First Things First:

Development and Global Warming

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Proposed controls over greenhouse gas emissions do not apply to developing countries that are expected to become major producers of such gases. Controls on the developed nations alone will do very little to reduce the accumulation of carbon dioxide in the atmosphere. Extending the controls to developing nations, however, will be very expensive, particularly if developing countries are asked to implement controls sooner rather than later. Furthermore, the potential benefits of controls on greenhouse gas emissions are more uncertain now than they are likely to be in several decades when more will be known about some of the outstanding scientific issues.

In any rational ranking of national priorities in developing countries, many activities ought to take precedence over combating global warming. These include such things as improving health and education, raising living standards and ameliorating other more urgent environmental problems. These benefits are not worth sacrificing for something which might – or might not – be the best way to handle what might – or might not – be a problem 50 to 100 years from now.

In order for the developing countries to take effective action on global warming, they will have to be compensated until the net cost is acceptable. Given the unimportance of the issue, relative to their other priorities, an acceptable net cost is likely to be close to zero. Thus, the cost of any sacrifice that is demanded of developing countries is likely to fall on the taxpayers of those countries whose politicians view the problem as a high priority. However, such massive transfers of resources will be resisted.

When policy goes against simple, powerful rationality one can predict three possible outcomes. The policy is not serious and will be abandoned when its other purposes have been achieved, the policy will fail, or major resource transfers accompanied by considerable political upheaval will occur in an attempt to make the policy succeed. Unfortunately, these are not mutually exclusive outcomes.

The Global Warming Issue

The basic facts about global warming are fairly simply stated. High concentrations of so-called 'greenhouse gases' in the atmosphere create a 'heat-absorbing blanket' that raises the temperature at the surface of the earth above what it would otherwise be. The Framework Convention on Climate Change (FCCC) defines greenhouse gases as 'those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and re-emit infrared radiation'. The relevant gases include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride. The most important greenhouse gas is water vapor.[1]

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[1] Davis, R. W., Legates, D., (June 1998).

The 'global warming problem' arises, as a theoretical result, from computer simulation models suggesting that an increase in the concentration of greenhouse gases – CO_2 in particular – will raise surface temperatures. The direct effect of higher concentrations of CO_2 on temperature is not large. Rather, most of the predicted increase in radiation absorption by the atmosphere results from higher levels of water vapor triggered by the increase in CO_2. A change in water vapor may be associated, however, with increased cloud and snow cover, both of which reduce warming by reflecting incoming solar radiation. Large computer models are needed to keep track of these and other interrelated effects. Since the original increase in CO_2 represents a small perturbation to a complex system, the likely consequences are difficult to predict. The result has been substantial disagreement about global warming science (see Appendices II-IV).

Since 1958, the concentration of CO_2 in the atmosphere has risen about 14% (a not inconsiderable rise in 40 years) and is now about 30% above pre-industrial levels.[2] The Intergovernmental Panel on Climate Change (IPCC) currently estimates that this will rise by another 48% during the next century to a level 90% above pre-industrial levels.[3] Claims in the mass media notwithstanding, the level of increase to be expected, and its likely consequences for temperatures, sea levels or extreme weather events, is unclear.

The latest (1995) IPCC report's median projection is an increase in average temperatures of 2ºC by 2100. This figure is 23% below the IPCC's 1992 median projection and 38% below their 1990 median projection.[4] It is only a quarter of the figure projected at the Toronto conference of 1988, the year the IPCC was created. The instability of the projections – with a 75% fall in seven years, almost 40% in five – is an indication of the uncertainty of the science in this area.

We have claimed the argument is mainly a 'theoretical result' because there is only weak *evidence* that past increases in the concentration of CO_2 in the atmosphere have raised average global temperatures. Surface temperature records have revealed a warming trend since the late nineteenth century. There is considerable doubt, however, whether these records are representative.[5]

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[2] World Resources Institute, (1997).

[3] Houghton, J. T. et al (eds) (1996) P.25. As is explained below, projections of future emissions and concentrations are subject to considerable uncertainty.

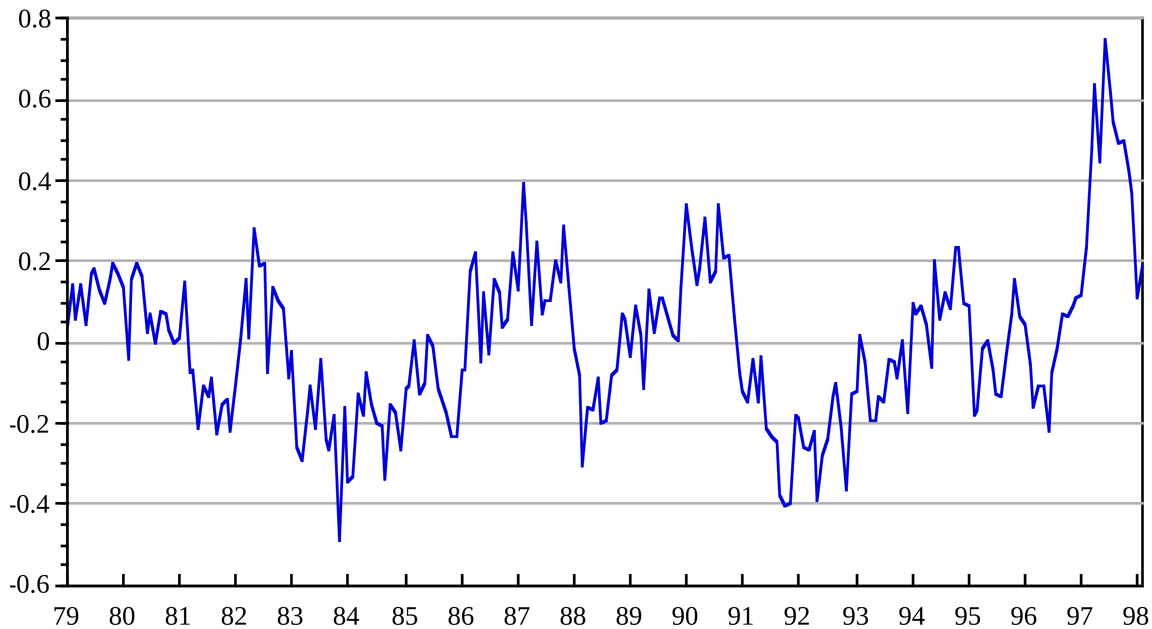
[4] Houghton et al (1996); Houghton et al (eds) (1992); Houghton et al (eds) (1990).

[5] For example, in a press statement accompanying a research report released on February 4, 1999, the National Research Council stated "Deficiencies in the accuracy, quality and continuity of the records … place serious limitations on the confidence that can be placed in the research results."

Over-sampling of urban, and other highly populated, areas contaminates many of the land-based records. In what has been called the 'heat-island' effect, urban areas are known to raise temperatures relative to the surrounding countryside. Walls of buildings and extensive areas of pavement absorb heat during the day and radiate it back to the atmosphere at night. There is also substantial doubt about the accuracy of the oceanic records – and oceans cover about two-thirds of the global surface area.

Last, but not least, there is an inconsistency between the global surface temperature record and the more representative record obtained, since 1979, from the Microwave Sounding Units (MSU) on the National Oceanic and Atmospheric Administration's (NOAA) TIROS-N series of polar-orbiting weather satellites. These data provide a global record of temperature fluctuations in the lower troposphere (the lowest 5 miles of the atmosphere) and the lower stratosphere (covering an altitude range of about 9-12 miles). The lower troposphere data from November 1979 until December 1998 are presented in Graph 1.

Graph 1: Global Temperature Anomaly as Measured by Satellites



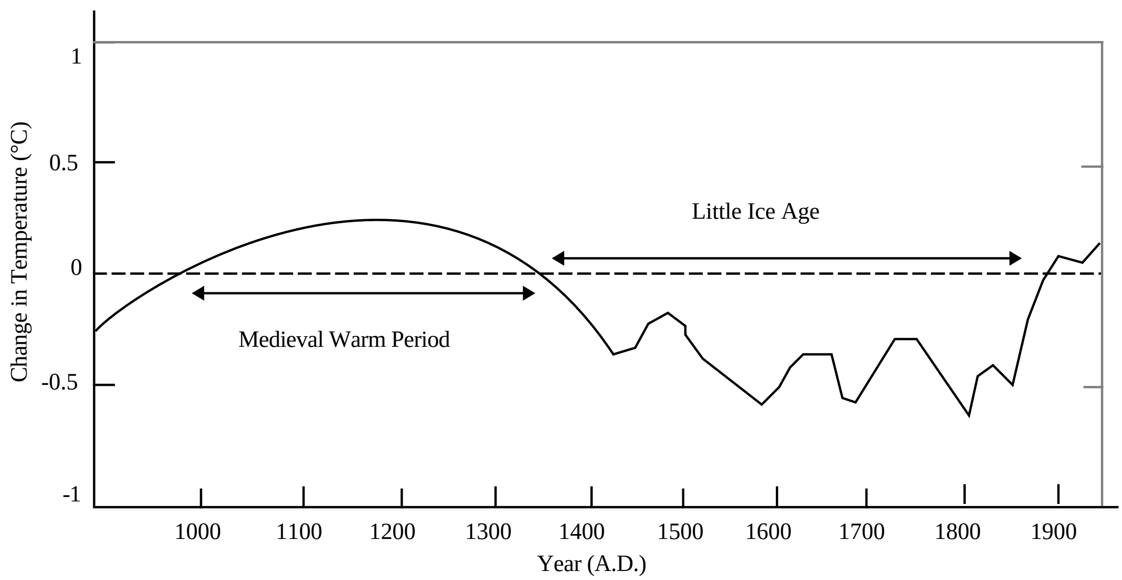
Source: NASA web-site *http://www.ClimateNews.com/*.

The satellite data show a warming trend of 0.059°C per decade. If such a trend continued for 100 years, the result would be an increase of little over one half of one degree centigrade by 2100. This is substantially below the warming trend in the surface record over the same period, and of course, substantially below the predictions from the greenhouse models. The satellite temperatures are consistent with two temperature series from weather balloons – one involving measurements made by thermometers and the other based on air pressure readings. The agreement between the three independently measured series, and the disagreement between those series and the surface record, suggests that the surface record is unrepresentative.[6]

Nevertheless, the satellite temperatures do reveal a positive trend in global average temperatures. There is also an indication that most of the warming that has occurred has been on winter nights in Alaska and Siberia. This pattern of warming is consistent with the predictions of the computer simulation models.

Even if we eventually conclude that modest warming has occurred over the last century, that is not proof that the greenhouse models are correct. The end of the nineteenth century was unusually cool relative to the previous 500 or so years (Graph 2) and the warming that may have occurred this century could be entirely the result of other natural processes, such as fluctuations in solar energy output.

Graph 2: Average global temperatures in the last 1000 years



Source: Thomas J. Crowley (1996, *http://www.gcrio.org/*). Compiled by R. S. Bradley and J. A. Eddy (EarthQuest, vol. 5, no 1, 1991) based on J. T. Houghton et al. (1990).

