ticket to view a world turned upside down. And climate change is the key to understanding it.

## From Third World debt to ecological debt

Third World foreign debt dominated the international development debate in the second half of the 1990s. But in many ways it was less a sophisticated exchange between policy experts, and more like the camp theatre of the silent movies. Wide-eyed campaigners pleaded on the streets and in the conference venues for the future of desperately poor and indebted populations. At the same time Victorian stage villains from the World Bank and IMF sniggered and said life wasn't that simple. Millions signed petitions. Thousands attended demonstrations. Dozens of reports were written, (several by me). And what was the result of the biggest international mobilisation since the anti-apartheid movement? Officials made a U-turn in policy. They decided that the debts of the poorest countries were, indeed, unsustainable and designed a labyrinthine mechanism to deal with it. In practice, however, little has changed.

In July 2001, Jubilee Plus, a successor to the Jubilee 2000 coalition campaign, declared that official debt relief measures were moribund.[1] They described how all 23 countries that had qualified for the so-called Highly Indebted Poor Country initiative (HIPC), from an original list of 41, were returning to 'unsustainable debt burdens'. In spite of winning limited debt relief for a handful of countries and building an international campaign movement, a harsh judgement would say that everyone's best efforts had failed. The poorest countries in the world were back where they started. The problem, most probably, was that the outstanding poor country foreign debt, mostly African, at around $350 billion, simply isn't big enough to worry the powerful and extract necessary action.

But during the debt campaign something happened that started to turn the world upside down. A connection was made and, looked at afresh, creditors became debtors and vice versa.

In 1998, Hurricane Mitch hit Central America. The Honduran President Carlos Flores commented: 'We lost in 72 hours what we have taken more than 50 years to build.' The map of the region was literally and metaphorically redrawn. Harvests of staple foods such as rice and sweet potato were destroyed. Virtually all banana plantations that provided Honduras' chief export crop were flattened. At the time, Nicaragua was paying over half a million dollars a day in debt service (sucking up 39 per cent of government expenditure) and Honduras was paying $1.5 million per day. Yet, even in light of the disaster, the official creditors' immediate response was to refuse to forgive the debt.[2]

Hurricane Mitch struck at the end of a decade in which climate-driven natural disasters had increased enormously. According to the reinsurance giant Munich Re the number of climate related so-called 'hydro-meteorological' disasters quadrupled during the 1990s compared to the 1960s. During the same period economic losses increased eight-fold. While no single method exists to measure it, the estimates of economic damage from climate change are growing.

The financial services initiative of the UN Environment Programme estimates that the extra economic costs of disasters attributable to climate change are running at over $300 billion annually. The best guess of development groups is that climate change could cost developing countries up to £6.5 trillion over the next 20 years, many times anticipated aid flows.[3]

Working, almost literally, at the coalface of global warming the insurance industry are most open to looking into a glass darkly and suggesting what the future may hold. A former director of insurance giant CGNU plotted a graph to see at what point climate change would bankrupt the global economy. He concluded that we have less than a lifetime left, just over half a century.[4]

## Industrialised countries become the largest debtors

It is generally accepted by climate watchers that, historically at least, industrialised countries are almost entirely responsible for human-driven global warming. So, stripped of cant and rhetoric here was the new situation.

AN ADDITIONAL 170 MILLION PEOPLE TO BE LIVING IN SEVERELY WATER-STRESSED AREAS BY THE YEAR 2050>>

In addition to having to pay to service dubious foreign debts, sacrificing health and education opportunities in the process, the poorest people in the poorest countries are also paying the price of global warming, or, in other words, the interest on the ecological debts of the rich world. Of all deaths from natural disasters, 96 per cent occur in developing countries.

If a target is set for an acceptable concentration of greenhouse gases in the atmosphere, and an 'emissions budget' set to meet it, it becomes possible to work out for every year from now until the target is met, what everybody's logical and equal share is of the atmosphere's ability to soak up our waste emissions. Pump out more than your fair share – or sustainable threshold – and you instantly run up an ecological debt.

Putting a price on the debt can be illuminating. In the report, *Who owes who? Climate change, debt equity and survival*, published in 1999, Nick Robins, Aubrey Meyer and I calculated that the value of economic output built on such a growing carbon debt attributable to the G7 countries was in the region of $13–15 trillion for a typical year in the 1990s. At the same time the conventionally indebted poor countries had a carbon credit that could be valued at three times their official foreign debts.

In terms of claiming compensation for ecological debt these may well be fantasy figures. But they say something more important. In the light of global warming and its physical and economic consequences, they turn the moral authority in all relations between industrialised and non-industrialised countries upside down. They also demand a reverse process of adjustment toward sustainability in rich countries.

## An environmental war economy

If the industrialised economies don't tackle this ecological debt by drastically cutting emissions, everyone faces environmental bankruptcy. But how can the argument for reducing voracious consumption be put in a way that conveys urgency and yet inhabits a framework of known experience?

One answer could be to elaborate the theme of an 'environmental war economy'[5] – with the enemy being a hostile climate rather than another country. The simultaneous focus on radical cuts in domestic resource consumption and the protection of the health and basic well-being of the population of the 1940s war economy is instructive. Over a six year period in Britain private vehicle use was cut 95 per cent and there was a significant drop in infant mortality, as well as wider health improvements.[6]

In 1943, Hugh Dalton, president of Britain's Board of Trade said: 'There can be no equality of sacrifice in this war. Some must lose their lives and limbs, others only the turn-ups on their trousers.' In Bangladesh today, 20 million people are likely to be made homeless through flooding so that we can drive our sports utility vehicles.[7]

Ultimately, though, the problem has to be addressed within a global framework. After the weak resolution of the Kyoto Protocol, which provides only the compromised Clean Development Mechanism and vague promises of adaptation funds to developing countries, a single contender is emerging, increasingly supported by governments, business and civil society. People are calling it 'Plan B' for global warming.

## 'Contraction and Convergence'

'The only effective framework in which past ecological debt can be resolved and an uncontrollable climate change avoided, is a deliberate framework of contraction and convergence,' says Aubrey Meyer of the London-based Global Commons Institute. 'This requires agreement that there is a global contraction of emissions from human sources of 60–80 per cent within a specified time frame. It also means that the international sharing of this process is arranged so that entitlements to emit are pre-distributed in a pattern of international convergence, with the result that shares become equal per capita globally.'

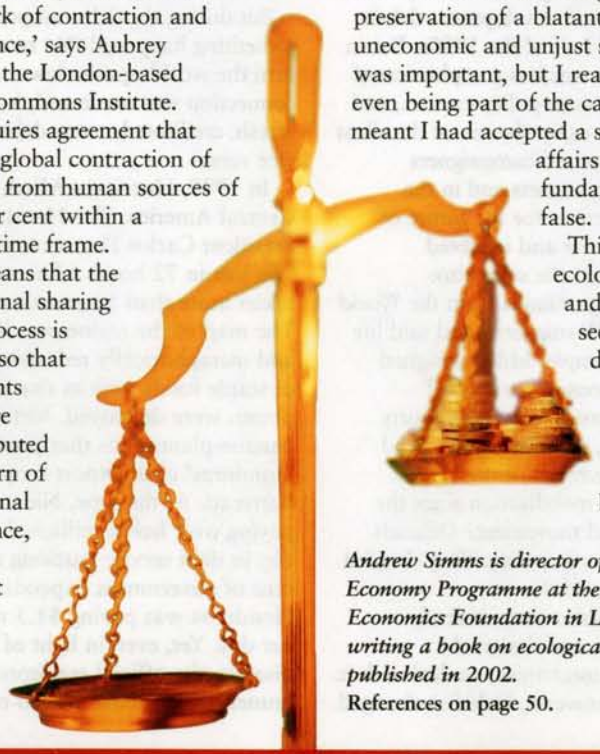
This doesn't mean that per capita fossil fuel use in the US and sub-Saharan Africa suddenly become equal overnight. Negotiations are needed both to agree an 'acceptable' greenhouse gas concentration target and a time frame over which to meet it. The model, moreover, is flexible: it uses a trading mechanism in emissions entitlements like a parachute, allowing resources to flow from rich to poor, smoothing the transition.

Behind Meyer's explanation of this mechanism lies an inescapable logical force that has drawn support from sources as wide as the insurance industry, the Royal Commission on Environmental Pollution and numerous developing countries. Meyer argues that contraction and convergence is even compatible with the negotiating position of a recalcitrant US.

The immediate practical benefits, too, are many. 'With this mechanism ecological debt is repaid because developing countries can achieve the clean energy paths necessary for sustainable development at zero cost. But only to the extent that they unite around this process,' says Meyer.

I was an agent in the Third World debt war. I wrote reports and agitated at international meetings. I attacked – on TV, radio and in print – Governments and World Bank for their inconsistent and illogical preservation of a blatantly uneconomic and unjust system. It was important, but I realised that even being part of the campaign meant I had accepted a state of affairs that was fundamentally false.

Think about ecological debt and you will see the world differently. It could even save the planet from bankruptcy.



GETTY IMAGES

*Andrew Simms is director of the Global Economy Programme at the New Economics Foundation in London, and is writing a book on ecological debt to be published in 2002.*

References on page 50.

>>>.....WITH HIGHER TEMPERATURES, THE IPCC PREDICTS THAT MALARIA WILL SPREAD FROM AFFECTIN

# Economic globalisation: catalyst for climate change

The boom in long distance trade and the growth of the multinational are founded on the currency of carbon, say Simon Retallack and Ladan Sobhani.


STILL PICTURES

While most of the world's governments have now come to accept the reality of climate change, hardly any have yet integrated the need to prevent it into their macroeconomic policies.

By pursuing economic globalisation, through the removal of national barriers to trade and investment, governments are vastly increasing demand for energy and universalising the carbon-intensive model of development worldwide, making the problem of climate change significantly worse.

The massive boom in long-distance trade precipitated by the dismantling of export and import barriers, and the re-orientation of production for export has required a vast increase in greenhouse gas-emitting transport. The average distance that goods travel from producer to consumer in the US, for example, now reaches 1,000km. Global shipping has grown approximately ten-fold by weight since 1950, consuming 140 million tonnes of fuel each year world-wide, more than the annual consumption of the entire Middle-East. Moreover, shipping is set to increase by about 85 per cent between 1997 and 2010 because of the expected expansion in global trade.[1] Similarly, world air cargo traffic grew by 280 per cent between 1985 and 1997 and Boeing forecasts a further tripling in air cargo traffic by 2017. Freight transport over land has increased too as a result of economic globalisation. Europe, for example, has witnessed a tripling of trans-border truck traffic from 400 billion tonne-km in 1970 to 1,200 billion tonne-km in 1997. Consequently, trade transportation is now responsible for the consumption of over one-eighth of world oil production, with serious implications for the global climate.[2]

The liberalisation of trade and investment around the world has also facilitated the global expansion of industrial agriculture and related food processing industries which are responsible for vast quantities of greenhouse gases. Industrial agriculture replaces the energy inputs of humans and animals with huge amounts of fossil fuel-derived energy, of which it consumes more than any other industry.

Refined petroleum products are used on farms to power machines for ploughing, planting and harvesting, fertiliser and pesticide application, and transportation, while electricity is used for irrigation. Even larger amounts of energy are consumed off the farm for manufacturing machines, fertilisers and pesticides, and for processing and packaging (almost 50 per cent of all consumer packaging in the US is used for food products). Industrial agriculture also requires the application of 70 million tonnes of nitrogen fertiliser every year on soils – a process which generates at least 10 per cent of total nitrous oxide emissions.[3] In addition, industrial farming methods lead to soil erosion, which, in the US alone, is estimated to cause the release of 16 million tonnes of carbon into the atmosphere each year.[4] Intensive, industrial practices also lead to higher methane emissions in rice and livestock production. Globalising such practices is thus a recipe for worsening climatic dislocation.

## Proliferation of cars

By tearing down barriers to trade and corporate investment, economic globalisation is also stimulating greater consumption of energy-intensive products such as cars and electrical appliances as these are disseminated to countries not yet dependent on them. After the opening of markets to foreign imports, South Korea and Thailand, for example, witnessed annual car growth rates of 25 and 40 per cent respectively in the early 1990s.[5] Such proliferation is significantly increasing the threat of global climate change as motor vehicles are a leading source of $CO_2$ emissions. These are only set to grow as transnational car companies increase sales to countries that are rapidly liberalising their markets such as India and China, where car ownership is still low.

As a result of investment liberalisation in China, where people until now have relied primarily on bicycles, public transport, and other low-input means of transportation, General Motors recently signed a $1 billion contract to produce 100,000 mid-sized cars annually.[6] GM has also set up production in Russia, where it hopes to profit not only by producing cheap cars for export but by gaining a larger share of the domestic market.

The climatic consequences of this global proliferation of the car will be disastrous. And the car is but one of a vast array of modern home and office products and appliances that require large inputs of climate-changing fossil fuels, and that are now being exported and produced worldwide.

The integration of developing countries into the global economy is also leading to the development of large new

>>>45 PER CENT OF THE WORLD'S POPULATION TODAY TO 60 PER CENT BY THE SECOND HALF OF THE>>>

## Pointless trade

The rise in exports in and out of countries often involves the same products, needlessly increasing greenhouse gas emissions. In the UK in 1997, 126 million litres of liquid milk was imported into the UK while 270 million litres of milk was simultaneously exported out of the UK. Likewise, Britain imported 240,000 tonnes of pork and 125,000 tonnes of lamb while it exported 195,000 tonnes of pork and 102,000 tonnes of lamb.

*Stopping The Great Food Swap*, Caroline Lucas MEP, March 2001.

fossil fuel-intensive projects, such as coal-fired power plants, often with the support of international financial institutions backed with tax-payers' money. These projects are being undertaken to generate large quantities of energy to fuel expanding manufacturing processes, to enable household consumption to rise, and to support the vast cities that the globalisation of industrial development is creating; further fuelling climate change.

The World Bank, for example, has financed $13.6 billion worth of energy projects in developing countries since the Rio 'Earth' Summit in 1992, including 51 coal, oil and gas-fired power plants and 26 coal mines. These projects will emit 38 billion tonnes of $CO_2$ over their lifetimes, nearly double what was emitted in 1996 by all countries combined.[7] The export credit agencies of most industrialised countries have devoted billions of dollars to similar projects. Most of these institutions systematically ignore renewable energy projects and undermine localised systems of production and consumption that would significantly reduce overall energy consumption.

Despite the growing threat posed by climate change, governments are being prevented from taking adequate mitigating action by a number of obstacles created by economic globalisation, including the increased power of large corporations – particularly those in the fossil fuel industry. By opening new markets around the world to foreign trade and investment, economic globalisation has greatly increased the opportunities for fossil fuel-related corporations to grow, increase their profits, and eliminate or absorb competitors, often through mergers. The merger of Exxon and Mobil in 1998, for example, has created the world's third largest corporation, valued at $250 billion, and the largest oil company by far.[8] The result of this corporate consolidation has been an unprecedented concentration of financial power in the hands of industries that profit from fossil fuels, to the point where many are now more economically powerful than a large number of nation states. The combined revenues, for example, of General Motors and Ford – the two largest automobile corporations in the world – exceed the GDP of all Sub-Saharan Africa.[9] This wealth has been used to great effect by such companies to influence government policy – through the funding of scientists, front-groups, lobbyists and politicians – in such a way as to block measures designed to reduce greenhouse gas emissions.

Another obstacle that governments face in seeking to take action to mitigate climate change is the huge increase in competitive pressures on domestic industry generated by economic globalisation. As opportunities for foreign investment increase and as moving manufacturing overseas becomes easier with economic globalisation, governments now compete with each other to lower or freeze environmental standards to attract foreign investment or to prevent the flight of industries based in their countries.

The EU's failed attempt to introduce a carbon tax in 1992 to reduce $CO_2$ emissions provides a clear example. Opponents of the tax argued that it would undermine the competitiveness of European companies abroad, because the tax would not apply to their competitors, who would therefore gain a commercial advantage.[10] In refusing to ratify the Kyoto Protocol, the US Senate and President George W Bush have cited similar reasons.

Global trade rules policed by the WTO could also pose a threat to national and international efforts to address climate change. The threat of dragging governments before a world trade tribunal for breach of world trade rules has already been used to challenge measures introduced by the European Union, Japan and the US aimed at increasing energy efficiency standards for motor vehicles, and serious disputes have followed.[11]

Conflicts between the WTO and the Kyoto Protocol could also yet arise. Under WTO rules, 'like products' cannot be distinguished or discriminated against on the basis of how they are produced or where they come from. However, the Kyoto Protocol mandates discrimination between different manufacturing technologies and processes, between signatories and non-signatories, and between higher-emitting developed countries and lower-emitting developing countries. Ultimately, without discrimination, the reduction of greenhouse gas emissions is all but impossible, as climate-changing technologies need to be discouraged.

Given the monumental threat that climate change poses, the re-subordination of global trade rules to climatic imperatives and the re-localisation of trade must be considered important strategies for reducing overall energy demand and cutting greenhouse gas emissions. The energy-intensive model of economic globalisation must be challenged if we are to stand a chance of preventing severe climate change.

