

Originally Processed With FOIA(s):
2005-0336-F

FOIA Number:
2005-0336-F

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Series: Bromley, D. Allan, Files
Subseries: Global Climate Change Files - Conferences/Meetings

OA/ID Number: 62055
Folder ID Number: 62055-006

Folder Title:
Global Warming: NOORDWIJK Publications [1989]

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THE NOORDWIJK DECLARATION ON ATMOSPHERIC POLLUTION
AND CLIMATIC CHANGE

(1) The composition of the earth's atmosphere is being seriously altered at an unprecedented rate due to human activity. Based on our current understanding, society is being threatened by man-made changes to the global climate.

(2) While there are still uncertainties regarding the magnitude, timing and regional effects of climate change due to human activity, there is a growing consensus in the scientific community that significant climate change and instability are most likely over the next century.

Predictions available today indicate potentially severe economic and social dislocations for future generations.

Assuming these predictions, delay in action may endanger the future of the planet as we know it.

(3) Fortunately, there is a growing awareness among the world population and their political leaders that action is needed. The basic principle of ecologically sustainable development has gained wide currency following the report of the World Commission on Environment and Development. This principle should be fundamental to efforts to tackle the problem of climate change and atmospheric pollution. The protection of the ozone layer is being addressed by the 1985 Vienna Convention on the Protection of the Ozone Layer and the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer. Further strengthening of control measures contained in the Protocol was called for at the London Conference on Saving the Ozone Layer in March 1989 and the first meeting of the parties to the Montreal Protocol at Helsinki in May 1989. A decision will be taken by the second meeting of the contracting parties to be held in London in 1990. The process aims at phasing out the production and consumption of chlorofluorocarbons (CFCs) controlled under the Montreal Protocol by the year 2000 by the developed countries. They should also phase out other controlled substances which deplete the ozone layer as soon as feasible. Developing countries should also phase out these substances as soon as possible after their technology and resource needs are met.

(4) Global warming is being addressed by the Intergovernmental Panel on Climate Change (IPCC), which was established by UNEP and WMO, and recognized by UN General Assembly Resolution 43/53 on Protection of global climate for present and future generations of mankind. The Hague Declaration of March 1989 put forward

challenging ideas for international co-operation, and legal and institutional measures. The 15th session of the UNEP Governing Council and the XLI session of the WMO Executive Council in 1989 requested their executive heads to begin preparations for negotiations on a framework convention on climate; these negotiations should be initiated as soon as possible after the interim report of the IPCC is adopted. This interim report will be reviewed at the Second World Climate Conference in November 1990. The 1989 Economic Summit agreed that a framework convention on climate change setting out general principles was urgently required and that specific protocols containing concrete commitments could be fitted into the framework as scientific evidence requires and permits. The Economic Summit also strongly advocated common efforts to limit emissions of carbon dioxide and other greenhouse gases. The July 1988 declaration of the states, parties to the Warsaw Treaty, and the meeting of non-aligned countries in Belgrade in September 1989 also addressed the issue of climate change. The Tokyo Conference on Global Environment and Human Response Towards Sustainable Development was held in September 1989. The Langkawi Declaration on Environment issued by the Commonwealth Heads of Governments in October 1989 stated the need to take new action to address the serious deterioration in the environment, including climate change. Given this base it is now time for governments of all countries to commit themselves to the IPCC, to strengthen and to extend the process of addressing climate change.

(5) Measures to limit climate change will have other significant benefits such as reducing acidification, protecting the ozone layer, preserving biodiversity and other natural resources, preventing mean sea-level change and promoting sustainable development.

(6) The Conference recognizes the principle of the sovereign right of States to manage their natural resources independently. The Conference also reaffirms that global environmental problems have to be approached through international co-operation. Solving the external debt problem of developing countries, and establishing fair economic and commercial relationships between industrialized and developing countries would assist developing countries in creating appropriate conditions to protect the environment.

(7) Climate change is a common concern of mankind. All countries should now, according to their capabilities and the means at their disposal, initiate actions and develop and maintain effective and operational strategies to control, limit or reduce emissions of greenhouse gases. As a first step, they should take those actions which are beneficial in their own right. Industrialized countries, in view of their contribution to the increase of greenhouse gas concentrations, and in view of their capabilities, have specific responsibilities of different kinds: i) they should set an example by initiating domestic action, ii) they should support, financially and otherwise, the action by countries to which the protection of the atmosphere and adjustment to climate change would prove to be an excessive burden and iii) they should reduce emissions of greenhouse gases, also taking into account the need of the developing countries to

have sustainable development. Developing countries establishing industrial facilities for the first time have a unique opportunity to include up-to-date technologies for controlling the emissions of greenhouse gases.

(8) For the long term safeguarding of our planet and maintaining its ecological balance, joint effort and action should aim at limiting or reducing emissions and increasing sinks for greenhouse gases to a level consistent with the natural capacity of the planet. Such a level should be reached within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and permit economic activity to develop in a sustainable and environmentally sound manner. Stabilizing the atmospheric concentrations of greenhouse gases is an imperative goal. The IPCC will need to report on the best scientific knowledge as to the options for containing climate change within tolerable limits. Some currently available estimates indicate that this could require a reduction of global anthropogenic greenhouse gas emissions by more than 50 per cent. These estimates should be the subject of further examination by the IPCC.

(9) While striving to preserve the global environment, it is important to work at the same time to ensure stable development of the world economy, in line with the concept of "sustainable development". Effort and action should include: i) the phasing-out of CFCs controlled by the Montreal Protocol, which are responsible for about one fifth of projected global warming, by national action and international co-operation in the context of the Montreal Protocol. This includes financial assistance and transfer of technology and information. In this connection, it is important that the substitutes for CFCs also should not contribute significantly to the global warming problem, ii) action especially by industrialized countries to limit or reduce CO₂-emissions, iii) action to reduce deforestation, prevent soil erosion and desertification; increase afforestation, and sound forest management in the temperate as well as the tropical zones, iv) action to limit or reduce the emissions of all greenhouse gases other than CO₂ and their precursors and to increase the sinks for such substances and v) intensified efforts for technological breakthroughs, for example with regards to renewable energy and removal and re-utilization of CO₂.

(10) The conference recommends that appropriate fora, including the IPCC, consider the necessity and efficiency of the introduction of the concept of CO₂-equivalence. This would provide a single parameter to describe the radiative effects of the various greenhouse gases, including CFCs. Such a concept, after taking into account other environmental considerations, creates a basis for negotiations in response measures for different greenhouse gases in the most cost-effective manner. The Conference further recommends the development of common definitions and the harmonization of methods to calculate CO₂-emissions.

(11) All countries should increase co-operation in developing new, environmentally sound technologies, to improve existing technologies and increasingly to use these technologies in order

to limit climate change or adapt to it. Maximum use should be made of existing international organizations, institutions and mechanisms, governmental and non-governmental, for technology co-operation with and transfer to interested countries, especially developing countries. Factors that impede effective transfer of appropriate technologies should be identified and measures implemented to overcome these impediments.

(12) Progress in reducing atmospheric pollution depends not only on technical and economic issues but also on attitudinal and conceptual changes. All countries, especially industrialized countries, should recognize the need to make their socio-economic activities and life-styles environmentally sound. Improved dissemination of information and better training of personnel is needed, both at the national and international level. Public awareness programmes, including school curricula, should include the issue of climate change and its connection with the way individuals use energy and other natural resources. Wider public awareness can be supported by increased scientific evidence arising from systematic research and monitoring activities. The Conference calls upon the non-governmental organizations to participate, in co-operation with international, regional and national authorities, in the efforts that are needed to respond to the problems of global warming, more specifically in the field of education and awareness building.

(13) Many countries, especially developing countries will require assistance in identifying the causes of anthropogenic climate change, in establishing its extent and effect and also in responding to it. They will need help in acquiring, using, developing and maintaining technologies that are appropriate to their industrial, energy, transport, forestry and agricultural infrastructure. Industrialized countries will take steps to facilitate the transfer to developing countries of technologies to limit the global climate change through financial assistance and other mechanisms to overcome the incremental costs of acquiring and using these technologies. Furthermore, the capabilities of these countries should be increased so that they can develop appropriate technologies themselves. In this context the concept of assured access to appropriate technologies in relation to proprietary rights needs to be explored.

Given this stage of development of the issue of climate change, the Conference more specifically:

CARBON DIOXIDE (CO₂)

- (14) Urges all countries to take steps individually and collectively, to promote better energy conservation and efficiency and the use of environmentally sound energy sources, practices and technologies with no or minimum environmentally damaging characteristics. These policies should be reflected in short and long term energy policies and be pursued by all relevant sectors, including industry and transport, taking into account the need of developing countries for an adaptation period in order to enable them to meet their technological and other developmental needs. One direct means of allowing markets to incorporate the risk of climate change could be to ensure that the prices of all

fuels reflect their full social, long run marginal and environmental costs and benefits.

- (15) Agrees that it is timely to investigate quantitative emission targets to limit or reduce CO₂ emissions and encourages the IPCC, in their interim report due in 1990, to include an analysis of target options.
- (16) Recognizes the need to stabilize, while ensuring stable development of the world economy, CO₂ emissions and emissions of other greenhouse gases not controlled by the Montreal Protocol. Industrialized nations agree that such stabilization should be achieved by them as soon as possible, at levels to be considered by the IPCC and the Second World Climate Conference of November 1990. In the view of many industrialized nations such stabilization of CO₂ emissions should be achieved as a first step at the latest by the year 2000.
Urges all industrialized countries to support the process of IPCC through the investigation of the feasibility of achieving targets to limit or reduce CO₂ emissions including e.g. a 20 per cent reduction of CO₂ emission levels by the year 2005 as recommended by the scientific World Conference on the Changing Atmosphere in Toronto 1988.
Urges all industrialized countries to intensify their efforts in this respect, while ensuring sustainable development and taking into account the specific circumstances of individual countries.
- (17) Agrees that industrialized countries with, as yet, relatively low energy requirements, which can reasonably be expected to grow in step with their development, may have targets that accommodate that development.
- (18) Calls on the IPCC to present the analysis and conclusions referred to above to the Second World Climate Conference in November 1990.
- (19) Agrees that developing countries endeavour to meet future targets for CO₂-emissions and sinks, with due regard to their development requirements and within the limits of their financial and technical capabilities. International co-operation, whenever available, would be a contributing factor for greater action. New processes or industries to be introduced should, as far as possible, incorporate technologies which are more energy-efficient and produce less pollution than present technologies.
- (20) Agrees that developing countries will need to be assisted financially and technically, including assistance with training, i.e. by strengthening relevant mechanisms to ensure that they will be in a position to manage, develop, and conserve their forest resources in a sustainable and environmentally sound manner. This will also contribute to combatting erosion and desertification. Recognition by the market of the total value of forests, including non-wood values, is a precondition for developing countries' being able to successfully use such financial and technical

assistance for sustainable forest management.

- (21) Agrees to pursue a global balance between deforestation on the one hand and sound forest management and afforestation on the other. A world net forest growth of 12 million hectares a year in the beginning of next century should be considered as a provisional aim. Requests the IPCC to consider the feasibility of achieving this aim. To this end; the world deforestation rate should be slowed inter alia through the suppression of acid rain and other pollutants and of fires and through the reduction of pressures on biota. Sound forest management practices should be encouraged and at the same time vigorous forestry programmes should be developed in both temperate and tropical zones; biological diversity should be maintained; strategies addressing climate change issues through forest management and afforestation should be integrated with strategies addressing the sustainability of other forest based values resulting in full multiple-use plans where appropriate, but with due consideration of the people living in or dependent on forest land. Welcomes the work of the Tropical Forestry Action Plan and the International Timber Trade Organisation in pursuit of these goals.

CHLOROFLUOROCARBONS (CFCs)

- (22) Welcomes the commitment of the industrialized countries to amend the Montreal Protocol and to phase out the production and consumption of controlled chlorofluorocarbons by the year 2000, and of other controlled ozone depleting substances as soon as feasible. Urges all countries to become Parties to the Vienna Convention for the Protection of the Ozone Layer and to the Montreal Protocol. To facilitate this broad participation suitable amendments of the Montreal Protocol should be considered urgently by the Parties to the Protocol. Urges industrialized countries to use financial and other means to assist developing countries in phasing out their production and consumption of controlled substances as soon as possible, by providing them with sufficient means to enable them to meet their target date. The development of alternative technologies and products in developing countries should be promoted.

OTHER GREENHOUSE GASES

- (23) Recommends that the development and implementation of specific means of limiting the atmospheric concentrations of greenhouse gases other than CO₂ and CFCs should be energetically pursued, taking into consideration the special situation of developing countries.

MINISTERIAL MEETING

- (24) Recognizes the need to convene a Ministerial Conference to review the interim report of the IPCC. The conference endorses the plan of the organization by WMO, UNEP, UNESCO and ICSU of such a meeting as part of the Second World Climate Conference in November 1990.

FUNDING

- (25) *Recommends* that existing institutions for development and financial assistance including the Multilateral Development Banks, Bilateral Assistance Programmes, the relevant United Nations organisations and specialized agencies, and scientific and technological organisations should give greater attention to climate change issues within their environmental and other relevant programmes by providing expanded funding including concessional funding. In addition, regional and subregional co-operation should be reinforced and funded so as to address and implement the required action at that level.

- (26) *Recommends* that additional resources should, over time, be mobilized to help developing countries take the necessary measures to address climate change and that are compatible with their development requirements. Further *recommends* that the scope of resources needed must be assessed. Such assessments should include inter alia country studies and the capabilities of existing institutions and mechanisms to meet the financing needs identified, similar to the approaches developed under the Montreal Protocol. Further consideration should be given to the need for funding facilities including a clearinghouse mechanism and a possible new international fund and their relationship to existing funding mechanisms, both multilateral and bilateral. Such funding should be related to the implementation of a future climate convention and associated protocols. In the meantime the donor community is urged to provide assistance to developing countries to support actions addressing climate change.

- (27) *Recommends* that, initially, international funding be directed towards
 - (i) funding of a CFC phase-out in developing countries in the context of the Montreal Protocol;
 - (ii) promoting efficient use of energy, including appropriate end use technologies, increasing the use of non-fossil fuels and switching to energy sources with lower greenhouse gas emissions, and the use of renewable energy sources;
 - (iii) increased financial support for forest protection and forest management improvement, for example through the Tropical Forestry Action Plan (TFAP), the Plan of Action to Combat Desertification, the International Tropical Timber Organization (ITTO) and other relevant international organizations;
 - (iv) assisting developing countries in planning how to address problems posed by climate change;
 - (v) supporting developing countries to enable their participation in the IPCC process and the other international meetings on this subject;
 - (vi) conducting research and monitoring;
 - (vii) arranging for technology transfer to and technology development in developing countries;
 - (viii) promoting public awareness, education and institutional and manpower development.

The use of financial resources could subsequently be extended inter alia to major energy sources with little or no environmentally damaging characteristics and for steps to reduce other global man-made emissions of greenhouse gases.

RESEARCH AND MONITORING

- (28) Urges all countries and relevant organizations to increase their climate change research and monitoring activities and to provide for adequate data bases on emissions. Also urges states to co-operate in, and provide increasing support for, international co-ordination of these activities building on international programmes such as the World Climate Programme and the International Geosphere Biosphere Programme, and on the present roles of the UNEP, WMO, ICSU, IEA, UNESCO, IOC, IGBP and other competent international organizations and bodies. The enhancement and strengthening of operational aspects of their work should be examined.
Recommends that more research should be carried out by 1992 into the sources and sinks of the greenhouse gases other than CO₂ and CFCs, like methane (CH₄), nitrous oxide (N₂O) and tropospheric ozone (O₃), including further research on the effect of the ocean on the concentration of radiatively active gases in the atmosphere.

CLIMATE CHANGE CONVENTION

- (29) 1. Urges all countries to join and intensify the ongoing work within UNEP and WMO through the IPCC with respect to the compilation of elements for a framework convention on climate change so that negotiations upon it can start as soon as possible after the adoption of the interim report of the IPCC.
- 2. *Recommends* that such convention will be framed in such a way as to gain the adherence of the largest possible number and most suitably balanced spread of countries.
- 3. Agrees that to this end the framework convention and associated protocols should commit the parties inter alia to:
 - enhancement of research and systematic observation of climate, aimed at detecting and monitoring climate variations and change;
 - action to deal with greenhouse gas emissions and the effects of global warming;
 - address the particular financial needs of the developing countries in the access to and transfer of technology; and
 - strengthen sustainable forest management.
- 4. Agrees further that in developing the framework convention on climate change special attention should be given to ensuring that provision is made for appropriate decision making procedures and powers.
- 5. Urges all involved or to be involved in the negotiations to do their utmost to conclude these negotiations to ensure adoption of the convention as early as 1991 if possible and no later than at

the Conference of the United Nations on Environment and Development in 1992.

6. *Considers* that in the preparation of the framework convention and protocols the relevant aspects of the Vienna Convention on the Protection of the Ozone Layer should be taken into account, as well as innovative approaches as may be required by the complex character of the problem.

- (30) *Recommends* that this declaration and the supporting papers be conveyed to the IPCC at the conclusion of this Conference for further consideration and action.



THE NOORDWIJK DECLARATION ON CLIMATE CHANGE

ATMOSPHERIC POLLUTION AND CLIMATIC CHANGE
MINISTERIAL CONFERENCE HELD AT NOORDWIJK,
THE NETHERLANDS ON 6TH AND 7TH NOVEMBER 1989

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INTRODUCTION

THE NOORDWIJK DECLARATION ON CLIMATE CHANGE

LIST OF PARTICIPATING COUNTRIES AND ORGANIZATIONS

NOVEMBER 1989

THE NOORDWIJK DECLARATION ON CLIMATE CHANGE

(1) The composition of the earth's atmosphere is being seriously altered at an unprecedented rate due to human activity. Based on our current understanding, society is being threatened by man-made changes to the global climate.

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Assuming these predictions, delay in action may endanger the future of the planet as we know it.

(3) Fortunately, there is a growing awareness among the world population and their political leaders that action is needed. The basic principle of ecologically sustainable development has gained wide currency following the report of the World Commission on Environment and Development. This principle should be fundamental to efforts to tackle the problem of climate change and atmospheric pollution. The protection of the ozone layer is being addressed by the 1985 Vienna Convention on the Protection of the Ozone Layer and the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer. Further strengthening of control measures contained in the Protocol was called for at the London Conference on Saving the Ozone Layer in March 1989 and the first meeting of the parties to the Montreal Protocol at Helsinki in May 1989. A decision will be taken by the second meeting of the contracting parties to be held in London in 1990. The process aims at phasing out the production and consumption of chlorofluorocarbons (CFCs) controlled under the Montreal Protocol by the year 2000 by the developed countries. They should also phase out other controlled substances which deplete the ozone layer as soon as feasible. Developing countries should also phase out these substances as soon as possible after their technology and resource needs are met.

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(5) Measures to limit climate change will have other significant benefits such as reducing acidification, protecting the ozone layer, preserving biodiversity and other natural resources, preventing mean sea-level change and promoting sustainable development.

(6) The Conference recognizes the principle of the sovereign right of States to manage their natural resources independently. The Conference also reaffirms that global environmental problems have to be approached through international co-operation. Solving the external debt problem of developing countries, and establishing fair economic and commercial relationships between industrialized and developing countries would assist developing countries in creating appropriate conditions to protect the environment.

(7) Climate change is a common concern of mankind. All countries should now, according to their capabilities and the means at their disposal, initiate actions and develop and maintain effective and operational strategies to control, limit or reduce emissions of greenhouse gases. As a first step, they should take those actions which are beneficial in their own right. Industrialized countries, in view of their contribution to the increase of greenhouse gas concentrations, and in view of their capabilities, have specific responsibilities of different kinds: i) they should set an example by initiating domestic action, ii) they should support, financially and otherwise, the action by countries to which the protection of the atmosphere and adjustment to climate change would prove to be an excessive burden and iii) they should reduce emissions of greenhouse gases, also taking into account the need of the developing countries to have sustainable development. Developing countries establishing industrial facilities for the first time have a unique opportunity to include up-to-date technologies for controlling the emissions of greenhouse gases.

(8) For the long term safeguarding of our planet and maintaining its ecological balance, joint effort and action should aim at limiting or reducing emissions and increasing sinks for greenhouse gases to a level consistent with the natural capacity of the planet. Such a level should be reached within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and permit economic activity to develop in a sustainable and environmentally sound manner. Stabilizing the atmospheric concentrations of greenhouse gases is an imperative goal. The

IPCC will need to report on the best scientific knowledge as to the options for containing climate change within tolerable limits. Some currently available estimates indicate that this could require a reduction of global anthropogenic greenhouse gas emissions by more than 50 per cent. These estimates should be the subject of further examination by the IPCC.

(9) While striving to preserve the global environment, it is important to work at the same time to ensure stable development of the world economy, in line with the concept of "sustainable development". Effort and action should include: i) the phasing-out of CFCs controlled by the Montreal Protocol, which are responsible for about one fifth of projected global warming, by national action and international co-operation in the context of the Montreal Protocol. This includes financial assistance and transfer of technology and information. In this connection, it is important that the substitutes for CFCs also should not contribute significantly to the global warming problem, ii) action especially by industrialized countries to limit or reduce CO₂-emissions, iii) action to reduce deforestation, prevent soil erosion and desertification; increase afforestation, and sound forest management in the temperate as well as the tropical zones, iv) action to limit or reduce the emissions of all greenhouse gases other than CO₂ and their precursors and to increase the sinks for such substances and v) intensified efforts for technological breakthroughs, for example with regards to renewable energy and removal and re-utilization of CO₂.

(10) The conference recommends that appropriate fora, including the IPCC, consider the necessity and efficiency of the introduction of the concept of CO₂-equivalence. This would provide a single parameter to describe the radiative effects of the various greenhouse gases, including CFCs. Such a concept, after taking into account other environmental considerations, creates a basis for negotiations in response measures for different greenhouse gases in the most cost-effective manner. The Conference further recommends the development of common definitions and the harmonization of methods to calculate CO₂-emissions.

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(12) Progress in reducing atmospheric pollution depends not only on technical and economic issues but also on attitudinal and conceptual changes. All countries, especially industrialized countries, should recognize the need to make their socio-economic activities and life-styles environmentally sound. Improved dissemination of information and better training of personnel is needed, both at the national and international level. Public awareness programmes, including school curricula, should include the issue of climate change and its connection with the way individuals use energy and other natural resources. Wider public awareness can be supported by increased scientific evidence arising from systematic research and monitoring activities. The Conference calls upon the non-governmental organizations to participate, in co-operation with international, regional and national authorities, in the efforts that are needed to respond to the problems of global warming, more specifically in the field of education and awareness building.

(13) Many countries, especially developing countries will require assistance in identifying the causes of anthropogenic climate change, in establishing its extent and effect and also in responding to it. They will need help in acquiring, using, developing and maintaining technologies that are appropriate to their industrial, energy, transport, forestry and agricultural infrastructure. Industrialized countries will take steps to facilitate the transfer to developing countries of technologies to limit the global climate change through financial assistance and other mechanisms to overcome the incremental costs of acquiring and using these technologies. Furthermore, the

capabilities of these countries should be increased so that they can develop appropriate technologies themselves. In this context the concept of assured access to appropriate technologies in relation to proprietary rights needs to be explored.

Given this stage of development of the issue of climate change, the Conference more specifically:

CARBON DIOXIDE (CO₂)

- (14) Urges all countries to take steps individually and collectively, to promote better energy conservation and efficiency and the use of environmentally sound energy sources, practices and technologies with no or minimum environmentally damaging characteristics. These policies should be reflected in short and long term energy policies and be pursued by all relevant sectors, including industry and transport, taking into account the need of developing countries for an adaptation period in order to enable them to meet their technological and other developmental needs. One direct means of allowing markets to incorporate the risk of climate change could be to ensure that the prices of all fuels reflect their full social, long run marginal and environmental costs and benefits.
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Urges all industrialized countries to support the process

of IPCC through the investigation of the feasibility of achieving targets to limit or reduce CO₂ emissions including e.g. a 20 per cent reduction of CO₂ emission levels by the year 2005 as recommended by the scientific World Conference on the Changing Atmosphere in Toronto 1988.

Urges all industrialized countries to intensify their efforts in this respect, while ensuring sustainable development and taking into account the specific circumstances of individual countries.

- (17) Agrees that industrialized countries with, as yet, relatively low energy requirements, which can reasonably be expected to grow in step with their development, may have targets that accommodate that development.
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- (20) Agrees that developing countries will need to be assisted financially and technically, including assistance with training, i.a. by strengthening relevant mechanisms to ensure that they will be in a position to manage, develop, and conserve their forest resources in a sustainable and environmentally sound manner. This will also contribute to combatting erosion and desertification. Recognition by the market of the total value of forests, including non-wood values, is a precondition for developing countries' being able to successfully use such financial and technical assistance for sustainable forest management.

- (21) Agrees to pursue a global balance between deforestation on the one hand and sound forest management and afforestation on the other. A world net forest growth of 12 million hectares a year in the beginning of next century should be considered as a provisional aim.

Requests the IPCC to consider the feasibility of achieving this aim. To this end; the world deforestation rate should be slowed inter alia through the suppression of acid rain and other pollutants and of fires and through the reduction of pressures on biota. Sound forest management practices should be encouraged and at the same time vigorous forestry programmes should be developed in both temperate and tropical zones; biological diversity should be maintained; strategies addressing climate change issues through forest management and afforestation should be integrated with strategies addressing the sustainability of other forest based values resulting in full multiple-use plans where appropriate, but with due consideration of the people living in or dependent on forest land.

Welcomes the work of the Tropical Forestry Action Plan and the International Timber Trade Organisation in pursuit of these goals.

CHLOROFLUOROCARBONS (CFCs)

- (22) *Welcomes* the commitment of the industrialized countries to amend the Montreal Protocol and to phase out the production and consumption of controlled chlorofluorocarbons by the year 2000, and of other controlled ozone depleting substances as soon as feasible. *Urges* all countries to become Parties to the Vienna Convention for the Protection of the Ozone Layer and to the Montreal Protocol. To facilitate this broad participation suitable amendments of the Montreal Protocol should be considered urgently by the Parties to the Protocol. *Urges* industrialized countries to use financial and other means to assist developing countries in phasing out their production and consumption of controlled substances as soon as possible, by providing them with sufficient means to enable them to meet their target date. The development of

alternative technologies and products in developing countries should be promoted.

OTHER GREENHOUSE GASES

- (23) *Recommends* that the development and implementation of specific means of limiting the atmospheric concentrations of greenhouse gases other than CO₂ and CFCs should be energetically pursued, taking into consideration the special situation of developing countries.

MINISTERIAL MEETING

- (24) *Recognizes* the need to convene a Ministerial Conference to review the interim report of the IPCC. The conference endorses the plan of the organization by WMO, UNEP, UNESCO and ICSU of such a meeting as part of the Second World Climate Conference in November 1990.

FUNDING

- (25) *Recommends* that existing institutions for development and financial assistance including the Multilateral Development Banks, Bilateral Assistance Programmes, the relevant United Nations organisations and specialized agencies, and scientific and technological organisations should give greater attention to climate change issues within their environmental and other relevant programmes by providing expanded funding including concessional funding. In addition, regional and subregional co-operation should be reinforced and funded so as to address and implement the required action at that level.
- (26) *Recommends* that additional resources should, over time, be mobilized to help developing countries take the necessary measures to address climate change and that are compatible with their development requirements.

Further *recommends* that the scope of resources needed must be assessed. Such assessments should include inter alia country studies and the capabilities of existing institutions and mechanisms to meet the financing needs identified, similar to the approaches developed under the Montreal Protocol.

Further consideration should be given to the need for funding facilities including a clearinghouse mechanism and a possible new international fund and their relationship to existing funding mechanisms, both multilateral and bilateral. Such funding should be related to the implementation of a future climate convention and associated protocols. In the meantime the donor community is urged to provide assistance to developing countries to support actions addressing climate change.

- (27) *Recommends* that, initially, international funding be directed towards
 - (i) funding of a CFC phase-out in developing countries in the context of the Montreal Protocol;
 - (ii) promoting efficient use of energy, including appropriate end use technologies, increasing the use of non-fossil fuels and switching to energy sources with lower greenhouse gas emissions, and the use of renewable energy sources;
 - (iii) increased financial support for forest protection and forest management improvement, for example through the Tropical Forestry Action Plan (TFAP), the Plan of Action to Combat Desertification, the International Tropical Timber Organization (ITTO) and other relevant international organizations;
 - (iv) assisting developing countries in planning how to address problems posed by climate change;
 - (v) supporting developing countries to enable their participation in the IPCC process and the other international meetings on this subject;
 - (vi) conducting research and monitoring;
 - (vii) arranging for technology transfer to and technology development in developing countries;
 - (viii) promoting public awareness, education and institutional and manpower development.

The use of financial resources could subsequently be extended inter alia to major energy sources with little or no environmentally damaging characteristics and for steps to reduce other global man-made emissions of greenhouse gases.

RESEARCH AND MONITORING

- (28) *Urges* all countries and relevant organizations to increase their climate change research and monitoring activities and to provide for adequate data bases on emissions. Also *urges* states to co-operate in, and provide increasing support for, international co-ordination of these activities building on international programmes such as the World Climate Programme and the International Geosphere-Biosphere Programme, and on the present roles of the UNEP, WMO, ICSU, IEA, UNESCO, IOC, and other competent international organizations and bodies. The enhancement and strengthening of operational aspects of their work should be examined.

Recommends that more research should be carried out by 1992 into the sources and sinks of the greenhouse gases other than CO₂ and CFCs, like methane (CH₄), nitrous oxide (N₂O) and tropospheric ozone (O₃), including further research on the effect of the ocean on the concentration of radiatively active gases in the atmosphere.

CLIMATE CHANGE CONVENTION

- (29) 1. *Urges* all countries to join and intensify the ongoing work within UNEP and WMO through the IPCC with respect to the compilation of elements for a framework convention on climate change so that negotiations upon it can start as soon as possible after the adoption of the interim report of the IPCC.
- 2. *Recommends* that such convention will be framed in such a way as to gain the adherence of the largest possible number and most suitably balanced spread of countries.
- 3. *Agrees* that to this end the framework convention and associated protocols should commit the parties inter alia to:
 - enhancement of research and systematic observation of climate, aimed at detecting and monitoring climate variations and change;

- action to deal with greenhouse gas emissions and the effects of global warming;
 - address the particular financial needs of the developing countries in the access to and transfer of technology; and
 - strengthen sustainable forest management.
4. Agrees further that in developing the framework convention on climate change special attention should be given to ensuring that provision is made for appropriate decision making procedures and powers.
5. Urges all involved or to be involved in the negotiations to do their utmost to conclude these negotiations to ensure adoption of the convention as early as 1991 if possible and no later than at the Conference of the United Nations on Environment and Development in 1992.
6. Considers that in the preparation of the framework convention and protocols the relevant aspects of the Vienna Convention on the Protection of the Ozone Layer should be taken into account, as well as innovative approaches as may be required by the complex character of the problem.
- (30) Recommends that this declaration and the supporting papers be conveyed to the IPCC at the conclusion of this Conference for further consideration and action.

LIST OF PARTICIPATING COUNTRIES

Argentina
Australia
Austria
Bangladesh
Belgium

Bolivia
Brazil
Bulgaria
Cameroon
Canada

China
Colombia
Costa Rica
Cuba
Denmark

Egypt
Finland
France
Gambia
German Democratic Republic

Germany, Federal Republic of
Ghana
Greece
Guinea
Hungary

India
Indonesia
Ireland
Israel
Ivory Coast

Italy
Jamaica
Japan
Jordan
Kenya

Luxembourg
Malaysia
Mali
Malta
Mexico

Netherlands, Kingdom of the
New Zealand
Nigeria
Norway
Pakistan

Philippines
Poland
Portugal
Republic of Korea
Saudi Arabia

Senegal
Spain
Sweden
Switzerland
Thailand

Trinidad and Tobago
Tunisia
Turkey
United States of America
Union of Soviet Socialist Republics

United Kingdom of Great Britain and Northern Ireland
United Republic of Tanzania
Venezuela
Yugoslavia
Zaire

Zambia
Zimbabwe

Commission of European Communities and International Organizations

Commission of European Communities

Food and Agriculture Organization
International Atomic Energy Agency
International Energy Agency
Organization for Economic Cooperation and Development
United Nations Development Program

United Nations Education, Scientific and Cultural Organization
United Nations Industrial Development Organization
United Nations Environment Program
World Meteorological Organization
World Bank

The Ministerial Conference, organized
by the Minister of Housing, Physical
Planning and Environment of The
Netherlands in cooperation with
UNEP and WMO.

Climate conference secretariat:
P.O. Box 450
2260 MB Leidschendam
Tel. 31 70209367, ext. 2125
Telex nr. 32 362 VROM NL
Telefax nr. 31 70 201858

VROM 90642/11-8
7704/126



BACKGROUND PAPER ON ELEMENTS OF AN INTERNATIONAL CONVENTION ON CLIMATE

OCTOBER 1989

FOR THE MINISTERIAL CONFERENCE ON
ATMOSPHERIC POLLUTION AND CLIMATIC CHANGE,
WITH PARTICULAR ATTENTION TO GLOBAL WARMING 6TH AND 7TH NOVEMBER 1989

THIS PAPER WAS PREPARED BY THE REPRESENTATIVES
OF CANADA AND MALTA
FOR THE RELEVANT WORKING GROUP
OF THE INTERNATIONAL STEERING COMMITTEE
WORKING ON BEHALF OF THE MINISTERIAL CONFERENCE
THE VIEWS EXPRESSED DO NOT NECESSARILY
REFLECT THE POLICY OR OPINIONS OF
THE GOVERNMENTS REPRESENTED IN THE WORKING GROUP

BACKGROUND PAPER ON ELEMENTS OF
AN INTERNATIONAL CONVENTION ON CLIMATE

BACKGROUND PAPER - SUMMARY

'Elements of an International Convention on Climate'

This paper covers the major elements that could be included in a future climate convention. After a suitable Preamble, including suitable references to various Treaties, Rights and Principles; and certain definitions of climate and climate change etc. the following points are covered by paragraphs in the Convention.

- * Measures to limit, reduce and, as far as possible, prevent climate change - parties would agree to take all appropriate measures for this purpose, including the development and implementation of appropriate policies and strategies;
- * Duty not to transform adverse effects on the climate into any other adverse environmental or health effects;
- * Bilateral, multilateral and regional agreements or arrangements - provided that they are not incompatible with the Convention;
- * General cooperation obligation;
- * Exchange of information - to encourage the exchange of scientific, technological, socio-economic and other information, and protect its confidentiality;
- * Research and systematic observations - this article would deal with the collection and transmission of such data, research and assessments;
- * Development and transfer of technology - and the provision of technical assistance, particularly bearing in mind the needs of the developing countries;
- * Prior notice and environmental impact assessment of planned activities;
- * Consultations - between both Parties whose activities may cause climate change and the Secretariat;
- * World Atmosphere and Climate Fund - a Protocol to establish such a Fund for use in initiating and supporting activities to limit, reduce, and prevent, as well as to adapt to climate change;
- * Transmission of information;
- * Assessment and review of limitation, reduction and prevention measures;
- * Monitoring implementation of the Convention;
- * Conference of the Parties;
- * Secretariat - this article would deal with the functions of the Secretariat;
- * Adoption of Protocols;
- * Amendment of the Convention or Protocols;
- * Adoption and Amendment of Annexes;
- * Peaceful settlement of disputes - leaving open various dispute settlement procedures;
- * Usual final clauses, as in the Vienna Ozone Layer Convention - signature; ratification, acceptance or approval; accession; right to vote; relationship between the Convention and its Protocols; entry into force; reservations; withdrawal; depositary; authentic texts.

(Cover note)

STEERING COMMITTEE WORKING GROUP
ELEMENTS OF A FUTURE CLIMATE CONVENTION

With reference to Article 3 (Measures to limit, reduce and, as far as possible, prevent climate change) the Conference may wish to consider an additional element to provide for stabilization of CO₂ emissions.

With reference to Article 16 (Conference of the Parties), this Article would provide for the creation of the Executive Committee charged with tasks to be carried out between sessions/meetings of the Conference of the Parties. Alternatively, this may be the subject of a separate Element.

This is without prejudice to either party to propose further or alternative elements at a later stage.

ELEMENTS FOR AN INTERNATIONAL CONVENTION ON CLIMATE

1. The Preamble would contain suitable references to:
 - UNGA Resolution 43/53
 - Principle 21 of the Stockholm Declaration
 - The ENMOD Treaty
 - The Fundamental Right to an environment of a quality that permits a life of dignity and well-being
2. Definitions

This section would include, inter alia, definitions of "Climate" and "Climate Change", for the purposes of the Convention.
3. Measures to limit, reduce and, as far as possible, prevent climate change

Parties would agree to take all appropriate measures for this purpose, including the development and implementation of appropriate policies and strategies.
4. Duty not to transform adverse effects on the climate into any other adverse environmental or health effects

Parties would undertake to act, as far as possible, so as not to so transform adverse effects on the climate.
5. Bilateral, multilateral and regional agreements or arrangements

This article allows Parties to enter into such agreements or arrangements, provided that they are not incompatible with the Convention.
6. General co-operation obligation

States would co-operate in the implementation of measures as stated above.

7. Exchange of information

Parties would facilitate and encourage the exchange of scientific, technological, socio-economic and other information, and protect its confidentiality where applicable.

8. Research and systematic observations

This article would deal with the collection and transmission of such data, research and assessments.

A list of relative items would be elaborated, possibly by means of an Annex.

9. Development and transfer of technology

Parties would co-operate in facilitating the development and transfer of relevant technologies and the provision of technical assistance, particularly bearing in mind the needs of the developing countries.

10. Prior notice and environmental impact assessment of planned activities

Initial action to be taken when a Party has reason to believe that its planned activities may result in climate change.

11. Consultations

Between, on the one hand, Parties whose activities may cause climate change and, on the other hand, the Secretariat, the relevant international organisations, and other interested parties.

12. World Atmosphere and Climate Fund

Parties would consider a Protocol to establish such a Fund for use in initiating and supporting activities to limit, reduce, and prevent, as well as to adapt to, climate change, and possibly to eventually extend the application of this Fund to certain other atmospheric alterations.

13. Transmission of information

Information on implementation measures adopted by Parties would be transmitted to the Conference of the Parties, through the Secretariat.

14. Assessment and review of limitation, reduction and prevention measures

Time-table for assessment of measures by the Parties.

15. Monitoring implementation of the Convention

The Parties would consider procedures and institutional mechanisms for monitoring implementation.

16. Conference of the Parties

Establishment of the Conference of the Parties, on the lines of the Vienna Ozone Layer Convention.

17. Secretariat

This article would deal with the functions of the Secretariat, also on the lines of the Vienna Ozone Layer Convention.

18. Adoption of Protocols

This article would provide for adoption of Protocols to the Convention.

19. Amendment of the Convention or Protocols

This provision would mirror that of the Vienna Ozone Layer Convention.

20. Adoption and Amendment of Annexes

This provision would mirror that of the Vienna Ozone Layer Convention.

21. Peaceful settlement of disputes

This Article would be modelled on the lines of the relevant section of the Statement of the Meeting of Legal and Policy Experts in Ottawa, February 1989, leaving open various dispute settlement procedures.

22. Usual final clauses, as in the Vienna Ozone Layer Convention

- Signature
- Ratification, Acceptance or Approval
- Accession
- Right to Vote
- Relationship between the Convention and its Protocols
- Entry into Force
- Reservations
- Withdrawal
- Depositary
- Authentic Texts

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Telefax nr. 31 70 201858



BACKGROUND PAPER ON CLIMATE, ENVIRONMENT AND DEVELOPMENT

OCTOBER 1989

FOR THE MINISTERIAL CONFERENCE ON
ATMOSPHERIC POLLUTION AND CLIMATIC CHANGE,
WITH PARTICULAR ATTENTION TO GLOBAL WARMING 6TH AND 7TH NOVEMBER 1989

THIS PAPER WAS PREPARED BY
J. VAN ETTINGER, T. H. JANSEN AND PROF. DR. C. J. JEPMA
FOR THE RELEVANT WORKING GROUP
OF THE INTERNATIONAL STEERING COMMITTEE
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BACKGROUND PAPER ON CLIMATE,
ENVIRONMENT AND DEVELOPMENT

BACKGROUND PAPER - SUMMARY

'Climate, Environment and Development'

This paper deals with global "climate" related problems of the "environment", with special attention to the effects on "development. In doing so, no attempt will be made to contribute to a further understanding of the functioning of the global climate system as such, nor of the measures required to address the increasingly urgent problem of development as a whole. Measures to be proposed, however, will aim at protecting the global climate and, thus, at safeguarding an essential condition for sustainable development.

One of the most important global climate problems is the "greenhouse effect" - rising global surface temperatures and sea levels, and more frequent droughts, hurricanes and floods - due to increasing atmospheric concentrations of carbon dioxide (CO₂) and of other greenhouse gases. The world's climatologists have reached near consensus that some global warming will be inevitable, even if the emissions of greenhouse gases would be so reduced that their atmospheric concentrations would eventually be stabilized at acceptable levels.

Given the long lead times for effective measures, the initiation of action cannot wait until remaining uncertainties as to time, place and extent of the greenhouse effect have been resolved. In view of these uncertainties, however, any course of action should not only be long-term and global but also highly flexible in character. This paper will discuss measures to mitigate the - as yet insufficiently predictable - impacts of climate change as well as measures to reduce net emissions of greenhouse gases.

As to costs of these measures the following guiding principles will be applied:

- the industrialized countries, because of past emissions, carry a special responsibility for the greenhouse problem;
- its eventual solution can, however, only be achieved through cooperation between industrialized and developing countries; and
- longer term sustainable global development should not hamper shorter term economic growth, especially in the developing countries.

The conclusions of the paper can be summarised as follows:

Though uncertainties as to its distribution remain, climate change, due to man-made greenhouse gas emissions, will pose serious problems to both industrialized (ICs) and developing countries (DCs). A "ballpark" estimate puts annual costs of a 2.5 °C warming at 3 percent of Gross Global Product. Damage in DCs, because of their relatively larger agricultural sector, could amount to 4 percent of their GNPs.

The generally unstable socio-economic situation in DCs makes climate change a serious development problem. The impact of climate change on a water resource system, for instance, will obviously be largest where water is already scarce, as it is in many DCs. DCs with precarious food supplies and a degradation of land resources appear especially vulnerable to climate change.

Climate change may be the fastest ever faced by mankind. Anticipatory action is, therefore, imperative. Measures to be taken fall under two categories:

- adaptation to climate change (or effect oriented measures); and
- limitation of climate change (or source oriented measures).

The more one limits climate change, the easier it will be to adapt to it.

Measures to better protect against or to lower vulnerability to climate change may be costly and can only effectively be taken after the distribution of its effects has become predictable. Accelerating socio-economic development in DCs will, anyhow, prove to be vital to reduce their vulnerability. This belongs to "development co-operation" and ODA rather than to climate change policies.

To "buy time", so as to clear remaining uncertainties, in terms of actual investments, highest priority should be given to the limitation of climate change. This means, priority to the various measures to reduce the increase of the atmospheric concentrations of greenhouse gases, through the prevention or absorption (incl. capture and disposal) of their emissions. Primary attention should be given here to energy which is essential to development and deforestation which is hazardous to the environment.

