

Report

Targets and Indicators of Climatic Change

edited by

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**The Stockholm Environment Institute
1990**

FOREWORD

This Report is one of four listed below which are devoted to three specific aspects of the issues involved in developing policies for responding to climatic change. They are presented here as useful supporting material, contributing to the process of ongoing work worldwide, especially that being continued via the Intergovernmental Panel on Climate Change (IPCC).

The work itself has grown out of the results of the two-stage Workshop process held in Villach and Bellagio in late 1987. Following a review of the output from this Process in December 1987, the Advisory Group for Greenhouse Gases (AGGG), recommended that it would be timely to address the three topics presented in these Reports and requested terms of reference, which it subsequently approved at the AGGG Meeting in Toronto, in July 1988.

The work has been carried out as an international collaborative effort by a wide range of specialists from various institutes and agencies working together with SEI personnel and co-ordinated by Dr Jill Jäger. I would like to thank all the many participants in the studies, particularly the Chairmen of the working Groups, the individual Report Editors and the reviewers.

On behalf of all the participants, it is a pleasure to acknowledge the advice and encouragement provided by the AGGG and to thank most warmly the former Beijer Institute, the Environmental Defense Fund, especially the Rockefeller Brothers Fund and the SEI for financial support. Additionally, the W. Alton Jones Foundation of the U.S.A. generously helped to defray publication costs.

Finally, my special thanks go to Jill Jäger for undertaking the very onerous task she has completed so successfully.

Stockholm, October 1990

Gordon T. Goodman
Executive Director, SEI

Responding to Climate Change: Tools for Policy Development.
Jill Jäger, Editor. Stockholm 1990. (Summary Report)

Options for Reducing Greenhouse Gas Emissions.
Diane Fisher, Editor. Stockholm 1990.

Targets and Indicators of Climatic Change.
F.R. Rijsberman and R.J. Swart, Editors. Stockholm 1990.

Usable Knowledge for Managing Global Climatic Change.
William C. Clark, Editor. Stockholm 1990.

Ultimately, the choice of objectives will be a product of the political process of negotiation and will depend on perceptions of the severity of the risks, the feasibility of implementing solutions, economic costs, and societal consequences associated with the various alternatives.

The Working Group recommends the use of the following series of indicators of climatic change, and selected quantitative targets for climate policies, in order to protect the structure and functions of vulnerable ecosystems. There are several potentially promising direct indicators of the effects of climatic change on ecosystems, but these require more research and are not yet operational. Instead, it is recommended that targets be specified for the rates and magnitude of temperature change and sea-level rise that will protect both ecosystems as well as human systems.

INDICATOR SEA-LEVEL RISE

- Targets**
- A maximum rate of rise of between **20 and 50 mm per decade**.
 - A maximum sea-level rise of between **0.2 and 0.5 m** above the 1990 global mean sea level.

The lower rate of rise -- 20 mm per decade -- would permit the vast majority of vulnerable ecosystems, such as natural wetlands and coral reefs to adapt. Beyond this rate of rise, damage to ecosystems will rise rapidly. Limiting sea-level rise to a maximum of 0.5 m would prevent the complete destruction of island nations, but would entail large increases in the societal and ecological damage caused by storms. A sea-level rise of 0.2 m would also entail such damage, but at much lower levels.

INDICATOR MEAN GLOBAL TEMPERATURE

- Targets**
- A maximum rate of change in temperature of **0.1 °C per decade**. The rate of temperature change target refers to realized warming.
 - Two absolute temperature targets for committed warming were identified. These limits entail different levels of risk:
 - (i) A maximum temperature increase of **1.0 °C** above pre-industrial global mean temperature.
 - (ii) A maximum temperature increase of **2.0 °C** above pre-industrial global mean temperature.

These two absolute temperature targets have different implications. It is recognized that temperature changes greater than the lower limit may be unavoidable due to greenhouse gases already emitted. The lower target is set on the basis of our understanding of the vulnerability of ecosystems to historical temperature changes. Temperature increases beyond 1.0 °C may elicit rapid, unpredictable, and non-linear responses that could lead to extensive ecosystem damage.

An absolute temperature limit of 2.0 °C can be viewed as an upper limit beyond which the risks of grave damage to ecosystems, and of non-linear responses, are expected to increase rapidly. The concept of dual temperature limits is elucidated in Figure 2.

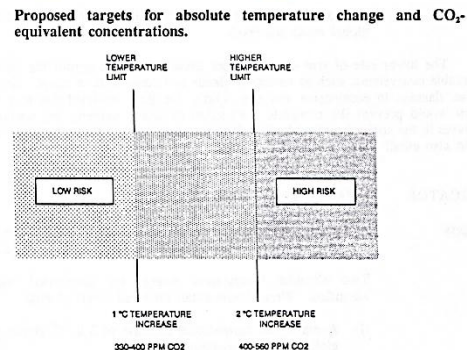
INDICATOR CO₂ CONCENTRATIONS

Targets

Maximum CO₂-equivalent² concentrations of 330 to 400 ppm (for a 4 - 2 °C range of climate sensitivity)³, to stay within the lower temperature limit, according to our estimates with the IMAGE simulation model; or

Maximum CO₂-equivalent concentrations of 400 to 560 ppm (for a 4 - 2 °C range of climate sensitivity, respectively) to stay within the higher temperature limit, according to our estimates with the IMAGE simulation model.

Figure 2: Proposed targets for absolute temperature change and CO₂-equivalent concentrations.