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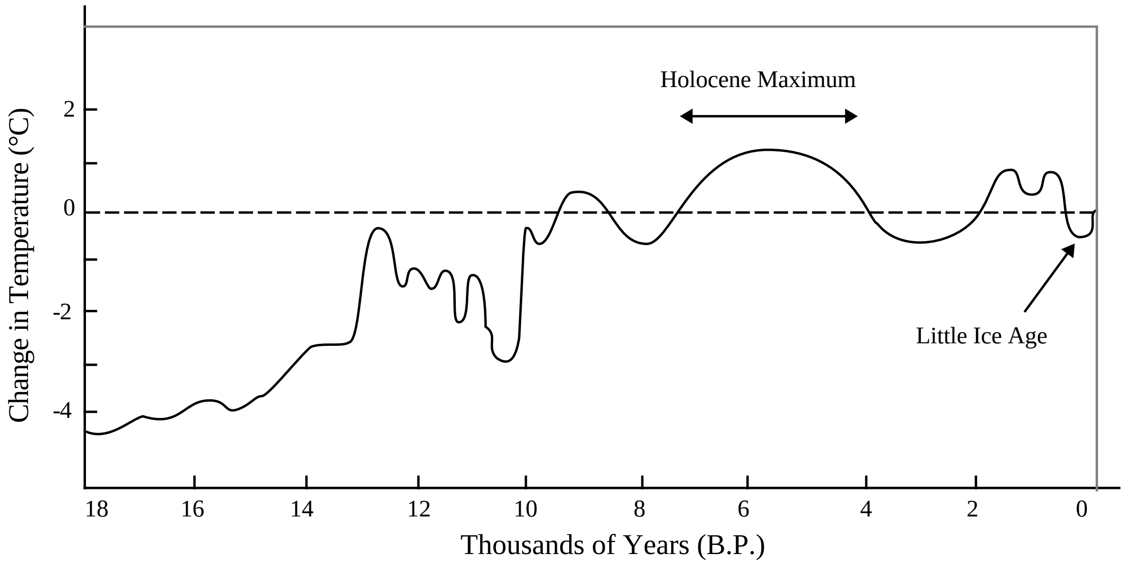
[6] Douglas Hoyt (http://www.erols.com/dhoyt1/index.html) observes "When the surface and MSU temperature trends are compared region by region, we note two things:

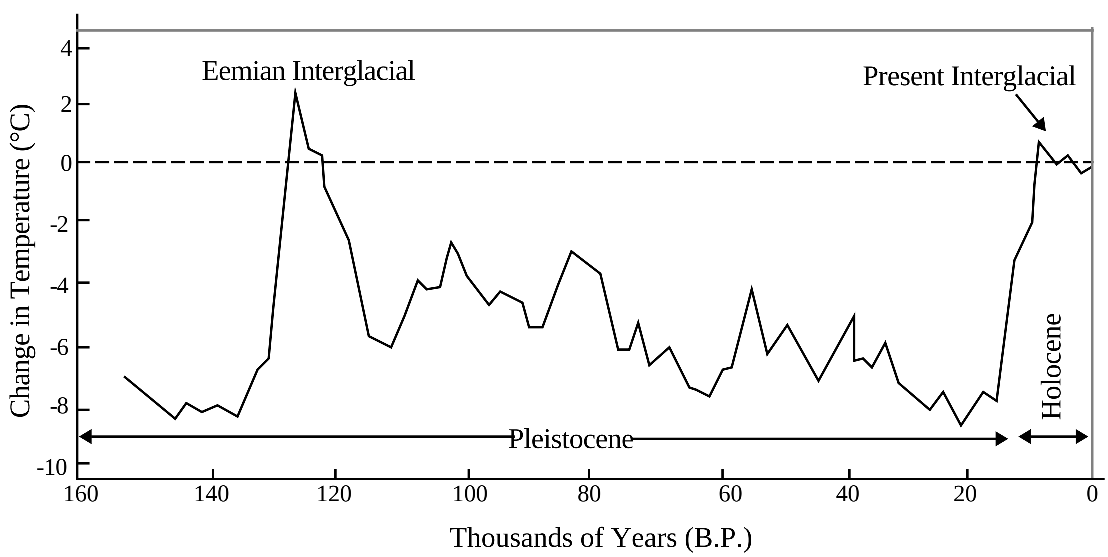
1. The MSU trends vary smoothly in passing from one region to another (i.e., smoothly geographically).
2. The surface network trends, in contrast, jump all over the place. For example, one region will appear to be sharply warming, but all the surrounding regions are markedly cooling. The MSU trends for the same region will show a smooth variation in cooling over the regions. It is physically implausible for a small region to warm with all surrounding regions, including the atmosphere above it, cooling." He also comments, "Many of the greatest discrepancies between surface and MSU observations occur in urban regions."



Graph 3: Average global temperatures in the last 18,000 years

Source: Thomas J. Crowley (1996). Compiled by R. S. Bradley and J. A. Eddy (1991) based on J. T. Houghton et al. (1990).

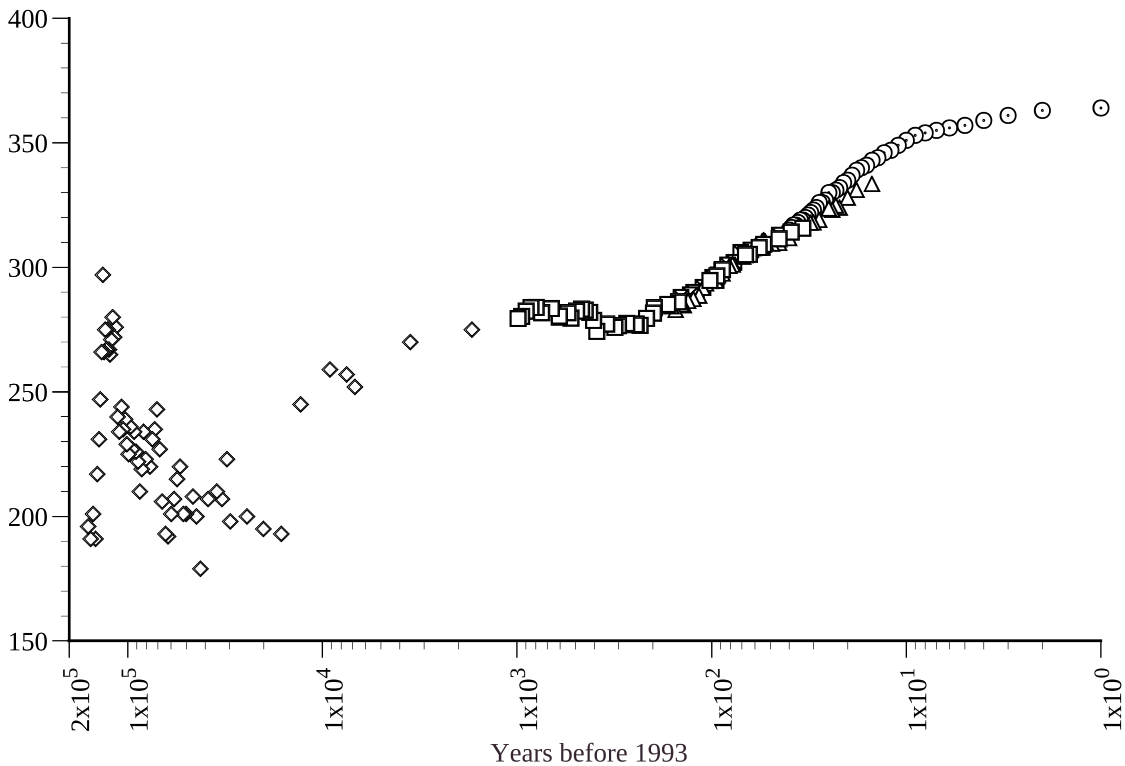
Graph 4: Air temperature near Antarctica for the last 150,000 years (inferred from hydrogen/deuterium ratios in an ice core)



Source: Thomas J. Crowley (1996). Compiled by R. S. Bradley and J. A. Eddy (1991) based on J. Jouzel et al., Nature vol. 329: 403-408, 1987.

Certainly, the time path of temperature changes in the surface record over the twentieth century does not track the time path of changes in CO_2 concentration in the atmosphere. Furthermore, the earth passed through ice ages in what is considered only the recent past on a geological time scale (Graph 2, Graph 3 and Graph 4 plot changes in °C, from the average global temperature for 1900). In fact, current IPCC projections of future temperatures are within the range of those previously encountered on a geological time scale. Admittedly, however, a high *rate of change* of temperature could overwhelm many ecosystems before they have time to adjust.

Graph 5: Atmospheric Concentration of CO_2 (parts per million by volume)



Source: Carbon Dioxide Information Analysis Center (http://cdiac.esd.ornl.gov/) based on measurements from a number of different locations, including air trapped in ice cores near the poles.

While the possible detrimental effect of higher atmospheric concentrations of CO_2 on temperature is controversial, another beneficial effect is much less so. Increased CO_2 in the atmosphere is a stimulant to plant growth (increased atmospheric CO_2 makes the Earth 'greener').[7] Carbon, the foundation of all organic molecules, was removed from the biosphere when fossil fuel deposits were formed. The burning of coal and oil thus liberates carbon to again become part of the biosphere.[8] The productivity of agriculture and forestry (and perhaps also fishing) may rise substantially as more CO_2 is added to the atmosphere (and oceans). If these beneficial effects are large enough, it might be wise to encourage fossil fuel consumption rather than discourage it, and instead cope with any

[7]Ellsaessar, H.W., (1997), P.11; Idso (1996), P.32. Michaels (1998) also notes evidence of increased take-up CO_2 from vegetation.

[8] Priem, H. (1996).

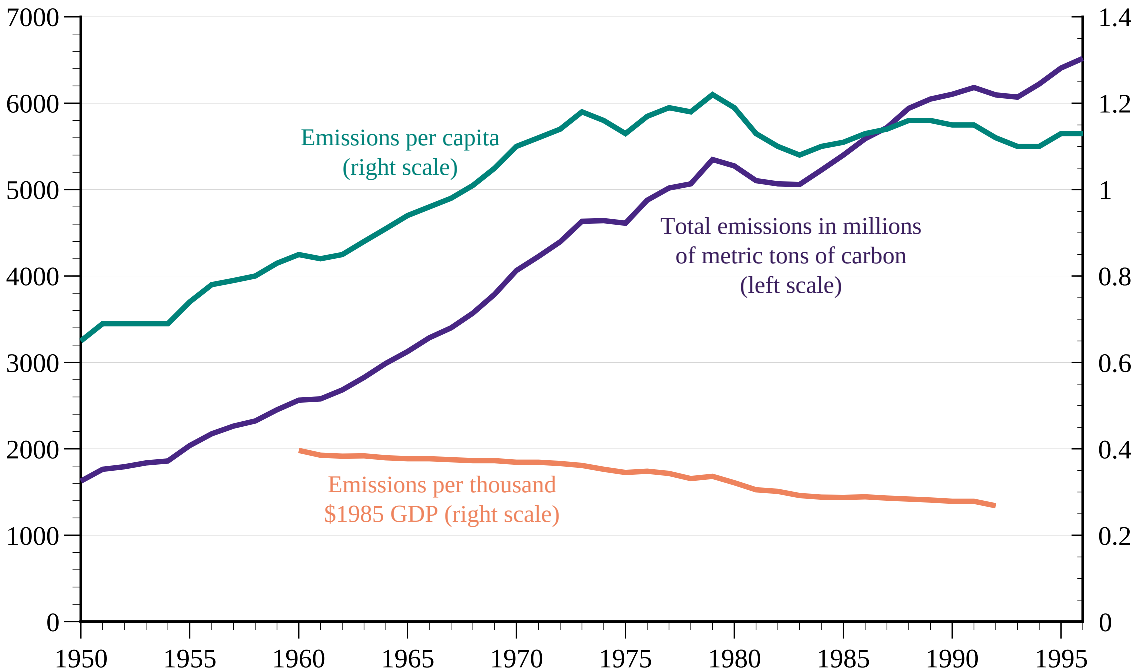
adverse consequences from temperature increases in other ways. A rise in the amount of carbon present in biosphere ‘sinks’ also limits the effect of CO_2 emissions on the atmospheric concentrations of CO_2 (Graph 5).

