THE GLOBE PAPERS

CLIMATE CHANGE & THE G8

A GUIDE for PARLIAMENTARIANS

GLOBE

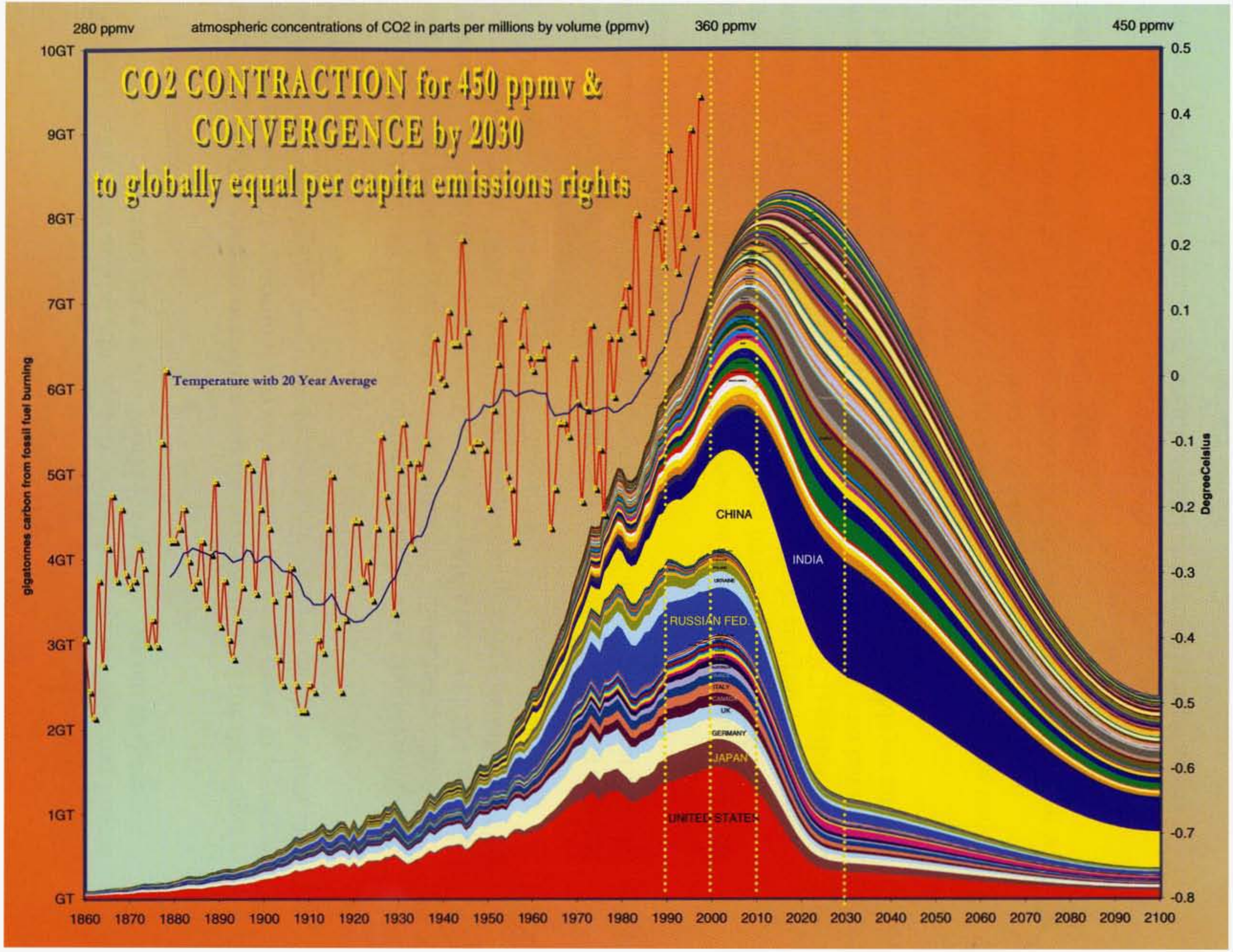
INTERNATIONAL

Global Legislators Organisation for a Balanced Environment

CLIMATE CHANGE & THE G8

A GUIDE for PARLIAMENTARIANS

By Tom Spencer MEP
President of GLOBE International



CO2 CONTRACTION for 450 ppmv &
CONVERGENCE by 2030
to globally equal per capita emissions rights
280 ppmv
atmospheric concentrations of CO2 in parts per millions by volume (ppmv)
360 ppmv
450 ppmv
gigatonnes carbon from fossil fuel burning
DegreeCelsius
Temperature with 20 Year Average
CHINA
INDIA
RUSSIAN FED.
UKRAINE
ITALY
CANADA
UK
GERMANY
JAPAN
UNITED STATES
10GT
9GT
8GT
7GT
6GT
5GT
4GT
3GT
2GT
1GT
GT
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
1860 1870 1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100

SUMMARY

On Sunday the 17th of May, the leaders of the developed world and Russia will sit down in Birmingham at the World Economic Summit to discuss climate change.

They will discuss emissions trading and the involvement of the developing world. They have an opportunity to consolidate the gains made in Kyoto and to include the developing world on an equitable basis, in an agreement that would last for centuries.

Alternatively, they can lower their vision and settle for a short-term 'hot-air' swap with the Russians that will outrage India and China and set back progress in climate change negotiations due to culminate at COP4 in Buenos Aires in November 1998. A sub-global agreement ignoring two thirds of the world would be a sordid and short-term cop-out.