*Simon Retallack is managing editor of* The Ecologist's *special issues and co-director of the Climate Initiatives Fund. Ladan Sobhani is the Energy Program Coordinator at Global Exchange in San Francisco, where she is working on a campaign to shed light on the causes of and solutions to California's energy crisis.*

## The real cost of far-flung food

What we eat and where it comes from makes a considerable difference to greenhouse gas emissions, and hence to the climate. A vegetarian meal with ingredients from domestic sources costs 200g in $CO_2$ equivalents. A meal with pork and vegetables from imported sources costs eight times more, at 1.8kg in $CO_2$ equivalents. And the same meal from domestic sources costs 600g. One kilogramme of apples imported from New Zealand, meanwhile, has an energy cost equivalent to 1kg of $CO_2$ compared with 50g of $CO_2$ for locally grown English apples.

EYEWIRE

*UNEP Environment and Industry Newsletter*, April–Sept, 1999

>>>CENTURY, POTENTIALLY INCLUDING THE INHABITANTS OF THE CONTINENTS OF EUROPE AND NORTH>>>

# Carbon injection:
## an addict's response to climate change

Under pressure to deal with $CO_2$ emissions, the oil companies have had a bright idea. Instead of sweeping the problem under the carpet, they plan to bury it underground, sealing our dependence on fossil fuels for good, say Greg Muttitt and Ben Diss.

As government ministers from around the world met at the climate talks in Bonn in July to attempt to save the Kyoto Protocol, the chairman of the UN's Intergovernmental Panel on Climate Change, Bob Watson, presented them with an upbeat view of the state of 'climate-friendly technologies'. Alongside renewable energies and energy efficiency was something many would think belongs to the realm of science fiction, or oil industry fantasy – underground carbon dioxide ($CO_2$) storage.[1]

Little word of this has reached the public, but it is clear that it is expected to be a key plank of action on climate change. In June, the technology was endorsed by someone on the mind of everyone in Bonn – George W Bush – in a White House speech on US climate change policy.[2] Bush's Energy Secretary, Spencer Abraham, is equally enthusiastic. 'Carbon sequestration is an important option to study,' he said, 'because it offers a way to address the global warming issue without having to make radical overhauls of our existing energy systems.' Revealing who was driving this policy, he added, 'Government research should be focused on those areas that industry tells us are worth pursuing.[3] The large response and significant cost-sharing from the private sector is a clear message that carbon sequestration is an option worth pursuing.'

### Carbon 'management'

The first step in carbon management is to 'capture', or separate, emitted $CO_2$. There are three different ways of doing this. The current favourite is to chemically remove carbon from hydrocarbons before they are burnt, leaving a hydrogen-based fuel. The second, more expensive, method is to remove $CO_2$ from waste gases after combustion, using amine-based solvents, cold methanol, or special separation membranes. The third option is to feed oxygen (rather than air) into a fossil fuel burning power plant, so that the waste gas from combustion is pure $CO_2$, which does not therefore need separation.

It clearly wouldn't be possible to fit these technologies to every point source of $CO_2$ (right down to the car exhaust), so combustion would need to be centralised in large plants, and a 'carrier' – such as hydrogen or electricity – used to transmit the energy to the location where it is needed.

The captured $CO_2$ must then be disposed of or stored – such as by pumping it underground. There are three

IMAGE BANK

AMERICA.....ACCORDING TO *SCIENCE*, THE YEARS 1995 TO 2000 EXPERIENCED THE HIGHEST LEVEL >>>

types of storage sites that could be used. First, fossil fuel reservoirs: oilfields, gasfields, or coalbeds. Second, deep saline aquifers. Or third, above-surface commercial applications – for example, in chemical feedstocks, or in enhancing plant growth in greenhouses.[4]

## Cash injection

These techniques have not remained on the drawing-board: large amounts of cash have been invested already to apply, test and develop them. The chemical separation of carbon from hydrocarbons is being undertaken or planned by Texaco at 72 sites around the world.[5] Last year, Shell, along with Siemens, began developing a pilot gas power station in Norway (which provides electricity to offshore oil rigs)[6] to 'capture' its $CO_2$ emissions using solid oxide fuel cells.

The Norwegian oil company Statoil, meanwhile, has been injecting about 1 million tonnes of $CO_2$ per year since 1996 from the Sleipner West gas field in the North Sea into deep saline aquifers.[7] Exxon and Pertamina (the Indonesian state-owned oil company) are considering a massive re-injection project of up to 100 million tonnes of $CO_2$ per year from the Natuna gas field in the South China Sea.[8]

BP and Ford have sponsored a $20 million, 10-year research project into carbon sequestration at Princeton University – the largest corporate grant in Princeton's history.[9] And nine oil companies have committed $15–20 million over 3.5 years to developing the technology through the $CO_2$ Capture Project, with further contributions from the European Commission, the Norwegian Klimatek programme and the US Department of Energy.[10] The US DoE spent $9 million on research and development in this area in 2000, and is expected to spend $85 million a year by 2008.[11] It hopes to develop capacity to sequester up to 1 billion tons of carbon per year by 2025 (compared to 6 billion tons emitted today), rising to 4 billion tons by 2050, through geological, ocean and biological approaches (see box below).[12]

## More fossil fuels

It's not hard to see the reason for the enthusiasm. With action on climate change becoming ever more pressing, carbon sequestration allows oil companies to continue growing their core business. BP, for example, plans to increase its extraction of oil and gas by up to 7 per cent year on year,[13] and Shell by 5 per cent.[14]

The reason we need technologies like $CO_2$ injection – the companies say – is that fossil fuels will remain the dominant source of energy for decades to come – renewable energies simply could not meet world energy demand.[15] But this is a prescription dressed up as a description – it comes from those companies which dictate the nature of the energy supply.

The promise of a future technological solution such as the 'technofix' of carbon sequestration clearly poses a real danger: it will relax the pressure to reduce fossil fuel use, as governments would find it a far easier option conceptually and politically than taking on powerful economic interests or people's lifestyles. And if it proves unsuccessful, after say a 25-year development time, it could be too late to start tackling the patterns of production and consumption that are at the root of the problem.

## Technofixes: the bad, the mad and the silly

'Technofixes' are widespread as industry solutions to a large number of environmental and social problems. Characterised as sticking plasters which fail to address root causes, very often they are ineffective fantasies, and many cause even greater problems than those they were supposed to solve. Geological sequestration is just one of many 'climate engineering' techniques – most even more fantastical or clearly ecologically damaging.[22]

There are essentially three types of climate technofix:

BIOLOGICAL CARBON CYCLE MANAGEMENT:
Includes forestation, ocean fertilisation (to increase algal growth), agricultural practices (tillage) and using genetically modified plants. Such approaches have attracted much investment, and also discussion within the Kyoto framework. At the same time, they have been very heavily criticised over recent months. There are major scientific concerns about the long-term integrity of biological carbon sinks, and also about their change in effectiveness as a result of climate changes. They could also have damaging ecological and social impacts.

OTHER METHODS OF CARBON STORAGE:
Include direct injection of $CO_2$ into the deep ocean (where it dissolves). This approach is also receiving serious attention (a joint research team from BP, Ford and Princeton is studying it, for example), although less now than geological storage. There are concerns both about its effectiveness (in relation to the stability of dissolved $CO_2$, especially when faced with turbulence, or with potential changes to ocean circulation currents due to climate change), and about its ecological impact (underwater concentrated 'lakes' of $CO_2$ would be acidic, and present possible asphyxiation threats – mainly to seabed organisms).

SOLAR RADIATION MANAGEMENT:
Includes launching orbiting mirrors into space and releasing sulphate aerosols into the stratosphere by aeroplanes. The most fantastical of the proposals, this approach would attempt to reduce the amount of energy from the sun entering the earth's atmosphere – by reflecting it back out into space. They address one imbalance in the climate system (greenhouse gases) by trying to shift a completely different variable.

Ben Matthews, a climate scientist formerly at the university of East Anglia, comments: 'The global climate is a highly non-linear system determined by complex feedback processes, and we still have a poor understanding of how it works. Any attempt to deliberately tinker with this system, could backfire very badly. Most new experiments do not work the first time as expected. There are always unwanted side effects. But if we tinker with the whole world, we only get one chance.'[23]

>>> OF NORTH ATLANTIC HURRICANE ACTIVITY SINCE RECORDS BEGAN – INCREASES IN NORTH ATLANTIC SEA


EYEWIRE

### A time-bomb?

This raises the question of whether human-engineered separation of $CO_2$ from the atmosphere and its storage underground will actually be effective. In many ways the problems raised are similar to those associated with the disposal of nuclear waste. What level of scientific study would make us sufficiently confident that such a potential time-bomb were safe?

If large volumes of stored $CO_2$ were suddenly to leak, severe climate change would occur without even the limited time we have now for mitigation or adaptation. What's more, a sudden release of $CO_2$ from an onshore reservoir could asphyxiate vast numbers of people and animals. A sudden release of naturally formed $CO_2$ in Lake Nyos in Cameroon in 1986, for example, killed over 1,500 people in this way. Can we justify these risks?

The oil and gas industry argues that the technology is not all that new: it has been injecting $CO_2$ into oil and gas reservoirs for about 25 years, in what is known as 'enhanced oil recovery'. In this process, when a field's production rate starts to decline, $CO_2$ (or sometimes water) is injected to increase the pressure and force more oil out.

However, in these cases, the injection was monitored, but not the subsequent stability of the $CO_2$ in the reservoirs – because the aims were different. Re-injection for climatic reasons (and hence monitoring for stability) has been going on for just five years (in Statoil's Sleipner West field). We therefore simply do not know how $CO_2$ behaves in these conditions over longer time periods – and to avoid dangerous climatic change, stability is needed over thousands of years.

There are reasons to have doubts. The re-injection process changes both the chemical and physical properties of the reservoirs. Dissolved $CO_2$ forms carbonic acid, which may corrode rock. Meanwhile, 'viscous fingering' arising from the viscosity difference between $CO_2$ and water could weaken the containing rock. And there is the possibility of escape or greater fracture from the holes that have necessarily been drilled in the reservoir (for the purpose of injection).

There are particular worries about the stability of deep saline aquifers – which have much greater available capacity, but are poorly understood geologically – especially since (unlike oil and gas fields) gas injection leaves them at higher pressure than in their original state.[16] There are also risks of forcing out saline water; contaminating drinking water aquifers.[17]

The industry's favoured storage site for $CO_2$ is oil and gas fields – as enhanced oil recovery has further commercial benefits. This starkly illustrates the short-sightedness of the technofix approach: not only does it fail to address the root cause of the problem (excessive production and use of fossil fuels), it actually adds to it, by making yet more carbon available to burn.

Another problem is that each of the carbon capture technologies require an extra energy input; estimated to be 15-37 per cent of the total energy used in a power station (and this doesn't count the extra energy for transportation and injection).[18] This 'energy penalty' will further add to the extent of the climate problem if $CO_2$ eventually escapes from storage.

The greatest fallacy in this technological approach lies in the belief that time can be collapsed. Natural processes draw carbon from the atmosphere into the earth's crust over geological timescales: this is how fossil fuels are formed. The technologists, however, hope to emulate this in timescales belonging to the world of engineering.

The fossil fuel industry does not seem particularly concerned about any of these problems. Most of the research to date has not been on environmental safety, but rather technical and economic feasibility.[19]

The focus of further research will be on reducing the cost (the cost of separation technologies in particular is still too high, at $120–340 per ton of carbon)[20], and on carrying out enough studies to 'convince governments, the public and the environmental NGOs this alternative is safe and effective,' according to BP.[21]

The oil industry seems to believe that it can manage not only our carbon addiction but also public opinion.

### Technocracy

The roots of this management approach to climate change can be found in the culture of the oil industry. Those personalities who have made their way to the top of oil companies are technologically minded; almost all have worked their way up through exploration and production: many with a background in engineering. They are technocrats whose narrow specialisations tend to give them a blind faith that their expertise is unchallengeable. They are part of a very masculine culture that is obsessed with technological toys, that believes that bigger is better, and that cares little for anyone's interests but its own. In this context, it's hardly surprising that it came up with the idea of drilling 1,000 metres into the ground to pump down carbon: what could be more masculine than that?

The development of carbon management technology can also be seen as the latest step in the ultimate industry holy grail – the quest for an abundant source of cheap, clean energy (following nuclear fusion in the 1980s, nuclear fission in the '50s and '60s, and even the far earlier perpetual motion machines).

Perhaps most importantly, this approach allows the oil industry to change the terms of the issue of climate change – moving it from a public debate of principle (about the use of fossil fuels) to a private debate of technical feasibility, controlled by the industry. Technologisation is a new Latin: it asks us to lend our faith to the techno-priests who claim to possess the divine knowledge to save us from the eternal flames, in this case of climate change. But theirs is a false god.

While carbon management allows the oil industry to have its cake and eat it – to continue to make vast fortunes from fossil fuels while avoiding responsibility for the consequences – it is not the solution to climate change. A serious approach must address the cause of the problem – our addiction to fossil fuels. In contrast, geological carbon engineering leads us deep into the unknown, and carries enormous risks. It is a dangerous diversion and needs to be treated with great caution.

*Greg Muttitt and Ben Diss work for PLATFORM, specialising in research and analysis on the systemic social and ecological impacts of the oil industry.* References on page 50.

URFACE TEMPERATURES HAVE HELPED CAUSE A DOUBLING OF OVERALL ACTIVITY IN THE LAST SIX >>>

# Should we pay farmers to sequester carbon in their soils?

To date, industrial societies have done little to address the costs of modern intensive agriculture, which range from soil degradation, to the contamination of water with nutrients and pesticides, damage to wildlife and landscapes, and damage to human health. According to Jules Pretty, of Essex University, the monetary cost of such externalities in an industrialised country such as the UK can amount to as much as $300 per hectare per year. That amount is equivalent to some 90 per cent of average net farm income.

But that's not all; substantial amounts of carbon dioxide are emitted from soils that degrade under intensive monoculture farming. In the UK, for example, the losses may be as much as 190 tonnes per hectare.

'In the past half-century,' declares Per Pinstrup-Andersen, director general of the International Food Policy Research Institute, 'about 2 billion of the 8.7 billion hectares of agricultural land, permanent pastures, and forests and woodlands [worldwide] have been degraded. Meanwhile, about 5 to 10 million hectares annually become unusable due to severe degradation.'

Just the emissions of carbon from severely degraded land, let alone from land in the process of losing its soil carbon, added up to at least 70 billion tonnes of carbon over the past 50 years alone, equivalent to nearly 20 per cent of total man-made emissions.

A price has been put on carbon to reflect its share of responsibility for causing climate change and its impacts. The upper bound of that price is $95 per tonne. Quite clearly, if farmers had to pay compensation for the damage done to soils alone, they would be bankrupted.

## Farming carbon

What if farmers were paid to conserve soils and improve land? This now looks increasingly likely. One of the 'flexibility' mechanisms agreed within the Kyoto Protocol allows carbon credits to be granted when it can be demonstrated unequivocably that soils and biomass are storing rather than venting carbon.

A realistic value for such credits, suggests Jules Pretty and Andrew Ball, lies between $1–$38 per tonne. On such a basis, for the UK, they estimate that a carbon credit system could bring arable and grassland farmers (not counting rough grazing) $27 million–$220 million per year.

The agricultural system that would most likely be promoted if governments chose to make use of this Kyoto provision is zero-tillage (ZT), which Jules Pretty and Andrew Ball have found gives the best returns in terms of carbon sequestration. 'With mixed rotations and leguminous cover crops,' ZT systems, they find, 'accumulate more than one tonne of carbon per hectare per year.'

A typical system is that of Jerry Willard's in Saskatchewan, Canada. He has planted shelter belts of Colorado Spruce to protect his crops of winter wheat which he plants with a direct drill. He leaves the straw stubble behind to protect the soil and to help hold in accumulated carbon. As a result of such a regime, the organic carbon has increased from barely 1 per cent to more than 5 per cent during the course of a 13-year rotation. Crop yields have also risen, and in Brazil and Argentina, where a total of some 20 million hectares is now under a ZT regime, yields of maize have risen from 3 to 5 tonnes per hectare and of soya beans from 2.8 to 4.7 tonnes.

However, even though ZT systems require as many as nine times fewer passes with machinery than conventional arable systems, they also require the routine use of herbicides, such as Monsanto's Round-up, and rely on fertilisers pumped in with the 'direct-drilled' seed. ZT systems therefore favour industrialised 'monoculture' systems with all the externalities and hidden costs that accompany them.

Hence, as Richard Young of the Soil Association warns, to give carbon credits simply on the basis of carbon uptake into the soil, without accounting for the carbon costs in terms of machinery, fertiliser and herbicides, encourages spurious claims as to the effectiveness of ZT systems in counteracting global warming.

