The Winners of the Blue Planet Prize
1995

1995

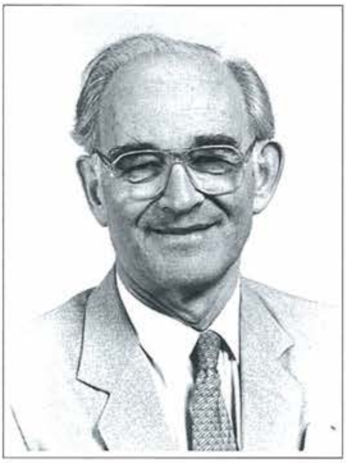
Blue Planet Prize

Dr. Bert Bolin (Sweden)

Professor Emeritus at the University of Stockholm

Maurice F. Strong (Canada)

Chairman of the Earth Council



As 1995 marked the 100th anniversary of the birth of Kenji Miyazawa, excerpts from his literary works on nature were featured in the 1995 awards ceremony slide presentation. The bountiful gifts of nature and humankind's hopes for the future were depicted in the photographs of Takeshi Hosokawa, an eminent nature photographer.

His Highness Prince Akishino congratulates the laureates.

His Highness Prince Akishino and Her Highness Princess Kiko at the congratulatory party.

The prizewinners receive their trophies and certificates of merit from Foundation Chairman Jiro Furumoto.

Dr. Syukuro Manabe, the first Blue Planet laureate, asks a question from his seat in the audience after Dr. Bolin's lecture.

Alf M. Vahlquist (left), ambassador of Sweden to Japan, and Donald W. Campbell, ambassador of Canada to Japan, congratulate the award recipients.

Dr. Bert Bolin

Professor Emeritus at the University of Stockholm

Education and Academic and Professional Activities

1946 Received B.Sc. from the University of Uppsala

1947–50 Studied under Professor C.G. Rossby and received M.Sc. from the University of Stockholm

1956 Earned doctorate degree from the University of Stockholm

1956 Became assistant director for the International Meteorological Institute (IMI) in Stockholm

1957–90 Served as director of the IMI

1961–90 Served as professor of meteorology at the University of Stockholm

1965–67 Served as scientific director of the European Space Research Organization in Paris

1967 Proposed the establishment of the Global Atmospheric Research Program (GARP) while serving as the president of the Committee of Atmospheric Sciences (CAS) of the International Council of Scientific Unions (ICSU)

1967–71 Served as the first chairman of the Joint Organizing Committee of GARP, which was jointly launched by ICSU and the World Meteorological Organization (WMO)

1974 Organized and chaired the first major planning effort for global climate research, which formed the starting point for the World Climate Research Program (WCRP), established in 1980

1979 Edited Report No. 13, entitled "Global Carbon Cycle," of the monograph series of ICSU's environmental committee (SCOPE)

1983–86 Led the ICSU-UNEP-WMO Scientific Assessment of Climate Change, which gave rise to the publication of SCOPE Report No. 29, entitled "Greenhouse Effect, Climatic Change, and Ecosystems"

1983–86 Served as a member of the Scientific Advisory Board (Forskningsberedningen) to the Swedish government

1985–91 Chaired an ICSU committee that proposed the establishment of the International Geosphere Biosphere Program (IGBP)

1986–88 Served as scientific advisor to the prime minister and deputy prime minister of Sweden

1988–97 Served as Chairman of the Intergovernmental Panel on Climatic Change (IPCC)

As professor of meteorology at the University of Stockholm and director of the International Meteorological Institute, Dr. Bolin has conducted basic research on global biogeochemical cycles, particularly the carbon cycle. Early in his career, he developed a sophisticated model of the carbon cycle that takes full account of influences of the oceans, atmosphere, and biosphere. His work is well known throughout the world and serves as a basis for today's general understanding of global warming. As head of numerous international scientific committees, Dr. Bolin has helped provide a sound scientific basis for policy decisions about global warming and greenhouse gases.

Since 1988, Dr. Bolin has chaired the Intergovernmental Panel on Climate Change (IPCC), which was established to assess the scientific body of knowledge concerning climate change which served as the basis for negotiations aimed at preventing global warming at the Earth Summit in 1992. These led to the adoption of the Framework Convention on Climate Change, which was adopted at the Earth Summit in 1992. In addition, Dr. Bolin has published more than 100 papers in his field and continues to play a major role in promoting academic research. Throughout his career, Dr. Bolin's research and leadership activities have served to shed light on the problem of global warming and to provide suggestions for its solution.

Essay

What We Know and What We Don't Know about Human-Induced Climate Change And What Should Be Done?

Dr. Bert Bolin

May 1997

Key findings

We know that:

- the global mean surface temperature has increased by 0.3–0.6°C during the 20th century, the uncertainty primarily being due to the natural variability of climate on time scales from decades to a century not being well known;
- atmospheric greenhouse gas concentrations (carbon dioxide, methane, nitrous oxide, halogenated hydrocarbons, tropospheric ozone) continue to increase, leading to an enhanced positive radiative forcing of the climate system;
- the enhanced concentrations of tropospheric aerosols primarily resulting from combustion of fossil fuels and biomass burning cause some negative forcing;
- our ability to determine the human influence on the global climate is still limited because the expected signal is only now emerging from the noise of natural variability, but the IPCC has nevertheless concluded that "the balance of evidence suggests that there is now a discernible human influence on climate;"
- the sensitivity of the climate system to greenhouse gas forcing is not yet well known; the earlier assessment—that an equilibrium warming of 1.5–4.5°C for a doubling of carbon dioxide concentrations in the atmosphere (or an equivalent increase of a mixture of greenhouse gases)—remains.

(See: IPCC Second Assessment Report, 1995; IPCC Synthesis Report: An Assessment of Scientific and Technical Information Relevant to Interpreting Article 2 of the UN Framework Convention on Climate Change; and Policy Makers of Working Groups I, II and III. WMO, Geneva)

Simple climate models, calibrated against complex models, can be used to assess the expected global temperature change due to the enhanced concentrations of greenhouse gases that have occurred so far, and in doing so the inertia of the climate system can also be recognized. Accepting the observed increases of greenhouse gas concentrations, the enhanced radiative forcing so far is about 2.7 Wm^{-2}, the central value for the negative aerosol forcing is assumed to be $-1.1\ Wm^{-2}$ as given by the IPCC, and spanning the full range of uncertainty of the climate sensitivity, this yields an expected increase of the global surface mean temperature of 0.3°–0.7°C. (cf. IPCC Technical Paper No. 3. Stabilization of Atmospheric Gases: Physical, Biological and Socio-Economic Implications. WMO, Geneva (TP 3)). Considering also the uncertainty of the negative aerosol forcing this range becomes about 0.1°—0.9°C, where the lower bound results from the combination of low sensitivity of the climate system to human forcing and a large influence of aerosols, while the upper bound corresponds to high climate system sensitivity and small forcing due to aerosols. In light of the observed changes so far, none of these extreme values seem likely, but neither can any be excluded because of the uncertainty of the computations.

It is appropriate in this context to recall the conclusion drawn already in the IPCC First Assessment Report that "...the observed increase of global mean temperature could largely be due to natural variability; alternatively this variability and other human factors could have offset a still larger human induced warming." As a matter of fact using (a) the central values for the sensitivity of the climate system to radiative disturbances, and (b) the radiative forcing due to enhanced greenhouse gas and aerosol concentrations, brings the calculated and observed changes of the global mean surface temperature into reasonable agreement. This must not, however, be viewed as proof of the human influence on global climate but it represents supporting evidence that this might indeed be the case.

Although we now have evidence for human-induced change to the global climate, we cannot yet tell how the occurrence of extreme events, such as storms, floods, and droughts, might change. This implies also that it is not yet possible to describe the impacts of climate change either globally or for individual countries, even though we can predict generally that floods as well as droughts might become more frequent. An increase of temperature by 2°C would have a marked influence on the forests—as much as 30% might no longer be well adjusted to the surrounded abiotic conditions. Finally, the sea level would rise by 15–95 cm if no mitigation were undertaken, but this would not be the same all around the world.

Stabilizing Greenhouse Gas Concentrations

The UN Framework Convention on Climate Change (FCCC) considers a stabilization of greenhouse gas concentrations and thereby also a stabilization of climate as the prime objective, but sets no specific level as a goal. Actually, such a level can hardly be determined accurately until better estimates of the likely damage due to changes of climate become available, which cannot be expected in the near future. Justifications for mitigation efforts must therefore be based largely on qualitative judgments. It is not surprising that the views on what should be done differ.

In view of this situation the IPCC has asked the question: What emissions scenarios for carbon dioxide are "permissible" in order not to exceed a set of alternative concentration levels? Those chosen are 450, 550, 650, 750, and 1000 ppmv, which should be compared with the preindustrial concentration of about 280 ppmv and present concentrations of about 360 ppmv. Alternative stabilization paths and the resulting emissions profiles are shown in Figures 1 and 2.

According to the FCCC, it is, however, important not to restrict analysis to the role of carbon dioxide; rather, all greenhouse gases should be considered. IPCC Technical Paper III also included considerations of methane, nitrous oxide and sulfur dioxide (which is transformed into sulfate aerosols). Table 1 shows the radiative forcing of the climate system in

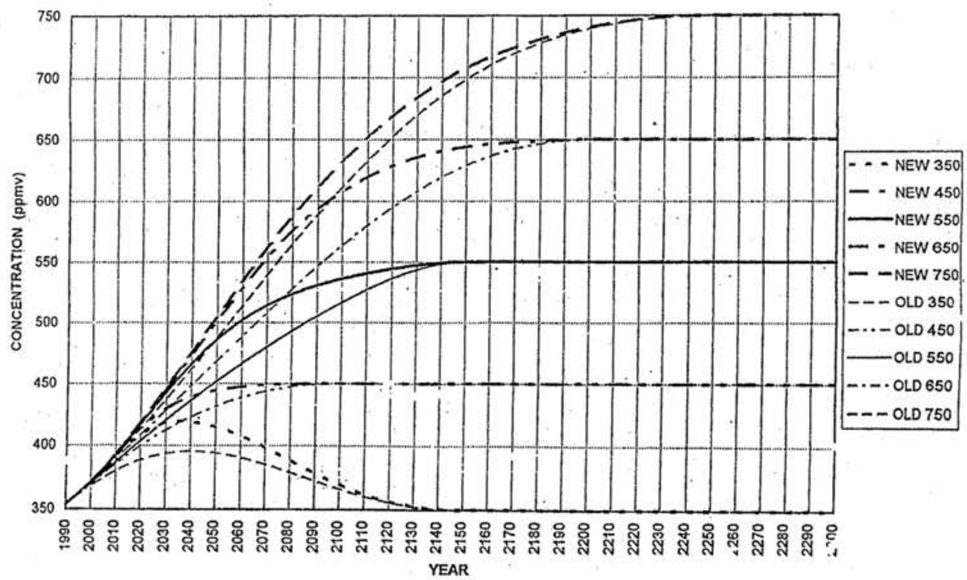


Figure 1. Alternative concentrations scenarios for stabilization of atmospheric carbon dioxide at 350, 450, 550, 650, and 750 ppmv. The "old" scenarios imply an immediate change of the energy supply infrastructure. The "new" scenarios, on the other hand, follow the IPCC Scenario IS92a ("Business as Usual") during one or a few decades in order to permit the change over of the energy supply infrastructure into one that can satisfy the restrictions that are required in order to reach the prescribed stabilization levels.

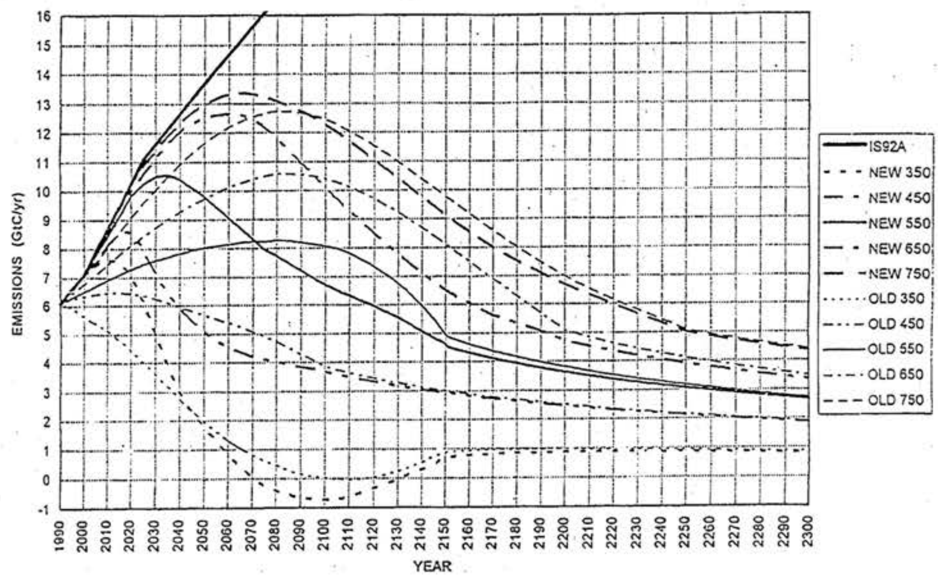


Figure 2. Emissions scenarios for stabilization of atmospheric carbon dioxide concentrations in accordance with the scenarios as given in Figure 1.

Table 1. Radiative forcing and temperature changes at the time of stabilization for alternative levels of stabilization. It has been assumed that methane,. nitrous oxide and sulfur dioxide will be emitted in according to the IPCC Scenario IS92a until 2100 and thereafter to remain constant. (See further Table 3 in TP 3.)

Level of stabilization (ppmv)	Radiative forcing (Wm^{-2})	Temp change lower bound (°C)	Temp change central value (°C)	Temp change upper bound (°C)
450	3.59	1.2	2.1	3.6
550	5.04	1.7	2.9	5.2
650	6.16	2.1	3.5	6.4
750	7.10	2.5	4.1	7.4

2100 for the different stabilization levels with the further assumption that the emissions of methane, nitrous oxide and sulfur dioxide increase in accordance with the IPCC Scenario IS92a ("Business as Usual") until 2100 and remain constant thereafter. The changes to the radiative forcing of the climate system due to these human emissions and aerosols so far are 2.3 Wm^{-2} and -1.1 Wm^{-2}, respectively. The emissions of sulfur dioxide presumably will decrease in the process of stabilization, because about 90% of present emissions occur when burning fossil fuels, an activity that will decline when stabilization is being approached. The computed temperature changes may therefore be underestimates. It should also be noted that the temperature changes as given in Table 1 refer to the time at stabilization, which for higher levels may be far into the 22nd century.

