NON-CO₂ GREENHOUSE GASES: WHY AND HOW TO CONTROL?

NON-CO₂ GREENHOUSE GASES: WHY AND HOW TO CONTROL?

*Proceedings of an International Symposium, Maastricht, The Netherlands,
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PREFACE

The background

This volume contains the proceedings of the first International symposium on "Non-CO₂ Greenhouse Gases: Why and How to Control?" held in Maastricht, The Netherlands from 13-15 December 1993. Of the known greenhouse gases, political attention to date has been primarily focused on carbon dioxide (CO₂) and the CFCs - the latter because of their interaction with stratospheric ozone. The other greenhouse gases, notably methane (CH₄), nitrous oxide (N₂O), HCFCs, HFCs and tropospheric ozone and its precursors nitrogen oxides (NO_x), carbon monoxide (CO) and volatile organic compounds (VOCs), may appear collectively to be of equal importance for global warming but have attracted less attention. Nevertheless, a comprehensive approach to climate change response, taking into account all sources and sinks of all greenhouse gases, is explicitly allowed in the Framework Convention on Climate Change. The Netherlands' policy on climate already addresses all greenhouse gases. In order to stimulate the development of international climate policy on this subject, the Dutch Ministry of Housing, Physical Planning and Environment supported the initiative of organizing an international symposium on the science and policy of the non-CO₂ greenhouse gases. An important rationale behind this initiative was recognizing that for the non-CO₂ greenhouse gases, abatement options are available that do not only address other environmental problems but that also do not require the major structural changes in society that an effective CO₂ policy may.

The Conference was organized by the Society for Clean Air in the Netherlands (CLAN) in cooperation with its sister organizations in Finland, France, Germany, Italy, the United Kingdom and the international bodies FAO, OECD, IGBP and Eurotrac. It was supported by a grant from the European Union and a financial guarantee from the Directorate-General of Environment of the Dutch Ministry of Health, Physical Planning and Environment.

Over 165 scientists, engineers and policy-makers from 29 countries participated in the three-day meeting. The symposium addressed the state-of-the-art for sources and sinks of non-CO₂ greenhouse gases and emission inventories, models and selected features of monitoring systems. In addition, attention was paid to the technological emission abatement options and to effective policies for their implementation. The symposium was closed with the presen-

tation of a conference statement containing the most important conclusions and opinions of the participants.

The results of the symposium have already formed a contribution to the drafting of the International Panel on Climate Change (IPCC) assessment reports, for example, those on radiative forcing and emission inventories. The review papers and the papers from the session on Emission Inventories; Source Strengths and Sinks and on Monitoring and Methodology will also appear in a special issue of the international journal *Environmental Monitoring and Assessment* to be published in August/September 1994.

The content and structure of the programme

To date, relatively few activities have taken place on the subject of non-CO₂ greenhouse gases. It was therefore decided to provide participants to this symposium with a general overview of the contribution of non-CO₂ greenhouse gases to the enhanced greenhouse effect. The programme covered different aspects of the cause-and-effect chain of climate change and the role of non-CO₂ greenhouse gases. However, in several presentations and discussions during the symposium it was brought forward that the discussion should not be limited to global warming alone, i.e. the increase of the global temperature at the Earth's surface. Other global changes such as effects on the local or regional radiation budget, the temperature variation as a function of height, and a global change in atmospheric chemistry and the consequences of this change for concentrations and fluxes of substances in the atmosphere and between, water, soil and vegetation. Finally, the meteorological and environmental effects of the global change should also be taken into account.

The symposium began with review papers on global budgets of greenhouse gases and an overview of

measures to combat the emissions. In his presentation, Professor Paul Crutzen of the Max Planck Institute for Chemistry emphasized the role of ozone as a greenhouse gas, and discussed the large changes in concentrations of ozone and several other greenhouse gases during the last decades.

Kornelis Blok, Utrecht University, showed that not only are a large number of measures to reduce emissions of non-CO₂ greenhouse gases available, but also that they often can be implemented at no or low costs: the emissions of non-CO₂ greenhouse gases could be manageable, at least in industrialized countries.