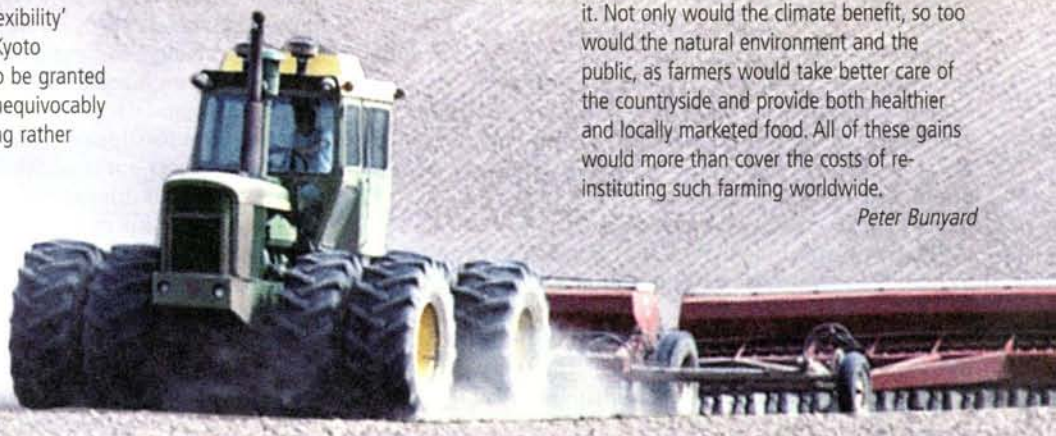
## Kyoto's green light

So, to what extent should developed countries be able to purchase or generate carbon credits for land managed in such ways in order to offset their commitments to reduce greenhouse gas emissions under the Kyoto Protocol, as Canada, Australia and the US have lobbied hard for? If they are to have any validity as offsets against a country's carbon emissions, such management systems should be permanent, which will be hard to guarantee. The credit system should also take all climate-related externalities properly into account. If that is done, ZT systems would probably rule themselves out. It must be remembered too that farming methods that conserve and replenish soil carbon are simply helping the land to return to a previous state before it was stripped of trees and then cultivated. Therefore carbon offsets should never replace more than a small fraction of the emissions subject to reductions.

Alternatives to actual reductions in emissions can be taken to absurd lengths if all is permitted and sanctioned in terms of carbon offsets. Indeed, if countries were allowed to make maximum use of all the 'loopholes' against their reduction targets, they would have 3 billion tonnes of carbon per year to offset against their Kyoto commitments – three times more than the total required for emission reductions.

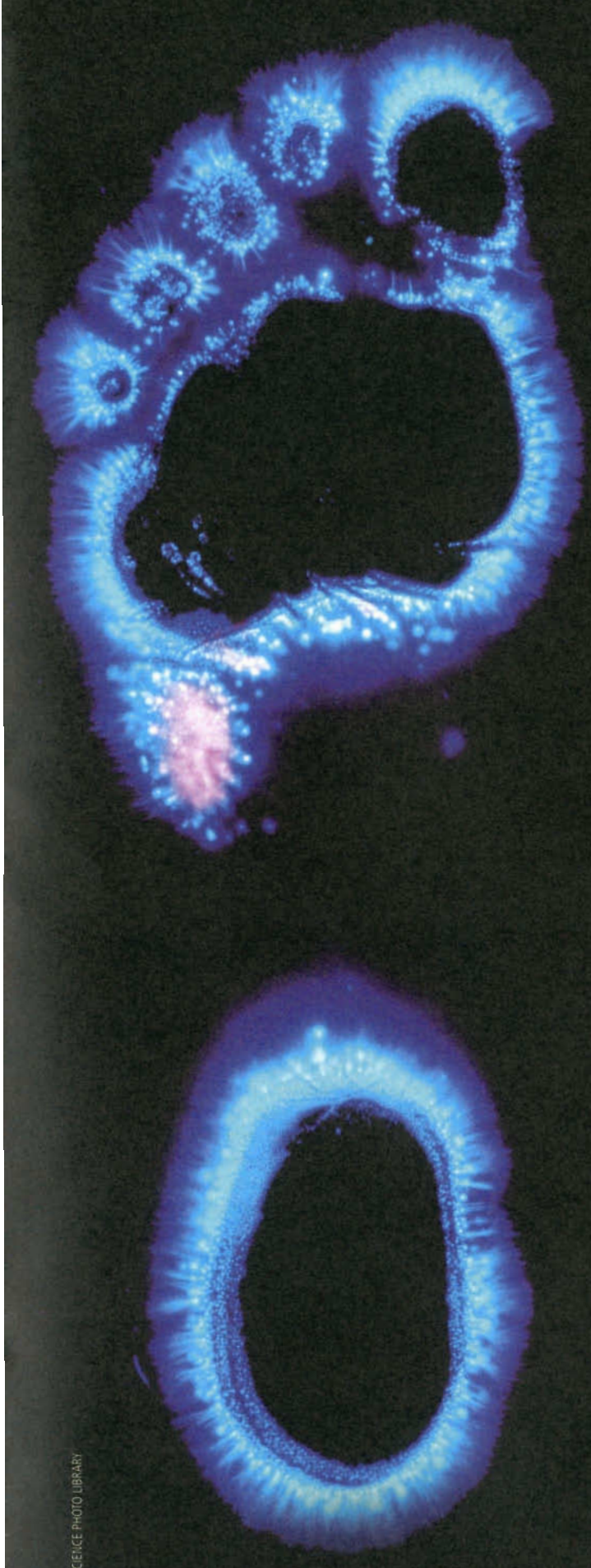
Nevertheless, the demonstrable benefits that would accrue from a large-scale switch to sustainable farming, including agroforestry, make the idea of allowing farmers to gain from carbon conservation practices extremely attractive – not as an alternative to reductions in fossil fuel use but in addition to it. Not only would the climate benefit, so too would the natural environment and the public, as farmers would take better care of the countryside and provide both healthier and locally marketed food. All of these gains would more than cover the costs of re-instituting such farming worldwide.

*Peter Bunyard*



EYEWIRE

>>> YEARS – A 2.5-FOLD INCREASE IN MAJOR HURRICANES AND A 5-FOLD INCREASE IN HURRICANES



SCIENCE PHOTO LIBRARY

# Tread lightly...

Tackling climate change is a global battle, but as individuals we all have a part to play. The only difficulty is working out which direction to take. Matilda Lee helps us on our first steps.

Following the lows ('Kyoto is dead') and the highs ('Long live Kyoto'), and vast forests-worth of rewritten negotiating text, the international agreement reached in Bonn is expected finally to initiate the transition to an energy- and carbon-constrained future. From now on, everyone will be increasingly expected to play a part in reducing their consumption of fossil fuels to help mitigate climate change. Exit coal, oil and gas, and enter 'green' and efficient energy.

Sounds fine in theory, but how realistic is it? If individuals are now expected to take responsibility for their contribution to climate change and act to reduce it, what actually can they do today that's meaningful and affordable? The benefits of solar, wind and other clean and efficient energy sources are many and hardly disputed, but are they accessible to a mass audience, and if not, how soon will they be? Can individuals really stop watching from the sidelines and take a proactive role in efforts to prevent climatic devastation? Can we shrink our carbon footprint?

## ENERGY EFFICIENCY AT HOME

Energy used in the home was responsible for around a quarter of the UK's carbon dioxide emissions ($CO_2$) in 2000. Each time you adjust your heating system, replace a light-bulb or cook a meal, you add to the amount of carbon your household emits. An average household in Britain emits 7.5 tons of $CO_2$, much of it unnecessarily and at a cost: the typical home wastes around £278 a year in energy inefficiency.

The home, therefore, is one of the places where you can make the most immediate difference to climate change. According to the UK's Energy Savings Trust (EST), nearly 50 per cent of household energy can be saved. Moreover, the first 10 per cent can be saved through no financial obligation, but merely through small lifestyle changes. All it takes is setting your mind on achieving big things in

AFFECTING THE CARIBBEAN.....30 OF THE WORLD'S LARGEST CITIES LIE NEAR COASTLINES: A ONE METRE>


PHILIPS

small ways, treating the most mundane acts as heroic deeds. These range from washing your clothes at 40°C or less instead of 60°C (which uses a third less energy than normally needed to heat the water for a hot wash), to turning your lights and appliances off fully when you don't need them. If everyone in Britain turned their television off at the set, for example, rather than leaving it on standby, it would save enough electricity to power a town the size of Basingstoke (For a list of simple low-cost or no-cost energy-saving measures see page 36).

### Intelligent insulation

Achieving greater savings, however, requires a little investment. The greatest amount of energy in any house is used by heating and hot water systems – which account for over half the cost of the average fuel bill. So investing in existing and widely available heat-loss-reducing technologies can save a considerable amount of energy.

According to the Energy Savings Trust, more heat is lost through walls than by any other route, but 60 per cent of that loss can be avoided by installing cavity wall insulation, a process of filling in the air gap in your walls that can be done in a day. The cost starts at about £500 but the savings generated mean that it can be recovered within four years.

Poorly insulated window frames and single glazing, meanwhile, are responsible for almost a quarter of heat lost from a home. Much of that can be reduced by having your windows double-glazed or fitted with low-emissivity glass, which reflects heat back into the room. It will cost about £170 and £275, respectively, above and beyond the cost of replacing singled-glazed windows, but will save you £25–40 on fuel bills per year.

### Efficient appliances

Replacing an old boiler with a 'condensing boiler' will save yet more energy, as condensing boilers convert 85 per cent of the fuel they use into heat compared with 65 per cent for standard boilers. It will cost you between £1,500 and £2,000 – up to £300 more than standard boilers – but could save you up to 32 per cent on your fuel bills.

It is also now possible to buy other energy efficient home appliances, such as domestic refrigerators, freezers, washing and drying machines, and dishwashers, which generally use between a third and half of the electricity of their inefficient counterparts.

All new appliances are now required to carry a label (as part of the EU's Energy Labelling scheme) denoting how energy efficient they are. The label is based on a rating system by which 'A'-labelled products are the most efficient and 'G' are the least efficient. Since late 1999, manufacturers of fridges, freezers and fridge freezers were required to stop producing the least efficient models, or those rated 'D' or below.

A typical 'A' rated washing machine (which is usually equipped with more operating options) would cost about £330 to buy, compared to £230 for a 'C' rated model, and £279 for a 'D' rated model. However, if the lifetime energy costs of the three models are taken into account (assuming one load of wash a week), the 'A' rated washing machine would cost £478 over its lifetime, only a little more than the 'C' rated model whose total lifetime costs amount to £430, and far less than the 'D' rated model, whose energy costs over its lifetime come to £1,279.

Clearly, spending a bit more up front for an 'A' model pays off in overall energy savings.

### GREEN ELECTRICITY

Another easy option now open to most UK households is to buy so-called 'green electricity' straight from electric utility companies. Most of the 10 primary electricity suppliers (and independent ones) run green electricity schemes, but each is different.

There are typically three different schemes to choose from. The first is a 'renewable tariff' where your supplier matches every unit of electricity you use by purchases of renewable energy. The other is an 'eco fund' where your money is put into a fund dedicated to developing new renewable energy. The third system is a hybrid of both.

According to Graham Carr, of the Energy Savings Trust, there are currently between 17,700 and 35,000 individual households in Britain that buy green electricity.

A typical green electricity scheme costs customers, on average, 8 to 12 per cent more than 'brown' electricity. Some groups have realised that this may be off-putting to potential customers and have created schemes with green rates no higher than conventional electricity. Greenpeace is running such a scheme, teaming up with the energy supplier npower, an Innogy group company, to offer 50,000 customers 'Juice' – which will initially supply customers with electricity from onshore wind and hydro power, but is also helping develop a large offshore wind farm in Wales. Another such scheme is run by the Royal Society for the Protection of Birds (RSPB), in cooperation with Scottish & Southern Energy, which provides electricity from hydro power, landfill gas and waste.

Far more green electricity should, in theory, be available to customers by the end of the decade. The government has launched the Renewables Obligation initiative to boost renewable energy electricity from 3 per cent of total electricity supply today (50 per cent of which is generated by large-scale hydro power installations) to 10 per cent by 2010 (from non-hydro power sources), which would offset millions of tons of $CO_2$ emissions.

Buying green electricity is a meaningful way to help cut emissions, but if you want to take the matter into your own hands, there are micro-level solar, wind and soon-to-be hydrogen based fuel cell systems that can be installed in your own home.

### Solar energy at home

Energy from the sun is silent, clean and free and can be harnessed domestically in three different ways. The first is by designing and orientating a new building in ways which maximise the amount of warmth from the sun inside the building.

The second is by installing a solar thermal

>>> RISE IN THE OCEANS WOULD PUT AN ESTIMATED 300 MILLION PEOPLE DIRECTLY AT RISK – A ONE METRE

system which uses the sun's energy to heat water – deployed already in 40,000 to 50,000 UK homes. Paul Allen, from the Centre for Alternative Technology, has described solar water heaters as simply water pipes painted black to improve heat absorption. The small diameter of the pipes ensures that a large surface area of water is exposed to the sun.

Typical installation costs vary from about £1,500 for a do-it-yourself system, to £5,000 for a commercial system, which can provide approximately 50 per cent of typical domestic hot water needs for a 3-4 bedroom house.

A third type of power – and probably the most significant – is the generation of electricity from light – the 'photovoltaic effect.' Solar electricity is produced by layers of sophisticated photovoltaic (PV) cells, made up of silicon semiconductor materials that, when hit by daylight, cause electricity to flow. PV generators operate with no moving parts or noise and can be installed directly on your roof (as slates), making PV, at present, the most likely renewable energy technology for use in homes in urban areas. And, thankfully for residents of the UK, PV panels do not require sunny skies, just daylight.

The climatic benefits are large. If every roof in the UK was covered with solar PV, research has shown we could close all our power stations. PV panels save between 30 and 34 tons of $CO_2$ in their lifetime and will indirectly save you energy as solar roof owners generally turn into 'energy-efficient addicts,' according to Jeremy Leggett, Chief Executive of Solar Century, one of the UK's leading solar PV retail companies.

They are expensive, however. Installing PV panels on the roof of an ordinary home to supply energy for an average household costs in the range of £15,000 to £20,000. Although electricity bills will be slashed and houses with PV panelled roofs have been known to sell for £10,000 above their market value, the net costs are still prohibitive for most people.

So when will PV become affordable?

Jeremy Leggett estimates that PV panel costs will match those of traditional roofing materials by 2005–7. In order for this to happen, the UK would have to increase production to around 100mW a year to allow for the economies of scale that would make prices competitive. Currently, the biggest plant in the UK, a thin film solar plant that is being built by United Solar, will produce 25mW a year.

Attracting industry giants to build manufacturing plants and bring the costs of PV down will require the government to commit to more extensive schemes to propel the market.

It could, for example, adopt the so-called 'premium price tariff' offered in countries such as Germany where electricity suppliers pay back consumers with excess solar PV from their homes at up to five times the normal retail rate for electricity. This, along with a 40 per cent low-interest loan for installation, and various Federal State programmes, led to a 150 per cent market increase in Germany's solar market in 2000.

In contrast, in the UK to date, electricity suppliers buy back excess electricity from PV suppliers at only about half the rate they charge for their own electricity. One supplier, TXU Europe is currently the only electricity supplier to pay back solar electricity producers at the same rate at which it charges consumers.

Another means of increasing the affordability of PV is by providing grants. The UK government is now rumoured to be considering matching the policy pursued in Japan by giving 50 per cent capital grants for solar roofs installations for 70,000 houses – a far more substantial offering than its current Domestic Field Trial involving around 200 homes. And building societies are in the early stages of offering 'solar mortgages' which will allow homeowners to spread the cost of installation.

But the 'holy grail' for the UK's solar market, according to Jeremy Leggett, may come from building integrated PV. That means installing solar panel roofs as part of the original structure of new houses, which number around 200,000 a year in the UK.

'The economics is different, you have to have a roof anyway, all you are doing is adding a few percentage points to the price of a house,' says Leggett. 'There are bags of evidence that if people are going to pay a certain amount for a house anyway, they would pay for a PV roof, very often, happily.'

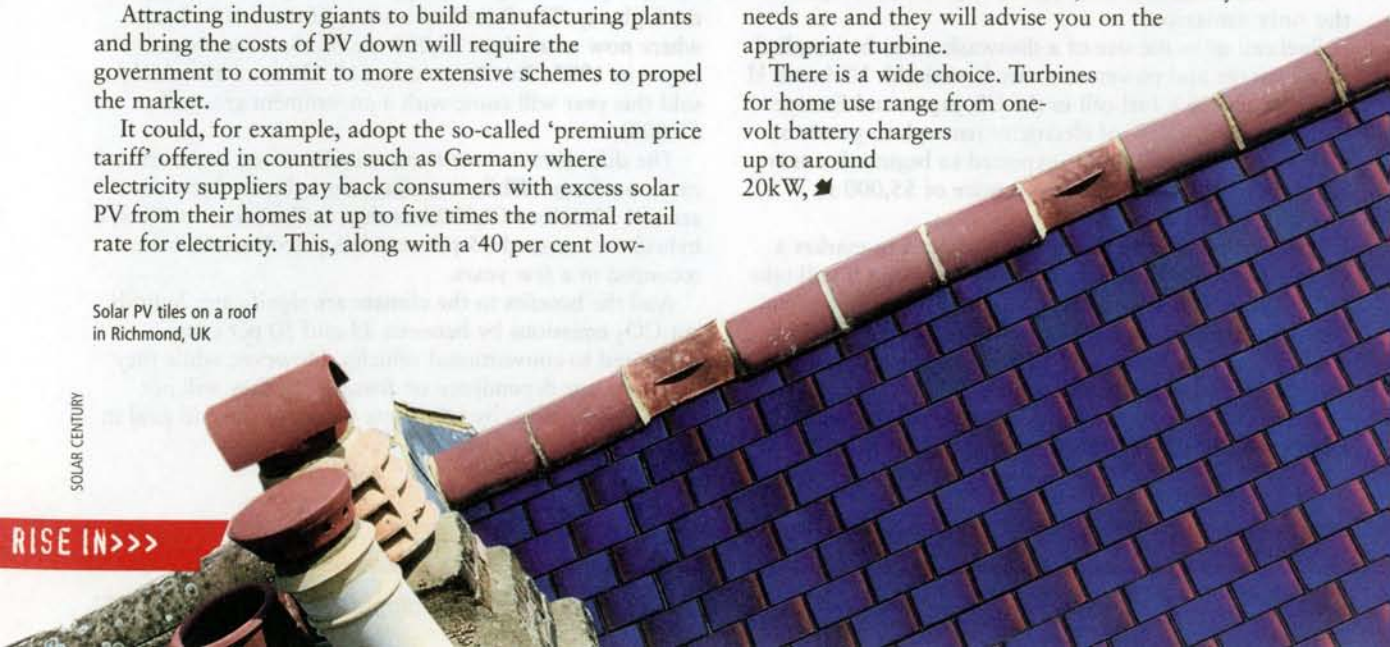
The government estimates that the costs of PV electricity, when it is installed in this way, will rival conventional electricity by 2015-2020.