It should be noted that the European Union has agreed that a future change of the global mean surface temperature due to human emissions should not exceed 2°C. In order to keep the risk of this happening reasonably low, carbon dioxide concentrations should not exceed about 450 ppmv, which is really quite a difficult task to achieve. It remains to be seen what the negotiations, which are under way in preparation for the third Conference of the Parties to the Convention in Kyoto in December 1997, will lead to.

Some comments are also warranted with regard to the issue of the timing of mitigation efforts and the relative importance of future measures taken by developed and developing countries to stabilize carbon dioxide concentrations in the atmosphere. The upper curve in Figure 3 shows total carbon dioxide emissions for the central IPCC Scenario IS92a, and the similarly rising curve below gives the part of the emissions due to developing countries. The areas below these respective curves are proportional to the cumulative emissions and therefore the area *between* them shows the cumulative emissions caused by developed countries.

Assuming that only developed countries stabilize or reduce their emissions, the top curve would be lowered as indicated in the figure. Three cases are shown that embrace *all* proposals for mitigation efforts so far made by countries for consideration in the ongoing negotiations:

1. Developed countries keep their emissions constant
2. Developed countries reduce emissions annually by 1%
3. Developed countries reduce emissions annually by 2%

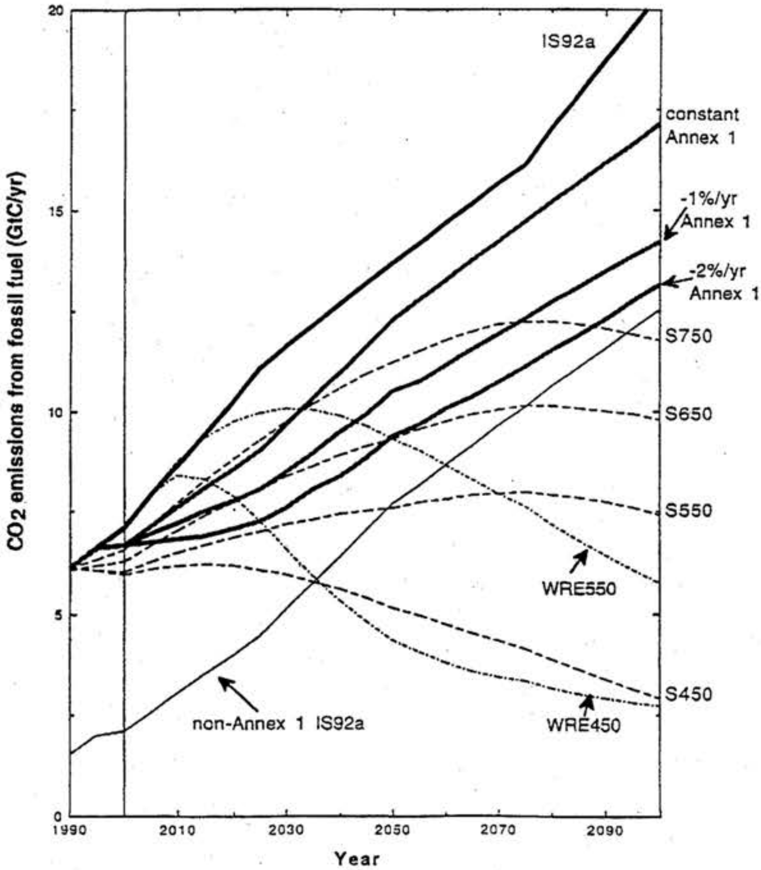


Figure 3. The IPCC Scenario IS92a for total emissions (upper bold line) and emissions from non-Annex 1 countries, i.e. developing countries (the similarly rising curve, thin line). The areas below these two curves are proportional to the cumulative emissions, and therefore the area between them shows the cumulative emissions by developed countries (Annex 1 countries). The three additional bold lines show the total emissions if the developed countries (a) stabilize their emissions at the 1990 level, (b) reduce them annually by 1%, and (c) by 2% during the next century. The emissions required to reach stabilization at 450 and 550 ppmv (in accordance with Figure 2) are also shown (dashed or dash-dotted lines).

It is obvious from this graph that no reasonable future reductions by developed countries would stabilize either global emissions or, hence, the global mean surface temperature. Several questions arise: How soon is it possible to reach agreements with developing countries that they reduce their rate of increasing emissions? When will they be able to rely instead on non-carbon-emitting energy sources and thus able to reduce their emissions? How can developed countries assist in this effort?

A simple carbon dioxide model can be employed to deduce the atmospheric carbon dioxide concentrations for the cases of stabilizing or reducing developed country emissions as illustrated in Figure 3. Slightly lower concentrations are obtained than those deduced from the IS92a scenario. The cumulative total emissions due to fossil fuel burning during the 25 years 1995–2020 according to IS92a are projected to be about 210 Gt, an amount that would be reduced by about 21, 29 and 36 Gt in the three cases referred to above. This is of course in itself important as the beginning of a long-term effort. It is, however, clear that the reduction of the rate of increase of atmospheric carbon dioxide concentrations during this period, 5–9 ppmv, is small compared with the projected increase according to the IS92a scenario, i.e. 50–55 ppmv. The induced increase of the global mean temperature during these 25 years due to emissions, according to the IS92a scenario, would actually in any one of the cases shown be reduced by less than 0.1°C, which would not be detectable.

The results described above are a consequence of the inertia of the climate system. They also show why it is important to analyze extended emissions profiles in order to understand the implications of different actions. Agreed actions would, however, presumably within only a few years be replaced by new agreements in the light of improved knowledge about the climate issue. In any case, collaboration among all countries will be required to stabilize and then gradually reduce total emissions. How quickly this can be achieved is a matter of political judgment which implies weighing risks against costs.

It is of interest to insert into the figure the emission profiles required for stabilization of atmospheric carbon dioxide concentrations at different levels. Alternative pathways towards stabilization can be chosen (two are shown, i.e. stabilization at 450, and 550 ppmv). It is interesting to note the stage, according to IS92a, when the emissions from developed countries begin to exceed the total emissions, that lead to stabilization at 450 ppmv, is reached rather early during next century. On the other hand, higher stabilization levels than 550 ppmv hardly require early actions.

The range of projected changes of the global mean surface temperature is large, particularly because of the uncertainty of the sensitivity of the climate system to changing greenhouse gas concentrations. The issues of how much and when to mitigate a climate change therefore need to be considered in terms of weighing the risks for a possible change of climate against the costs for mitigation. This remains difficult, particularly because of the difficulty of determining how serious a climate change might be.

Policies and Measures to Stabilize Greenhouse Gas Concentrations

The IPCC has prepared an extensive summary of available technologies, policies and measures for mitigating climate change (IPCC Technical Paper I. Technologies, Policies and Measures for Mitigating Climate Change. WMO, Geneva.) It provides an overview and analysis of technologies and measures to limit and reduce greenhouse gas emissions and to enhance greenhouse gas sinks under the FCCC. The paper focuses on technologies and measures for the countries listed in Annex I of the FCCC (industrialized countries), while noting information as appropriate for the use by Non-Annex I countries (developing countries). They are examined over three time periods, with a focus on the short term (present to 2010) and the medium term (2010–2030), but also including discussions on long-term (e.g. 2050) possibilities and opportunities.

The Technical Paper includes discussions of technologies and measures that can be adopted in three end-use sectors (commercial, residential, and institutional buildings; transportation; and industry); in the energy supply sector; and in the agriculture, forestry, and waste management sectors. Broader measures affecting national economies are discussed in a final section on economic instruments.

It is important to recognize the differences between technical, economic and market potentials for mitigation, defined as follows.

- Technical potential
  The amount by which it is possible to reduce greenhouse gas emissions or improve energy efficiency by using technology or practice in all applications in which it could technically be adopted, without considering its costs or practical feasibility.
- Economic potential
  The portion of the technical potential for greenhouse gas emissions reductions or energy efficiency improvements that could be achieved cost-effectively in the absence of market barriers. The achievement of the economic potential requires additional policies and measures to break down market barriers.
- Market potential
  The portion of the economic potential for greenhouse gas emission reductions or energy efficiency improvements that currently can be achieved under existing market conditions, assuming no new policies and measures.

Such distinctions have not always been made, which has led to unrealistic claims with regard to the possibility of quickly achieving substantial reductions of emissions. On the other hand IPCC Technical Paper No. 1 (TP 1) clearly shows that there are many possibilities to do gradually what may be required and, to begin with, at modest costs. Analyses are needed to clarify the situation for individual countries, since the opportunities vary considerably. Examples from TP 1 will illustrate some of the possibilities and opportunities that exist, but close analyses by countries are recommended, if this has not already been done.

Examples

Residential, commercial, and institutional buildings sector

Technical development is under way in many countries. It is today possible to construct houses that in temperate climates (e.g. in Germany) use exclusively solar energy, photovoltaics and direct solar heating. This includes the use of, for example, specially designed walls and windows, energy storage through the use of batteries (short-term storage) and hydrogen (seasonal storage), and the employment of heat exchange systems for ventilation. The technical feasibility has been proven, but costs are as yet excessive. The potential for the future is large.

A lot of specific equipment (e.g. household appliances) that reduce the need for energy are, however, available already today in many cases at competitive costs. The major administrative, institutional, and political issues in implementing market-based programs for residential and commercial building equipment are:

- Difficulties in improving integrated systems
- The need for, and shortage of, skilled persons capable of diagnosing and rectifying systems problems
- The fact that energy users are often not those responsible for paying energy bills, creating

a barrier to increased efficiency

- The need to structure incentives so that intervention in buildings aims at achieving all cost-effective energy efficiency measures
- The need to create institutional structures for market-based programs to work effectively
- Perception (or reality) of cross substitutes and related unfairness of expenditures.

Transport Sector

About 20% of today's emissions of carbon dioxide comes from the transport sector, and its relative contribution is expected to increase in the future, particularly from aviation. It may double within 25 years and triple by the middle of next century.

It is technically feasible to reduce the gasoline consumption substantially already today. Rapid changes are difficult to achieve because of the infrastructure that has developed during the 20th century. There are, however, several social and environmental costs associated with road transport at local, regional, and global levels that can be addressed simultaneously. Market instruments such as road-use charges can be used to reflect many of these costs, especially those at the local and regional levels. These instruments can also contribute to greenhouse gas mitigation by reducing traffic. Fuel taxes are an economically efficient means of greenhouse gas mitigation, but may be less efficient for addressing local objectives.

Changes in urban and transport infrastructure, to reduce the need for motorized transport and shift demand to less energy-intensive transport modes, may be the most important elements of a long-term strategy for greenhouse gas mitigation in the transport sector.

Industrial Sector

During the past two decades, the industrial sector fossil fuel carbon dioxide emissions of most developed countries have declined or remained constant as their economies have grown. Still, the present emissions from this sector contribute almost 50% of the total emissions, of which the industrialized countries are responsible for about three quarters. It is estimated that these countries could still lower their industrial sector emissions by 25 % relative to 1990 levels, by simply replacing existing facilities and processes with the most advanced technological options currently available (assuming a constant structure for the industrial sector). If such upgrading occurred at the time of normal capital stock turnover it would in most cases be cost-effective.

Energy Supply Sector

Energy consumed in 1990 resulted in the release of 6 Gt C (in 1995 6.3 Gt C). About 72% of this energy was delivered to end users, accounting for 3.7 Gt C, the remaining was used in energy conversion and distribution. It is technically possible to realize deep emissions reductions in the energy supply sector in step with the normal timing of investments to replace infrastructure and equipment as it wears out or becomes obsolete.

The efficiency of electricity production can be increased from the present world average of about 30% to more than 60% sometime between 2020 and 2050. Presently the best available coal and natural gas plants have efficiencies of about 45% and 52%, respectively.

While the costs associated with these efficiencies will be influenced by numerous factors, there are advanced technologies that are cost-effective, comparable with some existing plant and equipment. The combination of electricity generation with the utilization of the waste heat for local (or regional) supply of heat for the residential/commercial/institutional sector provide many opportunities for saving energy, particularly in temperate and cold climates.

Historically, the energy intensity of the world economy has improved, on average, by 1% per year, largely due to technology performance improvements that accompany the natural replacement of depreciated capital stock. Improvements beyond this rate are unlikely to occur in the absence of specific measures.

Agricultural Sector

Agriculture accounts for about 20% of the anthropogenic greenhouse effect, primarily due to the emissions of methane and nitrous oxide, but only about 5% of the anthropogenic carbon dioxide emissions come from agriculture. Considerable reductions of greenhouse gas emissions from the agricultural sector can be accomplished, primarily from offsets by biofuel production on land currently under cultivation. Reduction of anthropogenic methane production is primarily an issue for developing countries. It is still relatively small and is increasing only slowly. The need for systems analyses by country for determination of possible reductions of greenhouse gas emissions from the agricultural sector is apparent.

Forestry Sector

High- and mid-latitude forests are currently estimated to be a net carbon sink of about 0.7 ±0.2 Gt C/year. Low-latitude forests, on the other hand are estimated to be a net source of 1.6 ±0.4 Gt C/year, caused mostly by clearing and degradation of forests. These sources and sinks may be compared with the carbon release from fossil fuel combustion, estimated to have been 6 Gt C/year in 1990. It is to be noted, however, that emissions due to fossil fuel burning represent injection of carbon that has been buried in the ground for millions of years, while increases and decreases of carbon in forests should be viewed as redistributions of carbon between terrestrial reservoirs, which will necessarily remain rather limited in a long-term perspective, because of the comparatively limited amounts that they contain. Still, it is obviously important to halt deforestation. Governments in a few developing countries, such as Brazil and India, have instituted measures to achieve this.

Wood residues are used regularly to generate steam and/or electricity in most paper mills and rubber plantations, and in specific instances for utility electricity generation.

Solid Waste and Wastewater Disposal

An estimated 50–80 Mt CH_4 was emitted by solid waste disposal facilities and waste water treatment facilities in 1990. Although there are large uncertainties in such emissions estimates for a variety of reasons, overall emissions levels are projected to grow significantly in the future.

Technical options to reduce CH_4 emissions are available and, in many cases, may be profitably implemented by paper recycling, composting, and incineration and also through

CH_4 recovery from landfills and waste water, which in turn may be used as an energy source. This might be cost-competitive with other energy alternatives.

These few examples from different sectors of society should only be viewed as examples, since there are major differences between countries, the analysis of which requires special efforts.

Concluding remarks

Neither the climate system nor the world socio-economic system will be changing rapidly because of their great inertia. The oceans are the prime factor that slows down the response of the climate system, while the reluctant response by people—not the least in the political system—as well as the slow turnover of capital invested in the major infrastructures of a modern society, imply that mitigation will come about neither easily nor rapidly. Both these factors should be considered seriously when setting new goals for the FCCC to be realized in the 21st century.

