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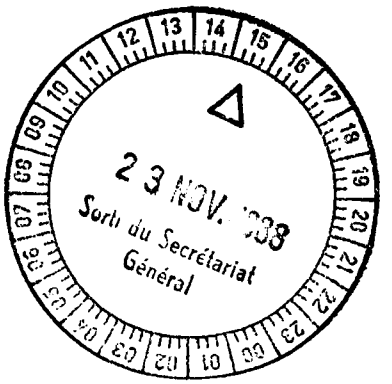
Communication au Conseil

L'EFFET DE SERRE ET LA COMMUNAUTE"

"concernant le programme de travail
de la Commission en matière d'évaluation des options politiques
permettant de faire face aux risques associés à
l'"effet de serre"
et
Projet de
Résolution du Conseil
concernant l'"effet de serre et la Communauté"

(présentés par la Commission)



Projet de Communication de la Commission au Conseil

concernant

"L'EFFET DE SERRE

ET LA COMMUNAUTE"

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RESUME ET CONCLUSIONS

A. RESUME

A.1. Introduction

Le 19 juillet 1988, la Commission a décidé de créer un groupe interservice chargé d'avancer, pour la mi-novembre 1988, des idées préliminaires sur une éventuelle action communautaire contre "l'effet de serre".

Le présent document vise à donner un aperçu général de ce problème et à présenter des conclusions et des recommandations quant aux travaux supplémentaires à entreprendre immédiatement, aux mesures à prendre par priorité et au rôle possible de la Communauté européenne dans le débat international sur ce sujet complexe.

A.2. L'effet de serre

A.2.1. Les conditions climatiques qui prévalent actuellement sur la terre sont régies dans une large mesure par la composition de l'atmosphère.
La vapeur d'eau, le dioxide de carbone (CO_2), le méthane (CH_4), le protoxyde d'azote (N_2O), l'ozone (O_3) et, depuis peu, les CFC, en absorbant une partie du rayonnement infrarouge émis par la terre pour équilibrer le rayonnement solaire, accumulent une partie de ce dernier dans l'atmosphère.

A.2.2. L'homme est en train de modifier, comme jamais auparavant, la composition de l'atmosphère. Les concentrations de tous les gaz entraînant l'effet dit "de serre" augmentent du fait que les cycles biogéochimiques de ces substances sont modifiés par les activités humaines. L'importance de ces modifications est grande en termes de changements climatiques possibles.

Nous savons aujourd'hui que l'équilibre thermique de la terre se modifie et que ces modifications se répercutent inévitablement, en fonction de leur ampleur, sur le climat.

A.2.3. Le principal gaz à effet de serre est le CO_2, dont les émissions sont principalement dues à la combustion de combustibles fossiles (5 gigatonnes de carbonne par an) [1].

Actuellement, le CO_2 est responsable à un peu plus de 50 % de l'effet de serre. Les CFC utilisés dans les aérosols, les contionneurs d'air, les réfrigérateurs, les solvants, les emballages, etc. en sont responsables à 25 %. Les autres coupables sont le méthane (CH_4), dont la production est liée à l'élevage, aux rizières, à l'exploitation du gaz naturel, à la mauvaise combustion de la biomasse et du charbon, le protoxyde d'azote (N_2O) dont la production est liée à la combustion de combustibles fossiles et à l'utilisation d'engrais azotés et l'ozone troposphérique dû aux processus photochimiques dans l'atmosphère polluée. Les émissions de gaz entraînant un effet de serre ont augmenté de manière significative au cours des dernières années.

A.2.4. Les résultats des modèles climatiques globaux permettent de conclure qu'un doublement de la concentration préindustrielle équivalenté des gaz entraînant un effet de serre provoquera une augmentation de l'ordre de 1,5 à 4,5° C de la température moyenne de la surface de la terre. Vu l'évolution actuelle, ce phénomène devrait se produire d'ici à 2050.

A.2.5. Les modèles climatiques actuels ne permettent pas de procéder à une évaluation régionale fiable des modifications climatiques potentielles correspondant à l'augmentation moyenne précitée de la température en surface. Des évaluations approximatives montrent qu'en Europe, l'augmentation de la température pourrait être plus importante que dans le reste du monde.

A.2.6. Les conséquences indirectes de ces modifications climatiques pourraient être résumées comme suit :

- une élévation du niveau des mers (de 30 cm à 1,5 m pour un réchauffement de l'ordre de 1,5 à 4,5°C);
- une fonte des banquises;

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[1] 1 gigatonne = 10^9 tonnes = 1.000 millions de tonnes.

- une diminution des ressources hydriques de certaines régions;
- des modifications de la productivité agricole;
- une incidence sur la santé humaine et sur l'écologie.

A.3. Cadre international et perspectives

A.3.1. Un consensus scientifique sur les éléments de base de l'effet de serre tels qu'ils ont été décrits dans le paragraphe ci-dessus a été atteint lors de la "conférence internationale sur l'évaluation et le rôle du CO_2 et des autres gaz entraînant un effet de serre dans les variations climatiques et leurs effets corollaires (Villach, 9-15 octobre 1985).

A.3.2. Les conclusions de la conférence de Villach ont été développées lors d'un symposium CEE à Bruxelles (3-5 novembre 1986) sur "le CO_2 et les autres gaz à effet de serre : effets climatiques et autres" et lors d'un atelier à Villach (28 septembre - 2 octobre 1987) et d'un autre atelier à Bellagio (9-13 novembre 1987) sur "la définition de mesures permettant de faire face à la modification du climat".

A.3.3. L'effet de serre a également été étudié dans le cadre des travaux de la Commission Brundtland. Faisant suite aux recommandations de cette commission, une conférence mondiale sur "les modifications de l'atmosphère" et implications pour la sécurité globale a été tenue à Toronto (27-30 juin 1988). Les actions suivantes ont été recommandées :

- Ratifier le protocole de Montréal sur les substances qui réduisent la couche d'ozone. Le protocole devrait être revu en 1990 en vue d'assurer une élimination presque totale des émissions de CFC entièrement halogénés d'ici à l'an 2000.
- Mettre en oeuvre des mesures de politique énergétique visant à diminuer les émissions de CO_2 et des autres gaz à l'état de traces et, partant, à réduire les risques de réchauffement global.
- Fixer comme objectif initial global pour les pays industrialisés une réduction d'environ 20 % des émissions de CO_2 entre 1988 et 2005.
- Fixer des objectifs relatifs à l'amélioration de l'efficacité énergétique qui soient directement corrélés à une réduction du CO_2 et des autres gaz à effet de serre.
- Entamer les préparatifs d'une vaste convention globale.

- Créer un fonds mondial de l'atmosphère.

A.3.4. A court terme, ces actions internationales pourraient déboucher sur l'ouverture déjà en 1989 du processus visant la préparation d'un accord concernant l'effet de serre et, à plus longue échéance, sur la mise au point de protocoles limitant les émissions de gaz à effet de serre.

A.3.5. Les prochaines étapes essentielles pour la réalisation de cet accord seront probablement :

- l'atelier international en matière de législation et de politique qui se tiendra à Ottawa au début de 1989;
- une conférence politique à haut niveau qui sera organisée en automne 1989 par le ministère néerlandais de l'environnement;
- la deuxième conférence mondiale sur le climat qui se tiendra à Genève en juin 1990;
- la conférence intergouvernementale sur un développement soutenable qui aura lieu en 1992 et pourrait être le point cluminant de cette série de manifestations.

A.4. Actions possibles

A.4.1. Les stratégies de lutte contre l'effet de serre pourraient inclure des actions de prévention et/ou d'adaptation.

A.4.2. L'action de prévention est celle qui vise à réduire les émissions de gaz à effet de serre et, partant, leurs effets prévisibles.

Dans le cas du CO_2, les domaines d'action les plus concernés sont le secteur énergétique en général et le secteur forestier des régions tropicales.

Voici quelques exemples de mesures énergétiques susceptibles de contribuer à réduire les émissions de CO_2 :

- amélioration de l'efficacité énergétique (au niveau tant de la demande que de l'offre);
- utilisation de combustibles dégageant moins de carbone;

- promotion des sources d'énergie renouvelables et de l'utilisation soutenable de la biomasse;
- promotion de l'énergie nucléaire assortie de toutes garanties de sécurité.

Dans ce contexte, le développement de techniques énergétiques innovatrices permettant de mettre en oeuvre de telles mesures revêt une grande importance.

A long terme, de nouveaux sytèmes énergétiques non basés sur le carbone pourraient contribuer de manière significative à la réduction des émissions de CO_2.

Toutes les mesures susmentionnées ne sont certes pas également efficaces. De plus, leur viabilité économique devra être soigneusement évaluée.

En matière de politique forestière, il conviendrait de renverser les tendances actuelles à la déforestation, notamment dans les régions équatoriales. Pour ce faire, il faudrait promouvoir, d'une part des produits de substitution du bois, massivement utilisé comme combustible dans ces régions, d'autre part des pratiques agricoles soutenables ne subordonnant pas le développement agricole à l'incendie de larges pans de forêt.

A.4.3. Les actions qui permettraient de réduire les émissions de gaz tels que le CH_4 et le N_2O sont moins faciles à identifier, vu les incertitudes liées aux émissions de ces substances.