### Wind energy from your garden

The UK is one of the windiest countries in Europe and harnessing that wind through the use of turbines is now the most cost-effective means of generating clean electricity. But wind power tends mostly to be associated with large commercial wind farms, and is not viewed as an option that the average consumer can deploy.

However, homeowners with plenty of space can generate their own electricity from wind, and according to Alison Hill of the British Wind Energy Association (BWEA), it is not as complicated as some may think. Find a company that manufactures wind turbines, outline what your needs are and they will advise you on the appropriate turbine.

There is a wide choice. Turbines for home use range from one-volt battery chargers up to around 20kW,



Solar PV tiles on a roof in Richmond, UK

SOLAR CENTURY

which could power a small industrial unit. Whatever size you chose, your wind turbine can power a battery bank, which then can be dipped into as needed.

The initial capital investment required, however, is substantial, and the government does not currently offer any grants to cover purchase or installation costs for domestic energy needs (nor can domestic users yet make money selling spare energy back to the electricity grid). If you are going to invest in a wind turbine, expect to pay around £14,000 to power an average household – but you will recuperate your costs in about 10 years.

Moreover, as Alison Hill points out, 'The costs of wind turbines have almost halved in a decade and we see the prices continuing to fall. Government support for commercial off-shore wind power will have the effect of bringing the cost of all wind turbines down.'

WWW.BERGEY.COM

### Fuel cells: a new source of clean domestic energy

In the near-future, possibly the simplest and most convenient way to produce clean electricity from your own home will be by using a device known as a fuel cell. This technology produces clean energy through a combustion-less process using hydrogen and oxygen, with water vapour the only emission.

Fuel cell units the size of a dishwasher can be installed in the garage and power an entire household. US-based H Power is testing a fuel cell in the US, Japan and Europe that generates 4.5kW of electricity (enough to power a 3–4 bedroom house) and is expected to begin sales next year with a full-scale production price of $5,000 to $6,000 (£3,500–£4,200).

Plug Power, another US company, hopes to market a slightly larger 7kW unit by next year, but says it will take several years before becoming financially viable. General Motors recently unveiled a natural gas run fuel cell that could be used in homes and businesses, but it will not be commercially available until around 2005.

In the UK, Johnson Matthey, in conjunction with TXU Europe and Energy Partners, are testing a 3kW micro-combined heat-and-power fuel cell system and aim to bring it to market within three years.

Fuel cells can be used to power appliances too. A fuel cell-powered vacuum cleaner being developed by Electrolux in the US is currently undergoing field trials and, when marketed, will cost as much as today's mid-range cleaners. The UK's ZeTek Power will make fuel cell products on a made-to-order basis, but warns that they will not be available on the mass market for another five to 10 years.

## TRANSFORMING TRANSPORT

After domestic energy use, individuals contribute most to climate change from their choice of transport: a sector which is responsible for about 22 per cent of the UK's $CO_2$ emissions.

Alternatives to car-driving have long existed – from walking to cycling and taking public transport. But it has only been fairly recently that those wedded to the car have been offered choices allowing them to continue to enjoy the 'comfort' of their machines while beginning to do less harm to the planet.

The internal combustion engine is being challenged at last by the onset of alternative fuelled vehicles (AFVs), which include hybrid electric cars and hydrogen fuel cell (HFC) cars.

### Hybrid cars

Hybrid electric vehicles combine the internal combustion engine of a conventional vehicle with the battery and electric motor of an electric vehicle. Benefits include regenerative braking, or the car's ability to generate and store electricity when braking, and greater fuel efficiency.

Hybrid vehicles have a much greater range than those relying on electric power alone; fuelling does not pose a problem as these cars rely on conventional petrol; and they are available today. As a result, hybrids are the most likely short-term leader among alternative fuelled cars.

Two hybrid vehicles are already on sale in the UK, Honda's 'Insight' and Toyota's 'Prius'. The Insight went on sale in Britain in September 2000 and is expected to get 61 miles per gallon (mpg) in the city and 70 mpg on the highway, and costs £17,000.

Toyota's Prius went on sale in the UK in October 2000 and is expected to get 52 mpg in the city and 45 mpg on the highway. The Prius had a successful debut in Japan where now more than 35,000 are on the streets since sales began in 1997. The Prius costs £16,430 (and all vehicles sold this year will come with a government grant of £1,000).

The difference in cost from a similar-sized conventional car is not huge. While a similar non-hybrid vehicle costs around £2,000 to £3,000 less than an Insight or a Prius, a hybrid uses around 55 per cent less petrol, so costs are recouped in a few years.

And the benefits to the climate are significant: hybrids cut $CO_2$ emissions by between 33 and 50 per cent compared to conventional vehicles. However, while they may ease our dependence on fossil fuels, they will not abolish it. Hybrids by no means represent the end goal in the revolution in transport.

>> SEA LEVEL COULD ALSO AFFECT UP TO 30 PER CENT OF THE WORLD'S CROPLAND .....THE VAST GREENLAND

### Hydrogen fuel cell vehicles

Hydrogen, considered by many experts to be the 'fuel of the future,' could offer a long-term solution to the challenge of eliminating transport emissions. Hydrogen can be used as a conventional transport fuel and in emissions-free fuel cells, such as those made by Ballard Power Systems, based in Canada, which have been proved in tests to have greater power and efficiency than the internal combustion engine at the same weight and height.

For now, there are only a handful of HFC-powered vehicles in the world; most being used in pilot programmes. But the world's major auto manufacturers are pouring large sums of money into fuel cell development in the hope that their model will become the industry standard. Bill Ford, chairman of the Ford motor company, predicts that HFCs 'will finally end the 100-year reign of the internal combustion engine,' and become the main power source for transport 'within 25 years'.

You won't find one for sale yet, though. Most of the car manufacturers have set loose deadlines for retail sales by around 2004, and large-scale mass production probably won't start much before 2010. The estimated cost of these vehicles is not being disclosed, although if they were to be sold tomorrow, we know that the price would likely be high: the cost of HFCs would need to come down 60-fold to about $50 per kW to be competitive.

The biggest stumbling block to commercialisation is the 'tower of Babel' effect where all the major parties (especially the car makers) are speaking in different tongues – mostly about the type of fuel and method to use to make the necessary hydrogen.

Ford, Honda and DaimlerChrysler have developed HFC prototypes using 'on-board' reformers to extract hydrogen from methanol, while General Motors, along with Hyundai, Toyota, Nissan and Renault are betting on a fuel cell powered by hydrogen reformed from gasoline. Ford and Honda are also now working on a model powered directly by hydrogen generated by electrolysis, using electricity to separate water into its constituent parts, hydrogen and oxygen. BMW, meanwhile, is alone in its quest to stick with the internal combustion engine but power it with liquid hydrogen.

And not all fuels are created equal from a climatic point of view. If the wrong choice of fuel production for HFCs is made, it could lead to minimal emissions reductions from 'well to wheels'. Extracting hydrogen from gasoline reformed on board an HFC-powered vehicle would reduce emissions just 22 per cent compared with an internal combustion engine, versus 35 per cent from methanol reformed on board, and 72 per cent from natural gas reformed in a large plant. Achieving zero-emissions would require using hydrogen produced solely by electrolysis using a renewable energy source.

Storing and distributing hydrogen are also problematic, and makers say that for a real hydrogen revolution to take place, governments need to develop safety and regulation standards for hydrogen use, help create the necessary infrastructure, and gear up consumer demand through subsidies and education – which so far they are failing to do.

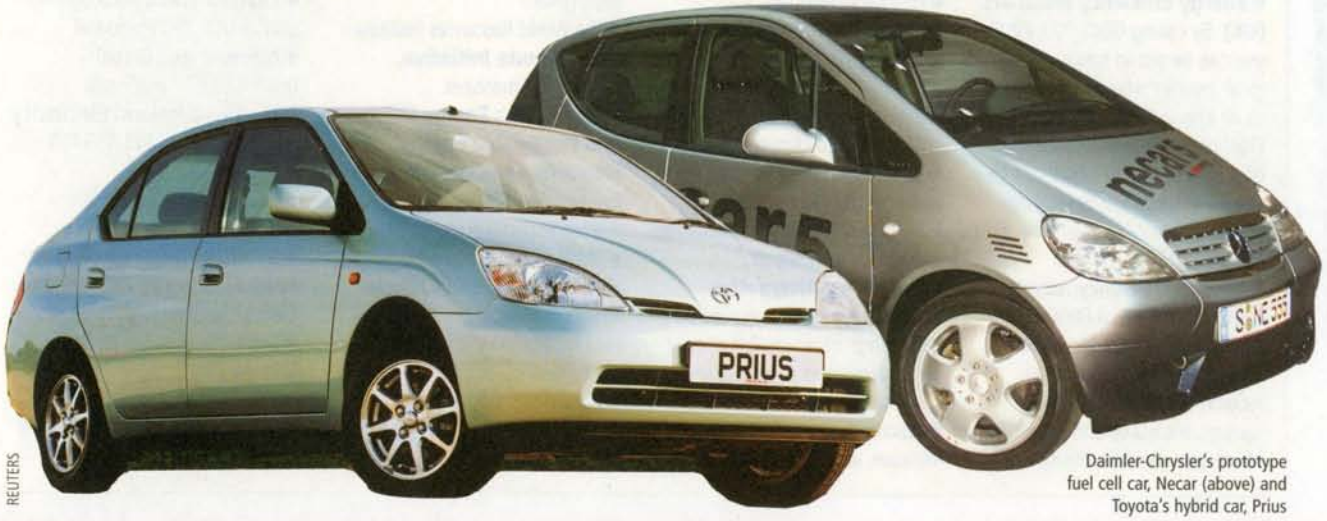
The British public will be given its first taste of riding in a hydrogen-powered vehicle from 2003, when three HFC-powered buses will be trialled in London as part of an EU-funded project. From then on, as Julie Foley from the London-based Institute for Public Policy Research says, we are likely to see government and taxi vehicle fleets convert to hydrogen, before finally reaching the commercial car market.

### Lighter living

The prospect of an emissions-free future is clearly tangible, and many low or no-cost measures are available now for each of us to start shrinking our carbon footprint. With a little forward-thinking, buying into the more expensive products such as intelligent insulation, energy efficient appliances, and hybrid cars today will save money in the long run. Solar PV and individual wind turbines are probably still beyond the reach of most people. But that will almost certainly change over the next few years.

Meanwhile, the world awaits the arrival of fuel cells for use in cars and homes – a technology with huge potential in the fight against climate change. All in all, each of us has the opportunity to make a real difference in this battle. Given the damage climate change is predicted to cause if emissions aren't reduced, do we really have a choice?

*Matilda Lee is a researcher at the Climate Initiatives Fund.*




REUTERS

Daimler-Chrysler's prototype fuel cell car, Necar (above) and Toyota's hybrid car, Prius

ICE SHEET IS ALREADY MELTING AT A RATE OF MORE THAN 17 CUBIC KM PER YEAR – ENOUGH TO FILL 8.5>>>

# 40 EASY STEPS TO REDUCE YOUR

Do you want to live in a greenhouse full of exhaust fumes and air pollution? No? Then you

comes from energy use in homes and 25 per cent comes from cars.

## NO COST OPTIONS

### In and around the home

1. Turn off the lights when you leave a room.
2. Turn off radiators and other heating or cooling vents in unused rooms.
3. Use economy settings on home appliances.
4. Cook with lids on pots and use a pressure cooker.
5. Run the washing machine and dish-washer with full loads.
6. Wash clothes at 40°C or less instead of 60°C – it uses a third less energy than normally needed to heat the water for a hot wash.
7. Use a washing line not a tumble dryer.
8. Turn down your thermostat – every 1°C less can cut your heating bill 10 per cent.
9. Turn your refrigerator up a notch – keeping it just 1°C warmer saves about 50kg of greenhouse gas a year.
10. Take shorter showers.
11. Turn your TV and other appliances off at the power point instead of using your remote and leaving them on stand-by.
12. Protect trees and shrubs (to absorb $CO_2$).
13. Minimise your use of paper and recycle the paper you use.

### Travelling

14. Walk, cycle, take public transport or consider a car-pool whenever possible.
15. Reduce your air travel.
16. Telecommute from home one or more days a week during normal business hours.

### Shopping

17. Shop locally rather than in out-of-town superstores.
18. Eat more plant-based and less meat-based meals (to reduce methane emissions from intensive animal rearing).
19. Buy products with the least packaging.
20. Avoid the products of companies like Esso (Exxon) that are obstructing solutions to the problem of climate change.
21. Switch your investments away from fossil fuel companies to renewable energy ones or ethical investment funds, or exercise your right as a shareholder to vote at companies' AGMs in favour of resolutions demanding reductions in emissions.

22. Lobby your political representatives to press them to act, and vote accordingly.

## FOR FURTHER INFORMATION AND ADVICE:

- **Energy Efficiency Installers (UK)**. By calling 0845 727 7200, you can be put in touch with a local installer who has signed up to an Energy Efficiency Code of Practice and can advise on the best energy efficiency options to suit your needs. For energy-efficiency wall insulation and heating installers: 0345 277 200
- **Energy Efficiency Advice Centres (UK)**. Call 0800 512 012 to talk to your local energy adviser for free, personalised recommendations for energy savings, measures and grants for which you could be eligible.
- For grants also see: www.est.org.uk/ee/common/cfm/grantsframeset.htm).

*Practical advice on reducing your contribution to climate change:*

- **The UK Energy Saving Trust,** www.est.org.uk.
- **National Energy Foundation**, www.natenergy.org.uk.
- **Centre for Alternative Technology** – runs courses on a wide range of renewable energy applications and technologies: www.cat.org.uk.
- Australian Government **Cool It** initiative, www.greenhouse.gov.au/pubs/gwci/.
- The World Resources Institute's **Safe Climate Initiative**, www.safeclimate.net
- The US DoE's **Energy Efficiency and Renewable Energy Network**, www.eren.doe.gov, and **Energy Star Program**, www.energystar.gov.
- The Rocky Mountain Institute's **Home Energy and Climate Briefs**, www.rmi.org/sitepages/pid171.php, and www.rmi.org/sitepages/pid331.php.
- **American Council for an Energy-Efficient Economy**, www.aceee.org.

*UK Power companies offering renewable electricity options:*

- **Eastern Energy** (Ecopower) – 0845 6011 290 (national)
- **Npower** (EverGreen) – 0800 632 632 (national)
- **Northern Ireland Electricity** (Eco-energy) – 0345 455455 (national)
- **PowerGen** (Green Plan) – 0500 240 500 (national)
- **SEEBOARD** (Go Green, Green Fund) – 0800 581 255 (Southern Electric Region only)
- **Scottish and Southern Energy** (RSPB Energy) – 0800 028 8552 (national)
- **ScottishPower & MANWEB** (Green Energy) –

>MILLION OLYMPIC-SIZE SWIMMING POOLS.....THE RED CROSS ESTIMATES THAT 440,000 PEOPLE WERE

# CONTRIBUTION TO CLIMATE CHANGE

can do something about it: 20 per cent of emissions of $CO_2$ – the main greenhouse gas – Here are 40 easy steps to reduce your contribution to climate change.

## LOW COST OPTIONS

23 Switch to a clean electricity or Green power supplier if you have the option.
24 Replace your light bulbs with Compact Fluorescent Lightbulbs. A fluorescent bulb can cost you around £9.00 up front, but it uses one-fifth of the electricity of an average bulb, lasts 10 times longer and saves half a tonne of $CO_2$ in its lifetime.
25 Increase your loft insulation to a depth of 20cm (8in) – this alone will slash the average fuel bill by 20 per cent.
26 Draught-proof windows and doors to prevent heat loss and save energy.
27 Insulate your water tank with at least 7.5cm (3in) thickness.
28 Put aluminium foil behind your radiators with the dull side of the foil against the wall.
29 Install a low-flow showerhead.
30 Service your car regularly – keeping the engine tuned saves up to a tonne of greenhouse gases a year for a family car and keeping your car tyres at the maximum recommended air pressure saves up to 100kg of greenhouse gases each year.
31 Buy regionally, seasonally and organically produced food whenever possible.
32 Buy recycled paper and only buy wood products that display the Forest Stewardship Council (FSC) label.
33 Plant new trees.