The conference addressed particularly the following issues:

1. Identification and quantification of sources and sinks on non-CO₂ greenhouse gases

Emissions from a large number of different sources were reported in these presentations. It was shown that although emissions of these gases varied substantially between source types and depended heavily on process conditions, a range of techniques is available to determine the emissions. It was stressed that emission measurements should be carried out in different regions of the world according to their specific sources and sinks.

2. Emission inventories

Presentations on this subject showed that both national emission inventories following national obligations resulting from the Climate Convention are being established as well as global emission inventories for meeting research needs. A report on the methodology of emission inventories prepared by the IPCC/OECD showed that this is a good instrument for comparing emissions from different sources. The need to take natural emissions into account was also expressed in the discussion.

3. Monitoring

An important subject of the presentations and discussions was the incomplete understanding of the changing trends in concentrations of several greenhouse gases in the atmosphere. This stressed the need for improving the global monitoring system, notably for greenhouse gases and short-lived ozone precursors.

4. The chemistry of non-CO₂ greenhouse gases and their contribution to the radiation budget

Because many of the non-CO₂ greenhouse gases and ozone precursors are chemically active in the atmosphere and since these processes are not fully understood, applying a concept such as Global Warming Potential for comparing the contribution of the different gases to radiative forcing and temperature change is hampered. It was acknowledged that assessing the role of non-CO₂ greenhouse gases should not be limited to radiative forcing and a change of the temperature at the surface of the Earth alone, but that radical changes in the chemistry of the atmosphere should be analysed in terms of risks of global change in general. In that respect the depletion of the ozone layer and climate change can be seen as intrinsically coupled.

5. Options for reductions of emissions: policy measures and strategies

In the sessions on this subject both technological, and policy options and strategies, were discussed.

A great number of technological options were claimed to be available for successful implementation. Criteria to evaluate different measures for different gases such as cost-effectiveness, environmental effectiveness, accountability, and uncertainty of climate change were presented. It was recommended that an effective climate policy could best be implemented in a dialogue between scientists, engineers and policy-makers.

Parallel to the sessions of the symposium, a conference statement based on output of the different sessions and building on conference results was prepared. The statement summarizes the main conclusions of the symposium. The background and the procedure of the making of the statement and the conference statement itself are included in this volume.

Epilogue

Recently, a slow-down in the increase of the concentrations of practically all greenhouse gases has been observed. There may be some common factors in the causes, as some participants suggested during the conference. Alternatively, because of the dissimilarity of sources and sinks, also quite different processes in the climate system or human society may have led to this slow-down. This exemplifies the large gaps in our current knowledge and also shows that changes in the concentrations of greenhouse gases in the atmosphere can occur quite rapidly and unexpectedly. As Paul Crutzen stated, "So Nature again has surprised us". This emphasizes the importance of research in finding explanations while, at the same time, policies will need to be implemented to reduce the risks associated with the changing atmosphere.

Delft, Bilthoven, May 1994

Joop van Ham, Leon Janssen, Rob Swart

CONFERENCE STATEMENT

Over 165 scientists, engineers and policy analysts from 29 countries, including developing countries, participated in the Symposium, that was held in Maastricht, The Netherlands from 13-15 December 1993. Information was shared and agreement reached on various aspects of non-CO₂ greenhouse gases.

Addressing the question 'Why to control?' the participants noted the following:

1. In 1992 the Framework Convention on Climate Change (FCCC) was signed in order to address the risks associated with climate change. Its ultimate objective calls for the stabilisation of greenhouse gas concentrations at a level that would prevent dangerous anthropogenic interference with the climate system. The Symposium focused on the role of the non-CO₂ compounds methane, nitrous oxide, halocarbons, tropospheric ozone and sulfur dioxide, and on mitigation options that will help achieve the Convention's objective.
2. Non-CO₂ greenhouse gases contribute now and expectedly in the future significantly to the enhanced greenhouse effect. Through the atmospheric chemistry of these gases, the problems of climate change, tropospheric ozone build-up and stratospheric ozone depletion are intricately connected. The non-CO₂ greenhouse gases and their precursors also contribute to a variety of other environmental problems, including urban air pollution, photochemical smog, acid deposition, groundwater pollution and eutrophication.
3. The recent unexpected slow-down of the growth rate of the concentrations of a number of greenhouse gases shows how little we still know and how rapidly some of these gases respond to changes in emissions and atmospheric conditions. However, without additional policies, emissions of greenhouse gases are expected to grow by a factor of two or more in the next century, due to expected global economic growth and population increase. Under these circumstances, it is likely that the long-term growth of greenhouse gas concentrations will continue.
4. Tropospheric ozone is not emitted, it is formed in the atmosphere due to chemical reactions involving compounds such