Les propositions suivantes pourraient être étudiées :

- Minimisation de la quantité de CH_4 dégagée lors de l'extraction, du transport et de l'utilisation du gaz naturel;
- minimisation de la quantité de CH_4 dégagée par les décharges;
- minimisation des émissions de N_2O liées à la combustion de combustibles fossiles;
- étude des modifications qui pourraient être apportées à la gestion du bétail, à la culture du riz et à la gestion des lagunes, en vue de réduire les rejets de CH_4;

- étude des modifications qui pourraient être apportées aux techniques de fertilisation en vue de réduire les réjets de N_2O liés à l'utilisation d'engrais azotés.

A.4.4. En ce qui concerne les CFC, il devrait être possible d'éliminer complètement leurs émissions d'ici à l'an 2000 en interdisant leur production et en recapturant, recyclant ou détruisant ceux qui se trouvent dans les produits existants.

A.4.5. Des mesures d'adaptation (visant à prévenir ou à réduire les effets négatifs des modifications climatiques et des phénomènes corrolaires) pourraient s'imposer en vue de contrer les effets qui, en dépit des actions de prévention, s'avéreraient inévitables.

A ce stade, il n'est pas possible de détailler les mesures d'adaptation qui pourraient être nécessaires dans la Communauté vu l'absence d'une évaluation régionale fiable de ces effets potentiels.

D'une manière générale, les mesures d'adaptation à la hausse du niveau des mers pourraient comporter la construction de digues de mer/barrières contre les inondations, la mise en place de programmes nationaux d'assurance contre les inondations, la construction de réservoirs (en vue de combattre l'augmentation de la salinité), l'abandon des terres basses exploitées, le transfert des populations loin des sites vulnérables, la protection des écosystèmes côtiers.

Des études supplémentaires devront être menées pour identifier les mesures d'adaptations qui pourraient être prises dans d'autres secteurs agricole et sylvicole.

B. CONCLUSIONS CONCERNANT L'ETAT DES CONNAISSANCES AU SUJET DE L'EFFET DE SERRE

B.1. La composition de l'atmosphère terrestre est modifiée de manière significative par les activités humaines.

Se fondant sur les résultats de modèles climatiques globaux, les scientifiques sont d'accord pour affirmer qu'un doublement de la concentration préindustrielle équivalenté de CO_2 dans l'atmosphère

fera augmenter de 1,5 à 4,5°C la température moyenne de la surface de la terre. Un tel doublement devrait être atteint endéans la première moitié du siècle prochain.

Selon ces modèles, les modifications qui affecteront les conditions climatiques globales moyennes dépasseront "ce qui s'est passé au cours des temps historiques et des périodes géologiques récentes".

B.2. Les différents effets de ces changements climatiques et leurs conséquences socio-économiques ne peuvent être évalués de manière détaillée et fiable à l'heure actuelle. Toutefois, les travaux préliminaires menés en la matière montrent que les risques sont dangereusement élevés et que les conséquences directes et indirectes probables peuvent être catastrophiques.

B.3. De récents événements internationaux ont introduit un facteur d'urgence dans le débat mondial en la matière. Il est apparu clairement qu'il était grand temps d'élaborer des stratégies viables et d'accélérer les efforts de recherche.

C. CONCLUSIONS DE LA COMMISSION

C.0. Les principales conclusions du présent rapport sont résumées ci-dessous. Une présentation complète en est donnée au chapitre IV.

C.1. La Communauté devrait mettre pleinement en oeuvre la convention de Vienne sur la protection de la couche d'ozone ainsi que le protocole de Montréal sur les substances qui réduisent la couche d'ozone et devrait participer activement à la renégociation de ce protocole.

C.2. La Communauté devrait approuver l'ouverture de discussions sur un éventuel accord international en matière de protection de l'atmosphère. Elle devrait être prête à participer activement à la préparation et à la négociation d'un tel accord qui pourrait fixer des objectis spécifiques de limitation des émissions incriminées et définir des mesures et des programmes de réduction de ces émissions.

C.3. La Commission devrait donc se décider à lancer, dans les plus brefs délais, un vaste programme d'étude visant à évaluer la faisablité, les coûts et les résultats probables des mesures éventuelles de limitation des émissions de gaz à effet de serre.

Les principaux secteurs de ce programme devraient être :

- l'identification et l'évaluation technique des mesures et technologies capables de réduire les émissions des gaz à effet de serre;

- l'analyse des conséquences économiques, industrielles, énergétiques, sociales et institutionnelles des mesures et technologies précitées;

- l'établissement et l'évaluation de scénarios, sur la base, notamment, des objectifs stratégiques possibles pour le plafonnement des émissions de CO_2 ;

- l'établissement d'un cadre d'analyse de décision;

- l'identification et l'évaluation de mesures d'adaptation.

C.4. La Communauté et ses Etats membres devraient désormais tenir compte dans leurs décisions politiques en matière de politique énergétique ou dans d'autres secteurs concernés) des changements climatiques potentiels liés à l'effet de serre. Ce faisant, ils éviteront des coûts plus élevés à l'avenir.

C.5. De plus, une action immédiate devrait être lancée en vue de renforcer et d'amplifier les efforts visant à économiser l'énergie, à améliorer son efficacité, à developper de nouvelles sources énergétiques et à développer l'utilisation de l'énergie nucléaire avec toutes les garanties de sécurité. Une grande priorité devrait être accordée au développement et à la promotion accélérées des technologies innovatives à l'échelle commerciale dans ces domaines. Une telle action se justifie pleinement du point de vue tant énergétique qu'environnemental, quelles que soient les incertitudes liées à certains aspects scientifiques de l'effet de serre. Il

serait particulièrement important de pouvoir quantifier les améliorations de l'efficacité énergétique en termes de réduction des émissions de CO_2.

C.6. La Communauté devrait soutenir de vigoureux programmes de recherche sur tous les aspects de l'effet de serre et devrait promouvoir de nouvelles technologies énergétiques pouvant limiter les émissions de CO_2.

I. AN INTRODUCTION TO THE GREENHOUSE ISSUE

What the "greenhouse effect" is in short

1. The climate conditions we experience on earth are due, among other things, to the presence of the atmosphere around it and to its present composition. Without the atmosphere, the average surface temperature of the earth, which is presently of around 15°C, would be as low as -18°C.

   In fact, the heat balance of the earth, which receives radiation from the sun and reflects or re-emits it into the space, is largely governed by the composition of the atmosphere.

   Firstly water vapour, mostly concentrated in the lower atmosphere, is an effective absorber of both incoming solar and outgoing infrared earth's radiation and contributes very significantly to determine the average surface temperature of the earth.
   Moreover, other substances such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and chlorofluorocarbons (CFCs) have the property of being nearly transparent to incoming radiation from the sun but to retain some of the energy re-emitted by the earth as long wavelenght infra-red radiation.

   Ozone also contributes to the absorption of infra-red radiation emitted by the earth.(1)
   The overall outcome of this mechanism is that part of the radiant energy coming from the sun is trapped in the lower atmosphere.

2. The present scientific knowledge allows us to conclude that any significant change in the atmospheric concentrations of the above mentioned substances would result in a change of the global thermal balance of the earth.

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(1) Stratospheric ozone (the "ozone layer") is a strong absorber of ultraviolet radiation from the sun. Moreover ozone contributes to the absorption of infrared radiation from the earth. Tropospheric ozone contributes therefore to trap heat in the lower atmosphere. Any change in the vertical distribution of ozone would contribute to affect the thermal balance of the earth.

In particular an increase in the atmospheric concentrations of CO_2, CFCs, CH_4, N_2O, tropospheric ozone, which are often called "greenhouse gases", would result in more heat to be trapped in the lower troposphere and then in some warming and possible associated climate changes depending on the size of such greenhouse gases concentration increase. This phenomenon is usually referred to as the "greenhouse effect" because its basic mechanism is similar to that in a greenhouse where incoming radiation energy from the sun is partly transformed to infrared radiation by the ground, warms the air and is then retained by the glass from escaping again.

Greenhouse gases : emission sources and atmospheric concentration trends

3. The atmospheric concentrations of all most important greenhouse gases have increased over recent times and are still increasing.

4. In case of carbon dioxide (CO_2) :

   a. Emission sources :

   Most of anthropogenic CO_2 emissions are due to fossil fuels burning (around 5 Gtons* of carbon per year). Moreover a significant contribution comes from burning of wood and decomposition of biomass related to deforestation (uncertain quantity, most likely in the range 0,5 - 2 Gtons of carbon per year corresponding to a rate of deforestation in the tropical regions of 10 to 20 millions ha/y).

   CO_2 world yearly emissions from burning of fossil fuels have increased in 25 years, since 1960, from around 2,5 Gt of carbon to more than 5 Gt of carbon in 1985.

   Coal and oil give by now an almost equal contribution to emission with slightly more than 2 Gt of carbon each, followed by gas with less than 1 Gt of carbon per year.

   It is estimated that since one century, around 170 Gt of carbon have been emitted, of which around 100 Gt in the last 25 years.