## MID-RANGE COST OPTIONS

34 Replace your old boiler with a condenser boiler – the most efficient way of heating water and space in a home (converting 85 per cent of fuel into heat compared with not much more than 65 per cent for standard boilers).
35 Buy the most energy efficient appliances (look for the 'energy efficiency recommended' logo, and labels showing how much energy each product uses, with 'A' being the most efficient and 'G' the least). An energy efficient fridge, for example, can use less than half the energy of an old, inefficient model, and can save you money.
36 Install cavity wall insulation (if you live in a house built after 1930) – it can reduce heat loss through walls by up to 60 per cent.
37 Install double-glazed windows – almost a quarter of heat lost from a home can be through poorly insulated window frames and single glazing.
38 If you need a car, buy one that gets most miles to the gallon (the most fuel-efficient cars are currently Toyota's Prius and Honda's Insight – hybrid petrol and electric cars).
39 Buy a solar water heater.
40 Invest in solar photovoltaic tiles for your roof.

0845 272 7111 (ScottishPower & MANWEB Regions only)
- **SWALEC** (Green Energy) – 0800 052 5252 (SWALEC Region only)
- **SWEB** (Green Electron) – 0800 328 9026 (England and Wales only)
- **Unit Energy Ltd** (Unit[e]) – 0845 601 1410 (England and Wales only)
- **Yorkshire Electricity** (Green Electricity) – 0345 227733
- For details see: www.est.co.uk/pdf/supplier_listb.pdf.
- For **Greenpeace's 'Juice'** electricity call 0800 316 2610 or see: www.greenpeace.org.uk, or www.npower.com/Juice.
- **Friends of the Earth** guide to green electricity suppliers see: www.foe.org.uk/campaigns/climate/press_for_change/choose_green_energy/index.html.

*Home solar hot-water and electricity systems:*
- **Solar Trade Association**, www.greenenergy.org.uk. Also www.thermomax.com.
- **Solar Century** designs, installs and maintains tailor-made solar PV systems for businesses, homes, industry and the public sector, www.solarcentury.com. Also www.unisolar.com, www.bpso lar.com, www.home-power.com

*For information on wind energy:*
- **British Wind Energy Association**, www.bwea.com.
- For a range of turbines, prices and installation information, try **Bergey WindPower** at www.bergey.com.

*Corn-burning stoves:*
**www.burncorn.com**
**www.magnumfireplace.com**
**www.cornburnersinc.com**

*To invest your savings in an ethical investment fund:*
**Holden Meehan** independent financial advisers, www.holden-meehan.co.uk/

*High-efficiency hybrid cars:*
- **Toyota**, www.prius.toyota.com. **Honda**, www.honda2001.com/models/insight.

*Useful books:*
- *Homemade Money: How to Save Energy and Dollars in Your Home*, by Richard Heede. Rocky Mountain Institute, ISBN 188317807. To order visit: www.rmi.org/store/p385pid961.php
- *Stormy Weather: 101 Solutions to Global Climate Change*, by Guy Dauncey. ISBN 0865714215. To order visit: www.newsociety.com/swfs.html

KILLED IN THE 1990S AS A RESULT OF HYDRO-METEOROLOGICAL DISASTERS (SUCH AS DROUGHTS, WIND >

# One house at a time

Forget Kyoto. Mike Tidwell explains how he and his family cut emissions by 96 per cent in their own home. If they can do it – why can't you?

MIKE TIDWELL

It's a lovely, breezy, autumn day, temperature around eight degrees, not a cloud in the sky. Inside my house I set the thermostat at a toasty 22°C then reach for a cold beer from the refrigerator while turning the television to an American football game. Later I'll unwind with a hot, steaming bath while listening to classical music CDs. Just another glorious day of modern Western life – and profligate energy use – leading inexorably to runaway global warming, right?

Wrong. All but a tiny fraction of my household energy budget comes from renewable, $CO_2$-neutral sources. The electricity arrives from photovoltaic panels on the roof, the heating from a thermostat-controlled pot-belly stove that burns corn kernels and warms my entire suburban home, and the hot water from a separate rooftop panel that converts sunlight to infrared heat.

Obviously, I'm a very wealthy man to be able to afford such extravagant gadgets. Everyone knows that amazingly effective renewable-energy technologies are out there. The problem is that average people – the very people who need to change if we're ever going to stabilise the climate – simply can't afford them. Right?

Wrong again. In my case, I'm a hopelessly middle-class, self-employed writer with a four-year-old son. No rich uncle died allowing me my wife Catherine and I to become self-indulgent techno-nerds. And we didn't scrape together years' worth of savings to make this dream come true. We made all of our energy changes abruptly, within the past year, and now we're spending the handsome sum of – get this – $9.50 (£6.64) per month to pay for them. That's all. For 31 cents (21 pence) a day at our home we've gotten off the planet's back almost entirely. And here's the best news of all: most of these planet-saving technologies are available and affordable right now for any homeowner willing to do a little bit of research, borrow a modest sum of money, and spend that money wisely.

For Catherine and I, last January's bombshell findings of the Intergovernmental Panel on Climate Change first set us to plotting our home energy revolution. Planetary warming of 5.8°C by 2100 is doubly horrifying each time you look down at your innocent son playing with building blocks on the carpet. We knew that the modest targets of the Kyoto protocol wouldn't pass muster, either. Most scientists believe the world's $CO_2$ emissions must drop 80 per cent below current levels to stabilise the climate.

So that became our goal: 80 per cent. If we could cut our household $CO_2$ emissions by that amount – or at least by 50 per cent – we would have done our part. It was the least we could do in a nation where our government sabotages even modest international efforts to stem climate change. If our leaders won't lead, we Americans owe it to the rest of the world to get the job done ourselves, house by house, neighborhood by neighborhood.

So, Catherine and I came up with a budget: $7,500 (£5,245). That's what we would spend, no more. And being of modest means, we had to borrow the money in the form of a home equity loan.

Our very first investment was a book called *Homemade Money*,[1] for people wanting to save money through improved energy use. The first step, we learned, was to eliminate unnecessary energy consumption and to use more efficiently the energy you can't live without. So we switched to compact fluorescent light bulbs, bought an extremely high efficiency refrigerator (it consumes less than half the electricity of our previous ten-year-old unit) and began drying our clothes on a line. With these and other painless changes, including never *ever* illuminating an unoccupied room, we cut our electricity use a remarkable 45 per cent from 3,900 kilowatt hours in the year 2000 to an annual rate of 2,200 kilowatt hours now.

With our electricity demand now well trimmed, it became plausible to meet at least part of that demand with our own solar generation. And here's where we encountered the first of several big and pleasant surprises: we could go solar, in a very big way, even on a very tight budget. We quickly learned that our state of Maryland offers $3,600 (£2,500) grants toward solar photovoltaic systems plus a $1,200 (£840) tax credit. Grant in hand, we then went shopping for solar panels and got another big surprise: a solar advocacy organisation in our region was

>> STORMS AND FLOODS), THE NUMBER OF WHICH HAS 'MORE THAN DOUBLED' SINCE 1996.....THE IMPACT

heavily discounting the price of panels thanks to a subsidy from the US Department of Energy. Taking advantage of both of these programmes and installing much of the system ourselves, we were suddenly able to realise our greatest dream: 36 solar panels on our south-facing roof – generating all of our electricity.

Amazingly, having tackled the big hurdle of electricity, we had almost half of our original $7,500 budget still in hand to apply to our next big challenge: we had to find a new source of heat for our house.

But what would it be? Thankfully, a small company in Hutchinson, Minnesota answered the question. Twelve years ago, ex-farmer Mike Haefner, president of American Energy Systems, engineered the first ever corn-burning stove designed to heat modern homes. This relatively small and easy-to-install stove easily heats a 2,000 sq ft home (ours is 1,600 square feet) and comes with a thermostat for extra convenience. The stove can store up to three days' worth of corn in a side bin, which it self-loads with a low-energy electric auger. Just set the thermostat to the temperature you want and enjoy the radiant heat.

Burning corn contributes almost nothing to global warming. Like all plant material, corn absorbs $CO_2$ as it grows, and, with this stove, the corn burns so efficiently that the net $CO_2$ released is negligible. Moreover, corn is much cheaper than natural gas – we'll save more than $500 (£350) per winter – and it's easily purchased even by big-city dwellers at outlying feed stores, the closest being 30 minutes from my suburban Washington, DC home. (I'm currently forming a cooperative with other corn-burners in my neighbourhood to buy from a nearby organic farmer who will make deliveries.) And corn is an almost endless energy source. Studies show US farmers can grow 10 times more corn than is needed to meet all US energy needs. It's easy, good for farmers, good for the climate, and saves money.

Even after all these purchases – fridge, bulbs, photovoltaic panels, stove – we still had enough money to tackle our last major source of greenhouse gas: heating our water. And here we got lucky. My local energy consultant stumbled across a used but perfectly good five-year-old solar hot-water system and sold it to us installed for $1,000 (£700), instead of $3,500 (£2,450) new, thus closing out our expenditures at just over $7,500. The solar system preheats the water for our natural gas heater. Thus, on sunny days, our hot water comes from the sun and on cloudy days we get as much help from solar as we can and then the gas burners bring the temperature up to the 48°C we desire. So we're guaranteed hot water year round.

Here's the bottom line: except to cook our food with natural gas and heat our water on really cloudy days, we now contribute nothing to global warming through home energy use. In the process, we've reduced our estimated $CO_2$ contribution from 19,488 pounds per year to just under 864, a drop of almost 96 per cent. If every household in the industrialised world made only half of these changes we would be well on our way to solving global warming.

We also do very well by doing good. Our changes save us an estimated $930 (£650) each year. That's $77.50 (£54) per month. The monthly payment for the $7,500 loan is $87 (£60), a difference of just 31 cents a day, a small price to help preserve the planet. And in 10 years, when the loan is repaid, that $930 will go straight into our pockets.

But where's the catch? Surely such an abrupt switch from fossil fuels entails some sort of hidden sacrifices?

Actually, there are none. Yes, twice a week in the winter we have to reload the stove with corn. That takes about five minutes. And since the stove radiates heat, a room can only be warm if its door is left open, meaning someone wanting an extended period of complete privacy might get a little chilly. Other than this, our lives of modern comfort are essentially unchanged.

Except for one more thing: we now live with greater hope for our son's future and that of the whole planet. If we can make such big changes so quickly and for so little money, the rest of the world, when it finally makes up its mind, can do the same.

*Mike Tidwell is a freelance writer and climate change activist in Takoma Park, Maryland, USA.* References on page 50.

## BUDGET: WHAT WE BOUGHT

- 1.5 kilowatt photovoltaic system (partially installed by author): $3,396 (£2,375)
- CO2-neutral corn-burning stove: $2,400 (£1,678)
- Solar hot-water system (used): $1,000 (£700)
- High-efficiency refrigerator: $750 (£525)
- 20 compact fluorescent light bulbs: $140 (£98)

TOTAL: $7,686 (£5,375)

## HOW WE PAID FOR IT

- $7,500 (£5,245) 10-year home equity loan at 7 per cent interest rate. Monthly payment: $87 (£61).
- Monthly energy savings: $77.50 (£54.10).
- Final cost of converting our house almost entirely to renewable energy: 31 cents (21 pence) per day (until loan is paid off.)

OF HURRICANE MITCH ON THE HONDURAN ECONOMY WAS EQUIVALENT TO ABOUT THREE-QUARTERS OF>>

# The psychology of denial

**As evidence of climate change mounts, the public increases its capacity for denial, and apathy reigns. Understanding the reasons for this phenomenon is crucial to mobilising the public, argues George Marshall.**

My first real exposure to the issue of climate change was reading a newspaper article in the *Sydney Morning Herald* in 1988, by a leading Australian climatologist. Climate change, he said, had the potential to destroy our society and even threatened our continued survival as a species. I was deeply moved (it even spurred me to write my only ever letter of appreciation to a newspaper).

However, what really shocked me in the following days was finding that the article had created not the slightest ripple; not one opinion, editorial, or letter. It may as well have never been written. It seemed to me that something very strange had happened. A highly qualified scientist had calmly and credibly outlined a process which, were he to be believed, made all other news in the paper marginal if not irrelevant. Yet the story had sunk without a trace. I could see only two explanations; either it was a hoax, which seemed unlikely, or it was so conjectural that no-one could seriously accept it. Either way, my immediate instinctive drive to do something was squashed.

In the following years, as the articles and documentaries and news items continued to appear, I realised that there was a third explanation – that people can accept the truth of what is said without accepting the implications.

In his excellent book, *States of Denial, Knowing About Atrocities and Suffering*, Stanley Cohen argues that this capacity to deny a level of awareness is the normal state of affairs for people in an information-saturated society.[1] He argues that 'far from being pushed into accepting reality, people have to be dragged out of reality'. According to Cohen's definition, denial involves a fundamental paradox – that in order to deny something it is necessary at some level to recognise its existence and its moral implications. It is, he says, a state of simultaneous 'knowing and not-knowing'.

This description is well suited to the current social response to climate change. The 'knowledge' of the problem is remarkably well established at all levels of society; the general public (68 per cent of Americans call it a serious problem in polls); the scientists (repeated letters of concern from scientific institutions); corporations (strongly worded statements by the CEOs of oil companies); the financial sector (reports warning of escalating insurance claims); the many heads of government (regular pious speeches warning of imminent disaster).

Yet, at another level, we clearly refuse to recognise the implications of that knowledge. Bill Clinton called for urgent action whilst his negotiators worked tirelessly to gut and destroy an agreement that scarcely began to reflect his own warnings. Newspapers regularly carry dire climatic warnings in the same issue as articles that breathlessly promote weekend breaks in Rio. Individuals, including my friends and family, can express grave concern, and then just as quickly block it out, buy a new car, turn up the air conditioning, or fly across the world for a holiday.

Cohen's analysis of the social responses to human rights abuses finds that the mechanisms of denial are extremely complex and varied. The circumstances that create any historical event are unique and it is unwise to make direct comparisons. However, following Cohen we can draw out certain consistent psychological processes that are highly pertinent to climate change.

Firstly, we can expect widespread denial when the enormity and nature of the problem are so unprecedented that people have no cultural mechanisms for accepting them. In *Beyond Judgement*, Primo Levi, seeking to explain the refusal of many European Jews to recognise their impending extermination, quotes an old German adage: 'Things whose existence is not morally possible cannot exist.'

In the case of climate change, then, we can intellectually accept the evidence of climate change, but we find it extremely hard to accept our responsibility for a crime of such enormity. Indeed, the most powerful evidence of our denial is the failure to even recognise that there is a moral dimension with identifiable perpetrators and victims. The language of 'climate change', 'global warming', 'human impacts', and 'adaptation' are themselves a form of denial familiar from other forms of human rights abuse; they are scientific euphemisms that suggest that climate change originates in immutable natural forces rather than in a direct causal relationship with moral implications for the perpetrator.

Secondly, we diffuse our responsibility. Cohen writes at length of the 'passive bystander effect' whereby violent crimes can be committed in a crowded street without anyone intervening. Individuals wait for someone else to act and subsume their personal

responsibility in the collective responsibility of the group. One notable feature of the bystander effect is that the larger the number of actors the lower the likelihood that any individual person feels capable of taking unilateral action. In times of war and repression, entire communities can become incapacitated. In the case of climate change we are both bystanders and perpetrators, an internal conflict that can only intensify our denial.

Psychoanalytic theory contains valuable pointers to the ways that people may try to resolve these internal conflicts; angrily denying the problem outright (psychotic denial), seeking scapegoats (acting out), indulging in deliberately wasteful behaviour (reaction formation), projecting their anxiety onto some unrelated but containable problem (displacement), or trying to shut out all information (suppression). As the impacts of climate change intensify we can therefore anticipate that people will willingly collude in creating collective mechanisms of denial along these lines.

It seems likely, however, that suppression will dominate. In South Africa, many white bystanders who intellectually opposed apartheid adopted a passive opposition. They retreated into private life, cut themselves off from the news media, refused to talk politics with friends, and adopted an intense immersion in private diversions such as sport, holidays and families. In Brazil in the 1970s a special term, 'innerism', was coined for the disavowal of the political.

We can also draw on historical experience to anticipate which defenses we will adopt when, as will surely happen, we are confronted by our grandchildren demanding to know why we did so little when we knew so much. We can expect to see denial of knowledge ('I didn't know'), denial of our agency ('I didn't do it'), denial of personal power ('I couldn't do anything', 'no one else did anything'), and blaming of others ('it was the people with the big cars, the Americans, the corporations'). For activists everywhere, it would appear crucial that an understanding of denial informs campaign strategy. As Cohen says, 'the distinctions [between different forms of denial] may be irrelevant to the hapless victim, but they do make a difference to educational or political attempts to overcome bystander passivity'.

One conclusion is that denial cannot simply be countered with information. Indeed, there is plentiful historical evidence that increased information may even intensify the denial. The significance of this cannot be over emphasised. Environmental campaign organisations are living relics of Enlightenment faith in the power of knowledge: 'If only people knew, they would act.' To this end they dedicate most of their resources to the production of reports or the placement of articles and opinions in the media. As a strategy it is not working. Opinion polls reveal a high level of awareness with virtually no signs of any change in behaviour. Indeed there are plentiful signs of reactive denial in the demands for cheaper fuel and more energy.