Not only is the latter choice undesirable, it is unnecessary. There is a global solution to the self-evidently global problem of climate change that already commands widespread international support.

GLOBE International adopted the *"Contraction and Convergence"* analysis in May 1977. Since then, I and my colleagues have campaigned for its acceptance. This pamphlet is a record of those efforts and provides a short summary of the work of the Global Commons Institute (GCI) in this field. I would like to pay tribute to all the GLOBE parliamentarians who have fought so hard for this cause and particularly to the work of Aubrey Meyer and the GCI team on whose brilliant analysis the campaign is based.

"Contraction and Convergence" is the only practical and convincing way forward for the world. It is vital that the G8 leaders recognize this and commit themselves to negotiating ahead of COP4 *the* global solution for what everyone accepts is *the* global problem.

Such negotiation can only be based on the principle of equity and the establishment of the robust and flexible model contained in these pages.

TABLE OF CONTENTS

1.	**GLOBE UK & GLOBE INTERNATIONAL**	**6**
2.	**GLOBE'S CLIMATE CHANGE CAMPAIGN**	**6**
3.	**CONTRACTION AND CONVERGENCE**	**6**
4.	**THE G8 SUMMIT, BIRMINGHAM, 17.5.98**	**7**
5.	**IS THE SCIENCE CLEAR ENOUGH?**	**7**
6.	**ACTION THIS DAY?**	**8**
7.	**CONTRACTION - DEFINING A GLOBAL BUDGET**	**9**
8.	**CONVERGENCE: A POLITICAL & DIPLOMATIC COMPROMISE**	**9**
9.	**EMISSIONS TRADING**	**10**
10.	**THE BIRMINGHAM MANDATE;**	**11**
	A GLOBAL SOLUTION FOR A GLOBAL PROBLEM	**11**

ANNEX ONE - FORMULAE FOR "CONTRACTION AND CONVERGENCE" **11**
CONTRACTION FORMULA 12
CONVERGENCE FORMULA 12

ANNEX TWO - CONSEQUENCES COMPARED **13**
THE 'LAGS' IN A 450 PPMV CO_2 SCENARIOS 13
THE 'LAGS' IN A 550 PPMV SCENARIO 14

ANNEX THREE - "CARBON BUDGET" SCENARIOS COMPARED **15**
THE PRECAUTIONARY PRINCIPLE (PP) BUDGET 15
THE WIGLEY, RICHELS AND EDMONDS (WRE) BUDGET 15
THE EFFICIENCY GAINS ONLY (EGO) BUDGET 15

1. GLOBE UK & GLOBE INTERNATIONAL

GLOBE UK is an All Party Group of environmentally committed parliamentarians, chaired by Cynog Dafis, MP. It is part of GLOBE International to which over 500 legislators from around the world belong. It is made up of GLOBE European Union, GLOBE USA, GLOBE Japan and the GLOBE Europe Network in the national parliaments across Europe. Networks also exist in Southern Africa and via Globenet to individual parliamentarians in many other countries. GLOBE welcomes democratically elected parliamentarians from all parties. Members of GLOBE speak for themselves individually and undertake not to act as representatives of governments.

2. GLOBE'S CLIMATE CHANGE CAMPAIGN

Climate change has been a key campaign for GLOBE International for 10 years. GLOBE was active in Rio and at every meeting of the Conference of the Parties on Climate Change since Rio. For the last two years GLOBE has worked closely with the Global Commons Institute (GCI), led by Aubrey Meyer. The GLOBE International General Assembly in Brussels in May 1997 laid the basis for GLOBE's policy. GLOBE Japan held a Seminar in Tokyo in July 1997. In October sixty GLOBE parliamentarians from twenty-seven European countries held a meeting jointly with the UN Climate Change Secretariat in Bonn which included a private session with key climate negotiators and a public session with seven environment ministers from the European Union. Questions have been asked and campaigns mounted in parliaments across Europe. GLOBE International wrote to 15,000 parliamentarians around the world, stressing the importance of the Kyoto meeting and the role of parliamentarians. GLOBE held a Symposium on Climate Change in Kyoto on the day before the Ministerial section of COP 3. It was attended by 70 Parliamentarians from around the world, many of whom stayed on to the lobby the Conference. As President of GLOBE I addressed the Conference of the Parties and proposed an Equity Protocol that was widely welcomed. GLOBE parliamentarians were active during the crisis in the early hours of the morning of the final day in Kyoto. It was at this moment that the tensions between the developed and developing world came close to disrupting the entire conference. We remain convinced that objections raised by India, China and Africa are valid and must be addressed by the developed world in the negotiations leading up to the COP 4 in Buenos Aires in November 1998.

3. CONTRACTION AND CONVERGENCE

"Contraction and Convergence" is GLOBE International's proposal for the international management of global reductions in greenhouse gas (ghg) emissions. *"Contraction and Convergence"* is an approach which has been described by some as *"not just the right but the only solution"* to climate change and by others as *"theoretically flawless, but politically unachievable"*. GLOBE believes that an issue of this importance cannot be politically unachievable. If it were, democratically elected politics itself would have failed.