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* 1 Gton = 10^9 tons = 1000 million tons

The share of CO_2 emissions per year from fossil fuels for different parts of the world and its recent evolution is showed in the following table :

CO_2 emissions in million tons of carbon/y
and as % of world total

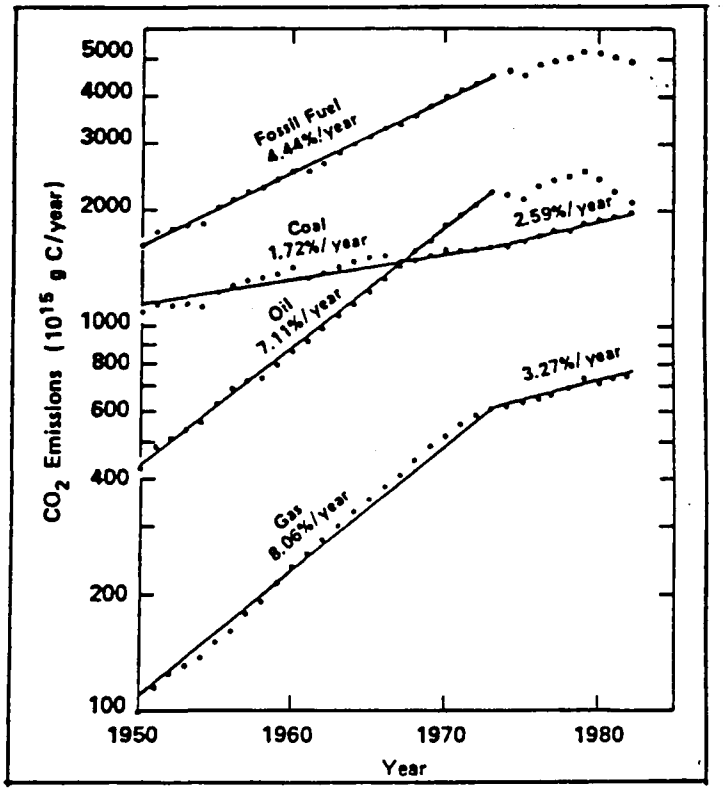
	1950		1965		1980	
Region	Mt/y*	%	Mt/y*	%	Mt/y*	%
North America	723	44,7	1003	32,1	1380	26,7
URSS and Eastern Europe	291	18,0	750	24,0	1251	24,2
China	23	1,4	178	5,7	439	8,5
Western Europe	379	23,4	643	20,6	853	16,5
Japan, Australia	45	2,8	137	4,4	300	5,8
Developing Countries	92	5,7	250	8,0	631	12,2
Others (worldwide gas flaring, bunkers)	63	3,9	163	5,2	310	6,0
World total	1618	100	3126	100	5170	100

Source : "Atmosphere carbon dioxide and the global carbon cycle"
US DOE/ER-0239, edited by J.R. Trabalka, Dec. 1985

* absolute figures are rounded to next million ton.

The figures above show the dramatic increase of CO_2 emissions in all regions of the world from 1950 to 1980.
The share of the total world emissions of China and developing countries has significantly increased in the same period due i.a. to the demographic trends in these regions.

The trends of CO_2 world emission from different fossil fuels for the period 1950-1982 are shown in next figure. (source : US DOE/ER-0239 report referred to above) :



The steep increase of yearly CO_2 emissions from oil and natural gas has been slowed down or even reversed after the first oil crisis, thus reflecting the worldwide energy policy efforts to restrict the use of oil, by improvements in energy efficiency and an increased use of nuclear energy and/or solid fuels. Consequently CO_2 emissions from coal have increased after the first oil shock, from a yearly rate of 1,72% to 2,59% up to 1982.

Emission data for 1985 show the following contribution from various fossil fuels :

Fuel	1985 CO_2 emissions in million tons carbon/y
gas	807
oil	2189
coal	2181
gas flaring	52
Total	5229

Source : I. Mintzer, WRI, 1988

Per capita CO_2 emissions from fossil fuels for different countries are shown in the following table, referred to 1982 :

Country	Per capita CO_2 emissions (tons of carbon per inhabitant)
United States	4,9
German Dem. Rep.	4,9
Canada	4,4
Czechoslovakia	4,1
Australia	3,9
Soviet Union	3,3
Poland	3,0
Belgium	3,0
Germany, Fed. Rep.	2,9
United Kingdom	2,5
Netherlands	2,5
France	2,0
Japan	1,9
Italy	1,5
Spain	1,4
China	0,5
Brazil	0,3
India	0,1
World average	1,0

Calculated from : Smith, I.M. (1988) : CO_2 and climate change; Draft technical review, EIA Coal Research, London, and UN statistical data

b. Atmospheric concentrations trends :

Since 1960 to 1985 the average yearly atmospheric concentration of CO_2 has increased from 315 to 345 ppm.*
There is evidence that the pre-industrial concentration of this gas was around 275-285 ppm. The rate of concentration increase for CO_2 has accelerated in recent years : it was an average of 1 ppm per year in the 70ties and is by now about 1,5 ppm per year.

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* 1 ppm = part per million = 0,0001%

CO_2 concentration increase is determined by the effect of manmade emissions, mostly due to fossil fuel burning and deforestation, on the global carbon cycle : natural carbon sinks (mainly the oceans and vegetation) are no longer sufficient to balance such increasing emissions and this leads to more CO_2 stored in the atmosphere.

5. In case of chlorofluorocarbons (CFC's) :

a. Emissions sources :

CFC's are man-made chemicals used in a variety of applications such as aerosol spray cans, air conditioning, refrigerators, solvents, packaging, etc.

b. Atmospheric concentration trends

The atmospheric concentration of CFC-11 and CFC-12 at four sites widely dispersed in the world ranged from 0,21 to 0,23 ppb* and 0,37 to 0,39 ppb respectively in 1985.

Even if the present atmospheric concentration of these substances is by several orders of magnitude lower than that of CO_2, one has to note that the rate of growth of such concentration has been much higher than that of CO_2, around 5-7% per year, the efficiency in trapping heat of some of them is 10,000 higher than CO_2' on a molecule by molecule basis and the residence time in the atmosphere of some of these substances is extremely long (up to more than 100 years).

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* 1 ppb = part per billion = 0,0000001%

6. In case of methane (CH_4) :

a. Emission sources :

Present man-made emissions of CH_4 come mainly from livestock, rice paddy fields, natural gas exploitation, burning of biomass and coal. Natural emissions from biota are also relevant and the overall CH_4 cycle is not well known.

Rough estimates give the following emission levels for the various sources (expressed in million tons; the range indicated in brackets shows the dispersion of estimates made by various authors) :

Natural Sources (million tons per year) :

Enteric fermentation (wild animals)	5 (+/- 3)
Wetlands (swamps, etc.)	110 (+/- 50)
Lakes	4 (+/- 2)
Tundra	3 (+/- 2)
Oceans	10 (+/- 3)
Termites and other insects	25 (+/- 20)
Other	40 (+/- 40)

Man-Made Sources (million tons per year) :

Enteric fermentation (cattle, etc.)	75 (+/- 35)
Rice paddies	70 (+/- 30)
Biomass burning	70 (+/- 40)
Natural gas and mining losses	50 (+/- 25)
Solid Waste	30 (+/- 30)

(Source : US Dept. of Energy - "A Primer on Greenhouse Gases" - DOE/NBB0083 - March 88.)

b. Atmospheric concentration trends :

Atmospheric concentration of CH_4 has increased since old times (from 0,7 ppm before 1700 A.D. to 1,54 and 1,68 ppm in the southern and northern hemisphere respectively, in 1983). Average yearly increase over 30 years from 1951 to 1981 has been of 1,1%.

7. In case of nitrous oxide (N_2O) :

a. Emission sources :

Man-made emissions of N_2O are mainly due to combustion of fossil fuels and biomass. Agricultural soils (both natural and fertilized) seem also to give a significant contribution.
Natural emissions are due to terrestrial and ocean biota.

Again the quantitative evaluation of emissions from various sources is most difficult. It is estimated that the overall emissions are as follows (expressed in million tons; the range indicated in brackets shows the dispersion of estimates made by various authors) :

Natural Sources (million tons of N per year) :

Oceans and estuaries	2.0 (+/- 1.0)
Natural soils	6.5 (+/- 3.5)

Man-Made Sources (million tons of N per year) :

Fossil fuel combustion	4.0 (+/- 1.0)
Biomass burning	0.7 (+/- 0.2)
Fertilized soils	0.8 (+/- 0.2)
Cultivated natural soils	1.5 (+/- 0.5)

(Source : US Dept. of Energy - "A Primer on Greenhouse Gases" - DOE/NBB0083 - March 88.)

b. Atmospheric concentration trends :

N_2O atmospheric concentration has increased from a pre-industrial 290 ppb to about 300 ppb in 1985. The present rate of increase is around 0,25% per year.

8. It is to be underlined that the present increase in concentration of greenhouse gases is due to the interference of human activities with the natural cycles. Yet there are significant uncertainties concerning the quantitative relationships between emissions of greenhouse gases and the observed increase of their atmospheric concentrations.

9. Moreover it is not possible at this stage to give reliable forecasts of future emission trends because of the wide range of factors influencing those trends. However scenarios may be developed using different assumptions.

10. It is reasonable to expect further and accelerating increase in the atmospheric concentrations of some greenhouse gases over the next 50 years.