PHOTODISC

A second conclusion is that the lack of visible public response is part of the self-justifying loop that creates the passive bystander effect. 'Surely', people reason, 'if it really is that serious, someone would be doing something.' The *Herald* article failed to inspire me to activity because I saw no evidence that anyone in wider society was paying any attention. Thirteen years later, we have vastly greater information with scarcely any more public action. The bystander loop has only tightened.

People will never spontaneously take action themselves unless they receive social support and the validation of others. Governments in turn will continue to procrastinate until sufficient numbers of people demand a response. To avert further climate change will require a degree of social consensus and collective determination normally only seen in war time, and that will require mobilisation across all classes and sectors of society.

For all these reasons, the creation of a large and vocal movement against climate change must be an immediate and overarching campaign objective. People will not accept the reality of the problem unless they see that others are engaging in activities that reflect its seriousness. This means they need to be confronted by emotionally charged activities; debate, protest, and meaningful, visible alternatives. Simply asking people to change their lightbulbs, plant a tree, or send in a donation, however desirable in themselves, will not build a social movement. These activities alone, although valuable, will persuade few.

Anyone concerned about this issue faces a unique historical opportunity to break the cycle of denial, and join the handful of people who have already decided to stop being passive bystanders. The last century was marked by self-deception and mass denial. There is no need for the 21st Century to follow suit.

*George Marshall works with Risingtide, a recently formed network encouraging local action against climate change. For more information on Rising Tide visit www.risingtide.org.uk, call +44(0)1865 241 097 or email: weathersave@netscapeonline.co.uk.*

MORE EXTREME WEATHER EVENTS AND 7 TIMES GREATER ECONOMIC LOSSES FROM 'NATURAL' DISASTERS>>

# Fast-forward: new ideas to accelerate change

Environmental organisations have had only limited success in bringing about the changes necessary to address climate change. Simon Retallack suggests it's time for new strategies.

We owe a lot to environmental organisations. Among their many achievements, green NGOs (non-governmental organisations) have done more than any other group to put climate change on the political map; forcing most governments to recognise it as a genuine problem.

However, after over 15 years of trying, NGOs have had only limited success in persuading politicians to follow through with sufficient action. National greenhouse gas emissions continue to rise, investments in renewable energy remain too low, and the only global agreement cobbled together to address climate change is in a very precarious state and is shot-through with loopholes. The overarching goal of achieving a rapid phase-out of the use of fossil fuels remains far from being fulfilled.

Looming large among the causes of this situation are the institutional inertia gripping most governments and the enormous influence wielded over them by industries determined to extract maximum possible returns from investments in fossil fuels.

These are formidable obstacles, but not impossible ones for NGOs to overcome. A key factor in the struggle will be the type of strategies climate NGOs choose to adopt. To date, and for understandable reasons, most NGOs, especially the larger ones, have spent much of their time and energy trying to influence policy at the national legislative level, at the UN Framework Convention on Climate Change, and in business boardrooms. Among the favoured tactics: the publication of policy documents, lobbying and dialogues with politicians, civil servants, negotiators, and business officials.

The emphasis placed on being 'insiders' within the policy process (particularly that of the UN), however, may have had the effect of leading some NGOs to moderate their demands and narrow their expectations. It may also have obscured the need to find effective ways of building sufficient leverage over governments to counteract the pressure applied by powerful elements of the business community, who deploy vastly greater funds than NGOs could ever match in defence of the status quo. Political leaders and heads of corporations have been able to pursue business as usual, with little if any price to pay for their inaction on climate change.

If this situation prevails, climate change could become unstoppable. It is time, then, for fresh thinking.

## Building a grassroots movement for change

One of the most important steps NGOs could take now to increase their leverage over governments and corporations is to build a popular, global, grassroots movement to bring pressure to bear for change.

Many of the most important political and cultural changes that have occurred in the last 250 years – the elimination of absolute monarchy, colonial independence, the abolition of slavery, the right to vote, the establishment of civil rights, and the end of apartheid – have been the result of pressure from popular movements. The fight to prevent climate change – to safeguard the survival of much of humanity and the natural world – is arguably just as important as the battles for justice and democracy of the past, appears just as daunting and will entail a similar level of effort.

As obvious as this may appear, the reality today is that the public worldwide remains almost wholly unengaged with the issue of climate change. Data from opinion polls and focus groups in the US show that it concerns people less than almost all other environmental issues. Right now, people do not believe it is a serious problem, or that it will seriously affect them in their lifetime. Half feel immediate action is unnecessary – in part a reflection of a widespread sense that the problem is beyond control or inevitable. Most are ambivalent about its basic causes – natural variability or human influence – and are unaware of how its causes relate to their own everyday actions, and consequently what they could do to make a difference.[1]

As governments and NGOs have tended to focus on the formal and highly technical decision-making processes that relate to the issue, climate change has been confined largely to the technocratic and elitist domain of scientific and policy analysts, not the popular arena. Consequently, people have been left with the impression that the problem is being dealt with, but mostly in terms that they can't understand or relate to, denying the issue much of the emotion and moral outrage that it should elicit.

That situation must be turned around. To achieve this, NGOs need to find the right mechanisms and language to reach out to people in every region of the world, explaining how climate change will affect them and their children, why it is happening, what they can do about it; and how the choices we make today can affect the future. At the very least, NGOs need to

>>THAN IN THE 1960S.....DROUGHTS AND SEA-LEVEL RISE WILL RESULT IN ABOUT 40-50 PER CENT OF

PANOS

mobilise all the constituencies that ought to care most about the issue, ranging from the victims of the fossil fuel economy, to those who stand to suffer the most from climate change, as well as the sectors that stand to gain the most from the solutions.

Members of such a movement could be encouraged to change their own behaviour in ways that have a direct and beneficial impact on the problem and be mobilised to apply pressure on their elected representatives at all levels during elections and around key votes in local, regional and national legislatures. They also need to be mobilised to put pressure on business to change, by taking part in campaigns, including boycotts, against the corporations that are causing the most damage to our climate, and those that are most active in blocking solutions. Campaigns of this kind have achieved significant results before. Most famously, boycotts of companies that traded with South Africa helped end apartheid. Those who refuse to act to address climate change today (be they governments or corporations) need to be treated in the same way.

Even more recently, the global movement that has emerged around the relatively abstract issue of trade policy, which burst forth to such startling effect in the streets and inside the conference centres of Seattle, shows what years of patient educating, mobilising and constituency-building by NGOs in many countries can achieve.

## Strengthening NGO capacity in the developing world

Related to this strategy, it appears increasingly important to devote time, energy and resources to the goal of bolstering the number and capacity of NGOs working on climate change in the developing world (a prerequisite for the generation of public pressure on governments there). This goal is important because the developing world will clearly have a significant impact on the problem of climate change through the choices it makes in energy policy and in relation to international politics.

Even though developing countries are predicted to bear the brunt of climate change, the issue currently barely registers on the radar of issues requiring political attention for most developing country governments – in part a result of the serious lack of NGOs working on the issue in developing countries. Of the 800 environmental NGOs in India, for example, less than a handful focus on climate change nationally.

That situation is likely to become an increasing obstacle to progress on reducing global greenhouse gas emissions, as it will continue to mean insufficient pressure is applied by developing countries on industrialised ones to reduce their contribution sufficiently, while simultaneously ensuring that developing country emissions grow exponentially.

Much is at stake. Many of the most populated developing countries have high economic growth rates (or

THE WORLD'S COASTAL WETLANDS BEING LOST BY THE 2080s.....THE BRITISH ASSOCIATION OF THE >>

growth rate projections) that will require major increases in energy production. Asia, for example, is predicted to double its energy use over 1990 levels by 2010, and energy use in Latin America is expected to grow by 50–77 per cent over the same period.[2] On the basis of current policies, the vast majority of this massive increase is likely to be met by burning fossil fuels (of which the largest developing countries have huge reserves). This would take developing country greenhouse gas emissions to over 50 per cent of the global total by 2020, spelling climatic disaster.

To avoid this threat, capacity-building initiatives on climate change will be essential. Through bottom-up, grass-roots educational work, tailored to local needs and circumstances, and outreach to other environmental NGOs, human rights organisations, farmers unions, and other groups that are currently unengaged on climate but who ought to become active, today's situation could be reversed.

EYEWIRE

## Mobilising the power of the private investment community

Another strategy of growing interest is that of building leverage over climate-changing corporations by bringing pressure to bear on them from the private investment sector.

Aside from customers, the key constituency that corporations concern themselves most with are their shareholders, who own, and in principle, control them, and whose interests they are legally required to place above all others. Persuading shareholders to use or shift their investments according to how corporations address climate change could prove to be a powerful means of halting the vast flow of money that is invested on a daily basis in projects designed to explore for and extract more fossil fuels. Funds could be re-directed instead to renewable energy and energy-efficient technologies.

One tactic that has been pursued already to try to mobilise shareholder action has been the tabling of resolutions at companies' annual meetings. ExxonMobil, Shell and BP have all been targeted in this way. However, this work could be more effective if it was accompanied by strategies designed to increase the awareness of climate change among the managers of large institutional investment funds, a relatively small group of people who control most of the world's invested capital.

This would require the development of approaches that adopt the language of financial institutions to appeal not to fund managers' consciences, but to their duty to protect their investors' interests. The key challenge is to explain the material risk that climate change poses to the value of corporate shareholdings.

These risks stem from direct financial losses as a result of extreme climatic events, and also from likely regulatory and fiscal action initiated by governments to address the problem, which is likely to leave high-emitting industries with large costs, hurting profitability. A further threat stems from possible shifts by consumers away from corporations with a poor climate change image or product-line.

Investment fund managers need to be made aware of these risks and persuaded of the need to act to avoid them, either by requiring the companies they invest in to take measures to reduce their contribution to climate change, or, by shifting their investments towards companies with a low carbon 'footprint'. That would clearly have a marked impact on the share price of energy-related corporations, affecting their ability to raise capital and expand (in a beneficial way for renewable energy and energy efficient companies, and in a negative way for heavy carbon emitters). The type of fund managers who could be targeted include public pension fund managers – who work to long time horizons (particularly those managing money in-house for churches, teachers and other public sector workers).

Other potential targets include institutional fund managers, and, more specifically, their public pension fund clients, as well as the in-house managers of insurance company investments which are already being placed under financial pressure by the increasing weather-related losses that are being linked to climate change.

Any movement on behalf of such fund managers could potentially have a huge impact, since they represent substantial pools of capital. Ten of the world's 15 largest pension funds are responsible for investing over $1 trillion; the ten largest investment funds, meanwhile, are responsible for investing $11 trillion; and the ten largest insurance companies are responsible for investing $3 trillion.[3]

If the fund managers of just these 30 funds could be persuaded to shift their investments by only 1 per cent away from carbon-heavy industries to low-carbon ones, this would represent a shift of $100 billion. Such a strategy could be combined with external approaches (such as boycott campaigns) to generate more pressure on funds and banks to change, involving the wider public, whose pension money, savings, insurance contributions and college funds are currently being counter-productively invested. Whatever approach is taken to achieve it, if the huge power of the private investment community can be mobilised, it is likely to have very significant and fruitful consequences in the pursuit of climate change mitigation.

## Shifting public funds out of fossil fuels

Shifting public sector investments is just as important a goal. At the moment, public funds are being used to subsidise and provide insurance for the development of new fossil fuel projects around the world, especially in developing countries. If such public backing was withdrawn, these projects would become more expensive and risky for corporations to undertake and therefore less likely to happen. Work designed to bring about an end to this misuse of tax-payers' money could therefore play an important role in the battle against global warming.

The use of public funds by national and international agencies to support fossil fuel projects in developing countries is particularly destructive. Many such countries are now in the process of building energy infrastructures that they will be committed to for at least 30 years. It is madness, therefore, for industrialised countries to help to

ensure that these infrastructures are based on fossil fuels. Once capital is sunk into the wrong energy systems, particularly in countries with scarce financial resources, change will be much harder to achieve. Such countries will be hooked on the carbon-intensive path of development pursued by industrialised countries and the severity and rapidity of climate change will be dramatically increased.

Yet, publicly-backed multilateral development banks (MDBs) and national export credit agencies (ECAs) are helping to guarantee precisely such an outcome.

Since 1992, the World Bank, for example, has spent $13.6 billion on coal mines, oil and gas fields and fossil-fuelled power plants in developing countries and the former Soviet bloc. That is 25 times more than it spent on renewable energy projects in the same period. Each World Bank dollar invested in fossil fuel projects, moreover, paves the way for five or six additional dollars in private investment. The Bank's projects will eventually contribute an immense burden of $CO_2$ to the atmosphere – 38 billion tonnes in total – equivalent to 1.7 times the total emitted by the world in 1996.[4]

Export credit agencies are doing even more damage with taxpayers' money. The volume of financial assistance they provide collectively exceeds that of the World Bank and all the other multilateral and bilateral aid agencies put together: a staggering $105 billion was provided in new loans, guarantees and insurance in 1997 alone.[5]

The two sectors that ECAs focus most of their support on are fossil fuel-powered plants (mostly coal-fired), and oil and gas development in developing countries. In the second half of the 1990s alone, ECAs from Europe, Japan, Canada and the US provided $73.8 billion to such projects, and $29.2 billion more to other energy intensive industries. Over the same period, renewable energy projects co-financed by ECAs totalled only $2 billion.[6]

This approach has to be changed. ECAs and MDBs should be forced as a first step to quantify the total volume of greenhouse gases each of their projects will emit. They should then be required to make a commitment to phase out their support for fossil fuel projects, shifting their resources instead to renewable energy projects.

Only a very small number of NGOs are currently working to achieve such goals. Their number must increase so that public awareness can be raised regarding the way in which tax contributions are being used to fuel climate change. Maximum pressure must be applied on governments to end these destructive and inexcusable practices that are placing us on a collision path with disaster.

## Using litigation

Faced with glacial progress in addressing climate change worldwide, the use of litigation against corporations and governments of countries responsible for large shares of greenhouse gas emissions is another option for leveraging change that deserves to be actively considered.

Litigation on climate change could be initiated in a number of different ways. In the domestic courts, one option would be to claim compensation from a corporation or state that has been a major contributor to climate change (and hence to the damages that have resulted). Another would be to seek to impose preventive action, such as an injunction, on a corporation or state whose actions, if unaltered, would be likely to contribute to future damages from climate change.

The most obvious targets (or potential defendants) in the corporate sector would include the largest oil companies, and among governments, that of the US. Potential plaintiffs could include the already large number of people who have suffered material damages from climate change (such as loss of life, injury, and loss of homes, land and livelihoods).

Cases could also potentially be brought under public international law. In such cases, State A would initiate litigation against State B on the grounds that State B was causing harm to the territory, property, health or life of citizens of State A. Such cases would most likely be brought by developing countries against industrialised countries, since it is the former that will be most heavily affected by climate change, while it is the latter that are responsible for the bulk of the problem.

Any legal action chosen should hold the prospect of having the greatest impact on its target and on wider industry and governmental behaviour. In this regard, lessons could be learned from the success of product liability suits against the tobacco industry.

The potential benefits could be huge. The very process of initiating litigation would generate a large amount of publicity, and would be likely to force governments or corporations to reveal potentially embarrassing internal documents, while putting pressure on them to engage with the problem far more seriously than before.

The impact of success, of course, would be even more beneficial. Above all, it would create a powerful incentive for governments to act, and it would send an unmistakable signal to the financial markets that fossil fuel investments entail new costly liabilities that it would be best to avoid. Carried out properly, the use of litigation could play a significant role in accelerating efforts to mitigate climate change.

PHOTODISC

## Moving on

These are just a few of the ideas now emerging on how campaigners could be more effective in the struggle to prevent climate change. Some NGOs are already beginning to adopt them. Others may find it harder to change track; the ties that bind us to the way we've always done things can be hard to break. But they just won't do any more; they haven't taken us where we need to be. Instead, we need to start thinking 'outside the box'; focusing beyond the traditional arenas of influence-seeking and decision-making, to where even greater sources of power lie: the public, investment capital and the law. Mobilising these forces could finally help deliver the changes we urgently need.

*Simon Retallack is managing editor of* The Ecologist *special issues and is co-director of the Climate Initiatives Fund.*

**References on page 50.**

COULD BE ACHIEVED USING EXISTING, COST-EFFECTIVE, ENERGY EFFICIENT TECHNOLOGIES, WITH A RATE>>>

# A question of survival

**Edward Goldsmith explains why he believes the fight against climate change should be given the highest priority.**

The problem of climate change is probably very much worse than the latest assessment of the Intergovernmental Panel on Climate Change (IPCC) makes it out to be. Many members of the IPCC are likely to agree. The IPCC admits that 'its models cannot yet simulate all aspects of climate'. This is not surprising as mathematical models can only take into account factors that can be quantified and, unfortunately, many important aspects of climate are very difficult to quantify with any great credibility.

The IPCC is quite honest about this. It warns of projected climate changes during the 21st century as having 'the potential to lead to future large-scale and possibly irreversible changes in Earth systems'. Among these changes it specifies 'accelerated warming' due to the release of carbon stored in the world's forests, soils, permafrost regions, oceans and hydrates in coastal sediments.

The amount of carbon that could be released from these natural reservoirs is enormous. The world's vegetation, including its forests, contains some 600 billion tonnes of carbon; tundra, permafrost and other soils contain about 1,600 billion tonnes of carbon; methane hydrates as much as 10,000 billion tonnes; and the oceans nearly 40,000 billion tonnes. In comparison, the atmosphere currently contains just 750 billion tonnes of carbon. Moreover, between them, terrestrial and oceanic sinks absorb some 50 per cent of carbon dioxide emissions. What happens to the biosphere as temperatures rise is thus of critical climatic importance, yet it has been largely left out of IPCC calculations.