The accumulation of CO_2 in the atmosphere at projected levels of concentration is not in and of itself dangerous to our health or survival. This makes CO_2 emission a very different type of air pollution problem than, for example, sulfurous or nitrous oxides. The spillover costs associated with the latter pollutants arise from the flow of current emissions. In the case of CO_2, possible spillover costs (or benefits) arise only from the gradual accumulation of past emissions in the atmosphere. If emissions had no effect on concentrations – because, for example, they were immediately absorbed in sinks, such as increased vegetation – there would be no greenhouse gas issue. The real policy target, if we are seriously concerned about global warming from greenhouse gases, is to stop the rise in greenhouse gas concentrations in the atmosphere. Unlike most other types of air pollution, control of CO_2 emissions in the future is a close substitute for control today. This makes the potential problem less urgent.

Forecasting Emissions Growth

Aside from whether emissions of CO_2 end up being harmful or beneficial on balance, another substantial uncertainty is the projected size of any increase in greenhouse gas emissions over the next century. Graph 6 shows that global per capita emissions of CO_2 have been relatively stable for 20 years while the emission intensity of overall economic production has been falling.

Graph 6: Global CO_2 emissions from industrial processes



Sources: The Carbon Dioxide Information Analysis Center (*http://cdiac.esd.ornl.gov/*) and the Penn World Tables (*http://www.nber.org/*).

Whether the stability in per capita emissions will persist is unclear. Indeed, getting an accurate picture of likely future emission patterns has been something of a problem for the IPCC.[9]

The falling ratio of emissions to GDP reflects, in part, the increasing proportion of services, and decreasing proportion of manufacturing, in the gross national production (and consumption) of developed economies. This trend could be expected to accelerate in the next century as a result of continued improvements in computer and communications technology. For example, teleconferences could displace air travel for business meetings, employees may spend more time working at home and households may turn to the internet for more of their entertainment.

The falling ratio of emissions to GDP may also reflect responses to higher prices for fossil fuels (particularly after tax). Higher energy prices directly discourage energy use, for example by decreasing driving. Changes in energy prices may also temporarily reduce energy demand by disrupting the economy at the macroeconomic level.

Higher energy prices also stimulate technological change aimed at improving the energy efficiency of capital equipment. For example, US average automobile fuel efficiency increased from 13 miles per gallon in 1977 to 21 miles per gallon in 1995. Since capital stock is replaced gradually, it takes time for technological changes to reduce the energy intensity of production. Capital stock turns over at varying rates. Power plants can be

[9] Lindzen, R.S. available at *http://www.cato.org/pubs/regulation/reg15n2g.html*.

expected to last 30 to 50 years, industrial manufacturing facilities 10 to 30, cars about 10, jet airplanes about 25, ships about 50, buildings about 50-80 and so on.[10] There is also a reasonable expectation that major advances in alternative energy technologies will occur in the relevant time frame. After all, we are speaking about the next 50–100 years, and the prices, for example, of solar cells for electricity generation, or fuel cells for powering automobiles, are already falling in real terms.

The conversion of the economies in the former Soviet Union and Eastern Europe from central planning to markets is also likely to provide a short-term reduction in the ratio of emissions to GDP. Managers in these countries previously had not paid much attention to energy efficiency since they had little incentive to do so. In response to new market pressures, they are likely to improve management practices and adopt more energy-efficient technologies.

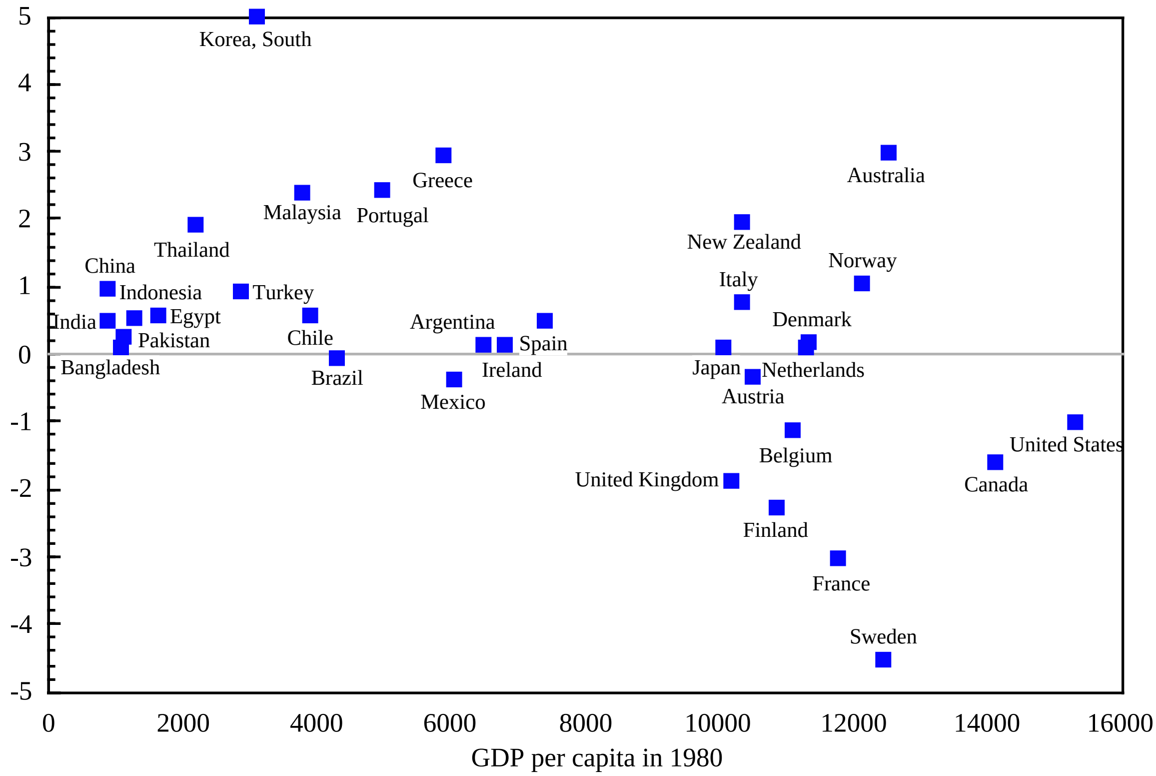
There are also extremely powerful forces tending the raise the ratio of CO_2 emissions to GDP. Developing countries, such as India and China, are turning toward low-cost manufacturing as a basis for development, attracting such industries away from the developed countries. On the one hand, since the technologies and mix of fuels currently used in the developing countries tend to produce more emissions per unit of output, a shift of manufacturing to these countries could increase world per capita emissions of CO_2. On the other hand, new manufacturing plants could incorporate advances in energy efficiency (which correlates strongly with emission-intensity), and so may contribute to the trend of declining emissions per unit of world GDP.[11]

Improved standards of living within the developing economies – and in China and India in particular – are major potential contributors to increased CO_2 emissions per capita. Higher incomes lead to increased demand for manufactured goods. Furthermore, new transportation infrastructure, made possible by economic development, facilitates increased commercial and personal use of transportation services.

Graph 7: Change in CO_2 emissions per capita 1980–1995 (metric tons of CO_2)

[10] Reinstein, R. (1998) available at *http://www.cei.org/gw.html*.

[11] Pearce, F., ‘Mythical Monster’ *New Scientist*, 9 January 1999, P.44.



Sources: Calculations by the authors based on data from the US Energy Information Agency, World Bank Development Indicators and the Penn World Tables.

In summary, the roughly constant ratio of emissions to population from 1973-1997 (Graph 6) may be the result of a delicate balance of offsetting factors. Population growth has been higher in countries with a lower level of per capita emissions, and this alone would tend to reduce the ratio of worldwide emissions to world population. In addition, many developed nations have experienced significant reductions in emissions per capita (Graph 7). In most developing countries, emissions per capita have increased.

Since some countries with large populations are beginning to experience faster economic growth, the constant ratio of CO_2 emissions to population may not persist. For example, by 1992, China was already emitting 55% of the US level of CO_2 emissions from industrial processes (Table 1) and was a larger emitter of methane (Table 2).

Table 1: CO_2 Emissions from Industrial Processes (1992)

	Total		Population		Per capita	
	(m tons)	(% world)	(millions)	(% world)	(tons)	(% world)
USA	4,881.350	21.9	255.2	4.7	19.130	466.6
China	2,667.982	11.9	1,175.3	21.6	2.270	55.4
India	769.440	3.4	874.4	16.0	0.880	21.5
Indonesia	184.585	0.8	194.3	3.6	0.950	23.2

Brazil	217.074	1.0	156.2	2.9	1.390	33.9
Sub-total	3,839.081	17.2	2,400.2	44.1	1.600	39.0
World	22,339.408	100.0	5,448.6	100.0	4.100	100.0

Source: World Resources Institute. Note that these figures are metric tons of *carbon dioxide* while Graph 6 focuses on metric tons of *carbon*. To convert from metric tons of carbon to metric tons of carbon dioxide multiply by 3.667 (the ratio of the molecular weight of CO_2 to the atomic weight of carbon).

Table 2: Other Greenhouse Emissions (1991)

	CO_2 from land use changes		Methane from anthropogenic sources	
	(m tons)	(% world)	(m tons)	(% world)
USA	-436.0	-10.6*	27.0	10.0
China	150.0	3.7	47.0	17.4
India	65.0	1.6	33.0	12.2
Indonesia	410.0	10.0	10.0	3.7
Brazil	140.0	3.4	9.9	3.7
Sub-total	765.0	18.7	99.9	37.0
World	4,100.0	100.0	270.0	100.0

Source: World Resources Institute. *Datum for 1990

The Australian Bureau of Agricultural and Resource Economics (ABARE) projects that annual average growth of CO_2 emissions for the period 1990-2010 will exceed 5% for the developing world compared to under 1% for the developed world.[12]

Elsewhere in this report, Medlock and Soligo (1999) have presented a model of the relationship between economic growth, population growth and energy use. We can use their model, along with UN and other projections of economic and population growth, to develop our own forecasts of the growth in emissions from the developing countries which are the four largest in terms of population – China, India, Indonesia and Brazil.

Table 3: GDP (1996) measured on an exchange rate basis

				Average annual % growth	
	$US bn	% world	% US	1980-90	1990-96
USA	7,433.5	25.2	100.0	2.9	2.4
China	906.1	3.1	12.2	10.2	12.3
India	357.8	1.2	4.8	5.8	5.8
Indonesia	213.4	0.7	2.9	6.1	7.7

[12] Tulpule et al, (1998a). p 11 available at *http://www.abare.gov.au/pubcat/climchang.htm*.

Brazil	709.6	2.4	9.5	2.7	2.9
Sub-total	2,186.9	7.4	29.4	…	…
World	29,510.0	100.0		3.1	2.2

Source: World Development Indicators 1998, World Bank

Table 3 presents statistics on recent annual economic growth rates for these four developing countries along with the United States and the world as a whole for comparison. There are a number of ways of converting GDP figures from different countries to a common basis. Table 3 results from converting foreign nominal GDP figures to US dollars using the official foreign exchange rate and then adjusting for changes in the purchasing power of the US dollar over the sample period. If the extent of over- or under-valuation of an exchange rate changed over the period in question, the growth rates will be biased.

Given the recent economic crises in East Asia and now also in Brazil, the historic economic growth rates in Table 3 probably overstate (in some cases by a substantial margin) the likely economic growth rates in these countries over the next decade or so. Furthermore, the growth convergence hypothesis implies that, even without the recent crisis (which hopefully will be temporary), the per capita economic growth rates of these countries should converge toward the US (and rest of the world) per capita growth rates in the long run. In our projections we have taken the likely GDP *per capita* growth rates to be 5% in China, 4% in India, 1% in Indonesia and 2% in Brazil.

The other major variable relevant to predicting energy consumption, and thus greenhouse gas emissions is population. Table 4 provides 1996 populations, and UN projections for population growth, in these same countries. We have used the figures in the final column of Table 4 for our projected population growth rates.