Potential climate consequences of increasing greenhouse gases concentrations

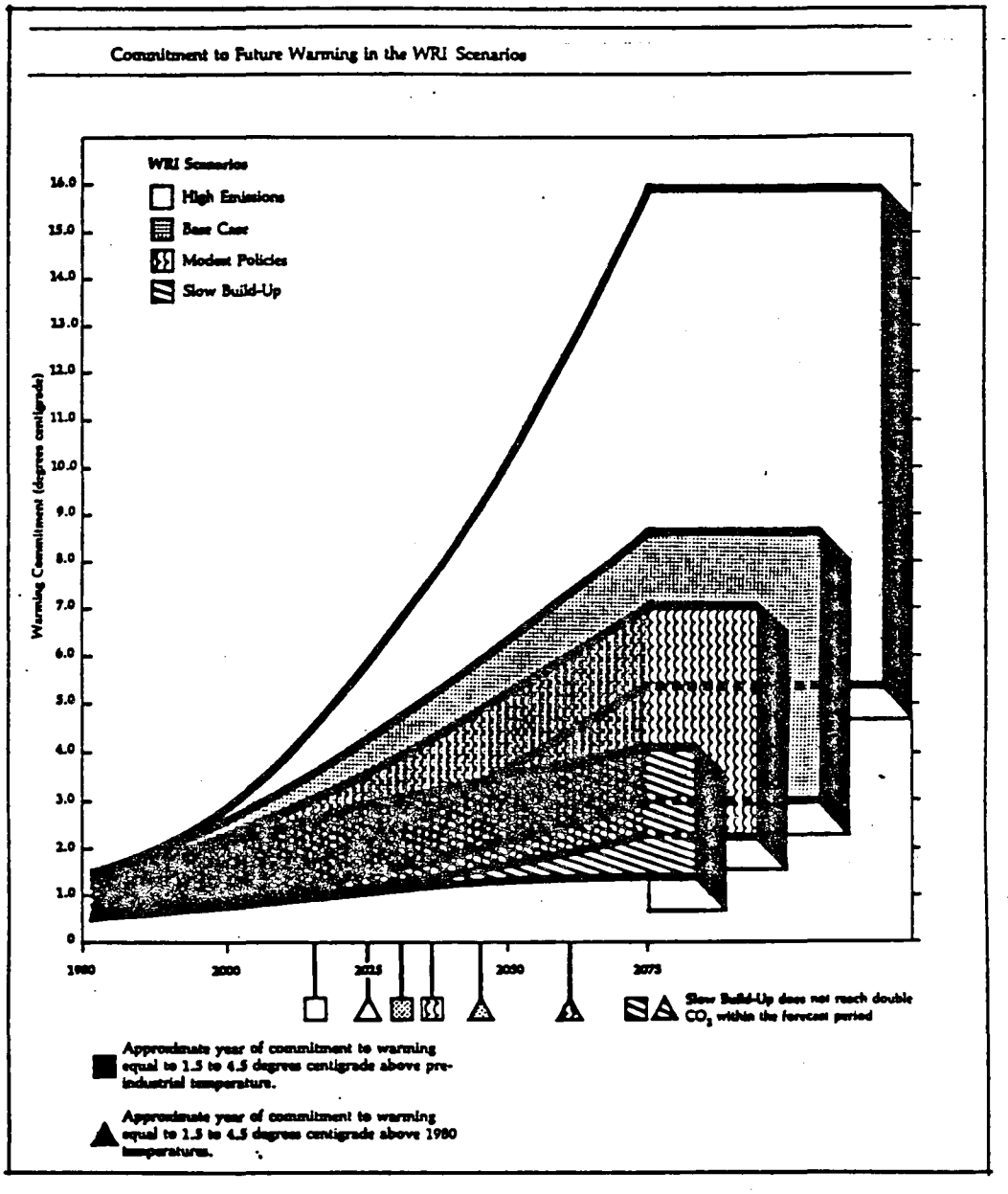
11. The observed and the expected increases in atmospheric concentrations of greenhouse gases (and then the increase in the heat quantity which is trapped in the lower atmosphere) undoubtedly will result in some warming and possible associated climate changes.
However, very significant uncertainties subsist about the shape and the rate of such climate changes and in particular about the degree of the warming and its timing.
From this point of view, uncertainties about the potential role of climatic feedbacks due to clouds, vegetation etc. are particularly relevant.
It is estimated that the different greenhouse gases contribute at present to the overall greenhouse forcing roughly in the following proportion : 55% for CO_2, 25% for CFC's, 20% for CH_4, N_2O and O_3 together.

The possible development of the overall greenhouse effect of the above mentioned gases until the year 2075 has been tentatively evaluated by the World Resources Institute in terms of forecasts for the average warming commitment with reference to 4 scenarios encompassing hypotheses about future developments from "do nothing" and high growth to voluntaristic emission reduction policies.

The hypotheses on which this exercise has been based are presented at page 23.
It should be underlined that it has not been taken account here of the likely positive consequences of the recent Montreal protocol on CFC's. The WRI study gives only a very limited role to nuclear energy in all scenarios. In none of the scenarios mentioned, the share of nuclear in total primary energy supply exceeds 4.5% by 2025. In other studies this share is much higher, for example, IIASA = 23%, WEC (83) = 13%, Goldenberg = 7%, Edmons = 19%. The Commission's own energy 2000 study sees the share of nuclear in world energy supplies as follows : 1983 = 3.3%, 1990 = 5.4%, 2000 = 7.1%. Environmental costs for nuclear range from $7.5 to $10/GJ whereas those for coal are between $0.15 and $1.20/GJ. In the case of oil $0.00 to $0.75/GJ. No environmental cost is assigned to renewable energies.

This model as any other one suffers from both structural and input data limitations. However the usefulness of such models is to help structuring the policy debate on such a complex issue and to identify critical areas for further research and study.

The results are summarized in next figure.