"Contraction and Convergence" aims to stabilise atmospheric greenhouse gas (ghg) concentrations at a safe level in accordance with the United Nations' Framework Convention on Climate Change (UNFCCC). This is done by calculating a global ghg emissions budget and then sharing out that budget on an equitable basis amongst the nations of the world. Many UNFCCC participants including India, China and the Africa Group support the approach. Others believe that no more than piecemeal sub-global arrangements are politically achievable at this time. GLOBE thinks that all the sub-global proposals tabled so far are environmentally inadequate because they do not set a ceiling on global emissions. They are also politically unachievable because they would create competitive tensions between the industrial countries that accepted ghg emissions constraints under the Kyoto Protocol and the rest of the world that did not. GLOBE believes that *"Contraction and Convergence"* is the only mechanism devised so far which answers both the scientific and political challenges of climate change. Formulae for calculating *"Contraction and Convergence"* are shown in Annex I.

4. THE G8 SUMMIT, BIRMINGHAM, 17.5.98

The second day of the Summit is scheduled to spend substantial time on two aspects of climate change - the so-called *"flexible mechanisms"* and *"the involvement of developing countries"*. This meeting of the leaders of the developed world, including Russia, is the best opportunity for the expression of the political will needed to give reality to the Kyoto Protocol before the COP 4 meeting in Buenos Aires. On the downside, the Summit could provide a terrible temptation to do a short term deal with the Russians and Ukrainians trading in 'hot air' which would inevitably make an agreement with the developing world more difficult. GLOBE International is bringing leading representatives of India, Africa, Brazil and China to a meeting in the House of Commons on May 14^{th}. The aim is to spell out the fundamental importance of G8 decisions, positive or negative and the consequences these will have for COP4 and for the future.

5. IS THE SCIENCE CLEAR ENOUGH?

Uncertainties about how much human-induced climate change has already taken place and what is likely to happen in the future are inevitable. However, as figures from the insurance industry reveal, serious economic damage is already being done as a result of the stronger winds, wilder storms and higher waves that global warming is now generating.

We know for certain that CO_2 concentrations in the atmosphere have been rising for the last two hundred years in line with the rising emissions of CO_2 from fossil fuel burning. Global mean surface temperature has risen by 0.6 degrees Celsius over the past century and the global sea level has risen by 10 - 25 cm over the same period.

The mechanisms linking these observations are understood sufficiently well to establish a causal link between them. Carbon dioxide and other greenhouse gases (ghgs) in the atmosphere trap heat radiated out from the earth's surface. As these concentrations increase, more heat is trapped and surface temperatures rise.

This simple relationship has been obscured by a number of other factors such as changes in solar radiation, changes in cloud cover, aerosol concentrations in the atmosphere and ocean circulation. While this noise has historically masked much of the signal, we are now reaching a point where the signal rises above the noise. That threshold is in itself very significant as it means that we are beginning to experience conditions beyond the range of natural variability. By breaking through this limit of natural variability, we expose ourselves to the risk that positive feedbacks will develop which would accelerate global warming beyond our control. Many such feedbacks are possible, but since we cannot say accurately when they kick in or how strong they will be, they are often excluded from the climate models used by the IPCC for its scenarios. Likely feedbacks include the partial melting of the permafrost that will release vast quantities of methane, a powerful ghg, and the melting of ice caps and glaciers that will mean that the Earth absorbs more heat from the sun because of lost 'albedo' or reflectivity. Increasing forest fires and other ground-cover changes now occurring also constitutes a positive feedback loop with atmospheric CO_2. Changes in cloud cover, a very complex and imperfectly understood area, could lead either to positive or to negative feedbacks, depending on the nature and altitude of the clouds.

6. ACTION THIS DAY?

It takes several decades for ghg emissions to change the global temperature or cause the sea level to rise. By not reducing emissions immediately, we condemn ourselves to the following chain of events - increased ghg concentrations in the atmosphere followed by rising temperatures, followed by sea level rise and other climatic changes - spread over decades and even centuries into the future. The existence of this chain obviously heightens the risk that we will provoke harmful positive feed-back mechanisms to kick in and be unable to do anything about them. A major and rapid climate change will have occurred with totally unpredictable consequences. The lags involved in a 450 ppmv and a 550 ppmv scenario are demonstrated in Annex II which stretches the analysis two centuries into mankind's future.

In its first report in 1990, the Intergovernmental Panel on Climate Change (IPCC) suggested humanity would need to reduce its ghg emissions by a minimum of 60% immediately in order to stabilise concentrations at the then current levels. The IPCC did not state that this had to be done because that was beyond its remit. It was left to the world's political leaders to decide what concentration of ghgs in the atmosphere it was safe to reach before storms became too serious or positive feedbacks kicked in. Since then, the European Union has indicated that it considers a CO_2 doubling from pre-industrial levels (280 ppmv in 1800) to around 550 ppmv to be a safe limit. More recently, Bert Bolin, the former chairman of the IPCC has suggested that 450 ppmv should be considered the limit. The truth is, no one knows. Moreover, it must not be forgotten that even the present ghg level of roughly 360 ppmv may prove not be safe because of the time lag between a rise in concentration and the effect that higher level has on the climate. Whatever limit we decide is safe, we still need to reduce our CO_2 emissions by at least 60% over some specified time frame if stabilisation at that limit is to be achieved.