In preventing emissions, "energy saving" deserves first priority. Its potential is twice that of "combustible fuel switch" and "alternative sources" combined, its investment per Ton Carbon displaced is lowest, and it is (largely) a self-paying proposition. Reforestation appears to be the most cost-effective, it helps to halt desertification and erosion processes, but only has a longerterm (after some 20 years) net effect.

If the ICs, as a first step, bring CO₂-emissions in 2000 back to the 1988 level, global emissions still increase to 130 % if the DCs just extrapolate their 1972-1987 energy growth rate. Given the need for an eventual reduction to 50 percent at the most, this can not be considered acceptable.

The DCs would in 2000 cause over 50 % of CO₂-emissions. The per capita energy use in ICs would, however, still be as high as 6 times higher than in DCs. In view of this and of past emissions, the necessary action should be initiated by the ICs. But, to ensure global success, the DCs should follow as soon as possible.

Given their already towering problems, the majority of the DCs can only be expected to share the burden of global warming if, and in as far as, the ICs give them access to additional public and private capital on concessional terms, and to appropriate (high) technology in the form of "co-development" schemes.

A Funding Mechanism for these purposes should not only address the emissions caused by energy use and deforestation. It should also include the phasing out of CFCs and, gradually, the reduction of greenhouse gases from agriculture, especially CH₄, and industry. Finally, it could contain an emergency facility.

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Acknowledgement

The authors wish to thank the many persons, who helped by providing relevant literature and/or giving constructive criticism and valuable suggestions.

In alphabetical order, special mention should be made of:

Lars Björkbom, Antony J. Dolman (for editorial help), Prof. Carl-Göran Hedén, M.S. Kismadi, and Dr. Bo Wiman (for detailed reviewing).

Although this paper could never have been written without their invaluable assistance, its shortcomings remain the sole responsibility of the authors.

Conclusions

1. The rapidly increasing man-made emissions of 'greenhouse' gases into the atmosphere will lead to 'global warming' or, in general, to climate change in terms of mean values and variability of the main climate parameters. Although uncertainties as to its distribution remain, especially the rate of change will pose serious problems to industrialized (ICs) and developing countries (DCs).

Some 'ballpark' estimates put the annual cost of a 2.5 °C warming at 3 percent of the Gross Global Product. The cost for the DCs, because of their relatively larger agricultural sector, could even amount to 4 percent of their GNPs. This would mean some \$400 billion per annum for the world (excluding the centrally planned ICs) of which some \$100 billion for the DCs (1988 prices).

The generally unstable socio-economic situation in DCs makes climate change a serious development problem. The impact of climate change on a resource system (e.g. energy or water), will obviously be largest where the resource is already scarce, as is the case in many DCs. DCs with precarious food supplies and a degradation of land resources appear especially vulnerable to climate change.

Special attention for the problems posed to the DCs does not mean to say that those posed to the ICs could be ignored. On the contrary, the temperature rises at higher latitudes may even be two or three times as large as in the tropics. But most ICs, especially most developed market economies, command the finances and technologies to face these problems alone or in co-operation.

2. Climate change may be the fastest ever faced by mankind. Anticipatory action is, therefore, imperative. Measures to be taken fall under two categories:

- *adaptation* to climate change (or *effect oriented* measures); and
- *limitation* of climate change (or *source oriented* measures).

The more the limitation of climate change, the easier the adaptation will be.

Measures to better protect against or to lower vulnerability to climate change will be costly and can only effectively be taken after the distribution of its effects - as to space and time, and in intensity and variability - has become predictable. However, investments with a long lifetime, as in buildings and infrastructure, must anticipate long-term climate changes ('risk management').

In agriculture, preparing for climate change should already start with a better adjustment to mean values and variability of the 'usual' climate. Accelerating socio-economic development in the DCs will anyhow prove to be vital to reduce their vulnerability. However, measures to this end belong to the sphere of 'development co-operation' and ODA rather than to climate change policies.

Finally, since some degree of climate change is probably already unavoidable, it is essential for all countries and international organizations to step up their climate change related R&D efforts. These should include: (i) the distribution of climate change; (ii) its effects on the different aspects of socio-economic development; and (iii) measures and costs to mitigate these effects.

3. To 'buy time', so as to clear remaining uncertainties, in actual investments the highest priority should be given to the limitation of climate change. This means, priority to the various measures to reduce the increase of atmospheric concentrations of greenhouse gases, through the prevention or absorption (incl. capture and disposal) of their emissions.

Primary attention should be given to the use of *energy* and *deforestation*. The former is vital to development and the latter is hazardous to the environment,

but is often essential for survival. These two activities together cause over 60 percent of the global warming likely to be committed in 1980-2030. Phasing out CFCs, to safeguard the ozone layer, could bring this to some 80 percent.

In preventing emissions, 'energy saving' deserves special mention. Its potential to displace carbon - estimated through our end-use analyses of the household, transportation and industry sectors - is twice that of 'combustible fuel switch' and 'alternative sources' combined. Its investment per unit of carbon displaced (\$30/TC), is lowest and it is (largely) a self-paying proposition.

Reforestation appears to be the most cost-effective (\$2/TC) measure and helps to halt land degradation processes. However, it only has a longer term (after some 20 years) net effect. For the shorter term, phasing out CFCs is probably the most cost-effective policy. Given uncertainties as to the cost structure and impact of other measures, a mix of policies should be carefully selected.

4. If the ICs would bring, as a first step, their CO₂-emissions in 2000 back to the 1988 level and if the DCs would at the same time merely extrapolate their 1972-1987 energy growth rate, then global CO₂-emissions would still increase to 130 percent of the 1988 level. Given the need of an eventual reduction to at most 50 percent, such a scenario could not be considered acceptable.

According to this scenario, the DCs would cause in 2000 slightly over 50 percent of global CO₂-emissions (from burning fossil fuels and biomass) and would thus have taken over the role of the ICs as major source of CO₂-emissions. It should be realized, however, that as an average the per capita energy use in the ICs would in 2000 still be 6x higher than that in the DCs.

Because the ICs have caused by far the major part of past emissions and in view of the remaining differences in per capita energy use between ICs and DCs, the action to stabilize the atmospheric CO₂-concentration must be initiated by the ICs. However, to ensure its global success, their action should be followed by the DCs as soon as possible.

5. Given their already towering problems, the majority of the DCs can only be expected to share the burden of global warming if, and in as far as, the ICs provide them with access to additional (public as well as private) capital on concessional terms, and with access to appropriate (high) technology, whenever possible, in the form of 'co-development' schemes.

A Funding Mechanism for these purposes should start to aim at the reduction of greenhouse gas emissions caused by the use of energy and by deforestation as well as at globally phasing out of CFCs. Gradually the Fund should also aim at reducing emissions of greenhouse gases from agriculture, especially CH₄, and from industry. Finally, it could contain an *emergency facility*.

To perform these functions, additional funds are needed to prevent that otherwise the shorter term economic growth of the DCs would be hampered. Stressing the need for additional funds, however, should not be misread as a suggestion that climate change policies should or even could be separated from environment policies in general or from development policies.

A sizeable Funding Mechanism - eventually in the order of \$10 billion per year, if not more - could help to make socio-economic development gradually more sustainable and even help to accelerate economic growth. Furthermore, it would constitute an effective response to the challenge of the UN General Assembly Resolution 43/53 recognizing climate change as a 'common concern of mankind'.

1. Introduction

This paper deals with global 'climate' related problems of the 'environment', with special attention to the effects on 'development'. In doing so, no attempt will be made to contribute to a further understanding of the functioning of the global climate system as such, nor of the measures required to address the increasingly urgent problem of development as a whole. Measures to be proposed, however, will aim at protecting the global climate and, thus, at safeguarding an essential condition for sustainable development.

One of the most important global climate problems is the 'greenhouse effect' - rising global surface temperatures and sea levels, and more frequent droughts, hurricanes and floods - due to rapidly increasing atmospheric concentrations of carbon dioxide (CO₂) and of other greenhouse gases. The world's climatologists have reached near consensus that some global warming will be inevitable, even if the emissions of greenhouse gases would be so reduced that their atmospheric concentrations would eventually be stabilized at the current (1988) levels.

Given the long lead times for effective measures, the initiation of action cannot wait until remaining uncertainties as to time, place and extent of the greenhouse effect have been resolved. In view of these uncertainties, however, any course of action should not only be long-term and global but also highly flexible in character. This paper will discuss measures to mitigate the - as yet insufficiently predictable - impacts of climate change as well as measures to reduce net emissions of greenhouse gases.

As to costs of these measures the following guiding principles will be applied:

- the industrialized countries, because of past emissions, carry a special responsibility for the greenhouse problem;
- its eventual solution can, however, only be achieved through co-operation between industrialized and developing countries; and
- longer term sustainable global development should not hamper shorter term economic growth, especially in the developing countries.

In this perspective, the interactions between *Climate Change and Development* will be reviewed in chapter 2. Special attention will be given to potential adverse effects of sea level rise and of increasing climate variability for development, in particular for agricultural production. An estimate will be made of the costs of climate change, globally as well as for the DCs.

Although uncertainties as to the distribution of the effects of climate change remain, chapter 3 will discuss *Measures to Mitigate Impacts*. Attention will be given to agriculture, forestry and fishery, to improving infrastructure, and to accelerating socio-economic development. Some observations will be made on the costs of adaptation measures.

Chapter 4 will treat *Measures to Reduce Emission Levels*. Primary attention will be given to greenhouse gases caused by the use of energy, which is essential to development, and deforestation, which is hazardous to the environment. Distinction will be made between measures to prevent and measures to absorb emissions. The phasing out of CFCs will be mentioned; some conclusions will be drawn.

Chapter 5 will consider *Climate Change: a 'Common Concern of Mankind'*. It will particularly focus on stabilizing the atmospheric CO₂-concentration. Some observations will, finally, be made with respect to a Funding Mechanism. This would aim at enabling developing countries, without hampering their economic growth, to play to the full their role in the necessary global co-operation.

Definitions

- **Global climate system.** The global climate results from interactions between insolation, physical and chemical processes in the atmosphere-ocean-ice system, and the world's biota. It manifests itself regionally through (a) mean values of temperature, moisture, insolation, wind speeds and directions; (b) seasonal changes in these mean values; and (c) variability in these parameters, mostly characterized by their extremes.
- **Greenhouse effect and gases.** There is near scientific consensus that global warming will take place due to the combined effect of increasing atmospheric concentrations of the main 'greenhouse gases'. These gases are: carbon dioxide (CO₂), methane (CH₄), ozone (O₃), nitrous oxide (N₂O), and chlorofluorocarbons (CFCs) and others. They contribute roughly 50%, 16%, 8%, 6%, and 20% respectively to the global warming likely to be committed between 1980 and 2030.
- **Energy sources and conservation.** Energy sources can be divided into renewables and non-renewables. Renewable energy sources are those which are virtually inexhaustible, whereas the total available amount of non-renewable energy sources will decrease if energy is used. Conservation includes all measures aimed at reducing the demand for all sources of energy, especially that for non-renewables.
- **Sustainable development.** The 'Brundtland report' (1987) defines it as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts:
 - . the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and
 - . the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs."
- **Developing Countries (DCs) and Industrialized Countries (ICs).** The term DCs refers to the UN grouping of developing countries, incl. the socialist countries of Asia; ICs encompasses the UN categories of developed market economies and the socialist countries of Eastern Europe and the USSR.

Units

Each form of energy has been converted in its conventional fuel equivalent. Energy data of supporting sources are put in ExaJoule(EJ) or GigaJoule(GJ). Greenhouse gas emissions are expressed in GigaTon of Carbon(GTC) equivalent and investment costs in U.S. dollars per Ton Carbon equivalent saved(\$/TC). Finally, where Ton Carbon Dioxide (TCD) is used as a unit: 1 TCD $\approx$ 3.66 TC.

1 EJ	= 10 ¹⁸ Joule	1 GTC	= 10 ⁹ Ton Carbon
1 GJ	= 10 ⁹ Joule	1 EJ biomass	$\approx$ 0.031 GTC x 2
		1 EJ coal	$\approx$ 0.027 GTC
1 billion	= 10 ³ million	1 EJ oil	$\approx$ 0.020 GTC
1 hectare	= 10,000 m ² = 2.471 acres	1 EJ natural gas	$\approx$ 0.014 GTC

2. Climate Change and Development

2.1 Climate change

Over the past ten million years, clouds, water vapour, and pre-industrial concentrations of CO₂ together warmed the earth's surface by some 33 °C, from an estimated average temperature of -18 °C to around +15 °C. Without this background greenhouse effect, the earth would be a cold and lifeless planet.

In former times mankind already faced many climate changes and developed many adjustment strategies. Man has dared to go to the limits of all climates. The way of coping with major climate change, if it did not lead to the extinction of complete civilizations, was one of massive migration. Now this option is no longer a feasible one. There is a lack of the space required for it and growing urban populations are firmly tied to past investments of money and imagination.

What has recently become known, however, is the following:

- Man-made emissions of CO₂, especially from burning fossil fuels and biomass, and of other trace gases do increase their atmospheric concentrations, thus affecting the global greenhouse.
- Global warming also results from emissions of greenhouse gases during the 'fuel cycle' (mining, transport, etc.) and from a decrease in the amount of CO₂ stored in the biosphere due to, significantly increasing, devegetation.
- Since 1800 the earth experienced a 0.5-0.7 °C warming. Computer simulations, supported by analyses of the age and CO₂-content of Antarctic ice masses, suggest a doubling of the CO₂ concentration will lead to a warming of 1.5-4.5 °C.
- Studies indicate large time-lags between emissions, increases in atmospheric concentrations and global warming. If emissions were halted at present levels, the greenhouse effect would still intensify for more than a century.
- After stopping CO₂ emissions, it would take more than 50 years for the oceans (when warmer, their absorptive capacity even decreases) to absorb enough CO₂ to bring its atmospheric concentration halfway down to its pre-industrial level.

Drastic cuts in emissions of greenhouse gases are required. Reductions of at least 50 percent are needed to eventually stabilize their atmospheric concentrations at present levels. Measures to reduce emissions should be complemented by those that stop deforestation and restore the earth's absorptive capacity.

2.2 Climate change and development

Since the discovery in 1985 of the 'hole' in the ozone layer over Antarctica, the awareness of the potential for rapid and surprising atmospheric shifts has strongly increased. Appearance of the 'Brundtland Report' in 1987 highlighted the until then neglected socio-economic implications of climate change. This new focus emphasized the need for a fundamentally new perception of the risks and uncertainties involved. Thus, the wait-and-see policy attitude characteristic of the 1970s has changed to one of finding strategies for buying the time needed to understand the interactions between climate and development.

With respect to these interactions the following three issues can be discerned:

- a) To what extent does climate change, due to the greenhouse effect, already take place and in which ways does this change manifest itself?

b) What would its impact be on agriculture, water management, energy use, well-being, etc.? In short, what are its direct socio-economic consequences?

c) What would these mean for labour mobility, production patterns, international trade, external indebtedness, in short, for the overall development process?

The consulted literature shows that our present insight into a) is limited, though less so than in b), and certainly less than in c). This insight is crucial for identifying the investments required and the cost likely to be incurred in combating the effects of climate change and preventing its further escalation. Hence, much additional research on the above issues is needed.

The generally unstable socio-economic situation in the DCs, their scarcity of alternative opportunities for production, and the fact that often seventy percent of their household energy use is in cooking on biomass with low efficiency, makes climate change a serious development problem. This is aggravated because the impact of climate change on a resource system (e.g. energy and water) will obviously be largest where the resource is already scarce or poorly managed, as is the case in many DCs.

2.3 The greenhouse effect and DCs

Special attention for the problems posed to the DCs does not mean to say that those posed to the ICs could be ignored. On the contrary, the temperature rises at higher latitudes may even be two or three times as big as in the tropics.

2.3.1 Ocean warming and sea level rise

The oceans reduce the speed of global warming but will gradually become warmer themselves. The resulting thermal expansion alone would lead to a substantial sea level rise. It is expected, however, that global warming will also lead to melting of the ice caps, and to changed patterns of ocean circulation in the upper layers and of up- and downwelling. Though the precise impacts of these phenomena in DCs remain unclear, it is not hard to imagine what they may mean for risks of flooding, for fishery resources, for salt water intrusion into fresh-water aquifers, and for wetlands and other productive ecosystems.

A rise in sea level will seriously affect developing regions barely above sea level. This specifically holds for large deltas, like in Bangladesh, Egypt and parts of China, and low island groups, such as the Maldives. Their existence is threatened since they may be flooded, unless they are protected by dikes and other infrastructure. Such protection will be sometimes technically impossible but in any case very costly to construct. The World Bank puts the costs of a substantial sea level rise protection plan for Bangladesh at \$6 billion.

According to the Worldwatch Institute, sea level rise could become the primary cause of 'environmental refugees' by the middle of the next century. Populations exposed to natural hazards are the most vulnerable. In 2050, habitable land might well be lost for 15 percent in Bangladesh and Egypt. The part of their populations displaced could amount to 13 percent.

2.3.2 Climate variability

Another, but much less predictable, impact of the greenhouse effect is a change in climate variability. Even though one cannot yet conclude that such climate change is already taking place (because changes have so far remained within natural fluctuation margins), simulation models strongly point in this direction. Moreover, circumstantial evidence is, for instance, provided by the 1987

monsoon failure in India, and the progressive Sahel desertification.

The impact on DCs can be considerable, given the generally vulnerable state of their infrastructure. More variability in rainfall, more frequent hurricanes, droughts, etc. can have catastrophic implications. If the amount and intensity of precipitation change, this may affect soil moisture conditions and enhance soil erosion and desertification processes, thus aggravating existing problems.

Water resources are also highly sensitive to climate variations. Wet spells, droughts, floods and more frequent hurricanes can affect the availability of water for agriculture, drinking and power generation, as well as river navigation, fisheries, and tourism. The key problem in projecting climate change in DCs is that results of climate models, though fairly unanimous about the threat of enlarged climate variability, differ significantly in regional detail.

Insight into impacts of climate change on average yields has grown recently. Simulation models, for instance, have shown for a number of crops in ICs that changes in the level of productivity are related to changes in mean temperature and precipitation. These models could be applied to DC agriculture, but this has not yet been done systematically. Much less is yet known about the impact of climate variability. However, available information suggests that its impact on agricultural production could be in the order of some tens of percents.

The impact of climate change on forests is also poorly understood, although forest simulation models have been used to assess the impact of temperature change on wood or biomass. The problem is again that changes in regional moisture patterns - which are still relatively the least known - rather than in mean temperatures are usually the determining factor.

2.3.3 Agricultural production

As to the consequences for agriculture, more information does exist for cool-temperate and cold areas, where temperature rather than rainfall is the major climatic determinant, than for semi-arid regions, where moisture is the primary climatic constraint. The majority of DCs belongs to the latter category. DCs with precarious food supplies and a degradation of land resources appear especially vulnerable to climate change.

It is probable that low-latitude, semi-arid developing regions will experience changes in rainfall. This calls for a re-appraisal of the recent emphasis on high-yielding cultivars and crop production, which has discouraged diversified, flexible and low-risk production systems prevalent in traditional agriculture. These high-yielding systems have evolved to a state where they can support vast populations, but are tolerant of only small changes in temperature and water and can probably not be adapted very quickly to significant climate changes.

2.4 Costs of climate change

According to some 'ballpark' estimates, the annual cost of a 2.5 °C warming could amount to 3 percent of the Gross Global Product. (Brown, 1987) This would mean some \$400 billion per annum for the world (excl. centrally planned ICs), of which some \$75 billion for the DCs (1988 prices). The cost in DCs may well be relatively higher than in ICs, because the agricultural sector is most vulnerable to climate change. Yields in DCs can be especially sensitive to changes in precipitation (Kenyan maize production showed a 15 percent crop loss when rainfall was 10 percent less than average). If the above 3 percent breaks down into 10 percent for agriculture and 2½ for the other sectors, the annual cost in DCs would amount to 4 percent of their GNPs or some \$100 billion.

3. Measures to Mitigate Impacts

3.1 Introduction

Though uncertainties remain as to the distribution in space and time of mean values and frequency and intensity of extreme events, climate change may be the fastest ever faced by mankind. Anticipatory action is, therefore, imperative.

The measures to be taken fall under the following two categories:

- *adaptation* to climate change (or *effect oriented* measures): to better protect against or to lower vulnerability to the adverse effects during production, distribution and consumption and to better use beneficial effects, if any; and
- *limitation* of climate change (or *source oriented* measures): to reduce the increase of atmospheric concentrations of CO₂ and other greenhouse gases, by the prevention or absorption (incl. capture and disposal) of their emissions.

These two categories are interlinked. The more one succeeds in limiting climate change, the easier it will be to adapt to it and vice versa. 'Adaptation' will be discussed before 'limitation' (see Chapter 4). This is not done to suggest an order of priority, quite the contrary. *Climate change may remain manageable only if enough source-oriented measures are soon taken to buy time.*

Three types of 'adaptation' measures will be distinguished: (i) mitigation of impacts on agriculture, forestry and fisheries; (ii) improving infrastructure; (iii) accelerating socio-economic development.

3.2 Mitigation of impacts on agriculture, forestry and fisheries

3.2.1 Agriculture

How can agriculture (incl. animal husbandry) best adapt to climate change? Preparing for climate change should start with better adjustment to the usual climate and its variability. In Mali, for example, a pilot project demonstrated that farmers using advice on how to profit from information on the effects of weather and climate increased production in drought years by 25-30 percent. But, as to DCs, so far only South East Asia has a regional climate data base.

Various types of technical responses are available: change in crop variety; change in irrigation, fertilizer and drainage; change in crop management; and change in farming strategies. Salt-tolerant crops (halophytes) deserve special mention. Some of them can be very successfully grown along the shore-line of coastal deserts when irrigated with ocean water. When this comes from shrimp farms, a waste water problem is solved and a crop is fertilized all in one.

Given our still limited understanding of climate change, however, the focus should be on *extending the range of policy options* rather than on refining technical responses. In this respect, the following policy options deserve to be considered: changes in land-use allocation; in farm support, and food security policies; reduction of post-harvest losses; developing potential of tropical (plant) species; and conversion to 'controlled environment agriculture'.

Changes in land-use allocation would include changes to optimize (different crops respond differently to climate change) and to stabilize production (reducing the risks of heavy losses). National farm support policies have to be adapted specifically to encourage different types of farm management and levels of input to match climate induced changes in agricultural potential. National

food security policies must be reviewed against possible climate change, especially in DCs with precarious food supplies.

Post-harvest losses - due to deficient systems of storage and transport, during which food is vulnerable to rodents and to perishing - amount in many DCs to 50 percent or more. Most of the world's plant food comes from only 20 species, so the potential of the vast majority of plant species has still to be developed. As to mammals, e.g., 'natural ranching' (Kenya) appears to offer great promise. Another fundamental way to mitigate impacts could be to make agriculture 'independent' from the climate via 'controlled environment agriculture'.

3.2.2 Forestry

As far as forestry is concerned, it should be recognized that the growing cycles of trees are some 10 - 100 times longer than those of food crops. Many of the measures applicable to agriculture cannot or can hardly be used for forestry. Because of their CO₂ absorption capacity - and other vital functions like soil protection, rainwater catchment, and safeguarding of genetic diversity - existing forests should be protected against deforestation (currently 11 million hectares per year) and climate change by local measures. These should, as far as possible, respect the legitimate rights of local people.

3.2.3 Fisheries

Climate effects on marine fisheries are hard to quantify, because of large natural fluctuations, human intervention, and generally poor data on fish populations. Climate change affects ocean circulation in the upper layers, upwelling and ice extent, all of which affect marine biological production and hence marine fisheries. Efforts to adapt marine fisheries to climate change should be complemented by intensified efforts to develop *aquaculture*; its potential for satisfying the world's protein needs is still largely unutilized.

Integrating aquaculture with 'controlled environment agriculture' has a great potential. In recent years, dramatic advances in marine biotechnology have been made. The almost sterile, nutrient rich bottom water from OTEC-systems promises much as culture medium for kelp, abalone, oysters and a range of fish species.

3.3 Improving infrastructure

To cope with the impacts of climate on development, infrastructure should be adapted in particular to changed precipitation - in terms of mean value and variability - as well as to higher sea levels. This concerns in particular irrigation/water storage systems, incl. (small) dams, drainage/sewer systems, dikes and locks, as well as urban building and construction.

Water resource development and management forms one of the most important life-sustaining activities. The rate of expansion of irrigation has varied over time. It peaked in the early 1970s and is now decreasing. Future irrigation investments in DCs should be specifically targeted at countries with persistent food deficits. Water is also needed for drinking and cooking, and for power production. Climate change may have large cumulative effects on water storage systems, particularly if their present capacity is approaching design limits.

Sea level rise, especially if attended with floods or hurricanes, may seriously affect deltas, wetlands, estuaries and low islands. Measures should be taken to prevent a loss of land and an increase in salinity. If sea borders of island states are affected, e.g. of Exclusive Economic Zones, legal measures (ongoing recognition) rather than technical ones (endiking) may have to be taken.

The 'heat island' produced by large cities at night is already a well-known phenomenon. With increasing mean and extreme temperatures, a reorganization of cities could be needed to prevent excessive heat accumulation and to facilitate cooling. Cost-effective means of alleviating urban climate extremes should be part of a strategy to reduce energy demands. Options that could be considered include reducing the need for air conditioning by planting trees, switching to lighter coloured surfaces and making use of passive solar heating concepts.

Settlement planning will need to anticipate the long-term spatial effects of climate change (in mean values and extremes). This is of particular importance to countries with vulnerable coast-lines or different climate types (such as Brazil, India and China). Given the long lifetime of buildings and urban infrastructure, it will be a hard challenge to successfully introduce into physical planning the increasingly needed notions of discontinuity and surprise.

3.4 Accelerating socio-economic development

Accelerating socio-economic development in the DCs will prove to be of vital importance to reduce their vulnerability to climate change, because:

- Eradication of mass poverty, especially in the rural areas, is imperative to redress the present imbalance between resources and population. This imbalance enhances processes of dry land degradation and deforestation.
- Agriculture (1986: in DCs 19% and in ICs 3% of GNP) is the most climate sensitive economic sector. To decrease overall vulnerability to climate change, development of the industry and services sectors should be accelerated.
- With the level of socio-economic development, the availability of financial and human resources will increase. These resources can, in part, be allocated to better adapt to climate change as well as to limit climate change.
- Higher levels of education and well-being have shown to be a 'conditio sine qua non' for effective population planning policies. The latter are crucial for redressing on the long run present imbalances between population and resources.
- An increase in the availability of modern telecommunications enhances mass information capabilities. Their importance is illustrated by the action of UNDR0, which reduced the effects of hurricane Gilbert (1988) in the Caribbean.

3.5 Costs of adaptation measures

The way to adapt to climate change may be 'controlled environment agriculture'. Cheap materials, simple construction techniques, and micro-biological systems would be combined to make agriculture + aquaculture 'independent' from climate change. Massive introduction of such integrated systems in DCs, at \$250 per capita as a 'ballpark' estimate, would require an investment of \$1,000 billion, or \$25 billion per year over a 40 year period. This long-term option, however, needs much further research: large-scale 'engineering the unknown (i.e. Nature) out of the system' may prove to be ecologically and economically vulnerable.

Measures to better protect against or lower vulnerability to climate change may be costly and can only effectively be taken after the distribution of its effects has become predictable. Accelerating socio-economic development of DCs will, in any case, prove to be vital to lower their vulnerability. Measures to this end belong to 'development co-operation' rather than to climate change policies. To 'buy time', so to clear remaining uncertainties, in actual investments highest priority should be given to limitation of climate change.

4. Measures to Reduce Emission Levels

The main greenhouse gases are: carbon dioxide (CO₂), methane (CH₄), ozone (O₃), nitrous oxide (N₂O), and chlorofluorocarbons (CFCs). Their emissions are caused by the following sectors of activity: energy, deforestation, agriculture, and industry. Table 1 gives estimates of the contribution of each gas and sector to the global warming *likely to be committed between 1980 and 2030*.

Table 1: Gases/sectors of global warming

gas sector	carbon dioxide (CO ₂)	methane (CH ₄)	ozone (O ₃)	nitrous oxide (N ₂ O)	chloroflu- orocarbons (CFCs ⁺)	percent warming sector
energy	35	4 ^{x)}	6 ^{x)}	4	--	49
deforestation	10	4	--	--	--	14
agriculture	3	8	--	2	--	13
industry	2	--	2	--	20	24
percent warming gas	50	16	8	6	20	100

⁺) and others ^{x)} of which 1 and 6 percent points indirect, respectively

Source: World Resources Institute, 1988

Primary attention will be given here to the use of *energy* and to *deforestation*. The former is essential to development whereas the latter is hazardous to the environment but often essential to survival. Together these two activities cause 63 percent of the global warming likely to be committed between 1980 and 2030. Including phasing out CFCs brings this to 83 percent. Thus 17 percent of the emissions are ignored. The sources of and limitation measures for these emissions, especially of CH₄ from agriculture, are still insufficiently known.

Measures to reduce net emission levels of greenhouse gases, caused by the use energy and by deforestation, should be distinguished in two categories:

Measures to prevent emissions:

- energy saving and efficiency;
- combustible fuel switch; and
- use of alternative energy sources.

Measures to absorb emissions:

- reforestation; and
- CO₂ capture and disposal.

4.1 Measures to prevent emissions

4.1.1 Energy saving and efficiency

Significant gains can be achieved, both in ICs and DCs, by a strategy focusing on the improvement of end-uses of energy. The scope for energy saving in the

ICs already manifested itself: in 1973-1984 industrial production increased over 30 percent, whereas energy use hardly expanded. For example, a study shows that the U.S. could cut, over the next two decades, its energy consumption in half without reducing its living standards. This would save \$110 billion per year, with annual energy saving investments of \$50 billion. (Keepin, 1988)

There is great potential for increased energy efficiency in DCs, since it is the most cost-effective means of dealing with a rapid growth in energy demand. According to a 1986 study of Brazil, \$10 billion investments in electric energy efficiency - in more efficient refrigerators, lighting, etc. - would offset the need for \$40 billion investments in power generation. (Goldemberg, 1987)

Our own end-use analysis of energy shows that economic growth, both in DCs and ICs, could even be achieved up to 2005 and beyond without increasing global energy use beyond its present level if a shift is made to modern energy saving techniques. This highlights the opportunities for DCs of technological 'leap-frogging', if they select less resource-intensive and environmentally-destructive technologies which are compatible with their local resource base.

The following factors prevent the above potential from being realized:

- there are obstacles to correct economic pricing of traditional forms of energy and a lack of policies to ensure correct economic signals;
- governments do not allocate sufficient funds to energy research and development, and are rather slow in applying results in their own organizations;
- more than 90 percent of investments go to large energy generating systems, whereas conservation accounted for less than 1 percent; and
- there is a lack of awareness among the general public and private enterprise of the benefits of and technologies available for energy saving and efficiency.

4.1.2 Combustible fuel switch

Per unit of energy, CO₂-emission of coal and oil is 2 and 1½ times respectively as large as that of natural gas. Fuel switch is thus an option which deserves serious attention, especially since world natural gas reserves are surpassing those of oil. The rate of global introduction of natural gas, however, will be limited by exploration, location and transportation constraints. The environmental advantages of switching to natural gas can be reduced by leakage of CH₄, a gas which is some fourteen times as harmful as CO₂ in contributing to the greenhouse effect ('CO₂ equivalents'). Strict technology and rules for handling natural gas are thus needed. Natural gas has further environmental advantages (e.g., very low emissions of sulfur dioxide). Besides, infrastructure for its distribution (pipelines) and combustion (advanced gas turbines) can also be used for gas from biomass or coal-gasification, and, in future, for hydrogen.

The contribution of biomass, per unit of energy, to the greenhouse effect is at least 2 times that of coal, if no compensation for the corresponding loss in CO₂ absorption capacity is made. In DCs the switch to kerosene and gas for cooking and to fluorescent lamps (from kerosene) for lighting should, also for reasons of efficiency improvement, be carried out as soon as possible.

Combining new technologies for coal-gasification with those for CO₂ capture and disposal (see 4.2.2), to replace direct use of coal for power generation, requires further development and may not generally be applied before 2005.

4.1.3 Use of alternative energy sources

The role of nuclear energy is not expected to grow globally. Even if its well-known problems - like the storage of nuclear waste, threats of nuclear terro-

risk and proliferation of nuclear weapons technology - are accepted, it is a relatively expensive option for displacing carbon. CO₂-emission reduction, per monetary unit invested, by nuclear energy has been calculated, under fairly realistic assumptions, to be less by a factor of 7 than that by energy saving. Although changing these assumptions does have impact on this factor (it ranges from 2½ - 10), the nuclear option remains one of the least cost-effective ones. As to (cold) nuclear *fusion*, it still has a long way (2030 or beyond) to go.

The slow rate of implementation of other non-combustion energy systems is partly caused by the large capital investments required and the associated risks involved. This is illustrated by the experience with large hydro-projects in DCs during periods of fluctuating energy prices. The inherently small-scale character of the main part of other non-combustible sources of energy - such as solar heating, photo-voltaics and wind power - is another drawback. A final impediment is the widespread application in DCs of subsidies on some forms of energy which discourage R & D of and investments in alternative sources.

4.1.4 Potential CO₂-reduction by 2005 and investment costs

Table 2 gives our rough estimates, for the above energy policy options, of the potential reduction of global CO₂-emissions by 2005 and of investment costs in \$/TC. For energy saving this potential was estimated, for the period up to 2005 and beyond, through our own analysis of end-uses of energy in the household, transportation and industry sectors.

Table 2: Policy options, potential CO₂-reduction by 2005 and investment costs

description	global CO ₂ -emissions		investment costs in \$ per TC less	
	before option	potential reduction	globally	in DCs
2005 before policy options	100			
policy options:				
- energy saving	100	- 33	30	22
- combustible fuel switch	67	- 8	70	.
- alternative sources	59	- 8	115	.
2005 after policy options	51	- 49	51	.

The investment costs of the nuclear option amount to some \$120/TC.

Source: costs computed with World Resources Institute and Dutch Gas Union data

The average costs computed here can differ substantially from the marginal costs due to (dis)economies of scale. Alternative sources are still relatively costly, but economies of scale and new technologies may gradually lower costs. The 'energy/profit ratio' - the energy in the fuel produced divided by the energy used to obtain and refine it - of photovoltaics, e.g., has increased from 1 in 1972 to 10 now for complete single-crystal systems. New amorphous cells are more promising and may even be surpassed by photo-chemical cells.

To fully utilize these policy options by 2005 would require global investments some \$300 billion per year, which constitutes around 30 percent of the 1986 global energy expenditures (based on a crude oil price of approx. \$18/barrel).

A limited energy price increase would suffice, therefore, provided the revenues were solely used to cover the costs of effective energy policies.

4.2 Measures to absorb emissions

4.2.1 Reforestation

Deforestation occurs at an annual rate of 11 million hectares against 1 million only for reforestation. Due to deforestation 1-3 GT carbon is released annually (compared to 6 GT from global fossil fuels use in 1988) and thousands of genetic species are extinguished. Halting deforestation and increasing reforestation would largely contribute to balancing the atmospheric CO₂ concentration.

A massive reforestation plan - to compensate for ongoing deforestation and make an average contribution of 3 GTC/year - of 750 million hectares in 40 years would cost (based on World Bank data) some \$6 billion per year. In terms of investments, reforestation is the most cost-effective (\$2/TC) measure to reduce net CO₂-emissions; it also helps to halt desertification and erosion processes.

There are, however, some caveats. First, these forests should not be turned into future (fuel)wood reserves. Second, it is assumed that all arising social, legal, and institutional land use problems can be overcome. Third, reforestation has only a longer term (after some 20 years) net effect and may show diseconomies of scale. Given these caveats, reforestation should be considered as an important but not as a major policy option for the immediate future.

4.2.2 CO₂ capture and disposal

CO₂ capture and disposal techniques are as yet insufficiently developed and their general use in power plants cannot be expected before 2005. Present indications are that, when advanced technology is installed, new power plants could capture and dispose of their CO₂-emissions at \$60-130/TC. This would prevent their emission until eventual, inadvertent or wilful, release. If made mandatory for coal-fired plants, resulting electricity price increases would positively effect energy conservation. The further development of clean coal technologies (CO₂ capture and disposal combined with coal gasification) is of great intermediate potential, especially for coal rich countries such as China.

4.3 Phasing out chlorofluorocarbons (CFCs)

CFCs contribute some 20 percent to global warming. Their phasing out globally ranks high on the international agenda, given the increasing concerns over the ozone layer. It could be carried out relatively 'easily', as compared to say the restructuring of global energy policy, and is considered to be very cost-effective, if at least CFCs are not replaced by HFCs (greenhouse gases).

4.4 Conclusions

- Dealing with CFCs and reforestation appears, in terms of investments, to be the most cost-effective policy for the short and long term respectively.
- Given uncertainties as to cost structure and differences in impact of other policy options, a mix ('portfolio') of policies should be carefully selected.
- In preventing emissions, energy saving deserves first priority given its CO₂-reduction potential and since it is (largely) a self-paying proposition.
- Fuel switch to natural gas provides a means to buy time in the medium term, alternative energy sources constitute the long-term sustainable option.
- R&D efforts should be increased with respect to the most viable measures to reduce emission levels in the medium and longer term.

5. Climate Change: a 'Common Concern of Mankind'

5.1 Stabilizing the atmospheric CO₂-concentration

To eventually stabilize the atmospheric concentration of CO₂ at the present high level, a reduction of 1988 emissions with at least 50 percent will be needed. Such a reduction can only be brought about through global co-operation. To demonstrate the need for global co-operation, a simplified scenario has been designed for the period 1988-2000. This scenario should not be mistaken for a projection, it merely shows the outcomes of certain assumptions. Furthermore, it is simplified: it does not take into account arising fuel shortages (e.g. in biomass) and resulting substitutions. Its main assumptions are the following:

- ICs bring, as a first step, CO₂-emissions by 2000 back to the 1988 level; they increase natural gas supply to 76 EJ (Committee J: 'rapid scenario'); and non-combustibles supply by 2 percent per year during the period 1988-2000.

- DCs extrapolate their 1972-1987 energy growth rate (4.8% per year); they increase non-combustibles by 2½ percent per year; and they make no combustible fuel switches during the period 1988-2000.

Table 3: Scenario CO₂-emissions and energy use in the period 1988-2000

description	1988			2000		
	in DCs	in ICs	total	in DCs	in ICs	total
CO ₂ -emissions (10 ⁶ tons C)						
. biomass	1,326	375	1,701	2,375	375	2,750
. coal	920	1,754	2,674	1,648	1,485	3,133
. oil	591	1,907	2,498	1,058	1,907	2,965
. natural gas	109	778	887	195	1,047	1,242
total CO ₂ -emissions	2,946	4,814	7,760	5,276	4,814	10,090
2000/1988	(38%)	(62%)	(100%)	(52%)	(48%)	(100%)
	.	.	.	1.79x	1.00x	1.30x
energy use (EJ per year)						
. biomass	21.6	6.1	27.7	38.7	6.1	44.8
. coal	34.2	65.2	99.4	61.3	55.2	116.5
. oil	30.0	96.8	126.8	53.7	96.8	150.5
. natural gas	7.9	56.4	64.3	14.1	75.9	90.0
total combustibles	93.7	224.5	318.2	167.8	234.0	401.8
non-combustibles	8.1	52.6	60.7	10.9	66.7	77.6
total energy use	101.8	277.1	378.9	178.7	300.7	479.4
2000/1988	(27%)	(73%)	(100%)	(37%)	(63%)	(100%)
	.	.	.	1.76x	1.09x	1.27x
population (in billions)	3.85	1.25	5.10	4.75	1.35	6.10
energy/capita (PJ per year)	26.4	221.7	74.3	37.6	222.7	78.6

Source: World Resources 1986/1987/1988-89; World Bank (Zachariah and Vu, 1988)

According to this scenario, the ICs would only increase their total energy use by 0.7 percent per year, compared to 1.7 percent per year during the period 1972-1987. This is largely explained by their per capita energy growth which would amount to in total only 0.5 percent over 1988-2000, compared to annually 0.9 percent during the period 1972-1988.

By 2000, the DCs would have increased their CO₂-emissions, compared to 1988, with almost 80%. With 52% of the total, compared to 38% in 1988, they would just have taken over the role of the ICs as major source of CO₂-emissions. It should be realized, however, that the per capita energy use in ICs would still be 6x higher than in DCs, against well over 8x in 1988.

Global CO₂-emissions would grow to 130 percent of the 1988 level. Since they should eventually be reduced to 50 percent at most, this would be unacceptable. In view of past emissions and the remaining gaps in per capita energy use, the ICs must initiate the action to stabilize the atmospheric CO₂-concentration. But to have global success, action of the DCs must follow as soon as possible.

5.2 A Funding Mechanism

Given their already towering problems, the vast majority of the DCs could not make sizeable investments to contribute to combating global warming without hampering their own economic growth. They can only share the burden of global warming if, and in as far as, the ICs give them access to additional (public and private) capital and to, climate related, appropriate (high) technology.

The access to additional capital should be on 'concessional terms' (compatible with the problems addressed): long maturities, grace periods, as well as modest interest rates. The access to appropriate (high) technology should, preferably, have the form of co-development schemes. Such schemes would ensure an efficient co-operation and an equitable benefit-sharing between ICs and DCs.

The access to the required capital and technology could be channeled through an existing or a new international body. In either case it should draw upon specific expertise of the World Bank, UNDP, UNCTAD, UNIDO and other competent international organizations. This would help to ensure that climate projects and programs do promote and not hamper socio-economic development in the DCs.

The Funding Mechanism should not only address the greenhouse gases (especially CO₂) caused by the use of energy and by deforestation. It should also include, from the start, the phasing out of CFCs and, gradually, the reduction of the (other) greenhouse gases caused by agriculture, especially CH₄, and industry.

Finally, the Funding Mechanism could contain an 'emergency facility', to cope with damages of climate extremes - hurricanes, floods, droughts, etc. - which will become more frequent and intense with global warming. The facility could draw upon UNDRR, as a centre for exchange of information, and be set up in the framework of the International Decade for Natural Disaster Reduction (1990s).

It is obvious that the larger the size of the Funding Mechanism would be, the more climate change could be limited and time would be bought, to clear remaining uncertainties. It would also become easier to adapt to climate change without hampering socio-economic development in the DCs.

A sizeable Funding Mechanism - eventually in the order of \$10 billion per year, if not more - could not only accelerate development but would also constitute an effective response to the challenge of the UN General Assembly Resolution 43/53, recognizing climate change as a 'common concern of mankind'.

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The Ministerial Conference, organized
by the Minister of Housing, Physical
Planning and Environment of The
Netherlands in cooperation with
UNEP and WMO.