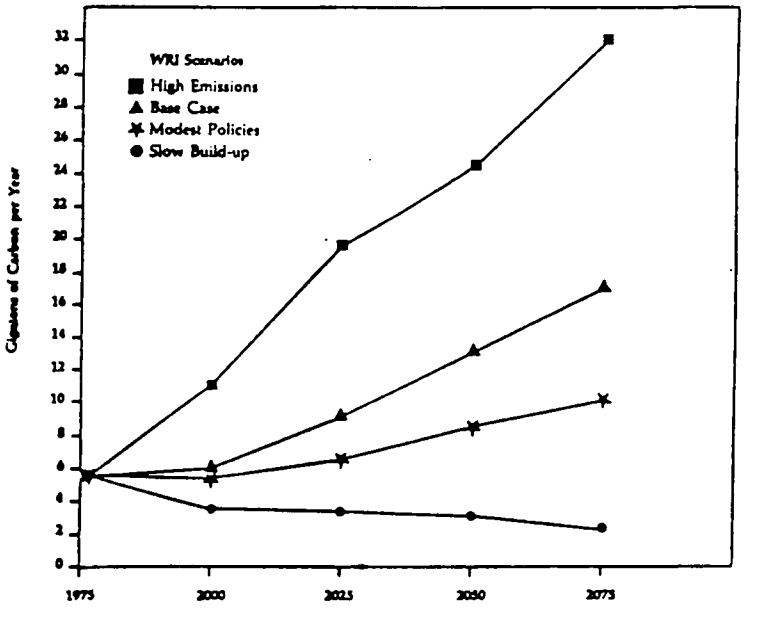


Source : Mintzer I.M. (1987); "A Matter of Degrees,
WRI, Washington DC, USA

Energy Policies in the WRI Scenarios

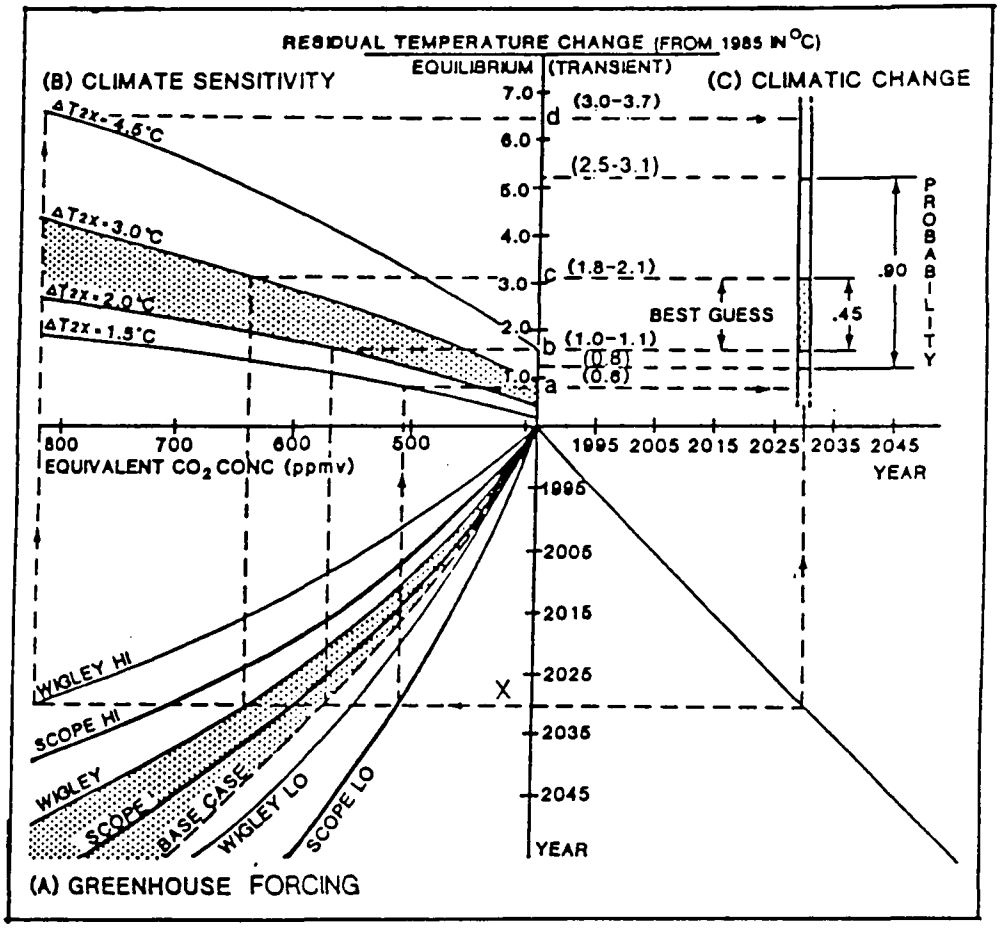
	Related Energy Model Parameter Value
Base Case Scenario	
• "Business-As-Usual," the inertial model of growth and change in the world energy industry	
• No policies to slow carbon dioxide emissions	
• Minimal stimulus to improve end-use efficiency	(Rate of change = 0.8% per year)
• Modest stimulus for synfuels development	(Final Price = $3.15-$4.25 per GJ in 2005)
• Minimal stimulus for development of solar energy systems	(Final Price = $16.50 per GJ in 2025)
• No policy to limit tropical deforestation or to encourage reforestation	
• Minimal environmental costs included in price of energy	($0.30 per GJ for coal; $1.00 per GJ for synfuels)
High Emissions Scenario	
• Accelerated growth in energy use is encouraged	
• No policies to slow carbon dioxide emissions	
• No stimulus to improve end-use efficiency	(Rate of change = 0.2% per year)
• Modest stimulus for increased use of coal	(Rate of improvement = 0.75% per year)
• Strong stimulus for synfuels development	(Final Price = $2.75-$3.50 per GJ in 1995)
• No stimulus for development of solar energy systems	(Final Price = $20 per GJ in 2040)
• Rapid deforestation and conversion of marginal lands to agriculture	
• Token environmental costs included in price of energy	($0.15 per GJ for coal; $0.50 per GJ for synfuels)
Modest Policies Scenario	
• Strong stimulus for improved end-use efficiency	(Rate of change = 1.0% per year)
• Modest stimulus for solar energy	(Final price = $15.00 per GJ in 2025)
• Substantial efforts at tropical reforestation and ecosystem protection, more intensive rather than extensive agriculture encouraged	
• Substantial environmental costs imposed on energy prices to discourage solid fuel use and encourage fuel-switching	($0.60 per GJ for coal; $1.50 per GJ for synfuels)
Slow Build-up Scenario	
• Strong emphasis placed on improving energy efficiency	(Rate of improvement = 1.5% per year)
• Rapid introduction of solar energy encouraged	(Final Price = $12.00 per GJ in 2000)
• Major global commitment to reforestation and ecosystem protection	
• High environmental costs imposed on energy prices to discourage solid fuel use and encourage fuel-switching	($1.20 per GJ for coal; $3.00 per GJ for synfuels)

Total Emissions of CO_2 in the WRI Scenarios (Gigatons of Carbon per Year)



By a different approach, Dr. R.A. Warrich of the Climatic Resarch Unit of the University of East Anglia in Norwich - UK, has recently tried to link emission forecasts and likely climatic changes and to assign probabilities to the possible outcome.

The results of this exercise are summarized in the following graph :



Legend :

- WIGLEY, SCOPE, BASE CASE indicate projections of greenhouse gases emissions
- T2X is the climate sensitivity expressed as equilibrium temperature increase due to a doubling of the equivalent CO_2 concentration
- "transient temperature" is the temperature increase at a given date due to the greenhouse forcing
- "equilibrium temperature" is the warming to which earth would have been committed at a given date due to the greenhouse effect.

The following conclusions i.a. have been drown by the author of the above mentioned evaluation :

"- Given the range of scientific uncertainties, the warming to which we will be committed in 2030 is 0.8-6.4°C. The chance of falling outside this range is less than 1%.

- The "best-guess" range is 1.5-3.1°C warmer than today. The probability of warming within this range is 45%.

- The 90% confidence interval is 1.1-5.1°C. This median value - the best guess - is 2.8°C."

12. The presently available climate models predict (with various degrees of uncertainties) the following climate and associated impacts[1] :

- **Global-Mean Surface Warming** (very probable). For a doubling of atmospheric carbon dioxide (or its radiative equivalent from all of the greenhouse gases), the long-term global-mean surface warming is expected to be in the range of 1.5 to 4.5°C. The most significant uncertainty arises from the effects of clouds. Of course, the actual rate of warming over the next century will be governed by the growth rate of greenhouse gases, natural fluctuations in the climate system, and the detailed response of the slowly responding parts of the climate system, i.e., oceans and glacial ice.

- **Global-Mean Precipitation Increase** (very probable). Increased heating of the surface will lead to increased evaporation and, therefore, to greater global mean precipitation. Despite this increase in global average precipitation, some individual regions might well experience decreases in rainfall.

- **Polar Winter Surface Warming** (very probable). As the sea ice boundary is shifted poleward, the models predict a dramatically enhanced surface warming in winter polar regions. The greater fraction of open water and thinner sea ice will probably lead to warming of the polar surface air by as much as 3 times the global mean warming.

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(1) Source : NRC (1987); Current Issues in Climate Change, National Research Council, Washington DC, USA.

- **Summer Continental Dryness/Warming** (likely in the long term). Several studies have predicted a marked long-term drying of the soil moisture over some mid-latitude interior continental regions during summer. This dryness is mainly caused by an earlier termination of snowmelt and rainy periods, and an earlier onset of the spring-to-summer reduction of soil wetness. Of course, these simulations of long-term equilibrium conditions may not offer a reliable guide to trends over the next few decades of changing atmospheric composition and changing climate.

- **High-Latitude Precipitation Increase** (probable). As the climate warms, the increased poleward penetration of warm, moist air should increase the average annual precipitation in high latitudes.

To complete the picture of expected direct effects, it is worth mentioning also a :

- **Large Stratospheric Cooling** (virtually certain). Reduced ozone concentrations in the upper stratosphere will lead to reduced absorption of solar ultraviolet radiation and therefore less heating. Increases in the stratospheric concentration of carbon dioxide and other radiatively active trace gases will increase the radiation of heat from the stratosphere. The combination of decreased heating and increased cooling will lead to a major lowering of temperatures in the upper stratosphere.

This last effect seems quite important as a possible efficient and rapid "finger-print" of the greenhouse effect given that "the expected changes in the upper stratosphere are nearly of an order of magnitude greater than the expected surface changes and that they are not affected by the ocean thermal inertia and by cloud feedback effects (processes which are a source of considerable uncertainty in assessing tropospheric climate change)" (WMO, 1985).

13. It is worth stressing again that uncertainties on the shape, on the regional distribution and on the rate of such changes should not hide the fact that observed and expected increase in greenhouse gases atmospheric concentrations will modify the thermal balance of the earth and therefore will bring some warming and possible associated climate modification.

As it was put as a conclusion at a symposium on "CO_2 and other greenhouse gases : climatic and associated impact" organized by the Commission on 3 to 5 November 1986 :

"- Although quantitative uncertainties in models remain, it is now believed that increasing concentrations of greenhouse gases will produce a significant change during the 21st century.
- ... This warming of 1.5 to 4.5° is expected ot occur over the next 50 years.
- Over Europe the range of model results shows that average summer temperatures could increase by 2 - 6°C, winter average temperatures by 4 - 10°C. In winter precipitation would increase ..."

Potential impacts of climate changes

14. Potential impacts of the above mentioned climate changes will of course depend on the size and rate of the latter. At the symposium on "CO_2 and other greenhouse gases" mentioned in paragraph 13, it was concluded that :

"The expected climatic change will have profound effects on sea-level, global ecosystems, agriculture, water resources and sea-ice."

In particular such impacts could involve :

15. Sea level rise

Over the past 100 years, while global mean temperature has increased by approximately 0.5°C, sea level has risen by 10-15 cm. (Source : US-EPA (1986); "Effects of Changes in Stratosphere Ozone and Global Climate", Volume 1).

The projected global warming could have the following results :

- heating and therefore expanding the ocean water;
- melting of mountain glaciers;
- melting of the large ice sheets in Greenland and Antarctica;
- a possible (but unlikely) surge of a major portion of the Antarctic ice sheet into the ocean.

A wide range of different estimates for future sea level rise are available.
The most likely range for such increase by the middle of next century seems to be in the order of 30 cm to 1,5 meter (Toronto Conference, June 1988).

A significant rise in sea level would :

- permanently inundate many coastal wetlands and lowlands;
- accelerate coastal erosion;
- exacerbate coastal flooding and storm damage;
- increase the salinity of estuaries and coastal aquifers.