Lecture

Biogeochemical Cycles and Climate Change

Dr. Bert Bolin

It is a great joy for me to be here and give this lecture on the very memorable occasion of having received the Blue Planet Prize of 1995. I will, however, change slightly what I originally thought I would present to you. Facts will not change, nor knowledge as presented. They are basic ingredients of my talk. But it is so important for science to express its findings in terms that are useful to society and therefore helpful for possible action. Having listened to Mr. Strong for a couple of hours, I find it even more important to see how we should best present the scientific issues to serve properly in this regard. It cannot be overemphasized that science has this responsibility and maybe does not always fulfill it adequately. Much of what we as scientists are saying is not easily understood. I hope indeed that I will be understood.

The world has existed for a long, long time—thousands of millions of years. What we see around us today has gradually evolved during this period, and we, as human beings, are part of it and we indeed wish, of course, to remain as part of it. We must therefore not do things that jeopardize our own existence—for example, change our environment excessively.

Life is dependent upon the availability of a rather few basic elements that were present already when the Earth was created. It is not surprising that the most important element is carbon. All organic matter is built around the carbon atom. But a number of other constituents are also important, e.g., nitrogen, phosphorus, and sulfur. We sometimes, however, consider them as pollution in the environment. They may appear as pollution because of their enhanced concentrations that are the result of the increasing number of people on Earth whereby more of these nutrients are being brought into circulation. Sustainable development for us as human beings means that we accept the requirement not to change the environment unduly and to respect the living part of our environment, the biosphere.

Satellites have given us a bird's-eye view of the Earth. Figure 1 is based on measurements from space and shows photosynthetic activity on Earth. The colors range from brown, which implies no photosynthesis, to green to white to purple, which show areas with maximum photosynthesis. Figure 1 displays conditions during August and February, i.e., during summer and winter as they alternate between the two hemispheres. During summer in the Northern Hemisphere, life is at full swing up to high latitudes but is slowed down in the Southern Hemisphere. On the other hand, in the Northern Hemisphere during winter the situation is reversed. The Sahara, as might be expected, is constantly characterized by very little plant growth. In contrast, the rain forests in the tropics show very high rates the year round; there, life is abundant.

These realities of today must not change too much in the future. They are indeed basic for life on Earth. Photosynthesis provides the energy we need and energy is required for a sustainable future for the human race and its society. We also know a lot about life on Earth in the past because the circulation of the fundamental elements of life has varied and these changes can be seen in remnants of life as found in lake and sea sediments, in the soils, and in ice as preserved in the major ice sheets. From these findings we can also deduce past climatic conditions because there is such a close relationship between climate and life.

Figure 2 shows what can be deduced from ice cores that have been extracted down to a depth of several kilometers from both the Greenland and Antarctic ice sheets. Measurements of the abundance of the oxygen isotope ^{18}O tell us about temperature variations during the past 220,000 years. The last ice age shows up very clearly with temperatures more than 10 degrees below present temperatures. The last interglacial epoch, about 120,000 years ago, was somewhat warmer even than the present one, which by now has lasted for about 10,000 years. The human civilization has developed during this geologically short period of time.

Methane in the atmosphere has also varied markedly (see Figure 2). We know this from

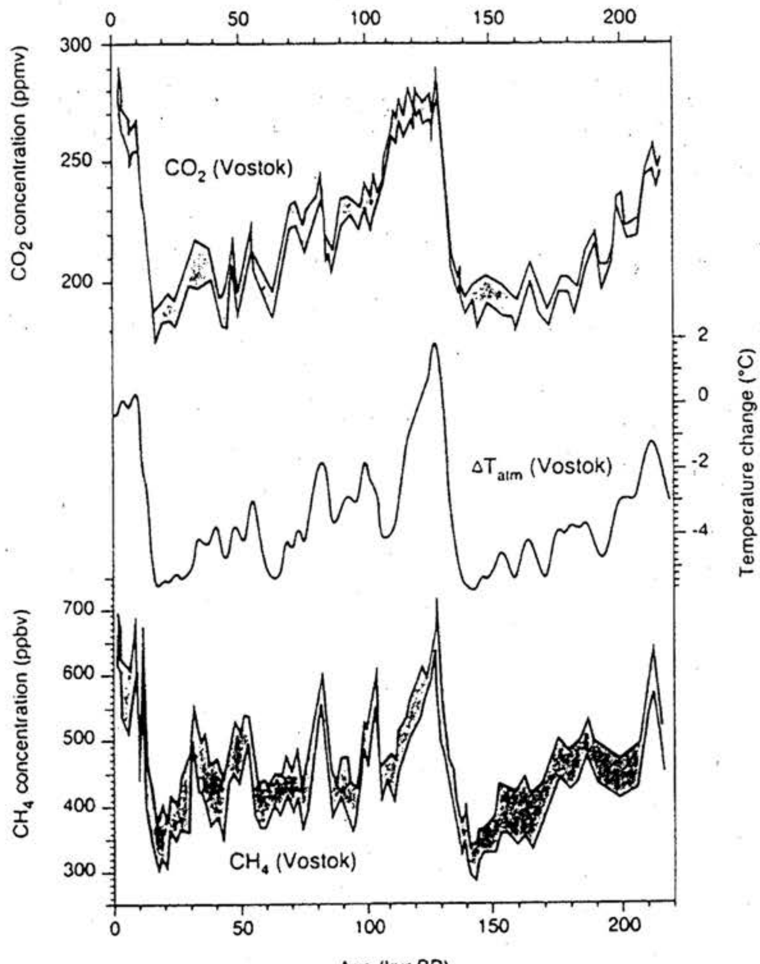


Figure 2. Variations of temperature, carbon dioxide, and methane during the past 220,000 years as deduced from analyses of glacier ice and air bubbles enclosed in the ice from an ice core record at Vostok in Antarctica (IPCC Special Report, 1994).

analyses of air buried in the form of small bubbles in the ice from Greenland and Antarctica. Records from approximately the past 220,000 years are available. The preindustrial concentration was about 0.7 ppmv (parts per million) and also about the same during the previous interglacial epoch. During the glacial period, on the other hand, it dropped to about half that. Methane is produced during the decomposition of organic matter and is therefore also an expression for the intensity of life on Earth. Apparently life was less active during glacial times, which is not surprising. The ice cores now also provide for a quantitative measure. Methane concentrations are at present about 1.7 ppmv, i.e., more than twice the undisturbed interglacial concentrations. This enhanced concentration is brought about by the expansion of rice cultivation and increasing numbers of cattle to provide food for humankind, but it is also due to leakage when exploiting coal, oil, and natural gas as sources of energy.

Carbon dioxide in the atmosphere shows similar major variations during the last glacial and interglacial epochs. It dropped to about 200 ppmv during the long glacial period as compared with about 280 ppmv before industrialization began early last century. A close interrelation between atmospheric concentrations of carbon dioxide and methane on the one hand and life on the other is obvious.

Figure 3 shows the steady increase of carbon dioxide, from 280 ppmv about 200 years ago to about 360 ppmv at present—an increase of almost 30%. About 80% of this increase is owing to manmade emissions of carbon dioxide by burning fossil fuels and about 20% owing

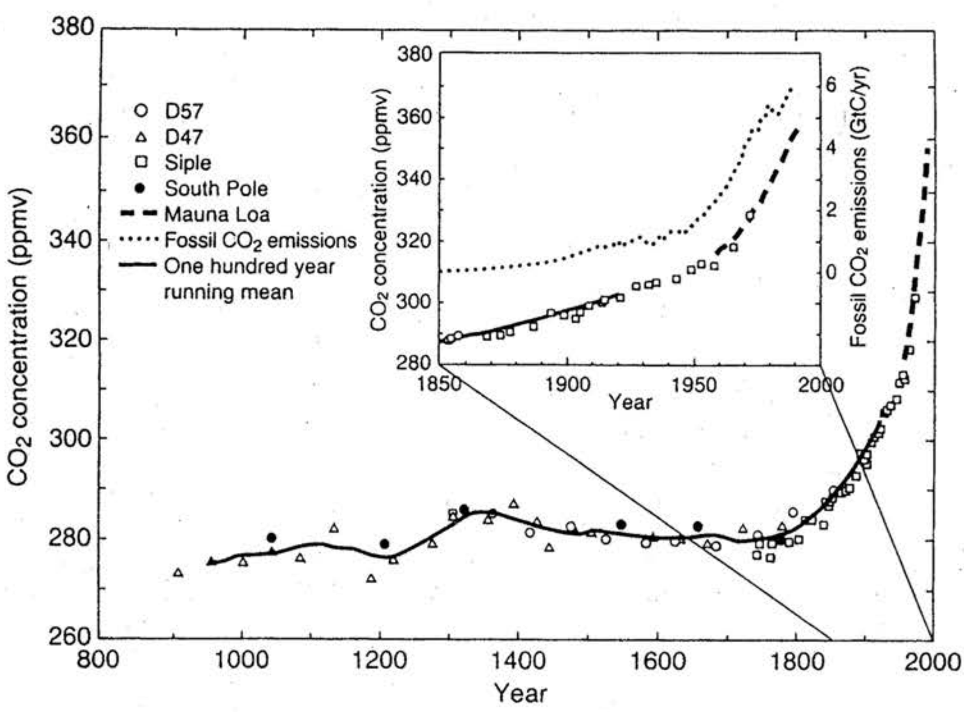


Figure 3. Carbon dioxide in the atmosphere, 900–1958, deduced from analyses of the composition of air in bubbles from glacier ice and since 1957 from direct measurements in the atmosphere. D57, D47, Siple, and South Pole show data from four different ice cores in Antarctica. Inserted, annual emissions of carbon in the form of carbon dioxide are also given (IPCC Special Report, 1994).

to deforestation and changing land use. Thus, there is less carbon in living plants on Earth and in cultivated soils today than a few hundred years ago. We think it is profitable to plow our fields, but we decrease their content of organic matter, which may not be sustainable from a long-term perspective.

Another graph, Figure 4, shows the changes of nitrous oxide. Its presence in the atmosphere is also related to decomposition processes. Figure 4 shows changes during approximately the past 2,000 years, also derived from analyses of air bubbles in ice from Greenland and Antarctica. A marked increase during the past few hundred years can be seen. We can thus see in the measurements from Antarctica the effects of 1,500 million cows and other animals kept for husbandry, primarily in the Northern Hemisphere.

As a matter of fact, we are today changing the composition of the atmosphere in many ways. We therefore urgently need to understand what is at stake and which parts of the biosphere take part in this process. We need to understand how the biogeochemical cycles function and how they interact in the processes of photosynthesis and plant growth. The key is of course the carbon cycle, but its interactions with and dependence on the cycles of the other elements must not be forgotten. They are indeed also part of the story.

We find carbon in the atmosphere, in living plants on land, as dead organic matter in the soils, in the oceans (both dissolved as inorganic carbon and as plants and animals, as well as dissolved organic carbon), and as deposits in the sediments at the bottom of the oceans (see Figure 5). There is about 50 times more carbon in the ocean's waters than there is in the air as carbon dioxide. Carbon dioxide stays on average about four years in the atmosphere before it

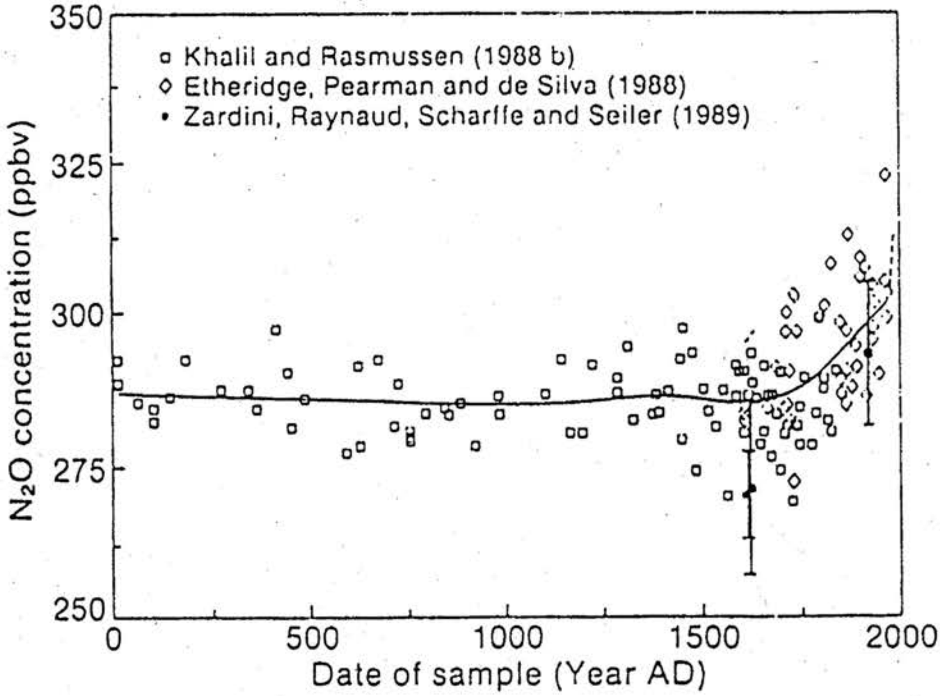


Figure 4. Nitrous oxide concentrations in the atmosphere measured in samples from ice cores (IPCC, 1990).