Table 4: Population in selected countries

	1996		2010		Growth
	millions	(% world)	millions	(% world)	(% pa)
USA	265	4.6	294	4.3	0.7
China	1,215	21.1	1,349	19.9	0.7
India	945	16.4	1,129	16.6	1.3
Indonesia	197	3.4	236	3.5	1.3
Brazil	161	2.8	190	2.8	1.2
World	5,755	100.0	6,788	100.0	1.2

Source: World Development Indicators 1998, World Bank

The results of using our model for 2010 are presented in Table 5. An assumption underlying these calculations is that the fuel mix in each sector remains the same over the next decade or so. This enabled us to translate projected energy consumption figures into output of CO_2.

Table 5: Projected emission levels in 2010 of four developing countries

Country	Year	CO_2 emissions in millions of metric tons of carbon					Per capita
		Residential/ Commercial	Transport	Industrial and Other	Final Consumption	Primary Requirement	*metric tons of CO_2*
China	1995	131.77	36.97	487.90	656.64	798.17	2.44
	2010	222.42	92.55	826.24	1141.21	1387.48	3.77
India	1995	18.14	32.77	85.95	136.86	228.28	0.90
	2010	39.14	60.23	153.78	253.15	422.49	1.37
Indonesia	1995	9.91	12.55	14.48	36.94	59.39	1.13
	2010	17.68	21.64	24.47	63.79	102.59	1.59
Brazil	1995	4.27	25.70	26.97	56.94	64.68	1.49
	2010	8.17	43.26	42.03	93.46	110.24	2.13

Source: Calculations by the authors as described in the text.

There are major uncertainties in making projections such as those outlined in Table 5. The continuing economic progress of China, for example, is not as inevitable as it is often made out to be. As the Soviet Union – one of the shorter-lived major imperial nations of history – showed, Leninist institutions are hard but brittle. There are many tensions which could see the current Chinese state suffer a major political and economic crisis – the contradictions between market modernization and long-term authoritarian rule, the major disparities in economic progress between regions, the inherent difficulty of departing sufficiently from the patterns of Chinese history to sustain modernization. Projecting the future is an inherently difficult exercise. One needs only to consider how unpredictable the global economic and political patterns of 1998 were in 1968 to understand that the global situation in 2028 is similarly opaque.

As China, India, Indonesia and Brazil develop economically it is reasonable to expect, however, that their per capita emissions of CO_2 will rise. Tables 1 and 5 show that per capita emissions in China, India, Indonesia and Brazil in 1995 were on the order of 5–10% of the per capita emissions in the US and substantially below the world average. Over the longer term, even minimal growth in per capita emissions in these countries with extremely large populations could be expected to have a dramatic effect on global greenhouse gas emissions. Each of these countries therefore is a necessary part of any effective regime for controlling emissions of greenhouse gases.

The Economics and Politics of Controlling CO_2 Concentrations

In order to understand the international relations dimensions of the greenhouse gas issue, it is important to recall that concentrations, not emissions, are the source of the externality. Current increased concentrations of greenhouse gases in the atmosphere are the result of past emissions. The developed countries, who currently emit about 60 to 70%[13] of total annual anthropogenic CO_2 emissions, also are responsible for the majority of past anthropogenic emissions (about 80% of human contribution to current concentrations[14]).

The Framework Convention on Climate Change was opened for signing at the June 1992 ‘Earth Summit’ held at Rio de Janiero. The Convention divides the world into so-called ‘Annex I’ countries, who have direct obligations under the Convention to mitigate their emission of greenhouse gases, and the developing world, who do not. This division of the world into Annex I countries and others, recognizes differing national priorities and capacity to pay. As noted in the previous section, however, CO_2 emissions are growing much faster in developing, than in developed, countries. On current trends, emissions by the developing world will exceed those of the Annex I countries during the first half of the next century (current UN projections are for that to take place by 2035[15] while ABARE projections assume equality of emissions by 2010.[16]) If the developed world takes any effective action to reduce emissions, this process will speed up. A process that limits emissions only of countries that end up producing a minority of annual global emissions is of limited practical value.

The mere fact that anthropogenic emissions from developing countries come to equal, and then exceed, those from the developed countries does not, of itself, undermine the argument that the developed world should bear the brunt of the cost of control. It merely increases the importance, for any effective regime, of gaining developing world participation.

Here, the news is bad. If we want to stop the rise in greenhouse gas *concentrations*, then anthropogenic global *emissions* cannot exceed 40% of their 1996 levels (6.518 billion tons of carbon),[17] which amounts to 2.6 billion tons of carbon.[18] This implies an emissions

[13] Heyhoe, E. et al (1998) available at *http://www.abare.gov.au/pubcat/climchang.htm*.

[14] *New Scientist* ‘Editorial’, 29 November 1997; *New Scientist*, ‘Buenos Aires Daily Diary’ 6 November 1998.

[15] United Nations (1999), *Setting the Record Straight: Global Climate Change*.

[16] Tulpulé et al (1998a) available at *http://www.abare.gov.au/pubcat/climchang.htm*.

[17] The Carbon Dioxide Information Analysis Center, http://cdiac.esd.ornl.gov/ftp/ndp030/global96.ems.

reduction on the order of *ten times* or more the level of emission cuts agreed to at Kyoto (a little under eight per cent of 1990 emissions by developed countries only).

Suppose we assume continuation of the past trend toward declining carbon-intensity of production and relatively stable per-capita emissions in the face of continuing economic growth. Annual per capita emissions from industrial processes would thus remain at 4.1 tons of CO_2 (Table 1 above). If global population increases in accord with the UN 'low variant' projection,[19] the global population in 2010 would be (see Table 3 above) 6.788 billion and annual emissions from industrial processes would be 27.83 billion tons of CO_2, which amounts to 7.6 billion tons of carbon. The annual emission reductions required in 2010 to stabilize the atmospheric concentration of CO_2 would then be about 5 billion tons of carbon.

Our own forecasts of emissions presented above can be used to derive an alternative estimate of annual emissions in 2010. The increased per capita emissions in China, India, Indonesia and Brazil as calculated in Table 5 imply that these four countries would produce 2.0 billion tons of carbon annually in 2010. Suppose we continue to assume that per capita emissions elsewhere in the world remain constant at their 1992 level of 6.07 tons of CO_2 (calculated from Table 1 above). Total emissions from the rest of the world in 2010 would then be 23.57 billion tons of CO_2, which amounts to 6.4 billion tons of carbon. The annual *world* total would then be 8.4 rather than 7.6 billion tons of carbon. The annual emission reductions required in 2010 to stabilize the atmospheric concentration of CO_2 would then be about 5.8 billion tons of carbon.

The cost per ton of reducing emissions has been estimated in many papers. A recent paper (October, 1998) by the Energy Information Administration (EIA, US Department of Energy) summarized the costs of meeting the Kyoto controls for the United States that have been calculated using a number of models. Specifically, the EIA examined results obtained from a number of general equilibrium models of the US economy. Each of the models was used to predict the effects of reductions in emissions to 7% below 1990 levels "without the benefit of sinks, offsets, international carbon permit trading, or the Clean Development Mechanism". The projected price in 2010 measured in $US1996 per metric ton of carbon ranged from $221 on the low side to $265, $266, $280 and $295 in the middle with the EIA's own estimate being the highest at $348. The agency researchers noted a number of features of the models that explained these differences. These essentially amounted to

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[18] Tucker (1998), available at *http://www.arts.monash.edu.au/ausapec/imppaps.htm*. The implicit assumption is that some emissions are re-absorbed through natural processes – particularly by the oceans and in increased vegetation growth – so that emissions do not need to be cut 100% to prevent an increase in ambient concentration levels.

[19] United Nations Press Release POP/684, October 27, 1998.

different judgements about the most likely values for various parameters that cannot be estimated accurately.

Table 6: Projected price of emissions per metric ton of carbon in 2010 in $US1992

	Independent abatement	Full trading in Annex B	Double bubble
United States	346	114	108
Canada	835	114	108
Japan	693	114	108
Australia	455	114	108
New Zealand	396	114	108
European Union	714	114	176
Former Soviet Union	0	114	108
Eastern Europe	40	114	176

Source: Tulpulé et. al. 1998b, Table 6, p15. The 'double bubble' involves emissions trading within Europe on the one hand and the rest of the developed world on the other hand.

Similarly, a recent ABARE study (Tulpulé et. al. 1998b) examined the costs of meeting the Kyoto targets using a global trading and environment model. Their results for 2010 in $US1992 are presented in Table 6 (where 'Annex B' refers to the countries entering into emission control obligations if Kyoto is ratified).

The costs in Table 6 (or forecasts of permit prices if trading were to be allowed) should be interpreted as *marginal* costs. The *average* costs of control for emission cuts of the size agreed to at Kyoto are likely to be less than this since the least costly control methods would be used first. The lower costs in column two of Table 6 reflect the fact that trading emission quota among countries allows the largest reductions to be made in those countries where controls are least costly.

The larger emission reductions needed to stabilize the accumulation of CO_2 in the atmosphere would impose marginal and average costs far above the amounts in Table 6. The differences between the marginal cost figures in different columns of Table 6 reflect the higher costs of increasing the size of emission reductions in each country. The larger reductions that, for example, Canada would have to make to meet the Kyoto total without emissions trading pale into insignificance relative to the reductions that would be needed to stabilize the accumulation of CO_2 in the atmosphere.

In reality, there is substantial uncertainty about the cost of achieving the level of emission reduction required to significantly retard the accumulation of CO_2 in the atmosphere. The cost would depend greatly on many factors, each of which is very difficult to forecast. These factors include:

- the link between emissions and CO_2 accumulation, and hence the size of the reduction;
- future population and economic growth;
- the nature of the control regime, including the possibilities for trading quota;
- incentives the regime generates for the development and adoption of new technologies;
- technological developments that are independent of the control regime;
- elasticities of substitution between energy and other inputs; and
- changes in the mix of industries and the location and age of industrial plant.

Suppose we take $US150 per metric ton of carbon (1996 prices) as an extremely conservative estimate of the average cost in 2010 of emission reductions needed to significantly retard the accumulation of CO_2 in the atmosphere. The annual cost of reductions needed in 2010 to stabilize greenhouse concentrations, therefore, would be at least $US750 billion under the assumption of constant world per capita emissions, and close to $US875 billion under the alternative estimates of emissions growth in Table 5. This is more than 2.5% of current world GDP (Table 4), and is of the same order of magnitude as the current GDP of China or Brazil, and more than the combined GDP of India and Indonesia.

The Kyoto agreement calls for emissions to be reduced by 2010 by an amount that is approximately one tenth of the above magnitude below 1990 emissions. The cuts under the Kyoto agreement therefore include any increase that otherwise would have occurred. Suppose we assume these lesser emission reductions involve a lower average cost of $US100 per metric ton of carbon (1996 prices). The reductions called for at Kyoto would still involve at least $US50 billion worth of cost, or maybe 0.2% of world GDP in 2010. And what would we be buying for that cost? Calculations using the same models that predict global warming suggest that full implementation of the Kyoto Protocol will decrease average world temperatures by about 0.07°C[20] to 0.2°C[21] – a difference so small that it could not be reliably detected by ground-based thermometers.[22]

The magnitude of these costs ought to be enough to make one skeptical that effective controls will be implemented. To even contemplate costs of such magnitude one would have to be very confident that significant global warming is occurring and that it will be highly damaging.

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[20] Wigley, (1998), quoted in Michaels (1998).

[21] Davis and Legates (June 1998).

[22] Michaels (1998), Davis and Legates (June 1998).