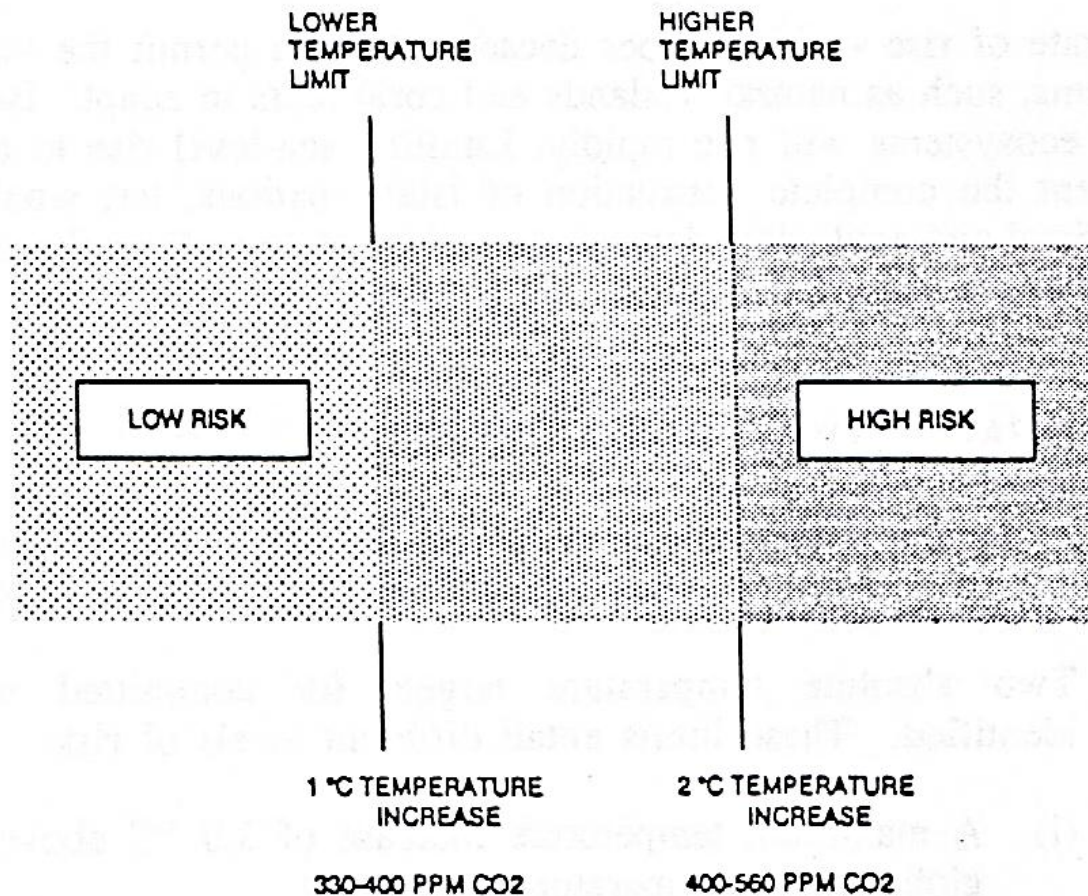


Temperature targets refer to committed warming expressed in global mean temperatures above pre-industrial levels, and concentration targets refer to stabilized CO₂-equivalent concentrations.

² Greenhouse gases differ in their heat-trapping capabilities. A CO₂-equivalent concentration of 400 ppm refers to a combined warming effect from increases in all greenhouse gases that is equal to increasing the concentration of CO₂ alone to 400 ppm.

³ Climate sensitivity is the estimated ultimate change in global temperature resulting from a doubling of the concentration of CO₂ (or other greenhouse gases) over pre-industrial levels. A 2 degree level of sensitivity allows for a greater increase in CO₂ than does a 4 degree level, in order to stay within the target temperature limit.

Proposed targets for absolute temperature change and CO₂-equivalent concentrations.



Varying combinations of concentrations of greenhouse gases --- and consequently varying combinations of emissions --- are possible to meet the same temperature targets; only the ranges of CO₂-equivalent concentrations are shown in Figure 2.

In order to achieve the above targets, detailed analyses are needed of the relationships between the emissions of greenhouse gases, the concentrations of greenhouse gases in the atmosphere, the effect of greenhouse-gas concentrations on temperature, and the relationship between temperature and sea level. Methods and models for determining these relationships are discussed in detail in Section 3 of the detailed report.

Critical Issues

- Although there are still many uncertainties, we believe that the present generation of assessment models makes the target-setting approach feasible for temperature and sea-level rise targets.
- The indicators and targets we can most accurately measure may not reflect the most severe impacts of climatic change. As our ability improves to measure climatic change and impacts, new targets may be identified.
- Targets must be subject to periodic review in light of feedbacks and nonlinearities that may introduce surprises and unexpected changes. Additional indicators may be identified and additional targets may be set to account for these feedbacks and for improvements in our understanding of climate dynamics.
- Policies to achieve these targets will vary from country to country and region to region, and must be subject to international negotiations and agreements.
- Some degree of climatic change appears to be unavoidable because of past emissions of greenhouse gases. We believe that some adverse impacts to ecosystems and human systems will occur even at the lower targets identified here.
- Other stresses, such as from acid precipitation and the depletion of stratospheric ozone will make it difficult to identify the effects of climatic change.
- A standard format for presenting scenario assumptions should be adopted to facilitate the comparison of results of various studies.
- Important scientific uncertainties remain, for example, about the precise relation between greenhouse-gas concentrations and temperature, and the relative importance of the different gases over time. **These uncertainties must not be used as an excuse to avoid adopting policies that would help achieve the**