as NO_x, CO and VOC, called ozone precursors. The role of tropospheric ozone in climate change is significant. Since the effect of precursor emissions and atmospheric chemical processes on tropospheric ozone levels depend on varying regional atmospheric conditions, it is difficult to predict future global changes in tropospheric ozone concentrations accurately. Both changes in the vertical temperature distribution associated with changes in the ozone profile and the regional distribution of tropospheric ozone are important for climate change.

5. The direct warming effects of CFCs and HCFCs (due to their radiative properties) cannot be simply compared to their indirect cooling effects (due to their depleting effects on the ozone concentration in the lower stratosphere). This is because the direct radiative effects of CFCs and HCFCs are distributed evenly over the globe while their indirect effects on global warming show regional differences in the depletion of the ozone layer, notably in the antarctic and arctic regions.
6. The Montreal Protocol has had a significant effect on the production of regulated CFCs and their atmospheric concentrations. However, CFC-replacements, such as HFCs, may become significant as greenhouse gases in the future.
7. Anthropogenic aerosol particles, in particular sulphates, originating from SO₂ emissions, at least partially offset the enhanced greenhouse effect in certain areas. As aerosol particles have a relatively short lifetime in the atmosphere, this effect is limited regionally and temporally. Emissions reductions, necessary to abate acid deposition, will quickly eliminate this offset.
8. In the FCCC, industrialized countries are requested to aim at returning their greenhouse gas emissions by 2000 to 1990 levels. Stabilisation of emissions represent a first step towards stabilisation of atmospheric concentrations.

Addressing the question 'How to control?' the participants noted the following:

9. Most technological and other options to control carbon dioxide, such as increasing energy efficiency, alternatives to fossil

fuels, and combating deforestation, also contribute to the reduction in emissions of many non-CO₂ greenhouse gases.

10. In addition, a wide variety of options is currently available to control the emissions of non-CO₂ greenhouse gases. Many of these options involve process improvements or emissions control devices, are relatively easy to implement and have other environmental and economic benefits, in addition to reducing interference with the climate system. Agricultural sources of non-CO₂ greenhouse gases are more difficult to control and would require long-term mitigation measures.
11. Despite uncertainties in source strength it is possible to rank different source categories according to their importance at the national level. Subsequently, governments can assess their own opportunities for emissions controls, taking into account least-cost options, environmental benefits and other impacts.
12. Implementation of options for the control of methane emissions, which are economically feasible, is likely to stabilise global methane emissions. Implementation of all options that are technologically feasible could probably at least stabilise atmospheric concentrations of methane.
13. Stabilisation of emissions of nitrous oxide in most industrialized countries appears to be feasible. However, this will not be enough to stabilise global nitrous oxide emissions and concentrations in the coming decades. Population increase and economic growth are likely to provoke an increase in N₂O emissions in developing countries.

The participants recommended the following:

14. Reduction measures for non-CO₂ greenhouse gases that could be implemented immediately, include: strongly reduce methane emissions from fossil fuel production, reduce landfilling of organic wastes and recover landfill gas, improve cattle nutrition in developing countries, control industrial N₂O emission, improve fertilizer efficiency, and promote non-halocarbon substitutes for CFCs.
15. The Guidelines for preparing national inventories of greenhouse gas emissions as currently developed by the IPCC/OECD

form an appropriate format for complying with the reporting requirements of the FCCC. The inclusion of several additional categories of gases, such as HFCs and PFCs, and of natural emissions is desirable.