Climate conference secretariat:
P.O. Box 450
2260 MB Leidschendam
Tel. 31 70209367, ext. 2125
Telex nr. 32 362 VROM NL
Telefax nr. 31 70 201858



BACKGROUND PAPER ON FORESTRY AND AFFORESTATION

"THE ROLE OF THE FORESTS IN RELATION TO CLIMATE CHANGE"

OCTOBER 1989

FOR THE MINISTERIAL CONFERENCE ON
ATMOSPHERIC POLLUTION AND CLIMATIC CHANGE,
WITH PARTICULAR ATTENTION TO GLOBAL WARMING 6TH, 7TH NOVEMBER 1989

THIS PAPER IS A COMBINATION OF DOCUMENTS
PREPARED ON BEHALF OF THE INTERNATIONAL STEERING
COMMITTEE OF THE CONFERENCE BY SWITZERLAND, SENEGAL AND BRAZIL
THE VIEWS EXPRESSED DO NOT NECESSARILY
REFLECT THE POLICY OR OPINIONS OF
THE RESPECTIVE GOVERNMENTS

BACKGROUND PAPER ON FORESTRY
AND AFFORESTATION
"THE ROLE OF THE FORESTS IN RELATION TO CLIMATE CHANGE"

BACKGROUND PAPER - SUMMARY

Forestry and Afforestation 'The Role of Forests in relation to Climate Change'

The paper begins by stressing the importance of forests to the well-being of the planetary ecosystem and the likely effects of changes in global forest stock on the world climate. It explains that forests are currently being depleted and degraded at an unprecedented rate, but that more research is required to establish a better and agreed database. It describes the situation where the forests, in addition to their supply of many products, species variety and as regulators of the hydrodynamics of the world's watersheds and river basins, also act as carbon sinks (and source) for CO₂ of the atmosphere. As a result the fate of forests is of legitimate concern of all nations. However, this does not imply, let alone require, any sort of rights on the part of the world nations in any individual nation's forest patrimony. The Developed Countries must accept that they are playing a growing part in the deforestation of temperate forests and have much to gain through the slowing down of tropical deforestation, because of the forest products they enjoy (timber and climate stability). Forested Developing Countries must accept that it is in their own interest to safeguard their forests, need to tackle the reasons for the problem, and should indicate what they are prepared to do in return for financial and technical assistance. Thus, both Developed and Developing Countries have different reasons but a similar interest in preserving forests.

The paper then outlines the present status of knowledge on linkages, mechanisms, causes and consequences of the relationship between forests and climate. It states where uncertainty remains but gives quantification of the data wherever possible. The paper distinguishes between better management of the remaining forest, and reforestation and afforestation possibilities. It deals with direct and indirect causes of deforestation both from the social and economic point of view, together with natural influences (disease and accidental fires). It also considers planning at the local, national and international levels. The recommended forest protection measures are divided into those for temperate forests and for tropical forests; self help measures and other country assistance; direct and indirect measures, and national and international political strategies.

The conclusions include the general need for additional legal instruments (such as a climate convention) concerned with forest action taking into account of the work of the IPCC; that Developing Countries will need financial and technical assistance for developing, protecting and managing forest resources and to maintain their longer term competence. They will also need support for appropriate technology, research and training. In this aspect UNEP and WMO are asked to strengthen their efforts on matters related to possible climate change. More specific conclusions included the introduction of forestry into national planning, to assess the full range of forest output and to allow market mechanisms to fully reflect the costs of exploitation. In addition, the aim is to reduce world deforestation rates by half by the year 2000, stop forest degradation resulting from air pollution, and aim for reforestation and afforestation at a rate of 12 mln ha./yr. for at least the following 20 years. Finally, proper targeting of financial, technical, economic and institutional assistance is vital together with priorities for action and the promotion of problem awareness at all levels.

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THE ROLE OF FORESTS IN RELATION TO CLIMATE CHANGE

1.1

Background

Forests are arguably the most important vegetation zone on the face of the earth today. They play a far greater role in the well-being of the planetary ecosystem than they are often given credit for, and we may soon find that forests will effectively be called upon to make a still more critical contribution to planetary stability. Yet on every side, from the equator to the arctic, forests are being depleted or will shortly be depleted through human agency at a rate that could well reduce many of them to impoverished remnants by the end of the next century. Indeed, forests, which have been the predominant form of vegetation on our planet for hundreds of millions of years, may soon become a minority presence- whereupon we shall discover (by default) the full measure of their part in underpinning the ecological welfare of our biosphere.

What is the nature and scope of the role of forests in planetary workings? By "forests" is meant tree-dominated communities with substantial canopies, (by contrast with woodlands which feature much sparser tree cover) that are the repository of a greater abundance and diversity of terrestrial life forms than the rest of the earth put together. Tropical forests are specially rich in species and in the evolutionary capacity to generate new species. As tropical forests are cleared wholesale, there will be an impoverishing impact on the very course of evolution itself.

Moreover, forests help to regulate the hydrodynamics of great watersheds and river basins such as those of the Ganges and the Amazon. When forests are cut, particularly on sloping land, water runs off unimpeded, taking large quantities of soil and nutrients with it, thus depleting the agricultural potential of the deforested area and causing increased flooding and silt accumulation downstream. Forests also help to regulate climate, at least at local level, through their moisture-cycling processes and their reduction of the reflectivity of the earth's surface (albedo). Forests harbour much more carbon in the form of plant tissue, detritus and soil than the rest of the planet put together so they play a critical role in the global carbon budget. As forests are eliminated by burning, they serve as an anthropogenic source of carbon dioxide, thus contributing to the "greenhouse effect", a phenomenon that may transform our planet to a profound degree within just another few decades. In various ways, then, forests exert a great gyroscopic effect in maintaining the dynamic stability (homeostasis) of many biospheric functions, including many functions that keep the planet capable of sustaining life as we know it (Myers 1987).

1.2

Policy Framework

If the statements of the background section are accepted then it inevitably leads to a recognition that the world's forests represent a legitimate interest of all nations, for all manner of interdependency reasons apart from the predominant factor of climate regulation; and

that this recognition need not be construed to conflict with sovereignty considerations. After all, legitimate interests do not imply, let alone require, any sort of rights on the part of the world's nations in any individual nation's forest patrimony.

The Developed Countries must accept that they have much to gain through a slowing of tropical deforestation and extensive reforestation of tropical lands, because of the tropical-forest products they enjoy (e.g. specialist timbers, genetic resources, climate stability).

At the same time, Developed Countries play a growing part (through over-logging on the part of North-based timber corporations, marketplace demand for "cheap" hardwoods, beef, cassava, etc.), the debt burden, inequitable trade/aid relationships, and the like) in the deforestation going on.

Thus Developed Countries should explicitly accept the rationale for a joint campaign among the community of nations to safeguard and restore tropical forests, and to do it in a manner that reflects a spirit of true partnership.

On the other hand the forested Developing Countries must accept that it is in their own interests to safeguard their forests, quite apart from the genetic materials, let alone the climate connection.

At the same time the Developing Countries, must see that tackling the problems themselves will be less than sufficient and that the time has come to tackle the reasons for the sources of the problem, which principally lie in migrant throngs of landless peasants.

The Developing Countries should also realise that whilst they are looking (and rightly so) to the developed countries for various sorts of financial and technical assistance, they must indicate what they are prepared to do in return. What policy shifts, reformulated strategies, integrative programmes, macro level planning and the like, are they prepared to undertake measures of a character, scope, scale, energy and urgency that will mark a big break with the past.

The policies toward forestry in all countries are frequently too circumscribed in scope, concentrating largely on timber, beef and a few other products, while omitting the vast number of other products that often prove more valuable than timber etc. --plus of course the environmental services (including climate regulation) that are often difficult to quantify in comparable terms.

If governments often fail to introduce policies that support forestry in a rational fashion, they often introduce policies that (perversely and unwittingly) serve to militate against forestry. These adverse policies include such wide ranging policies as tax, credit and pricing systems; covert subsidies for anti-forestry activities; rural development generally (or lack thereof); and land-tenure patterns. All these factors can sometimes do more to harm the forestry cause than the entire coterie of ranching lobbyists and other overt, witting

destroyers of forest resources.

It is not enough to engage only in rational development of forests themselves. Government must enable forests to make their full-scope contribution to development processes of many kinds, especially the more salient sectors such as agriculture, energy, communications and public health, generally in areas far outside forests. This means of course that the main rationale for safeguarding forests is to enable them to interface with the leading spheres of activity in territories way beyond forests themselves. Most important of all, in our view, is the forests "contribution to development overall, via environmental services (hydrological systems, watershed regimes), and - the most significant factor of all - climate regulation. At present, governments are inclined to think that development and management of their forest resources should be perceived only within areas occupied by trees. So they place much emphasis on natural forests, plus plantations, agroforestry/social forestry projects, and the like. They give next to no thought to the crucial role of forests outside the forests themselves. Hence forestry is left to foresters, who generally have little interest, indeed next to no understanding, of how forests support human activities in lands often hundreds if not thousands of kilometres outside the forest themselves.

The need for external assistance (technical, economic, financial commercial, institutional) for tropical forestry reflects the common stake in tropical forests on the part of the entire community of nations. Assistance should not be extended in a spirit of charity. Rather it should reflect an acknowledgement on the part of industrialized countries that they too contribute, indirectly, to tropical deforestation through multinational timber corporations and cattle-ranching concerns, the cassava connection/hamburger connection, and over-consumption of tropical hardwoods at artificially low prices. In addition, industrialized countries will lose in all kinds of ways through the demise of tropical forests, most notably through climatic dislocations. So it is in the enlightened self-interest of the industrialized countries to engage in a common campaign with tropical-forest countries to safeguard the forest - but as a hand-in-hand endeavour on the part of equals, to do it in a way that respects the sovereignty sensitivities of tropical-forest countries.

The most important type of forestry expertise that can be supplied by outside experts lies with policy analysts, also institutional experts, who have enough grasp of the "big picture" of forestry to be able to help governments to achieve something which is more essential than any other measure in the entire tropical forestry field. A case of "Only more so and better so" will not be enough to do the job. What is required is a fundamental shift towards comprehensive appraisal of forests" part in development policies and socioeconomic advancement at nation-wide level.

PART II. ACCOUNT OF THE PRESENT STATE OF KNOWLEDGE

2. Significance of the forest ecosystem and the dynamics of the global forest stand

2.1 Significance of the forest ecosystem

Forests have a very special importance amongst the world's ecosystems. They comprise the second most important biological solar energy collector after the marine exosystem. Through its photo-synthetic activity, 150 kPJ of solar energy are included in the biomass each year, thus producing the oxygen essential for the life of heterotrophic organisms. Tropical forests contribute more than three-quarters of this amount. Forest plants use atmospheric carbon dioxide as a source of carbon in the production of their biomass. This gas has the capacity of absorbing part of the IR rays released by the earth into space, thus produces a warming in the lower layers of the atmosphere. Although other gases also affect the climate, carbon dioxide is by far the most important, with a contribution of almost 50%. In this way, forest help to control concentrations of carbon dioxide and consequently affect the temperature of the atmosphere.

The makeup of the soil cover also influences the earth's albedo, as well as the global water cycle. Much of the energy that converts surface moisture into water vapour comes from the sun's radiational heating of the land surface. The energy thus depends on surface albedo, or relevant degree of reflectant "shininess" of the land surface. In turn, the albedo depends on vegetation, which absorbs more heat than does bare soil. Over thick vegetation, there are vigorous thermal currents taking moisture (provided by the same plant cover) up into the atmosphere, where it condenses as rain. Because of its influence on convection patterns and wind currents, and hence on rainfall regimes, the albedo effect constitutes a basic factor in controlling climate. In tropical-forest zones, it appears to be, together with surface roughness, the most important factor by which the land surface can effect climate.

When vegetation is removed from the Earth's surface in large quantities, the result is often a selfpromoting cycle of albedo enhancement, leading to a new stable state of less warm soil, lower rainfall and sparser vegetation. There ensues a significant decrease in rainfall and evapotranspiration, also in cloud cover. Where albedo-derived processes to become disrupted through tropical deforestation, the repercussion could well external, via altered patterns of air circulation, through an entire region. If, say, the whole of Amazonia were to be deforested during a period of 35-50 years, giving way to grasslands and crops (more likely would be a mosaic of these two types of vegetation with scrub, thicket and other degenerate forms of vegetation), the surface albedo is estimated to increase from 0.11 to 0.19, and rainfall to decrease by 0.5-0.7 mm. per day, with both evapotranspiration and cloud cover being reduced.

Tropical forests contain an extraordinary variety of living organisms. Although a mere 1.7 million species have been identified up till now,

the total number of plant and animal species inhabiting the earth is estimated at anywhere between 5 and 30 million. Of these, 60% to 80% are thought to inhabit the tropical rain forests and 80% to 90% in the tropics taken as a whole.

Forest constitute an important factor both directly as sources of raw materials and places of work and indirectly in respect of their external functions. In 1985, the total raw material production of the earth's forests exceeded 3 billion tons. This production consisted, for the greater part, of fuel wood (both firewood and charcoal), and the rest being log timber.

For about 1.5 billion human beings, firewood is the most important and sometimes the unique source of energy. Of these, more than half live in areas which already suffer from a scarcity of such fuelwood; and one in fifteen simply cannot lay hands on enough fuelwood for their basic needs. By the year 2000 the number suffering from scarcity of fuelwood may increase to almost 2.4 billion, and the number facing acute shortages may grow from 110 million to over 350 million.

In 1985, log timber to the value of \$30 billion was traded throughout the world. The total value of log timber exported from the developing countries in that year was estimated at \$1.5 billion.

The external functions of the forests can be defined only in terms of quality. Forests provide a source of plants, chemical agents, medicinals and pharmaceuticals, a host of industrial raw material such as gums, exudates, essential oils, ethereal oils, edible oils, resins, latexes, waxes, tannins and dyes, also a large variety of fruits and vegetables, plus wild meat.

Increasingly, forests also provide areas of recreation or tourist attraction. Although the economic importance of these has not been greatly appreciated hitherto, it may be safely assumed that, at least in certain circumstances, their economic benefits will be even greater than those of wood production. For instance, recent research by Peters *et al.* (1989) shows that in certain sector of Amazonia it is possible to take a sustainable harvest of fruits and wild rubber, plus a number of other materials (fibres, natural oils and medicinal plants) that are small in volume while high in value, thus enabling one hectare of forest to eventually generate well over six times as much income as through logging, and these extractive products can all be harvested sustainably, by contrast with commercial logging which is likely to be a one-off affair.

Particularly in mountainous areas, forests play a very considerable role in providing protection for hydrological regimes, thus safeguarding against flood and draught repercussions as well as against landslides, avalanches and rockfalls. By reason of their water gathering and earth stabilizing effects, upland forests with their catchment-safeguard functions exert a pronounced influence over downstream dwellers, for instance 400 million people in the Ganges valleylands alone, and well over one billion throughout the tropics.

2.2 Existing forests

The extent of the world's forest surface is not known with any precision. According to available estimates, it amounts to something in the region of 4 to 4.5 billion hectares, of which 2.8 billion hectares may be designated as closed forests and 1.3 billion hectares as open forests. Tropical forests, including open-canopy woodlands, make up about 2.55 billion hectares of this total, including 850 million hectares of undisturbed closed forest, 250 million hectares of disturbed (sometimes grossly disturbed and degraded) closed forest, 770 million hectares of open forest and 620 million hectares of scrubland.

2.3 Forest destruction and forest degradation

Since pre-agricultural days, the closed forest surface has decreased by one fifth. Forests in temperate areas have suffered the greatest losses, followed by sub-tropical tree savannahs and tropical climax forest communities. Tropical forests accounted for the smallest overall losses until the early 1950s. Since then this trend has changed markedly.

In temperate areas, agriculture has become increasingly intensive, so that land requirements have not increased. New types of threats to forest areas have arisen (the unexplained dying out of forests), but these have not yet resulted in a globally important depletion of the temperate forest surface. In tropical-forest countries, however, increasing population growth and pervasive poverty, smallholder agricultural encroachment, together with commercial timber harvesting, cattle ranching and fuelwood gathering, have led to strong acceleration of the forest clearance rate.

Since the beginning of the 1980s, there have been reports from various European countries and later also from other continents of new types of damage to forest trees. This was first observed in Central European coniferous forests and later also with respect to hardwood and fruit trees. The extent of the damage has varied very considerably from one area to another. A number of forest inventories which were carried out in Europe in 1987 showed that a proportion of 15% to 40% of trees were slightly damaged, while 5% to 25% had either died or suffered moderate to serious damage. Further afield there has been recorded extensive acid rain-type damage in the forests of southwestern China; and sound scientific opinion (Rodhe and Herrera, 1988) indicate that similar damage of extensive scope could soon start to emerge in parts of Indonesia, Malaysia, Thailand, India, West Africa, Brazil, Venezuela and Central America-forestlands that are all the more susceptible due to their largely acidic soils.

According to the Tropical Forestry Action Plan, in Latin America 4.3 million hectares of closed forest, of which 1.1 million hectares were hitherto completely untouched, are being cleared every year, while in Asia the annual clearance rate of closed forest areas amount to 1.8 million hectares and in Africa to 1.3 million hectares. In the temperate climatic zones, registered forest depletion amounted to about 0.3 million hectares per year in North America and about 0.2 million

hectares per year in the Soviet Union. In Europe, a gross increase in forest surface has been recorded during the last thirty years. However it should be remembered that the various assessments of original forest extent and depletion rates in recent past have produced widely differing results. This can be attributed to constraints of all sorts. For example, the term 'forest' as applied in forestry, in biology or ecology has no universally adopted single definition. Besides this, it is a matter of fact that most of the areas under forest cover as well as their depletion are estimates based on secondary approximations that are usually based on rough comparisons of available data. Thus, due to these constraints any data regarding forest extent cover and depletion rates are subject to doubt and/or criticism and consequently they should be cautiously considered.

Due to an increasing deforestation in tropical areas and its likely influence on atmosphere and climate, this matter has become a major concern throughout the world. So, sophisticated monitoring programmes allied to several computer models have been developed in order to attempt to monitor this process, forecast future rates and relate them to effects on atmosphere and climate. However, despite these efforts their results have widely differed. Most of them still rely heavily on estimates by FAO and government forestry departmentw rather than measurements by modern forms of monitoring, such as satellites and other forms of remote sensing.

2.4

Potential forest surface and afforestation activity

Surfaces which are available for afforestation may be defined in two ways. We may either base ourselves on present land utilisation and consider that treeless areas, as well as very degraded secondary forests, are capable of afforestation - or we may start out from the ecological and climatic properties of the soil and try to establish on this basis where a successful forest, considered as a climax community, might be expected to flourish. In the second method, we may define as areas capable of afforestation all potentially wooded areas, including soils which have been cleared and used for other purposes during a period of many years.

According to the first criterion (treeless areas), regions of the earth's surface capable of afforestation in 1980 amounted to about 800 million hectares. By far the greater part of this was situated in tropical and sub-tropical zones. Africa was estimated to contain 166 million hectares, South America 137 million hectares and Asia 150 million hectares. In the temperate zone, only 40 million hectares of suitable treeless areas were reported - all of these in North America. However, potential forest areas are in fact far greater. Their distribution and extent may be defined roughly in terms of climatic parameters, such as amount of precipitation and the warmth of the climate, as well as the physiological requirements of forest trees. Of course, land is only available when they are not already occupied by presumably unchangeable (at a gross scale) activity such as agriculture.

However, if we use the second criterion and compare the potential distribution of tree species with potential forest areas (i.e. areas which are no longer forest-covered), we reach a different estimate of potential afforestation.

Calculations on this basis provide us with an area capable of afforestation of about 1000 million hectares. These surfaces are partly used for agriculture today. 32% to 35% of them are in temperate zones, 24% to 25% are in the subtropical tree savannah areas, and 15% to 20% are in the climax forest communities of the tropics. Tropical evergreen rain forests account for the smallest total surfaces capable of afforestation, with a share of only 4% to 6%.

In 1985, 91 million hectares of plantations intended for the industrial utilisation of wood were recorded. In the tropics, the surface of industrial plantations amounted to 9.9 million hectares, of which 4 million were in America, 1.3 million in Africa and 4.6 million in Asia. To these totals must be added 7 million hectares of non-industrial afforestation. Between 1980 and 1985, new plantations were being laid down at an annual rate of 107,000 hectares in Africa, 870,000 hectares in Asia and 470,000 hectares in South America.

3. Causes and Mechanisms

3.1 Damage to forests caused by air pollutants

Eight years after the first precise descriptions of the dying out of forests, discussions about the causes of the phenomenon are still continuing. Very little is still known about its primary causes. This fact is generally accepted, and it applies equally to Europe and to other continents.

According to present knowledge, the dying out of forests results from a complex of diseases having several causes which act and interact either simultaneously or consecutively. In all hypotheses regarding the origin of these diseases, air pollutants are considered to be a primary cause. Such pollutants comprise large numbers of both gases and aerosols which are deposited on plants and soils - in both wet and dried forms and often after having travelled over very considerable distances. This constant action by emission having numerous components whose phytotoxicity is unknown, leads to a reduced vitality of trees, as well as of other elements in the ecosystem. This is expressed in an increasing predisposition to damage through extreme climatic conditions, higher mortality of the fine root system, poorer mycorrhisation and loss of nutrient supply.

It is certain that during the past 35 years air pollution has increased to an enormous degree in the developed countries. For example, in Switzerland emissions of nitrogen oxide and hydrocarbons have multiplied by eight since 1950 and those of sulphur dioxide have doubled.

The origins of the different emissions are very varied. 63% of sulphur dioxide emitted comes from industrial furnaces, 25% from non-industrial heating appliances, 6% from motor vehicles and 5% from the burning of rubbish. Nitrogen oxide and carbon monoxide originate from motor vehicles to the extent of 70% and from industrial furnaces to the extent of 17%. Ozone is produced in the atmosphere through a combination of solar energy with nitrogen oxide and hydrocarbons. 23% of hydrocarbons originates from motor traffic, 51% from evaporation of solvents in households and industry, 13% from natural sources and 9% from industrial furnaces.

3.2

Forest depletion by clearance in the tropics

The reasons leading to the depletion of forest areas in the tropics are of a very varied nature. They are the expression of a complex structure of relationships which include the natural environment and the human beings who exploit it and are to a large degree closely linked. Although both the dominant factors and their weighting vary from region to region, four main causes may be distinguished which are of decisive importance for the depletion of tropical and subtropical forests:

a) The rapid growth in population

In many parts of the tropics and sub-tropics, the population growth rate amounts to 2.5% and even more. In order to satisfy the increased requirements in land, food, firewood and living space which result from this, parts of the population in question fall back on forest clearance as their only resource.

The exploitation and utilisation of this resource often takes the form of burning off immense areas of forest; this encourages the destruction of the ecosystem of the forest. Additional large areas are degraded, often severely, through associated activities of slash-and-burn cultivators and cattle ranchers among other agricultural colonists, whether through planned projects or spontaneous settlement. Inappropriate and unsustainable utilisation is often due to the fact that the population has immigrated from other areas and consequently has no familiarity with the forest ecosystem.

b) Mainly export-oriented mining and exploitation of raw materials to satisfy industrial requirements

In the course of industrial wood production, the felling of tropical high-value specialist woods plays an important role, as also the felling of ordinary wood for building and for the production of cellulose. Although clear felling is not normally practised, a considerable disturbance of the ecosystem often results from this. More important still, the new roads which have to be built to reach the wood exploitation areas provide access for new settlers and thus greatly contribute to the forest clearance to which they have to resort to create their living space. Furthermore, the large open areas required for cattle ranching for cash-crop plantations contribute to the reduction of the forest.

We may add to this catalogue the construction of dams for the provision

of electricity, as well as the associated road networks and the exploitation of important sources of raw materials (iron, copper, etc.) - all of which lead to the disappearance of other large areas of forest.

However, in terms of area, timber harvesting is much more important than mining. For the time being, at least in the short and medium terms, future supplies of tropical hardwoods will come largely from natural forests rather than plantations. However, as it is well known, the management of tropical forests sustainably still persists as one of the greatest challenges. To do so, a prerequisite to sound management requires a thorough knowledge of the resource base. Thus, it is fair to assume that an increase in new investments in the management and protection of natural forests makes sense. Accurate longterm monitoring studies are therefore greatly required for assessing the forest cover, depletion rates and its implications on the atmosphere and climate alterations.

c) The political and socio-economic background

The lack of sufficient land to satisfy the needs of a growing population, often impoverished and landless, derives in considerable measure from the political and socio-economic background. The following factors may contribute to this:

- the increasing concentration of land ownership in the hands of relatively few landowners;
- land reforms which have never in fact been carried out or, if so, have not had the intended results;
- settlement policies which are inappropriate to ecological conditions in the forests;
- modernisation and mechanisation of agriculture which has led to the unemployment of large numbers of workers who cannot be absorbed elsewhere in the labour market;
- a scarcity of land and the resulting fallback of the populations concerned on to their only available resource: the forest.
- land speculation as an investment to counter rampant inflation (as in Brazil); and with a view to a lucrative, primarily export-oriented, agro-industrial utilisation (cultivation of cash crops, cattle breeding over large areas);

Natural resources, and among them forest resources, are critical to the economies of many less developed countries (LDC's). In the promotion of economic developments the governments of LDC's frequently seeked to increase production in agriculture, forestry and other sectors dependent upon natural resources. Yet, many of the economic policies adopted by LDC's to promote this increased production led to inefficient or destructive use of natural resources with negative long-term impacts both on the environment and on economic development.

In the realm of agriculture, although various policies can be used to increase agricultural output (e.g. investing in agricultural research and improving agricultural extension services), governments have often adopted policies that increase output by altering incentives for farmers (e.g. through subsidizing agricultural inputs and granting tax exemptions for targeted investments).

Many LDC's have adopted such policies to capture the economic benefits

of increased agricultural output - the increase of government revenues of foreign exchange earnings, or the holding down of domestic food prices - all of which have the opposite effect of diminishing the incentives for production. The effects to these frequently conflicting policies on farmers often led to unintended economic and environmental results.

Substantial benefits could be gained from reform of agricultural input subsidies in many LDC's. Phasing out these subsidies could save money, encourage prudent and efficient use of inputs and lessen natural resource degradation.

In the Forestry field, many LDC's have concentrated on short term development and economic benefits by leasing concessions to private logging firms, taxing exports and promoting domestic wood processing industries, through import and export controls and tax incentives. By adopting such policies many LDC's fail to recognize the economic and environmental benefits of standing forests, the need to sustain timber harvests over the long term and even the full revenue potential of correct timber harvests. The result is rapid and unsustainable exploitation of forests and extensive forest degradation. The long-term impacts of this degradation include: loss of habitat and biodiversity and loss of watershed protection, soil erosion prevention and other environmental services.

In timber concessions, policies are often aimed at deriving the maximum short-term financial value from timber harvesting.

The central problem of concessionary leases is that they significantly undervalue forests. The low prices of the user fees leads logging firms to cut out more timber than they would if the prices were higher. At the same time, the forgone revenues to developing countries' governments reduce incentives and budgets to invest in reforestation and management of forests for sustained timber production. I.e., the system does not take into account appropriately the effective replacement costs of the forests removed. The lease fee structure also affects depletion rates and degradation of forest resources. Flat annual license fees per hectare and uniform royalty and export taxes that fail to recognize different values for different log species encourage selective logging (high grading) of trees with the highest value. All of this has significant impacts in depressing prices of wood and of wood products.

Substantial economic and environmental benefits could be realized by increasing the user fees, taxes and other charges to firms with logging concessions. The higher costs of wood extraction would reduce the environmentally damaging and economically inefficient rates of forest exploitation.

Developed countries, by their turn, have generally erected much higher tariff barriers to imports of processed wood than to logs to protect their own wood processing industries. As a result, fostering wood processing industries has required substantial incentives. The effects of these economic policies and incentives are broad: the economic costs of such growing industrial activity and employment may be high and their impacts on forest degradation can also be significant.

In most developing countries, the distribution of agricultural land reflects the distribution of wealth. Unequal distribution of land, combined with growing rural populations, and with governmental policies

that favours the expansion of agricultural frontiers and forests is a way of securing tenure, exacerbate poverty as well as deforestation in the developing world.

d) Natural factors

Natural forest fires, tropical storms leading to blowdowns, as well as the forest regeneration process as a phase of the natural growth cycle, taken together with many other natural factors, may also lead to a short to medium term depletion of forest surface. In Canada, during the period 1945 - 85, 8.9 mln. hectares of foreste were harvested, whilst 21.9 mln hectares were consumed by fires. In 1989 alone, over 6 mln hectares of forest was consumed by fires. It cannot, therefore, be assumed, that in the long run such depletion would be cancelled out in any entirely natural system untouched by man.

4. Effects of the general global warming process

4.1 Global effects of forest destruction

a) Effects on the climate

As a result of the reduction in the forest area and the consequent changes in soil consistency, carbon which was previously contained in the biomass of the forest and in the earth humus is released. Through oxidation, this carbon reaches the atmosphere in the form of carbon dioxide (CO_2). The increase in the CO_2 content of the atmosphere is probably responsible for almost 50% of the general global warming process. It can thus be calculated that depletion and degradation of forest areas is responsible for between 5% and 15% of the global warming which is expected in the coming years.

Estimates of the amount of carbon which are in this way released into the atmosphere yearly as a result of the reduction in forest area vary between 0.1 and 2.8 gigatonnes (Myers). These emissions are thought to take place almost entirely in the areas of tropical forest.

The importance that tropical forests have for the chemical composition of atmosphere is not fully known. So, present forecast of the climatic change associated with deforestation of tropical forests lacks a certain credibility. In fact, the widely accepted assumption regarding the burning of tropical forests as one of the chief contributions to the greenhouse effect has been challenged with the discovery that other trace gases collectively contribute to greenhouse warming on a scale comparable to the former.

However, it is not just in relation to tropical forests that more comprehensive information is needed. Although temperate forests have been more researched, there are still many aspects which remain elusive. An example of such is the complex interaction of anthropogenic pollutants and natural stresses, with forest decline in Europe and in North America, although the mechanisms are not fully understood. So, this leads to the need of a continuing research which will allow to

identify the causes of forest damage and gauge its extent.

The total amount of carbon which is released into the atmosphere as a result of depletion and degradation of tropical forests is equivalent, according to varying estimates, to 7% to 50% of the amount released by fossil energy products. The large variation in these estimates is due to differing assumptions with respect to the rate of deforestation, as well as the amount of carbon contained in the biomass and the decomposition rate of the biomass which is cleared but not burned.

The albedo (the percentage share of sunlight reflected by the earth's surface), together with soil conditions in the tropics, is among the most important terrestrial factors influencing the climate, at least at local levels. Any reduction in vegetation results in an increase in the albedo. This leads to a decrease, generally localized in extent, in the earth's warmth, combined with a decrease in precipitation, both of which taken together result in a further reduction in vegetation. In addition, any change in the vegetation cover can influence the evaporation process in a given area over a long period of time. This in turn can affect the amount of precipitation, since a considerable proportion of all tropical precipitation - about 50% - is often due to transpiration from the tropical forests which cover the area. In light of these remarks, it may be assumed that precipitation will sometimes be reduced or at least disrupted, by the process of forest clearance, not only locally but also far away from the clearance areas. This will also have its effects on the ecosystem in general and on agriculture in particular.

As a result of the increased CO₂ content of the atmosphere, plant productivity will be enhanced, provided the related moisture balance remains acceptable (which may often not be the case, especially in view of increasing temperature). For example, a doubling of the CO₂ content of the atmosphere, assuming similar climatic conditions, could lead to an increase in yields from agricultural products. This can be estimated at about 10% for maize, sorghum and sugar cane, while in the case of wheat, rice and soya the difference may rise to a point between 10% and 50% according to the variety. There seems to be a possibility that plants which receive an increased dose of CO₂ are able to compensate for the limited nutrient content of most tropical soils, provided, to reiterate a key point, the moisture available for plant absorption remains favourable. However, it is unlikely that this increased productivity can in any way offset the enormous disadvantages caused by the disappearance of the tropical forests and the extremely unfavourable effects that this would often have on the climate and on the planetary ecosystem as a whole.

b) Effects on the gene pool

In the event of a further depletion of forests in the tropics and sub-tropics, millions of animal and plant species - some of them not yet even identified by scientists - are threatened with extinction. This reduction in species which is due to man-induced developments is happening at least 1.000 times more rapidly than in the course of natural processes. It is estimated that up to 50 species are

disappearing every day.

Apart from the depletion of the forest areas, permanent disturbance by work taking place in the forests, the breaking up of the forest areas by agricultural clearance, roads and other infrastructure works, as well as hunting by the forest inhabitants, all contribute to the mass extinction of species.

4.2 Local effect in the temperate climate zones

a) Effect on the local climate

The rise in temperature will be more noticeable in the temperate climatic zones than in the tropical and equatorial regions. In temperate continental areas, the climate will not only become warmer but in many areas also drier on average. In the grid 5° - 15° East, 45° - 55° North, which contains Switzerland, climate calculation models exist which indicate a rise in mean summer temperatures of 0° - 6° C and in mean winter temperatures of 4° - 8° C.

This new climate may be described as warm to hot in summer, with almost continual sultriness from May to September, and cool in winter with frequent precipitation and wet snowfall. In these conditions, a totally different kind of vegetation is likely to appear: the whole flora will be similar to that of the later Tertiary period, which means a majority of evergreens and considerable wealth in fern life. In addition, a predominance of deciduous species will appear at fairly high altitudes - about 800 to 1.000 metres. The higher average temperatures will lead to an acceleration of the soil formation process, as well as water erosion processes. In drier areas, a marked depletion of the water content of the soil, especially during the spring and summer growing seasons, will occur for various reasons, including the increased transpiration activity of the vegetation.

The present distribution of tree varieties in the forest will change dramatically. The main characteristic of this will be a high rate of substitution of coniferous by deciduous trees. Many tree species will have to migrate northward at a speed 10 times greater than they have moved in the prehistoric past--and do it while avoiding cities, agricultural lands and other forms of human activity. Of course we could assist individual species by e.g. transplanting seeds into new habitats. But this will reduce the species. All in all, a massive and very expensive intervention will be required to save a single tree species--often enough, a species that we do not now view as threatened at all.

Worse, the boreal forests face a dismal prospect overall. Although these forest will not disappear entirely, they will be reduced from 23 percent of global forests today to 1 percent or less (Houghton and Woodwell, 1989). The rising temperatures, with the greatest increase projected for polar regions, will cause the present range of boreal forests to give way to vegetation patterns encroaching from the south. Yet the boreal forest will have little space to migrate northwards. They will be largely eliminated, possibly as quickly as during the period of a few decades of the second half of the next century.

b) Ecological effect

The dying out process in the temperate forest is leading to the early felling of diseased trees. This forced utilisation, together with the lessened vitality and growth capacity of the remaining and newly planted trees, will lead to a reduction in the total stock and consequently also in the density of the forest stands affected. As a further result of the dying out process in the forests, there will be a reduction in the evaporation of precipitation and in the transpiration rate. This means that more water will flow out of a given surface area rather than being absorbed within it. In its turn, this will lead to a greater erosion danger in the areas concerned and to a growth in the number of outflow points. Land areas which will consequently be poorer in water content than previously, will no longer be in a position to the same extent as before to withstand long drought periods through use of their own hidden water reserves. The rate of discharge of mountain torrents will become greater, partly because of earlier snow melt. The thinner forests remaining will also lose to some considerable extent their capacity to stabilise snow masses. The dying out of forests used as protection against avalanches will lead to a greater frequency of the latter. In mountainous regions, rockfalls will increase - with all their consequences in risk for human life and the integrity of the landscape. In this sphere also, forests render considerable protective services - services which can be provided less easily as a result of the damage done to them and their consequent loss of density.

c) Economic

Comparisons of the stock, growth and total amount of wood available for industrial utilisation in our diseased forests with past reference figures have shown that we must reckon with considerable loss of revenue due to these diseases even if future developments are favourable. In the best possible case, the amount of stock and growth is likely to be reduced by 15%. If both the main economic elements - the increased revenue through sales of wood from diseased trees which had to be exploited and the reduced value of the stricken forests - are expressed in financial terms, we may say that on balance there will be an overall reduction in value by the year 2005 of \$50 per hectare per year.

Besides the direct costs of the dying out of the forests, forestry has to support a whole series of indirect costs which can be attributed to the reduction or the complete loss of the beneficial functions of the forests. The most important effects in this respect are the loss or reduction of protective functions with respect to avalanches, rockfalls, flooding and landslides, as well as the impairment of the human recreation functions of forest landscapes.

The reduced capacity of the diseased forests to store and maintain water supplies will lead to an increase in wasted humidity. The highest increases in this respect may be expected in the framework of annual precipitation. The maximum waste of rainfall would increase by from 25% to 60% according to the degree of forest damage. This change in the amount of rainfall wasted will lead to a situation in which the

dimensions and costs of new construction for water supply and control would increase. If such new construction does not take place, damage from flooding may be expected to increase.

4.3 Local effects in the tropics

a) Effects on the local climate

The increase of temperature in the tropics is likely to be less than in the temperate zones. Other climatic changes forecast include a growth in humidity of from 5% to 20%, a widening of the monsoon belt and an increase in the frequency of extreme climatic events in continental regions - although these are not expected to be felt as frequently in the northerly as in the central and southerly regions of the tropical zone. An increase in the level of the ocean could endanger a number of densely inhabited regions, such as the Ganges and Nile deltas, as well as coral islands.

As concerns the monsoon belt and seasonal forests, it looks eminently possible that there will be a significant disruption of rainfall patterns, with an intensification of rainfall-producing processes (concentrated rainfall in erratic stages, leading to too much water for plants followed by too little, i.e. flood-and-drought regimes). In monsoonal regions live some two billion people, of whom at least half are dependent not only on "normal" monsoon rainfall but on the stability of upstream watersheds. Consider the valleylands of the Ganges, Brahmaputra, Salween, Irrawaddy and Mekong Rivers in Southern Asia, also the southern rivers in China, also the rivers in subtropical China, plus the Niger River in Africa, all supporting ultra-large communities of smallscale farmers.

b) Ecological effects

Much of the soil in the tropics is characterised by an extreme poverty in terms of nutrients. About 90% of the nutrients available are to be found in the biomass rather than in the earth. Thus, there is no real basis for conventional agricultural exploitation. Clearance of forest areas disturbs the symbiosis between earth and vegetation and leads to a rapid deterioration of the quality of the soil--plus widespread increase in soil erosion. As a result, a very rapid drop in yields from agriculture can be expected within the space of 2 to 3 years. There is no doubt that cleared areas are subject to denudation and degradation processes. Associated phenomena are land erosion (through wind or water), earth movement (through landslides and subsidence), as also flooding and material deposits along the courses of rivers. All such phenomena may result not only in loss of human life, but also in considerable damage to cultivable areas, roads, buildings and other material assets.

c) Economic effects

Any reduction in the forest area obviously leads to a scarcity of the natural supply of wood. It is true that the exploitation of wood for industry is affected by this.

However, alongside the damage to soils already described, the most

serious and acute economic effect of forest depletion in tropical countries is undoubtedly the scarcity of fuelwood. As we have already seen, 2 billion human beings rely on fuelwood for their energy supplies. More than half of this number are already affected by scarcity. Forecasts for the year 2000 suggest that the number of people who will be suffering from a lack of fuelwood will then have reached 2.4 billion.

The problem of fuelwood scarcity affects essentially savannah areas in general, and the Himalayan and Andean regions in particular. In these places, women and children spend between 100 and 300 days a year in collecting fuelwood. Water can no longer be heated for long periods of time, with the result that foodstuffs which can be cooked fast are replacing the much more nutritious but slow-cooking beans which used to form the traditional diet. In addition, manure is dried and burned - thus further depriving the soil of essential nutrients.

PART III ACTION STRATEGIES: REQUIREMENTS AND POSSIBILITIES

5. Forest protection and afforestation as a means to combat climatic changes

The depletion of forest areas and forest density accounts for approximately 13% (5-18) (Myers) of the global warming phenomena. Thus, after the carbon dioxide emissions of energy systems, forest depletion takes a place which is comparable with other human-induced causes of climatic change, particularly in respect of methane, chlorofluorocarbon, and hydrocarbon emissions. However, forest depletion presents so many and such very serious global threats to the biosphere and, the human habitat, that among the various strategies being worked out to prevent changes in climate it appears that a very special urgency should be devoted to it.

Any increase in the global forest biomass and the wood mass which is linked to it - this being affected by the economic cycle in wood production - means that carbon dioxide is withdrawn from the atmosphere and definitively fixed in the biomass. However, this withdrawal cannot alone compensate for the permanent input of carbon dioxide into the atmosphere by the burning of fossil fuels. The limits of this strategy will have been reached only when the areas of the world which are capable of afforestation have actually become forest regions. At the moment, we have not reached this stage, and in the short term and taking into account the high rate of forest depletion in the tropical areas it is the task of maintaining the present forest areas and stemming the rate of deforestation which is judged to be the most certain and the most rapid measure which can contribute to slowing down the present increase in carbon emission. However, any degree of afforestation will have an added and very positive effect in reducing the concentration of carbon dioxide in the atmosphere. In order to obtain a 50% reduction in the excess of carbon dioxide, afforestation

to the extent of 200 million hectares would have to take place - and this would of course have to be accompanied by a complete stop (perhaps a naive assumption) in the present rate of forest depletion. In the event of afforestation to the extent of 300 million hectares, harmful accumulation of carbon dioxide in the atmosphere would be entirely eliminated.

In principle, there exist three methods of procedure for putting an end to carbon emissions into the atmosphere through the depletion and degradation of forests, or for reducing such depletion and degradation, or even for transforming such depletion and degradation into an increase: maintaining the present stand, engaging in afforestation of the areas available for such activity, and increasing the carbon dioxide intake capacity of the forests.

a) Maintaining today's existing forests in their present density. Maintaining the world's forest surface would not only mean the absorption of a very important proportion of carbon dioxide, but it would also help to put an end to the ever increasing degradation and erosion of tropical soils. In the same way, continual impoverishment of the world's genetic variety would be prevented. In addition, the basis for long term economic utilisation of the world's tropical forests would be maintained.

b) Reforestation and afforestation

Forestation provides an opportunity to alleviate the negative climatic, ecological and economic consequences which stem from the depletion of forests in both the tropical and the temperate zones. As a result of forestation, carbon dioxide will be stored in forest trees through the process of photo-synthesis - which means that for a certain period at least it will be withdrawn from the atmosphere. According to the eventual use of the wood - whether short-term (fuelwood), mediumterm (log timber) or long term (genuinely protected forest) - it will, in one form or another provide a buffer against the excess of carbon dioxide in the atmosphere. For example, planting one hectare of forest represents the production, on average, of 30 tons of biomass, which contains approximately 50% carbon. This can also be expressed by saying that one hectare of forest can absorb ten tons of carbon per year. Thus, 100 million hectares can absorb 1 gigaton of carbon over an average forest life of from 8 to 50 years. As we have seen, in order to absorb the global accumulation of CO₂ in the biomass, it would be necessary according to the estimations of various authors to proceed with reforestation or afforestation to the extent of about 300 million hectares. However, there is a divergence of opinions as to whether the necessary areas are available, and if so where, which species of trees should be used, and to what extent the profitability estimates which have been put forward actually correspond to reality.

c) Promotion of adapted utilisation systems

Adapted utilisation systems have the virtue of permitting an increase in biomass productivity while at the same time taking into account the necessity for sustained utilisation.

6. Recommended forest protection measures

Since the problems faced in the temperate climatic zones are of a quite different nature from those of the tropical forest, the two subjects will be handled separately in the following list of measures to be taken. Thus, section 6.1 is concerned with temperate forests and section 6.2 with tropical forests. And within these two subjects we also have to differentiate between measures directly concerned with forestry and procedures which are less directly targeted at forest maintenance. At the end of each of these sections, we shall summarise some of the necessary changes which we believe ought to be made at the level of national and international political policy.

Within the individual catalogues of measures to be taken, our separate recommendations are listed roughly according to the type of measure in question. First, we deal with obtaining the necessary data, and then this is followed by strategies in the fields of law, finance, information and research, as well as any technical recommendations. In our opinion, any project likely to be succesful must take its place in one or other of the strategies which are sketched out in this document.