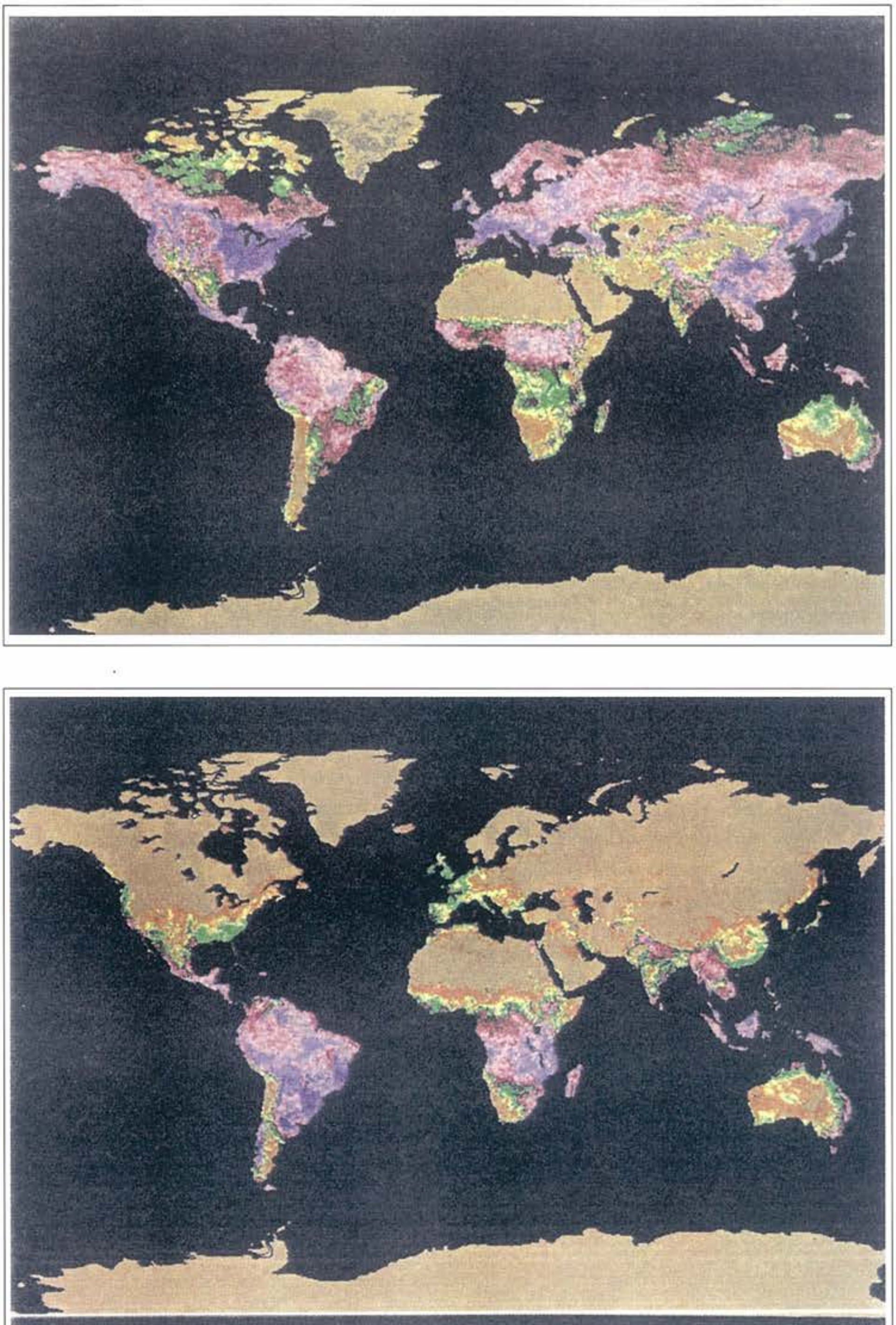
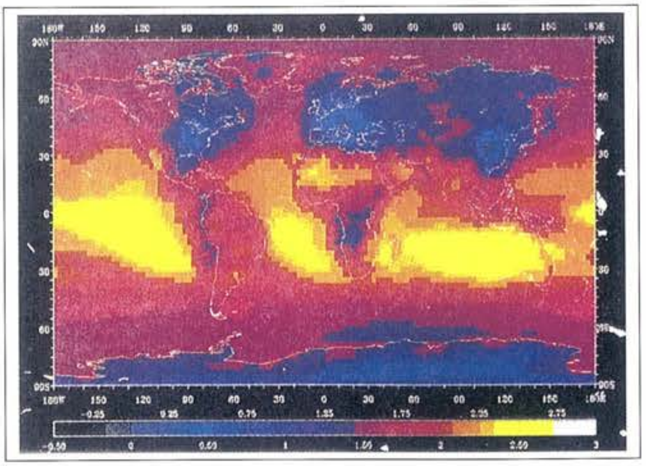


Figure 1. Rate of photosynthesis as deduced from satellite measurements (AVHRR) for August 1982 and February 1983 (Tucker et al., 1986).

Figure 7. Global distribution of radiative forcing (Wm^{-2}), including the effects of enhanced concentrations of both greenhouse gases and aerosols (Kiehl and Briegleb, 1993).



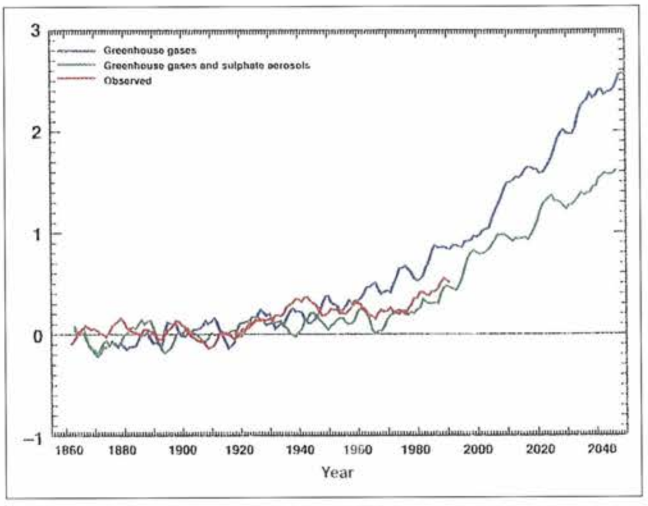


Figure 8. Observed changes of the global mean surface temperature, 1860–1994 (red curve), and model computations of expected changes, 1860–2050, based on likely changes of atmospheric composition in the past (until 1994) and projections of future changes estimated by IPCC until 2050, Scenario IS92a (no mitigation of a possible climate change). Temperature projections have been computed based on radiative forcing due only to enhanced greenhouse gas concentrations (blue curve) and also if including the effects of aerosol emissions (green curve) (Hadley Centre, 1995).

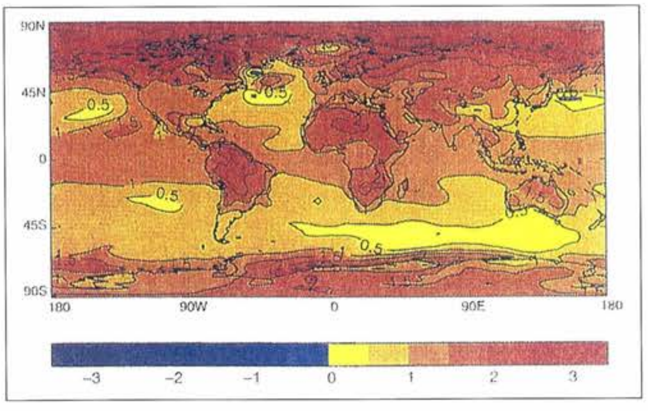


Figure 9. Changes of surface temperature between the average conditions computed for the 20-year periods 2030–2050 and 1970–1990 in the projections, including the effects of aerosols as shown in Figure 8 (Hadley Centre, 1995).

either enters the oceans or is assimilated by plants on land. In a natural equilibrium, about the same amounts are returned to the atmosphere and a balance is maintained. Because of its size and the fact that the sea is not well mixed, carbon stays in the oceans for centuries to millennia. Human emissions of carbon dioxide into the atmosphere are now disturbing this natural balance because we are burning carbon that was accumulated in the Earth's crust during hundreds of millions of years and is now being extracted. It is being and possibly will be released in increasing amounts in a matter of perhaps a few centuries. This represents a major disturbance of the carbon cycle. What will it mean in a longer perspective?

It is well known that many plants grow better if the atmospheric carbon dioxide concentration is enhanced, but only if there are enough water and nutrients. It is therefore reasonable to expect that the global rate of photosynthesis will increase, but it is difficult to tell by how much. The rate of decomposition may, however, also change in response to an increased rate of primary production and higher temperature. The total enhancement of the carbon reservoirs in the form of plants and dead organic matter in the soil is also limited. Eventually, most of the carbon dioxide from burning fossil fuels will therefore end up in the oceans. We will thus also gradually change the composition of the sea. We will increase its acidity because the dissolution of carbon dioxide means the formation of carbonic acid. This is, however, a slow

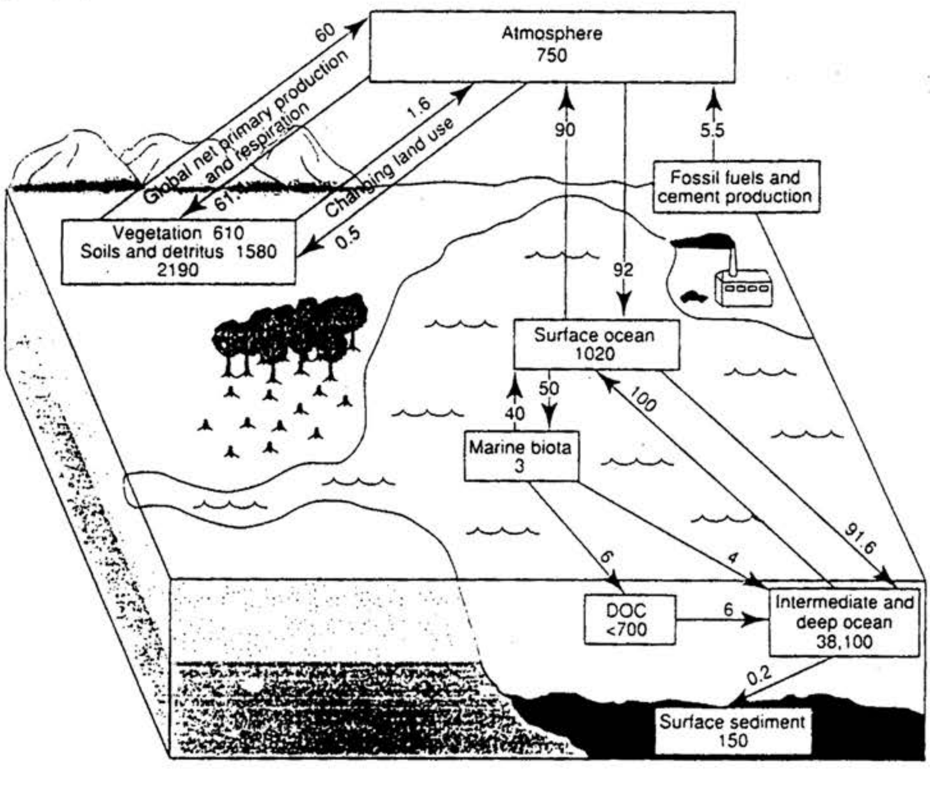


Figure 5. The carbon cycle. The numbers in the boxes indicate the size in GtC (billion tons of carbon) of each reservoir. On each arrow is indicated the magnitude of flux between the reservoirs in GtC/year; DOC=dissolved organic carbon (IPCC Special Report, 1994).

process and has as yet hardly influenced the oceans at all. If the accumulated emissions are ultimately many times more than what has been emitted so far, the pH of sea water might decrease by possibly as much as half a unit. In the long term, the natural equilibrium between ocean water and the sediments as well as the carbonate structures of marine plants and animals might also be disturbed. This all goes to show that life on Earth as we know it has been built on the availability of the basic elements in approximately the proportions as we now know them. But let us not forget that life is "clever." If some basic nutrients are lacking, the biochemical processes of plants and animals may be able to accumulate them in order to provide for what is required to create the molecules that are needed.

Let us return to what man has been doing in the recent past and what may happen over the decades and centuries to come. Is it likely that we may reach a level of carbon dioxide concentration in the atmosphere which might be destructive for the present ecosystems on Earth and therefore ultimately also for humankind? The increase so far has been about 30%. We know, however, that plenty of coal, oil, and natural gas is available in the Earth's crust. The amount in the atmosphere could be tripled or quadrupled. This would, of course, require a lot more industrial activity on Earth, but rapid economic growth is under way in, for example, East

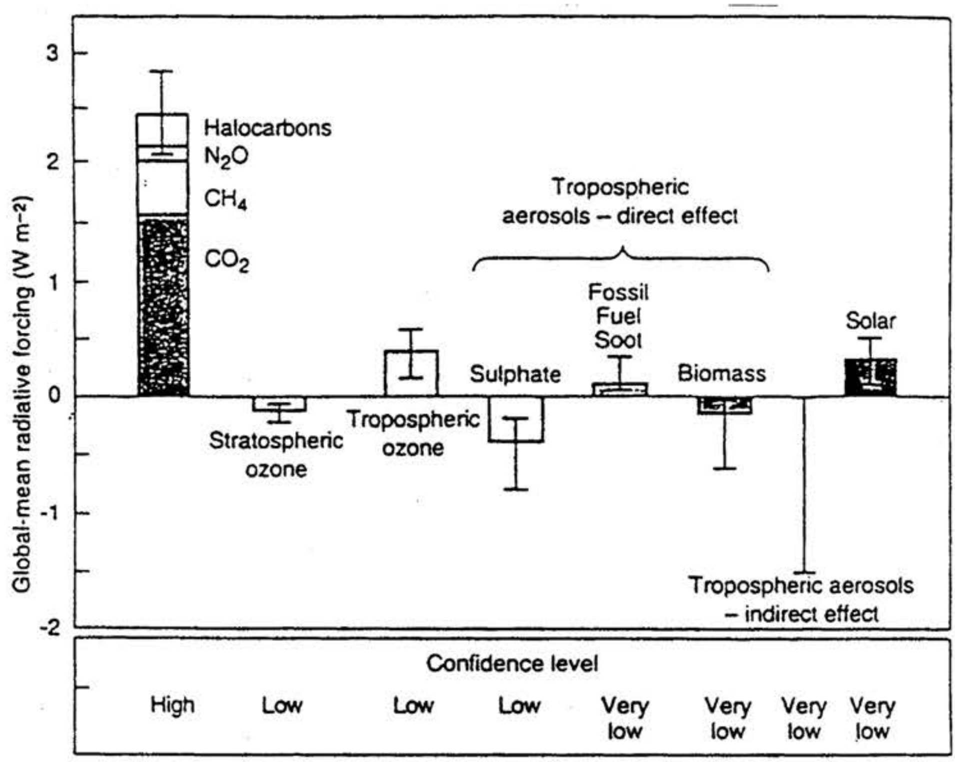


Figure 6. Percent of radiative forcing (in Wm^{-2}) of the atmosphere due to changes in the composition of the atmosphere because of human emissions, 1850–1990. The uncertainties of the different estimates are also given. It should be noted that the estimates of the forcing due to enhanced concentrations of tropospheric aerosols (not including sulfate aerosols) range between 0 and 1.5 Wm^{-2}. For comparison, variations of solar forcing are also given (IPCC Working Group I, 1996).

and Southeast Asia. It is only because of the lull in the expansion of industrial activities in former Soviet Union and Eastern European countries, in turn owing to a process of major economic restructuring, that the global emissions are temporarily not increasing at present.

Carbon dioxide, methane, and nitrous oxide, as well as some other gases that humankind is emitting into the atmosphere, are so-called greenhouse gases, which change the radioactive balance of the Earth with space. Figure 6 shows that this change is equivalent at present to an additional radiative forcing of the Earth's system by about 2.5 Wm^{-2}. This is just about 1% of the total solar forcing, but, on the other hand, about 100 times larger than the present rate of energy use by humankind. It means that the atmosphere in equilibrium might become or may already have become somewhat warmer than it was during the undisturbed conditions that preceded the industrial revolution.