16. To analyze the regional to global distributions of the concentrations of short-lived non-CO₂ greenhouse gases, notably the vertical profile of tropospheric ozone, the global monitoring system for these gases should be expanded. Currently, monitoring activities are biased towards the industrialized countries in the northern hemisphere. Measurement methods around the world should be harmonized to allow for global comparison. A coordinated effort is supported to establish a truly global system of observations.
17. The symposium identified the following research priorities: 1) to quantify indirect global warming effects of chemically active trace gases, 2) to analyze chemical, physical and biological processes determining the strength of the different sources, 3) to analyze the interacting roles of the non-CO₂ greenhouse gases in climate change and in tropospheric and stratospheric ozone chemistry, 4) further identification and optimization of short and long-term control options in energy, industry, transport and agriculture and 5) to quantify uncertainties in GHG emissions estimations. This research should be carried out in reference to policy issues in order to enhance the dialogue between scientists and decision makers.
18. To apply Global Warming Potentials (GWPs) in integrating climate effects of non-CO₂ greenhouse gases, it is necessary to use best available science in quantifying atmospheric reactivity and radiative potential of these gases. To account fully for their important indirect radiative effects, quantitative assessment of such effects is necessary.
19. To ensure an effective participation of developing countries it is recommended that developed countries promote institutional support as part of capacity building. Notably, developing countries need further assistance to develop their own monitoring and assessment capabilities.

THE CONFERENCE STATEMENT: PROCEDURE AND FOLLOW UP

Procedure

Parallel to the sessions of the symposium a conference statement based on the output of the different sessions was prepared

The procedure for its production was as follows:

- Prior to the symposium, a draft Conference Statement had been prepared by the drafting committee, taking the submitted abstracts into account. This draft statement was submitted to the Scientific Committee.
- The comments of the Scientific Committee were taken into account in the second draft of the statement, which was presented to the participants of the symposium in the opening session.
- The statements in the draft were grouped according to the content of the different symposium sessions. The chairmen of the sessions were asked to report to the drafting committee on the outcome of their sessions with respect to the draft conference statements.
- Also, all participants were asked to deliver their suggestions and comments on the statement to the drafting committee through the symposium secretariat.
- Based on these comments, the drafting committee prepared a third draft on the evening of the second day, which was submitted to the Scientific Committee.
- The comments of the Scientific Committee were entered into the fourth draft, which was distributed to all participants on the morning of the third conference day.
- This version of the statement was discussed during a plenary session on the conference statement chaired by Professor D. Fowler in the afternoon of the third day.
- On the basis of the comments and suggestions of the participants, which were summarized into conclusions by Professor Fowler during the plenary session, the drafting committee produced the fifth and final version of the conference statement. This was handed out to all participants during the closing session of the symposium and is included in this volume.

Evaluation

After the conference the drafting committee evaluated the written material on the conference statement which had been collected during the symposium. There were more than 40 written comments, some of them very extended. Of the many comments made during the plenary session, more than 10 suggestions for entries in the

text were included in the final statement. The drafting committee concludes that many remarks, comments and suggestions contributed - often literally- to the text of the conference statement. Making the statement is concluded to be fruitful to the discussions and opinions on the contribution of non-CO₂ greenhouse gases to the global change issue with the contribution of the participants playing an essential role.

A number of additional recommendations were either voiced during the conference or emerged during the organizers' evaluation of the conference but are not included in the conference statement. These include:

- the necessity of more research to enable an assessment of risks based on an evaluation of uncertainties, feedbacks and potential atmospheric changes; this is important to implementing the precautionary principle in policy development;
- the attention that has to be paid to long-term risks and the associated short-term policy options, for example, in relation to very long-lived gases;
- the recommendation to coordinate research and monitoring programmes well to enhance the effectiveness of both;
- the recommendation to evaluate whether precursors of tropospheric ozone should be addressed by inclusion in the Framework Convention on Climate Change or by extension of agreements on transboundary air pollution;
- the importance of the research and policy question of how to reconcile the need for increased agricultural production with the need for lowering emission factors of (non-CO₂) greenhouse gases;
- different from CO₂ emissions, the emissions of non-CO₂ greenhouse gases depend strongly on process conditions. Therefore intensified research of different systems under varying process conditions is necessary;
- environmental side-effects of policy options have to be evaluated carefully; for example, the increased emissions of N₂O associated with the introduction of catalytic converters.

Follow-up

The conference statement has been sent together with the international Dutch Climate Change Newsletter to 5000 scientists and policy-makers all over the world. It has been made available to all participants and separately to the heads of the delegations at the

ninth meeting of the International Negotiating Committee (INC) last February 1994 in Geneva, which is preparing the first Conference of Parties (CoP) of the Framework Convention of Climate Change (FCCC) to be held in March-April 1995 in Berlin.