6.1 Forest protection measures in the temperate climatic zones

6.1.1 Measures in the field of forestry

a) Possible self-help measures by the countries in question

A prerequisite for working out a succesful strategy is a precise knowledge of the present state of forests. This requires:

- a precise registration of damage to forest through air pollutants and methods of utilisation up till now, both at the quantitative and qualitative levels; supervisory programmes must be established so that the state of the temperate forests is recorded regularly; appropriate evaluations must be worked out for the use of the responsible forestry authorities, for politicians and for the population in general.

Present legislation relating to the protection of forests must be supplemented and strengthened. In this respect, the following aspects must be specially emphasised:

- a very restictive policy with respect to clearance authorisation (particularly in the vicinity of already existing settlements and in ecologically sensitive locations) and the introduction of an obligation to compensate any authorised clearance with substitute afforestation of equivalent ecological importance;
- introduction of a clear forest management obligation om the part of forest owners; if an owner is unwilling or financially unable to carry out such forest management, he must allow it to be carried out by a third party; the objective of such a measure must be to ensure

that isolated, poor quality and topographically disadvantageous areas should be subject to forest management in the interest of the service functions of the forests as a whole; this is particularly important for forests with important protective functions (water balance, avalanches, erosion protection;

- areas which cannot be exploited economically should be transformed into natural forest reserves, in so far as this does not detract from their protective functions. Thus, they will be enabled to carry out the role of a genetic reserve for other forests and supply watershed functions and a host of other environmental services that are critical for agriculture, energy (hydropower dams), communications (rivers, ports), public health and several other salient sectors of development overall.

Financial measures which should be considered include:

- government assistance for adapting forestry management structures (rationalisation, mechanisation, product marketing, etc.) and providing subsidies for necessary but unprofitable forestry operations (for example, thinning out in mountain areas);
- providing compensation for lost recreation functions of forest areas either by those who exploit them or by the government.

In the short and medium terms, a number of technical measures are of obvious importance:

- damaged trees to be felled in order to prevent increased parasite infestation of the areas in question;
- provision where necessary of an improved and more closely woven network of forest tracks;
- introduction or acceleration of widespread afforestation programmes with the object of obtaining a stable, or according to the country or region in question, an increased forest surface.

b) Possible measures by other countries

- No recommendations

6.1.2

Measures which have an indirect effect on forestry

a) Possible self-help measures by the countries in question

In many industrialised countries, the need still exists for legislative action to prevent one of the most important short-term causes of the dying out of forests. These measures concern in the first place a reduction in air pollution:

- strengthening emission limits for all atmospheric pollutants likely to damage forests (vehicle emission limits, NO_x limitation for small industrial installations, etc.); i.e. immediate and rigorous reduction of acid rain.
- an obligation to install filters for emissions from large coal and petrol furnaces; the aim of such a measure would be to eliminate completely the sulphur content of emissions from all large-scale

- furnace installations;
- legislation to lower the sulphur content of heating oil and coal authorised for use in small-scale heating appliances; where this is not possible for reasons of scale, a number of small appliances should be connected to a central installation which is large enough to be fitted with a filter;
 - obligatory installation of catalysers in all newly manufactured private vehicles;
 - tax reductions to encourage the installation of catalysers on all cars not already equipped with them (petrol taxes, motor vehicle taxes);
 - introduction of measures designed to reduce the density of private transport (traffic-free zones, limited through traffic in residential areas, increase in the price of fuel, reduction in the number of parking places, motor vehicle tax to be dependant on the distance travelled);
 - shifting long-distance goods transport from road to rail (transit prohibitions, more severe emission standards for heavy vehicles, combined motorail solutions, technical improvements to mixed rail/heavy vehicle transport in the field of reloading);
 - strengthening conversion emission controls on industrial installations; conversion requirement for installations which do not conform to the law.

Financial encouragement to environment-friendly behaviour and penalisation of environmental pollution:

- introduction of a targeted energy tax; environment-friendly energy users should receive fiscal advantages at the expense of those causing environmental damage;
- financial encouragement for the use of renewable sources of energy in the heating industry, particularly for the introduction of solar energy;
- government subsidies for expanding the supply of public transport (increased frequency, increase of offer in terms of destinations and routes, improved comfort, active marketing, connections between the various public transport networks);
- support for tropical countries in the field of environmental protection through the transfer of environment-friendly technologies.

Research and development should take place in the following fields:

- air pollution inventory;
- emission registration;
- effects of emissions;
- technologies for the reduction of air pollution;
- political strategies (policy).

Introduction of the study of ecosystems at all levels of schooling.

Informing public opinion about the following aspects of the general problems connected with forest destruction:

- the present situation and the results of damage to forests;
- the necessary transformation measures;
- stabilisation of population growth; even in many industrialised countries, high population density is one of the main causes of forest destruction; the basic land requirements of the population are of course already covered, and the threat to forest areas is not primarily caused by the expansion of areas subject to human settlement; however, the manufacture of a steadily increasing number of products catering for a high population density is inevitably accompanied by increased environmental pollution; alongside the need for technical solutions to the problems which appear, which must sometimes be combined with sacrifices on the part of the consumer, a stabilisation or even a reduction in the number of consumers still represents a valid option.

b) Possible measures by other countries

- avoiding the mistakes already made by the industrialised countries; including the notion of environmental friendliness in development projects;
- accepting the increasingly environmentally friendly but more expensive technologies being developed in the industrialised countries;
- refusing rights of establishment to industries liable to produce a high degree of pollution - and which have fled from the industrialised countries because of the more severe environmental protection regulations which have been laid down there.

6.1.3 Consequences for national and international political strategies

a) National political strategies

- continuing, strengthening or introducing forest maintenance policies;
- implementing strong air pollution policies; the objective of reducing air pollution from burning processes, and other industrial operations using pollutants damaging to the forests, must be given the highest priority;
- demographic policies aimed at stabilising population growth;

b) International political strategies

International treaties and other agreements aimed at reducing global air pollution:

- the Vienna Agreement of March 22, 1985, on protection of the ozone layer;
- the Montreal Protocol of September 16, 1987, on materials which contribute to a reduction of the ozone layer;
- bilateral and multilateral agreements aimed at the reduction of air pollution.

Incorporation of environmental protection in all aspects of technical cooperation.

6.2 Measures for the protection of tropical forests

6.2.1 Measures in the field of forestry

a) Possible self-help measures by the countries in question

Obtaining basic data:

- creation of efficient programmes to register present land utilisation and its development; transferring this knowledge into up-to-date maps for the use of the agricultural and forestry authorities. On the basis of such information, it will be possible to regulate optimal utilisation of individual areas by planning programmes having the force of law. In most areas the policing and other oversight functions are undertaken by far too few foresters, guards and other personnel. So, much more important is to persuade governments to implement policies that are truly directed at rational conservation, management and overall development of tropical forest - in strong contrast to those many countries where government policies often and perversely have the opposite effect, serving (albeit unwittingly) to promote unsustainable exploitation of forests.

The following zones should be identified and clearly distinguished:

- agro-forestry areas; mainly in zones where agriculture and forestry are already mixed or in treeless agricultural areas which are threatened by erosion; pressure on the forest by farmers is reduced by local availability of firewood; since the forest trees are growing on his own land and thus belong to him, the farmer will be motivated to exploit his wood resources with moderation and at the same time stimulated to maintain his tree stock by new plantations.

The actual forest areas can be sub-divided according to various types of utilisation as follows:

- plantations of (preferably) indigenous or exotic trees should be used for the production of wood for building and firewood for the domestic market, as well as for export - this in order to reduce pressure on the primary forest areas; primary forest should in no case be made to give way to new plantations; suitable for the latter are treeless areas, secondary forest areas and areas with deteriorated soils;
- secondary forest areas may also be used for wood production; secondary forests often feature fewer tree species overall, and more commercially-usable species, than is the case in primary forests. Moreover they are at a very rapid growth stage of the S-curve. They could alternatively be subject to 'salvage logging' by clear cutting, before being given over to tree plantations.
- buffer zones should be created around national parks and other

protected areas, which then form a safeguarded core within a series of concentric circles that feature ever-increasing levels, amounts and intensities of human activity.

- particular important and ecologically significant forest areas should be designated as special nature reserves and should be maintained in their natural state. The present network of parks and reserves in tropical forests amounts to far less than one third of what is needed overall - and many of them are not located in the most efficient places.

The various forms of utilisation should be laid down in the relevant forestry regulations. Particularly important in this respect is:

- the introduction of an absolute requirement to draw up long-term utilisation programmes which will have as their aim the setting up of forms of cultivation which can be sustained over a long period of time.

The various forms of utilisation aimed at should be promoted through financial incentives:

- establishment and financial promotion of tree plantations, including indigenous and exotic species of trees; especially for small farmers;
- concessions for new tree plantations and for the sustained utilisation of secondary forests must be linked to the provisions of the utilisation programme;
- concession fees for the industrial utilisation of forests should be increased; the height of these fees should be adapted to the international market value of the wood felled rather than to the local market value or to the volume of wood felled; wherever the forest structure of the relevant region makes it possible, a difference in price should be introduced which favours the use of secondary forests over that of primary forests; holders of concessions should be made responsible for lasting damage caused by unsound utilisation of their respective areas; these objectives can also be helped by a flexible system of concession duration linked to the ecological behaviour of the holder of the concession;
- increases in government investment in afforestation programmes and in the upkeep of forests;
- promotion of integrated forestry and agricultural land utilisation (agro-forestry) - for example, by financing new such schemes;
- the forestry service must be placed in a position in which it can better comprehend the areas placed under its control both qualitatively and quantitatively, in which it can work out plans for their utilisation and protection, and in which it can exercise control over any changes in their utilisation; in addition, improved training and the provision of more staff and a more effective infrastructure for the forestry service and forest guards are normally necessary.
- induce LDC's to put a value on deforestation and insert costs into national economic and development plans, so that governments and international development agencies follow a more rational path to

protect tropical forest ecosystems.

b) Possible measures by other countries:

- support in training and further training of forestry service staff for tropical countries;
- support by providing model projects in the framework of development cooperation;
- to assist producing countries to develop better techniques for reforestation and tropical forest management, to develop ways to modify logging systems to reduce their environmental impact, to encourage increased timber processing, and to support research and development programme to achieve these goals;

6.2.2 Measures to support forestry indirectly

a) Possible self-help measures by the countries in question

At the legislative level:

- transfer of ownership and utilisation rights over forests from central government or large landowners to local economic actors (municipalities, private individuals); legal establishment of the autonomous responsibility of local communities for forest resources;
- participation of local communities in forest utilisation in the framework of utilisation programmes through a system of financial compensation (wood exploitation taxes);
- prohibition or limitation of forest clearance by burning for agricultural purposes;
- prohibition of new building and settlement in forest areas;
- levelling out cattle stocks, particularly in areas where these are not necessary for local meat consumption;
- reducing the propensity for cattle husbandry to degenerate into a form of 'shifting ranching' due to poor management. Provision of technical expertise to make more sustainable use of existing pasture lands.
- elimination of resettlement programmes in forest regions; the rapid population growth which results from such programmes soon cancels out any short-term advantages, with the effect that resettlement is often very costly and the results disappointing; moreover, spontaneous migration of the population seems to guarantee a better allocation of resources.

Financial means

- decentralised creation of employment in the non-agricultural field; in particular, by setting up commercial and industrial wood-processing undertakings in the regions in which the raw material originates; this may be achieved through higher export taxes for log timber than for wood products and could be further assured by international agreements; subsidising domestic wood-processing industry has in the past proved itself less successful than the above-mentioned policy;

- elimination of favourable interest rates, promotion credits and other measures of economic encouragement for the exploitation of primary forest areas and their industrial utilisation;
- introducing or strengthening favourable interest rates, promotion credits, tax relief and other measures of economic encouragement for new plantations and afforestation programmes;
- elimination of obstacles to economic growth, such as price distortion in the field of infrastructure, interest rates higher than those set by the market, the fixing of arbitrary prices based on the interests of city-dwellers and the statutory authorities; the elimination of subsidies for inflated and unprofitable undertakings in both the industrial and agricultural fields;
- increased promotion of self-sufficiency instead of supporting export-oriented cash crops and meat production; the aim of such measures is to prevent the phenomenon of farmers producing for self-sufficiency or the domestic market being driven from their land by export-oriented agricultural operations and consequently being forced to move into forest areas.

Research and development is necessary in the following spheres:

- the social and economic conditions for forest maintenance;
- ecology of the tropical forests;
- wood selection techniques;
- forest regeneration;
- wood processing technologies;
- the type and function of the domestic market for wood products;
- supply of energy from wood;
- agro-forestry;
- the key linkages between tropical forests and climate.

At the technical level:

- the introduction or extension of more efficient combustion technologies for firewood is of great importance; in addition, firewood should wherever possible be replaced by other, renewable and inexpensive domestic energy providers, such as solar energy, biogas and biomass provided by agriculture, as well as energy derived from wind or water.

The entire rural population should be informed:

- about the present situation of the forests;
- about the effects of a continuation of the methods of exploitation used so far;

In addition, the continuation and intensification of the birth control information campaign is of the greatest urgency.

b) Possible measures by other countries

At the legislative level, it seems important that:

- environmental protection aspects, and particularly the protection of forests, should be taken into consideration in all projects in which the industrial countries participate financially, both at the governmental and the private levels; this can be achieved by the introduction of an imperative duty to examine the environmental compatibility of all such projects;
- the possibility of introducing import limitations on tropical precious woods should be examined; an effective limitation would be the association of the allocation of an import certificate with proof of economic planning and sustained utilisation programmes in the region of origin of the wood to be imported; such a measure would not diminish the economic significance of the forests for the countries of origin (something which would certainly have counter-productive effects), but would on the other hand work in the direction of encouraging long-term planning in the field of forest resources.

In the financial field, attempts should be made:

- to eliminate or reduce import duties and other import barriers for products emanating from the wood-processing industry in the tropical countries; this would result in the rationalisation of this industrial branch in the country of origin, which would in its turn promote an improvement in the exploitation of these raw materials;
- to examine the possibility of purchasing areas of tropical rain forest by private or public organisations in the industrialised countries in order to maintain biospheric reserves.

Research and development in the above-mentioned field must also be carried out in the industrialised countries.

However, it is important that:

- the transfer of newly obtained knowledge is guaranteed; this can be achieved through exchanges of research experts and students, through the organisation of seminars and further training courses in the tropical countries, as well as through cooperation with private and public firms and institutions connected with forestry and the wood-processing industry.

6.2.3 Consequences for national and international political strategies

a) National political strategies:

- setting up an energetic forest maintenance policy
- reform of land ownership in the fields of both agriculture and forestry; promotion of a wider spread of land ownership;
- starting up - or extending and intensifying - demographic policies which are based on reducing the rate of population growth;
- consolidating policies of economic growth through the elimination of regulations which distort free market processes.

b) International political strategies:

- Tropical Forestry Action Plan (TFAP of the FAO, UNDP, WRI, World Bank);
- International Tropical Timber Agreement (ITTA);
- the creation of a "World Atmosphere Fund", which will be largely financed by taxation on fossil energy products in the industrial countries; intensification of the activities of the above-mentioned TFAP could also be financed in this way;
- setting up an international forest maintenance fund in order to create meaningful incentives for the developing countries to exploit their secondary tropical forests and at the same time to protect their remaining primary forest areas;
- bilateral and multilateral agreements for the protection of the tropical rain forests;
- establishment at an international level of the minimum charges for the international exploitation of forest resources; these should be high enough to cover the costs of re-afforestation and forest maintenance;
- debt forgiveness in exchange for environmental protection, particularly forest maintenance; for example, the repurchase of bank claims on the secondary market through financial means provided for development assistance or by development banks has been proposed - this to be followed by the exchange of such debt paper for environmental investment through conversion into local currency at the effective market value of the original claims;
- compensation for refraining from utilising certain areas; in the industrialised countries, farms regularly receive compensation on the one hand for continuing cultivation in unfavourable zones and on the other hand - a matter which is up for discussion at the moment - for refraining from cultivation in certain zones which are considered sensitive from an ecological and a landscaping point of view; a similar system of subsidies would be thinkable as a reward for refraining from exploiting the tropical rain forest in certain tropical countries.

CONCLUSIONS - GENERAL AND SPECIFIC

- To develop legal instruments, or further framework conventions, concerned with or comprehending actions in the forestry field, necessary to establish institutional authority and to implement principles to protect the atmosphere and to counter climate change (in particular global warming), should start from and take into account the studies, and consequent agreed recommendations, that the IPCC will define in relation to the forestry matters.
- Developing countries will need to be assisted financially and technically to ensure that they will be competent to address the issues of concern of the climate change question in relation to developing, protecting and managing their forest resources, so that they become adequately, informed for assessing practical response strategies.
- Arrangements must be made to ensure developing countries maintain and develop their competence in the longer term to effectively consider the forestry issues relating to global climate change. This will require that the scientific knowledge base as well as infrastructure of developing countries, be upgraded in order that the interaction of the role of forests with climate change be more adequately understood and assessed, and its consequences effectively considered in response actions.
- Assistance to Less Developed Countries (LDC's) in developing their capability to cope with the problems and issues of climate change will need emphasis for using and developing support technologies appropriate to LDC's and their forest systems, rather than simply importing technologies and solutions that only increase dependence on aid from developed countries.
- Financial assistance must include provisions for climate change research to upgrade the existing facilities in LDC's and/or to create new ones.
- UNEP and WMO should strengthen their help in identifying activities under their existing programmes that would contribute directly or indirectly to the development or transfer of relevant and adequate information, technology and expertise to developing countries.
- UNEP and WMO should expand their consultation with UNDP to identify all existed and new opportunities for training and education activities for developing countries that will increase the pool of suitably qualified scientists to tackle the climate change issue. They should also consider further how best to involve other agencies (such as ECLA, FAO and others), with responsibility for other topics such as agriculture, water resources, forestry and economics so that training programmes in these areas might reflect the increased importance of climate change from the impacts and response point of view.

- To promote the introduction of an integrated and overall policy framework which includes forestry at national levels of planning, and an awareness of deforestation consequences at grassroots level, throughout the world.
- To assess the full range of forest output, to encourage better forest management, to allow the economic market mechanisms to properly reflect the full economic and social costs of exploitation.
- To reduce the World deforestation rate by half by the year 2000 AD and, in addition, slow the forest degradation rate through the suppression of acid rain and other pollutants.
- To aim at a global afforestation rate of 12 mln ha/yr by the year 2000 AD, and maintain this rate of new planting for at least 20 years, in both temperate and tropical zones, to overcome a backlog of new planting being much less, in recent years, than forest clearing.
- After the year 2020, to balance forest cutting with new planting both in terms of volume, tree type and region.
- The need for the creation and proper targeting of financial, technical, economic, and institutional assistance, from the forest market (beneficiary) countries to the forest output (supplier) countries.
- The need to list priorities for action, and to improve the quality of data on the size and interconnectivity of the deforestation and climate problem.
- To allocate the new efforts to various organisations for the monitoring of their progress.

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The Ministerial Conference, organized
by the Minister of Housing, Physical
Planning and Environment of The
Netherlands in cooperation with
UNEP and WMO.

Climate conference secretariat:
P.O. Box 450
2260 MB Leidschendam
Tel. 31 70209367, ext. 2125
Telex nr. 32 362 VROM NL
Telefax nr. 31 70 201858



BACKGROUND PAPER ON FUNDING

MECHANISMS

OCTOBER 1989

FOR THE MINISTERIAL CONFERENCE ON
ATMOSPHERIC POLLUTION AND CLIMATIC CHANGE,
WITH PARTICULAR ATTENTION TO GLOBAL WARMING 6TH AND 7TH NOVEMBER 1989

THIS PAPER WAS PREPARED BY MCKINSEY & COMPANY, INC.
FOR THE RELEVANT WORKING GROUP
OF THE INTERNATIONAL STEERING COMMITTEE
WORKING ON BEHALF OF THE MINISTERIAL CONFERENCE
THE VIEWS EXPRESSED DO NOT NECESSARILY
REFLECT THE POLICY OR OPINIONS OF
THE GOVERNMENTS REPRESENTED IN THE WORKING GROUP

BACKGROUND PAPER ON FUNDING
MECHANISMS

BACKGROUND PAPER - SUMMARY

'Funding Mechanisms'

International Action - A Promising Necessity

To limit global warming joint, international action is required. Drastic reductions in the man-made emissions of nearly all greenhouse gases are required to avoid or contain global warming. In view of the nature and magnitude of the problem there is no single country or even region which, by itself, holds the key to the solution of the climate change issue. Actions by individual countries will - most probably - not be sufficient to arrest the build-up of greenhouse gases. Therefore, to solve this global issue, joint action is required. Cost-effective opportunities for international action exist, thereby presenting the nations of our world with the challenge of truly international cooperation.

Approach in Two Phases

A high-impact response to the greenhouse problem can be realized through an initial emphasis on domestic action, as in most nations efficient opportunities will be available. Parallel, on a second policy track, experience and credibility should be strengthened with regard to international cooperation in dealing with the issue of climate change. As the most efficient opportunities for domestic action are depleted it will be possible to broaden the action, to include the vast range of measures at acceptable costs in countries which - in all likelihood - do not possess the financial resources to take action by themselves. Accordingly, two action 'phases' are distinguished to clarify and develop an international approach that is both effective and efficient:

'Phase' 1: Primarily Domestic Action: emphasis on major initial progress through domestic action, with gradually increasing international action for peak-shaving purposes

'Phase' 2: International Solution: emphasis on maximum environmental yield through expanded international action via the mechanism of a clearinghouse.

The overall approach would include preliminary deadlines and emission reduction targets, with intermediate evaluation points. The targets may be differentiated by country, primarily on the basis of their stage of economic development. A medium-term target for developed countries is proposed, whereby the net man-made emissions of greenhouse gases are reduced by 30 percent by the year 2000, relative to 1986.

Relatively low-cost domestic action will form the mainstream of 'Phase' 1. It is likely to take place primarily in the developed world and will be found in a phase-out of CFCs and in reducing emissions from fossil fuel energy use. Limited international funding, addressing CFCs worldwide and forest management measures, may be initiated to complement these efforts as a "peak-shaving" device and to gain experience and credibility in the international cooperation on this global issue.

The main thrust of 'Phase' 2 is joint, international action covering all greenhouse gases worldwide. In order to minimize the cost to society a central role is assigned to an international clearinghouse.

The clearinghouse concept enables action of countries to be substituted by more efficient action of others. Individual countries continue to take domestic action and provide the means for international action.

Within the concept proposed, maximum flexibility during the entire process can be maintained. It also allows for a step-by-step approach with respect to both emission sources and geographic regions covered.

Organising the International Approach

First, an urgent need is identified to accelerate the work towards a framework convention on protecting the global atmosphere, which establishes appropriate coordinating mechanisms including a Ministerial Conference, and recognizes the two-phase approach. In parallel, a differentiated model for international financing is proposed.

The coordinating mechanisms rely on administrative and policy support to the Ministerial Conference and on a focused infrastructure to provide the fact base, improve communication and develop the necessary policy tools. In recognizing the two distinct phases the framework should provide the means to achieve significant results and build or redirect institutions in Phase 1.

A differentiated model to fund international action may reconcile the concerns and preferences of various countries with regard to either voluntary financing, using existing bi- and multilateral channels, or "burden sharing" through the intervention of a multilateral institution. During Phase 1 voluntary flows would provide for the needs of a CFC-phase out in Developing Countries through, for example, the World Bank; for an expanded Tropical Forestry Action Plan; and for infrastructure enhancements. As the international action broadens into Phase 2, a need for greater coordination will be felt. The clearinghouse, operating as a multilateral institution, would pursue substantial efficiency gains through international action exchanges. The World Bank would appear to be well qualified to manage this international exchange mechanism.

Moving Forward

Specific initiatives, which present themselves for action in the short term, include: (a) establishing a target of minus 30 percent with regard to the net man-made GHG emissions for industrialized countries, to be achieved by the year 2000 relative to 1986; (b) initiating or confirming measures to phase out CFCs and to stabilize fossil fuel or CO₂-emissions in developed countries in addition to reducing deforestation and stimulating forestation worldwide; and (c) providing a meaningful impetus to international policy coordination and action through the availability of initial international funding on the order of \$500 million per year. The latter funding, although relatively minor in relation to overall problem, can provide a significant and meaningful contribution to the strengthening of international cooperation through a particular emphasis on a CFC phase out in developing countries, international approaches to (de)forestation that are beneficial to all parties concerned and a short-term improvement of the infrastructure that is required for international policy making on the issue of climate change.

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INTRODUCTION

The world is faced with an environmental problem of unprecedented complexity. Across the globe a large number of countries at all levels of economic development contribute to global warming through the emission of so-called greenhouse gases ("GHG"). Their sources are widely distributed and include fossil fuel energy use, industrial processes, agriculture and the burning and decay of forests. Experts are concerned about the absolute rise in global temperature and the rate of temperature change, which in combination may exceed natural adaptation mechanisms. Even if atmospheric concentrations of these gases were stabilized now, the global temperature is expected to rise by 1-1.5° C between now and the year 2050. The significance of this is shown by the fact that total global warming since the Ice Age roughly 20,000 years ago is only 5° C. To achieve stabilization, drastic reductions from today's emission levels must be realized, necessitating structural adjustments in all major economies.

The issue of global atmospheric pollution and climate change was comprehensively addressed in the final report of the World Commission on Environment and Development ("Our Common Future"). Since then a number of important initiatives have been taken to further the major recommendations of this report. Noteworthy were the conferences in Toronto (June 1988), London (March 1989), The Hague (March 1989), Helsinki (May 1989) and the meetings within the context of the Intergovernmental Panel on Climate Change.

A further Ministerial Conference on Atmospheric Pollution and Climate Change will be organized by the Minister of Housing, Physical Planning and Environment of the Netherlands in cooperation with UNEP and WMO in the Netherlands in November 1989. Following earlier conferences, which put forward the recommendation to establish a World Atmosphere Fund financed in part by a levy on fossil fuel consumption, the November Conference will address, inter alia, international funding mechanisms to accompany the necessary policy measures. It is against this background that the Netherlands' Minister has asked McKinsey & Company, Inc. to consider possible approaches which can contribute to serious progress towards international consensus and action at the November Conference.

This second interim report carries a summary of the findings and conclusions of the first two phases of the project undertaken by McKinsey in pursuit of this objective. It builds on and extends the initial findings, presented to the Steering Committee in the Interim Report dated June 27, 1989.

In accordance with the project proposal of April 3, 1989, the project team focused on interviews with the leadership among politicians and civil servants in virtually all nations represented in the Steering Committee for the Ministerial Conference, and with leading officials of selected international organizations (Exhibit 1). In addition, major international research institutions were consulted. At the same time an overview has been

Exhibit 1

Extensive interview round forms basis for findings

OVERVIEW DISCUSSION PARTNERS

		POLITICAL LEADERSHIP	SENIOR OFFICIALS
Countries	Brazil		•
	Canada		•
	China (PRC)	•	•
	Egypt		
	France	•	•
	Germany (FRG)	•	•
	India	•	
	Indonesia	•	•
	Japan	•	
	The Netherlands	•	•
	Poland	•	•
	Saudi Arabia		•
	Senegal	•	•
	Sweden	•	•
	Switzerland		•
	USA	•	•
	USSR		
International organizations	EC		•
	OECD		•
	TFAP/FAO		•
	UNEP		•
	World Bank		•

assembled of the scope of current and anticipated GHG emissions, as well as costs and effectiveness of suggested measures for corrective action. Specific attention was given to potential measures in the energy field, to forest management opportunities and to the problem of CFC substitution in developing countries. Finally, the project team reviewed existing and potential channels for the international financing of corrective action.

The conclusions and recommendations of this report are based on assessment of the opinions and facts as they were made available to the team during the project to date. They also take into account the reactions of Steering Committee members to the first phase findings. Several options for an international approach to counter climate change, identified during the first project phase, were elaborated since then. Upon further evaluation by Steering Committee members and agreement in broad terms, the corresponding conclusions may form the basis for draft resolutions, leading up to the Ministerial Conference in November.

* * *

The report consists of four chapters, in which the interim findings and conclusions of the study are outlined. They address, in sequence, (a) the challenge of joint, international action; (b) the proposed concept for such action; (c) the organization of the recommended international approach; and (d) specific short-term initiatives proposed.

Background documentation and specific analyses in support of the findings of the report are provided in Appendices A through D.

1 - INTERNATIONAL ACTION

A PROMISING NECESSITY

The protection of the global atmosphere poses a joint challenge to all nations. Only action on a truly international scale holds the promise to provide a solution to the threat of climate change. This conclusion rests on the observations that (a) action in major regions of the world is required for an adequate response; (b) efforts are likely to be insufficient unless joint, international action is undertaken; and (c) the challenge of international cooperation lies in utilizing available opportunities for joint action.

GLOBAL ISSUE

There is at present no political consensus on the objective of a policy response to climate change. Stabilizing atmospheric concentrations at today's levels is frequently cited. However, this may be insufficient due to possible positive feedbacks in the climate system which may continue to raise global temperatures. It is equally conceivable that the world can live with more elevated concentrations of greenhouse gases, provided the average temperature changes at a relatively moderate pace.

Whatever the appropriate objective may be, most experts agree that the current rate of climate change is high and that the consequences of such change are potentially disastrous. Moreover, the time lags in the system are too long for the world to await confirmation of climate change or further knowledge on the greenhouse build-up and its consequences. Early action is required, and should - according to many experts - be aimed at the ultimate stabilization of GHG concentrations. Consequently, any international approach to counter climate change should be capable of accommodating stabilization policies, yet be sufficiently flexible to pursue either more stringent or more relaxed objectives.

If the world is to engage in successful policies to halt the rise in average global temperature, all major geographic regions and political or economic blocs should be actively involved. Required emission reductions are so far-reaching and current or anticipated emissions so widely distributed across the globe, that no single country or regional bloc will be capable of realizing such a global objective by itself.

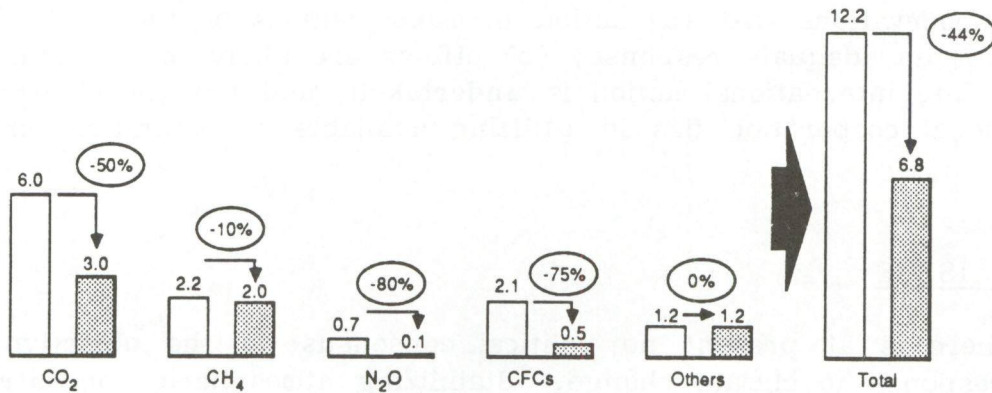
The United States Environmental Protection Agency (EPA), inter alia, has estimated the emission reductions required to stabilize atmospheric concentrations at current levels. These drastic targets include minimum emission reductions of 50 percent for carbon dioxide (CO₂), 10 percent for methane (CH₄), 75 percent for chlorofluorocarbons (CFCs) and 80 percent for nitrous oxide (N₂O). Emissions of different gases can be combined into a common denominator through the notion of "CO₂-equivalence". The equivalence factors take into account the contribution of man-made

Exhibit 1 - 1

Drastic emission reductions required

MINIMUM EPA ESTIMATES OF MAN-MADE EMISSION REDUCTIONS FOR STABILIZATION*

Emissions in Gt C in CO₂-equivalents



* I.e., reductions in current emissions to stabilize atmospheric concentrations at current levels

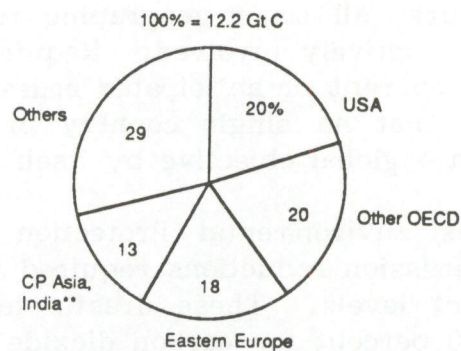
Source: EPA; McKinsey analysis

Exhibit 1 - 2

Man-made emissions globally distributed

CONTRIBUTION TO GLOBAL WARMING

Distribution of man-made emissions greenhouse gases ("GHG")*, 1985



* Expressed in CO₂-equivalents

** Centrally planned Asia and Indian subcontinent

Source: EPA; UN; Greenpeace; McKinsey analysis

emissions of a specific gas to rising atmospheric concentrations and the impact of the latter on global warming (see Appendix A). Accordingly calculated on a weighted-average basis, total GHG emission reductions would need to be at least in the 40-50 percent range relative to 1985 (Exhibit 1 - 1).

Analyzing regional contributions to global warming in terms of CO₂-equivalence, a wide distribution is found (Exhibit 1 - 2). By implication, even complete elimination of, for example, the 40 percent of the global total that is emitted by OECD nations would fall short of the minimum global reduction target for stabilization. It follows that no single region by itself holds the key to the solution of the climate change issue.

JOINT ACTION REQUIRED

Efforts to combat the greenhouse effect are likely to be insufficient, if no joint, international action is taken. Individual actions by major countries will not produce the desired result.

However, since significant regional differences exist in the composition of emissions, the required corrective measures will also differ. In the developed world, prime contributors are fossil fuel combustion and the release of CFCs in various applications. In industrializing and developing nations, agriculture is an important source as is, concentrated in a relatively small number of countries, the deforestation process (Exhibit 1 - 3).

These regions also differ significantly in their financial capacity to deal with the problem. Regional averages of per capita Gross Domestic Product (GDP) range from about one-tenth of the world average for centrally-planned Asia and the Indian subcontinent, to about 5 times the world average for the OECD. There are, of course, significant variations among countries within these regional groupings.

In order to better understand the implications of these regional differences, a range of measures to reduce GHG emissions was analyzed for three areas (OECD, Eastern Europe and the "Rest of World", consisting mainly of developing nations) and for two GHGs, viz. CO₂ and CFCs. These measures collectively apply to approximately two thirds of all GHG emissions. They cover a sufficiently broad range of actions to provide a fair assessment of policy mechanisms, but do not pretend to be complete. Appendix B elaborates on the analysis of possible emission reduction measures in the energy field.

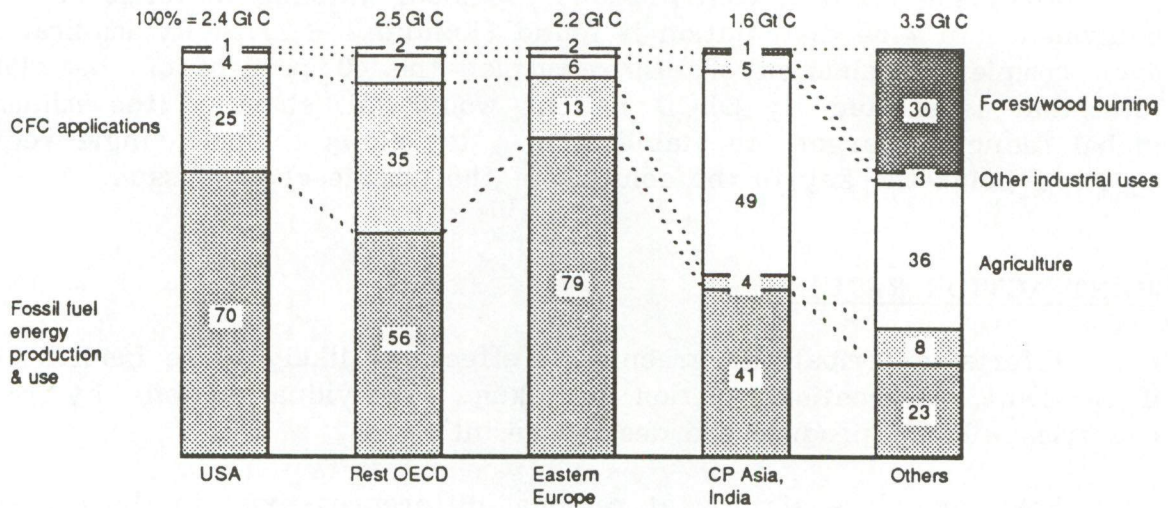
The analysis indicates that considerable progress can be made, but that - for different reasons - results are likely to be insufficient both in the OECD countries and elsewhere.

Exhibit 1 - 3

Composition of emissions differs by region

GHG EMISSIONS BY HUMAN ACTIVITY

Percent of CO₂ - equivalents, 1985



Source: McKinsey analysis

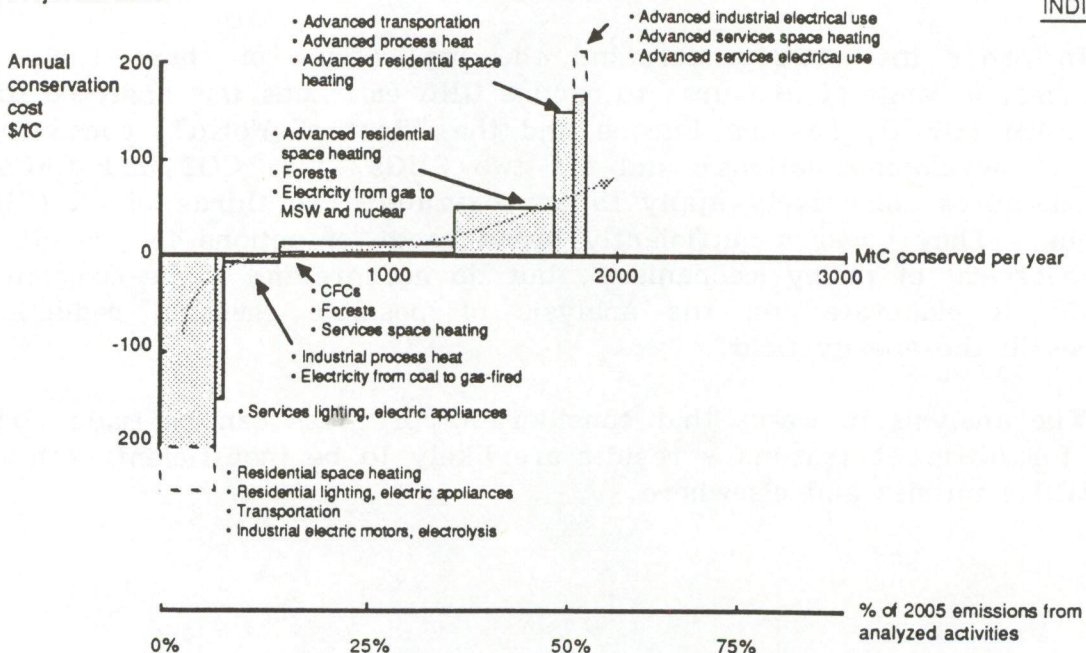
Exhibit 1 - 4

Efficient measures may generate approximately 30 percent emission reduction in OECD

COST CURVE OECD

Projection 2005

INDICATIVE



Note: Based on available research material

Source: International energy consultants; McKinsey analysis

OECD Action Probably Not Enough

A range of opportunities for the reduction of GHG emissions exists in the OECD countries. Some of these are profitable, i.e., they result in a net gain to society due to corresponding energy savings. Others form a net cost to society, because energy savings or other contributions are insufficient to offset initial investment and incremental operational costs. The various measures can be ranked according to their net dollar gain or cost per unit of CO₂-equivalent ("carbon") conserved and can be plotted in a "cost curve" indicating the absolute amount of carbon potentially conserved (Exhibit 1 - 4).

Of crucial importance to the realization of possible measures is their potential penetration in daily practice. Measures that involve extreme unit costs or require major societal change must be expected to meet with strong resistance, i.e., they generally will have lower penetration rates. The OECD cost curve shown assumes that, on average, energy conservation measures will achieve 50 percent of their technically attainable penetration by the year 2005*. A higher rate of penetration is probably unrealistic. Above this level the total improvement in the energy intensity of the OECD economies would exceed the maximum historical improvement achieved (Exhibit 1 - 5).

Implementation of a first set of the more efficient measures for carbon conservation might result in a 30 percent improvement in GHG emissions over time. This assumes complete elimination of emissions from CFCs (phase out, recycling) and the 50 percent average penetration of fossil fuel energy measures as discussed above. Even such a reduction would fall short of an overall OECD target implied by the gas-by-gas reduction goals to halt global warming (Exhibit 1 - 6).

Action Outside OECD Equally Constrained

As in the OECD, other nations of the world are facing relatively attractive opportunities for carbon conservation (Exhibits 1 - 7 and 1 - 8). However, in practical terms it must be assumed that, given the prevalent economic conditions, the major up-front investments associated with the realization of these conservation measures will seriously delay or even block implementation.

For example, the annual capital costs for the first 5 percent reduction of GHG emissions, relative to the 2005 volume, represent a substantially higher proportion of GDP in Eastern Europe and developing countries than in the OECD (Exhibit 1 - 9).

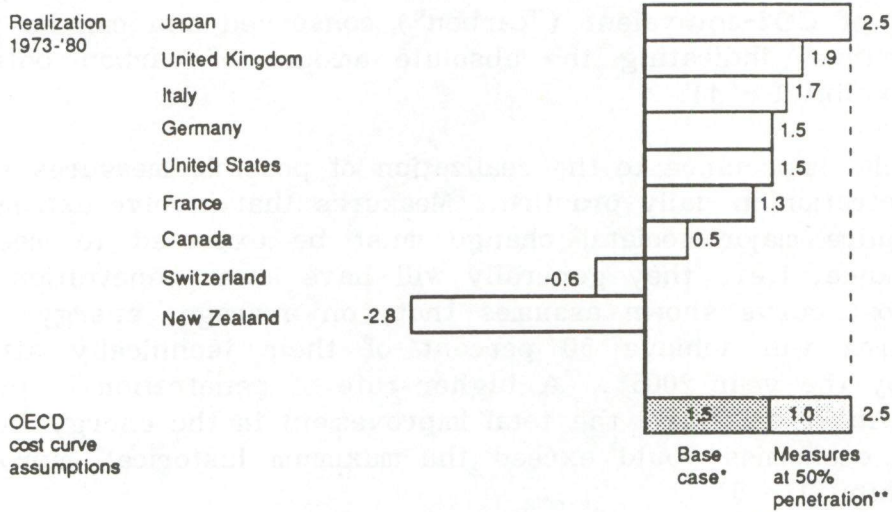
* This period was chosen to exceed the average lead time required to plan, design and construct a large power generation facility.