Other things, however, have happened simultaneously. The increasing concentrations of halocarbons in the atmosphere reduce the amount of ozone in the stratosphere, which in turn tends to cool the Earth's surface. Humankind also emits particulate matter. When we burn oil and coal, the sulfur in these fuels is also burned and sulfate aerosols are formed. Similarly, biomass burning in the tropics causes emissions of large amounts of particles. They settle to the Earth's surface or are washed out by precipitation within a week or two, but the emissions are being maintained constantly and therefore so also is an enhanced atmospheric concentration. These aerosols tend to scatter the sun's rays and in this way counteract the greenhouse gas warming. It has been estimated that the warming due to the greenhouse gases being emitted by humans and reinforced by an expected enhancement of the amounts of water vapor in the atmosphere may be reduced by 20–40% by the scattering of solar radiation that the aerosols bring about (see Figure 6). It is important to emphasize, however, that the aerosols are not as evenly distributed over the Earth as are the greenhouse gases and their scattering is therefore not a simple offset of the global mean warming due to enhanced concentrations of greenhouse gases.

There is an additional complication. Soot is also emitted by burning organic matter. Soot is elemental carbon, which absorbs solar radiation very effectively. The present view is, however, that the amounts of soot are insufficient to play a significant role in the radiative balance of the Earth, but measurements are still too few to permit a firm conclusion.

An assessment of the radiative forcing that might be caused by enhanced concentrations of greenhouse gases in the atmosphere does not directly tell us how much the climate of the Earth might change. There are many processes that interact in the creation of the present-day climate. Elaborate models of the climate system are needed in order to interpret the changes of atmospheric composition in terms of a climate change. Even though these models are still rather simple, they give a rough idea about the climate changes to be expected for a given change of the radiative forcing that humankind's interventions bring about. Some of the most valuable analyses are due to Dr. S. Manabe, the first laureate of the Blue Planet Prize in 1992. When embarking on a discussion of this field of scientific endeavor I also leave my own field of expertise and will rather rely on results as achieved by researchers such as Dr. Manabe and above all on the broad assessments of our present knowledge that has been carried out by the Intergovernmental Panel on Climate Change (IPCC), which I have led since 1988.

Climate models are first used to deduce the present climate due to forcing by solar radiation and an atmosphere with preindustrial concentrations of greenhouse gases and aerosols. A reasonable agreement between model results and observations is obtained (the "control run"). Then another experiment is conducted in which changes of the radiative forcing that result from changing concentrations due to humankind's emissions during the past 200 years. The climate system is thus subject to a changing radiative forcing, and the change of the climate brought about in this way can be computed. Figure 7 is an example of the global distribution of the enhanced forcing that has been deduced for 1990 (Kiehl and Briegleb, 1993). We can see the rather uniform forcing between about 1.5 Wm^{-2} (in polar regions) and 2.5 Wm^{-2} (in tropical regions) due to greenhouse gases, on which the spatially very inhomogeneous negative forcing that aerosols bring about is superimposed. In small areas over central Europe and the eastern United States, the total forcing is negative, i.e., the aerosols more than compensate for the warming due to enhanced greenhouse gas concentrations.

Figure 8 shows the changes of the global mean surface temperature as derived both with and without forcing due to aerosols and also, for comparison, observed changes until 1994 (Hadley Centre, 1995). Until about 1950 there are irregular changes of a similar kind in both, as deduced by model experiments and those observed. The observed irregular changes during this period of time are therefore not likely to be due to humankind's emissions. During the latter part of the century, however, all three curves bend upwards. Good agreement between observations and the model experiments is found when the effects of aerosols are included, but this may be fortuitous, since the sensitivity of the model to a given forcing still is quite uncertain. Although the model results and observations agree, this finding is hardly a proof of the quality of the model. It has recently, however, also been found that some of the more detailed features of model results and observations are in accord: warming is essentially restricted to the troposphere, while the stratosphere cools. It is more pronounced in the Southern Hemisphere, where there is no enhanced cooling due to aerosols. The regional patterns of change show some similarities, particularly with regard to the effects of the rather patchy forcing due to the inhomogeneous distribution of aerosols in the atmosphere. This has led the IPCC to the conclusion that "the balance of evidence suggests that there is a discernible human influence on global climate." Humankind does play a role in changing the global climate. The sensitivity of the climate to human interventions is, however, still not well determined.

These findings mean that the climate models may be considered to be somewhat more reliable than was the view a year or two ago. This means that their use in projecting plausible scenarios for the future also has become more reliable. We do encounter another difficulty, however. Projections of likely future human emissions are most uncertain. The IPCC therefore commonly presents alternative projections of such emissions and emphasizes that we as yet cannot tell whether one or the other of such projections is the most plausible one. A number of experiments have been carried out using a "central" projection of emissions, which need not be the most likely one to occur, but still gives an idea about what might happen. Figure 8 (Hadley Centre, 1995) includes projections for approximately the next 50 years. The uncertainty of it is, however, at least ±50% owing to the uncertainty of both projections of future emissions and sensitivity of the climate system to disturbances in the radiative forcing.

Presumably the curve that includes the consideration of aerosols is the most plausible one, but it is still uncertain. It is important to stress that uncertainty means that high projections should be considered to be as plausible as low ones, until we know more accurately the reasons for the remaining uncertainties.

Figure 9 shows the projected global distribution of surface temperature change at about the middle of the next century. It should be recalled that regional changes in different areas may differ significantly from the mean global change and are also subject to stochastic variations that cannot be foreseen. We note, for example, that although a significant change of the global temperature is projected, the spatial distribution shows two regions in the world, one in the North Atlantic and the other one in the North Pacific, that do not experience any warming at all. It is thus important to recognize that spatial variations of the expected changes of climate may well be considerable. This should be considered statistically when assessing impacts of climate change.

A change of climate does not, of course, mean only a change of temperature. Availability of water or, in other words, precipitation and evaporation, may also change what is most important for life on Earth. Generally, the warmer it gets, the more water is being circulated between the oceans, the land, and the atmosphere. But more water is also required to avoid droughts. Since it is by no means certain that the regional distribution of warming will mean a similar increase of precipitation, the prospects for agriculture in a warmer world may change significantly in some regions but less so elsewhere. We cannot foresee the changes very well, and a precautionary approach to climate change therefore becomes the most appropriate.

What should and what can be done? Obviously all greenhouse gases as well as the aerosols play a role, but it is also very clear that carbon dioxide is the most important constituent to consider. We can of course not rely on the cooling effects of enhanced concentrations of aerosols to prevent climate change, since their acidification of precipitation and fresh waters implies that their unrestricted increase is not acceptable. Carbon dioxide is at present responsible for about 60% of the enhanced radiative forcing due to increasing amounts of greenhouse gases in the atmosphere, and it may well grow to 75% or even perhaps 80% if no restrictions on their emissions are imposed. Scientists have tried to derive the "permissible" emissions, if a condition is imposed that atmospheric concentrations must not exceed a given level and that thus a stabilization at that level is aimed for.

We do not know which level of stabilization to be aiming for, however, and the choice really is a political one to be based on careful consideration of costs and benefits of various mitigation options, not by considering the matter exclusively in terms of money. A set of alternative stabilization paths therefore has been chosen to achieve stable concentrations at 450, 550 (close to doubling of preindustrial concentrations), 650, 750, and 1,000 ppmv (see Figure 10). The highest level is not far from quadrupling preindustrial concentrations and would represent a major disturbance of the heat balance of the Earth, i.e., by 6–8 Wm^{-2}. Few consider that this would be acceptable.

Figure 11 shows the outcome of such an analysis. It should be noted that two different pathways toward a certain level of stabilization have been considered in several cases. One can see clearly that delaying preventive measures and thus permitting emissions to rise more steeply to begin with will require stricter reductions later. Also, quite soon, emissions will have to be considerably below what has been projected to occur without restrictions being imposed on the use of fossil fuels in all cases, the more so the lower a level of stabilization is pre-

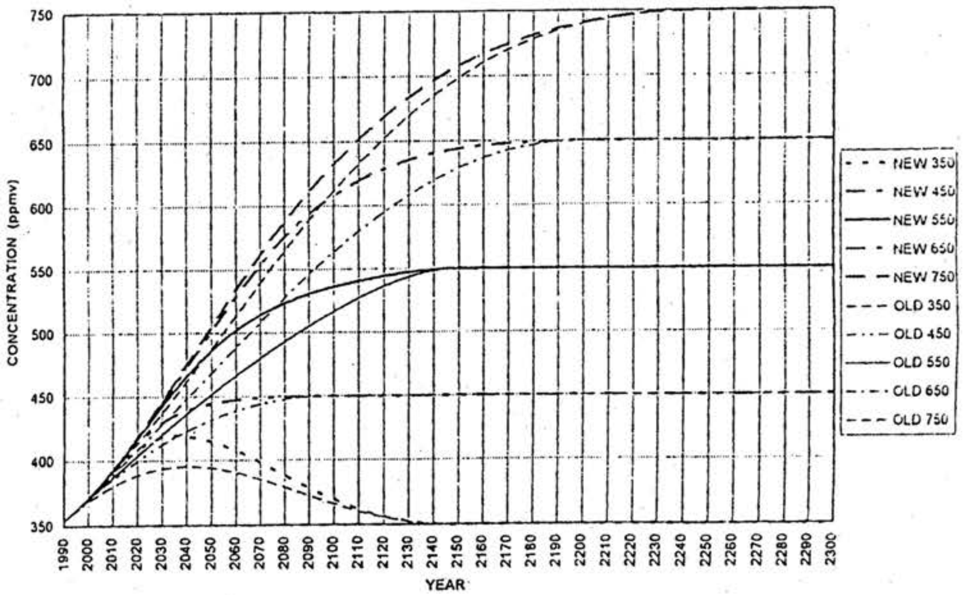


Figure 10. Alternative assumed future changes of atmospheric carbon dioxide concentrations to serve as a basis for assessing alternative future emissions (according to Wigley; see IPCC Working Group I, 1996).

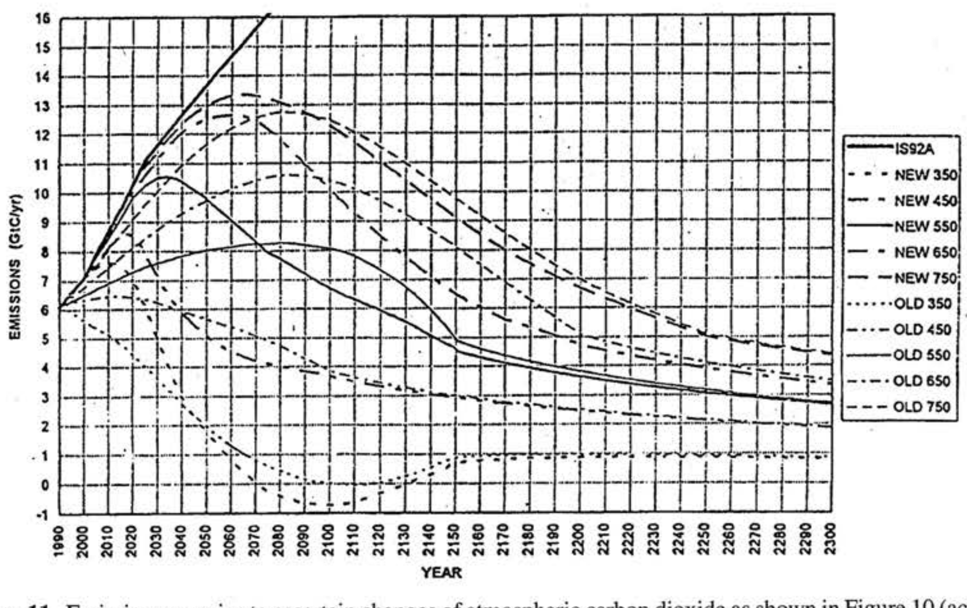


Figure 11. Emission scenarios to ascertain changes of atmospheric carbon dioxide as shown in Figure 10 (according to Wigley). Uncertainty of the values given is ±10–20%. "NEW" and "OLD" show the two alternative stabilization paths as given in Figure 10. The steeply increasing curve shows emissions according to IPCC Scenario IS92a ("Business as Usual"). See IPCC Working Group I and *Synthesis Report*, 1996.

scribed. Although this analysis still is somewhat uncertain because of our limited knowledge about the carbon cycle, it becomes very clear that nature puts some restrictions on how much we may allow ourselves to disturb the global environment, and we are able to give an approximate indication of what may be required.

To be more specific, consider as an example the stabilization level of 550 ppmv. If emissions are permitted to rise to about 10.5 billion tons of carbon per year, the emissions will have to be reduced rather quickly thereafter and need to be well below present emissions of about 7 billion tons before the end of the century (also including emissions due to net deforestation and changing land use). A more precautionary approach would lead to maximum emissions of merely 8–9 billion tons of carbon per year and permit somewhat higher emissions during the latter part of next century.

Some further insight is gained if, for a moment, we instead consider the emissions per capita and also take note of the marked prevailing differences between developed and developing countries. The global average annual per capita emissions of carbon dioxide due to the combustion of fossil fuels is at present about 1.1 tons (as carbon). In addition, a net amount of about 0.2 ton per capita is emitted owing to deforestation and changing land use, i.e., in total about 1.3 tons per capita. The average fossil fuel emissions per capita in developed and transitional economy countries is about 2.8 tons, and emissions range from about 1.5 to 5.5 tons for individual countries. The figure for developing countries, on the other hand, is 0.5 ton on average, ranging from 0.1 ton to, for a few countries, above 2.0 tons (figures are for 1990).

Because of the expected growth of the world population during the first half of the next century, the emissions as given in Figure 11 imply that per capita emissions must not increase

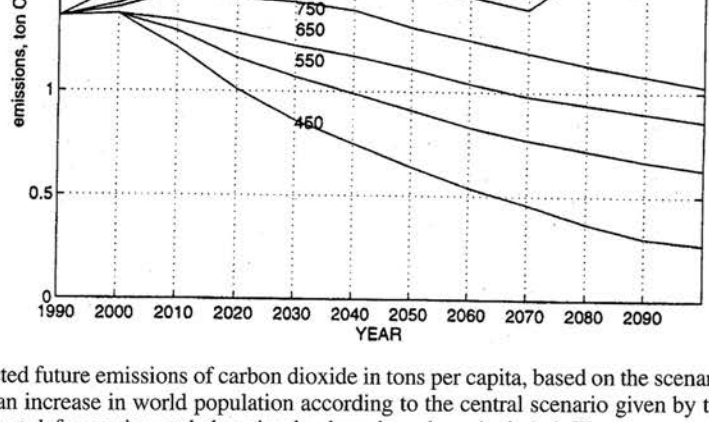


Figure 12. Projected future emissions of carbon dioxide in tons per capita, based on the scenarios given in Figure 11 and assuming an increase in world population according to the central scenario given by the United Nations. Emissions due to net deforestation and changing land use have been included. The uppermost curve is the IPCC Scenario IS92a ("Business as Usual"). See also IPCC *Synthesis Report*, 1996.

at all if stabilization at or below 550 ppmv is aimed for (see Figure 12). It is likely, however, that developing countries will consider themselves entitled to some increase of per capita emissions above their present levels because of the prevailing major differences between developed and developing countries that I referred to before. This reinforces the need for developed countries to take early steps to reduce their emissions of carbon dioxide, if stabilization below doubling is to be accomplished. But even very drastic reductions in developed countries would not permit developing countries to exceed by much the present annual per capita emissions for the world—1.3 tons, a figure which includes emissions owing to deforestation.