One would also need to be convinced that action is urgent. As we noted above, unlike most other types of air pollution, the *flow* of emissions is not the problem. Rather, the potential problem arises only from the long-term accumulation of CO_2 in the atmosphere. Reduced emissions in the future are a substitute for reduced emissions today, and the earlier the implementation of controls, the higher the costs. If controls are imposed sooner rather than later, technology will be less advanced, the life of more capital equipment will be prematurely shortened, and fewer resources will be available to compensate for the losses (given the continuing tendency of wealth to increase over time).

The case for urgent action requires a careful consideration of the likely costs and benefits. To date, policy has been largely driven by the science with economic considerations given short shrift. Yet there is not even a consensus in the scientific community that global warming ought to be an urgent national or global concern – as the 1992 Washington Statement, the 1996 Leipzig Declaration and the 1998 Oregon Petition by concerned scientists indicate (see Appendices II to IV).

There is also no precedent for countries agreeing to incur costs of such magnitude, let alone for actually following through with the implementation. To be sure, governments regularly impose costs on their society of one form or another. But that is for purposes such as buying off interest groups, retaining political power or implementing deeply held beliefs. Global warming falls into none of these categories.

Polling in the US, for example, indicates that global warming is a declining concern – according to CNN/Gallup polling, in 1989 about 35% of Americans worried 'a great deal' about global warming, but in 1997 only 24% did.[23] (Given the fall in semi-official and official projections for warming from 1988 to 1995 such declining concern can hardly be characterized as irrational.) As for other reasons for socially destructive government effort – gaining support from interest groups and retaining power – serious attempts to devote major extra resources, particularly by developing countries, to cut greenhouse emissions are likely to conflict strongly with both these goals.

National Priorities

What are the ongoing national priorities for the four most populous non-Annex I nations (China, India, Indonesia and Brazil) with over 40% of the world's population (Table 4)? Table 7 sets out some selected development indicators for those four nations, with the equivalent figures for the United States for comparison.

[23] *http://www.cnn.com/SPECIALS/1997/global.warming/hot.air/*

Table 7: Selected Development Indicators

	Life Expectancy at birth (1996)				Calories available 1988-90	Child malnutrition (1995-96)	Child illiteracy rate, 15+ (1995)		Per capita GDP PPP based (1996)	
	Male		Female				Male	Female		
	(years)	(% US)	(years)	(% US)	(% need)	(% under 5)	(%)	(%)	($US)	(% US)
USA	74	100	80	100	138				28,020	100
China	68	92	71	89	112	7	10	27	3,330	12
India	62	84	63	79	101	16	35	62	1,580	6
Indonesia	63	85	67	84	121	60	10	22	3,310	12
Brazil	63	85	71	89	114	40	17	17	6,340	23
World	65	88	69	86	n.a.	n.a.	21	38	6,200	22

Source: World Development Indicators, 1998, World Bank, World Resources 1996-97, World Resources Institute

Current life expectancies in these developing nations range between 6-12 years lower for males and 9-17 years lower for females than the US. While, on average, an adequate number of calories are available, this was marginal for India at the beginning of the decade. Malnutrition remains a problem in all four countries, but particularly India. Talk of a possible mortality cost from global warming must be weighed against the mortality cost of lower economic growth. These costs most likely would be concentrated in the developing world, though action to reduce emissions could result in significant mortality costs even in developed societies.[24]

Illiteracy is still high in India and still a major issue, particularly for women, in all four countries. Even on a purchasing power parity basis, the level of resources available to tackle these basic problems is low. Brazil, the most prosperous of the four, has a per capita GDP less than a quarter of that of the US, China and Indonesia less than an eighth and India less than a seventeenth of the US.

Economic growth matters. The more resources that are available, the easier it is to achieve better outcomes. There is, for example, a vast difference between spending $US375 per person per year on health (US), compared to $US12 (China), $US9 (India), $US7 (Indonesia) and $US27 (Brazil).[25] Admittedly, countries with similar levels of GDP can have quite different life expectancies — Mozambique and Ethiopia have similar per capita

[24] Cross (1998).

[25] Estimates made from data from WRI and World Bank 1998.

GDP (the two lowest recorded by the World Bank), yet their average life expectancies are very different (44 years for Mozambique, 67 for Ethiopia).[26] Nevertheless, life expectancy is positively correlated to per capita GDP.[27]

Development, in its broadest sense, has to be a priority for countries such as China, India, Indonesia and Brazil. Policies that impede economic growth generally can be expected to affect more than material standards of living. Benefits need to be commensurate with the sacrifice made.

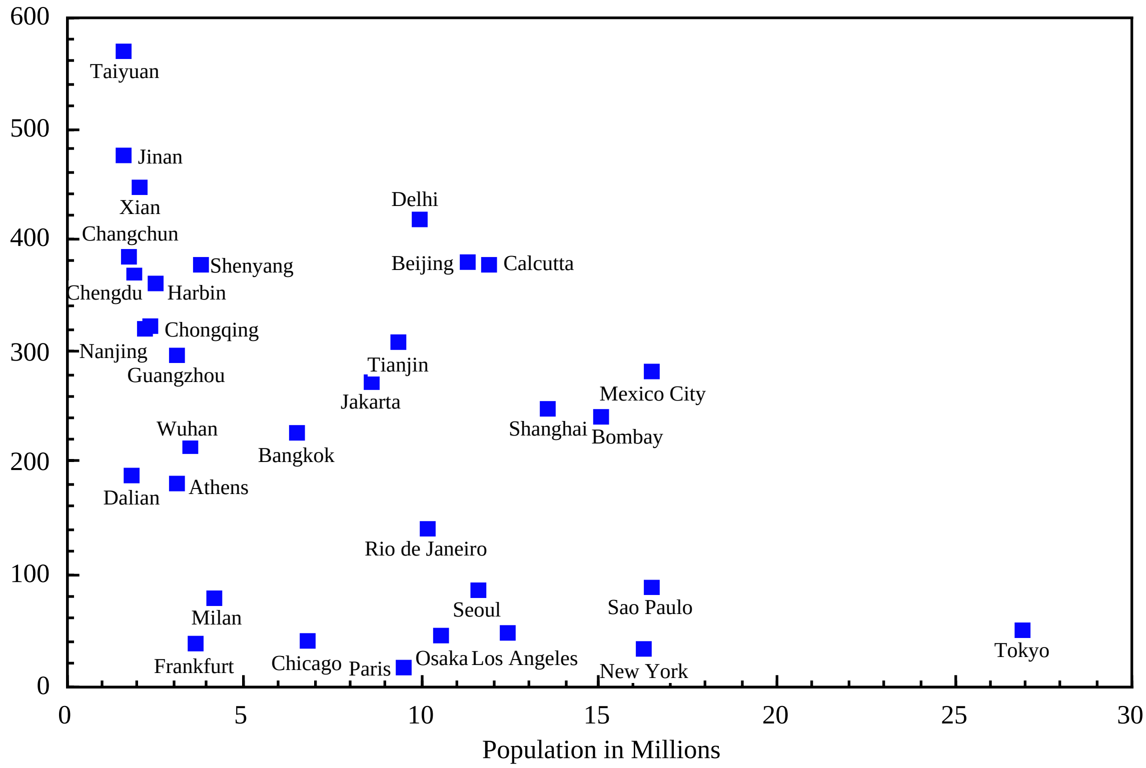
While developing countries no doubt fear lost economic development as the major cost of climate change policy, it is not the only potential cost. Within the realm of environmental policy, other issues – including environmental problems that are blighting lives and killing people here and now – loom much larger than the future potential costs of even the latest IPCC projected level of global warming.

Resources devoted to reducing emissions of greenhouse gases could instead be applied to ameliorating other types of air or water pollution. Graphs 8 through 10 present some air pollution statistics for a number of major cities in both the developed and developing countries. It is clear from these that major cities in the developing world typically suffer much worse air pollution than comparably-sized cities in the developed world. A recent report by Wood Mackenzie Global Consultants (1999) notes that 17% of deaths in China are from respiratory disease compared to 7% in the US.

Graph 8: Suspended particulates (micrograms/m^3) for selected metropolitan areas

[26] World Bank 1998, (male life expectancy).

[27] The correlation between male life expectancy and per capita GDP (purchasing power parity basis) for 132 countries from the World Bank *World Development Report 1998* is 0.62.



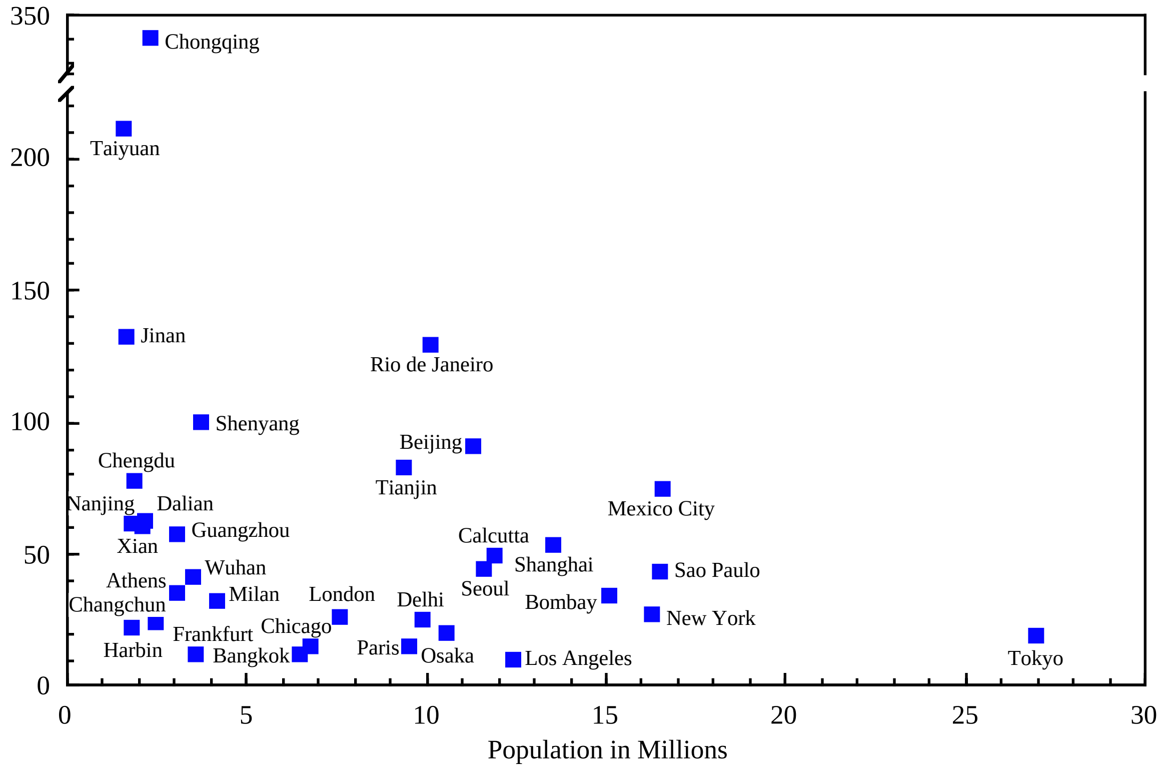
Sources: For cities outside the US, data is for 1995 and from World Bank World Development Indicators 1998; for the US, data is for 1997 and from the Environmental Protection Agency (http://www.epa.gov/).

Many developing countries also suffer from substantial water pollution from their relatively few, but generally poorly regulated, industrial firms (Table 8). In addition, the generally inadequate water supplies and sewerage treatment facilities in the burgeoning cities of Asia and Latin America constitute a major health hazard. Less directly destructive, but also serious, are questions of deforestation and other ecological pressures. Scarcity of resources dictates giving priority to the most urgent environmental issues first.

While efforts are being made to deal with air and water pollution in the developing world, the results are far from satisfactory.[28] Environmental goals have to be weighed against other national goals, including the goal of higher economic growth. This is not merely a matter of 'consumer aspirations', powerful though these can be. Issues such as life expectancies, education, health care and quality of life for oneself and one's children are at stake.