Exhibit 1 - 5

A penetration in excess of 50% would not appear justified by historical results

RATE OF IMPROVEMENT IN ENERGY INTENSITY OF GNP

Compound annual % change



* Ongoing energy improvements and structural changes
 ** Additional policy measures

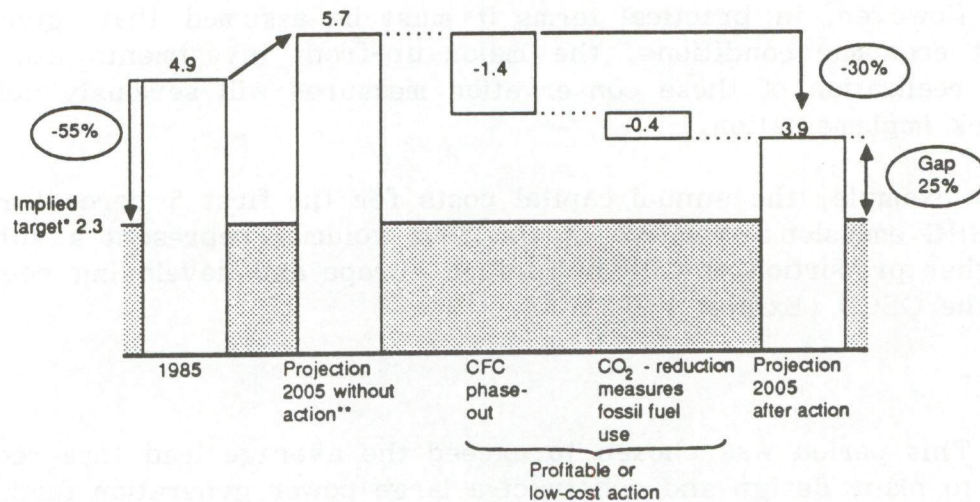
Source: OECD; McKinsey analysis

Exhibit 1 - 6

Initial OECD action most likely insufficient

OECD GHG EMISSIONS

Gt C in CO₂ -equivalent



* N₂O -80%, CFCs -75%, CO₂ -50%, CH₄ -10%
 ** Including all CFCs

Source: EPA; UN; McKinsey analysis

Similarly, some countries where tropical deforestation takes place on a major scale may need annual expenditures of up to 4 percent of GDP to halt this process. Clearly, with the many other demands on the national economies these up-front investments will handicap the implementation of drastic programs to reduce GHG emissions.

Moreover, an increasing number of industrializing nations must be expected to experience significant growth in CO₂-emissions in particular, as their energy needs increase. This will further strain the overall impact of corrective action.

CHALLENGE OF COOPERATION

With restricted low-cost opportunities available in the developed nations of the OECD and action elsewhere likely to be constrained by investment requirements in particular, the total measures by individual countries will not prove sufficient to eventually halt global warming. Thus, to provide a response to the global problem of climate change that is both effective and efficient, the answer must be found in addressing the challenge of international cooperation. Preliminary analysis indicates that there are sufficiently promising prospects to do so in a way that is beneficial to all nations involved.

During the interview round it became apparent that the dilemma presented by the different financial capabilities and national development priorities is generally recognized. Building on the experience gained in reaching agreement on international environmental issues such as the long-range transportation of SO₂, NO_x and also CFCs, the shared expectation is for a differentiated policy approach to the issue of global warming. From a practical point of view the wealthier industrialized countries are expected to implement domestic policies that, in the near term, ensure stabilization followed by a substantial reduction of GHG emissions. At the same time it is generally realized that other, less wealthy or developing countries cannot sit idle. Rather, they must implement policies that aim at possibly more relaxed GHG emission targets and - where possible - contribute to the overall solution by "buying time", for example through appropriate forest management. Since the potential and therefore the financial and societal burden of especially the latter type of policy action is spread unevenly across the world, international cooperation is a must. Only if the wealthier nations cooperate in financially facilitating action elsewhere, one can realistically expect serious progress towards the protection of the global atmosphere.,

Thus the challenge of international cooperation can be presented in a simplified manner. Once the most attractive opportunities within the OECD (fossil fuel savings, CFC reductions) and - in some degree - in Eastern Europe have been depleted, a large further potential in Eastern Europe and, particularly, the developing nations remains available at relatively low cost (Exhibit 1 - 10). Possible measures include reduction of deforestation and the creation of carbon sinks through forestation; accelerated reduction

Exhibit 1 - 7

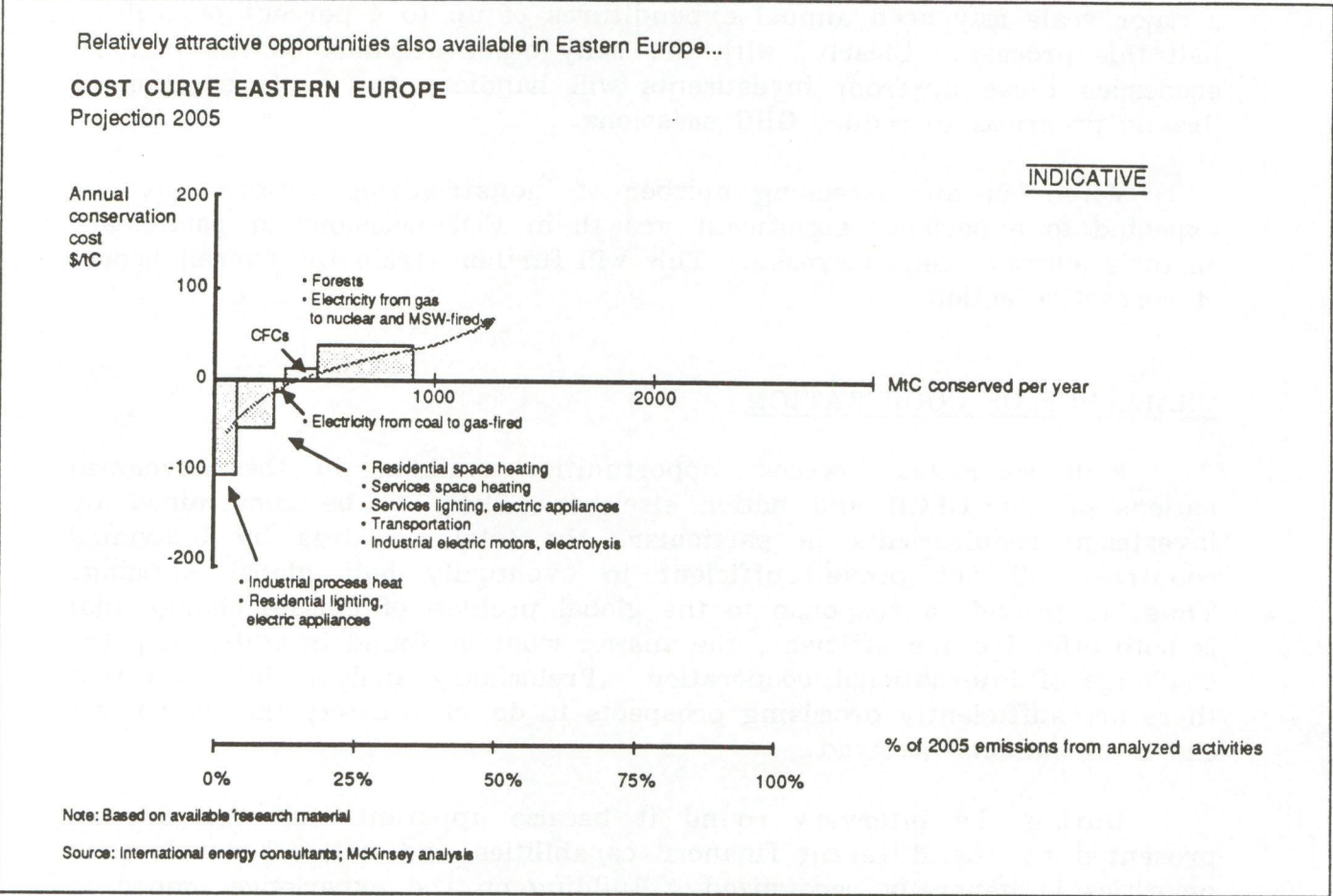
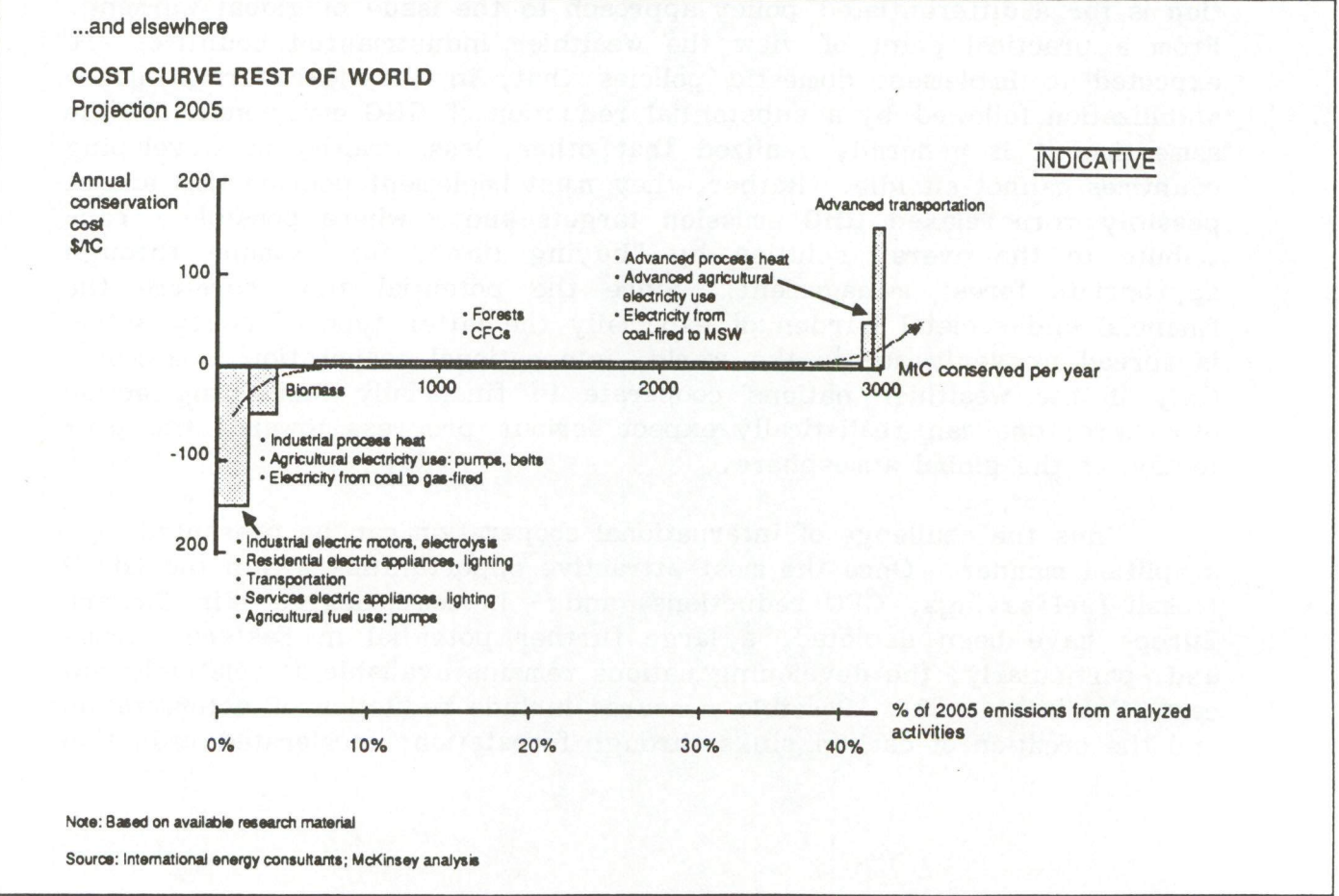


Exhibit 1 - 8



of CFC applications; improvement in fossil fuel energy efficiency; and reduction of methane emissions from agriculture and land fills. These opportunities should be facilitated to realize the potential carbon conservation.

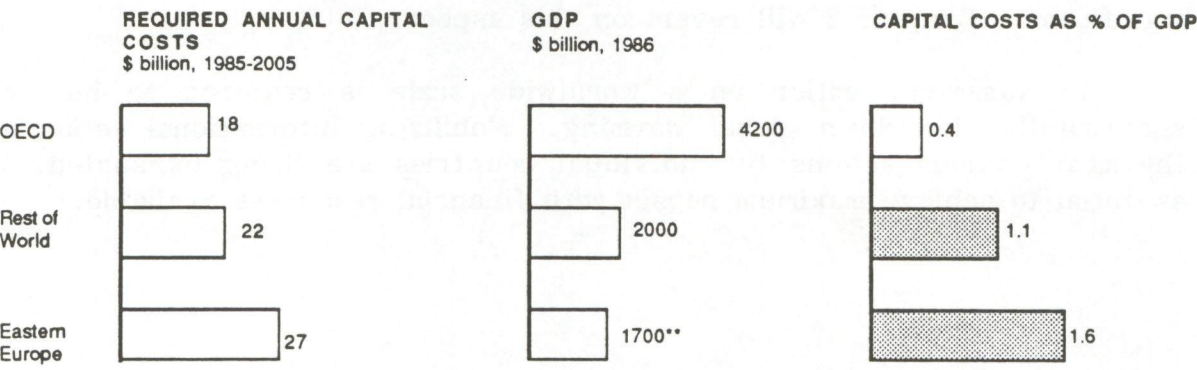
The financial savings from such international opportunities relative to further, higher-cost action in the developed world cannot be ascertained without improved and more detailed cost analyses. However, based on preliminary assessments the potential benefits to society as a whole appear significant. Chapter 2 will revert on this aspect.

In summary, action on a worldwide scale is required to halt or significantly slow down global warming. Mobilizing international action as the most obvious actions by individual countries are being exhausted, is essential to achieve maximum impact with financial resources available.

Exhibit 1 - 9

Investment requirements will form a higher threshold to Eastern Europe and developing countries

ESTIMATED INVESTMENT BURDEN*



* For first 5% reduction relative to 2005 base case
** Net Material Product at official exchange rates

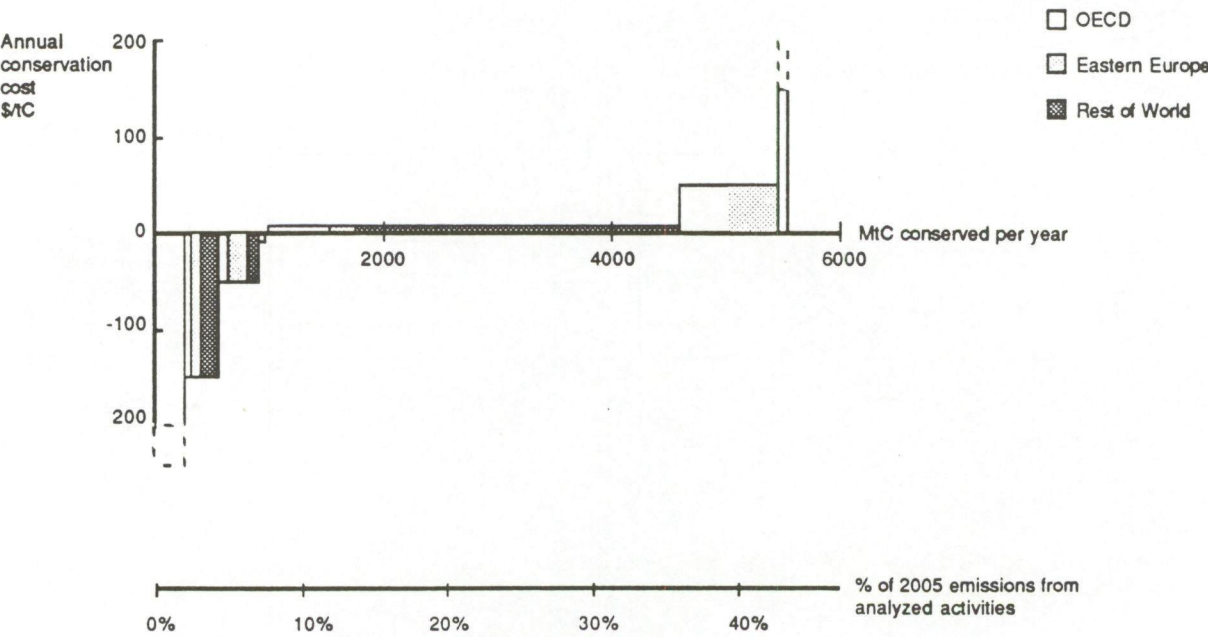
Source: UN; IMF; McKinsey analysis

Exhibit 1 - 10

Large potential of relatively low-cost opportunities outside OECD

GLOBAL COST CURVE
Projection 2005

INDICATIVE



Note: Based on available research material
Source: International energy consultants; McKinsey analysis

2 - APPROACH IN TWO PHASES

International action is necessary to combat the greenhouse effect. This opinion is widely shared by Steering Committee members and other representatives and experts. Their constructive comments and suggestions with respect to the objectives, opportunities and limitations regarding the mobilization of international resources provide the basis for the recommended approach which is outlined in this chapter.

In line with the input received, the approach aims for maximum flexibility while vigorously pursuing the reduction of GHG emissions. It also recognizes that serious progress on an all-encompassing issue such as global warming can only be made in a step-by-step manner.

The objective of a worldwide action plan to substantially reduce greenhouse gas emissions would be to provide an effective, yet efficient response to global warming. Thus eventually a plan must be based on agreement with respect to overall objectives such as the acceptable GHG concentrations in the atmosphere, the permissible worldwide GHG emissions and the corresponding time paths.

The current scientific fact base provides insufficient certainty for a "hard" long-term climate objective. Most experts would agree that, ultimately, net man-made emissions* should not exceed the Earth's natural absorption capacity. This would eventually lead to stable atmospheric concentrations. The earlier this is achieved, the more restrained the rise in average global temperature. To incorporate this notion, some countries argue for a long-term climate objective that aims at an anticipated temperature increase which remains well below 2°C relative to pre-industrial times. Alternative suggestions include limiting the rate of climate change, e.g. to 0.1°C per decade.

Despite the absence of scientific consensus on an appropriate long-term objective, there appears to be broad agreement among scientists and policy makers with respect to the need for immediate action. Therefore it is recommended to distinguish (a) two tracks and (b) two phases in an international action plan to combat climate change.

The first track is that of unilateral action. Building on the experience gained from recent international agreements on, for instance, SO₂, NO_x and CFCs, individual nations would commit to a proportionate domestic contribution to reduce net GHG emissions. In line with earlier approaches to environmental policy with regard to other issues such a track could be vigorously pursued in the short term.

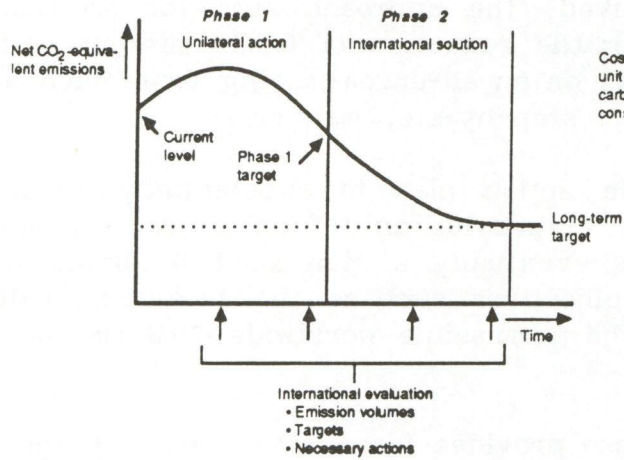
* I.e., man-made emissions minus man-made absorption.

Exhibit 2 - 1

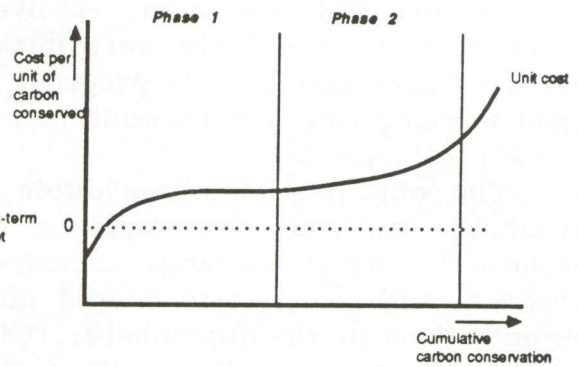
Phased approach includes targets and intermediate evaluations

COUNTRY A

NET EMISSIONS



EMISSION REDUCTION COSTS



The second track presents the challenge of truly international co-operation. Although ultimately this track is expected to play a decisive role in addressing the issue of climate change, a gradual build-up of experience and credibility is required to deal with the many intricacies of, for instance, sustainable development and international flows of funds. Starting from a narrow base the second track therefore is expected to widen and, longer term, assume its essential role in realizing a worldwide solution to global warming that is both effective and efficient.

The latter words are the central elements in distinguishing the two phases in the proposed approach to combat climate change.

In the first phase, the key word is effectiveness. The primary emphasis should be on differentiated unilateral action by individual nations. In line with existing international protocols, for instance those dealing with SO₂, NO_x and CFCs, developed nations would agree to stringent GHG emission reductions. Other nations would face more relaxed targets, in particular in view of their rising energy needs during industrialization. To augment these domestic measures a number of international "peak-shaving" measures should be introduced, building on existing international mechanisms (Tropical Forestry Action Plan, Montreal Protocol and subsequent Helsinki conclusions).

However substantive such action, it must be expected to fall short of the ultimately necessary GHG emission and emission targets. Costs of further corrective measures would become very high and societal resistance considerable. Therefore, during a second phase the emphasis should shift to joint, international action. This time the key word becomes efficiency: how can the issue of climate change be brought under control at the greatest possible expedience and at the lowest overall cost to society?

The overall approach would include preliminary deadlines and emission reduction targets for the ends of Phases 1 and 2, with intermediate evaluation points established in advance. At those points in time, an international evaluation of greenhouse gas emissions and existing targets will take place in order to determine the necessary strengthening or possible easing of efforts (Exhibit 2 - 1).

PHASE 1: EMPHASIS ON DOMESTIC ACTION

Phase 1 would clearly benefit from early international agreement on planned GHG emission reductions. Such agreement might stipulate a reduction target in terms of net man-made GHGs, rather than individual gases.

At first sight, separate gas-by-gas targets might appear to be more practical, because they focus directly on specific problem areas. For example, a CO₂-target as such would drive the search for energy conservation measures, etc. However, an overall GHG target is to be preferred

for two reasons. First, targets by individual gases may lead to suboptimization, because they do not allow for economic trade-offs even at the national level. An overall target leaves maximum flexibility for national priorities and preferred options. Second, individual targets obscure the combined effect of all GHGs on global warming. This perspective will be required for longer-term management of the issue.

For industrialized countries a target of minus 30 percent net man-made GHG emissions, to be achieved by the year 2000 relative to 1986*, would constitute a challenging but realistic goal. In 1985, CFC applications in OECD countries on average accounted for 30 percent of their GHG emissions. CFC consumption rose by 10 percent from 1985 to 1986, thereby raising the average share of CFCs in OECD emissions. Preliminary analysis suggests that most of these countries would be capable of reaching this target if they were to eliminate CFC emissions while holding net CO₂-emissions constant. The latter would be achieved for example if emissions from fossil fuel energy use were stabilized or if any growth is compensated with forestation measures.

Whatever the appropriate target, in order to achieve early and substantial progress in reducing GHG emissions, Phase 1 will focus on profitable and low-cost domestic action, which is likely to take place primarily, although not exclusively, in the developed world. These opportunities will be found in virtually eliminating CFCs and reducing the emissions from fossil fuel energy use. Limited international funding may be initiated to complement these efforts.

Domestic Action

At the May 1989 Helsinki Conference the parties to the Vienna Convention and Montreal Protocol declared their intention to phase out the use of CFCs controlled by the Protocol by the year 2000. The driving force for this agreement is the ozone layer depleting potential of these substances. However, it should be realized that an additional and important argument for immediate action can be found in the greenhouse effect. Within the OECD CFCs not only represent roughly one-third of total GHG emissions, but - in majority - they also provide one of the more efficient emission reduction options.

In the fossil fuel area, domestic opportunities exist in most countries for end-use conservation, energy conversion efficiency and fuel mix adjustments. All of these measures would use known and proven technology; a substantial part is located on the low-cost side of the cost curve. Examples include major improvements in automobile efficiency, high-efficiency lighting and space heating, and switching to power generation based on natural gas.

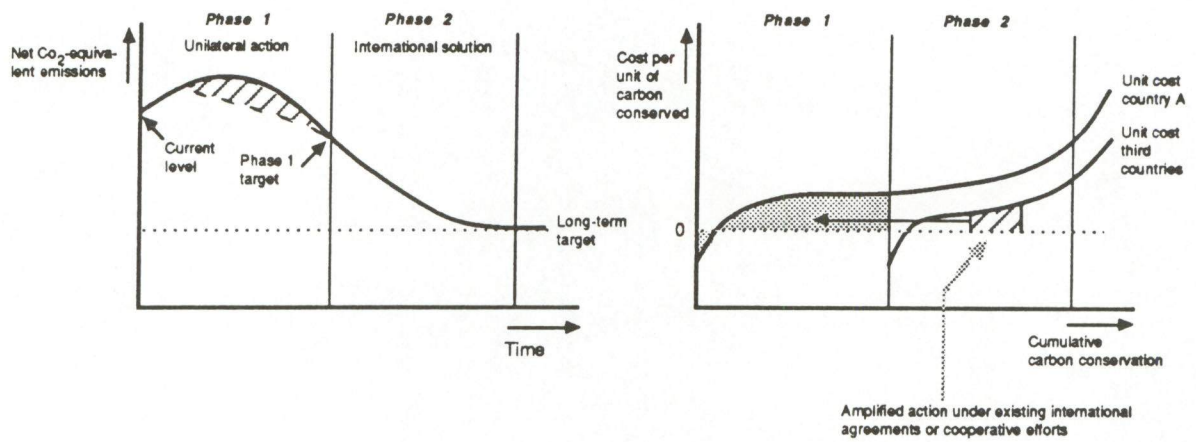
* The Montreal Protocol uses 1986 as its base year.

Exhibit 2 - 2

Early international steps for "peak-shaving" purposes

NET EMISSIONS COUNTRY A

EMISSION REDUCTION COSTS



Agricultural GHG emissions still are characterized by considerable uncertainty and lack of knowledge. The potential for measures to reduce methane emissions from rice paddies is subject to major debate; the same applies to methane resulting from animal husbandry. Some cost and effectiveness indications are available for improving rice crop yields per hectare, which reportedly would reduce methane emissions relative to total rice production. However, a coherent perspective is not available at this stage. Further research should take place during Phase 1, with more substantive measures being deferred to Phase 2.

International Funding for Peak-shaving

Notwithstanding major unilateral actions, the delayed impact of such actions and expected economic growth will contribute to a further increase of the global GHG emissions in the immediate future. Therefore, in addition to domestic action within individual countries, Phase 1 should include international action that can help by "buying time" for the new policies to attain actual impact. Such action should concentrate on low-cost measures which are relatively easy to implement under existing international mechanisms and which, without international funding, would be deferred. Expressed in simple terms, the purpose would be global "peak-shaving", i.e., to limit or level the autonomous growth of emissions during the period required to prepare or initiate major adjustments (Exhibit 2 - 2).

Two opportunities to implement relatively efficient international measures present themselves for initiation in this first phase. Again, both measures use known and proven technology, but they are otherwise motivated on different grounds.

First, the Helsinki Conference recommendation to phase out CFCs worldwide using appropriate funding may be implemented. Current use outside the developed world is relatively small and - given the old environmental adagio: pollution prevention pays - our common interest may be served best by the rapid, worldwide introduction of less harmful substitutes.

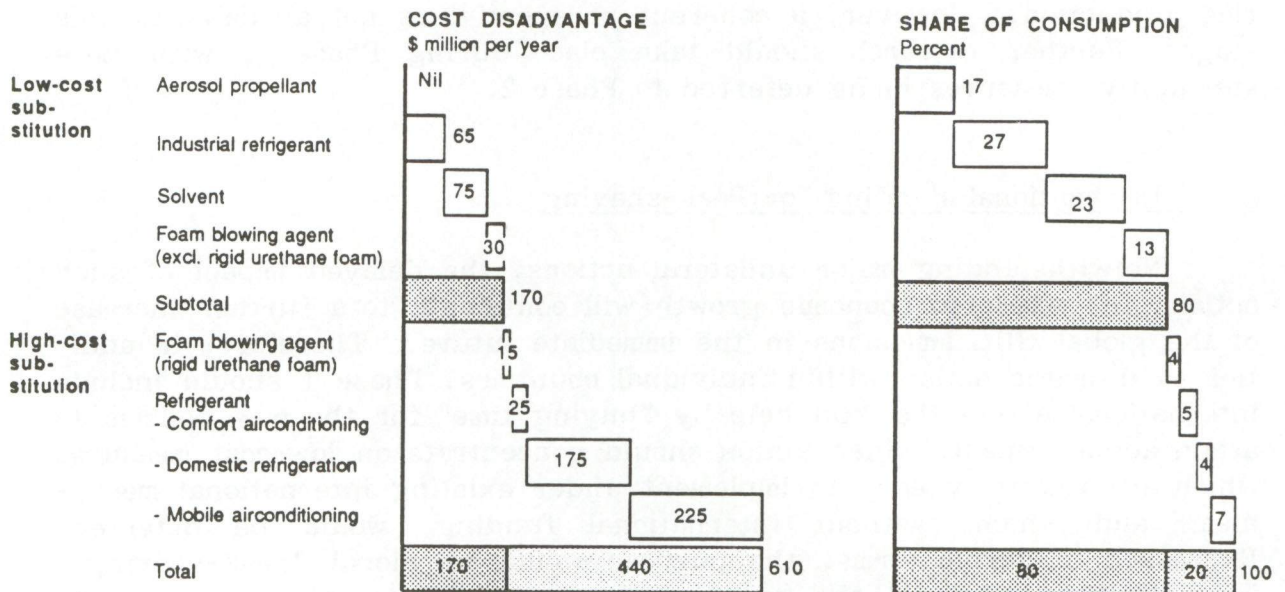
Second, forest management measures in the tropics may be employed to "buy time". Forestation in tropical zones and measures to stop deforestation would result in carbon absorption and emission prevention, respectively. The theoretical potential for such measures is vast and they are attractive in pure economic terms relative to most other alternatives (see Appendix C). In addition, action in this area will also serve the cause of maintaining biological diversity. To be effective, however, forestry measures require extensive technical assistance, an understanding of specific local climatic and socio-economic conditions, and the availability of appropriate institutional channels. In tropical countries forest management is directly linked to issues of general economic development and, accordingly, will need to be incorporated in the overall planning to be sustainable.

Exhibit 2 - 3

Limited cost disadvantages for most of the volume

CFC SUBSTITUTION DEVELOPING COUNTRIES

ESTIMATES



Note: Based on late 1990's volumes and costs, expressed in constant 1989 dollars; excluding halons

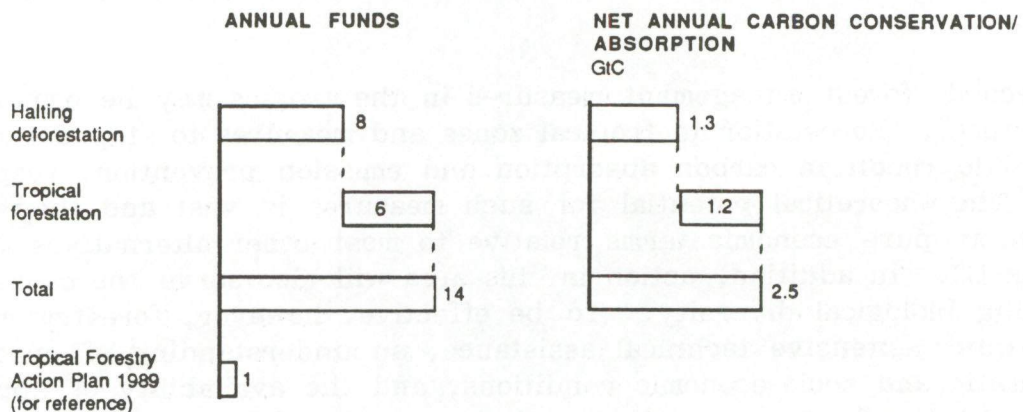
Source: McKinsey analysis

Exhibit 2 - 4

Forest management in tropics may theoretically demand \$ 10 - 15 bln per year

FOREST MANAGEMENT MEASURES

INDICATIVE



Source: TFAP; FAO; McKinsey analysis

In principle, the beginning of Phase 1 would not see major financial transfers for international action, but they may rise gradually towards the end of the phase:

- ¶ CFC funding for substitution in developing countries: if a global phase out is pursued, international transfers are likely to be limited. They can be expected to reflect the cost disadvantages to developing countries as a group, which are estimated to amount to \$150-200 million per year for approximately 80 percent of the volume, and \$600-700 million per year for the total (Exhibit 2 - 3; see also Appendix D). This analysis is based on estimates of incremental costs over the present cost of using CFCs in industrialized countries. It assumes that substitution will not take place before the middle to late 1990's, when costs are likely to come down following full-scale production and application of alternative substances in industrialized countries. Also, major write-offs of existing facilities may be avoided in this manner.

Actual funding needs of developing countries may differ from the estimated cost disadvantages as a result of specific local circumstances and the generally smaller scale of operations. Funding requirements and time frames could be established within the context of national phase out scenarios.

- ¶ Forest management funding for initiation of forestation and reduction of deforestation in the tropics. At full theoretical potential this may require \$10-15 billion per annum for an annual carbon uptake of 2.5 Gt* C (Exhibit 2 - 4), or approximately half the total OECD emissions. However, the minimum project size is relatively small in the absence of substantial economies of scale. In addition, institutional and other preconditions must be met prior to any large-scale forestry measures, as explained above. Finally, the capacity of a country's economy to deal with major forestry financing will need to be considered. From a practical point of view, substantially lower funding amounts are therefore more realistic.

- ¶ Monitoring and research funding may also be addressed during Phase 1. Suggestions and proposals brought forward include resources to be made available for awareness building; for climate monitoring and research needs, e.g., as identified by the WMO Executive Council; and for research on man-made methane and nitrous oxide emissions and on cost effectiveness of corrective action. Amounts involved - probably \$50-100 million per year - are small compared to the requirements of emission reduction measures.

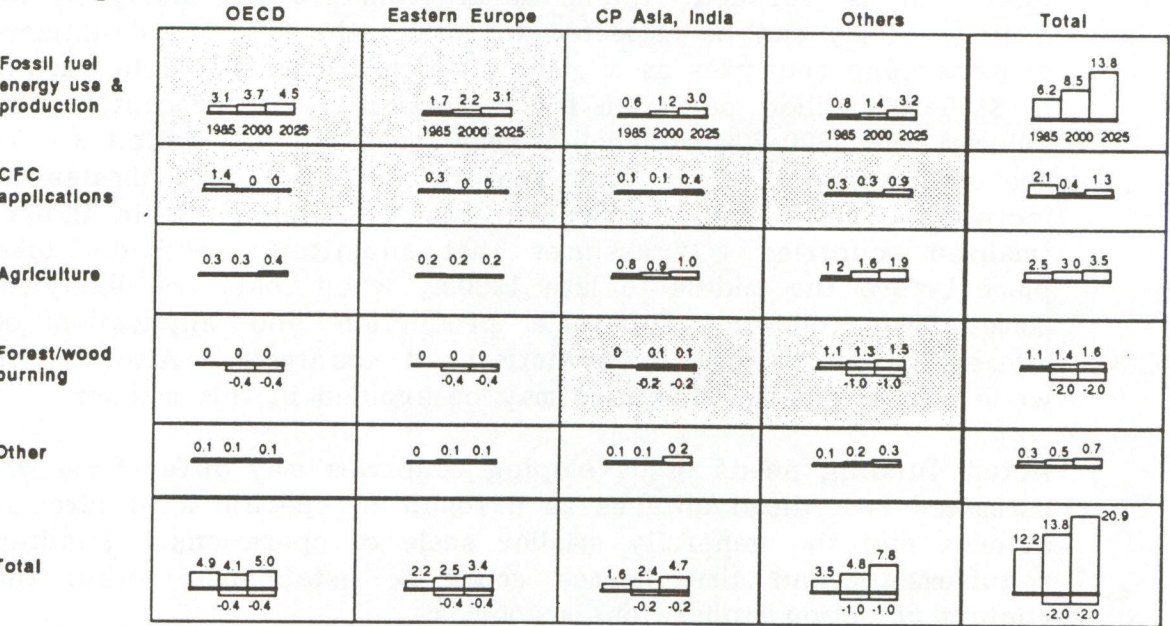
* Gigaton or a billion metric tons.

Exhibit 2 - 5

Selective focus in phase 1, to be subsequently broadened

DISTRIBUTION CONTRIBUTION TO GLOBAL WARMING
Gt C in CO₂ equivalent/year

Phase 1
emphasis



Note: Projections in principle based on EPA "2030 High" scenario, but assuming implementation of "Helsinki"
Source: EPA; UN; Greenpeace; McKinsey analysis

If approached in this manner, action in Phase 1 would be aimed at selected measures on those GHG sources and those geographic regions, which together account for two-thirds of current man-made emissions. Further action in these and the remaining areas would be addressed in Phase 2 (Exhibit 2 - 5).

PHASE 2: INTERNATIONAL SOLUTION

The main thrust of the second phase of the proposed action plan is joint, international action in order to guarantee an optimal efficiency of the overall solution to global warming. Phase 2 should in principle cover all man-made GHG emissions. Continued from Phase 1 and possibly extended are steps to conserve carbon in fossil fuel energy use within the developed world, in CFC-applications worldwide and in forest management in the tropics in particular. Emission reductions in fossil fuel energy use outside the developed world and in agriculture will be introduced in this phase.

Given the extreme complexity of the issue and the potentially enormous costs, it is of utmost importance to ensure an institutional arrangement that minimizes the total cost to society. A central role therefore should be assigned to an international clearinghouse mechanism with as its primary objective the worldwide maximization of emission reductions per dollar expended. Analysis suggests that a well-managed clearinghouse mechanism has indeed the potential to ultimately lead to significant international financial savings relative to a purely unilateral approach, although further study (e.g., more complete cost curves, particularly also for non-OECD countries) is required to obtain improved estimates of the absolute size of funding requirements.

Clearinghouse Mechanism

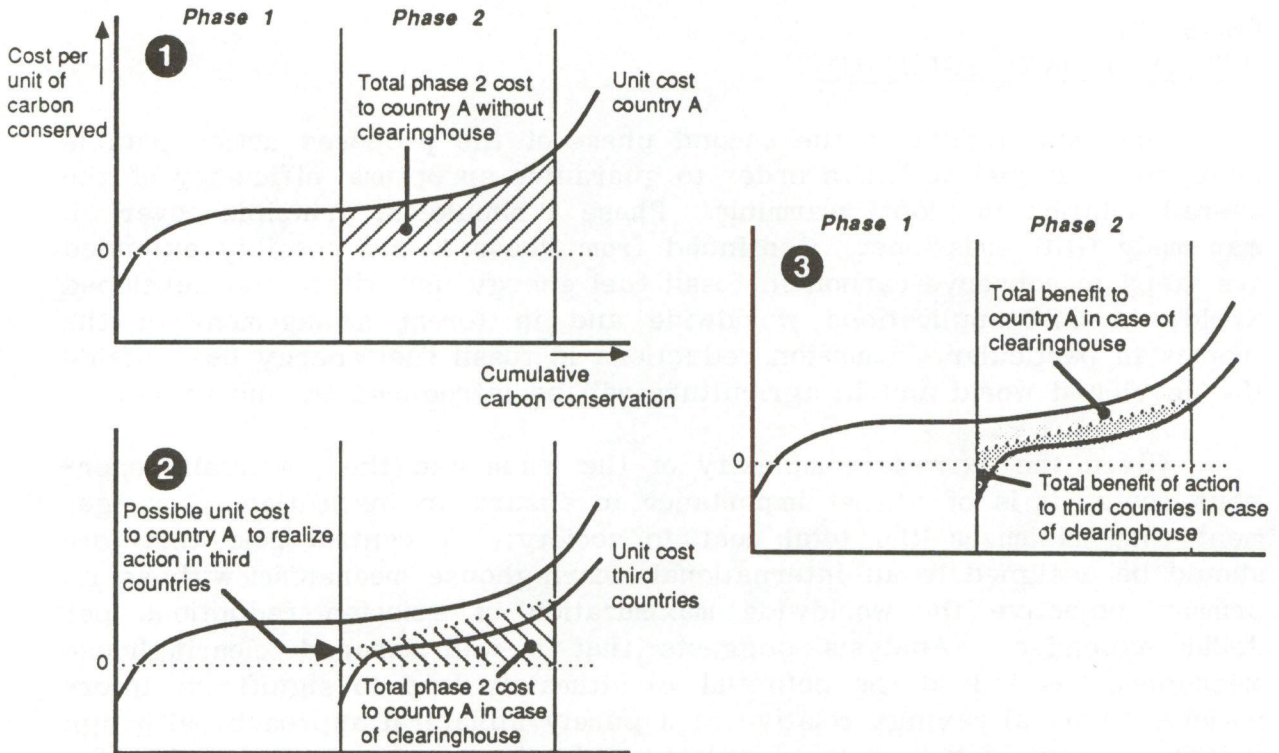
The clearinghouse concept enables action of one country to be substituted by more efficient action of other countries. It builds on the potential for such international action following the depletion of the most attractive opportunities within the developed nations during Phase 1. The clearinghouse mechanism is explained in Exhibit 2 - 6.

A more concrete illustration is the comparison of incremental costs in low-carbon power generation in, for instance, a Western European country versus a forestation project in the tropics. At equal carbon conservation, switching from gas fired installations to power generation from municipal solid waste might cost on the order of \$30 per ton C conserved. On the other hand, analysis to date indicates that major forestation efforts in the tropics can be achieved at an average annual cost of \$5-10 per ton of annual carbon uptake. An exchange of the two actions therefore yields a potential benefit of \$20-25 per ton C (Exhibit 2 - 7).

Exhibit 2 - 6

Clearinghouse mechanism mutually beneficial

CLEARINGHOUSE CONCEPT



EXPLANATION

- 1** Assume country "A" has higher cost curve to reduce GHG emissions; cost of domestic action A represented by area I.
- 2** Assume third countries have lower cost curve for equal carbon conserved as "A". "A" subsidizes action within third countries at terms represented by dashed line, to meet its international obligations; cost to "A" is represented by area II.
- 3** Benefits are mutual:
 - Net gain to "A" represented by lightly shaded area
 - Net gain to third countries represented by dark area, reflecting excess of international subsidy over their domestic costs

The potential benefit of a global clearinghouse can only be ascertained with more complete cost curves. It also depends on GHG emission reduction targets agreed internationally. To provide a broad indication only, the environmental gain from international exchange has been analyzed using an average 35 percent reduction target for the OECD and Eastern Europe, and more relaxed goals elsewhere. In this specific example, up to 30 percent more emission reduction may be achieved for the same worldwide financial effort (Exhibit 2 - 8).

International Action Funding

The volume of international action in Phase 2 and the associated financial transfers are obviously dependent on progress realized in Phase 1 and on further targets agreed. However, if employed to its full potential, it might include:

- ¶ Continued CFC funding, reflecting cost disadvantages of \$150-200 million per year initially and \$600-700 million per year should a 100 percent phase out be pursued.
- ¶ Expanded forest management funding, up to a maximum of \$10-15 billion per year.
- ¶ Funding of fossil fuel energy conservation. Here, international financing requirements may have the same order of magnitude as those potentially involved in forest management, i.e., \$10-15 billion per year. This indication is based on the current understanding of the scope for relatively efficient energy conservation in the developing world. Since the international body of knowledge on potential energy conservation in those countries is thin, the highly preliminary nature of this estimate should be emphasized.