Sustainable development would become easier if more efficient energy use could be achieved in both developing and developed countries. In this way, some more time would become available for finding long-term solutions, since it is obviously not enough to provide and use energy more efficiently. We must find other sources for energy besides fossil fuels, something which cannot be accomplished quickly, since about 80% of the energy used in the world today comes from burning fossil fuels. To develop the technology, demonstrate its feasibility, and introduce it into the energy market will necessarily take time if the costly early retirement of capital investments in the existing energy system is to be avoided.

The choices we have are, on one hand, solar energy or other forms of energy derived from it, particularly bioenergy and hydropower, or on the other hand, nuclear energy. There is plenty of solar energy available, directly in the form of solar radiation and indirectly as hydropower, wind energy, bioenergy, and geothermal energy. We will never run out of it, but it is not always easy to harness efficiently and cheaply. The resources of nuclear energy are limited, and for a long-term supply breeder reactors (and in the very long term, fusion reactors) will in any case be required. Major development projects will be required and funding for research and development must increase substantially rather than decrease, as is presently the case. Developed countries must take the lead also in this regard, and it is doubtful that private initiatives will be adequate until the prospects for new markets become much more obvious. Only the governments of the world can provide the incentives to achieve this by agreeing that new energy systems will be required in the future.

The previous analysis is important because some semiquantitative bounds are established for future development, but it should be emphasized that they are still only indicative. Merely carbon dioxide was considered. We should also recall that whenever burning coal and oil, sulfur is emitted into the atmosphere in the form of sulfur dioxide. It ameliorates the warming due to enhanced greenhouse gas concentrations. Emissions of sulfur, however, contribute in a major way to the acidification of fresh waters and soils as well as to air pollution in industrialized regions. Some developing countries are at present trying to cope with these environmental issues by decreasing such emissions, and many more will have to do so rather soon. Their elimination would obviously imply that the greenhouse gas warming would be more fully realized. Similarly, the gradual decrease of CFC gases, which is expected at about the beginning of the next century as a result of human efforts to prevent the destruction of the ozone layer, would also decrease greenhouse warming. On the other hand, stratospheric ozone concentrations would then be restored and also the full effect of ozone as a greenhouse gas. These examples, and there are more of them, illustrate that the global environmental issues are all more or less interrelated. The global system needs to be considered as a whole.

The difficulty is, of course, that only a small part of the global population and politicians of the world as yet really consider these environmental issues as sufficiently serious to justify more concerted action. It is then interesting to dwell for a moment on the ozone issue, which was dealt with remarkably quickly once it had been established and generally accepted that humankind's emission of CFC gases was the cause of the development of the "ozone hole" over Antarctica. The warnings of possible serious modifications of the ozone layer due to our emissions of CFC gases had been voiced already during the early 1970s. Almost 10 years of negotiations finally led to an agreement on a convention for the protection of the ozone layer in 1985. However, it did not really contain any specific restrictions on the use of CFC gases. But when the ozone hole was discovered in 1985, it took only about 18 months to reach an agreement on rather powerful measures, known as the Montreal Protocol. These were made even more stringent by international agreements reached in 1990 and 1993. The measures that entered into force at the beginning of 1996 will presumably stabilize the atmospheric concentrations of these compounds at about the turn of the century.

The climate change issue is, however, a much more difficult one. Its possible consequences, as well as measures to prevent a change of climate, affect the global society as a whole. The CFC gases were produced by merely a handful of companies and their use was limited to rather few products on the market. The emissions of carbon dioxide and the use of energy that it signifies really concern almost everybody.

One may of course ask the question if we will one day see climate change become politically equivalent to the ozone hole. I think, however, that this is a dangerous attitude to the issue. Even though the increased occurrence of extreme events such as severe storms, floods, and droughts may be the signature of a climate change, it will for some time yet be difficult to ascertain whether one or another event of this kind is really due to an ongoing human-induced change of the global climate. This constitutes a real dilemma and may delay actions. My simple answer at this moment is that scientists will have to pursue their research but perhaps plan their theoretical and observational efforts in a manner that is most useful to the politicians and others who will have to deal with this issue. But, perhaps more droughts, floods, and the like will be necessary anyway before more far-reaching measures will be taken.

A few additional words about the role of the scientific community in the context of climate change might be of interest. The research process will of course go on and may be financed more or less adequately. The key questions I want to address, however, are how to assess and synthesize our knowledge, and how might interaction be best organized between scientists on the one hand and politicians, representatives of industry, the press, and the public in general on the other.

- It is first of all important to aim at participation by scientists from all over the world in the assessment of the climate change issue. By far most of the relevant research, particularly concerning truly global aspects of the problem, is carried out in developed countries, although increasing numbers of researchers from developing countries are becoming engaged. The most efficient way of communicating new scientific findings to a broad community all over the world is through the scientists. Leading politicians, not the least in developing countries, are likely to take more notice of views held by scientists in their own country than to accept advice from scientists abroad. A global network of scientists is therefore essential.

- The scientific process must be open. The aim is, however, not necessarily to reach agreement on every relevant issue. Scientific controversy is, after all, the basis for scientific progress. It then becomes essential to clearly bring to the public those issues on which agreements can be reached, and at the same time describe where the scientific frontier is to be found and what the controversies are. To achieve this, it is important also to reach out to the scientific community in a scientific review process so that the core groups that are given the responsibility to carry out scientific assessments cannot be accused of not being fair and objective in carrying out their tasks. Even though there are some that are not satisfied with the way the IPCC has been carrying out this task, there is in reality a broad backing of IPCC views from the scientific community. This credibility is essential in order for the assessment process to be recognized. If there were some other group of scientists that in a credible, scientific manner could maintain a different view on the issue of climate change, the world would of course be bewildered and it would be difficult to achieve anything politically.

Future actions to address the issue of climate change cannot be successfully initiated unless cooperation within the business community, i.e., the industrial complex, is established. Some kind of partnership is desirable. I would like to see leading representatives from these communities present their views on how to best approach these environmental issues on the basis of the IPCC assessment of technological and financial implications. What would their difficulties and priorities be? The IPCC would welcome such cooperative efforts.

Social considerations also become very important when attempting to assess damage due to a climate change as well as judge the implications of measures to be taken. The IPCC addresses these issues in its most recent assessment. It is clear that the economic evaluations usually do not yet adequately include social aspects of the issues at stake. Rather, exclusively economic analyses dominate. And yet we know that major changes in social systems might well be necessary in order to deal with climate change. And also, we see daily around us how easily crises develop when stress on people or groups of people, i.e., countries, cannot be managed peacefully. Not only is the climate system complex and in a sense chaotic, but so is society. Presently available socioeconomic models then usually break down and science then is hardly any longer the key to finding solutions. Perhaps it will be possible to judge on the basis of further research when such situations may be on the way. A dialogue between the scientific community and the political community is in any case a prerequisite for making use of what scientific research can possibly achieve. This is not really well developed yet, but perhaps on the way.

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Profile

Maurice F. Strong

Chairman of the Earth Council

Professional Activities

1966–70 Left the private sector to head Canada's International Development Assistance Program and subsequently guided its growth into the Canadian International Development Agency
1969 Served as visiting professor at York University, Toronto
1970–72 Served as secretary-general of the UN Conference on the Human Environment
1973–75 Served as executive director of UNEP, Nairobi, Kenya
1976–84 Held top positions at major corporations, including president, chairman, and CEO of Petro-Canada
1985–86 Served as undersecretary-general of the United Nations and executive coordinator of the UN Office for Emergency Operations in Africa
1986–90 Held the position of chairman at Strovest Holdings, Inc., and served on the boards of several utilities and natural resource related corporations
1990–92 Served as secretary-general of the 1992 UN Conference on Environment and Development (the Earth Summit)
1992–95 Chairman and CEO of Ontario Hydro, North America's largest utility
1995– Appointed senior advisor to the president of the World Bank
1997 Under-Secretary General and Executive Coordinator for United Nations Reform

Maurice F. Strong served as secretary-general of the UN Conference on the Human Environment, the United Nations' first international conference on the environment, which was held in 1972 in Stockholm. Twenty years later he was again called upon by the United Nations to organize the 1992 UN Conference on the Environment and Development in Rio de Janeiro. As secretary-general of both conferences, Mr. Strong smoothed the way for important environmental initiatives, including Agenda 21.

Prior to 1970, Mr. Strong spent many years in the business world and in the Canadian government, and from 1972 to 1992 he served in various capacities at the United Nations. He was also active as chairman of Canada's government-owned oil company, Petro-Canada, and served as a director of many utilities and natural resource related corporations worldwide. Widely acclaimed in academic circles, Mr. Strong is the recipient of honorary doctorates from 40 universities.

Today, Mr. Strong's many activities include chairing the Earth Council, the World Resources Institute, and other nongovernmental organizations. He also serves as Under-Secretary General and Executive Coordinator for United Nations Reform and Senior Advisor to the President of the World Bank. Thanks to Mr. Strong's untiring efforts, environmental issues now rank high on political and business agendas worldwide. In all his many undertakings, Mr. Strong has steadfastly supported the concept of sustainable development.

Essay

The Rio +5 Forum: Taking the Earth Summit from Agenda to Action

Maurice F. Strong

April 1997

Many dedicated organizations and individuals are committed to the Earth Summit's goal of sustainable development, including finding innovative ways to reduce pollution and use our natural resources more wisely. Indeed, some remarkable progress has been made, particularly at the local level, where much of the basic work in implementing Agenda 21 must be done. But far too many governments, companies, institutions, communities, and citizens have yet to make the choices and changes necessary to advance the mutually reinforcing goals of sustainable development. That is why the Rio +5 Campaign was launched and the Rio +5 Forum was held in Rio de Janeiro, Brazil, from March 13 to 19, 1997.

Rio +5 was coordinated by the Earth Council in partnership with a broadly representative group of other civil society organizations. The Earth Council is an international nongovernmental organization established in San José, Costa Rica, as a result of the Earth Summit in 1992. The Earth Council promotes and advances the worldwide implementation of the Earth Summit agreements. We do this by raising public awareness of the issue of sustainable development, facilitating public participation in relevant decision-making processes, and building needed cooperation between governments and the important representatives of civil society, who must participate directly in all aspects of this effort.

The key goal of Rio +5 was to forge new alliances and set in motion new initiatives to move the sustainable development pledges of the 1992 Earth Summit "from Agenda to Action." To that end, the Forum aimed to develop recommendations for regional and global governance of sustainable development to present to the United Nations Commission on Sustainable Development (UNCSD) in April and to the subsequent Special Session of the UN General Assembly in June 1997. Rio +5 was specifically designed as an opportunity for civil society institutions and actors to provide input to the parallel review processes of the UN, much the same way thousands of nongovernmental organizations participated in the "peoples'" summit, the Global Forum, during the United Nations Earth Summit in 1992.

Among others, the Earth Council was joined in this extraordinary endeavor by the World Resources Institute, the Women's Environmental and Development Organization, the World Conservation Union, the World Business Council for Sustainable Development, the International Council of Scientific Unions, the Brazilian NGO Forum and the Brazilian Foundation for Sustainable Development. Members of the National Councils for Sustainable Development from 66 nations, as well as some 450 representatives from business, industry, citizen groups, nongovernmental organizations, philanthropies, international financial institutions and United Nations agencies also participated.

All of the organizations that took part in this effort share the fundamental concern that despite progress in many areas, the world has failed to make sufficient progress towards achieving the vision of the Earth Summit: an environmentally sustainable and socially equitable global economy. The passage of nearly five years has witnessed a waning in the excitement and momentum initially generated by the Earth Summit. Through the Rio +5 Campaign and Forum, and in the period immediately following, the Earth Council will reinforce and revitalize commitment to the agreements reached at the Earth Summit as the issues that were raised in Rio and the challenges it addressed have not diminished.

A particular disappointment since the Earth Summit has been the fact that most of the industrialized countries will not meet the initial targets set for reduction of carbon dioxide emissions. And developing countries have reason to be especially disappointed that the "new and additional resources" identified at Rio as essential to enable them to make the transition to sustainable development have not been forthcoming. A welcome exception has been Japan, as the leading provider of Official Development Assistance and the strongest supporter of the Global Environmental Facility, the only new financing mechanism to emerge from the Earth Summit. On the whole, despite significant progress in some areas since Rio, the processes of environmental deterioration continue while its underlying causes persist—continued growth in the human population and in the scale and intensity of human activity.

On the positive side, many developing countries have responded positively to the results of the Earth Summit and some, like China, have enacted their own national versions of Agenda 21 despite the fact that the additional international funding they had expected as a result of Rio has not materialized. Most encouraging is the progress that has been made at the level of business and civil society. Professional societies, notably engineers, architects and educators, have made a commitment to sustainable development. Some 1,800 cities and towns are developing their local versions of Agenda 21. Important industrial sectors, including the road transport industry and the tourism and travel industry, have developed their own Agendas 21. A reconstituted and expanded World Business Council for Sustainable Development with a growing number of regional and national counterparts, is leading the movement to sustainable development within the business community.

Some 100 National Councils for Sustainable Development, bringing together representatives of both government and civil society, have been established in every region of the world as primary instruments for implementation of the results of Rio in their own countries. These National Councils for Sustainable Development were at the core of the Rio +5 process. I am particularly pleased that Japan has recently taken steps to form its National Council, which participated with some 90 other National Councils in Rio +5. Many of these countries produced valuable National Reports for the Forum.

The forum also called for establishment of a Global Environmental Organization, building on the foundations of the United Nations Environment Program, with a status and strength equivalent to that of the major international trade and economic organizations. The first meeting of the Earth Charter Commission also produced a benchmark draft of the Earth Charter, which it presented at Rio +5 and the participating organizations undertook to take a lead in ensuring its wide dissemination and promotion of consultations and dialogue by people throughout the world, which will be the source of the credibility and authority of the Charter when it is presented to the United Nations in the year 2000.

Five years after Rio, at the Rio +5 Forum, we were presented with an opportunity to pinpoint the obstacles which need to be overcome if the agreements reached at the Earth Summit are to be fulfilled and extended.