More sophisticated models are beginning to give us an idea of what would happen to global climate if such factors are taken into account. The Hadley Centre has built a new model which projects that within the next 50 years, if emissions continue at the present rate, much of our forests and soil will be transformed into *sources of*, rather than *sinks for*, $CO_2$ and methane. As a result, the Hadley Centre finds itself forced to project an extra 3°C increase in world temperatures by the end of the century. The IPCC's maximum of 5.8°C now becomes 8.8°C.

> 'This means a dramatic transformation in a very short space of time in the way we conduct our economic activities and indeed the way in which we live.'

Still left out of this forecast, however, is the full impact of higher temperatures on the oceans and on methane hydrates, from which releases are already occurring. The question we must ask is: 'How much will be released, and at what rate?' Also, by how many degrees would the IPCC projections for temperature rise this century have to be increased if these and other such factors were to be properly included? Climatologists Jerry Mahlman and Alberto di Fazio foresee a 10–14°C change in temperature by the end of the century. Who knows if they are right?

Whoever is correct, when each of the recent temperature change predictions are presented as a percentage of the average world temperature, which is about 14°C, it is apparent that we are in a very grave situation. Viewed in this way, the IPCC's 5.8°C change implies a 41 per cent increase in world temperature, which is enormous. The Hadley Centre's 8.8°C means a more than 60 per cent rise, whereas Mahlman and di Fazio's 10–14°C change involves an incredible 71–100 per cent increase in temperature. Can we survive such massive changes? Who knows?

However, it is well worth mentioning a well-known ecological principle called 'the principle of tolerance'. It states, in the words of ecologist Robert McIntosh that 'for each feature of the environment there are limits beyond which organisms cannot grow, reproduce, or in the ultimate extreme survive'.[1] According to Eugene Odum of the University of Georgia, the eggs of the brook trout can only develop in water that is between 10 and 12°C.[2] According to David Pimental potatoes do best when temperatures are between 15 and 20°C, but do

badly when they are above 28°C.[3] But I doubt if anyone has worked out under what temperature regime the key life processes on our planet can still occur. Is it all that certain that they can still occur in the conditions that such changes are likely to bring about?

What makes the whole problem even more worrying is that even if we stop burning fossil fuels tomorrow our planet will go on heating up for possibly another 150 years and the oceans for maybe a thousand or more years. With decisive and effective action, however, we could slow down this terrible process so that when climate eventually stabilises our planet can still remain largely habitable. As Peter Bunyard makes clear (page 15), by taking the necessary action we can still avoid the worst, but this action must be taken very quickly.

This brings us to the key issue. What actually has to be done and how can it be done? To begin with, we must obviously phase out, and phase out rapidly, the burning of fossil fuel – coal, oil, and natural gas. At the same time, we must equally rapidly phase in the use of energy derived from renewable sources such as wind, waves, and the sun – though this is unlikely to satisfy the full requirements of a growing world economy (assuming that it grows again after the present global economic collapse).

But much more than that has to be done. A massive campaign is required to protect our forests, our soil, and the oceans, more so, the whole world of living things, and to take whatever measures are required to increase rather than reduce its capacity to absorb emissions of greenhouse gases. All this means a dramatic transformation in a very short space of time in the way we conduct our economic activities and indeed the way in which we live. What is more, if we are to avoid all the possible positive feedbacks from becoming operative, this campaign must have precedence – total precedence – over everything else we do, including the economic activities to which we attach so much importance.

As Andrew Simms points out (page 23) we must put ourselves on a veritable 'war footing' if we are to achieve this in time. Everyone must be made to realise that economic development is no longer really an option. By its very nature it involves further increasing the impact of our activities on the world of living things and on its atmospheric environment. Even a 2 per cent growth rate in gross natural product (GNP), which is considered by most economists as being totally insufficient to keep the world economy going, would lead to roughly an eight-fold increase in the size and impact of our economic activities on the natural world and on its atmospheric environment. This is not even remotely tolerable.

The issue today is *survival* not *development*, and the strategies required to enable us to survive in the ever less propitious climatic conditions are *the exact opposite* of those required to promote development, let alone global economic development.

Needless to say, to take this action is not easy in the aberrant conditions we have created. How do we assure the phasing out of oil production when the oil industry in the US, as Simon Retallack notes (page 18) no longer has to lobby the government, *it is the government?*. How do we ensure the protection of the world's remaining tropical forests when the logging companies have become so massive and so powerful that two years ago they succeeded in persuading the then President, Bill Clinton, to make it his priority at the World Trade Organisation Ministerial Conference at Seattle to pass what became known as 'the free logging agreement' which would have left the loggers free to log everything, everywhere, to their heart's content?

REUTERS

Fortunately, the global economy, from which the multinationals derive their power and influence, is a highly unstable structure, as the numerous financial crises of the last 10 years have made only too clear. Today it is in the grips of a global crisis from which it may or may not recover. In the meantime, the world's biggest economies that have provided the main market for most of the developing countries' exports are ever less capable of doing so. Hence, indebted developing countries are having ever greater difficulty in exporting their way out of their financial difficulties and indeed of funding their imports. As a result, international trade is rapidly diminishing.

To deal with the resulting chaos and unemployment, developing countries will have no alternative but to reconstitute their seriously diminished domestic economies. This would mean putting globalisation into reverse and correspondingly reducing the power of the transnational corporations that control it, and that are the main obstacle to taking the measures required to assure our survival on this beleaguered planet.

In any case, civil society is beginning to realise the full horrors of economic globalisation, and in particular the globalised poverty that it is giving rise to. More so, the anti-globalisation movement is developing incredibly fast. What is urgent is that society be made to understand the even greater horrors of global warming so that an even more powerful movement develops to bring about the transformations required to slow down global warming to a minimum and to enable us to adapt to the climate changes that lie ahead. We are lucky in that it is the same transformations that are required to achieve both these ends. But there is no time to lose – time is short.

*Edward Goldsmith is the founder of* The Ecologist. References on page 50.

HEAT (AN AVERAGE OF TWO-THIRDS THE AMOUNT OF FUEL USED) EQUAL TO THE TOTAL ENERGY USE OF>>

# climate change campaigns

## ECUADOR Stop the oil barons

In June 2001, amidst widespread controversy and protest, Ecuador's Noboa administration gave the green light to Oleoducto de Crudo Pesado Consortium Ltd to begin construction of the $1.1 billion pipeline that will run through the pristine cloud forests in the Mindo valley (see *The Ecologist*, Campaigns, Vol 31/2). Germany's largest public bank, Westdeutsche Landesbank, is providing a $900 million 17-year loan package (to be syndicated to Citigroup, J P Morgan, Chase Bank and Deutsche Bank). The project is due to become operational by mid-2003 and will double Ecuador's oil production capacity. The government estimates that more than $2.5 billion in new oil production and exploration will be made over the next five years to fill the pipeline's capacity.

In addition to bisecting the rare Mindo Nambillo Cloud Forest Reserve, which could lead to the irreversible loss and destruction of some of the country's last remaining old-growth rainforest and the territories of isolated indigenous peoples, Ecuador is about to set off a boom in new oil exploration. Hundreds of new oil wells and flow lines would be built from existing oil concessions along with facilities to process and refine the heavy crude for transport across the country,

STONE

threatening a wealth of protected areas.

Since last spring there have been demonstrations, occupations of government offices, congressional hearings, lawsuits, and tours of fragile ecosystems along the pipeline 'right of way' challenging the project. Yet President Noboa, under pressure from the IMF to bring in US investment, affirmed in May that the project must go ahead. In response to public opposition, he declared: 'I'm not going to let anyone screw with the country, I'll give them war'.

### Make a difference

Write a letter to Mr Friedel Neuber, Chief Executive Officer, WestLB, Herzogstr. 15, 40217 Dusseldorf, Germany. Copy your letter to Amazonwatch, 115 S Topanga Canyon Blvd, Suite E, Topanga, CA, USA 90290; fax +1 310 455-0619, email: amazon@amazonwatch.org. Join Friends of the Earth International's letter campaign to phase out international financial institutions' lending for fossil fuel and mining projects. For sample letters and more information visit www.foei.org and www.amazonwatch.org.

## UK Rescue the government's energy review

In June, Prime Minister Tony Blair announced a review of energy policy for the 21st century. Chaired by Brian Wilson, Minister for Industry and Energy, the review is set in the context of 'meeting the challenge of global warming, while ensuring secure, diverse and reliable energy supplies at a competitive price' (see *The Ecologist*, News, Vol 31/7). A report is expected by December this year.

Early indications of what is likely to emerge are worrying. British Nuclear Fuels' submission to the energy review calls for no less than 20 new nuclear power stations as the solution to Britain's energy and climate needs. That call may be heeded given that Tony Blair is now actively considering the go-ahead for a Mox plant at Sellafield.

Meanwhile, Brian Wilson has indicated that he believes the current production of 2.3 million barrels of North Sea oil per day isn't enough. At the Offshore Europe oil conference he told companies 'to use, or surrender unexploited oil fields to new operators'. In a move aimed at 'rejuvenating North Sea production', Wilson said that the fallow and unused licences are 'a luxury we can no longer afford'.

If the UK government is serious about meeting the increasing challenge of climate change, it is neither oil nor nuclear power but renewable energy sources that should be its top priority.

### Make a difference

Urgently send your comments to Allan Brereton, Energy Review Team, PIU, Cabinet Unit, Admiralty Arch, The Mall, London SW1A 2WH, or email: energyteam@cabinet-office.x.gsi.gov.uk. For more information visit: www.cabinet-office.gov.uk/innovation/2001/energy/energyscope.shtml.

>> JAPAN.....A SINGLE 18-WATT COMPACT FLUORESCENT LAMP, REPLACING A 75-WATT INCANDESCENT LAMP,

## GLOBAL Think globally act locally

Effecting the kind of changes necessary to avoid the devastating effects of human-induced climate change will require far more drastic cuts in $CO_2$ emissions than the majority of our elected representatives currently advocate. However the democratic process leaves room for individuals and communities to shape their communal policies in a manner that embraces innovative solutions and minimises mankind's ecological footprint.

OXFORD SCIENTIFIC FILMS

In late summer this year, Seattle Mayor Paul Schell introduced policies committing 'City Light', the city's public electric utility, to a policy of zero net greenhouse emissions. Having sold its share of coal-fired power plants, 'City Light' will eliminate emissions from its remaining fossil-fuel resources, over the next ten years, through energy efficiency, conservation and by acquiring power from non-hydro renewable energy.

Meanwhile, in the Brazilian city Curitiba, the mayor has introduced multiple cycle paths, affordable public transport, waste recycling schemes and incentives for businesses that embrace Green solutions. The list goes on. Shortly after the agreement on the Kyoto protocol was reached this summer, Yorkshire's regional development agency announced that it will stand by its target of cutting over a fifth of its emissions by 2010.

The message? Think global, act local. Make your community emissions-free.

### Make a difference:

Get a copy of *Stormy Weather – 101 solutions to Global Climate Change* by G Dauncey and P Mazza; ISBN: 0865714215. The International Council for Local Environmental Initiatives (ICLEI) www.iclei.org helps cities – large and small – to develop environmental strategies and climate action plans. Form a local/regional group, make alliances and pressure your local MP and Regional Council to take up the challenge and embrace the vision for change.

## AUSTRALIA Save the Great Barrier Reef

The Texas-based company TGS-NOPEC wanted a major Christmas present last year, but Santa didn't come. With your help, the company will have an empty stocking this year, too.

As part of their long-term quest for oil, the gift they've got their eye on is permission by the Federal Government for a 5,000km trail of seismic detonations – more than one a minute, 24 hours a day, over 50 consecutive days less than 50km from the Great Barrier Reef World Heritage Area.

Numerous threatened marine species; including whales, turtles and at least six dolphin species would be in the region during testing. The company itself admits that seismic testing has 'the potential to cause physiological damage' to some marine species.

The results of TGS-NOPEC's seismic testing could open up oil exploration all over the region, and despite the fact that 92 per cent of Australians believe that oil drilling should not be allowed in areas near the sensitive Great Barrier Reef, the Australian environmental minister is still considering sanctioning the seismic tests.

For the full story, see *The Ecologist*, Campaigns, Vol 31/8.

### Make a difference

Send a letter to the Australian environment minister Robert Hill and the shadow environment minister Nick Bolkus. Senator the Hon. Robert Hill, Parliament House, Canberra, ACT 2600, Australia. Senator the Hon. Nick Bolkus, Parliament House, Canberra, ACT 2600, Australia. Please copy your letters to the Australian Conservation Foundation, 340 Gore St, Fitzroy, Vic. 3065 Australia; or email Bruce Atherton media@acfonline.org.au. For more information visit www.wwf.org.au/. For a report on the state of coral reefs visit www.unep.net.

## GLOBAL Deal with hidden emissions

At any given moment, there are about 10,000 airplanes in the skies. Faced with ever-cheaper flights and increasing demand, numbers of both commercial and freight flights are increasing at about 6–7 per cent per year. Numbers of people flying are estimated to double over 15 years.

Planes are fuelled with kerosene, a fossil fuel. Planes also release nitrogen oxides into the troposphere, where they oxidise into heat-trapping ozone. The world's 16,000 commercial jet aircraft generate more than 600 million tonnes of $CO_2$ per year. Put into perspective, aviation generates nearly as much $CO_2$ as from all human activities in the continent of Africa each year. Altogether, their impact reaches a possible 10 per cent of the greenhouse effect. Similarly disturbing is the fact that no-one in the world taxes airplane fuel; thus giving the industry an unfair advantage over buses and trains; making tickets ever cheaper; encouraging ever more people to fly.

Yet despite this, aircraft were left out of Kyoto because the parties could not agree how to allocate $CO_2$ emissions.

In early September Loyola de Palacio, EU transport and energy commissioner set out the EU's strategy: 'To get airlines airborne again' – designed to liberalise the global air market. Given the fact that Ms de Palacio is also energy commissioner, and that previous moves to introduce a kerosene tax in Europe have been blocked by Spain – her country – the future of a liberalised global sky won't be blue and clear but grey and dirty.

STILL PICTURES

### Make a difference

Write to Romano Prodi, President of the European Commission and Loyola de Palacio, VP. Contact for both letters: The European Commission, 200 rue de la Loi/Wetstraat 200, B-1049 Brussels. Visit www.greenskies.org for argument ammunition, or calculate $CO_2$ emissions for your journey at www.chooseclimate.org/flying.

CAN SAVE A TON OF CO2.....IF EVERYONE IN BRITAIN TURNED THEIR TELEVISION OFF AT THE SET RATHER>

# useful campaign websites

## boycotts

**www.stopesso.com**
Stop Global Warming & boycott Esso – great animations, reports and campaign ideas.

**www.pressurepoint.org**
Find out why ExxonMobil is the target for more than just changing our climate.

**www.fabclimate.org**
If you don't like President Bush's climate politics, visit this site to help change his mind.

**www.foecanada.org**
Friends of the Earth Canada's call to boycott Imperial Oil and its dirty Esso brand

## petitions

**www.greenpeace.org**
Write to Japanese Prime Minister Koizumi and ask him to ratify the Kyoto treaty as soon as possible so that it can enter into force by 2002.

**www.shoeworld.co.uk/protest/**
Join this petition to take the 'air' (sulphur hexa-fluoride, $SF_6$) out of 'Nike Air' shoes. $SF_6$ has a Global warming potential 22,000 times greater than $CO_2$ and can remain active for up to 500 years.

**www.legitgov.org/protests_SOP.html**
Pro-democracy and environmental groups campaign against Bush's environmental and energy policies.

**www.greenpeaceusa.org/bin/actionframe.pl?action_id=36**
Send a letter to Sir John Browne, CEO of BP/Amoco and tell him why drilling in the Artic National Wildlife Refuge is a bad idea.

**www.greenpeace.org**
Click on 'Australia', and email the managing director of Caltex to call on him to make a public commitment to stop buying dirty shale oil and destroying the Great Barrier Reef.

**www.foei.org**
Call upon the President of the World Bank Group to institute a moratorium on new World Bank fossil fuel and mining investments.

**www.bankwatch.org**
Sign the NGO letter to multilateral development banks and export credit agencies demanding phase out of fossil fuel investments and encouragement of renewable energy projects.

**www.eca-watch.org/index1.html**
International export credit agencies reform campaign with excellent action alerts.

**www.choose-positive-energy.org/**
Greenpeace and The Body Shop have joined forces to challenge governments to provide access to renewable energy for the two billion people who live without any power, within ten years. Log on to find out how this can be achieved and lend your support.

**www.peopleandplanet.org/climatechange/actionguide/default.asp**
UK student organisation campaigning for universities to switch to Green electricity – make the switch!

**www.EcoAction.ca/campaign.htm**
Fax and email-based campaign to press Canadian politicians to develop renewable sources of energy.