The above indication represents the net potential assistance required to stimulate international action. However, many energy measures have a positive return once the hurdle of incremental investment has been taken or a marginal subsidy has been provided. Accordingly, if international financing were to take the form of loans for investment in equipment as opposed to grant-type aid, the scale of commitments might rise to \$30-40 billion per year. Funds initially committed will be higher, but a return flow will follow in view of the (largely) self-financing nature of most energy measures.

- ¶ Agriculture funding. Given the uncertainties surrounding nitrous oxide and, particularly, methane emissions, the potential amounts involved in international action with respect to agriculture and the nature of funding are impossible to ascertain at this stage.

Exhibit 2 - 7

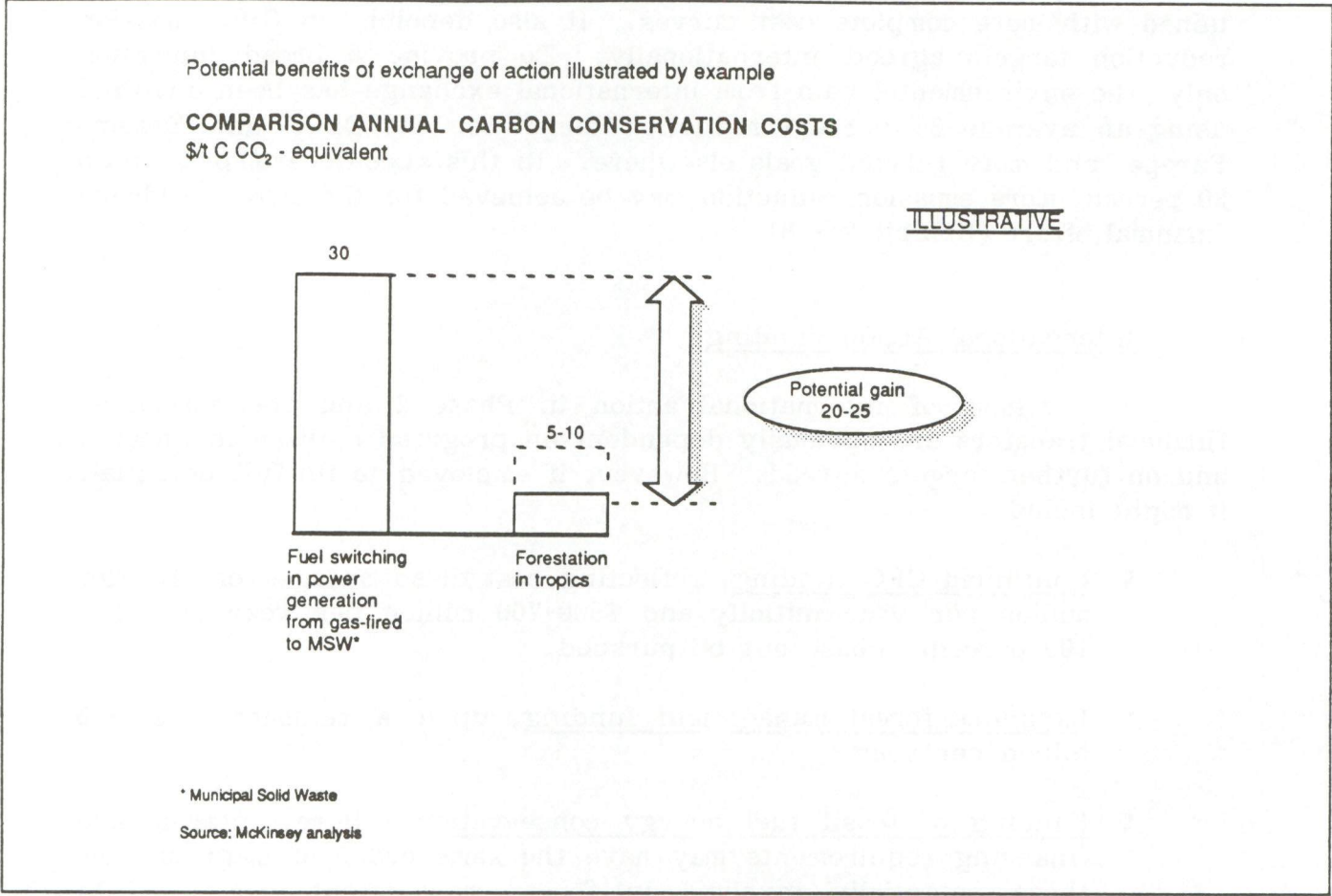
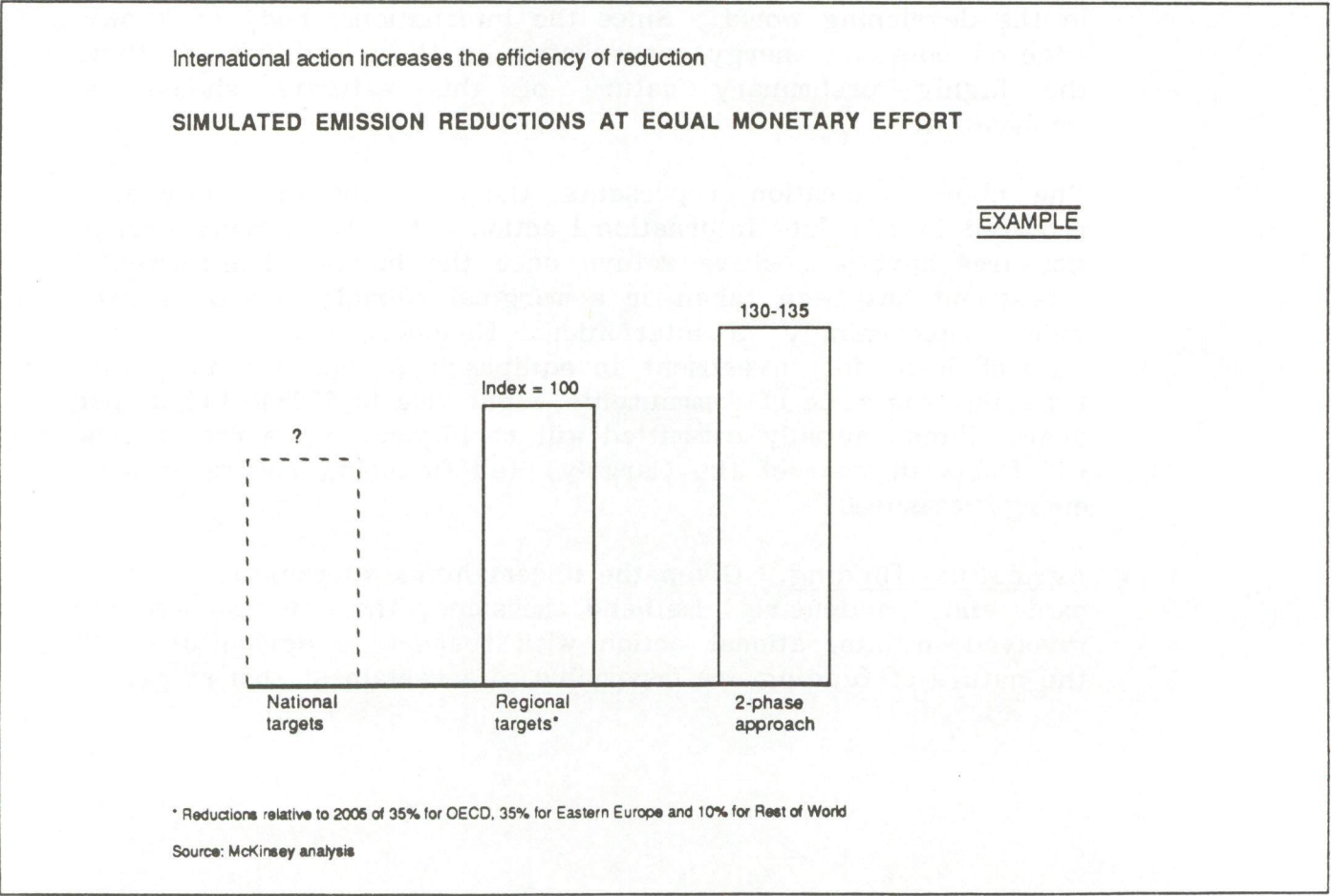


Exhibit 2 - 8



¶ Continued monitoring and research funding. Finally, Phase 2 is likely to involve continued spending on climate monitoring and research, and on research on GHG emissions. As in Phase 1, the sums involved will be a fraction of those required for meaningful international action.

3 - ORGANIZING THE INTERNATIONAL APPROACH

Over a period of approximately 2 years, the global warming issue has shifted from the meeting places of scientific experts and non-governmental organizations to the political arena. The attention presently given by political leaders around the world is considerable, witness only the G-7 summit meeting in Paris on July 16 of this year. This momentum should be maintained and converted into measurable progress.

To pursue this objective, the approach outlined in the previous chapter should be structured and, ultimately, institutionalized. It requires: (a) accelerating work currently underway towards a framework convention on protecting the global atmosphere; and (b) identifying the appropriate mix of financing channels to fund international action.

DEVELOP FRAMEWORK

The members of the Steering Committee are, without exception, convinced that an international framework is needed to capture and coordinate the multiple initiatives and proposals presently being launched around the world. A framework is required both to serve as the basis for facilitating and formalizing international agreements and to provide the proper coordinating mechanisms. Moreover, it should recognize the international approach discussed earlier and ensure the necessary infrastructure.

Prepare Framework Convention

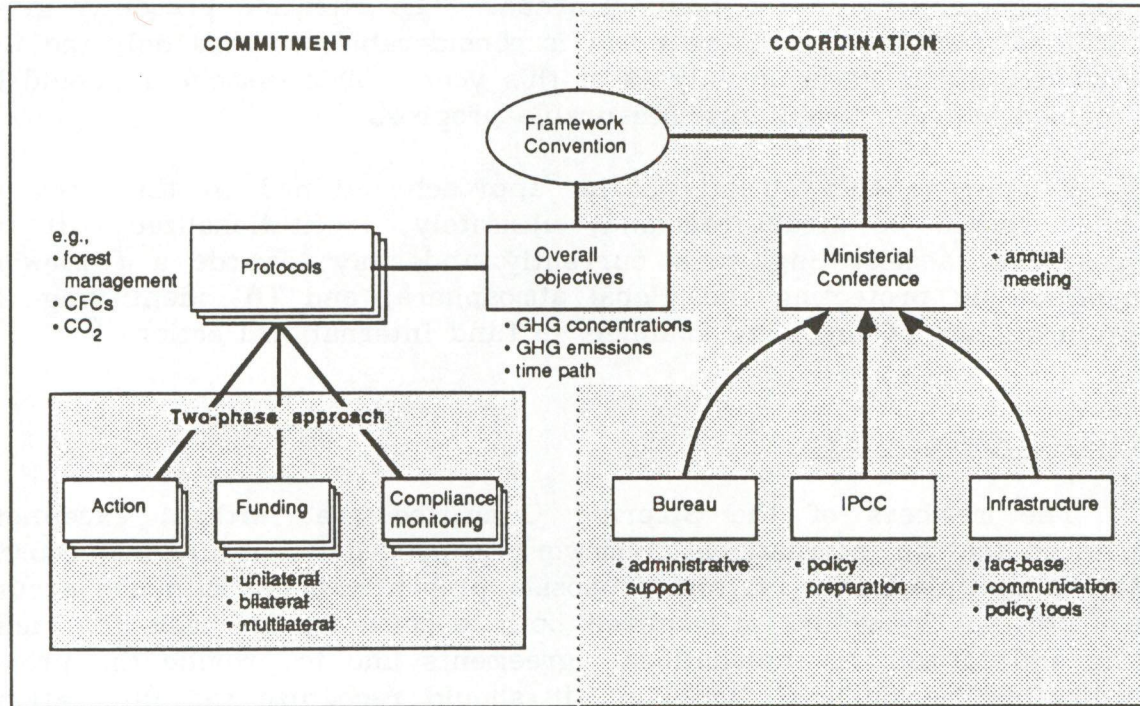
Among Steering Committee members there are essentially two lines of thought with respect to the development and negotiation of a framework convention. Some would like to see a convention agreed within a relatively short period of time, e.g., in the course of 1990. These countries favor the convention to take the form of a "shell", to be subsequently substantiated with successive protocols. The argument here is one of time, i.e., the early establishment of a framework will guide and accelerate more substantive international agreements. On the other hand, there are those countries which favor a substantive framework convention, including international agreements on concentration levels and emission reduction targets. Their preference is for such a convention to be negotiated as early as possible, but in any case not later than 1992. Here, the essential rationale is the need for explicit international agreements on the reduction of GHGs.

Balancing these lines of thought suggests a framework convention, established by 1990, specifying the overall policy framework as well as a single, overall emission reduction target. Such a target might take the form of, for example, the 30 percent medium-term net emission reduction, outlined in Chapter 2. It would thus ensure the required policy

Exhibit 3 - 1

Framework needed for international commitment and coordinating mechanism

POLICY FRAMEWORK



coordination and provide meaningful progress towards further international commitments, without detailed agreements at an early stage.

Although various alternatives are still under discussion, most interview partners suggest to establish this framework in the form of an international convention on protecting the global atmosphere (Exhibit 3 - 1). The convention would incorporate and be governed by the overall objectives to be realized in terms of GHG concentrations and emissions and the corresponding time paths. As stated before, the emission levels could be differentiated among countries, depending on financial capability and stage of economic development. However, only signatories in good standing (i.e., having fulfilled their obligations) can participate in any of the policy making or benefit from possible flows of funds. Moreover, as part of the general rules the convention should define appropriate moments along the time path to formally evaluate progress in terms of concentrations and emissions, study new scientific evidence on global warming and its impact, assess the best available forecasts and - whenever necessary - adjust the overall objectives and the policy that is required to meet these new objectives.

The main text of the convention would be further built around two elements. First, it should lay out the foundations of a simple but effective institutional mechanism to coordinate overall policy development. Essential to this mechanism is a Ministerial Conference, that meets at least once a year to evaluate progress and recommend necessary actions.

Second, the convention should establish the framework for formalizing international commitments and facilitating the implementation thereof through appropriate funding mechanisms. International commitments can be negotiated and formalized in the form of protocols. To ensure an integrated approach to global warming it is preferable, at least in Phase 2, to include under the framework umbrella existing protocols and agreements such as those on CFCs and the Tropical Forestry Action Plan. Further protocols might aim for obtaining commitment with respect to, for instance, forest management and fossil fuel use; conceivably the latter protocol might be preceded by some more manageable subparts, for instance dealing with automobile energy efficiency or power generation. During Phase 2 further action could be formalized to deal with methane and nitrous oxide emissions.

Establish Coordinating Mechanisms

Overall policy coordination would preferably be provided by a Ministerial Conference on the Protection of the World Atmosphere. Experience, for instance within the European Community but increasingly also in the UNEP, ECE and OECD, has shown that regular meetings of Environment Ministers, if well prepared, are highly instrumental to test and build consensus and eventually to make decisions. The Conference will be the highest platform for policy development and coordination on issues of climate change. Its role will be that of an - at least - annual meeting of

Exhibit 3 - 2

Strengthening infrastructure in three areas
INFRASTRUCTURAL FUNCTIONS

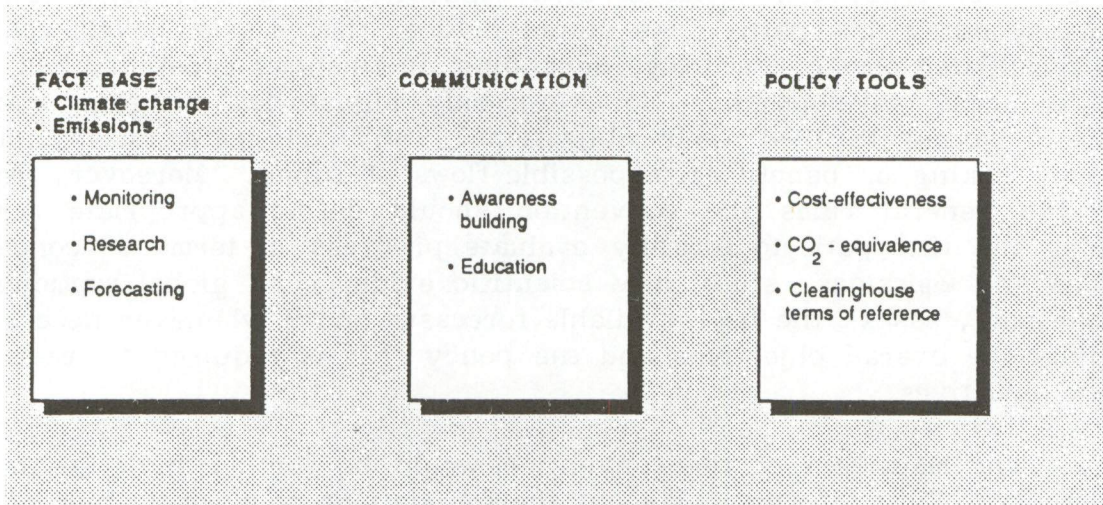
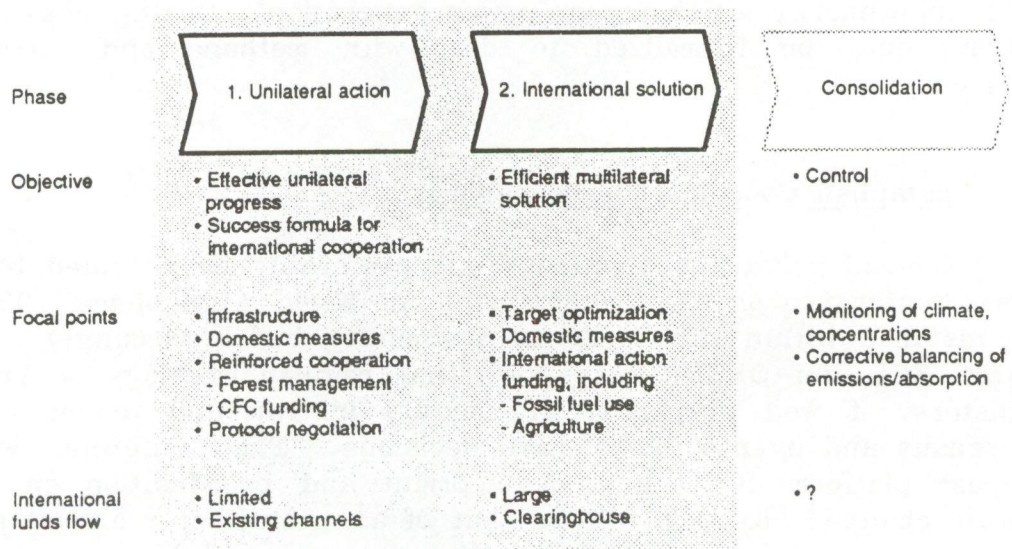


Exhibit 3 - 3

Framework convention should recognize different nature of two phases

TWO-PHASE APPROACH



the parties to the framework convention, charged with responsibility both for overseeing steps taken within the realm of the convention and for evaluating the need for policies beyond the then existing framework.

The Ministerial Conference requires administrative support, for example from a permanent small bureau. In addition, coordinated international policy support is essential to prepare policy recommendations for the Ministerial Conference and to set up implementation channels. Involving senior officials from governments and relevant international bodies, this role could be assigned to the Intergovernmental Panel on Climate Change (IPCC).

Finally, the convention must recognize that for both policy formulation and day-to-day operations the mechanisms outlined above rely on a focused infrastructure. Most of the required functions are being carried out today in international organizations. To the extent practical, these should be utilized and - wherever necessary - redirected and/or strengthened.

It is all too obvious that the current infrastructure is inadequate for a satisfactory approach to the issue of global warming. Given the extreme stakes and the relatively minor costs of reinforcing the infrastructure to an acceptable level - probably on the order of \$50-100 million per year - immediate action should be taken in at least three areas (Exhibit 3 - 2):

- ¶ Providing the fact base through research, monitoring and forecasting of climate conditions, atmospheric concentrations and - globally - GHG emissions. Existing institutions in this area include WMO and UNEP (climate) as well as IEA and FAO (emissions).
- ¶ Improving communication, both to build awareness of climate change with the general public and to educate researchers, technicians, foresters, etc. in required tasks. Various UN agencies are active in these areas.
- ¶ Developing the policy tools, including the assessment of cost-effectiveness of alternative measures; establishing CO2-equivalence factors; and defining terms of reference for the clearing-house (qualifying funding, eligible projects). Existing institutions include the OECD, FAO (including Tropical Forestry Action Plan) and WMO.

Recognize Two Phases

The framework convention to be developed should allow for the shift in emphasis from Phase 1 to Phase 2 in the approach recommended and provide commensurate sequencing of substantive agreements (Exhibit 3 - 3).

The key to Phase 1 is effectiveness. It is first and foremost results oriented, to achieve as much GHG emission reduction as possible at acceptable cost within a short period of time. But Phase 1 also is a building phase, where the groundwork must be done for the establishment or redirection of institutions and to advance the state-of-the-art on the greenhouse effect as a basis for policy choices. Also, in view of its importance to the worldwide awareness, among the first specific actions ought to be concerted efforts on climate research and monitoring and on communication. At the same time policy tools must be sharpened and supplemented.

Phase 2 would then expand the Phase 1 initiatives and put the clearinghouse mechanism to work. The key now becomes worldwide efficiency in addressing the joint challenge. Thus, recognizing the possible magnitude of the necessary funds, its aim is to maximize the environmental yield given limited financial resources. Ultimately, once the issue of global warming is under control, this phase is followed by one of consolidation, where established operating and monitoring patterns are being followed and policy measures hopefully can be limited to corrective balancing of worldwide emissions and absorption.

Monitor Compliance

More so than in traditional international agreements on environmental protection, the nature of the greenhouse issue and the recommended approach place significant emphasis on the monitoring of compliance with targets and other provisions. With targets specified in terms of net man-made GHG emissions, individual nations will be able to trade-off emission reductions in individual gases. Consequently, multiple gases will need to be monitored.

The terms of reference for compliance monitoring will have to be specified in the framework convention and any subsequent protocols. They should include paragraphs on standards and measurements of emissions and absorption, and on CO₂-equivalence.

While more complicated in nature, the compliance monitoring role here is not principally different from the role in the Montreal Protocol. There, UNEP has preliminary responsibilities in this regard parallel to its role as Secretariat to the Protocol. It would not be illogical for UNEP to assume the same role in a framework convention on climate.

ORGANIZE FUNDING

Steering Committee members agree that, at some future point in time, substantial financing is required to initiate international action to reduce GHG emissions. However, a uniform position with regard to the preferred financing channels does not yet exist.

It would seem that there are essentially three models for international financing within the recommended approach: (a) voluntary financing, using existing bi- and multilateral channels; (b) financing based on international assessments ("burden sharing"), in principle via a multilateral institution; and (c) a mixed approach, differentiating the use of financing channels according to the two phases of the overall approach. The last model appears to provide a practical reconciliation of varying points of view.

Voluntary Financing

Under this model, international action in both phases is financed through existing bi- and multilateral channels. The volume of funds and allocation by channel are at the discretion of all countries directly involved. As in existing Official Development Assistance (ODA), which consists of multilateral flows for approximately one-third in terms of net disbursements, bilateral channels are likely to dominate.

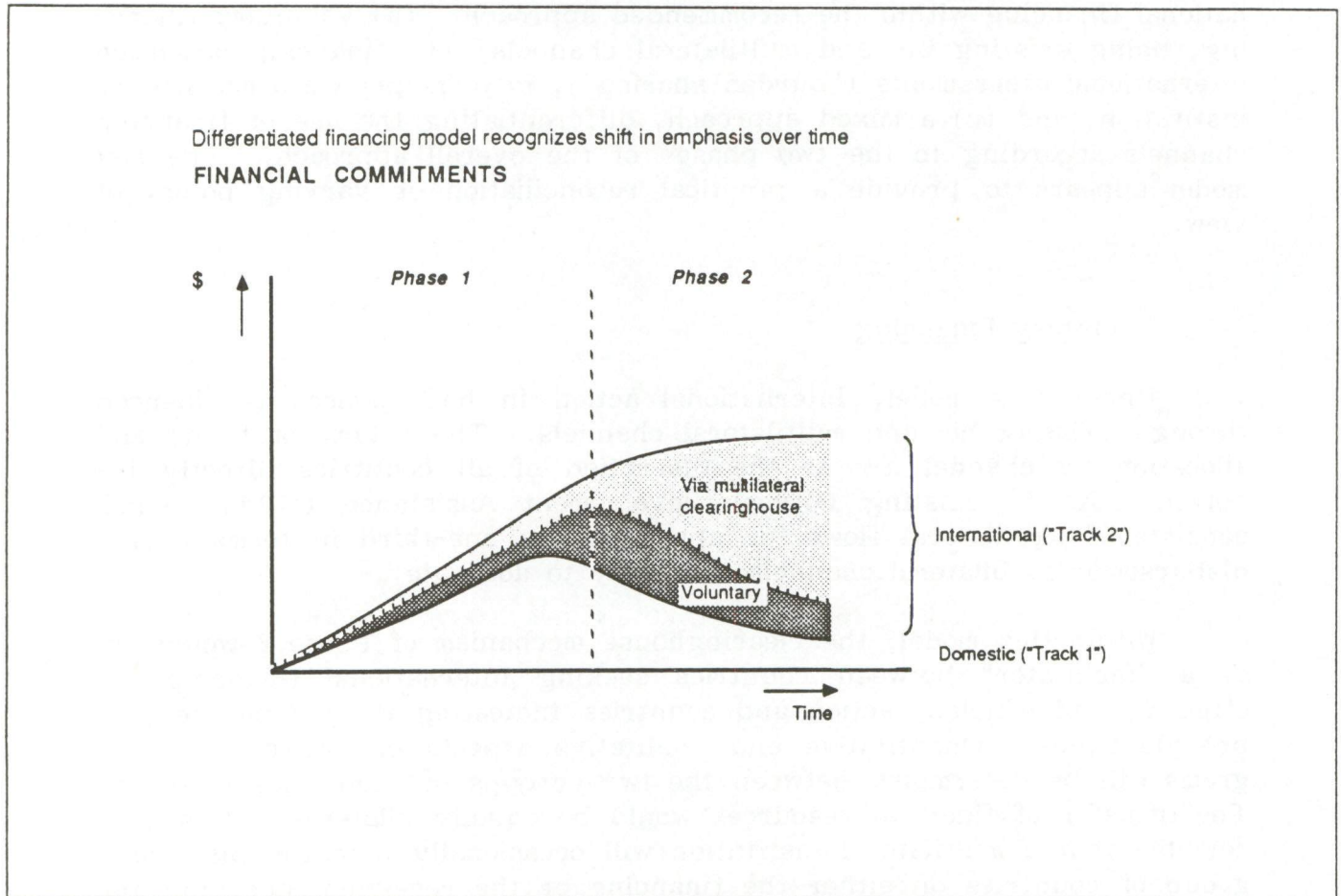
Within this model, the clearinghouse mechanism of Phase 2 would act as a "facilitator" between countries seeking international financing for effective and efficient action and countries indicating their commitment to provide funds. Quantitative and qualitative aspects of projects or programs will be determined between the two (groups of) countries involved. The transfer of financial resources would be equally bilateral. It is conceivable that a multilateral institution will occasionally take the place of a group of countries on either the financing or the receiving side, but the principle will remain the same.

There are major advantages and disadvantages associated with this model. First, it corresponds with the existing organization of development assistance and so will involve minimal change. Second, the sovereignty of all countries involved should in principle not be affected. However, because the financing will be interwoven with existing development assistance, additionality of funds will be more difficult to establish. In addition, the continuity of funding cannot be guaranteed, which may jeopardize multi-year projects and ongoing programs. Political considerations may be mixed with environmental selection criteria. Finally, an international approach using this model will be difficult to coordinate across nations, thus risking suboptimization.

Burden Sharing

Under a diametrically opposed model, industrialized countries would be requested to contribute funds for international action on the basis of a common indicator such as Gross National Product, primary energy requirements, fossil fuel use or (net) CO₂-emissions. The funds would be provided to a multilateral institution; given the fungibility of funds, use of bilateral channels would render meaningless the burden sharing notion of this model.

Exhibit 3 - 4



Here, the clearinghouse might take an active "middleman" position. As a multilateral institution it could select or develop a range of effective and efficient projects or programs. Knowing the financing requirements it might then assess the total levy for international action for a given period of time and apportion this according to its terms of reference. Payment and execution schedules would constitute fixed obligations under international agreement to all participating countries.

Major advantages of this model are its potential to finance larger projects and programs and the improved safeguard for continuity of funding. In addition, where the development banks are involved, use of their borrowing capacity may leverage the total volume of funds from contributing nations. To the extent funds available are additional to existing development assistance, it will be clearly recognizable. This model would also seem to offer better prospects for international consistency, coordination and efficiency. However, both countries providing funds and recipients will relinquish some authority and control to the institution involved. Finally, since the burden sharing may not reflect a country's achievements towards its emission reduction targets, some countries may perceive this model to be inequitable.

Differentiated Financing

While recognizing the legitimate concerns and preferences expressed with respect to both voluntary financing and burden sharing, a mixed model may reconcile such points of view. The model would allow for differentiated financing in line with the international approach. The gradually increasing international action could initially be funded by voluntary flows through existing channels. As the international approach gains momentum moving into Phase 2, an increasing flow of funds through the clearinghouse mechanism, managed and leveraged within the World Bank system, could be envisaged (Exhibit 3 - 4). This model is further discussed below.

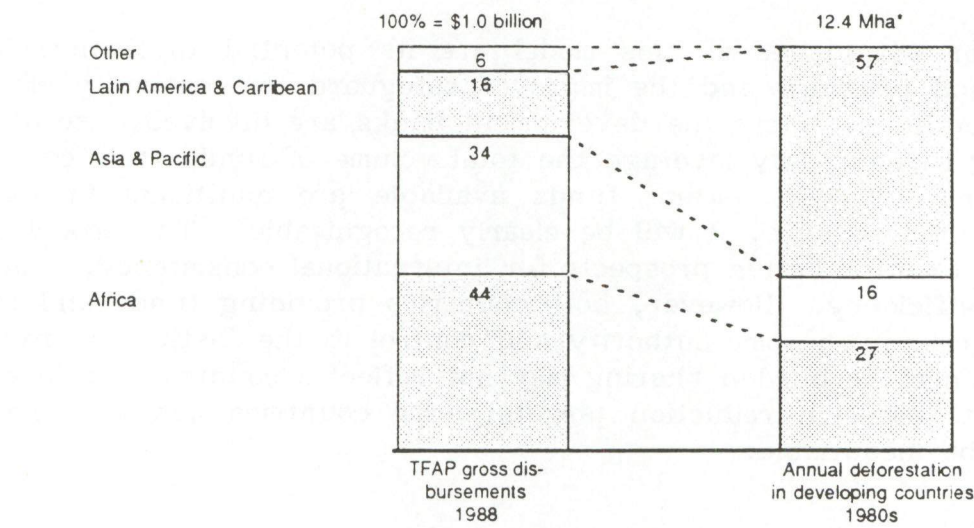
During Phase 1 financing of international action might continue to be provided on a voluntary basis via existing bi- and multilateral channels. Amounts will be limited, particularly during the initial stages. In addition, for each of the funding purposes during this period, there are existing institutions well equipped to handle the flow of funds:

- ¶ Cost disadvantages associated with the phase out of CFCs in developing countries were earlier estimated at \$150-200 million per year for approximately 80 percent of the volume. Any subsidy scheme would preferably be applied consistently across developing countries, thus suggesting the leading role of a multilateral institution. In addition, subsidies are likely to be provided within the context of a national industry restructuring plan covering production facilities and applications of controlled substances. Its integrated economic perspective and ability to field technical

Exhibit 3 - 5

Scope for aligning TFAP priorities with forest management needs

REGIONAL DISTRIBUTION TFAP AND FORESTRY NEEDS



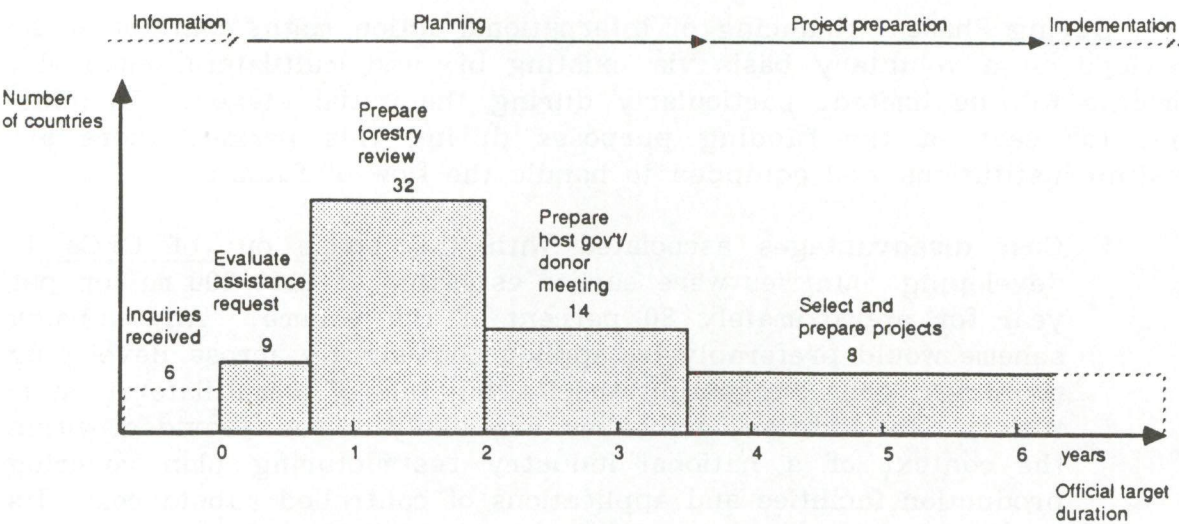
* Million hectare

Source: TFAP; WRI

Exhibit 3 - 6

Accelerating implementation through increased planning and project preparation capacity

TFAP PROCESS AND MID-1989 STATUS



Source: TFAP; McKinsey analysis

expertise make the World Bank a serious candidate among the multilaterals to manage the flow of funds for this purpose.

Various practical options exist. A subsidy scheme could be administered as a Trust Fund with contributions to the fund applied by the World Bank as loans or grants. Alternatively the World Bank could act as lead agency, directly providing loans and coordinating grant-type co-financing from bilateral or other multilateral sources. By comparison, the additionality of funds could be more clearly established in the first instance.

- ¶ The Tropical Forestry Action Plan was identified earlier as a major existing mechanism to coordinate funds for forest management purposes. The TFAP, acting as a meeting place and catalyst for donors and recipients, in itself appears to be relatively non-controversial. Under the Plan, funds are provided directly as bilateral assistance or via multilateral agencies, particularly World Bank, FAO and World Food Program. Here again, financing of international action can follow established channels for the immediate future. However, if the forestry sector is to absorb multiples of the current TFAP expenditures of \$1 billion, a shift in emphasis may be appropriate.

First, from a greenhouse perspective the TFAP might benefit from prioritization of those countries, which offer the largest potential for forest management measures. As far as can be judged from available data on deforestation, this is presently not the case (Exhibit 3 - 5). Likewise, within national forestry plans the objective of eliminating deforestation and optimizing carbon absorption opportunities through forestation could be made explicit and used for the management of the plan. Second, within the TFAP most countries are at the planning and project preparation stages, which are time consuming (Exhibit 3 - 6). By increasing the capacity within both FAO/TFAP and countries whose forestry sectors are being reviewed, the process could conceivably be accelerated. Naturally, any acceleration would have to be balanced against the developing countries' capacity to effectively integrate and implement the forestry measures.

- ¶ The need for an early strengthening of infrastructural functions was discussed before. Limited amounts for supplementary budgets as well as practical considerations argue for the use of existing institutions active in this regard. These were earlier identified as various specialized UN agencies and the OECD (including IEA).

Towards the end of Phase 1 and during Phase 2 the action will broaden, i.e., more emission sources will be covered and international financing flows - the second track of the two-track policy approach - are likely to grow substantially. Accordingly, the need for greater coordination will be felt.

Exhibit 3 - 7

Clearinghouse to generate efficient international action

CLEARINGHOUSE MECHANISM

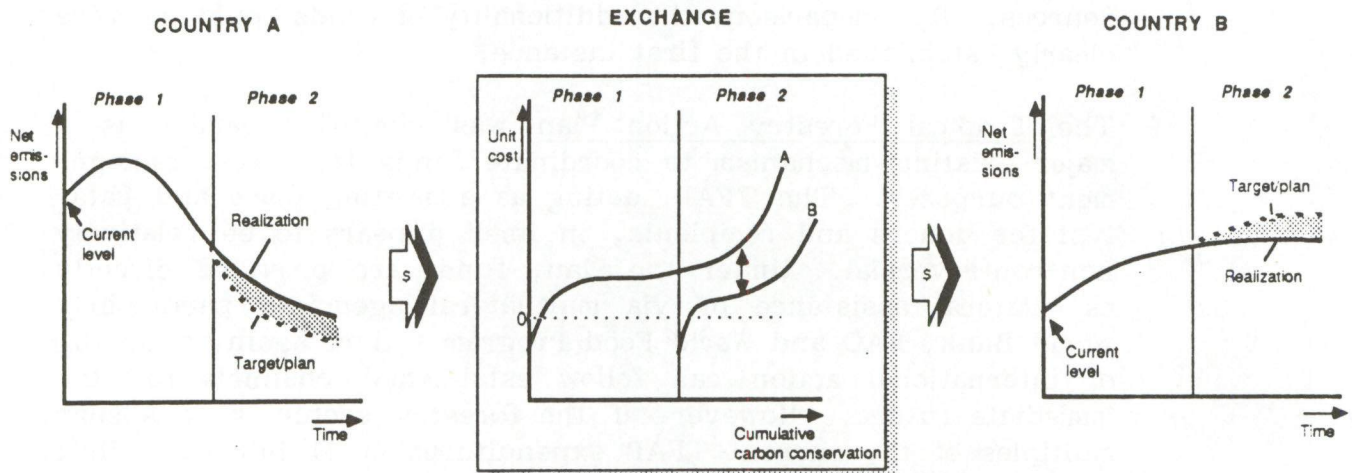


Exhibit 3 - 8

Important role World Bank in relevant sectors

PROPORTIONAL DISTRIBUTION OF ODA Percent

		World Bank	Other multilateral	Bilateral	100% = \$ bln.
DAC commitments*, 1987	Industry, mining and construction	40	13	47	3.9
	Energy	57	3	40	7.6
	Agriculture (incl. Forestry)	46	13	41	9.8
TFAP gross disbursements**, 1988	Forestry- Technical assistance	4	10	86	0.4
	Forestry- Investments	33	25	42	0.6

* Excluding regional development banks

** Regional development banks included with World Bank

Source: DAC; FAO; McKinsey analysis

Although the clearinghouse concept as such will provide some increase in coordination, it is unlikely that this will be sufficient under voluntary financing. From a global perspective, the objective of Phase 2 - maximizing worldwide environmental yield given limited financial resources - will be difficult to approach in this manner. Moreover, additionality of funds may be difficult to establish and, conversely, financing flows for greenhouse purposes may not be distinguishable from other flows.

The clearinghouse might therefore need to operate as a multilateral institution, under the differentiated financing approach described here. A shift would then take place from voluntary financing in Phase 1 to burden sharing in Phase 2. Burden sharing for clearinghouse purposes may take the form of a uniform assessment (GNP or CO₂ levy, etc.). In parallel, targets for domestic emission reductions might be slackened as long as sufficient progress towards the longer-term global objective is being made through international action (Exhibit 3 - 7).

With respect to the choice of multilateral agency to manage the clearinghouse, the World Bank appears well qualified among existing institutions for several reasons. First, much international action is likely to be financed along a North/South axis. Second, the World Bank already has extensive experience and plays a major role in relevant sectors of development assistance (Exhibit 3 - 8). Most funds, particularly in the energy sector, can be provided in the form of loans rather than grants. The Bank is capable of bringing to bear an integrated perspective on a developing economy across those sectors. Among the multilaterals, the Bank is unique in its experience in the handling of large flows of funds; moreover, its borrowing capacity would enable it to extend the funds available to the clearinghouse. Finally, while not beyond criticism in both industrialized and developing countries, the institution appears to meet with a significant degree of respect from both.

4 - MOVING FORWARD

Many Steering Committee members emphasized the need for unambiguous, substantive success in the near future on the climate change issue. The greenhouse gas build-up requires major adjustment in the short term. With many political leaders directly involved, the general public will not accept slow or vague progress. Finally, success breeds on success and a proven case on one specific aspect may accelerate progress on others.

Progress is being made within the IPCC framework on substantive issues relating to climate change. Members of the Steering Committee without exception maintain a positive attitude towards the IPCC work program and respect its achievements. At the same time, an opportunity is recognized to take early initiatives, which would represent meaningful progress from an environmental point of view by strengthening an international approach. They cover steps which would not prejudice further IPCC work, but rather acknowledge progress realized in understanding the nature of the problem and feasible solutions.

The specific initiatives, which present themselves for action in the short term, fall in three categories: (a) establishing a medium-term emission reduction target; (b) initiating large-impact measures; and (c) strengthening practical international funding steps.

ESTABLISH MEDIUM-TERM TARGET

The advantage of an early understanding on emission reduction targets was discussed in Chapter 2. A target of minus 30 percent net man-made GHG emissions, to be achieved by the year 2000 relative to 1986, would pose a realistic challenge to industrialized countries.

A demanding target in terms of CO₂-emissions as such may, for a variety of reasons, pose serious problems for some Eastern European and OECD countries. From the point of view of international cooperation it is of great importance to include as many countries as possible in an international understanding; thus a reduction target should be stretching but realistic for most countries concerned. This objective can be furthered by setting the target in terms of net man-made GHG emissions rather than for individual contributors. In this way, flexibility and possibilities for policy consideration at the national level are enhanced, while the overall perspective on the climate change issue is maintained. Where practicable, national policies in individual countries of course could set more stringent goals.

However, some countries may have legitimate concerns that the time is not ripe for an overall GHG target. If that view prevails, two courses of action remain open. First, countries might agree to review preliminary assessments of CO₂-equivalence and national emissions data on GHGs, and revert on the issue in, say, 3 months' time. Alternatively, they might

prefer to establish a target reduction for CO2 emissions as such, in order to gain early commitment and initiate action.

INITIATE LARGE-IMPACT MEASURES

The initial stages of the overall approach are geared to major, highly effective measures to reduce GHG emissions. These would include steps that will need to be taken in any case, whatever the eventual long-term objective and medium-term targets in combatting climate change.

There appears to be a broad understanding that the following steps would fall into this category:

- ¶ Phasing out CFCs in industrialized countries, as expressed in the Helsinki Declaration of May 1989
- ¶ Stabilizing CO2 emissions from fossil fuel energy sources in industrialized countries at today's levels not later than the year 2000
- ¶ Stimulating the reduction of deforestation of tropical zones and promoting forestation, both in developed and developing countries.

STRENGTHEN PRACTICAL INTERNATIONAL STEPS

Recognizing that time is required to establish the appropriate international agreements, coordinating mechanisms and infrastructure, it is conceivable that five to eight - and preferably more - nations join in providing an additional short-term impetus to policy coordination and funding. In signalling commitments it would reinforce awareness of the urgency of the problem and convey the commitment to action. It would also strengthen and - if possible - expedite the cooperative efforts on policy coordination within the IPCC.