Today, the demographic, social, and economic forces that drive unsustainable development remain dominant. Although the conventional approach to development has been highly successful at expanding economic activity, it has not proved to be a panacea for all of the world's people or for generating a sustainable future for the planet. It has yet to benefit many countries. Although economic development remains at the top of most nations' political agenda, it has failed to reduce income differences or satisfy the basic needs of the world's poorest one billion people. Making a real difference in the lives of these people requires a revitalized commitment to Agenda 21 and the vision of Earth Summit—a formidable challenge, yes, but as Rio +5 has made clear, still within reach.

Now we must focus our collective efforts on the next phase of work: putting sustainable development into practice, particularly at the level of civil society, so that 10 years from now, the world will be a more sustainable place.

Achieving this vision will require the development and strengthening of indicators, tools, operational policies, business practices, institutional arrangements, public understanding, and commitment. Fortunately, we do not have to start from scratch. Many of the best achievements outlined above are participatory in their design and action, involving citizens, civic organizations and governments, nongovernmental organizations, businesses, labor unions, and other stakeholders.

In building sustainable development from the ground up, all sectors of civil society, as well as business and government, have essential roles to play in applying its principles. It is only through unrelenting follow-up and implementation that the vision of the Earth Summit—so enthusiastically proclaimed and welcomed the world over—can be fulfilled.

Lecture

Japan: Leading the World to a Sustainable Civilization

Maurice F. Strong

I think those of you who know me know that the lecture platform is not my natural habitat. I am a practitioner, an operator, one who tries to translate the guidance that scientific leaders like Dr. Bolin give us into practical measures and actions. And I want again to say what a great privilege it was yesterday to receive the honor of the Asahi Glass Foundation's Blue Planet Prize.

I also have to say that this is a very auspicious place to be delivering these lectures, considering my lifetime of association with the UN and, indeed, a long association with the UN University, and a great friendship with Rector de Souza.[1]

I am also particularly delighted to return to the land of the rising sun. Since my very first visit here more than 40 years ago, I have developed a strong affinity for this precious and distinctive land, and an immense admiration and affection for its exceptional people. During my first visit here, which was very much in the rural parts of Japan, I was deeply impressed by the dedication, the resourcefulness, and the resilience of the Japanese in rebuilding their war-shattered society. I've spent a great deal of my time over the years in rural Japan, and I've come to appreciate that much of the strength and the character of the Japanese people, and the distinctiveness of Japan's culture and value system, is rooted in the lives of its farmers and villagers, in the spirit of *musubi*.

One of the first things that I came to admire about Japan was not its great economic growth, but the respect of the Japanese people for nature and the profound degree to which this is reflected in Japanese art, poetry, and culture. While this reverence for nature, it must be said, has to some degree been subordinated to Japan's commitment to economic growth in the post-World War II period, it nevertheless remains at the core of Japanese traditional culture and value systems. And I'm encouraged by the signs I see today of revitalization of Japan's deep affinity with nature, and the fact that the current generation of Japanese young people in fact is rediscovering this affinity. When I visited Japan in preparation for the first World Environmental Conference held in Stockholm in 1972, a heavy pall of gray, polluted air hung over Tokyo, making it no longer possible, most of the time, to see Mount Fuji from the Tokyo television tower. And I've seen the resolute and effective manner with which Japan dealt with these problems, reducing levels of air and water pollution more than any other industrialized country. But I'm sure my Japanese friends would be the first to say that there are still many problems yet to tackle.

Improvement in air and water quality, though, is evident everywhere today, and one can

[1] The Commemorative Lectures were held at the United Nations University in Tokyo.

now see Mount Fuji again from the Tokyo Tower, though they have kept me so busy during this trip that I have not been able to do so this time. At the same time, Japan's awareness of its dependence on external supplies of energy and raw material, which became acutely evident during the oil shock of the late 1970s, was an opportunity for Japan to achieve the highest level of efficiency in the use of energy and raw materials of any major industrial nation. And again as I come to Japan today, I see Japan confronting the consequences of the worst economic slowdown it has experienced since World War II. And I am confident that it will again make the adjustments and apply the lessons of this experience to the task of ensuring that Japan will continue to be a prime leader in shaping the future of the human community in the 21st century.

No country is more vulnerable to a breakdown in the sustainability of the world economy than Japan. Japan cannot have a secure and sustainable future in an insecure and unsustainable world. There is, therefore, a strong incentive for Japan to be the world leader in sustainable development, to be the first country to make its economy truly sustainable in environmental, social, as well as economic terms. The progress it has made to date has laid the foundations for this. But it will take a good deal of resolute work and commitment to build on these foundations.

In April of 1992 I had the great privilege of addressing the Eminent Persons' Meeting on Financing Global Environmental and Development Issues, just on the eve of the Earth Summit. And I have to say that meeting made a very important contribution to the positive results of the Earth Summit. And I want here to record my profound gratitude to the three eminent Japanese leaders who co-chaired that event: Mr. Noboru Takeshita, Mr. Toshiki Kaifu, and Mr. Gaishi Hiraiwa. Their leadership meant a tremendous amount to the Earth Summit and its follow-up. Again last October they hosted the Tokyo Conference on Environment Action, which made a number of important proposals, including one for the establishment of the National Council for Sustainable Development in Japan, and an International Strategic Policy Research Institute for Sustainable Development here.

Japan's capacity for leadership is reflected nobly and practically in the Asahi Glass Foundation's own guiding principle, to contribute to the creation of a richer, more vibrant society and civilization, and in its recognition of the fact that the global environment is the most important topic as humanity moves toward the 21st century. I am persuaded that the 21st century will be decisive for the human species, for all of the evidences of environmental degradation that we have seen to date have occurred at levels of population and human activity that are much less than they will be in the period ahead. Theoretically, one can make a case that these problems will be manageable. But in practice, to manage them would require a degree of social discipline and cooperative management that only a few of the more successful modern societies like Japan have thus far evidenced. In many countries of the world, and particularly in some of the newer developing countries, the political and institutional structures are fragile and vulnerable.

In my view, the only answer is a new global partnership for security and sustainability. This would not require world government, but a world system of governance and management. It would require agreement on the fundamental boundary conditions that all nations and people must respect to ensure that our collective behavior does not transgress the thresholds of safety required to ensure our common survival and well being. We don't have to agree on everything, we don't have to be homogenous. But we do have to agree on those limits, those boundary conditions that we must all respect for our common survival and well being. This will require a major extension and strengthening of the system of partnerships that is now emerging within civil society, as well as a new impetus to strengthening the multilateral system of institutions through which governments cooperate. As we mark the 50th anniversary of those institutions, particularly the United Nations, the need for them has never been more compelling. But the will to support them has never been weaker since the time of their creation.

One institutional driver that we think of today on the eve of the APEC meeting here in Japan is, of course, the Asia-Pacific Economic Cooperation, an institution that is helping to influence and promote sustainable development in the Asia-Pacific region. The intensification of economic growth and integration within the APEC region will clearly have very broad and far-ranging environmental impacts.

At times when so few nations are meeting their commitment to contribute 0.7% of their gross national product (GNP) for official development assistance, I want to commend Japan as the No. 1 provider of development assistance. However, as you know, the ratio of Japan's overseas development assistance (ODA) to GNP is still relatively low, about 0.25%. By share of GNP, then, Japan, despite its good record in all, would still be only No. 12 among the Organization for Economic Cooperation and Development (OECD) donors.

I'd like to mention the non-governmental role in respect to Japan's activities. Japanese non-governmental organization (NGO) aid to developing countries is only slightly more than 1% of its ODA. A particularly encouraging development, though, is the creation in May 1993 of the Japan Fund for Global Environment to support environmental activities of NGOs. It has already supported, I understand, more than 400 projects amounting to some ¥1.6 billion. And I hope that there will be further additions to this budget and a strengthening of this very promising organization, which basically is an instrument for strengthening the kinds of partnerships which I believe are so important. And I see encouraging signs in Japan of an increasing interest among universities, professional associations, and other nongovernmental actors in extending their interests and activities, and sharing their skills with the international community, particularly the developing countries.

May I say that the world community today needs a greater and more active involvement by Japan's non-governmental actors. And I hope that Japan in its own distinctive way will develop more effective mechanisms for doing this. I find that Japan is sometimes left out of some of these initiatives and only brought in later on, because those developing these initiatives outside don't always know where to plug into Japanese society, they don't know where to connect, they don't know which are the appropriate institutions. I would invite our Japanese friends in your own way to improve and develop these mechanisms so that you can be in at the beginning, where we need you, where your ideas and contributions are needed to shape these initiatives and not just to wait to be asked to respond to them. We don't need just a Japan that can say "no," we also need a Japan that can say "yes" without waiting for everybody else to say "yes."

Japan's economy has come from being historically one of the most self-sufficient nations on earth with little contact with the outside, to one of the most dependent, the least self-sufficient, relying to such a great extent on imports of petroleum and other raw materials to sustain the economy and on exports for its economic performance. It is, therefore, intrinsically unsustainable and more dependent than most on a secure and sustainable political and economic system. It is therefore in Japan's own interest, as well as that of the world community, for Japan to continue to assume the international leadership and responsibilities that inevitably accompany its economic strength. It is also essential to assure the future security of Japan and the sustainability of its economy.

Less than three and a half years after the Earth Summit, it is still too early to pronounce final judgment on its ultimate results. After all, Rio called for fundamental changes in our economic life, and fundamental change does not come quickly or easily. Nevertheless, it has to be said that the process of following up and implementing the results of Rio by governments has in many respects been disappointing. But there have been bright spots, and Japan is one of those bright spots. You enacted a new basic environmental law that I commend as highly progressive. And you have increased your development assistance in the environmental field, in particular.

Some other nations have also moved to implement the agreements made at Rio. In May 1994, your great neighbor China launched its own national Agenda 21 in response to Rio's agenda, and it is one of the most extensive and comprehensive of any national sustainable development agenda. But in some countries, notably the United States, there has been a recession in the political will for change ignited at Rio, accompanied by a movement to reverse, even, some of the progress made between Stockholm and Rio.

I firmly believe that the risks that we face in common from the mounting dangers to the environmental natural resource and life support systems of our planet are far greater as we move into the 21st century than the risks we face or have faced in our conflicts with each other. And these risks can only accelerate as the levels of population and human activity continue to grow in the period ahead. All people and nations have, in the past, been willing to accord highest priority to the measures required for their own security. We must now give the same kind of priority to ensuring the security and sustainability of the life-support systems of our earth. This will clearly take a major shift in the current political mindset and the priorities for allocating resources. Necessity will compel such a shift eventually. The question is whether we can really afford the costs and risks of waiting. We have become addicted to a wasteful and destructive mode of economic growth that is not sustainable.

I am an economic practitioner myself, running a great utility company, so I feel it—I am part of this system—trying to change it from within. But I am convinced that our pattern of economic growth is like a cancer that is eating away at the vital organs of our society. By the time its symptoms become more acute, it may well be irreversible. Significantly, a new generation of enlightened leaders is emerging in both business and government who realize that our present industrial system is not viable, that we must make a fundamental transition to a sustainable economy. Some of you will recall the report to the Rio conference which I commissioned, headed by the Swiss industrialist Stephan Schmitai and involving some 50 other chief executive officers, including some of your leading executives. Their book, *Changing Course*, called for fundamental changes in our industrial life based on eco-efficiency, or efficiency in the use of energy and resources, and in the prevention, disposal, and recycling of waste. Eco-efficiency is good for business, as well as for the environment. It must ultimately lead to a new industrial ecology in which wastes are reused or contained within closed-circuit industrial systems. This is essential, and it does not mean a diminishment in our economic life, but a reorientation. And those who see in this the new opportunities that it creates will be at the forefront of the new eco-industrial revolution.

I know the Japanese businessmen are keenly aware of these possibilities. Japanese industry is facing formidable challenges but is responding to them with typical realism, foresight, and determination. Through Keidanren's Global Environmental Charter and the guidelines of MITI, Japanese business leaders are demonstrating that they are not only on the leading edge of technology, but also in the vanguard of environmental awareness and action.

Energy is at the center of the environment-development nexus. Already, consumption of commercial energy by the developing countries of Asia is growing faster than in OECD countries. And the World Energy Council's task force on energy for tomorrow's world estimates that by 2020 developing countries will need some $30 trillion in new investment to meet their energy needs. This is nearly 50% greater than the entire world GNP, clearly an impossible prospect in economic terms and also in environmental terms.

We still do not have environmentally sound alternatives to fossil fuels. I know as one who has to take decisions on our future energy supplies how difficult it is to create a good balance of choice. Nuclear has attractions, but it also has some disadvantages. These are not easy choices. That is why energy efficiency is so essential. My own corporation, Ontario Hydro, has made a massive commitment to energy efficiency and has joined with others to create a Global Energy Efficiency Collaborative to foster energy efficiency throughout the world. In Japan you've done a good job. You use only about half the amount of energy for a unit of GDP than is used in the U.S.A.

In the past three decades, we have become increasingly aware of a new set of risks to our common future from the same processes of modernization and economic growth that have created such unprecedented levels of wealth and well-being for the privileged minority of the people on the planet, to whom most of its benefits have accrued. Yet, these risks are shared by rich and poor alike and accentuate rich-poor differences, both within and among nations.

When preliminary news of the latest report of the Intergovernmental Panel on Climate Change (IPCC), chaired by Dr. Bolin, appeared in our newspapers in Canada, there were some people who were quick to point out that the evidence is not conclusive. True, but surely the degree of scientific consensus is impressive, and surely, too, on an issue that affects the fate of humankind we cannot afford to wait for the certainty of a post mortem, especially when most of the things that we must do in the short term to avert the problem make good economic and environmental sense, in any event, particularly energy efficiency. There were some in my own country who suggested that Canadians really should not worry, as it might actually improve Canada's climate. And Canada's climate can, in fact, do with some improvement. But to act on this dubious premise would be both reckless and irresponsible.

As you know, Japan will host the third conference of the parties to the framework convention on climate change in 1997, just before the special session of the UN General Assembly, which will review the results of the Rio Earth Summit after five years. And it will represent a very essential opportunity to move the process of agreement very much forward and faster than now. And the report of the IPCC will provide the basis for this.

Some 40 months have now passed since an unprecedented number of world leaders and people representing every sector of civil society gathered in Rio to frame a new vision for a secure and sustainable future of the human community. Now it didn't do everything that we wanted, but it did agree on two important framework conventions, on the Declaration of Principles and a program to give effect to them, Agenda 21. Despite shortcomings, it's still the most comprehensive agreement for the future of our planet ever to be agreed upon by world leaders. Ironically, the progress we have made in dealing with many of the most visible and acute environmental problems of industrialized countries, as you have done here in Japan, is fostering in some a growing sense of apathy and complacency. Some of you may have heard of or read the recent book by Greg Easterbrook, the environmental journalist, called *A Moment on the Earth*, which strikes a responsive chord in many when he says that environmentalists have been too pessimistic. But he also concedes that the progress that has been made in our industrialized countries has come about largely as a result of government regulation and incentives. And rather than providing a pretext for getting rid of these regulations and incentives, it provides evidence that they are in fact what is necessary to produce change.