The delays in the way the climate system behaves are probably the most compelling reason for acting immediately in a comprehensive, risk-averse manner. Now that the basi science is no longer in serious dispute, most politicians have accepted that action is necessary. Nevertheless, there is a general reluctance to take long-term decisions because the electoral cycle of democracies has a built in, short-term focus. Politicians fear that climate change requires hard, short term, changes that will be publicly unpopular and have only medium and long-term benefits. Political leadership, not followership, is needed. For these reasons, the preference up to now has been for a piecemeal approach. Yet, there is only a limited 'budget' of CO_2 emissions left for the next century before any particular emission limit is reached. We need to plan now in order to ensure a relatively smooth transition to a low-emission economy dictated by this 'budget'. The consequences of delay are examined in Annex III, where three possible scenarios of future action are compared.

7. CONTRACTION - DEFINING A GLOBAL BUDGET

"Contraction and Convergence" is designed to provide a framework for the desired smooth transition to a low level of CO_2 emissions from human economic activity. While other ghgs are significant and need to be addressed, each gas should be dealt with individually because of their different nature, sources and sinks, scientific understanding and monitoring capabilities. CO_2 is by far the most significant ghg since it is responsible for over 70% of the human-made greenhouse effect. It is the ghg created by man that mar can most certainly reduce and should be given the most urgent attention. The first step in the *"Contraction and Convergence"* process must be to determine a safe global annual emissions level far enough into the future for them to be directly linked to a target concentration level. The GCI analysis plots emissions from 1860 to 2200. This provides decision-makers in government and industry with a long-term perspective for planning and investment. To allow for the remaining uncertainties over the scale of climate change impacts, it is important to design a system that can be reviewed and adjusted at regular intervals. This flexibility should also facilitate initial negotiations where a contraction formula can be agreed for the achievement of a given ghg concentration target. On the basis of these criteria, it is possible to establish a formula for a contraction curve that can accommodate any sensible combination of cumulative budget and final emissions level. The contraction formula used by the GCI is shown in Annex I.

8. CONVERGENCE: A POLITICAL & DIPLOMATIC COMPROMISE

Having defined a global budget, the next problem is to fit all countries, regardless of thei current GDP, into the ever-decreasing space beneath that global cap. The core aims of an distribution system proposed under this contraction curve are to achieve multi-lateral consensus, co-operation and emissions trading.

Such a consensus can only be formed around a universally recognised equity rule as the basis for emission entitlement allocations. The problem is that so far, there are diverging views on what is equitable. The most fundamental proposition of an equitable allocation would be based on an equal per capita distribution.

This is clearly not an immediately acceptable proposition from the perspective of industrialised countries that have very high per capita emission levels. But developing countries will not accept pro rata reductions based on present consumption patterns either, since they are not historically responsible for the problem. This stand-off threatens to delay agreement and dissipate political will.

The simple compromise is convergence. One starts from the present distribution of emissions moving gradually along an agreed trajectory, to a point after which the allocation of emission entitlements has become proportional to population globally, with reductions pro rata thereafter. This might involve an agreement to 'freeze' the population numbers in the accounts beyond a chosen date. Because such convergence is purely a diplomatic mechanism, it is probably easiest to use a straightforward, linear convergence path. The trajectory is not of critical importance as long as it can be agreed by all parties. Exponential and linear convergence formulae are shown in Annex I.

Once a trajectory has been accepted, negotiations can begin to agree on a convergence date by which emission entitlements are to be equalised. Under overall contraction, the convergence process progressively allocates each country an annual percentage share of the global budget. In this way, any reviews of the global budget can be undertaken in light of evolving scientific knowledge without having to renegotiate the distribution.

9. EMISSIONS TRADING

The *"Contraction and Convergence"* package is completed with an emissions-trading mechanism established on the back of the allocations of ghg emissions entitlements. There has been some opposition to emissions trading on the basis that it provides a loophole and would help industrialised countries to maintain the development status quo. These criticisms only apply where trading is intended under a sub-global agreement in other words without a global emissions cap and without a globally negotiated distribution of the new property rights. Trading under the Kyoto Protocol, as it is currently expressed, will be prejudicial to achieving and effective global solution. For related reasons, the US Senate threatens non-ratification demanding *"a global solution for a global problem"*. The targets for Russia and the Ukraine embrace the idea that emissions entitlements can be retrospectively enlarged beyond what was actually emitted since 1990 to compensate for the economic collapse in the Former Soviet Union. This is intended to create a surplus of tradable entitlements that can be exchanged against the surplus of emissions that occurred from the USA since 1990. This superficially attractive idea is currently driving much of the impetus towards emissions trading. But the manner in which these particular credits and debits are being calculated is at present both arbitrary and asymmetrical. This has led to the justifiable criticism of the arrangement as 'hot air' trading. These problems do not arise if governments use the global calculus of *"Contraction and Convergence"*.

Indeed, *"Contraction and Convergence"* rationalises the global distribution of permits in a way that makes emissions trading both necessary and desirable for most parties. The least developed countries will receive high emission allocations, much of which they will be able to trade for funds to invest in more sustainable economic development. Trading gives developing countries a real incentive and credit for early emission control measures.

Industrialised countries on the other hand can avoid costly measures, such as early power plant closures by buying emission permits. Trading provides efficiency by achieving global emissions reductions or carbon-contraction at least cost to the world economy. It also addresses problems such as the migration of firms to countries with more generous allocations.