16. **Reduction of Sea Ice**

As the climate warms, total sea ice is expected to be reduced. This is a very probable effect.

17. **Water Resources Impacts**

Greenhouse warming may result in significant changes in precipitation patterns. While it is likely that global mean precipitation will increase, some regions may experience decreases in rainfall. Several studies predict substantial increases in summer dryness at mid-latitudes. As well as the impacts that this will have on agriculture, water resource reduction may affect the following :

- availability of water for human consumption;
- power generation;
- effluent dilution;
- navigation.

18. **Agriculture**

It should be mentioned that an increase in the CO_2 atmospheric concentration would stimulate vegetable growth by increasing photosynthesis rate and therefore could have per se a beneficial direct effect on crops and vegetation. This direct effect is difficult to quantify especially since the concomitant temperature increase would reduce the rate of net photosynthesis. Moreover any attempt to take it

into account should try to strike a balance between such direct effect and indirect impacts of increasing CO_2 concentration through climatic modifications.

The greenhouse warming could affect agriculture and forestry mostly by altering :

. total water availability and seasonal distribution of rainfall at regional level;
. length of growing season;
. number of extreme temperature events.

There are two perspectives on the agricultural impacts of climate change.

- The "Slow change" view : emphasises the significance of gradual increases in mean surface temperatures expected to lead to gradual, long-term and cumulative changes in average regional climates and agricultural patterns.

- The "Extreme events" view : emphasises changes in the frequencies of unusually disruptive events; impact of climate change comes not only from the average but mainly from the extreme event, e.g. droughts, flooding.

There is already concern among some experts that recent regional extreme events could be more than just climate fluctuations.

The main possible effects of climate variations on agriculture are summarised below [2] :

"- changes in length of the potential growing season and changes in plant growth rates;

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(2) Source : Parry M.L. et al (Eds) (1987) ; The Impact of Climate Variations on Agriculture, Volume 1, Assessments in Cool, Temperate and Cold Regions, Reidel, Dordrecht, The Netherlands.

- changes in mean yield and in the variability of yields;

- changes in the level of crop certainty and in the crop quality;

- changes in the sensitivity of plants to application of fertilisers, pesticides and herbicides."

Moreover climate changes could indirectly significantly affect agriculture in certain regions of the world through possible effects on soil characteristics, water resources, hydrology, pests and diseases etc.

At present, there is uncertainty about the nature, the magnitude and location of impacts. Studies so far conclude the following :

- Areas particularly sensitive to shifts in temperature and rainfall levels are high latitude, semi-arid and high-altitude regions.

- Warming appears to be detrimental to cereals in the core wheat-growing areas of Europe and North-America.

- Investigations of possible impacts in Canada, Finland and Northern USSR using climate data from the model by Hansen [1] et al, show reduced yields of spring-sown crops such as wheat, barley and oats, due to the increased moisture stress early in the growing period.

Impacts on agriculture would result in impacts on the local community, regional and national economies, in particular through changes in farm income and profitability, changes in regional production costs, changes in regional and national food production, changes in regional farm income disparities, changes in regional economic activity and employment.

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(1) Hansen J. et al (1983) : "Efficient Three-Dimensional Global Models for Climate Studies : Models I and II", Monthly Weather Review III, pp. 609-662.

In conclusion it is not possible under the present state of knowledge to give more than a tentative and qualitative description of possible effects of climate changes on agriculture given the large uncertainties about the regional shape and size of such changes and the lack of detailed research and studies on the likely response of agricultural systems in various regions of the world.
Urgent efforts are required to improve understanding of these aspects both at global level because of the potentially disruptive food security effects and at Community level because of the direct potential socio-economic impacts.

19. **Forest Ecosystems and Timber Production**

It is worth noticing that the same general comment on the direct potential effect of CO_2 on vegetation made at the beginning of paragraph 18 applies here too.

Predicted impacts include the following :

- modification of botanical and zoological composition of natural forest ecosystems;
- increase of forest decline in natural and manmade forest stands;
- modifications in forest productivity and forest management;
- disturbance of timber- and woodproducts markets and trade;
- danger of extinction of certain forest tree species and local ecotypes with a limited geographical distribution and by this a reduction of global genetic variability of forests.

20. **Human Health Impacts**

It should also be mentioned that a global warming could also have impacts for human health. It could in particular :

- possibly enable some diseases which require warm year-round temperatures to survive at higher latitudes;
- cause more frequent famines and shortages of food supplies (extreme events);

Expansion of tropical climates and concurrent expansion of the range of tropical diseases would mostly affect developing countries that already face health problems.

21. **Ecology and Fisheries Impacts**

The following potential ecological impacts are worth mentioning :

- impacts on less managed ecosystems;
- impacts on marine ecosystems;
- multiple stresses on some species which could become extinct, resulting in a significant decline in biodiversity;
- impact on wildlife reserves (the impact would depend on whether the reserve's boundaries encompass areas to which plants and animals could migrate).

The level of impact would depend on the rate of change in climate and thus the time allowed for acclimatisation and ecological species shifts.

Finally it is worth mentioning that since the ocean and atmosphere are coupled, both the distribution and abundance of fishery resources are capable of being modified by climate.
However, it is controversial how much observed changes in particular fishery stocks are due to climate and other natural causes or to overfishing.

II. THE INTERNATIONAL FRAMEWORK AND PERSPECTIVES

Introduction

22. Le rôle joué par certains gaz présents dans l'atmosphère dans les équilibres thermiques de la terre était connu dans ses grandes lignes déjà vers la moitié du siècle dernier (Tyndall, 1863; Arrhenius, 1896; Chamberlin, 1899).

Les premières mesures systématiques de la concentration du CO_2 par un réseau mondial ont toutefois démarré seulement en 1958.

Depuis lors l'augmentation observée de cette concentration a poussé les milieux scientifiques à entreprendre et à intensifier la recherche sur tous les aspects de l'effet serre.
Ce n'est toutefois que très récemment que ce sujet a commencé à faire l'objet de l'attention des responsables politiques.
Les problèmes bien connus concernant la couche d'ozone qui ont entraîné des négociations internationales et des décisions politiques ont en effet porté l'attention de ces responsables politiques sur les risques globaux liés aux modifications de notre atmosphère causées par l'action de l'homme et sur la necessité de préparer les réponses concrètes à donner aux indications scientifiques de plus en plus inquiétantes concernant l'éventualité de modifications du climat.

As a consequence, the following recent events have marked an important evolution in attitudes towards the greenhouse issue :

- the "Villach" conference (Villach-Austria, 9-15 October 1985);
- the European Parliament resolution on measures to counteract CO_2 rising concentrations (September 1985)
- The EEC Symposium on "CO_2 and other greenhouse gases" (Brussels, 3-5 November 1986);
- The Workshops on "Developing policies for responding to climatic change" (Villach-Austria, 28 September-2 October 1987 and Bellagio-Italy, 9-13 November 1987);
- The Brundtland Commission's report
- The World Conference on "The changing atmosphere" (Toronto, 27-30 June 1988).

The last event is of particular importance for future development and its outcome is presented in the next paragraph.

Details about the other events mentioned above are given in the Annex to this document.

The world conference on "The changing atmosphere, implications for global security" - Toronto, 27-30 june 1988

23. This high level conference has been organized at the initiative of the Canadian government to follow-up some of the conclusions and recommendations of the Brundtland commission report.
More than 300 scientists and policy makers from 48 countries, United Nations organizations, other international bodies and non-governmental organizations participated in the sessions.

Of the conference conclusions and recommendations, the following seem most important and are therefore reproduced in full :

"- Humanity is conducting an enormous, unintended, globally pervasive experiment whose ultimate consequences could be second only to a global nuclear war. The Earth's atmosphere is being changed at an unprecedented rate by pollutants resulting from human activities, inefficient and wasteful fossil fuel use and the effects of rapid population growth in many regions. These changes represent a major threat to international security and are already having harmful consequences over many parts of the globe.

- Far-reaching impacts will be caused by global warming and sea level rise, which are becoming increasingly evident as a result of continued growth in atmospheric concentrations of carbon dioxide and other greenhouse gases. The best predictions available indicate potentially severe economic and social dislocation for present and future generations, which will worsen international tensions and increase the risk of conflicts among and within nations. It is imperative to act now."

The following immediate actions are recommended :

"A. <u>Actions by Governments and Industry</u>

- Ratify the Montreal Protocol on Substances that Deplete the Ozone Layer. The Protocol should be revised in 1990 to ensure nearly complete elimination of the emissions of fully halogenated CFCs by the year 2000. Additional measures to limit other ozone-destroying halocarbons should be considered.

- Set energy policies to reduce the emissions of CO_2 and other trace gases in order to reduce the risks of future global warming. Stabilizing the atmospheric concentrations of CO_2 is an imperative goal. It is currently estimated to require reductions of more than 50 percent from present emissions levels. Energy research and developmental budgets must be massively directed to energy options which would eliminate or greatly reduce CO_2 emissions and to studies undertaken to further refine the target reductions.

- Reduce CO_2 emissions by approximately 20 percent of 1988 levels by the year 2005 as an initial global goal. Clearly, the industrialized nations have a responsibility to lead the way, both through their national energy policies and their bilateral and multilateral assistance arrangements. About one-half of this reduction would be sought from energy efficiency and other conservation measures. The other half should be effected by modifications in supplies.