The statement has been sent to the IPCC Bureau, to UNEP, WMO and the OECD . The international journals: *IUAPPA Newsletter*, *Staub* and *Clean Air* included the statement in their volumes and similar suggestions have been made to a number of other international journals.

The drafting committee hopes that, in this way, the results of the symposium in Maastricht will stimulate the exchange of information and opinions on the science and policy-making with respect to the role of non-CO₂ greenhouse gases in climate change.

Bilthoven, May 1994

L.J.H.M. Janssen and R.J. Swart

WELCOME

J.J. VERHOOG
President Vereniging LUCHT

On behalf of the Dutch Society "CLEAN AIR" it is my pleasure to welcome you this morning at Maastricht to the international NCGG symposium. Every European citizen knows the name of this city from radio and TV. And everybody here present knows that NCGG stands for

NON-CO₂ GREENHOUSE GASES

WHY and HOW to control? Those are the questions of TO BE OR NOT TO BE.

To begin with: Thank God there is a greenhouse effect. Without the greenhouse effect there would be no life on earth. To put it with the words of the Bible: God created the firmament (our biosphere) on the second day to filter the light of the first day and as a precondition for His work on the third day, the creation of the green vegetation on earth.

The result was a GREEN PEACE garden on EARTH.

The issue which we are dealing with during this symposium is not the greenhouse effect but the ENHANCED GREENHOUSE EFFECT.

Due to the enhanced activities and enhanced consumption of an enhanced number of people we run the RISK of becoming OUT OF BALANCE, compared with the background of natural fluctuations. There are people who fear that the act of God to create mankind on the sixth day cannot be considered as a "NO REGRET" measure.

Scientists have the duty to deal with this subject both as an issue of

- Risk Assessment: The answer to the question WHY to control.
- Risk Management: The answer to the question HOW to control.

And while searching for the answer to those questions the scientific world has to report their findings, their results and their conclusions and to avoid the risk of "jumping to conclusions". Somebody has to carry the message, also in case it would be an unpleasant message. And here are some examples of the unpleasant messages that are spread around by researchers in the field of Environmental & Health Risk Assessment:

STOP smoking, it might be hazardous to your health.
STOP acid rain, it might cause "WALDSTERBEN".

STOP jogging during smog alarm, hopefully an adequate alarm system is in place in your region.

STOP driving your motor car, at least do not use it too frequently and too far away.

STOP DRIVING ME CRAZY with all your bad messages might be the (unwise) reaction from public, press or politicians to all this scientific information (or should we say the reaction to the translation of all this scientific information).

The city of Maastricht has a long history. It is one of the oldest cities of the Netherlands. So probably also in this city - back in the Middle Ages - carriers of bad news might have been killed.

Fortunately our symposium is not held in the Middle Ages. We don't do that anymore in these days. We are too civilized, at least in the scientific world. But a decision to cut financial support for environmental research programs would be a modern - call it civilized - way of killing. Such a decision would be very unwise and who am I to accuse somebody of unwise financial assessment of financial management. Nevertheless the warning has to be given:

DON'T STOP adequate financing of the Research on Climate Change, it might be dangerous to the health of mankind!

Scientists should be able to continue their research and to gather the relevant facts. I said "relevant facts". It is my personal opinion that killing mice by an overdose of UV light to simulate the effect of a hole in the ozone layer is not in anyway relevant at all!

The Research Show must go on. Not to drive us crazy but driven by the right sense of duty.

May this symposium be a contribution to a better understanding of this complex field of research and for a better future for all of us. And may you all enjoy your stay in Maastricht. I am confident that nobody will be killed, regardless the unpleasant messages we have to deal with.

I herewith declare open the NCGG Symposium at the European city of

MAASTRICHT

OPENING ADDRESS

Dr BERT METZ

Deputy Director for Air and Energy

Ministry of Housing, Physical Planning and Environment

P.O.Box 30945, 2500 GX DEN HAAG, The Netherlands

It is a great pleasure to welcome you to Maastricht on behalf of the Dutch Ministry of Housing, Physical Planning and Environment. We are very happy that there is such a broad interest in the issue of the other greenhouse gases.