"Contraction and Convergence" provides a complete package for CO_2 emissions abatement that is both politically acceptable and fulfils the scientific requirements to prevent catastrophic climate change. The key point is to realise that this solution will not happen through a fortunate accident or an 'evolution' involving a gradual incorporation of developing countries into the framework established by the Kyoto Protocol. This, because of its loopholes and unambitious targets, will only manage to reduce the projected growth trend of atmospheric CO_2 concentrations by about one half of one percent. Delaying the start of *"Contraction and Convergence"* by 10 years could require 10% more emission final reductions from 1990 levels to achieve the same atmospheric concentration stabilisation.

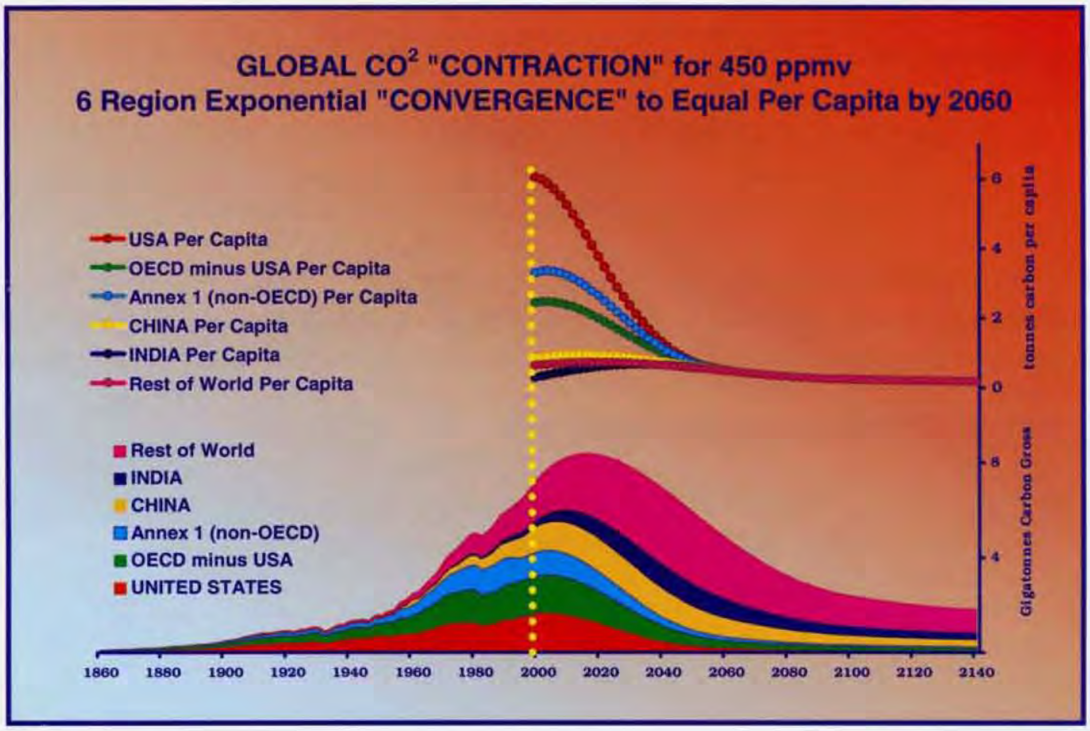
10. THE BIRMINGHAM MANDATE;

"A GLOBAL SOLUTION FOR A GLOBAL PROBLEM"

The rationale outlined above is the only practical and convincing way forward. It is vital that the G8 leaders recognise this and commit themselves to negotiating ahead of COP 4 a global solution for what everyone accepts is a global problem. It can only be based on the principle of equity and the establishment of the robust and flexible model provided by the *"Contraction and Convergence"* analysis.

ANNEX ONE - Formulae for "CONTRACTION AND CONVERGENCE"

[See GCI website for full details of model 'CCOptions' http://www.gn.apc.org/gci]



Contraction Formula

The path of the global emissions curve is established by fixing five conditions:

1. Start date for the contraction period;
2. Target date of emissions stabilisation;
3. Rate of change to be zero in target year (i.e. stable emissions);
4. Initial rate of change to be equal to the actual rate of change at that time;
5. The total level of emissions to be set in accordance with a chosen level of atmospheric concentration stabilisation.

These criteria can be satisfied by a quartic equation of the form

$$Y=k+lx+mx^2+nx^3+px^4$$

where Y equals the annual global emissions budget, x is the time variable and the parameters k, l, m, n, p are determined by the five criteria above by a series of multiple equations.

$$k = y_0$$
$$l = r$$
$$m = 30A - 18y_0 - 12y_1 - 4.5r$$
$$n = -60A + 32y_0 + 28y_1 + 6r$$
$$p = 30A - 15y_0 - 15y_1 - 2.5r$$

where y_0 and y_1 are the emission levels at the beginning and end of the contraction period respectively, r is the annual increase in emissions at time 0 and A is the cumulative emissions over the contraction period divided by the length of the period in years.

Convergence Formula

The variables for a convergence formula are set by three conditions:

1. Start from actual shares at the beginning of the convergence period;
2. All countries to converge to equal per capita shares by the target date;
3. Arithmetic to rely only on actual population data (potentially subject to a cap).

The third point is to avoid complications over controversial population projections. In order to counter the argument of per capita allocations promoting population growth, the population figures can be frozen at any time for the purposes of emissions allocations.