- Set targets for energy efficiency improvements that are directly related to reductions in CO_2 and other greenhouse gases. A challenging target would be to achieve the 10 percent energy efficiency improvements by 2005. Improving energy efficiency is not precisely the same as reducing total carbon emissions and the detailed policies will not all be familiar ones. A detailed study of the systems implications of this target should be made. Equally, targets for energy supply should also be directly related to reductions in CO_2 and other greenhouse gases. As with efficiency, a challenging target would again be to achieve the 10 percent energy supply improvements by 2005. A detailed study of the systems implications of this target should also be made. The contributions to achieving this goal will vary from region to region; some countries have already demonstrated a capability for increasing efficiency by more than 2 percent a year for over a decade.

- Apart from efficiency measures, the desired reduction will require (i) switching to lower CO_2 emittaing fuels, (ii) reviewing strategies for the implementation of renewable energy especially advanced biomass conversion technologies; (iii) revisiting the nuclear power option, which lost credibility because of problems related to nuclear safety, radioactive wastes, and nuclear weapons

proliferation. If these problems can be solved, through improved engineering designs and institutional arrangements, nuclear power could have a role to play in lowering CO_2 emissions.

- Negotiate now on ways to achieve the above-mentioned reductions.

- Initiate management systems in order to encourage, review and approve major new projects for energy efficiency.

- Vigorously apply existing technologies, in addition to gains made through reduction of fossil fuel combustion, to reduce (i) emissions of acidifying substances to reach the critical load that the environment can bear; (ii) substances which are precursors of tropospheric ozone; (iii) other non-CO_2 greenhouse gases.

- Label products to allow consumers to judge the extent and nature of the atmospheric contamination that arises from the manufacture and use of the product.

B. Action by Member Governments of the United Nations, Non-Governmental Organizations and Relevant International Bodies.

- Initiate the development of a comprehensive global convention as a framework for protocols on the protection of the atmosphere. The convention should emphasize such key elements as the free international exchange of information and support of research and monitoring, and should provide a framework for specific protocols for addressing particular issues, taking into account existing international law. This should be vigorously pursued at the International Workshop on Law and Policy to be held in Ottawa early in 1989, the high-level political conference on Climate Change in the Netherlands in the Fall, 1989, the World Energy Conference in Canada in 1989 and the Second World Climate Conference, Geneva, June 1990, with a view to having the principles and components of such a convention ready for consideration at the inter-governmental Conference on Sustainable Development in 1992. These activities should in no way impede simultaneous national, bilateral and regional actions and agreements to deal with specific problems such as acidification and greenhouse gas emissions.

- Establish a World Atmosphere Fund, financed in part by a levy on fossil fuel consumption of industrialized countries, to mobilize a substantial part of the resources needed for implementation of the Action Plan for the Protection of the Atmosphere.

- Support the work of the Inter-governmental Panel on Climate Change to conduct continuing assessments of scientific results and initiate government-to-government discussion of responses and strategies.

- Devote increasing resources to research and monitoring efforts within the World Climate Programme, the International Geosphere Biosphere Programme and Human Response to Global Change Programme. It is particularly important to understand how climate changes on a regional scale are related to an overall global change of climate. Emphasis shouls also be placed on better determining the role of oceans and global heat transport and the flux of greenhouse gases.

- Increase significantly the funding for research, development and transfer of information on renewable energy, if necessary by the establishment of additional and bridging programmes; extend technology transfer with particular emphasis on the needs of the developing countries; and upgrade efforts to meet obligations for the development and transfer of technology embodied in existing agreements.

- Expand funding for more extensive technology transfer and technical cooperation projects in coastal zone protection and management.

- Reduce deforestation and increase afforestation making use of proposals such as that in the World Commission on Environment and Development"s (WCED) report, "Our Common Future", including the establishment of a trust fund to provide adequate incentives to enable developing nations to manage their tropical forest resources sustainably.

- Develop and support technical cooperation projects to allow developing nations to participate in international mitigation efforts, monitoring, research and analysis related to the changing atmosphere.

- Ensure that this Conference Statement, the Working Groupe reports and the full Proceedings of the World Conference, "The Changing Atmosphere : Implications for Global Security" (to be published in the Fall, 1988) are made available to all nations, to the conferences mentioned under paragraph 26, and other future meetings dealing with related issues.

- Increase funding to non-governmental organizations to allow the establishment of environmental education programmes and public awareness campaigns related to the changing atmosphere. Such programmes would aim at sharpening perception of the issues, and changing public values and behaviour with respect to the environment.

- Allocate financial support for environmental education in primary and secondary schools and universities. Consideration should be given to establishing special groups in university departments for addressing the crucial issues of global climate change.

Future possible developments

24. A possible short-term outcome of the above mentioned international activites is initiation, already in 1989, of the process for preparing a comprehensive global convention on the protection of the atmosphere.

Limitations to the emissions of greenhouse gases would then be agreed by specific protocols in the frame of such convention.

25. Next essential events on the way to that convention might probably be :

- the international workshop on law and policy to be held in Ottawa early in 1989;

- a high level political conference to be convened in the autumn 1989 by the Netherlands Ministry of the Environment;

- the Second World Climate Conference, Geneva, June 1990;

- the Intergovernmental Conference on sustainable Development in 1992 which could be the culminating event.

26. The substance of the convention mentioned under 24 above (and of associated protocols) as far as the greenhouse issue is concerned could probably consist in :

a) greenhouse gases emission reduction targets for developed countries;

b) new development aid schemes to help developing countries to limit the increase of their greenhouse gases emissions by use of appropriate technologies and to reverse deforestation trends;

c) a new impetus to scientific and technical international cooperation on all the aspects relevant for the greenhouse issue.

27. Renegotiation of the Montreal Protocol on CFC's is a very likely short term development.

28. Policy discussions on the way how to deal with the greenhouse effect might be very complex because of the many far reaching and interrelated aspects of the issue.

In this respect, it is worth stressing the global, complex and differentiated nature of the challenge put by the greenhouse issue.

This was well presented in the following statement at the Bellagio (1987) workshop (see Annex) :

"... the participants emphasized the relationship between the issue of climatic change, including policy responses to it, and a number of other issues, above all in the field of environment and development. This relationship underlines the importance of the differences in impact by region, and hence by country, of climatic change and the extent to which these differences affect the effort of the international community in promoting sustainable development.

The report of the Brundtland Commission has explained the ramifications of these numerous interconnections. The significance of the difference in regional impact should not, however, be allowed to detract from the emphasis on the comunity as a whole in facing it. Still less should it encourage any attempts to divide countries or regions into "winners" or "losers". This is not a "zero-sum" game. Unless action is taken, it could be a negative sum game of highly uncertain proportions."

III. REVIEW OF POSSIBLE ACTIONS

Introduction

29. Preliminary indications from research results and the state of the international debate call for urgent consideration of further action on the greenhouse issue.

Such action, of which the following paragraphs give an overview, could include :

- research;
- preventive measures (i.e. measures to curb greenhouse gases emissions);
- adaptive measures (i.e. measures to adapt to climatic changes and to their impacts if those seem likely to be unavoidable despite preventive measures).

30. Policy measures may be classed into three groups :

(a) those which have to be taken at an international level and require international agreement (e.g. reduction of CO_2 emissions);
(b) those which may be taken at a European level (e.g. planning for water resources, agricultural and forest planning) or in specific countries e.g. through development aid programmes (conservation of tropical forests, wetlands, coastal ecosystems, appropriate energy policies, etc.);

(c) those of an intermediate character (e.g. decisions on the energy mix to be adopted, taking account of (a) and of particular European conditions).

The group to which any particular measure belongs may determine the time necessary to its adoption and require a proper approach.
Measures of an international character may ignore specific local conditions; local measures cannot do so.

31. The above mentioned factors have to be taken into account in order to correctly coordinate the policy decision timing and the research timing. In fact this coordination is essential for two reasons :

(a) the uncertainties as regards the climate change and its impacts increase with increasing spatial and temporal definition : the ultimate answer one is expecting from scientific research is what will happen, when, where. Now the "what" becomes increasingly uncertain as the range of the "when" and "where" becomes smaller. Yet such knowledge is vital for any planning which decision makers could consider.

(b) in order to take policy decisions it is crucial to know

- which danger, when and where, one has to face and what consequences upon the environment, the economy, the society at large are to be expected;
- how to implement at best the measures decided;

Therefore, the study of policy options and scientific research have to go in parallel, and there must be a continuous feedback between the two. Only in this way can one avoid that decisions are unduly delayed or that they are taken without taking fully into account research results. Research itself should benefit from that interaction process, by being continuously reoriented towards specific objectives and actual problems and needs.

Research activities

32. Already since 1980, the Commission of the European Communities is carrying out a research programme in Climatology, whose main research areas are concerned with the study of the evolution of climate in the past, with climate modelling, with the man-induced climate change and with the impacts that such change could have on European land and water resources. The symposium held in Brussels in November 1986 (Annex B) was organised in the frame of this programme and was meant to provide the scientific consensus available at that date.

Research is being focussed especially on the climatic effects of greenhouse gases, and climatologically significant processes imperfectly understood as yet, such as atmosphere-ocean interactions, the water vapour-greenhouse feedback, the cloud feedback, aerosol and cloud climatology, biospheric sources and sinks of trace gases, climatic aspects of ozone changes and troposphere-stratosphere interactions, the effects of glabal warming on the melting rate of ice shelves.