A meaningful impetus would require international funding of approximately \$500 million per year, broadly divided over the following purposes:

- ¶ CFC funding: \$150 million per year
- ¶ Forest management through enlarged funding of the TFAP: \$300 million per year
- ¶ Infrastructure funding: \$50 million per year.

By collectively reserving this amount, participating countries would demonstrate their willingness to make contributions for these purposes

when called upon by competent institutions, notably the World Bank, FAO (including TFAP), respectively WMO and UNEP. They might ask these institutions to prepare, within a year, detailed project and program proposals for these purposes. No budget outlays would appear to be necessary or even practical before that time, save perhaps for limited amounts for technical assistance in preparing proposals.

* * *

If an international understanding on each of these three sets of initiatives can be achieved at the November Ministerial Conference in the Netherlands, substantive progress would be realized in combatting the global challenge of climate change.

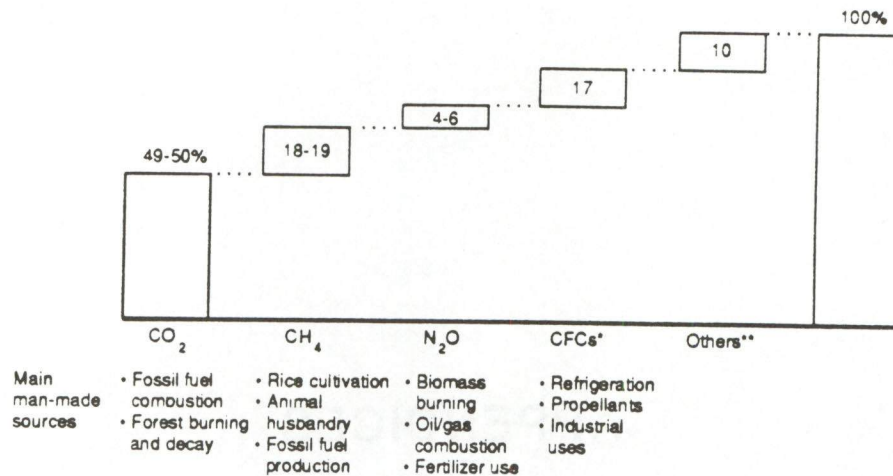
APPENDICES

Exhibit A - 1

Relative contribution estimates are available from existing reports

CONTRIBUTION OF GASES TO GLOBAL WARMING 1980s

Percent



* CFC - 11, CFC - 12 and others

** Such as NO_x, CO and stratospheric water vapor

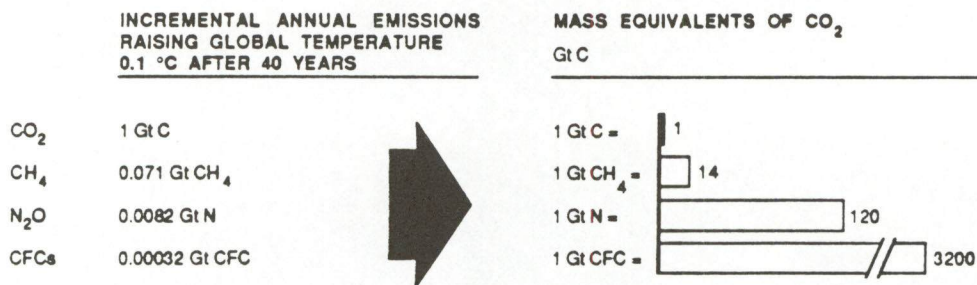
Source: EPA, FRG parliamentary report

Exhibit A - 2

Contribution individual gases can also be assessed through climate model simulation

RIVM "IMAGE" ASSESSMENT OF CO₂ EQUIVALENTS

Percent, 1985



Source: IMAGE model (RIVM), McKinsey analysis

CO2-EQUIVALENCE

To compare the man-made emissions of greenhouse gases in terms of their contribution to global warming the notion of CO2-equivalence is used. There are alternative ways to convert physical emission quantities of non-CO2 greenhouse gases into their CO2-equivalent. The method followed throughout this report results in a more conservative estimate of the relative contributions by non-industrialized countries.

The radiative forcing leading to global warming is directly related to the atmospheric concentrations of greenhouse gases. Increases in atmospheric concentrations are in part due to net man-made emissions* and in part result from natural GHG sources and sinks. The latter include exchanges with the biosphere and oceans as well as atmospheric decay processes. Some of the natural sources and sinks are better understood than others. Because of these uncertainties and because of unknown factors in the radiative forcing of atmospheric concentrations, a one-on-one relationship between net man-made emissions and changes in atmospheric concentrations or average global temperature has not been established. However, various estimates exist.

Two distinct approaches to establish the global warming contribution of man-made emissions have been compared:

- ¶ Incremental changes in concentrations: reports by the U.S. Environmental Protection Agency (EPA) and a West-German Parliamentary Commission provide estimates of the relative contributions of changes in atmospheric concentrations of individual gases (Exhibit A - 1). It is then assumed that these proportions equally apply to man-made emissions.
- ¶ Incremental man-made emissions: in a sensitivity analysis using a climate model**, the relative contributions of net man-made emissions can be estimated on the basis of their physical properties. By taking into account natural sources and sinks and dynamic atmospheric processes, estimates are derived for the incremental man-made emissions of individual gases which, if sustained, result in additional global warming of approximately 0.1 °C after 40 years. A comparison of these estimates establishes the relative contribution of current net man-made emissions of individual GHGs (Exhibit A - 2).

* I.e., man-made GHG emissions minus man-made absorption (e.g., forestation).

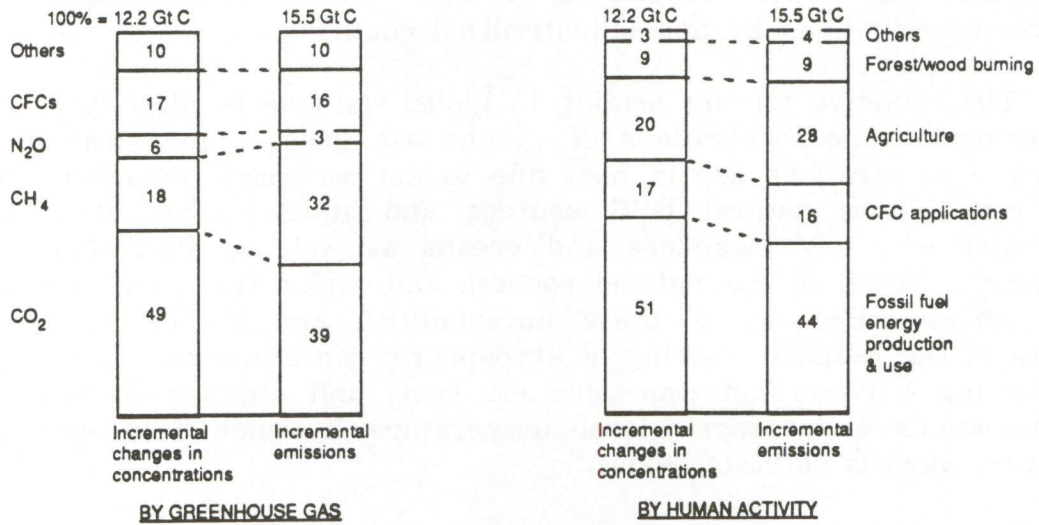
** "IMAGE" model of the Netherlands' National Institute of Public Health and Environmental Protection.

Exhibit A - 3

Differences particularly in methane and therefore agriculture

COMPARISON RELATIVE CONTRIBUTION ASSESSMENTS

Percent, 1985



Source: EPA; FRG parliamentary report; UN; IMAGE model (RIVM); McKinsey analysis

The two approaches differ in particular with respect to the estimated greenhouse impact of man-made methane emissions. These emissions are primarily produced by agricultural sources (rice cultivation, livestock, biomass burning) (Exhibit A - 3). The different results do not suggest that a particular approach or model is superior. Rather they reflect the distinct perspectives taken. For practical reasons, this report follows the first approach, thereby potentially understating the collective contribution of nations outside the OECD and Eastern European areas.

Exhibit B - 1

Energy analysis involved four steps

OVERVIEW OF METHODOLOGY

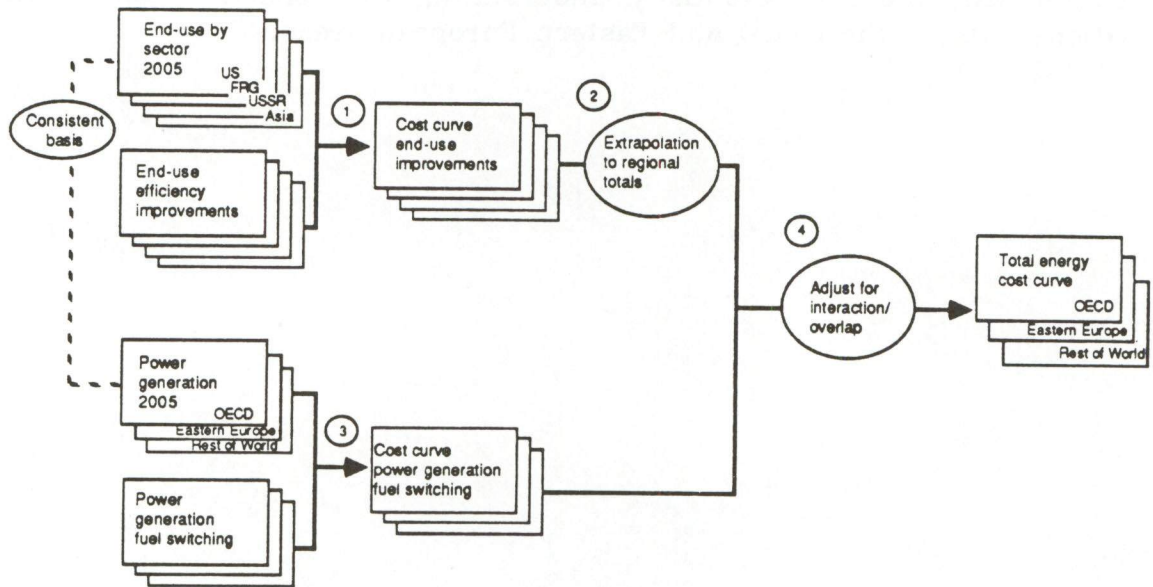
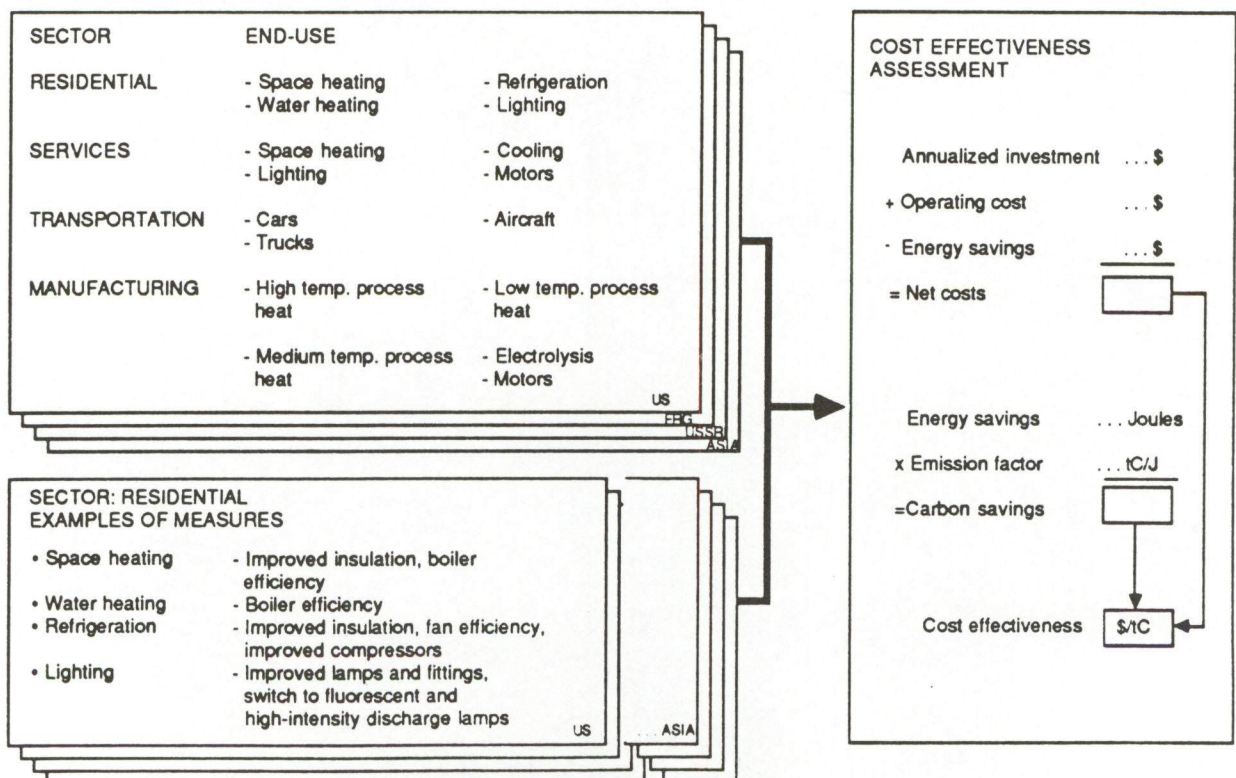


Exhibit B - 2

Bottom-up analysis performed for four areas

OVERVIEW OF SECTORAL ANALYSIS



COST EFFECTIVENESS OF ENERGY MEASURES

An assessment has been made of the cost effectiveness of various energy conservation and fuel switching measures in reducing CO₂-emission. Combined with the cost effectiveness of CFC reductions and forest management measures the analysis is essential in understanding the economics of the climate change issue.

This appendix will briefly discuss the methodology used in the analysis and the main assumptions made. The results are incorporated in the cost curves shown in Exhibits 1 - 4, 1 - 7 and 1 - 8 of this report.

METHODOLOGY USED

The objective of the analysis is to establish the cost effectiveness of energy conservation measures, expressed in dollars per ton of carbon conserved. For this purpose three regions (OECD, Eastern Europe and Rest of World) and four end-use sectors (residential, services, transportation and manufacturing) were distinguished. The analysis involves four steps (Exhibit B - 1):

1. Bottom-up, sectoral analysis of end-use efficiency improvements for representative countries, carried out in close cooperation with a team of international energy consultants in Berkeley, California and based on available research material and industrial sources (Exhibit B - 2);
2. Extrapolation to totals for the regions OECD, Eastern Europe and Rest of World (Exhibit B - 3);
3. Analysis of the fuel switching/efficiency improvement potential in power generation for each region;
4. Adjustment for interaction of end-use and power generation measures. The most important adjustment is that end-use conservation measures reduce the potential for fuel switching in power generation by limiting the growth in electricity demand.

MAJOR ASSUMPTIONS

In carrying out the energy analysis the following assumptions were used:

- ¶ The analysis is based on a macro-level assessment, using a real discount rate of 6 percent. At the micro-economic level many barriers prevent the realization of actions which, from a macro-economic point of view, appear to be efficient. For example, not all benefits may accrue to the party making the investment,

Exhibit B - 3

Sectoral analysis extrapolated to regional totals

REGION	EXTRAPOLATION METHODOLOGY
OECD	- Separate analysis for United States - Use German analysis to extrapolate to W-Europe and Canada (Germany generally considered representative) - Use German analysis to derive Pacific region
Eastern Europe	- Use Soviet Union analysis to extrapolate to Eastern Europe (USSR represents 75%)
Rest of World	- Use DC Asia analysis to extrapolate sector-by-sector to whole region

resulting in an inadequate micro-economic return to him. Sensitivity analysis, applying a higher discount rate of 10 percent, proved to have minimal impact on the overall results.

- ¶ Energy conservation and fuel switching measures were evaluated based on available research material. This explains the relatively limited set of measures analyzed for Eastern Europe and the Rest of the World.
- ¶ The measures were analyzed relative to a base case for the year 2005, in which ongoing energy conservation and fuel switching steps are included. The measures analyzed over and above the base case are taken at a 50 percent penetration rate. Any higher penetration rate would yield improvements in the energy intensity of GNP within the OECD, which would exceed the maximum improvement realized over any extended period of time. This would clearly be unrealistic.

The same 50 percent penetration rate has been assumed for the other two regions.

- ¶ In determining the application potential of specific measures no early retirement of current facilities and associated capital loss are assumed to take place. Consequently, new installation or equipment can only replace decommissioned facilities or fill the volume created by growth.
- ¶ In most cases the measures maintain the output level of "energy consuming" activities, but lower the GHG emissions accompanying those activities by reducing the energy required and/or by switching fuels. Hence, major changes in worldwide lifestyle and behavior are not considered. The more drastic policy options, e.g., to reduce GHG emissions by restricting economic output levels, have not been incorporated in the analysis.

RESULTS

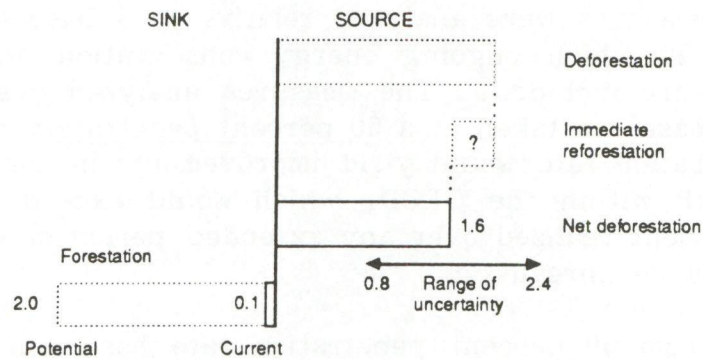
The results are shown in the cost curves discussed in Chapter 1. An important observation is, that in general end-use energy efficiency improvements appear to be substantially more cost-effective than investments in power generation fuel switching.

Exhibit C - 1

Both forestation and reduction of deforestation form substantive measures

ANNUAL CARBON FLOWS DUE TO LAND USE CHANGES

Gt C in CO₂ - equivalent per year, 1985



Source: Houghton et al., Tellus (1987); WRI

FOREST MANAGEMENT MEASURES

Forest management measures may have the capacity to yield a net carbon emission reduction of 2.5 Gt per year. The annual costs involved in fully utilizing this theoretical capacity are estimated at \$10-15 billion. Both measures to reduce deforestation and activities to stimulate forestation can contribute significantly in adjusting the world's carbon balance for the coming decades.

Forest management opportunities are to a large extent situated in tropical zones, almost always involving developing countries. In general, forestry measures relate directly to the socio-economic development of these countries, both at the macro level (integrating forestry into national development planning) and at the micro level (recognizing local needs and skills). The implications are twofold.

First, estimates of costs involved in either halting deforestation or stimulating forestation may vary widely depending on general economic conditions, taxation and local circumstances. Notwithstanding such variations, the limited information available and expert opinions provided center on the cost indications discussed below.

Second, it is clear that problems of deforestation or forestation will not be solved merely by making funds available. This may be even more true in the forestry sector than in development assistance in general. Technical expertise, an understanding of local climatic and socio-economic conditions as well as the availability of appropriate institutional channels are key ingredients for the success of most forestry projects. However, the argument may not be reversed; major forest management efforts can not be accomplished without substantial financing.

Focusing on quantitative aspects of forest management there is considerable uncertainty about the carbon flows due to so-called land use changes. Most recent estimates of carbon released in the burning of forests center around 1.6 Gt C for the year 1985*. Currently, forestation takes place on a relatively small scale. The corresponding carbon absorption is on the order of 0.1 Gt C per year. However, the potential carbon absorption at reasonable cost is estimated at roughly 2.0 Gt C per year (Exhibit C - 1).

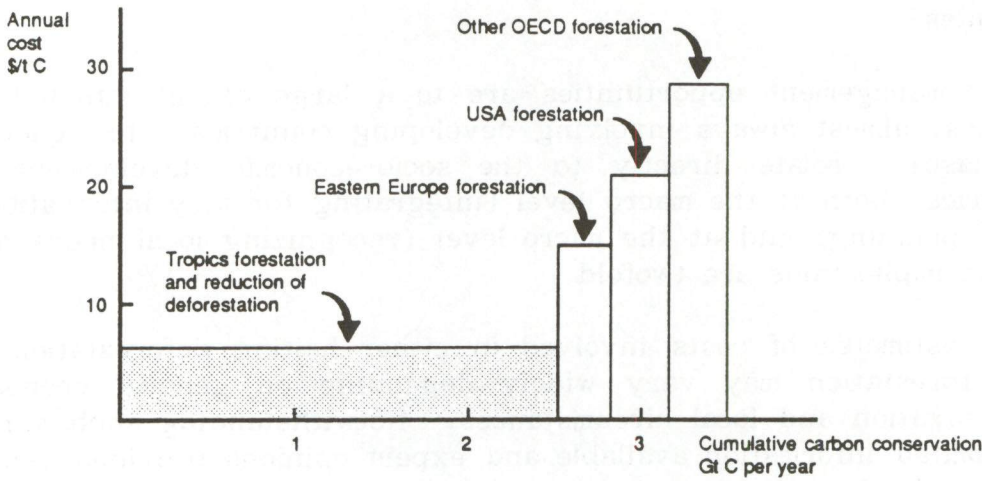
* Comparative analyses of regional contributions to global warming, etc. in Chapter 1 use an emission estimate of 1.1 Gt C CO₂-equivalent to be consistent with estimates for other human activities provided by the same source.

Exhibit C - 2

Most attractive opportunities in tropics

COST CURVE FOREST MANAGEMENT MEASURES

REGIONAL AVERAGE INDICATIONS

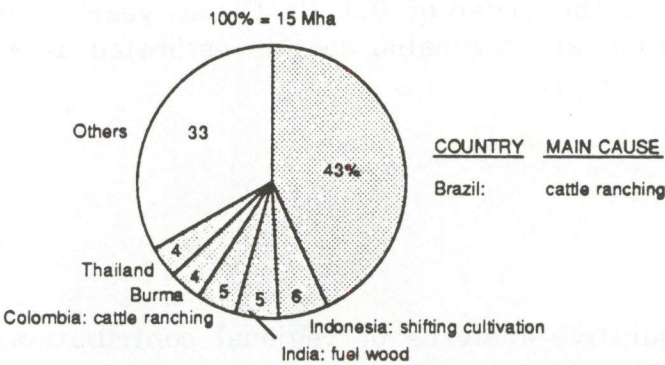


Source: FAO; WRI; McKinsey analysis

Exhibit C - 3

Two-thirds of tropical deforestation in six countries

DEFORESTATION OF TROPICAL FOREST
Percent of total, 1988



Source: Dr. N. Myers; WRI

Assuming non-financial conditions and requirements can be met, forest management opportunities in the tropics are economically more attractive than in industrialized countries (Exhibit C - 2).

Collectively, they potentially reduce the annually deforested area by 10 million hectare and provide for the forestation of an area of 150 million hectare over a period of 10-15 years.

REDUCING DEFORESTATION

Reducing deforestation by 70 percent of its current level is estimated to cost roughly \$8 billion per year for a total annual carbon conservation of 1.3 Gt C:

- ¶ Varying estimates and indications are available on deforestation in tropical zones, most of them relatively dated. One recent estimate puts total tropical deforestation at 15 million hectare per year, with two-thirds taking place in only six countries (Exhibit C - 3).
- ¶ In many situations marginal use of land drives deforestation; only 20 percent of the wood is used for industry or trade (Exhibit C - 4). A small part is used as fuel wood and the balance is destroyed (burned) in the deforestation process. Lack of economic alternatives or inappropriate incentives reportedly constitute major underlying factors.
- ¶ The cost of stopping the deforestation process has not been uniformly assessed, but is estimated by various sources at up to \$800 per currently deforested hectare in pure economic terms. Actions would include the initiation of forest protection programs and stimulation of sedentary cultivation. Technically, perhaps as much as 10 million hectare per annum of the current deforestation of 15 million hectare per annum might be retained in this manner. The annual cost per ton of carbon conserved would be on the order of \$6.

STIMULATING FORESTATION

Used to its full potential, forestation in the tropics is estimated to cost on the order of \$6 billion per year and absorb roughly 1.2 Gt C per annum.

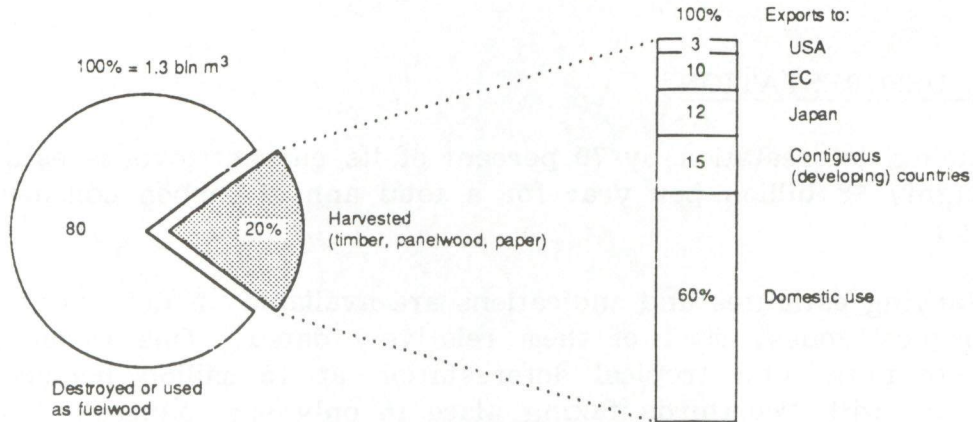
Worldwide forestation may cost anywhere up to \$25 billion per year for a corresponding carbon uptake of up to 2 Gt C. However, the cost-effectiveness of forestation measures ranges from roughly \$5 per ton of annual carbon absorption in the tropics to around \$30 per ton in Western Europe (Exhibit C - 5). Half of the potential forestation areas are outside the OECD and Eastern Europe; most of this, in total approximately 150 million hectare, is situated in the tropics.

Exhibit C - 4

Only 20% of tropical deforestation for industrial or trade purposes

USE OF WOOD IN DEFORESTATION

Percent, 1983



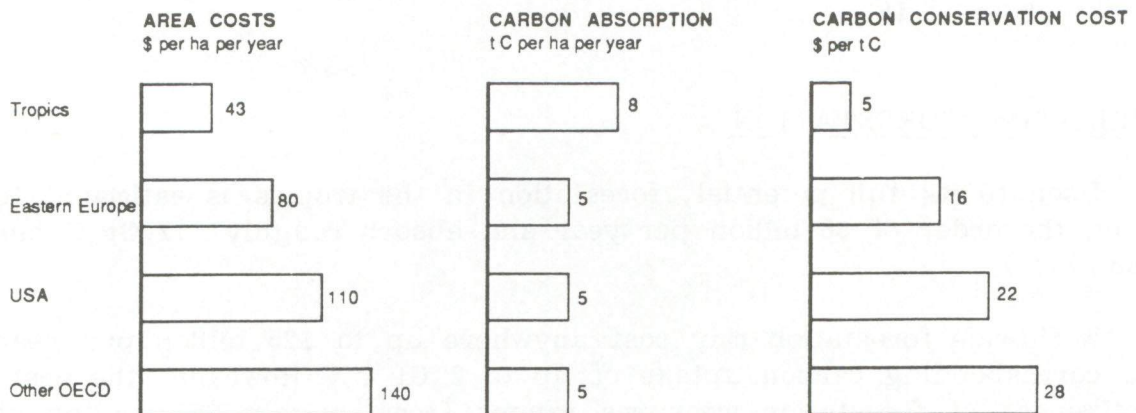
Source: Netherlands Timber Trade Association

Exhibit C - 5

Cost-effectiveness of forest management measures ranges from \$5 to \$30 per ton C

FORESTATION COSTS

INDICATIVE



Source: FAO; WRI; McKinsey analysis

CFC SUBSTITUTION IN DEVELOPING COUNTRIES

The Helsinki Conference of May 1989 recommended to phase-out chlorofluorocarbons (CFCs) worldwide using, inter alia, appropriate funding mechanisms to assist developing countries. This appendix outlines a possible approach to funding, building on an analysis of cost disadvantages resulting from the substitution of CFCs with substances not controlled by the Montreal Protocol.

The main conclusion is that approximately 80 percent of CFC consumption in developing countries by the year 2000 can be substituted at a cost penalty of \$150-200 million per year. Eliminating the use of the remaining 20 percent may incur an additional cost penalty on the order of \$400-500 million.

These substitution cost estimates should be regarded as order-of-magnitude indications of funding needs of developing countries. They are based on estimates of incremental costs in developed countries applied to the projected consumption levels in the developing world. Actual financing requirements may be higher, owing to the smaller scale and wider distribution of operations in developing countries.

To elaborate on these conclusions, the appendix will address: (a) growth in CFC consumption in developing countries; (b) substitution economics; and (c) step-by-step national phase-out scenario's.

CFC CONSUMPTION

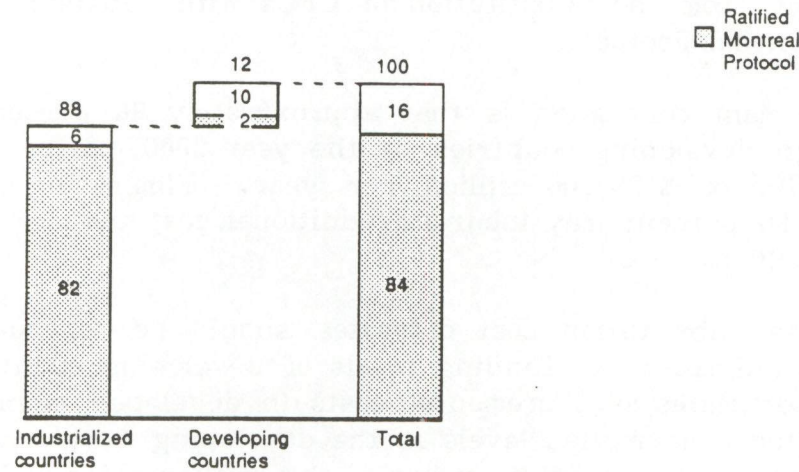
Establishing a funding mechanism to eliminate CFC consumption in developing countries is desirable from an environmental point of view. Even if the Montreal Protocol would apply to these countries, it would not effectively constrain their projected consumption growth.

Currently, CFC consumption in developing countries accounts for approximately 12 percent of the world total. By and large, these countries have not ratified the Montreal Protocol (Exhibit D - 1). Their consumption volume is projected to grow significantly in the coming decade. This applies in particular to producing countries, notably the People's Republic of China and India (Exhibit D - 2). Although in most cases the assumed CFC growth far outpaces economic growth, the 0.3 kg CFC per capita limit, stipulated by the Montreal Protocol, will not be reached by the year 2000. Therefore the Protocol, even if ratified, will not be an effective constraint on consumption.

Exhibit D - 1

Developing countries, which account for 12% of total consumption, for the most part did not ratify the Montreal Protocol

WORLD CFC* CONSUMPTION
Percent, 1986**



* I.e., "Controlled substances" under Montreal Protocol: CFC-11; CFC-12; CFC-113; CFC-114; CFC-115; Halon 1201; Halon 1311
** Montreal Protocol base year

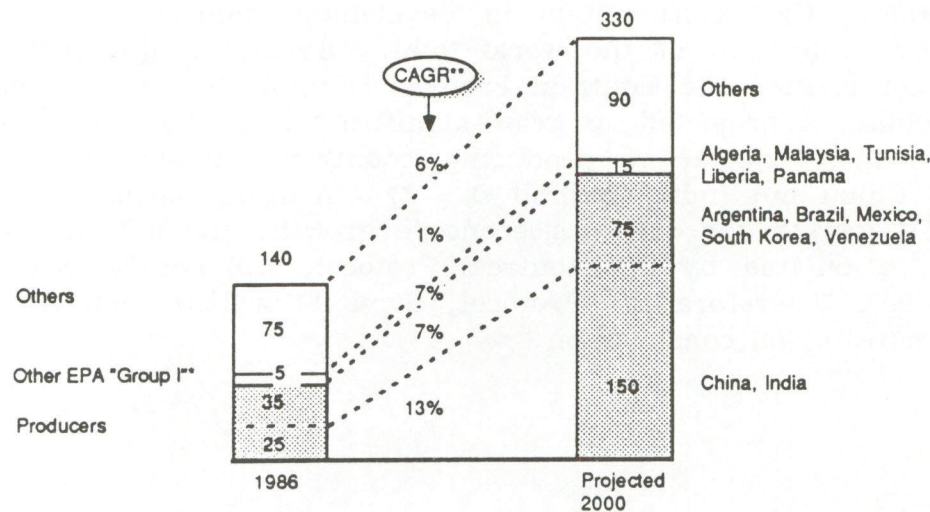
Source: UNEP; EPA

Exhibit D - 2

Major volume growth assumed to be with producers

CFC CONSUMPTION DEVELOPING COUNTRIES
kt

ESTIMATE



* EPA "Group I" countries: having 0.1 to 0.2 kg per capita use (Algeria, Argentina, Liberia, Malaysia, Mexico, Panama, South Korea, Tunisia, Turkey)

** Compound annual growth rate

Source: UNEP; EPA; McKinsey analysis

SUBSTITUTION ECONOMICS

In order to minimize cost disadvantages, CFC substitution in developing countries should await the development and full market penetration of alternative substances in industrialized countries.

The economics of CFC substitution are driven by the technological and commercial stage of development of alternative substances. In principle, newly developed substitutes may be relatively costly until they are widely accepted in the market place and fully benefit from cumulative experience in production and application (Exhibit D - 3). The development stages presently differ for the various CFC applications, but most substitutes are expected to be widely available by the late 1990's, subject to successful testing (Exhibit D - 4).

Approach

For each application, estimates have been prepared of the incremental costs of producing or importing alternative substances relative to the current price of CFCs. Where applicable, a distinction has been made between the costs at introduction and full-scale market acceptance. Potential cost disadvantages in the application of CFCs have been similarly assessed. Cost estimates distinguish research and development costs, investments in plant and equipment and operational costs, including costs of raw materials. Not included in the analysis are potential cost increases of indirect imports, i.e., goods made with or containing controlled substances.

The analysis furthermore assumes that existing facilities will be closed or converted in accordance with their normal depreciation schedules. No early retirements and associated capital losses are supposed to take place. Given the time frame involved, this would not appear unrealistic.

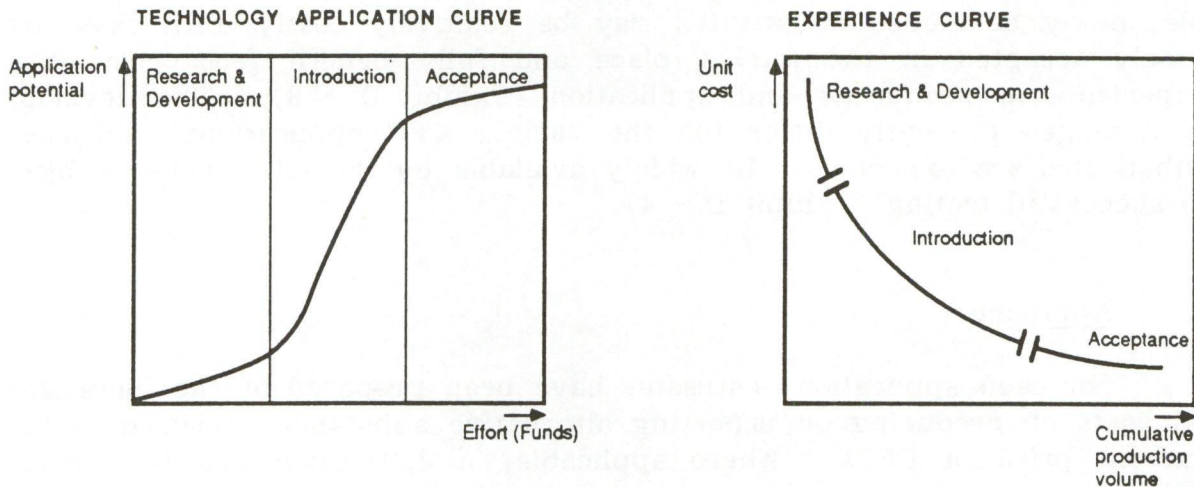
The cost estimates are based on publicly available information on the technical possibilities and economic consequences of CFC replacement in industrialized economies. This includes reports under UNEP auspices, analyses prepared by the U.S. Environmental Protection Agency and economic evaluations carried out in Australia, Canada and the Nordic countries. The public information has been complemented with industrial sources covering both CFC production and application.

While care has been taken to check for and ensure consistency, the accuracy of data made available to the project team has not been verified. The information is still being reviewed in part and, accordingly, the conclusions carry a preliminary character.

Exhibit D - 3

Newly developed substitutes may be relatively costly until widely accepted

CONCEPTUAL

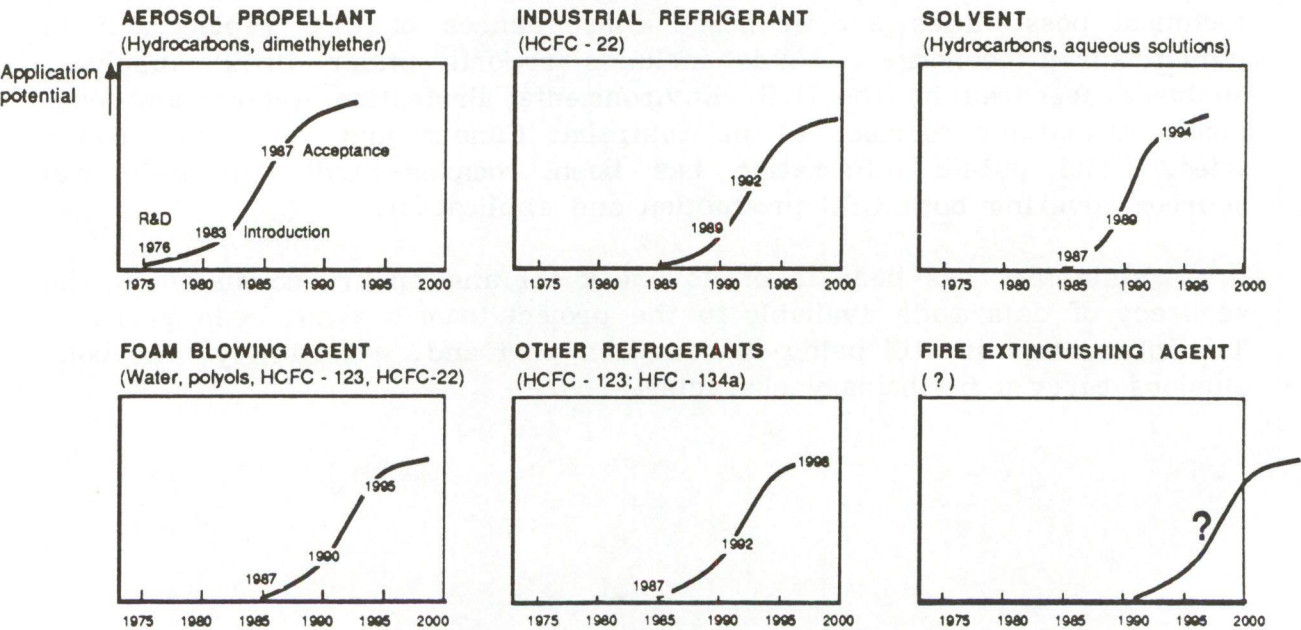


Note: Various stages may differ considerably in duration

Exhibit D - 4

Although development stages differ, most substitutes expected to be widely applicable by late 1990's

TECHNOLOGY APPLICATION CURVES
(Examples of substitutes)



Source: Environment Canada; Industry sources; UNEP; McKinsey analysis

Results

Taking into account the anticipated evolution of the costs of CFC alternatives and further substitution economics, the various applications can be ranked according to their incremental unit costs over the use of controlled substances (Exhibit D - 5). The analysis demonstrates that approximately 80 percent of developing country consumption can be replaced at relatively low additional costs in the course of the 1990's. This volume covers the application as aerosol propellant, solvent, industrial refrigerant and most foam blowing uses. The total cost disadvantage, based on substitution economics in industrialized countries and projected developing country volume, is estimated to be \$150-200 million per year.

Approximately 20 percent of the volume would face substantially higher substitution costs, - particular in cooling agent applications other than industrial refrigeration. Although costs are projected to drop significantly once full market penetration takes place by the late 1990's, these applications would still face a total disadvantage on the order of \$400-500 million per year. For halons, no substitutes are presently available or under development. However, there seems to be a consensus that most of the emissions can be eliminated through better operating practices. Also, the use could be restricted to the most critical applications only, e.g. in high-technology environments.

The cost disadvantages of CFC substitution are more or less equally distributed over production and application. Some one-time costs are involved in research and development and in investments in new equipment. Examples include more expensive production facilities, protective measures necessary to deal with higher inflammability of CFC substitutes, etc. Most incremental costs, however, will be of an ongoing nature. Here, examples include higher raw material and energy costs in view of the multiple process steps, as well as more expensive lubricants in new compressor designs for refrigeration.

PHASE-OUT SCENARIO

The volume and projected evolution of CFC substitution costs suggest a phase-out scenario in two stages:

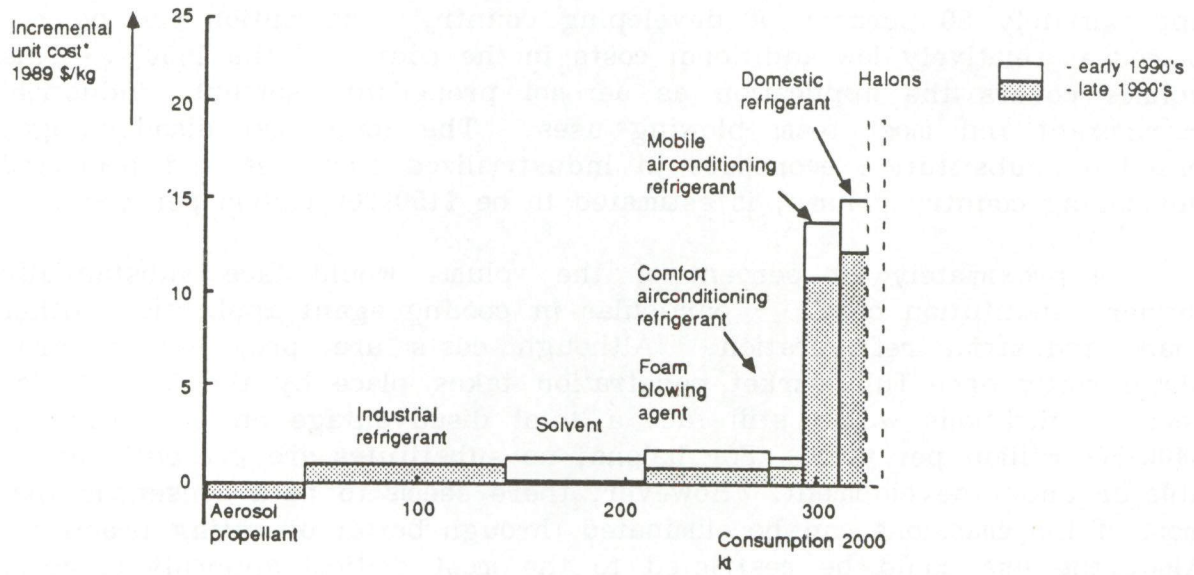
- ¶ Stage 1, through 1995: elimination of CFCs in applications with relatively low substitution costs, as indicated above; use of Best Practicable Means in other applications;
- ¶ Stage 2, from 1995 onward: in principle introduction of Best Technical Means to eliminate CFCs in all applications, with the pacing of this stage subject to evaluation of then existing estimates for substitution costs.