There is more than CO₂ in the greenhouse! Sometimes we tend to forget this because of all the political commotion around CO₂, in particular in relation to the discussion on the need for a tax on energy. The symposium that is starting today will allow you to explore "the other world" of non-CO₂ greenhouse gases. Under the title "why and how to control?" you will cover the whole spectrum of their contribution to the greenhouse effect: the different gases, their sources, the atmospheric processes that lead to conversion of gases to others, the modelling of these processes, possibilities to control the emissions and policy responses. The "why" seems to be getting much less attention. Maybe because we are all convinced of the necessity to do something about the man-made greenhouse effect.

Why should we control the emissions of greenhouse gases?

So, let us get back for a moment to the question why we should control the emissions of greenhouse gases. Scientist have issued warnings for quite a while that man-made emissions of greenhouse gases are causing substantial changes in the radiative balance of the planet. Although we do not yet have a complete understanding of how all the processes in the atmosphere, the oceans and the biosphere work, it is likely that this will lead to significant changes in the climate over the next 100 years. The exact magnitude and the regional distribution of these changes is not known yet, but serious consequences for food production, ecosystems, health and the economy are possible. This is the picture the 1990 IPCC report paints, supported by the great majority of the scientific community. The message was: if mankind continues on a business as usual basis we face serious risks.

Politics reacted quickly. Rapidly the issue appeared on the political agenda. A couple of political meetings in 1988 and 1989 and

the Second World Climate Conference in 1990 led to a decision of the General Assembly of the UN in the autumn of 1990 to start negotiations on a Climate Convention. During UNCED in June 1992 the UN Framework Convention on Climate Change was signed by more than 150 countries. Many industrialised countries had already started to formulate policies before. So in a couple of years the climate change problem had been accepted as an important issue by governments around the world. As of December 1st 43 countries had ratified the Convention. The 50 ratifications required for entry into force are likely to be reached before the end of this year. That will put the machinery of emission controls for greenhouse gases into motion very soon, starting with the industrialised countries. So if you want a good reason for "why we should control non-CO₂ greenhouse gases" this is a good start: to comply with the Climate Convention!

No regret

What do the obligations for industrialised countries under the Convention mean in terms of the costs for emission controls? There is general agreement that so far only so called "no regret measures" will be required. Energy savings that pay themselves back, recovery of valuable gases from landfills or oil and gas production, reductions of tropospheric ozone precursors to control the smog problem in urban areas, etc. In other words, only those emission controls that would make sense anyway, either because they are profitable or because they are needed to manage other environmental problems. There are many possibilities for such no-regret measures. Much of what is covered in the various sessions of this symposium is basically "no regret".

Beyond "no regret"

It seems we are in good shape. Scientific understanding is gradually growing. The problem has been accepted politically. Measures are being implemented around the world. But what if we need to go a step further than "no regret"? And that is what it will take to gradually get the problem under control. With the Climate Convention commitments we are just about to make the first step in the right direction, the first step of a very long journey. How solid is the political support to make the second step and the third?

Look around. The failure to introduce an energy tax in the US. The endless debate on a European energy/CO₂ tax. Resistance of the business community to the idea of stricter controls of greenhouse gases for competitiveness reasons. The growing lobby of the coal industry against further action. Even in the Netherlands whe-

re support of greenhouse gas reductions has been strong, resistance against further steps is growing. "Old" questions are being raised again by critics: do we really have a climate problem?, can we really say something about the magnitude of the possible changes?, are there not powerful feedback mechanisms that will compensate for the effect of growth of greenhouse gas concentrations? With economies all over the world in bad shape, determination of governments to push for further action is diminishing. Scientific uncertainties are paralysing the decision making process.

Is the ice thick enough?

We have a national hobby in Holland in winter-time: ice skating, at least during periods of cold weather (you will understand now why the Dutch are so eager to fight global warming). You may have seen old paintings or recent photographs of people skating on lakes and canals. When all the water is frozen over, the ice is very inviting. It stretches for miles. But is it reliable to hold you? Or do you run the risk of breaking ice? And is it maybe better to wait a little more before making the skating tour? Is the ice thick enough? That is the crucial question. Is the ice thick enough? That is also the question we need to ask about the political support for further reductions of greenhouse gas emissions. And the answer at this moment unfortunately is: no!