Graph 9: SO_2 (micrograms/m^3) for selected metropolitan areas (1995)

[28] For an informative discussion of the environmental problems confronting developing nations, see Brandon and Ramankutty (1993).



Source: World Bank, World Development Indicators 1998.

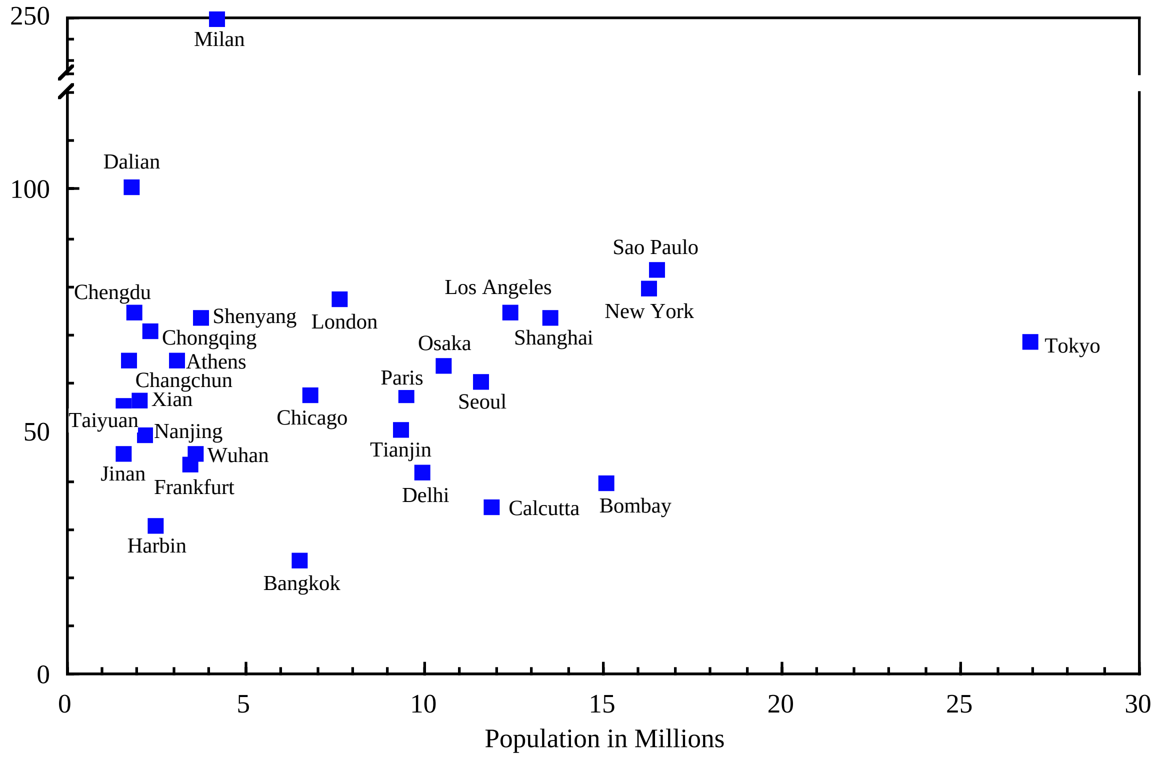
In any rational ranking of national priorities, and allocation of resources, all of the above pressing domestic environmental, social and public health issues must take precedence over global warming as their negative effects are clear, known and current. Developing countries can reasonably say to developed countries 'you cannot expect us to rank global warming – something which may or may not be a problem decades down the track – above social and environmental problems that need to be attended to now'. Nor would it be proper that developed countries do so.

Table 8: Emissions of Organic Water Pollutants (1993)

Country	Kilograms per day	Kilograms per day per worker
USA	2,477,830	0.15
China	5,339,072	0.15
India	1,441,293	0.20
Indonesia	537,142	0.19
Brazil	855,432	0.17

Source: World Bank World Development Indicators, 1998.

Graph 10: NO_x (micrograms/m^3) for selected metropolitan areas (1995)



Source: World Bank, World Development Indicators 1998.

The radically different situation of developing countries is explicitly acknowledged in the FCCC, not merely in the division into Annex I and non-Annex I nations, but in wording such as the following extracts from the Preamble:

> ***Noting*** *that … per capita emissions in developing countries are still relatively low and that the share of global emissions originating in developing countries will grow as they experience economic growth to meet their social and development needs….*

> ***Recognizing*** *that States should enact effective environmental legislation, that environmental standards, management objectives and priorities should reflect the environmental and developmental context to which they apply, and that standards applied by some countries may be inappropriate and of unwarranted economic and social cost to other countries, in particular developing countries…*

> ***Recognizing*** *the special difficulties of those countries, particularly developing countries, whose economies are particularly dependent on fossil fuel production, use and exportation, as a consequence of action taken on limiting greenhouse gas emissions…*

> ***Recognizing*** *that all countries, especially developing countries, need access to resources required to achieve sustainable social and economic development and that, in order for developing countries to progress towards that goal, their energy consumption will need to grow…*

Western and, increasingly, East Asian experience has encouraged developing nations to believe that higher living standards are attainable. The developed world's present is the developing world's future. Indeed, the World Bank rates three formerly less developed

East Asian societies — Singapore, Hong Kong and Japan — amongst the top five richest on a per capita purchasing power parity GDP basis (Table 9).

Table 9: Five Richest Countries by per capita GDP (1996)

	Per capita GDP (PPP terms)		**Life expectancy at birth**	
	($US)	(Ratio to world av.)	Male	Female
USA	28,020	4.5	74	80
Singapore	26,910	4.3	74	79
Switzerland	26,340	4.2	75	82
Hong Kong	24,260	3.9	76	81
Japan	23,420	3.8	77	83

Source: World Development Indicators 1998, World Bank

A key element in raising standards of living is increasing use of energy. Despite the decreasing energy intensity of production, high standards of living require high energy use (Table 10).

Table 10: Energy use by selected countries

	1973		1993		1973-93	2013 if growth constant	
	Petajoules	(% world)	Petajoules	(% world)	(% change)	Petajoules	(% world)
USA	60,135	24.9	65,547	19.4	9	71,446	15.1
China	12,905	5.4	31,359	9.3	143	76,202	16.1
India	2,429	1.0	8,088	2.4	233	26,933	5.7
Indonesia	538	0.2	2,658	0.8	394	13,131	2.8
Brazil	629	0.3	2,491	0.7	296	9,864	2.1
Sub-total	16,501	6.8	44,596	13.2	170	120,527	25.5
World	241,084	100.0	337,518	100.0	40	472,525	100.0

Source: World Resources Institute

India and Brazil both more than doubled their share of global energy use from 1973 to 1993, while China's share increased almost 70%. Even so, their total energy use was still considerably below that of the US, though increasing notably from 27% to 68% of the US total. If those growth rates continue, by 2013, China's total energy use will exceed that of the US, though it will remain only a fraction of energy use in the US on a per capita basis.

A reasonable doubt at this point might be whether the world has sufficient energy resources to enable growth in use over the next two decades commensurate with growth over the last two decades. However, current ‘economically recoverable’ reserves of fossil fuels are huge (Table 11). These reserves represent enormous easily useable energy sources (Table 12). There are also extremely large reserves (including oil shale) available at higher recovery costs.

Table 11: Proven recoverable energy reserves (1993)

	Black coal		Brown coal		Crude oil		Natural gas		Uranium		Potential hydro		Installed hydro	
	(m tons)	(%)	(m tons)	(%)	(m tons)	(%)	(bn m^3)	(%)	(tons)	(%)	(MW)	(%)	(MW)	(%)
USA	106,495	20.5	134,063	26.2	3,900	2.8	4,599	3.3	112,000	7.3	376,000	n.a.	77,384	12.6
China	62,200	12.0	52,300	10.2	3,264	2.3	1,670	1.2	n.a.	n.a.	2168304	n.a.	59,655	9.7
India	68,047	13.1	1,900	0.4	776	0.6	686	0.5	n.a.	n.a.	205,000	n.a.	19,843	3.2
Indonesi	962	0.2	31,101	6.1	759	0.5	2,000	1.4	0	0.0	709,000	n.a.	2,169	0.4
Brazil	n.a.		2,845	0.6	542	0.4	137	0.1	162,000	10.6	1116900	n.a.	48,193	7.9
Sub-	131,209	25.3	88,146	17.2	12,341	8.8	4,493	3.2	162,000	n.a.	4199204	n.a.	129,860	21.2
World	519,358	100.0	512,252	100.0	140,676	100.0	141,335	100.0	1532000	100.0	n.a.	100.0	612505	100.0

Source: World Resources Institute

Table 12: Energy content of proven recoverable fossil energy reserves (1993)

	Black coal (27†)		Brown coal (9.8†)		Crude oil (45†)		Natural gas (39†)	
	petajoules	Use ratio*	petajoules	Use ratio*	petajoules	Use ratio*	petajoules	Use ratio*
USA	2,875,365	35.2	1,313,817	16.1	175,110	2.1	179,361	2.2
China	1,679,400	56.6	512,540	17.3	146,554	4.9	65,130	2.2
India	1,837,269	196.8	18,620	2.0	34,842	3.7	26,754	2.9
Indonesia	25,974	9.8	304,790	114.7	34,079	12.8	78,000	29.3
Brazil	n.a.	n.a.	27,881	7.3	24,336	6.4	5,343	1.4
Sub-total	3,542,643	77.9	863,831	19.0	554,111	12.2	175,227	3.9
World	14,022,666	43.1	5,020,070	15.4	6,316,352	19.4	5,512,065	16.9

Source: Calculations based on Table 9. †Conversion Factors. *Ratio to annual energy consumption in that country in 1993.

Black coal reserves alone (as measured in the tables) are equivalent to almost 42 years worth of total global energy use. Since huge oil fields continue to be discovered — most recently in Baku and in deep water in the Gulf of Mexico —there is obviously a vast and continuing potential for fossil fuels to provide energy for economic development. These resources will be used until cheaper forms of energy abound.[29]

Technological progress in solar cell, fuel cell, nuclear and perhaps other, as yet unknown, technologies is likely to result in fossil fuels being replaced in most energy uses sometime in the next century. While the prospect over the next three decades may be for increased CO_2 emissions from the burning of fossil fuels, there is also a reasonable expectation that emissions could decline dramatically in the latter half of the next century. Until then, developing countries in Asia and elsewhere will not explicitly forgo the aspirations of development by limiting their use of, or increasing the domestic cost of, fossil fuel energy sources.

Indeed, developing countries have a positive incentive not to participate in any serious greenhouse gas control regime. They can seek to benefit from the relocation of carbon-intensive industries as developed countries raise the cost of such activities. The US Senate is certainly alive to the possibility of a transfer of industries, as the recent ‘Byrd-Hagel’ resolution passed 97-0 by the US Senate indicates (Appendix V).

‘Carbon leakage’ — the transfer of carbon-emissions by displacement of industries from countries undertaking serious abatement action to those not undertaking such action — is not a mere theoretical possibility. The first ‘Oil Shock’, which greatly increased the price of electricity in Japan, resulted in the transfer of aluminum smelting from Japan to Australia.[30] Even an industry as reliant on investment in immobile capital as aluminum smelting proved to be mobile in a relatively short time period given a sufficiently unfavorable shift in energy prices. Similarly, the implementation of the Montreal Protocol on Substances that Deplete the Ozone Layer has seen CFC production fall in developed countries by over 80% but rise in developing countries by about 130% (though global production overall has fallen near 70%).[31] Economic models have produced estimates of ‘carbon leakage’ ranging from 0 to 70% (ABARE estimates are in the range of 6 to 18% depending on whether emission trading occurs).[32]

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[29] Recent world prices for oil – in real terms considerably below those after the 1973 ‘Oil Shock’ – suggest falling scarcity, relative to demand, of fossil fuels. At about $US12, or even $US20 a barrel, oil prices contrast markedly with projections – made during the previous energy hysteria of the ‘Energy Crisis’ of 1973-74 – that oil would reach prices of $US100 a barrel – more if we adjust for inflation – by the end of the century (Mills 1998).