If the sense of common risk, then, is too distant and remote at this stage to drive concerted action, it is important that we make a stronger case for the positive elements of common interest, which can derive from a new sense of partnership, or what I call cooperative stewardship. Again, the Rio agreements, particularly Agenda 21, and the conventions on climate change and biodiversity, provide the basic framework for this partnership. The need for such new partnerships was highlighted by the Commission on Global Governments, co-chaired by Prime Minister Carlsson of Sweden and former Commonwealth Secretary General Sir Sridath Rampath. A wide variety of new governmental actors is now emerging and leading the processes of change and the development of the new complexes of partnerships necessary to effect change. In a thoughtful article in the summer 1994 issue of *Foreign Affairs*, Lester Salmon compared the growth in numbers and influence of voluntary nongovernmental organizations in the last half of this century with the emergence of the nation-state system in the 18th century. This is a process that is clearly occurring in Japan, but again will occur in relation to the distinctive nature of Japanese society.

Many of the seeds planted are beginning now to bear fruit in a proliferation of initiatives by various civil society actors and grassroots organizations. Let me just mention a few. The Business Council for Sustainable Development has been expanded and reconstituted as the World Business Council for Sustainable Development, including some 120 of the world's principal business leaders. Some 15 million engineers have committed themselves to sustainable development and their own Agenda 21 through the World Engineering Partnership for Sustainable Development. A process launched in The Hague, Netherlands, is picking up on an important piece of unfinished business from Rio to produce an earth charter for presentation to the United Nations in 1997 with the object of having it accepted by governments by the year

2000. On the initiative of the International Union of Local Authorities, in partnership again with the Earth Council, some 1,600 cities and towns have established their own community partnerships to launch their own local Agenda 21. The World Tourist and Travel Council and the World Tourist Organization, together with the Earth Council, recently launched in London an Agenda 21 for the tourist industry, which is the world's largest single industry. One of the most promising results of Rio has been the establishment of National Councils for Sustainable Development in some 100 countries, bringing together representatives of government and the various sectors of civil society in a new species of public-private partnership type organization, which I very much hope will soon arise in some fashion here in Japan.

The Earth Council, which has been associated with most of the initiatives that I have just mentioned, is in the business of developing partnerships, linking people at the grassroots and community level with the larger policy- and decision-making processes which affect them. Its headquarters in San Jose, Costa Rica, a developing country, links together some 30,000 partner organizations around the world—some of the largest, yes, but also many very small local grassroots organizations.

The more rapidly developing countries of Asia and Latin America, what I call the New South, are leading the revitalization of the global economy, challenging its domination by the traditional industrialized countries, and reshaping the geopolitical landscape. And I don't need to say that if these countries continue to grow, particularly as we have grown, they will bring us beyond the safe thresholds of the environmental margins that we must respect for a sustainable future. Indeed, the immense geopolitical implications of this shift of economic power have not yet begun to be reflected in the existing world order. And I'm sure that I can say with a sobering degree of confidence that our environmental future will in fact be largely settled in developing countries. Paradoxically, these threats will come not only from their rapid economic progress, but also from the other extreme of poverty, which continues to afflict these countries. The gaps between rich and poor, privileged and underprivileged, are deepening both within and among societies, and this if not reversed will inevitably lead to greater social tensions and potential for conflict. *The Economist*, hardly a radical publication, recently said in a review of the world economy that one of Karl Marx's main premises may yet be validated in the emergence of a new rich-poor war.

I don't want to give you a catalog of doom and gloom. But I do want to make the point that there are evidences everywhere of the fact that even at present levels of population and human activity we are effecting vast amounts of damage—immediate damage to our environment, and long-term deterioration of the conditions that make life possible, notably in terms of global climate. To effect fundamental change, we need a new set of partnerships between North and South—not just a new set of dependency relationships, but true partnerships. These must be based on the understanding that our future is being decided to a large extent in the South, and that the South's future depends very much on our setting an example of sustainability in our own economies and in our own behavior as nations, individuals, and enterprises. Japan is a major source of private capital for developing countries, as well as development assistance. And Japan, I hope, will join the process that a number of us have initiated of trying to develop guidelines and criteria for the greening of private capital and for new and innovative ways of raising funds for sustainable development. Foreign aid is no longer sufficient. We have to find new ways. A voluntary green tax on products from developing countries is one that the Earth Council is trying to launch. We're also trying to launch a new global environment trading system to provide a mechanism for trading CO_2 emission permits, so that the monies available to reduce emissions can be spent in the places where they will buy the most reduction, and that's normally in the developing countries.

There is an intrinsic complementarity between the economies of developing countries and the economy of Japan. And there will be an increasing degree of interdependence between Japan and the developing world in the period ahead. This is an area in which Japan's leadership is needed and would be welcomed by the world community. Leading the world toward the establishment of a sustainable civilization in the 21st century would surely be fully consistent with Japan's national character, its values, its traditional respect for nature, and its objective interests. What finer challenge, what more noble role could there be for a nation and a people that have shown such remarkable ingenuity, perseverance, and resourcefulness in building one of the world's truly great nations?

Major Publications

Maurice F. Strong

Articles

Article for Commemorative Journal *Relief and Rehabilitation of Ethiopia*, January 9, 1995.

Chapter Submitted for Book on the United Nations: "Making the UN More Businesslike." January 12, 1995.

Article for Op-Ed Page of the *New York Times:* January 19, 1995.

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Article for Argentinean Newspaper *Clarin*: "El Gran Diario Argentina 50th Anniversary." April 20, 1995.

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"Beyond the Impasse." Article for *Globe and Mail*, Canada. December 13, 1995.

Year-End Review, Cordex Petroleum Inc. December 21, 1995.

Foreword to *Exploring Soul and Society*, by M.T. Kalaw, Jr. 1996.

Foreword to *Environment and Development Values in the Pacific*, 1996.

Article for *Environment Matters*, September 8, 1996.

Lectures

Opening Statement, The United Nations Conference on Environment and Development. Rio de Janeiro, Brazil. June 3, 1992.

Opening Statement, Ontario Standing Committee on Government Agencies. December 9, 1992.

"Save the Children," Second Annual Meeting, Advisory Council. New York, New York. January 26, 1993.

Keynote Address, 1993 National Symposium, National Academy of Engineering. Irvine, California. February 26, 1993.

"Doing Business with First Nations," A Conference of the Canadian Institute. Toronto, Ontario. March 1, 1993.

Green Industry Conference, CEIA and Ontario Ministry of Environment and Energy. Toronto, Ontario. March 1, 1993.

Canadian Environmental Defence Fund. Toronto, Ontario. April 14, 1993.

The Sierra Club of Eastern Canada. Toronto, Ontario. April 18, 1993.

The Empire Club of Canada and the Canadian Club of Toronto. Toronto, Ontario. April 23, 1993.

International Museum Day Lecture, Denver Museum of Natural History. Denver, Colorado. May 7, 1993.

Commencement Address, Colorado School of Mines. Denver, Colorado. May 7, 1993.

Second Annual United States-Japan Seminar on the Global Environment, The Paul H. Nitze School of Advanced Environmental Studies, Johns Hopkins Foreign Policy Institute.

Washington, D.C. May 11, 1993.
Opening Statement, O.H. Survey of E7 Member on Agenda 21. Montreal, Quebec. May 14, 1993.
Commencement Address, King's College. Wilkes-Barre, Pennsylvania. May 16, 1993.
Commencement Address, 136th Commencement of the Fletcher School of Law and Diplomacy, Tufts University. Medford, Massachusetts. May 23, 1993.
The Receipt of the 1993 Delphi Prize for Man and His Environment. Athens, Greece. May 24, 1993.
Commencement Address, University of Victoria. Victoria, British Columbia. May 28, 1993.
Keynote Address, Conference on Water and Environment in Sub-Saharan Africa, International Institute for Infrastructural, Hydraulic and Environmental Engineering. Delft, The Netherlands. June 4, 1993.
The Royal Ontario Museum. Toronto, Ontario. June 7, 1993.
World Congress of Architects 1993. Chicago, Illinois. June 21, 1993.
Canadian Bar Association, Ontario Branch, Natural Resources and Energy Section. Toronto, Ontario. June 28, 1993.
Financial Executive Institute. Toronto, Ontario. September 10, 1993.
The Royal Botanical Gardens Environmental Lecture. Kew, England. September 16, 1993.
Fondazione Cervia Ambiente Environmental Lecture. Cervia, Italy. September 18, 1993.
"Into the Next Century: An Agenda for the Responsible City," London 200 Congress. University of Western Ontario. London, Ontario. October 27, 1993.
The Canadian Institute of Strategic Studies. Kingston, Ontario. November 3, 1993.
The European Institute. Washington, D.C., November 4, 1993.
Japanese Business Leaders' Conference on the Environment and Development. Tokyo. November 10, 1993.
The Donald McQ. Shaver Symposium, University of Guelph. Guelph, Ontario. November 23, 1993.
University of Tulsa Centennial International Conference. Tulsa, Oklahoma. February 25, 1994.
1994 Canadian Graduate Business Conference. Toronto, Ontario. March 12, 1994.
North American Institute Conference (NAMI). Vancouver, British Columbia. March 21, 1994.
Globe 94. Vancouver, British Columbia. March 22, 1994.
Bicentennial Environmental Institute, Bowdoin College. Brunswick, Maine. April 8, 1994.
Professor Carl Gustaf Bernhard Lecture, Royal Academy of Sciences. Stockholm, Sweden. April 27, 1994.
Environmental Business Council of New England. Boston, Massachusetts. May 4, 1994.
"From Forest to Society," Parallel Summit. San Jose, Costa Rica. May 9, 1994.
Global Change Forum. Ottawa, Ontario. May 30, 1994.
Asian Development Bank. Manila, Philippines. June 6, 1994.
"The Alliance to Save Energy." Washington, D.C. June 15, 1994.
The High-Level Roundtable Conference on China's Agenda 21. Beijing. July 7–9, 1994.
Environmental Business Council of the United States, Environmental Industry Summit 1994.

Washington, D.C. September 13, 1994.
"Remarks at the World Industry Summit." Stanford, California. September 18, 1994.
"Human Face of Urban Development," National Academy of Science. Washington, D.C. September 19, 1994.
Indira Gandhi Memorial Lecture. New Delhi, India. November 18, 1994.
Lynda Shaw Memorial Lecture, University of Western Ontario. London, Ontario. February 9, 1995.
"The United Nations at 50," Conference on the United Nations. Saskatoon, Saskatchewan. March 3, 1995.
SDPI-IUCN Distinguished Lecture. Islamabad, Pakistan. March 30, 1995.
"After Rio: The Question of International Institutional Reform." Ottawa, Ontario. March 1995.
"Cities and a Sustainable Earth," American Planning Association. Toronto, Ontario. April 9, 1995.
Commercial Markets Conference, Renewable Energy Trade Show. Ottawa, Ontario. April 10, 1995.
"Climate Change and the Need for Energy Efficiency." Berlin, Germany. April 12, 1995.
Remarks to Annual General Meeting, American Philosophical Society. Philadelphia, Pennsylvania. April 20, 1995.
Acceptance Speech for the Blue Planet Prize, presented by the Asahi Glass Foundation. Tokyo, Japan. April 30, 1995.
Notes for Statement at Meeting of United Nations Governing Council. Nairobi, Kenya. May 24, 1995.
"The United Nations in the 21st Century," Speech to UN Association. Washington, D.C. June 18, 1995.
"Competition, Customer Choice, and Convergence: A New Structure for Ontario's Electricity Industry." Huntsville, Ontario. July 4, 1995.
"The Engineer as Agent of Global Change." Snowbird, Utah. August 4, 1995.
"Environmental Stewardship and the New Parochialism," Acceptance Speech for 21st Century Award. St. Louis, Missouri. August 5, 1995.
"The New South Key to a Sustainable Future." London, England. September 8, 1995.
"Nuclear Power, Competition and Sustainable Development." London, England. September 8, 1995.
Pan American Congress on Health and the Environment. Washington, D.C. October 2, 1995.
"Servicing Innovative Financing of Environmentally Sustainable Development," Remarks to Joint Plenary Session on Ethics and Spiritual Values. Washington, D.C. October 2, 1995.
"Faith in Humanity: The Environmental Perspective," 25th Anniversary Larkin Stuart Lecture, Trinity College and St. Thomas's Anglican Church. Toronto, Ontario. October 5, 1995.
"From Human Environment to Sustainable Development," Stichting Ikea Foundation, Awards and Grants. Stockholm, Sweden. October 21, 1995.
"International Development Challenges," 25th Anniversary Dinner of the International Development Research Centre and launching of "Friends of Idre." Ottawa, Ontario. October 28, 1995.

"Local Initiatives: The Heart of the Sustainable Development Movement," Closing Plenary Session of the Second Biennial Iclei Council Meeting. Omiya, Japan. October 28, 1995.

"Making Our Civilization Sustainable in the 21st Century," School of Policy Studies, Kwansei University. Sanda, Japan. October 30, 1995.

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Statement to the Dubai International Conference on Best Practices in Improving the Living Environment. Dubai. November 6, 1995.

"Business and Education Driving Sustainable Development," Fourth International Research Conference on the Greening of Industry. Toronto, Ontario. November 13, 1995.

"Environmental Sustainability in the Travel and Tourism Industry," Caribbean Conference on Sustainable Tourism. Punta Cana Beach Resort, Dominican Republic. November 30, 1995.

Cerf International Research Symposium and Technology Showcase. Washington, D.C. February 8, 1996.

World Tourist and Travel Conference. London, England. March 11, 1996.

"Report on Business and Sustainable Development," Globe '96 Trade Fair and Conference. Vancouver, British Columbia. March 26, 1996.

"Why I Have Agreed to Come to the Congress," Opening Ceremony of 25th Iru Congress. Budapest, Hungary. May 23, 1996.

Habitat II Forum on Human Solidarity. Istanbul, Turkey. June 8, 1996.

Dinner for Energy Ministers of OECD Countries. Aarhus, Denmark. June 15, 1996.

North American Regional Meeting of Civicus. Toronto, Ontario. June 20, 1996.

North American Water and Environment Congress. Anaheim, California. June 26, 1996.

"Financing Sustainability Strategies," MIT Symposium. Cambridge, Massachusetts. September 5, 1996.

Korea Institute for International Foreign Policy. Seoul, Korea. October 22, 1996.

First Meeting of the International Advisory Board of Toyota Motor Corporation. October 24/5, 1996.

"The Ethical and Spiritual Values of Sustainable Development," Keynote Address to the U.S. National Conference of the Humane Society. Washington, D.C. November 17, 1996.

Winston Scott Memorial Lecture. Bridgetown, Barbados. November 25, 1996.

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