But, you may argue, we have accepted the precautionary principle. It is even written into the Climate Convention. And that principle says that lack of scientific certainty should not be used as a pre-text for not taking action. Unfortunately, this principle does not tell you when the next step has to be made and what that next step should be. It does not tell you whether waiting for stronger evidence of global warming or waiting for new technologies to penetrate the market is acceptable or not. There are many different pathways to control greenhouse gas emissions over a long period of time: a quick start with gradual reductions or a later start with more aggressive reductions using new technologies that will be available in due course. How does the decision maker come to the appropriate solution? How are decisions taken in the light of continuing uncertainties?

The situation we face is indeed full of uncertainties. Science basically tells us that we need to move in a certain direction. It does not tell us where we exactly need to be 100 years from now. It also tells us we are currently heading in the wrong direction. It is as if our ship is heading for Greenland while our destination is somewhere in South America. Even if we don't know what our exact destination in South America is - Caracas in Venezuela or

Buenos Aires in Argentina - the direction our ship has to take is clear. And we better make that turn from Northbound to Southbound. Sooner rather than later. Starting to make the turn is roughly what the obligations under the Climate Convention mean.

A strategy for further action

So how do we find the best route to our destination? What should be our strategy in the short and medium term to get on the right track? A project undertaken in the framework of the Dutch National Research Programme on Climate Change has made an attempt to find such a strategy. Various alternative strategies were explored (see sheet).

The first is : continue on a "no regret" basis. With ongoing technological development and innovation and (possibly) rising energy prices no regret measures will continue to make emission reductions possible. Problem of this strategy: it is likely to be too slow to really control emissions sufficiently.

The second strategy (hitchhiking): make use of measures taken to control other problems such as acid rain, urban air pollution, waste management, traffic congestion, energy security, etc. If actions taken are chosen to contribute to greenhouse gas emission abatement, the problem of uncertainties about climate change is circumvented. Problem with this strategy: it is likely to put not enough restrictions on greenhouse gas emissions.

The third strategy option: aggressive technology development, leading to the breakthrough of clean technologies and renewable energy systems. Japan is more or less practicing this approach with its "New Earth Programme" that has a 100 year time horizon. The philosophy behind the Japanese approach seems to be: the world will need these technologies in the long run and we want to be the (sole?) suppliers. Problem with this strategy: will technological development be rapid enough?

A fourth strategic option that was considered in the project was: lifestyle change. The idea behind this option is that cultural and behavioural changes, motivated by ethical considerations about the need for sustainable development, will be a very powerful (and the only lasting?) driving force to make the necessary cuts in greenhouse gas emissions (as well as appropriate action to address other problems). Weakness of this strategy: cultural and behavioural change is a very slow process.

Least regret

The fifth and last option identified was: "least regret". What do I mean with least regret? It basically is a "balancing act", balancing the risk of climate change (or the risk of inaction) with the risk of being too aggressive with taking action in view of costs or in view of the competition. This approach is also referred to as a "hedging" strategy. It means that if progressive reductions of greenhouse gases will be required, those cuts can be made without big losses or even with some advantage over the competition. At the same time, if required reductions are modest and phased in only gradually, the competitive position of countries/ companies is not seriously affected. Or to put it in a cost perspective: if reductions can be made later using new technology at lower costs and postponement does not increase the risk of climate change it is economically more efficient to do so. The other side of this is to be careful with investment decisions that lock yourself into a certain pattern: a coal fired power plant lasts for 40 years, an automobile oriented transportation system with accompanying infrastructure lasts probably 50- 100 years, houses are built to last more than 100 years. This "lock-in" phenomenon reduces the flexibility to make adjustments when risk information becomes available. The least regret approach also makes it easy to think in terms of "buying insurance" against the risk of climate change by making those investments that will reduce costs of possible sudden adjustments to be made in the future.

The advantage of the least regret approach is that it is familiar to both the private sector and government. Important decisions are always taken in the light of risk minimisation. The risk is then that of unemployment, market changes, currency exchange rates, aggressiveness of foreign powers, etc. And indeed, in the Dutch project I referred to the least regret approach proved to be a good basis for different interest groups to find a common language. Perceptions of risks may still vary, but the concept of balancing risks is shared. The least regret strategy therefore seems to be the most promising one. Elements from the other options can even be integrated easily.