[30] Presentation by Dr Vivek Tulpulé, Royal Society of Victoria Symposium, 21 October 1997.

[31] Lieberman (1998), available at *http://www.cei.org/gw.html#CEI "Costs of Kyoto" Lectures.*

[32] Tulpulé, et al (1998b).

Refusing to participate in a global greenhouse gas control regime therefore has a double benefit to developing countries. They do not bear the costs of cutting their own anthropogenic greenhouse gas emissions, and they can increase their own rate of economic development by the transfer of manufacturing from countries participating in the greenhouse gas control regime. (They may nevertheless oppose the policy since they would expect to suffer negative trade effects from reduced economic activity in the developed world.)

Any effective global greenhouse gas regime must confront the very powerful reasons developing countries have for not expending significant amounts of their own resources in such an effort. Mere preaching from the developed world — responsible, according to most estimates, for about 80% of the human contribution to current greenhouse gas concentrations — will not change this, as has been eloquently expressed in another context:

> *Social forces have been set in motion that will not be contained … Electricity, telephones, running water — once humans experience these things, they want more of them … It is easy for outsiders to warn against the long-term costs of damming Africa's rivers, ruining its scenery, or destroying its woodlands, but it is akin to a glutton admonishing a beggar on the evils of carbohydrates — he lacks a certain moral authority.*[33]

Leaders of developing countries can hardly be expected to be *more* willing than the US Senate to countenance significant costs for the people they govern. It is unreasonable to expect the citizens of developing countries to accept a policy that permanently relegates them to the status of 'second class global citizens' by denying them the chance to achieve developed world income levels.

Some in Asia might see in climate change policy echoes of the history of the early twentieth century. Prior to the Pacific War, Japan saw Western disapproval of its policy in China as a hypocritical attempt by powers already possessing empires to deny Japan the same privilege. Developing countries today similarly are likely – with some justice – to see environmentalism as an excuse by already-developed nations to deny the developing world's aspirations to the same status. It is surely hard to see such aspirations as other than entirely legitimate. As a matter of practical politics, they will not be explicitly denied since no regime is likely to long survive disavowal of them. Whether they will be satisfied is another matter, but no government is going to have their denial as *explicit* policy.

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[33] Mark Hertsgaard, *Earth Odyssey* quoted in the *Australian Financial Review*, January 22 1999, Review 6.

Conclusion

There are so many layers of rational skepticism about climate change policy. Eminent scientist Sir Fred Hoyle has expressed the most basic level of skepticism eloquently (K stands for degrees Kelvin: degrees above absolute zero):

> *Given the choice, I imagine nobody would opt for a world without any greenhouse, that is a world with a mean temperature of about 259K. And probably few would opt for an ice-age world with a mean temperature of 275K to 280K. To this point, the greenhouse is seen as good. Further still, a clear majority continues to see the greenhouse as good up to the present-day mean of about 290K. But, at the next 1.5K a drastic change of opinion sets in: the greenhouse suddenly becomes the sworn enemy of environmental groups, world-wide, to the extent that they rush off to Rio and elsewhere and make a great deal of noise about it. I find it difficult to understand why. If I am told that computer calculations show immensely deleterious consequences would ensure, then I have a good laugh about it. In private, of course, since I am always careful to be polite in public.*[34]

It will not be a laughing matter, however, if greenhouse theory is translated into policies that succeed in stabilizing greenhouse gas concentrations in the atmosphere. Such an outcome could only be achieved through a massive and very costly reduction in current and prospective greenhouse gas emissions.

An effective regime has to include developing countries. Those countries are likely to produce a rapidly growing share of world greenhouse gas emissions in coming decades. Furthermore, if developing countries are excluded from emission controls, many energy intensive industries will simply migrate from the developed to the developing world and possibly increase CO_2 emissions per unit of world GDP. Developing countries will not agree to control greenhouse gas emissions, however, unless the costs are low enough to be acceptable given the seriousness and urgency of the other problems such countries face. The only net cost likely to be acceptable (and result in actual action) is close to zero.

The inescapable conclusion is that effective controls over emissions will only be implemented at enormous cost to the taxpayers of the developed countries.[35] There is a (partial) precedent for this. The 1987 Montreal Protocol on controlling emissions of CFCs has seen significant costs incurred by the US in particular. The US is the major jurisdiction effectively enforcing the ban on ozone-depleting substances. It is also the major country making compensatory contributions to assistance to developing countries to forgo use of

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[34] Hoyle (1996), p. 185.

[35] Note that the mechanism by which any such payments and transfers might be made is not part of the ambit of this paper. There may also be serious doubts about whether *any* type of compensation could lead developing nations to forgo the burning of more fossil fuel in the coming decades.

CFCs and other chemicals to be phased out under the protocol.[36] But CFCs are far less central to economic processes than greenhouse gases, and the costs involved are far lower.[37] Compensating the developing world, and China and India in particular, to accept substantially lower rates of economic growth will require an extraordinary level of resource transfer – equivalent to the current GDP of major developing nations.

Perhaps the governments of Western Europe and North America are insincere in their professed desire to implement energy taxes in the name of countering potential global warming. Maybe they are placating 'green' sentiment within their political support base of voters and activists while remaining secure in the knowledge that nothing really is going to happen. They are merely presenting a façade policy – though a façade that would be very expensive if the unfortunate occurs and the Kyoto protocol really is implemented.[38]

The proposed policies may serve a hidden agenda. Western European governments may be attempting to protect their heavy dependence on fossil fuels as a tax base. Without higher energy taxes elsewhere (particularly the US), competition from countries with lower energy costs might eventually force the Europeans to reduce their own taxes on energy use.

Alternatively, the attempt to control greenhouse gas emissions, though sincere, will simply fail. It will be subverted by the aspirations of the developing world to turn the developed world's present into their own future. Such an outcome might represent a gain to the developing world at the expense of the developed world. There may also be a net loss overall, however, since economic growth in the developing world relies largely on access to the markets of the developed world.

The threat of global warming elicits a primitive fear in many people – a fear not based on sound scientific evidence. The cost of assuaging this fear will be high, and the developed world will pay the price through increased taxes, lower productivity and a reduced standard of living.

[36] Lieberman (1998).

[37] CFCs are also, incidentally, manufactured at far fewer places and are far easier to detect than CO_2 and therefore are much easier to include in a formal treaty or protocol aimed at controlling emissions.

[38] That implementation dates have been set outside the likely term of office of incumbents signing the Kyoto Protocol is suggestive of an element of façade building.

Appendix I

Units and Conversions

Standard metric prefixes

kilo (k)	=	10^3	(thousand)	mega (M)	=	10^6	(million)
giga (G)	=	10^9	(billion)	tera (T)	=	10^{12}	(trillion)
peta (P)	=	10^{15}	(quadrillion)	exa (E)	=	10^{18}	

Standard conversions

(barrel to litres)

1 barrel = 158.987 L

(kilowatt hours to kilojoules)

1 kWh = 3600 kJ

(BTU to kilojoules)

1 BTU = 1.055056 kJ

Energy content of fuels

(gigajoules per metric ton)

Black coal: 13.5 to 30. [27]*

Brown coal: 9.8

Coke: 27.0

Wood (dry): 16.2

Crude oil: 44.9

(megajoules per cubic metre)

Natural gas: 38.5 to 40.8 [39]*

(petajoules per metric ton)

Uranium: 0.56

Source: *Energy Demand and Supply Projections Australia 1992-93 to 2004-05*, Australian Bureau of Agricultural and Research Economics (ABARE), Research Report 93.2, Canberra, 1993.

Average carbon dioxide emissions from burning fuels *(millions of metric tons of carbon per quadrillion BTU of energy)*

Coal (average US quality): 26.13; Oil: 19.47; Natural gas: 14.47

Source: *Emissions of Greenhouse Gases in the United States 1997*, Energy Information Administration, Washington D.C., Document DOE/EIA-0573(97), October 1998.

* Figures used for conversions in text.

Appendix II

Statement by Atmospheric Scientists on Greenhouse Warming

WASHINGTON, D.C., FEBRUARY 27, 1992 — As independent scientists, researching atmospheric and climate problems, we are concerned by the agenda for UNCED, the United Nations Conference on Environment and Development, being developed by environmental activist groups and certain political leaders. This so-called Earth Summit is scheduled to convene in Brazil in June 1992 and aims to impose a system of global environmental regulations, including onerous taxes on energy fuels, on the population of the United States and other industrialized nations.

Such policy initiatives derive from highly uncertain scientific theories. They are based on the unsupported assumption that catastrophic global warming follows from the burning of fossil fuels and requires immediate action. We do not agree.

A survey of U.S. atmospheric scientists, conducted in the summer of 1991, confirms that there is no consensus about the cause of the slight warming observed during the past century. A recently published research paper even suggests that sunspot variability, rather than a rise in greenhouse gases, is responsible for the global temperature increases and decreases recorded since about 1880.

Furthermore, the majority of scientific participants in the survey agreed that the theoretical climate models used to predict a future warming cannot be relied upon and are not validated by the existing climate record. Yet all predictions are based on such theoretical models.

Finally, agriculturalists generally agree that any increase in carbon dioxide levels from fossil fuel burning has beneficial effects on most crops and on world food supply.

We are disturbed that activists, anxious to stop energy use and economic growth, are pushing ahead with drastic policies without taking notice of recent changes in the underlying science. We fear that the rush to impose global regulations will have catastrophic impacts on the world economy, on jobs, standards of living, and health care, with the most severe consequences falling upon developing countries and the poor.

The statement was signed by 47 physicists, climatologists, meteorologists, environmental scientists and related specialists. Their names are available at http://www.his.com/~sepp/statment.html (23 Oct. 1997)

Appendix III

The Leipzig Declaration on Global Climate Change

As scientists, we – along with our fellow citizens – are intensely interested in the possibility that human activities may affect the global climate; indeed, land clearing and urban growth have been changing local climates for centuries. Historically, climate has always been a factor in human affairs - with warmer periods, such as the medieval "climate optimum," playing an important role in economic expansion and in the welfare of nations that depend primarily on agriculture. For these reasons we must always remain sensitive to activities that could affect future climate.

Attention has recently been focused on the increasing emission of "greenhouse" gases into the atmosphere. International discussions by political leaders are currently underway that could constrain energy use and mandate reductions in carbon dioxide emissions from the burning of fossil fuels. Although we understand the motivation to eliminate what are perceived to be the driving forces behind a potential climate change, we believe this approach may be dangerously simplistic. Based on the evidence available to us, we cannot subscribe to the so-called "scientific consensus" that envisages climate catastrophes and advocates hasty actions.

As the debate unfolds, it has become increasingly clear that – contrary to conventional wisdom – there does not exist today a general scientific consensus about the importance of greenhouse warming from rising levels of carbon dioxide. On the contrary, most scientists now accept the fact that actual observations from earth satellites show no climate warming whatsoever. And to match this fact, the mathematical climate models are becoming more realistic and are forecasting temperature increases that are only 30 percent of what was considered the "best" value just four years ago.

We consider the Global Climate Treaty concluded in Rio de Janeiro at the 1992 "Earth Summit" to be unrealistic; its goal is stabilization of atmospheric greenhouse gases, which requires that fuel use be cut by 60-80 percent worldwide! Energy is essential for all economic growth, and fossil fuels provide today's principal global energy source. In a world in which poverty is the greatest social pollutant, any restriction on energy use that inhibits economic growth should be viewed with caution. For this reason, we consider "carbon taxes" and other drastic control policies – lacking credible support from the underlying science – to be ill-advised, premature, wrought with economic danger, and likely to be counterproductive.