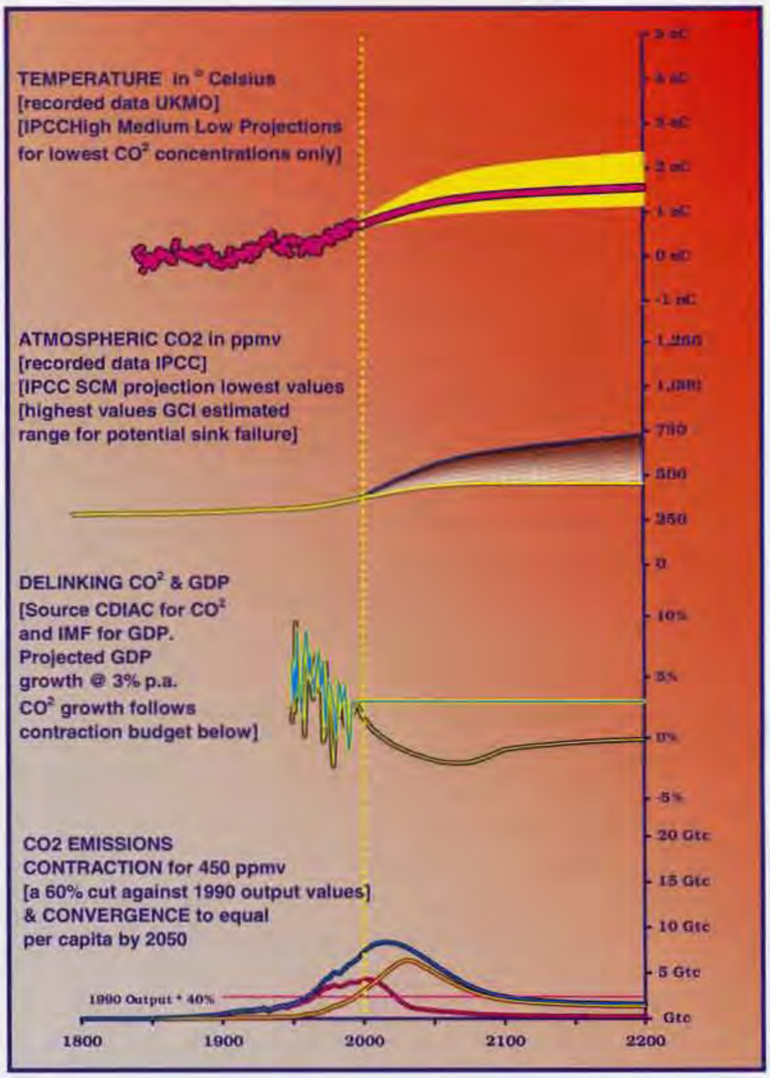
GCI has proposed two alternative formulas:

$$s_{y+1} = s_y - (s_y - p_{y+1})^{-a(1-x)} \quad \text{(Exponential convergence)}$$
$$s_{y+1} = s_y - x\,(s_y - p_{y+1}) \quad \text{(Linear convergence)}$$

ANNEX TWO - CONSEQUENCES COMPARED

The 'Lags' in a 450 ppmv CO_2 Scenario

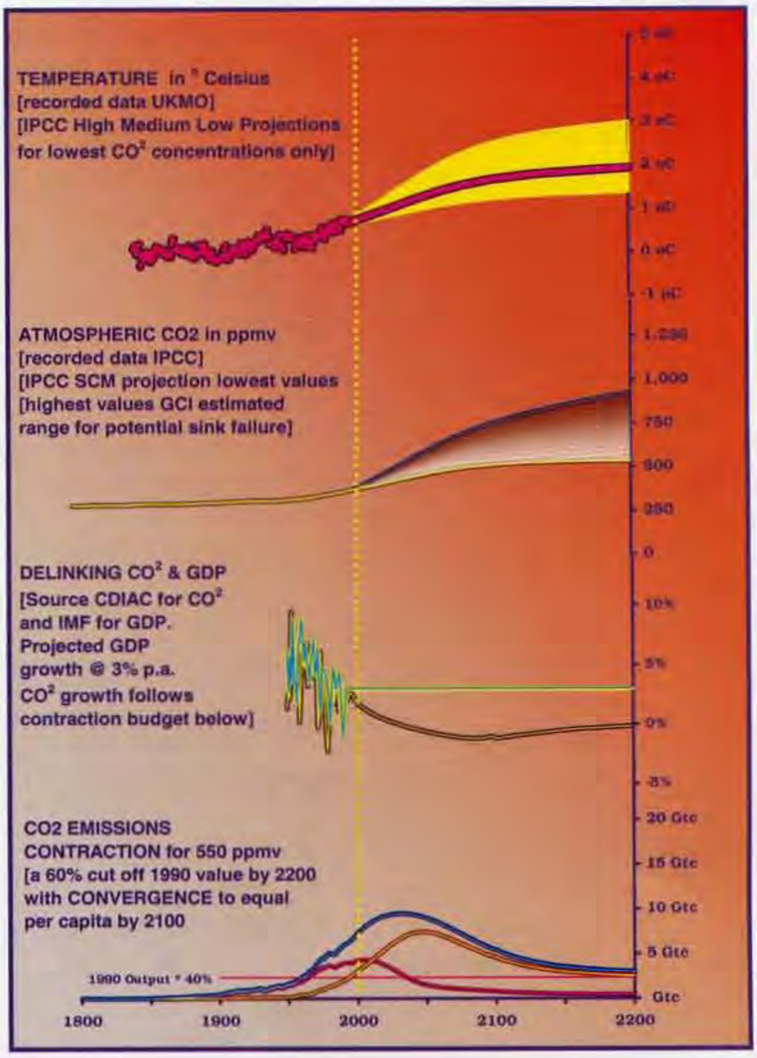
The following graphics make clear the lagged sequential structure of events that are triggered by release of CO_2 emissions from human sources. Only CO_2 is used to portray the case made, as it is only for these emissions that reasonably complete global datasets exist. Human CO_2 emissions, 80% of which come from fossil fuel burning, represent over 70% of the net anthropogenic forcing of global mean temperature. So assuming no sudden surprises, the temperature values recorded are about 30% less than they will be when all the equivalent effect of the other gases such as methane are included. The observed events of the past two hundred years are shown as well on the left-hand half of these graphics. The sequence of recorded events showing the relationship between rising emissions and rising atmospheric concentrations is beyond dispute. UKMO, NOAA and the IPCC accept the functional link via rising concentrations, between rising ghg emissions and rising global mean temperature.