If "least regret" is the approach that can help us to make the appropriate next steps in addressing the emissions of greenhouse gases, what does that mean to the scientific community? What is the message I would like to give you?

Communicate in risk terms

There are two very important points to remember. First, if decision makers will base their decisions on balancing risk, scientists

have to formulate their findings in terms of risk and not in terms of uncertainties. That may seem a minor difference but it is not. If the likelihood of mean global temperature rise over the next 100 years between 1.5 to 4.5 degrees Celsius can be identified as 9 out of 10, that says more than "we think it will be between 1.5 and 4.5 degrees, but we are not certain". Uncertainties tend to have a paralysing effect on decision makers. Postponement of decisions is the natural reflex. Risks, especially serious risks, are more easily seen as challenges that cannot be ignored. Information regarding the costs of measures should also be expressed in risk terms: what is the economic risk of making those investments in the light of the global market place, what are the risks of "locking-in" through business as usual investments? Risks of various problems can also be compared, which will help decision makers to put things in perspective.

The need for dialogue

The second point I want you to keep in mind is the need for dialogue with policy makers, politicians and society in general. If the risk of climate change is to be weighed by decision makers and compared to other risks a brilliant article, a good report, a conference statement or even a broadly supported IPCC assessment will not be enough. Scientists will have to engage themselves in the debate. Explain your knowledge in a way decision makers understand. Try to put yourself in the shoes of the decision maker! You possess the key to better decisions!

With this message to you about thinking in terms of risk and about the importance of dialogue I want to conclude my remarks. I wish you a very productive symposium and a pleasant stay in Maas-tricht. Your work in the coming days can lay the foundation for decisions about the next steps to be taken to address greenhouse gas emissions. And that is what we need.

INTRODUCTION
of
THE EUROPEAN SYMPOSIUM ON ENVIRONMENTAL PROTECTION

Dr L.A. Clarenburg
President TESEP

The strategy of least regret still requires a lot of effort to close the gaps of uncertainties.

1. The idea to bring together european scientists and professionals on selected topics in the field of environmental protection, arose already some years ago, say early 1989. Under the influence of the pending threat to the global radiation balance by a complex mix of trace gases forces, both in the troposphere and in the stratosphere, it seemed wise to unite to cope with the problems in a scientific and technological sense.
2. In Europe there is a vast reservoir of professionals, covering the broad domain of environmental protection. Each of them goes to the national symposium on his/her specific field once a year. And so each year roughly spoken as many symposia as there are countries are being organised on about the same topics, having in common that they are poorly attended. A wasteful situation, and ... not sustainable.
3. If it is already possible to unite tens of millions of European people behind a TV-screen at the occasion of name it whatever European soccer match, it must be easy to unite the European scientists at one, leading European symposium on a well selected topic of their choice. It should be felt as an honour to be offered the opportunity to present a paper there, moreover, people want to go there to listen to and speak to the leading scientist in their field. That is The European Symposium.
4. In Karlsruhe earlier this year the federation named the European Symposium on Environmental Protection was founded, with the principle objective: "to encourage professional activity in Europe in the field of air pollution and environmental protection and related (control) technology and so help to find solutions for European environmental pollution problems timely; ... to foster cooperation among European professional experts and organizations".

In order to further the attainment of the objectives the Federation may:

"develop programmes of scientific and technical symposia on selected topics in the field of air pollution and environmental protection; these topics can be specialised.

The foundation sees it as its task to develop a well coordinated programme of selected topics; it leaves it to the member association to organize the actual symposia, and to take responsibility for it.

5. The symposium we are about to start on Non-CO₂ Greenhouse Gases offers an excellent example of the idea behind TESEP. About 90 highly qualified scientists from 15 different countries will give presentations. Would any association present here would have achieved this at their own. I doubt it. Though I admit to be somewhat biased, still I dare say: look at the great potential for the European Symposium.

So today the first European Symposium starts. The symposium on biological waste gas cleaning, the 3rd of its kind in the cooperation between VDI and CLAN, will be convened in Heidelberg from 9-11 March 1994 and will be the 2nd European Symposium. Tomorrow the Board of the new Federation will meet, and will hopefully establish a programm for the next two years. I am confident that the European Symposium will soon become a Major happening. I wish you a good symposium.