**www.pirg.org/enviro/energy**
A campaign for R.E.A.L. energy – renewable – efficient – affordable and lasting.

## greener living

**www.foe.co.uk/campaigns/climate/press_for_change/index.html**
Tells you how to buy Green energy, and much more.

**www.cleancarcampaign.org**
If you must have car – have a clean one.

**www.greenpeace.org/~climate/ksolutions/initiatives.html**
Or if you have a 'dirty' car, use this site to write an instant letter to the manufacturer, asking them about what they are doing to develop fuel efficient vehicles, and let them know what you expect of them.

**www.climatesolutions.org**
Some great ideas and case studies for everyone to copy.

## shareholder pressure

**www.campaignexxonmobil.org**
A shareholder initiative to compel ExxonMobil (Esso) to take responsibility for its role in causing global warming and to make a serious commitment to renewable energy.

**www.sanebp.com**
Sane shareholders argue against new oil exploration and for renewable energy..

## climate news and information

**www.ienearth.org/climate_lnk.html**
An excellent source of news and campaigns on climate change from indigenous peoples' perspective.

**www.climateark.org**
Great research and campaign tool for anything to do with climate change.

**www.ecoquity.org**
Campaign for climate justice. Provides excellent argument ammunition.

**www.heatisonline.org**
Highly accessible information for combating climate change

# references


**The truth about climate change** p4

1. IPCC: *Summary for Policymakers*. Third Assessment Report, March 2001.
2. Donald A Yerxa. 'Harvard Astrophysicist Throws Cold Water on Global Warming', *Research News*, April 2001, Templeton Foundation Press.
3. Richard A Betts, 1999. 'Self-beneficial effects of vegetation on climate in an Ocean-Atmosphere General Circulation Model', *Geophysical Research Letters*, Vol 26, No 10, 15 May.
4. Peter M Cox, Richard A Betts, Chris D Jones, Steven A Spall & Ian J Totterdell, 2000: 'Acceleration of global warming due to carbon-cycle feedbacks in a coupled climate model.' *Nature*, Vol 408, 9 November.
5. Richard A Betts: 'Offset of the potential carbon sink from boreal forestation by decreases in surface albedo.' *Nature*, Vol 408, 9 November, and Richard A Betts: 'Biogeophysical impacts of land use on present-day climate: near-surface temperature change and radiative forcing.' *Atmospheric Science Letters*, Vol 1, No 10.
6. *Science* (24 March, 2000 and April 2001), Levitus, Antonov, Boyer and Stephens, the US National Oceanographic Data Center and National Oceanic and Atmospheric Association.
7. Richard Wetherald and colleagues at the Geophysical Fluid Dynamics Laboratory. *Geophysical Research Letters*, 15 April, 2001.
8. *Equinox*, Channel Four, 17 June, 2001
9. Fred Pearce: 'Something nasty brewing in the bog', *New Scientist*, 2001, 25 August p 8.

**Back to the future** p10

Sources: PJ Barrett: Climate change – an Antarctic perspective, *New Zealand Science Review*, , 2001, Vol 58 (1), and PJ Barrett: 'Antarctic Palaeoenvironment through Cenozoic Times – A Review', *Terra Antarctica*, 1996, Vol 3 (2) 103-119.

**Baked Alaska** p12

'Potential Consequences of Climate Variability and Change for Alaska', in *Climate Change Impacts on the United States*, by the US Global Change Research Progam. On the web at www.usgcrp.gov/usgcrp/Library/nationalassessment/default.htm

**Is it too late to make a difference?** p15

1. Alberto Di Fazio: 'Climate Crisis,' *The Ecologist*, Vol 29/2, March/April.
2. The Met Office, 2000: *Climate change. An update of recent research from the Hadley Centre.*
3. The Met Office, 1999: *The Greenhouse effect and climate change. A briefing from the Hadley Centre* and The Met Office, 1999: *Climate change and its impacts: Stabilisation of CO2 in the atmosphere.*
4. *op cit* 2.
5. Royal Commission on Environmental Pollution, 2000. Energy - The Changing Climate. 22nd Report, HMSO.
6. Tim Radford: 'As the world gets hotter, will Britain get colder?' *The Guardian*, 21 June, 2001.
7. *ibid*, and Peter Capella. 'Disasters will outstrip aid effort as world heats up.' *The Guardian*, 29 June, 2001.
8. Paul Brown: 'Halting global warming is the cheapest option.' *The Guardian*, 21 July, 2001.

**Ask the experts** p17

1. *Global Change Open Science Conference: Challenges of a Changing Earth*, Amsterdam 10-13 July 2001, UNFCCC press release based on statements made by the Executive Secretary (www.unfccc.int/press/releases/index.html).
2. CD Keeling and TP Whorf: 'Atmospheric $CO_2$ Concentrations derived from in-situ air samples collected at Mauna Loa Observatory, Hawaii.' Scripps Institute of Oceanography, August 1998. A Neftel *et al, Historical $CO_2$ Record from the Siple Station Ice Core*, Physics Institute, University of Bern, Switzerland, September 1994. Also, see World Resources Institute website: www.igc.org/wri/powerpoints/climate/sld001.htm.
3. *United Nations Framework Convention on Climate Change*, Article II.

**We've saved Kyoto!** p18

1. Report of Working Group I for the First Assessment Report of the IPCC, 1990.
2. President Bush's spokesman, Ari Fleischer, cited in: 'Bush


>>THAN LEAVING IT ON STANDBY THE ELECTRICITY SAVED COULD POWER BASINGSTOKE.....HALF OF ALL CAR

"no" to Kyoto puts treaty at risk,' *The Financial Times*, 29 March, 2001.
3. Kevin A Baumert and Nancy Kete: *The US, Developing Countries, and Climate Protection: Leadership or Stalemate?* World Resources Institute, Washington DC, June 2001.
4. A Meyer and T Cooper: 'Why convergence and contraction are key,' *Environmental Finance*, May 2000.
5. Julian Salt: 'Why the insurers should wake up,' *Environmental Finance*, September 2000.
6. The Centre for Responsive Politics, *Election Cycle 2000, Top Contributors.*
7. Malte Meinshausen and Bill Hare: 'Extended quantitative analysis of the COP-6 President's text,' *Greenpeace*, June 2001, pp 2-3.
8. *ibid*, p 8.
9. 'Emissions of $CO_2$, $CH_4$, $N_2O$, HFCs, PFCs and $SF_6$ 1990–1998, excluding $CO_2$ emissions/removals from land-use change and forestry.' *Report on national green house gas inventory data from Annex I Parties for 1990 to 1998: Table B1, (UNFCCC/SBI/2000/11).*
10. *ibid*, and 'EU greenhouse gas emissions down 4%, more cuts needed – EEA.' European Environment Agency. News Release. Copenhagen, 20 April 2001.
11. *Second compilation and synthesis of second national communications: Table C6, (FCCC/1998/11/Add.2)*
12. 'Energy experts say EU may not meet Kyoto target,' Reuters, May 23, 2001.
13. National Environmental Trust, USA.
14. 'National Energy Policy,' May 2001. 'The Bush-Cheney Energy Plan: How it Fares in the 21st Century' The Energy Foundation, May 2001.
15. *Bush-Cheney Energy Plan*, Energy Foundation May 2001.
16. *Power up the Power Plants*, David Whitman, May 21 2001
17. US Federal Budget and Appropriations records, cited by the Sustainable Energy Coalition
18. *ibid.*
19. US Federal Budget and Appropriations records, cited by the Sustainable Energy Coalition.
20. 'US Sticking With Fossil Fuels, Cheney Says,' Environmental News Service, 1 May, 2001.
21. Christopher Wright from the Department of Trade and Industry in correspondence with Matilda Lee.
22. This figure excludes large-scale hydroelectric plants, landfill gas and incineration. Source: *The role of the Renewables Directive in meeting Kyoto targets*, October 2000, Royal Society document 11/00 ISBN 0 85403 548 6 published jointly with the Royal Academy of Engineering.
23. The Millennium Dome cost over £750 million and the Government's total managed expenditure was £371.6 billion in 2000. Sources: Environmental News Service, 'UK Sets Sights on Solar Powered Future,' 26 March, 2001; and Sustainable Development Commission: Spending Review 2000 and Sustainable Development. Background note for members: Sustainable Development Commission.
24. Royal Commission on Environmental Pollution, 22nd Report, *Energy – The Changing Climate*, June 2000.
25. Editorial, *The Guardian*, 22 June, 2001.
26. Department of the Environment, Transport and the Regions (DETR): *Climate Change Levy – frequently asked questions and answers, fact sheet 9.*
27. DETR, *Transport Statistics, Great Britain*, 2000 Edition.
28. DETR and quoted in *Transport 2000 'Favourite Facts'*
29. 'Energy Subsidies in Europe' commissioned by Greenpeace from the Institute for Environmental Studies, Vrije University in Amsterdam, 1997.
30. Simon Jeff from the Department of Trade and Industry in conversation with Matilda Lee.
31. The Soil Association, UK.
32. Kevin A Baumert and Nancy Kete: *The US, Developing Countries, and Climate Protection: Leadership or Stalemate?*, World Resources Institute, Washington DC, June 2001.
33. *The US, Developing Countries, and Climate Protection: Leadership or Stalemate?*, by Kevin A Baumert and Nancy Kete of the World Resources Institute.
34. Tom Gray of the American Wind Energy Association in conversation with Matilda Lee.
35. Kevin Porter of Solar Cookers International in conversation with Matilda Lee.

**Who's in the red now?** p23
1. Jubilee Plus, HIPC, *Flogging a dead process: The need for a new, independent and just debt workout for the poorest countries*, July 2001, London.
2. *Christian Aid, Who owes Who? Climate change, debt, equity and survival*, 1999, London.
3. International Federation of Red Cross and Red Crescent Societies: *World Disasters Report 2001: Focus on recovery*, 2001, Geneva.
4. *Environmental Finance* May 2000, Vol 1 No 7, pp19-21.
5. This theme is explored more fully in *An Environmental War Economy - the lessons of ecological debt and climate change* by Andrew Simms, published by the New Economics Foundation.
6. *Ibid.*
7. Op cit: *World Disasters Report 2001.*

**Economic globalisation** p25
1. International Bunker Industry Association, 1998. www.seanet.co.uk/classifi/marrosoc/ibia/ibia.htm MergeGlobal Inc, *World Seaborne Trade by Aggregated Route.*
2. Tim Lang and Colin Hines, *The New Protectionism*, New York, New Press, 1993.
3. Rosenzweig, Cynthia and Daniel Hillel. *Climate Change and the Global Harvest*, Oxford University Press, 1998.
4. USDA-ARS News Service. 'Cropland Helps Control $CO_2$ and Ease Greenhouse Effect', 29 September,1998.
5. D Matthews and A Rowell: 'The Environmental Impact of the Car', Washington DC, *Greenpeace*, 1992, p 6
6. Cable News Network, 'GM to Sign China Contract', 10 March, 1997.
7. Wysham, Daphne, 'The World Bank: Funding Climate Chaos.' *The Ecologist*, Vol 29/2.
8. Farrelly, Paul: 'Oil Sisters Troop to Altar as Price Sinks.' *The Observer*, 12 June, 1998.
9. J Karliner: *The Corporate Planet; Ecology and Politics in the Age of Globalization*, San Francisco, Sierra Club Books, 1997, p 5.
10. Lang, Tim and Colin Hines: *The New Protectionism.* New York, New Press, 1993.
11. Lori Wallach and Michelle Sforza, *Whose Trade Organization: Corporate Globalization and the Erosion of Democracy*, Public Citizen, 1990.

**Carbon injection** p27
1. Robert Watson, 19/7/01: *Climate change 2001*, summary presentation of findings of Intergovernmental Panel on Climate Change to high-level session of COP6-bis, Bonn.
2. Remarks by President George W Bush on global climate change, the Rose Garden, Washington DC, 11/6/01.
3. Quoted in *Techline*, 3/7/01, 'Energy department to study new ways to capture, store greenhouse gases', pub National Energy Technology Laboratory (US Department of Energy).
4. See Howard Herzog, Elizabeth Drake & Eric Adams: *$CO_2$ capture, reuse and storage technologies for mitigating global climate change*, MIT Energy Laboratory, 1997.
5. Jeff Seabright, Arthur Lee and Richard Weissman of Texaco Inc, 15/5/01: 'Environmental enterprise: carbon sequestration using the Texaco gasification process', presentation to NCCS.
6. Shell, 3/4/00, *op cit.*
7. TA Torp (of Statoil), 2/6/98, 'Capture and reinjection of $CO_2$ in a saline aquifer at Sleipner field and the future potential of this technology', dinner-debate with the Fondation Européenne de l'Energie, Brussels.
8. Princeton University, Center for Energy and Environmental Studies, September 1997 workshop report, 'Fuels decarbonization and carbon sequestration'.
9. Princeton University, Corporate and Foundation Relations website, at www.princeton.edu/cfr/fall00/BPAmoco.html.
10. Personal communication with Arthur Lee (of Texaco), 17/7/01. See also project website, www.co2capturepro ject.org
11. Paul Knox & Susan Hovorka, 2000, 'Geologic sequestra tion of greenhouse gases: opportunities for industry-academe research partnerships', in *Houston Geological Society Newsletter.*
12. US DoE, December 1999, *op cit.*
13. BP, strategy presentation to financial analysts, 13/2/01.
14. Shell, strategy presentation to financial analysts, 18/12/00.
15. All discussions on the issue, by companies or academics, begin with this premise.
16. US DoE, December 1999, *op it.*
17. Knox & Hovorka, *op it.*
18. Herzog, Drake & Adams, Jan 1997, *op it.*
19. The US Department of Energy, for example, admits that 'The primary uncertainty is the effectiveness of storing $CO_2$ in geological formations – how easily $CO_2$ can be injected and how long it will remain. Only through expe rience will enough knowledge be gained to assess the ultimate sequestration potential.' US DoE, Office of Fossil Energy, December 1999, *Carbon sequestration research and development.* And researchers from Harvard university comment that 'carbon management's technical progress is outpacing consideration of its limi tations and potential risks.' EA Parson & DW Keith in 'Fossil fuels without CO2 emissions', *Science*, Vol 282 No 5391, 6/11/98.
20. The US DoE hopes to cut this to $10 per ton – SH Kim & JA Edmonds, February 2000, *Potential for advanced car bon capture and sequestration technologies in a climate constrained world*, pub. US DoE.
21. Presentations to National Conference on Carbon Sequestration (NNCS) (org. National Energy Technology Laboratory), 15/5/01, by Gardiner Hill (of BP) and Craig Lewis (of Chevron), 'An industry perspective on geologic storage and sequestration', and Gardiner Hill & Robert Moore (both of BP), 'A collaborative project to develop technology to capture and store $CO_2$ from large combustion sources'. This pair of priorities also stated in eg IEA, *op cit*, and in Robert Socolow (Princeton University Carbon Management Initiative) presentation, 20/2/01, 'Managing carbon in a greenhouse-constrained world'.
22. See the review of the various technological options in Ben Matthews, November 1996, *Climate Engineering*, pub Scientists for Global Responsibility.
23. Matthews, November 1996, *op cit.*

**Tread lightly...** p31
1. The Energy Savings Trust, www.est.org.uk.
2. *ibid.*
3. *New and Renewable Energy: Prospects for the 21st Century*, Department of Trade and Industry, 2000.
4. *A Shining Example*, by Paul Allen, the Centre for Alternative Technology, 1997.
5. 'Here comes the Sun,' by Alex Benady, *The Guardian Weekend*, June 30 2001.
6. *Photovoltaic (PV) Government-Industry Group: Final Report*, March 26, 2001.
7. *ibid.*
8. The Energy Savings Trust's Powershift programme, www.est-powershift.org.uk.
9. Statement by Chairman Bill Ford quoted in a MSNBC.com news report on November 1, 2000.
10. *Climate-Friendly Hydrogen Fuel*, by the Pembina Institute and the David Suzuki Foundation, 2000.
11. *$H_2$: Driving the Future*, by Julie Foley, Institute for Public Policy Research, July.

**One house at a time** p38
*Homemade money: How to Save Energy and Dollars in Your Home*, by Richard Heede, Rocky Mountain Institute 1995, $14.95, ISBN: 188317807.

**The psychology of denial** p40
1. *States of Denial, Knowing About Atrocities and Suffering*, by Stanley Cohen, is published by Polity Press, ISBN: 0745623921.

**Fast-forward** p42
1. *American Attitudes to the Environment and Global Warming: An Overview of Public Opinion*, By Meg Bostrom for the FrameWorks Institute, Washington DC, April 2001.
2. World Resources 1996-97, *A Guide to the Global Environment*, World Resources Institute.
3. Tessa Tennant, Jeremy Smith, Paul Dickinson, DST Group, *Carbon Disclosure Project.*
4. Daphne Wysham, 'The World Bank: Funding Climate Chaos,' *The Ecologist*, Vol 29/2, March/April 1999.
5. Simon Retallack, 'ECAs Exposed,' *The Ecologist*, Vol 30/4, June 2000.
6. *WRI report reveals export credit agencies fuel increases in greenhouse gases*, WRI, May 31, 2000.

**A question of survival** p46
1. Robert McIntosh: 'Some problems of theoretical ecology', in Esa Saarinen editor, *Conceptual Issues in Ecology*, D. Reidel, Dordrecht, 1982.
2. Eugene Odum, *Basic Ecology*, Saunders College Publishing, Philadelphia 1983.
3. David Pimental, *Global Climate Change and Agriculture*, College of Agriculture and Life Sciences, Cornell University, 3 November 1998.