The period 2000 to 2100 shows a 450 ppmv "Contraction" budget for human CO_2 emissions. Annual CO_2 emissions are reduced to 40% of 1990 value by 2100 and remain so until 2200. Here "convergence" between Annex One and Non-Annex One is set to reach globally equal per capita emissions entitlements by 2050. Contraction is pro rata from then onwards. In 1800 atmospheric concentrations of CO_2 were 280 ppmv. By 1998 they reached 263 ppmv. During the emissions contraction, concentrations continue to rise slowing to 450 ppmv by 2100. This assumes the sinks function as before, re-absorbing roughly half of each year's human emissions. If sinks were to fail, concentrations could rise higher on the path shown with an upper limit reaching 750 ppmv by 2200. The temperature curves shown here are linked only to CO_2 and its lowest concentration path. Temperature is set at 0.0° C in 1800 and 0.7° C up in 1998. The range continues rising by between 1 and 2.4° C as late as 2200 (best guess at 1.5°). Rising sea level at 3 to 10 cm per decade is not shown and continues beyond the stabilisation of temperature.

The 'Lags' in a 550 ppmv Scenario

Here, from 2000 to 2100 a 550 ppmv "Contraction" budget for human CO_2 emissions is shown. Annual CO_2 emissions are reduced to 40% of 1990 value by 2200. "Convergence" between Annex One and Non-Annex One is set to reach globally equal per capita emissions entitlements by 2100. Contraction is pro rata from then onwards. During the global contraction of emissions, concentrations continue to rise slowing to 550 ppmv by around 2150. This assumes the sinks function as before, re-absorbing roughly half of each year's human emissions. If sinks were to fail, concentrations could rise higher on the path shown with an uppermost path reaching 950 ppmv by 2200 and rising. Again, the temperature curves shown are linked only to CO_2 and its lowest concentration path. Temperature is 0.0° C in 1800 and 0.7° C up in 1998. The range continues rising by between 1.5 and 3° C as late as 2200 (best guess at 2°). Rising sea level as before is not shown but continues at between 3 and 10 cm per decade and goes beyond the point of stabilisation of temperature.



In the 450 ppmv case the annual rate of contraction reaches over 2% per annum. In the 550 ppmv case the annual rate of contraction reaches just over 1% per annum. GDP in both cases is assumed to grow constantly at an average of 3% per annum. But when we compare the extent of delinking of CO_2 emissions and GDP between the 450 budget and the 550 budget, the general rate of de-linkage (or gain in terms of $s per tonne carbon) is between 4 to 5% per annum. This is unprecedented. Yet in any scenario set on stabilising atmospheric concentrations, this is the scale of achievement required. So short of just trying to adapt to climate change, these efficiency gains have to be made. Moreover, because the higher ppmv scenarios incur more damages from climate, more of GDP will have to be diverted into damage compensation with less for avoiding emissions and de-carbonization strategies. Since we have to execute the solution at a rate that exceeds that at which we create the problem, soonest is best as the higher the concentration path the worse the odds of doing this become.

ANNEX THREE - "CARBON BUDGET" SCENARIOS COMPARED

This graph compares three ways of looking at the future evolution of the global budget of CO_2 emissions from fossil fuel burning. The levels of atmospheric CO_2 concentrations, temperature rises and dollar per tonne carbon efficiency gains associated with each budget concept are shown as well (colour-coded).

The Precautionary Principle (PP) budget

This budget assumes the need for early controls for "Contraction".

The Wigley, Richels and Edmonds (WRE) budget

This budget assumes the delay, or even the total absence of controls.

The Efficiency Gains Only (EGO) budget

This budget assumes the absence of controls and even the need for controls.

The primary policy level of choice examined here is that between the need for controls and the rejection of controls, in other words between the PP or WRE concepts on the one hand, and the EGO concept on the other. The international debate has already reached this stage and there is a general acceptance that controls will be necessary.

This means that the next choice is between introducing them immediately rather than later, in other words between the PP concept and the WRE concept. The IPCC states that the key determinant for the stabilisation level of concentrations is not so much the emissions trajectory but the total amount emitted between now and the time of concentration stabilisation. If so, we appear to have some flexibility over the timing of reductions.