As explained before, the funding needs associated with CFC replacement in developing countries cannot be precisely estimated at the macro-

Exhibit D - 5

Majority of applications faced with relatively low-cost substitution

COST CURVE CFC SUBSTITUTION DEVELOPING COUNTRIES



* I.e., over current cost of using CFCs

Source: EPA; UNEP; Industrial reports; Interviews; McKinsey analysis

level. In practice, initial funding requirements may deviate substantially from the estimated \$150-200 million for the developing countries as a group. However, it is unrealistic to assume that there will be an order of magnitude difference.

Actual phase-out opportunities and funding needs should probably be assessed on a country-specific basis, taking into account the economic infrastructure and specific national circumstances while maintaining an integrated perspective. Ideally, a single lead agency would coordinate such phase-out plans to concentrate international expertise and ensure consistency across countries. Industrial corporations in developed countries can contribute by providing this expertise and by transferring appropriate technologies at reasonable terms.

The lead agency would develop the plan in close cooperation with the national government and with those industries that are most directly involved (chemical manufacturing and trading, as well as relevant user industries). In addition to regulating the transition to CFC alternatives, the plan would provide incentives or subsidies to give (partial) compensation for the incremental costs in producing, purchasing or using the substitutes. Such a subsidy scheme would apply for a pre-defined period of, say, 5 to 10 years.

The Ministerial Conference, organized
by the Minister of Housing, Physical
Planning and Environment of The
Netherlands in cooperation with
UNEP and WMO.

Climate conference secretariat:
P.O. Box 450
2260 MB Leidschendam
Tel. 31 70209367, ext. 2125
Telex nr. 32 362 VROM NL
Telefax nr. 31 70 201858

BACKGROUND PAPER ON GREENHOUSE

GASES, ENERGY AND CO₂

"MITIGATION OPTIONS FOR ENERGY RELATED GREENHOUSE GAS EMISSIONS"

OCTOBER 1989

FOR THE MINISTERIAL CONFERENCE ON
ATMOSPHERIC POLLUTION AND CLIMATIC CHANGE,
WITH PARTICULAR ATTENTION TO GLOBAL WARMING 6TH AND 7TH NOVEMBER 1989

THIS PAPER WAS PREPARED BY THE REPRESENTATIVES OF THE
FEDERAL REPUBLIC OF GERMANY AND THE UNITED STATES OF AMERICA
FOR THE RELEVANT WORKING GROUP
OF THE INTERNATIONAL STEERING COMMITTEE
WORKING ON BEHALF OF THE MINISTERIAL CONFERENCE
THE VIEWS EXPRESSED DO NOT NECESSARILY
REFLECT THE POLICY OR OPINIONS OF
THE GOVERNMENTS REPRESENTED IN THE WORKING GROUP

BACKGROUND PAPER ON GREENHOUSE
GASES, ENERGY AND CO₂
"MITIGATION OPTIONS FOR ENERGY RELATED GREENHOUSE
GAS EMISSIONS"

BACKGROUND PAPER - SUMMARY

'Mitigation Options for Energy Related Greenhouse Gas Emissions'

Whilst the Intergovernmental Panel on Climate Change (IPCC) gains a better scientific understanding of global climate change, its magnitude, timing and effects, it is now widely recognised that significant global warming is being brought about through anthropogenic emissions of greenhouse gases. These greenhouse gases derive from a number of activities including energy production and use, chlorofluorocarbons, deforestation and other agricultural and industrial practices. Furthermore, the primary greenhouse gas, CO₂, derives in the main from the production and use of fossil fuels.

In view of the uncertainties still outstanding, particularly in regard to the magnitude and timing of the processes, but in the knowledge that we cannot wait until all of the uncertainties have been resolved before we act, decision makers need to know the best available response alternatives and something of their cost-effectiveness. Such options will be applied in the light of the specific regional and local scale of the problem, and be the better for substantial international cooperation.

The major conclusions/recommendations of the paper are as follows:

The recommendation of the conference "The Changing Atmosphere" at Toronto, regarding CO₂ emissions, could be taken as one basis to formulate quantified objectives for further consideration by the IPCC.

With respect to specific situations of and differences between nations and regions, a promising approach seems to be to deliberate a trade-off in response measures for different greenhouse gases and the protection of the biotic carbon sink, bearing in mind the global objectives for emissions of greenhouse gases which may ultimately be agreed upon.

Priority should be given to improvements in efficiency and rational use of energy which in the short term are the most promising options to reduce CO₂-emissions.

One direct means of allowing markets to incorporate the risk of climatic change is to assure that the prices of fossil fuels and other sources of greenhouse gases reflect their full social and environmental costs. One option for achieving this goal are emissions fees, which should be imposed according to the relative contribution to global warming of each fuel type. This approach has the advantage of raising revenues that can finance other mitigation programs. Another option is to revise tax and incentive structures to allow non-fossil and low pollutant energy sources to compete on a level playing field with fossil fuels.

Regulatory programs can be a useful complement to pricing policies. Reducing greenhouse gas emissions could be incorporated into existing programs to reduce other air pollutants. New programs could focus directly on reducing greenhouse gas emissions through requirement such as emissions offsets, performance standards such as a "best-available-technologies" approach, or marketable permits.

Progress in reducing greenhouse gas emissions depend not only on technical and economic issues but attitudinal aspects are of the same importance. Therefore increased dissemination of information and better training of personnel, both on the international and national level is needed. Public awareness programs should incorporate the problem of climate change and the relation to individual energy use.

There is a need for broad international participation in the efforts underway in the IPCC to identify the elements of a framework convention on climate change and possible follow-up protocols which might be envisioned. Work on the convention should not preclude pursuit of national policies which can help mitigate greenhouse gas emissions, especially those which are justified on other grounds.

The goal of economic development and environmental quality should be pursued in a mutually reinforcing manner.

The development and selection of technology in and for developing countries should consider the local resource base and be supportive of broad development goals, offer opportunities for cost reductions by the national use of energy as well as the minimization of negative environmental effects.

Industrialized countries could put more emphasis on bilateral and multilateral lending for technologies and programs that reduce greenhouse gas emissions in developing countries. Multilateral development banks could be encouraged to redirect their policies toward more lending for energy efficiency and alternative energy technologies, and discourage lending for projects that result in deforestation and increased use of fossil fuels.

The establishment of specific programs for energy savings, promotion of renewable energy and transfer of appropriate technology within existing international organizations should be considered.

Private Industry, especially multinational industry must be encouraged to play an active role in implementing strategies of reducing energy-related greenhouse gases and protecting tropical forest, especially through the development and distribution of less polluting technologies. The shift of energy-intensive, high pollutant industry from industrialized to developing countries should be avoided.

In a long term perspective funding priorities for research, development and demonstration should be increased for technologies that can reduce greenhouse gas emissions.

An inventory of measures, instruments and tools to mitigate the greenhouse effect is attached as an Annex to the paper.

Introduction

Led by the Intergovernmental Panel on Climate Change (IPCC), an international process is underway to assess the scientific understanding of global climate change, its impacts and potential response strategies. Planned and ongoing work being conducted in support of the IPCC will improve on the estimates of the magnitude, timing, and effects of global climate change and provide technical and economic information on mitigation options. The first report of the IPCC is scheduled for completion by October 1990 for presentation at the Second World Climate Conference in November 1990.

The problem of greenhouse gases and global warming is now widely recognized as one of high and ever growing urgency. Greenhouse gas emissions derive from a number of activities, including energy production and use, chlorofluorocarbons, deforestation and agricultural and industrial practices.

The bulk of emissions of CO₂, the primary greenhouse gas, derive from the production and use of fossil fuels.

There are still uncertainties regarding climatic change, but there is a growing consensus in the scientific community that significant global warming due to anthropogenic emissions of greenhouse gases is probable, and rapid climatic change over the next century is possible. Therefore the internationally coordinated research on the effects of a continuing built-up of greenhouse gases must go on. Nevertheless, there are still uncertainties regarding climatic change, but there is a growing consensus in the scientific community that increasing concentrations of greenhouse gases in the atmosphere could lead to changes in global climate over the next century. These changes could include a rise in global atmospheric temperatures, a change in the frequency and severity of storms, shifts in precipitation patterns, and a rise in sea level. The strengths, rates and timing of such changes are currently uncertain. A better understanding of the problem of greenhouse gases and global warming, especially the resulting effects in a regional scale, is therefore necessary. The resolution of scientific uncertainties will require significant international cooperation. Nevertheless, we can probably not afford to wait until all of the uncertainties have been resolved before we act. Improvement in energy-efficiency, phase out of CFC production and use, and reforestation offer significant opportunities for reducing greenhouse gas emission.

Thus, decision makers need to know the best available response options, their cost and effectiveness, the constraints to their implementation, and the best criteria to use in selecting those options that can be used to develop effective response strategies for their countries. The objective of this paper is to provide background on technology and policy options, implementation constraints, and selection criteria for dealing specifically with energy-related emissions of greenhouse gases. Recommendations for immediate action and for options for further consideration by the IPCC are included at the end of the paper.

Energy use and its contribution to global warming

The relative contribution to global warming from different human activities is illustrated in Figure 1. The single largest factor is the use and production of energy from fossil fuels (57 %).

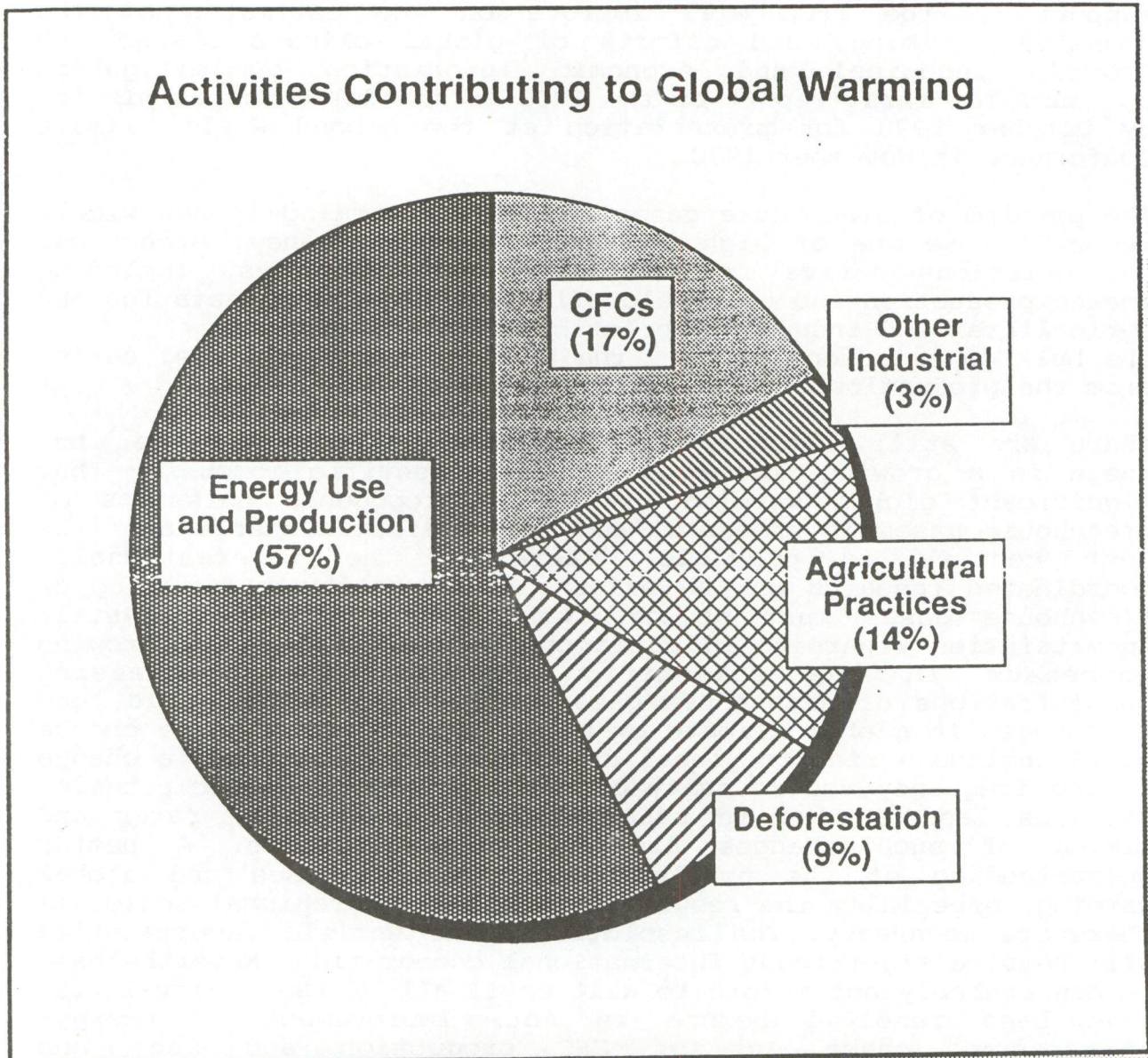


Figure 1 Estimated contribution to greenhouse warming for the 1980s, based upon each activity's share of greenhouse gas emissions, weighted by the greenhouse gas contributions to global warming. (EPA draft report)

Between 1950 and 1985 annual global primary energy consumption grew from 80 to 290 exajoules (EJ) (U.N., 1976, 1987), and annual CO₂ emissions grew from 1.6 to 5.2 petagrams of carbon (PgC) (Rotty and Masters, 1985). Even though emissions have been relatively stable during the last decade, atmospheric concentrations have continued their steady rise because CO₂ emissions remain substantially greater than uptake by the oceans and the terrestrial biosphere. Recent evidence suggests that emissions may be on the rise again due to the drop in real prices of fossil fuels (Geller, 1989).

Energy use and production is also an indirect source of methane, another key greenhouse gas, although energy's contribution to total concentrations of methane is relatively minor. Sources related to energy production include emissions from coal beds, leaks from natural gas transmission and distribution lines, venting of natural gas from oil wells, and incomplete combustion of fossil fuels.

In developing countries, wood is the most common fuel for cooking and heating and contributes significantly to carbon emissions. Since this practice is a major factor in deforestation, it may compound the problem of global warming by reducing the forests which serve as important carbon sinks.

There is also a link in the end-use of energy with CFCs, which are estimated to contribute approximately 17 % to global warming. Of concern here is the use of certain CFC substitutes that may lower the energy efficiency of certain end-use technologies, such as refrigerators. The resulting increase in energy use could lead to higher emissions of CO₂.

Global energy consumption has increased almost four-fold during the last 35 years. This growth has also been accompanied by a significant shift in its global distribution. In 1950, countries belonging to the Organization for Economic Cooperation and Development (OECD) consumed about three-fourths of all commercial energy supplies, the centrally-planned economies of Europe and Asia, 19 percent, and developing countries, 6 percent.

By 1985, OECD countries consumed just over one-half of all commercial energy globally, while the European and Asian centrally-planned economies and the developing countries had increased their relative share to 32 percent and 15 percent, respectively (U.N., 1976, 1983). Recent projections of primary energy consumption indicate that these trends will continue. The OECD share of primary energy consumption will fall to 47 percent in 1995 and 41 percent in 2005. The same shares for centrally-planned countries will rise to 33 percent and 35 percent in 1995 and 2005 respectively, and 20 percent and 23 percent respectively for developing countries. (IEA, draft 1989) This increase in energy consumption translates directly into greater increases in CO₂ emissions. Based on these projections, energy-related emissions of CO₂ will increase to approximately 6.5 petagrams of carbon in 1995 and 8.2 petagrams of carbon in 2005.

On a per capita basis, carbon emissions vary substantially between different countries. Presently, global average CO₂ emissions are approximately four metric tons per capita per year.

However, the figures range from 21.5 in the U.S. to 0.7 in Nigeria and India. Japan averages 8.2, the Federal Republic of Germany 12.8, and Brazil 1.3. (FRG data)

In 1985, the OECD countries accounted for about 45 percent of the greenhouse gas emissions; the USSR and Eastern (Centrally Planned) Europe accounted for about 20 percent; and the rest of the world accounted for about 35 percent.

Present projections and scenarios (except low-CO₂ scenarios with assumption of far reaching measures), however, predict a further increase in world-wide energy consumption and CO₂ emissions, due especially to population growth and the needs of the developing countries. E.g. the scenario of the World Energy Conference (WEC) of 1986/87 assumes in its lower path till 2060 a 25 % increase of world-wide per capita consumption of energy and a doubling of overall fossil fuel consumption and CO₂ emissions, even with a high increase in the contribution of nuclear and renewable energies.

Response Options (technical and attitudinal)

The introduction of technologies and practices that use energy more efficiently or produce energy from alternative sources will be critical to reducing greenhouse gas emissions. The main options, where the technologies are on the shelf or nearly available, are measures to enhance energy supply and end-use efficiency, economic measures to effect production and consumption patterns, fuel switching, technology development and deployment. Influencing attitudes and behavior would play an important role in the implementation of any of these options.

Because energy-related emissions of CO₂ and other greenhouse gases derive from such a wide range of activities, there is no single solution to the energy/greenhouse problem. The solution therefore must be sought by a combination of the various available options. The proper mix of these options will vary from sector to sector and from country to country. Nevertheless, the observation that opportunities are individually small and that a broad range of far reaching measures, covering all economic sectors, has to be implemented to achieve substantial results, is likely to be broadly applicable.

Significant reductions in current and projected emissions can result from the cumulative effects of a large number of specific policies at all levels of government. A broad consensus exists that, in this context, improvements in efficiency and rational use of energy should be given priority, with a leading role of industrialized countries. The discussion below briefly summarizes the information on energy efficiency options for the transportation, residential and commercial, and industrial energy sectors, as well as options for alternative energy supply sources.

Transportation

In transportation substantial reduction of the specific consumption of motor vehicles can be realized with advanced engine options, more efficient power transmission systems, advanced vehicle design, adoption of alternative fuels, and electric and hybrid vehicles.

A number of technologies have been demonstrated that could increase automobile fuel efficiency from current levels for new cars (25-33 mpg or 9.4-7.1 liters/100 km) to better than 50 mpg (4.7 liters/100 km) (IEA, Renewable sources of Energy 1987).

Improvements demonstrated on prototype vehicles could increase fuel efficiency even more, as new technologies that are under development become cost effective. The cost-effectiveness of these technologies - and similar ones for diesel trucks and aircraft - is highly dependent on the cost of fuel, which can vary by a factor of three or more, depending on the country.

However, widespread use of higher efficiency vehicles may be hindered by consumer demand for larger cars, engines with higher performance and by an increase in kilometers driven and increased congestion. For this reason, high importance has to be attributed, in addition, to greater use of public transport, increase of the attractiveness of public transport, carpooling and changes in infrastructure to reduce the need of transportation.

Residential and Commercial

Substantial savings can be achieved in the residential and commercial sector by improving energy efficiency of building and building energy conversion equipment, especially when also applied to the building stock. In new houses careful attention has to be paid to the building design, particularly regarding orientation, windows, the building envelope, and the interaction of the various building subsystems. Advanced prototypes and design calculations indicate that new homes could technically be built that use only 10 % of current average energy requirements (15 kJ/m²/degree day) (Goldemberg, 1988).

In existing buildings, gains can be made by insulation and draft exclusion. Special attention deserve also new transparent insulations materials, suitable for an effective insulation of glass roofs, e.g. in industry. More efficient space heating/cooling equipment is relevant to all locations. Retrofitting heat recovery in air conditioning equipment may reduce energy consumption up to over 50 %. Similar savings are also possible by using advanced equipment for electric appliances in buildings, e.g. improved and selective lighting, advanced refrigerators, freezers, and cooling devices etc.

Industrial

In industry, a large number of options and technical possibilities are available to reduce energy requirements and greenhouse gas emissions substantially, e.g. better energy management, improved combustion, energy cascading including cogeneration, waste heat recovery, waste utilization, improved processing, proper adaption of various components, better insulation, improved design of installations, and careful choice of the materials used in production and packing. As an example, it is possible to reduce the energy demand of brewing beer by about 75 % of the present average. The difference between packing beer in a return-bottle or an aluminium can, however, accounts for a difference in specific energy consumption more than ten times higher than the possible savings in the brewing process. Examples of advanced technologies that could contribute to savings in energy are: ceramic composite reactor vessels and heat exchangers; biotechnology and other conversion processes for upgrading industrial wastes to higher value products; stable electrodes for electrolytic processes; new separation technologies such as continuous chromatography, membranes, freeze crystallization, and chemical air separation; new metals, paper, and textile processing technologies; advanced sensors and controls and new high pressure/high temperature cogeneration systems.

Of outstanding importance in industry is an analysis aimed at an overall conception, combining all possible measures. E.g. by analysis, optimization, and restructuring of energy supply and use in a German chemical complex a reduction of energy consumption by 60 % was achieved in spite of an increase of production by 60 %.

Improved Energy Supply Technologies

In the energy supply sector, better technology as combined cycle power plans for electricity generation may reduce the specific energy consumption by more than 20 %. A special emphasis must be given to efficiency when converting and using coal especially by means of coal gasification combined cycle given the high specific and absolute contribution to CO₂ emissions and the role coal is likely to play in developed and developing economies over a foreseeable future.

The possibilities of reducing greenhouse gases by modification of the mix of the present energy sources are limited mainly by their availability and characteristics. The use of natural gas in end use appliances e.g. reduces CO₂ emission. In transportation, LPG and ethanol have a potential to reduce total emissions of greenhouse gases. Methanol from gas and electric vehicles are unlikely to have a significant impact whereas methanol from coal is likely to cause an increase.

Non-fossil fuels offer - besides the use of waste heat - the lowest level of CO₂ emissions. There is an important base of renewable energy resources world-wide. Renewable energy technologies can be designed to produce fuel and generate electricity or heat for many applications. Renewable energy,

especially solar and wind energy, is to be regarded as an energy source with very little environmental impact. Nevertheless, environmental considerations have to be taken into account, especially when using e.g. biomass- and hydropower. In developing countries there are important links between environmental issues and renewable energy sources. Slowing down deforestation is important to reduce global warming, as well, or erosion and water problems. To meet the energy requirements of wide sections of the population in rural areas, particularly those who live outwith the main electricity network, appropriate technological solutions for the use of renewable energy sources can play an important role in the residential, agricultural and commercial sectors. Reforestation/afforestation can, furthermore, increase the net size of the biotic carbon sink and lower the increase of atmospheric CO₂ concentration. The plantation of forests for all purposes, including energy, and the efficient use of bio-energy is crucial.

World-wide, the contribution of nuclear energy to meeting world energy demands continues to grow and nuclear power plays an important role in limiting output of greenhouse gases. A major problem, however, is public acceptance of nuclear power with respect to the inherent risks, some countries having even decided not to use it, to phase it out, or to stop their programs. With respect to the greenhouse gas issue, the possible contribution of Kr-85, connected with the nuclear fuel cycle, needs further clarification.

Regarding emission control options, the removal of CO₂ from the flue gases is theoretically feasible, but, in practice, overwhelming impediments are the high energy intensity, high costs, and potential environmental impacts of the disposal of the resulting waste material. As a result, CO₂ scrubbing and disposal is - perhaps with exception of some less important cases from an overall perspective - not a viable option.

Concerning CH₄, the reduction of leaking and flaring of natural gas is urgent to limit its emissions to the atmosphere. Instead, CH₄ should be captured and burnt productively as a fuel. Capturing and productive burning should also take place at coal mines, oil wells, landfills, manure piles, in feedlot facilities and from sewage treatment plants.

Policy Response Options

The development and widespread implementation of technical options is often dependent on effective government policies. No single policy approach is likely to be both effective and acceptable as means of achieving substantial reductions in greenhouse gas emissions from energy production and use. Strategies appropriate for developing countries, for example, may be quite different from those that are appropriate for the United States or European countries. However, many policy options are available that offer benefits for reducing emissions to all countries. In the short-term, the most effective means of reducing emissions is through strategies that rely on pricing and regulation. In the long-term, policies to increase research and development of new technologies and the enhance markets

through information programs, government purchases, and other means could also make a major contribution.

One direct means of allowing markets to incorporate the risk of climatic change is to assure that the prices of fossil fuels and other sources of greenhouse gases reflect their full social and environmental costs. A drawback of pricing strategies is the difficulty of placing a precise value on many externalities. Where this is the case, more careful research may provide the necessary information. One option is to impose emission fees on these sources according to their relative contribution to global warming. This would create incentives to develop higher efficiency end-use products, such as automobiles and appliances. It would also raise revenues that could finance other programs. An alternative to fees or taxes are subsidies for technologies that reduce or eliminate emissions of greenhouse gases that allow them to compete on an equal footing with conventional technologies.

Regulatory programs complement pricing strategies when externalities are too difficult to measure or changes in prices would conflict with other government policies. Greenhouse gas emissions are already influenced by programs to control air pollution by emission control standards, increase energy efficiency by appliance efficiency standards, and recycle solid waste. Reducing greenhouse gas emissions could be incorporated into the goals of these programs. New programs could focus directly on reducing emissions through requirements such as emissions offsets (e.g., tree-planting), performance standards, or marketable permits. For ways to reduce impacts, regulatory programs that have the effect of increasing greenhouse gas emissions should be reassessed.

Policies often implemented at the local level that could make an important contribution to reducing greenhouse gas emissions include utility regulation, building codes, waste management, transportation planning, and urban forestry. Utility regulation is particularly important both because utilities are a major source of greenhouse gas emissions and there are a range of control mechanisms that can be applied to them. Least-cost utility planning (LCUP) embodies a number of these mechanisms in one policy approach that is gaining wider acceptance in the United States and Europe. One of the primary objectives of LCUP programs is to increase the use of energy efficiency as a low-cost, clean "source" of energy. This is accomplished through appliance rebate programs, energy audit programs, direct installation of energy conserving measures, etc. These programs have significant potential for reducing greenhouse gas emissions, particularly when utilities are allowed to ratebase energy savings and thus profit from reducing energy production.

Over the long term, other emission reduction policies can complement pricing and regulatory strategies. These include redirecting research and development priorities in favor of mitigation technologies, information programs to build understanding of the problems and solutions, and the selective use of government procurement to promote domestic markets for technological alternatives.

International cooperation among the industrialized countries and between the industrialized and developing countries will lead to -- and be necessary for -- the development and implementation of many policy options. These include international fora to exchange information on and promote greenhouse mitigation options; cooperative international R&D and technical assistance programs to further the development and adoptions of specific countries; technology transfer and information dissemination; increased bilateral and multilateral funding programs for greenhouse mitigation efforts; and working with industry to find ways to accelerate deployment of commercial technologies that can limit greenhouse gas emissions.

Constraints on Implementing Options

Every technological and policy option for reducing emissions of greenhouse gases faces some form of constraint to its widespread adoption. Many constraints are likely to impact most countries, such as natural resource constraints, pricing policies, energy security, and large economic commitments to current forms of energy production and use. Some constraints will vary depending on the country, and particularly whether it is an industrialized or developing nation. For the latter, lack of technological sophistication, financial and technical resources, cultural constraints, and competing development goals may be more important.

Industrialized countries as the world's leading consumers of energy and manufactured goods and as the dominating producers of greenhouse gases have the possibilities, the means, and a special responsibility to adopt a leading role towards the reduction of greenhouse gases. There exist, however, mainly non-technological barriers to the widespread adoption and implementation of measures to reduce energy consumption and mitigate the release of greenhouse gases. These barriers may be summarized as follows:

- Insufficient information, especially regarding to individual options, e.g. to save energy, and about the environmental consequences of individual decisions
- Insufficient transparency of markets, e.g. regarding the energy costs of a dwelling or the conditions for industrial cogeneration
- Unfavorable institutional situation, e.g. absence of industrial associations or governmental agencies for the promotion of the rational use of energy and of renewable energies dependance on utilities with specific priorities, insufficient cooperation between authorities
- Financing problems, e.g. limited frames for investments and credits
- High requirements with respect to the return on investment, resulting in market disparities to the disadvantage of the rational use of energy, these requirements being in most

cases for investments of the demand side much higher than on the supply side

- Energy prices and tariffs that do not reflect the long-term marginal costs and do not internalize environmental costs
- Insufficient legal frames that favor the extension of energy supply in comparison to demand oriented measures and policies.

In industrialized countries the problem of environmental damages and their consequences has been widely recognized during the last two decades - although often in a relatively non-specific manner. Despite extensive information about local, international, and global environmental problems and their causes, the majority of citizens in their consumption patterns still aim at maximizing their individual comfort. This attitude is widely reflected by priorities for private investment so that, in consequence, it has to be assumed that in the residential and commercial sector there is still a substantial potential even for economically favorable energy saving measures.

Also in industry it has to be assumed that there is still a substantial potential for economically feasible measures to reduce energy consumption. Besides a lack of information and analysis, especially in medium-size and small facilities, the main barriers are high requirements regarding the return on investment, resulting in a required pay back time for energy installations normally between 2 and 4 years - comparable to requirements for investment in production installations. Energy installations, however, have a substantially longer average service life than production installations. Furthermore, measures to reduce energy consumption should be regarded as being equivalent to emission abatement technologies and having to meet similar criteria.

In developing countries, a primary concern is to rapidly increase energy production to support economic growth. Environmental aspects are, in many cases, regarded as not to be neglected but having minor importance compared with multiple other problems. Energy being a key component for development, these countries can be expected to account for most of the increase in demand for energy in the future. At the same time there is a considerable potential for saving energy in developing countries, and from the outset, growing economies should be given the opportunity of using energy more efficiently. For many reasons, however, management designed to save energy in developing countries may be much more difficult than in industrialized countries. Inadequate pricing plays a significant role here, since it does not give consumers adequate impetus to save energy. If present trend continue, however, energy supply would become a constraint, these countries not being able to afford neither the technologies needed to protect the environment and to save energy nor the high capital costs of supply investments.

Population growth has a major influence on the consumption of resources and the release of greenhouse gases. Limiting population growth is - according to UN-Population-Fund-

especially a problem of the Third World and closely linked to the economic and social situation as a whole, especially medical care and health, information, the social status of women and, above all, the presence of family planning programs.

Furthermore, there are international barriers to be overcome with respect to agreements upon the reduction of greenhouse gases:

- Differences between countries in perceptions of the costs to them with regard to taking no action, adopting limitation policies or adaptation policies
- Differences in ability to action and political priorities between countries
- Some countries doing little or nothing, relying on the rest of the countries to solve the problem
- Detriments for countries with large reserves of fossil fuels when substituting these energies with others.
- Reduction of the scientific uncertainties surrounding climate change
- Lack of information on the costs of technology and policy responses to climate change.

Criteria for Selecting Response Options

The main criterion to be applied when selecting measures is certainly their potential contribution, the cost-effectiveness and economic efficiency of the selected options to mitigating greenhouse gas emissions and limiting global warming. There is a general agreement that, in case of non-action and if present emission trends continue, an anthropogenic rise of global mean temperature could occur in the first half of the next century that would be greater than ever in the history of civilization. This warming would be associated with changes of precipitation distribution, winds, ice covers, ocean currents, and other climate variables, resulting in a rise of sea level, impacts on agricultural systems, forestry, water resources, regional and global ecosystems, public health, disruption of current patterns of human habitation and international economic relationships. Equally important is the complex criterion of sustainability which means meeting the needs of today and not compromising the needs of the next generations. By this definition, sustainability can be understood as a process of permanent adaptation of measures, taking into account various aspects as welfare, security of supply (comprising indigenous fuels, as well as regional distribution of resources, supply and consumption), least possible technical, environmental and health risks, compatibility with resources, economics and affordability.

This is closely linked to the criteria of equity, proportionality and solidarity, which take into account that different sectors of economy and different nations have different responsibilities for

the emergence but also different potentials, possibilities and viable approaches to the solution of a common problem.

Seeing the great reduction potentials for greenhouse gases in industrialized countries, their exploitation could offer the developing countries more space for development, giving them more room to tackle e.g. the problem of deforestation. The Third World should be given a fair chance to develop. However, the possibilities for increasing energy efficiency in an economically more favorable way should not be ignored. The development and selection of technology in and for developing countries should consider the local resource base and be supportive of broad development goals, offer opportunities of cost reductions by the rational use of energy as well as the minimization of negative environmental effects.

There are feasible strategies that could be developed to control greenhouse gas increase in the atmosphere. Given the magnitude of the problem and the high percentages of greenhouse gas reduction, estimated necessary to limit global warming, even drastic measures, covering all sectors, have to be deliberated.

The complexity of the problem and the links between technological, cultural and economic aspects, nevertheless, require a complex and differentiated approach and a thinking in whole systems. As an example, all energy consumers have scope to improve efficiency and choices of various options (fuel, technology), particularly when the capital stock is replaced. In this area, there is a positive role for governments by helping consumers to make more informed choices. Such information programs, however, often need to be run in conjunction with economic and/or regulatory approaches. Achieving significant potentials for energy saving will be extremely difficult without prescriptive measures (including incentives and penalties), information, awareness rising and education playing an important complementary role.

A pragmatic access to the problem of global warming may start with measures that can be judged to be widely accepted and cover multiple objectives. In particular, policies are needed to encourage and enforce energy conservation, to improve efficiency of energy use, to limit long-term commitment to fossil fuels, to develop energy alternatives (especially renewable energies), and to turn trends from deforestation to reforestation/afforestation.

A broad range of options for action have already been proposed in the context of various international activities and are under discussion. An inventory of those measures is attached (see Annex 1). According to the specific national and regional situation, they should be considered and implemented, if suitable, on an national or international basis.

Recommendations

1. The recommendation of the conference "The Changing Atmosphere" at Toronto, regarding CO₂ emissions, could be taken as one basis to formulate quantified objectives for further consideration by the IPCC.
2. With respect to specific situations of and differences between nations and regions, a promising approach seems to be to deliberate a trade-off in response measures for different greenhouse gases and the protection of the biotic carbon sink, bearing in mind the global objectives for emissions of greenhouse gases which may ultimately be agreed upon.
3. Priority should be given to improvements in efficiency and rational use of energy which in the short term are the most promising options to reduce CO₂-emissions.
4. One direct means of allowing markets to incorporate the risk of climatic change is to assure that the prices of fossil fuels and other sources of greenhouse gases reflect their full social and environmental costs. One option for achieving this goal are emissions fees, which should be imposed according to the relative contribution to global warming of each fuel type. This approach has the advantage of raising revenues that can finance other mitigation programs. Another option is to revise tax and incentive structures to allow non-fossil and low pollutant energy sources to compete on a level playing field with fossil fuels.
5. Regulatory programs can be a useful complement to pricing policies. Reducing greenhouse gas emissions could be incorporated into existing programs to reduce other air pollutants. New programs could focus directly on reducing greenhouse gas emissions through requirement such as emissions offsets, performance standards such as a "best-available-technologies" approach, or marketable permits.
6. Progress in reducing greenhouse gas emissions depend not only on technical and economic issues but attitudinal aspects are of the same importance. Therefore increased dissemination of information and better training of personnel, both on the international and national level is needed. Public awareness programs should incorporate the problem of climate change and the relation to individual energy use.
7. There is a need for broad international participation in the efforts underway in the IPCC to identify the elements of a framework convention on climate change and possible follow-up protocols which might be envisioned. Work on the convention should not preclude pursuit of national policies which can help mitigate greenhouse gas emissions, especially those that are justified on other grounds.

8. The goal of economic development and environmental quality should be pursued in a mutually reinforcing manner. The development and selection of technology in and for developing countries should consider the local resource base and be supportive of broad development goals, offer opportunities for cost reductions by the national use of energy as well as the minimization of negative environmental effects.
9. Industrialized countries could put more emphasis on bilateral and multilateral lending for technologies and programs that reduce greenhouse gas emissions in developing countries. Multilateral development banks could be encouraged to redirect their policies toward more lending for energy efficiency and alternative energy technologies, and discourage lending for projects that result in deforestation and increased use of fossil fuels.
10. The establishment of specific programs for energy savings, promotion of renewable energy and transfer of appropriate technology within existing international organizations should be considered.
11. Private Industry, especially multinational industry must be encouraged to play an active role in implementing strategies of reducing energy-related greenhouse gases and protecting tropical forest, especially through the development and distribution of less polluting technologies. The shift of energy-intensive, high pollutant industry from industrialized to developing countries should be avoided.
12. In a long term perspective funding priorities for research, development and demonstration should be increased for technologies that can reduce greenhouse gas emissions.

Annex 1

**INVENTORY OF MEASURES, INSTRUMENTS AND TOOLS
TO MITIGATE GREENHOUSE EFFECT**

Information, Awareness Increasing, Education

- Increased dissemination of information about environmental issues and challenges, e.g. by extended use of mass media, formal and informal education programs, and other means of communication to raise awareness among the general public and decision-makers in the public and private sector
- Information for consumers about energy consumption of goods (including dwellings and buildings), e.g. by energy labelling; working out of principles for energy labelling and of test routines
- Detailed information for the commercial and industrial sectors about the state-of-the-art technologies and their appropriate combinations regarding the reduction of energy consumption
- Enhancing the awareness of the environmental implications of different energy options, in particular with regard to global warming, by providing detailed information, covering the whole fuel cycle, to the general public and decision-makers in the public and private sector
- Better training of personnel in industry and buildings with regard to the rational use of energy and the operation of installations with the best possible emissions
- Increased monitoring of results of conservation measures in order to foster further application, to steer future programs, and to prevent failures
- Better energy systems analysis and improvement of the statistical evidence to assess alternative options according to specific conditions and to develop priorities for action at all levels
- Use of supply/demand scenarios to identify and rank both energy and technology options and to assess their societal cost, emissions and other impacts; support of such studies especially in developing countries
- Support of prompt international transfer and exchange of

information, technology and know-how, e.g. by creating an international data bank of technical economic and environmental information

Institutional Measures/Public Participation

- Scrupulous analysis of decision processes as a basis for action programs to overcome institutional barriers at all levels
- Establishment of energy conservation centers or energy (saving) agencies to make diagnosis, analysis, information, advice, and financing of conservation measures easier accessible and viable to consumers and industry
- Establishment of industrial associations comprising all those engaged in energy conservation (e.g. manufacturers, consultants) to effectively support endeavors in this field from the side of industry
- Establishment of companies contracting the delivery of energy services rather than sources of energy (independent or as part of an utility)
- Establishment of markets for competitive bidding and offering of energy services where offers for enhancing energy efficiency can compete on with investments in new supply facilities
- Extended cooperation with industry to develop and implement technologies that improve energy efficiency, and to set targets in this sector

Planning Processes/Infrastructure

- Development of agreed strategies for reducing emissions of greenhouse gases within a given time-table as a framework condition for planning processes at all levels
- Incorporation of environmental objectives into the planning and development of energy schemes and other infrastructure schemes relevant to energy (land use, community and transportation planning) which is of outstanding importance not only but especially for the Third World whose infrastructure is just developing
- Design and planning of cities (building density, height and orientation, street design) with the aim of promoting less energy-intensive structures and lifestyles
- Giving priority to re-urbanization, constraining outer area development of cities and facilitating growth of inner areas
- Promotion of mass transit as a most efficient mode of transport for people and goods

- Development of less energy-intensive industrial structures and consumption patterns
- Application of least-cost utility planning, internalizing externalities as far as possible, involving the side-by-side evaluation of supply- and demand-side energy resources for meeting energy service needs, taking into account an efficient combination of centralized and decentralized supply structures
- Extended use of resource accounts supplementing traditional national accounts as a planning instrument

Economic Measures (Incentives, Disincentives, Taxation, Pricing)

- Creation of a general economic environment favorable to the conservation and the rational use of energy and promoting the use of non-fossil energy sources
- Examination of international energy markets with respect to real cost pricing, market distortions by subsidies, monopolies etc.
- Further development and use of economic indicators that reflect environmental impacts of production and consumption
- Removal of subsidies for energy production, conversion and consumption as far as they result in a reduction of the costs of energy services
- removal of subsidies tending to maintain energy intensive industrial structures, behaviors and consumption patterns
- Use of financial incentives and aids to encourage development and use of environmental sound technology, conservation, more efficient and rational use of energy, and of alternative energies
- Introduction of improved calculation methods and financing conditions for energy and environmental investments by end-users
- Provision of securities for loans destined at the reduction of energy consumption and the use of alternative energies
- Creation of funding mechanisms for technology transfer and assistance to developing countries (including reforestation/afforestation)
- Development of procedures to ensure that the prices of inputs to industry and of products reflect their environmental costs
- removal of price controls as far as they hamper the

transmission of true price signals to the consumers

- Introduction of prices and tariff structures which convey to the consumer information on long-term marginal costs (including externalities) without leading to windfall profits for the energy supplier
- Ensuring that buy-back rates, paid by the utilities for electricity generated by renewable energies and cogeneration, reflect the avoided long-term marginal costs, including externalities
- Adaption of the level of energy taxation to the aims of the approximation of an internalization of external costs, of the encouragement of the use and development of environmentally more benign forms of energy, and of the reduction of the level of consumption
- Examination of emissions charges, which should be imposed according to the relative contribution to global warming of each fuel type

Regulations, Enforcement Measures

- Definition of areas for government intervention by regulatory measures
- Strengthening of legal means and institutional capacity to ensure compliance with laws, regulations and standards with regard to energy and environment
- Extended use of energy and environmental labelling of products
- Information on energy requirements when selling or letting real estates
- Integrating environmental aspects in to the planning and realization process of measures/investments with major energy related implications
- Strict enforcement of the Polluter Pays Principle
- Definition of emission standards for greenhouse gases wherever possible (e.g. CH₄)
- Development of better design/performance standards for conversion facilities (e.g. power plants), buildings, industrial equipment, end-use devices (e.g. cars, boilers)
- Creation of a legal environment favoring the use of materials and products which cause less environmental impacts (e.g. recycling of materials and packing)

Research and Development/Demonstration

- Exploitation of technical options for low-energy/emission paths
- Enhancement of research, development and demonstration for conservation, efficiency improvements, energy technologies and systems with low emissions of greenhouse gases, and non-fossil fuel options (mainly renewable energies)
- Adaption of new and existing technologies to the needs of developing countries
- Government playing a leading role in demonstration state-of-the-art technologies, reducing their own energy consumption, their emission of greenhouse gases and, doing this, influencing the marketplace

International Cooperation

- Definition of overall reduction targets for greenhouse gases and provision of advice to national governments in formulating national reduction rates
- Exploring international agreements and follow-up conventions and protocols aiming at binding strategies, measures and time schedules
- Creating confidence on the side of developing countries by providing support and advice in the design of low-energy paths
- extended application of the Polluter Pays Principle in a Transboundary context
- Creation of a fund aimed at the reduction of technology/efficiency gaps and of the emission of greenhouse gases in developing countries, funding of measures being bound to the adoption of reduction targets
- Enhancement of international cooperation to shorten lead times, share risks and define market potentials for technologies to save energy and reduce greenhouse gas emissions
- Agreement on principles for sharing the costs of preventing overexploitation and environmental degradation of resources of global interest, such as tropical rain forests
- Agreement on environmental criteria for operations of industries from industrialized countries in developing countries, e.g. with respect to prevent relocation of energy-intensive industries in such countries
- Subjection of international aid to environmental criteria

The Ministerial Conference, organized
by the Minister of Housing, Physical
Planning and Environment of The
Netherlands in cooperation with
UNEP and WMO.

Climate conference secretariat:
P.O. Box 450
2260 MB Leidschendam
Tel. 31 70209367, ext. 2125
Telex nr. 32 362 VROM NL
Telefax nr. 31 70 201858