This statement is based on the International Symposium on the Greenhouse Controversy, held in Leipzig, Germany on November 9-10, 1995, under the sponsorship of the Prime Minister of the State of Saxony. For further information, contact the Europaeische Akademie fuer Umweltfragen (fax +49-7071-72939) or The Science and Environmental Policy Project in Fairfax, Virginia (fax +1-703-352-7535). Updated as of July 16, 1996

The declaration was signed by 80 scientists from around the world. Their names can be found at http://www.vision.net.au/~daly/leipzig.htm (22 October 1997)

Appendix IV

Oregon Petition

We urge the United States government to reject the global warming agreement that was written in Kyoto, Japan, in December 1997, and any other similar proposals. The proposed limits on greenhouse gases would harm the environment, hinder the advance of science and technology, and damage the health and welfare of mankind.

There is no convincing scientific evidence that human release of carbon dioxide, methane, or other greenhouse gases is causing or will, in the foreseeable future, cause catastrophic heating of the Earth's atmosphere and disruption of the Earth's climate. Moreover, there is substantial scientific evidence that increases in atmospheric carbon dioxide produce many beneficial effects upon the natural plant and animal environments of the Earth.

Current list of signers is available at *http://zwr.oism.org/pproject/*. (These numbered over 17,000 basic and applied scientists as at 8 April 1998.)

Appendix V

The Byrd-Hagel Resolution

U.S. Senate, June 12th 1997

105th CONGRESS 1st Session

S. RES. 98

Expressing the sense of the Senate regarding the conditions for the United States becoming a signatory to any international agreement on greenhouse gas emissions under the United Nations Framework Convention on Climate Change.

IN THE SENATE OF THE UNITED STATES

June 12, 1997

Mr. BYRD (for himself, Mr. HAGEL, Mr. HOLLINGS, Mr. CRAIG, Mr. INOUYE, Mr. WARNER, Mr. FORD, Mr. THOMAS, Mr. DORGAN, Mr. HELMS, Mr. LEVIN, Mr. ROBERTS, Mr. ABRAHAM, Mr. MCCONNELL, Mr. ASHCROFT, Mr. BROWNBACK, Mr. KEMPTHORNE, Mr. THURMOND, Mr. BURNS, Mr. CONRAD, Mr. GLENN, Mr. ENZI, Mr. INHOFE, Mr. BOND, Mr. COVERDELL, Mr. DEWINE, Mrs. HUTCHISON, Mr. GORTON, Mr. HATCH, Mr. BREAUX, Mr. CLELAND, Mr. DURBIN, Mr. HUTCHINSON, Mr. JOHNSON, Ms. LANDRIEU, Ms. MIKULSKI, Mr. NICKLES, Mr. SANTORUM, Mr. SHELBY, Mr. SMITH of Oregon, Mr. BENNETT, Mr. FAIRCLOTH, Mr. FRIST, Mr. GRASSLEY, Mr. ALLARD, Mr. MURKOWSKI, Mr. AKAKA, Mr. COATS, Mr. COCHRAN, Mr. DOMENICI, Mr. GRAMM, Mr. GRAMS, Mr. LOTT, Ms. MOSELEY-BRAUN, Mr. ROBB, Mr. ROCKEFELLER, Mr. SESSIONS, Mr. SMITH of New Hampshire, Mr. SPECTER, and Mr. STEVENS) submitted the following resolution; which was referred to the Committee on Foreign Relations

A RESOLUTION

Expressing the sense of the Senate regarding the conditions for the United States becoming a signatory to any international agreement on greenhouse gas emissions under the United Nations Framework Convention on Climate Change.

Whereas the United Nations Framework Convention on Climate Change (in this resolution referred to as the ‘Convention’), adopted in May 1992, entered into force in 1994 and is not yet fully implemented;

Whereas the Convention, intended to address climate change on a global basis, identifies the former Soviet Union and the countries of Eastern Europe and the Organization For Economic Co-operation and Development (OECD), including the United States, as ‘Annex I Parties’, and the remaining 129 countries, including China, Mexico, India, Brazil, and South Korea, as ‘Developing Country Parties’;

Whereas in April 1995, the Convention’s ‘Conference of the Parties’ adopted the so-called ‘Berlin Mandate’;

Whereas the ‘Berlin Mandate’ calls for the adoption, as soon as December 1997, in Kyoto, Japan, of a protocol or another legal instrument that strengthens commitments to limit greenhouse gas emissions by

Annex I Parties for the post-2000 period and establishes a negotiation process called the 'Ad Hoc Group on the Berlin Mandate';

Whereas the 'Berlin Mandate' specifically exempts all Developing Country Parties from any new commitments in such negotiation process for the post-2000 period;

Whereas although the Convention, approved by the United States Senate, called on all signatory parties to adopt policies and programs aimed at limiting their greenhouse gas (GHG) emissions, in July 1996 the Undersecretary of State for Global Affairs called for the first time for 'legally binding' emission limitation targets and timetables for Annex I Parties, a position reiterated by the Secretary of State in testimony before the Committee on Foreign Relations of the Senate on January 8, 1997;

Whereas greenhouse gas emissions of Developing Country Parties are rapidly increasing and are expected to surpass emissions of the United States and other OECD countries as early as 2015;

Whereas the Department of State has declared that it is critical for the Parties to the Convention to include Developing Country Parties in the next steps for global action and, therefore, has proposed that consideration of additional steps to include limitations on Developing Country Parties' greenhouse gas emissions would not begin until after a protocol or other legal instrument is adopted in Kyoto, Japan in December 1997;

Whereas the exemption for Developing Country Parties is inconsistent with the need for global action on climate change and is environmentally flawed;

Whereas the Senate strongly believes that the proposals under negotiation, because of the disparity of treatment between Annex I Parties and Developing Countries and the level of required emission reductions, could result in serious harm to the United States economy, including significant job loss, trade disadvantages, increased energy and consumer costs, or any combination thereof; and

Whereas it is desirable that a bipartisan group of Senators be appointed by the Majority and Minority Leaders of the Senate for the purpose of monitoring the status of negotiations on Global Climate Change and reporting periodically to the Senate on those negotiations: Now, therefore, be it

Resolved, That it is the sense of the Senate that —

(1) the United States should not be a signatory to any protocol to, or other agreement regarding, the United Nations Framework Convention on Climate Change of 1992, at negotiations in Kyoto in December 1997, or thereafter, which would —

(A) mandate new commitments to limit or reduce greenhouse gas emissions for the Annex I Parties, unless the protocol or other agreement also mandates new specific scheduled commitments to limit or reduce greenhouse gas emissions for Developing Country Parties within the same compliance period, or

(B) would result in serious harm to the economy of the United States; and

(C) any such protocol or other agreement which would require the advice and consent of the Senate to ratification should be accompanied by a detailed explanation of any legislation or regulatory actions that may be required to implement the protocol or other agreement and should also be accompanied by an

analysis of the detailed financial costs and other impacts on the economy of the United States which would be incurred by the implementation of the protocol or other agreement.

SEC. 2. The Secretary of the Senate shall transmit a copy of this resolution to the President.

This resolution was passed without dissent.

References

Australian Bureau of Agricultural and Research Economics (ABARE), "Energy Demand and Supply Projections Australia 1992-93 to 2004-05," Research Report 93.2, Canberra, 1993.

Brandon, C. and Ramankutty, R., "Towards a Sustainable Environmental Strategy for Asia," World Bank Discussion Paper 224, 1993.

Cross, F.B., *Could Kyoto Killl? The Mortality Costs of Climate Policies*, CEI October 1998.

Crowley, Thomas J., "Remembrance of Things Past: Greenhouse Lessons from the Geologic Record," *Consequences*, US Global Change Research Information Office, vol 2(1), 1996.

Davis, R. W. and Legates, D., *How Reliable are Climate Models?*, CEI, June 1998.

Ellsaessar, H.W., *What You Never Hear About Global Warming*, Paper prepared at the request of the Center for the Study of American Business, 1997.

Energy Information Administration, Office of Integrated Analysis and Forecasting, U.S. Department of Energy, "Impacts of the Kyoto Protocol on U.S. Energy Markets and Economic Activity", Report SR/OIAF/98-03, October 1998.

Energy Information Administration, "Emissions of Greenhouse Gases in the United States 1997," Washington D.C., Document DOE/EIA-0573(97), October 1998.

Heyhoe, E., Anderson, M., Jakeman, G., Brown, S., and Beil, S. *Emissions Trading and the Kyoto Protocol*, ABARE October 1998

Houghton, J.T., Jenkins J.G. and Ephraums J.T. (eds) *Climate Change: the IPCC Scientific Assessment*, WMO, UNEP, 1990.

Houghton, J.T., Callander, B.A., and Varney, S.K., (eds) *Climate Change 1992: The Supplementary Report to the IPCC Scientific Assessment*, WMO, UNEP, 1992.

Houghton, J. T. et al (eds) *Climate Change 1995: The Science of Climate Change*, Contribution of WGI to Second Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, 1996.

Hoyle, F., 'The Great Greenhouse Controversy' in Emsley J. (ed.), *The Global Warming Debate*, European Science and Environment Forum, March 1996, Pp 179-90.

Idso S. B., 'Plant Responses to Rising Levels of Atmospheric Carbon Dioxide' in Emsley J. (ed.), *The Global Warming Debate*, European Science and Environment Forum, March 1996, Pp 28-33.

Lieberman, B., *Doomsday Déjà Vu: Ozone Depletion's Lessons for Global Warming*, CEI, October 1998.

Lindzen, R.S., *Global Warming: The Origin and Nature of the Alleged Scientific Consensus*, Regulation, The Cato Review of Business & Government.

Michaels, P., *Long Hot Year: Latest Science Debunks Global Warming Hysteria*, Cato Policy Analysis No. 329, December 31, 1998.

Mills, M. P., "Kyoto Economics: The Costs and Follies of Eco-Energy Planning", paper presented at the Cooler Heads Coalition's Economic Lecture, Washington, July 24, 1998 available at http://www.cei.org/pubs/1998/mills%20paper2.PDF

Pearce, F., "Mythical Monster," *New Scientist*, 9, January 1999.

Priem, H. 'The Past is the Key to the Future' in Emsley J. (ed.), *The Global Warming Debate*, European Science and Environment Forum, March 1996, Pp 87-94.

Reinstein, Robert, *Emission Credits: The Supply and Demand Gap*. CEI, October 1998.

Tucker, Brian, *The Scientific Impact*, Paper to Kyoto the Impact on Australia Conference 12-13 February 1998.

Tulpulé, V., Brown, S., Lim, J., Polidano, C, Pant, H., and Fisher, B. S., *The Economic Impact of the Kyoto Protocol*, ABARE, 1998a.

Tulpulé, V., Brown, S., Lim, J., Polidano, C, Pant, H., and Fisher, B. S., *An Economic Assessment of the Kyoto Protocol using the Global Trade and Environment Model*, ABARE, 1998b.

United Nations, Department of Public Information, "Global Climate Change", Setting the Record Straight: Facts About the United Nations (http://www.un.org/News/facts/), 1999.

United Nations, "UN Releases 1998 World Population Estimates and Projections," Press Release POP/684, 27 October 1998.

WEFA, Inc. "Global Warming: The High Cost of the Kyoto Protocol: National and State Impacts," 1998.

Wigley, T., "The Kyoto Protocol: CO_2, CH_4, and Climate Implications," *Geophysical Research Letter* 25, 1998, 2715-18.

Wood Mackenzie Global Consultants, *Asia Pacific Energy Markets Service: China*, January 1999.

World Bank, *World Development Indicators*, 1998.

World Resources 1996-97, World Resources Institute, 1997.