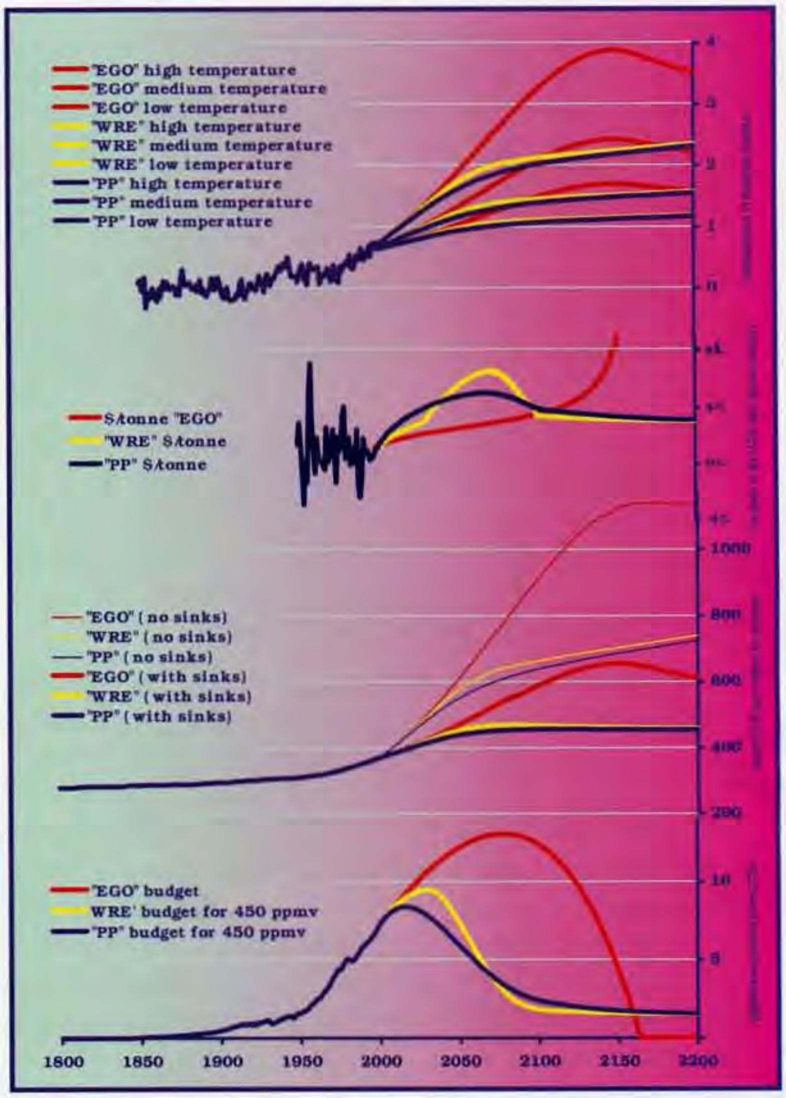
However, the WRE curves were produced in the belief that it is better to wait for technological improvements to make reductions more cost efficient before embarking on them. It uses a capped emissions trajectory to deliver a given concentration level but keeps the trajectory on a business-as-usual (BAU) path for as long as possible before making sharp reductions since technology should have improved considerably by then, making the necessary reductions cheaper.

The flaw in this argument is that this trajectory will require more rapid reductions and hence much greater economic efficiency gains once we depart from BAU. Assuming a steady annual growth of the economy at 3%, economic efficiency gains measured in CO_2 emissions per unit of GDP would have to improve by up to 7% per annum. Even if this is feasible, the implementation costs will probably outweigh the cheaper technology. Furthermore, capital investments made along the BAU path early on may have to be made redundant before the end of their normal life span. Both sets of curves have a similar emissions trajectory, but the precautionary approach tries to limit the maximum rate of emissions reductions by imposing an early departure from BAU. This reduces the risk of not being able to meet the greater reductions without major economic disruption.

It is widely accepted that even on present technology we can take 'no regrets' measures to reduce CO_2 emissions by up to 30%. If this is the case, there is little point in delaying this action and placing a heavier burden on future generations. Furthermore, it seems that technological efficiency gains and low-emission technology is incentive driven. There have to be clear targets for industry to aim for.

If we decide to follow the WRE curves and find that the rapid reductions down the line are not realistic, we will face an ever-growing struggle to control CO_2 concentrations along the EGO path. This scenario also represents the most optimistic position where a zero emissions economy can be achieved driven by economic efficiency gains alone. Whichever way it is interpreted, the EGO scenario represents a gradual improvement in the rate of economic efficiency gains. Due to the limits of thermodynamics, gains would have to be made through completely new technology such as nuclear fusion as well as massive improvements in current renewable energy. If recovery from delayed action proves impossible because the required technological fixes do not emerge, CO_2 concentrations will rise above 650 ppmv with no stabilisation - let alone reduction - in prospect. This is clearly not an option in accordance with the objective of the UNFCCC.

Scientifically, there may appear to be little to distinguish the PP and the WRE control options in terms of their climatic impact. But just the earlier arrival at 450 ppmv and corresponding temperature rise may take us to thresholds of instability the retreat from which is then dependent on crash control programmes for reduction which will be more costly than the earlier and milder controls of PP.



The PP approach is also more sensible than the WRE and the EGO approach because it initiates best use of present options. It reduces the risks of large-scale unpleasant surprises down-stream and with *"Contraction and Convergence"* in place, encourages compliance because it is both more intra and inter-generationally equitable.

Following this reasoning, pursuit of the EGO approach either by default or design is the least prudent option possible.