33. In the near future the Climatology research programme of the Commission will put a greater stress on the impacts which climate change could have on important sectors of the European environment.

Such intensified research should concern in particular :

(1) The rise in sea level and its impacts on the European coasts (prediction of future sea-level changes, the change in storm surge risks for European coastal installations, the impacts on coastal ecosystems and coastal land use).

(2) The impacts of a changing climate on European crops, forests, water resources (bioclimatic shifts of crops and forests, changes in productivity, the sensitivity of European crops to increased CO_2 and climate change, the impacts on surface and ground water supplies).

(3) The effects of the climate change as regards the progressive aridification of the Mediterranean Europe (effects of climatic and meteorological factors on soil degradation, the impact of progressive drought on vegetation).

(4) The occurrence and frequency of extreme events and their impacts upon agriculture and industry (the impacts of the alternance of droughts and heavy rainfall on European land resources, the impacts of meteorological extremes such as hail and frost on European agriculture and industry).

(5) The melting of Alpine glaciers.

(6) The study of the social, economic and political factors conditioning probable future emission rates of greenhouse gases, and likely to be affected by any policy option that could be adopted.

(7) The study of socio-economic impacts, in particular in the Community, due to climatic changes, for the various relevant aspects, such as consequences for agriculture, consequences for costline regions of the sea level rise, etc.

Such research should be supplemented by a sound monitoring of atmospheric and oceanic conditions. International agreements should allow to place instrumentation where it is needed and to have access to space based monitoring systems. A vital component of a monitoring programme is the utilisation of space technology to understand the processes which control the earth's climate system and its sensitivity to natural and man-induced changes.

34. Environmental constraints, especially the reduction of air pollution, call for a balanced pursuit of environmental and energy objectives. As far as CO_2 is concerned, the objective can also be achieved through progress in the development and availability of techniques, processes and products allowing rational use of energy and the efficient and economic use of renewable energy sources and by safe nuclear energy.

These considerations provide ample justification for a specific energy R&D programme in the fields of renewable energies, rational use of energy and safe nuclear technology which will ensure continuity of the progress made since 1975 and guarantee that optimum benefits be gained from the new energy technologies developed so far.

35. Elimination of CO_2 at the source could eventually become a new domain of resarch. No economically or technically feasible technologies are yet available.
New directions for research in this field should be explored.

36. Moreover, the management of the CO_2 problem implies both the definition of global reduction objectives and the implementation of these objectives. The first aspect of the problem requires to determine by how much the emissions will need to be reduced and the pace of that reduction. The implementation action will have to determine the economic activities that will bear the major part of this reduction, the allocation of this reduction among the different actors and the institutional approaches to arrive at these objectives.

System Analysis can, in principle, provide the adequate basis for looking at these questions. Energy-Environment models give the possibility of finding efficient ways of achieving emission goals; Climate models are there to assess the impact of emissions on the environment and to help construct scenarios of adaptive measures; Energy-economy models allow to compute the impact on the economic systems of the costs incurred by the reduction of emissions.

The models developed in the System Analysis Community research programme should be adapted and used in the direction defined above for analysing energy related CO_2 emissions reduction measures and programmes.

The aim of such research would be to evaluate the feasibility and the costs of various reduction objectives as well as to assess their impact on the energy and economy sectors.

Preventive action (greenhouse gases emission reduction)

37. Preventive action is any action aiming at curbing the expected increase in greenhouse gases atmospheric concentrations.
This could mean aiming first at reducing the rate of increase of those concentrations and in the longer term at stabilizing them. Reduction of greenhouse gases concentrations does not seem at this stage a realistic objective but could be a very long term goal.

38. The only way at hand to control future trends of greenhouse gases concentrations is limiting man-made emissions including, in case of CO_2, reversing the present trend of deforestation in tropical regions.

Preventative action is further discussed with reference to the most relevant greenhouse gases here below.

39. **Carbon dioxide (CO_2) emissions**

As shown in paragraph 4 of chapter I, CO_2 emissions are mostly due to fossil fuels burning and forest wood burning or forest biomass decomposition.
Preventive action could therefore include measures to be taken in the energy sector (including energy for industry and transportation) and in the forestry and agricultural sectors as far as action in these sectors could help to preserve forests.

A tentative list of actions aiming at CO_2 emissions reduction which could be studied might include :

A. Energy related measures for CO_2

There are several types of technical energy related measures that could curb CO_2 emissions, as listed below.
Of course not all those measures are equally efficient or cost-effective and one should make a clear distinction between the physical potential of CO_2 emission reduction of a given measure and its economic viability.

The following technical measures, which are listed without any ranking or priority, may provide ways to reduce CO_2 emissions from carbon-based fuels :

a. Energy Efficiency

- improving the efficiency of energy demand (e.g. more efficient light bulbs, better insulation, more efficient cars, electronic regulations, etc.);

- improving the efficiency of energy supply (e.g. cogeneration, introduction of combined cycle possibly integrated with high-temperature nuclear reactors, develoment of MHD, etc.);

b. Energy Supply

- fuel switching to less CO_2 emitting fuels (the relation of CO_2 emitted quantities with regard to a unit of energy produce for the combustion of lignite, hard coal, oil and natural gas is as follows : 121, 100, 88, 58);
- increased use of non carbon based renewable energies (pe. solar, windpower, hydro, geothermal, photovoltaics);
- increased use of nuclear power.

c. Biotic sources

- Use biomass for energy purposes (such as wood for heating or cooking in developing countries) in a sustainable way so that the CO_2 atmospheric balance is not affected significantly;

d. CO_2 technology abatement

- Although at present no economically or technically feasible technologies seem to be available, this possibility should not be excluded for the future.

e. Long-term development

- Introduction of non-carbon based energy systems in their various forms combined with electricity and hydrogen as secondary energy carriers.

Any policy decision aiming at reducing CO_2 emissions in the energy sector should be carefully examined taking fully into account the specific objectives and constraints existing at international, community and national level in this sector. On the other hand, any future decision in the field of energy policy should take into account the problem of potential climate changes linked to the greenhouse effect.

System analysis models have been extensively used in the past for exploring consequences of economic-energy-environmental related measures and the use of such analytical models may provide information on the feasibility of measures to achieve CO_2 reduction goals. Scenarios analysis can complete such information and identify technologies which have a good chance of contributing to that objective and hence should deserve more attention.

B. Measures related to forestry and natural ecosystems

a. Conserve forest resources

- promote appropriate agricultural practices and organization in developing countries to avoid that agricultural land demand cause further deforestation;

- assist developing countries to improve their ability to manage forests in a manner that ensures that they are exploited on a sustainable basis;

- reinforce prevention and fighting of forest fires;

- promote actions to monitor and restore declining forests;

- provide alternatives to and improve the efficiency of the utilisation of fuel-wood for cooking in developing countries.

b. Promote afforestation

- increase reafforestation efforts notably in subtropical and tropical regions;

- promote agroforestry, especially in developing countries.

c. Natural ecosystem protection

- promote the conservation of ecosystems directly or indirectly relevant for the global carbon cycle.

40. CFCs emissions

Possible preventative actions are :

a. Constrain use
b. Constrain production
c. Recapture and recycle or destroy

41. CH_4, N_2O emissions

Actions which could be considered are :

a. Minimize CH_4 losses in extraction, transport and use of natural gas.
b. Minimize CH_4 losses from landfills.
c. Minimize N_2O emission from fossil fuels burning.
d. Study possible improvements in livestocks management, rice cultivation and lagoons management, aiming at reducing CH_4 release.
e. Study possible improved fertilizing management practices to reduce N_2O release from nitrogen fertilizers use.

42. The possible use of mechanisms such as taxation of products that cause greenhouse gas emissions or of emissions themselves where this is feasible, could be considered to stimulate or complement technology measures.

Planned adaptation

43. Planned adaptation involves taking account of potential greenhouse impacts in long-term planning, most likely at the regional and national levels.
Consideration of such measures in long term planning becomes necessary if it is believed that :

- impacts are likely to occur which society will not be able to adjust to in the short term;
- implementation of preventative measures is unlikely to be sufficiently effective in time (e.g. even if emission controls were implemented now, it is possible that significant impacts will occur due to the atmospheric warming to which we are already committed).

At this stage it is not possible to cover, even in qualitative and simple way, all the adaptive measures which could be worth considering in relation to the various potential impacts of the greenhouse effect. However, it is worth giving some indications concerning potential measures for possible sea-level rise and for impacts on agriculture.

44. **Possible adaptation measures concerning sea level rise could include :**

- Sea walls/flood barriers.
- National flood insurance programmes.
- Construction of reservoirs (to combat increased salinity).
- Abandonment of developed regions in low lying areas.
- Other relocation of populations away from vulnerable sites.
- Protection of coastal ecosystems.

45. **Examples of measures which could be considered in order to adapt to impacts on agriculture are :**

- More efficient use of fertilisers.
- Changes of land use to optimise and to stabilize production;
- Changes of policy to maintain national food security;
- Changes to policies supporting land management, such as soil erosion control, water management, etc.

Cooperation with developing countries

46. All the above measures, both as regards preventive action and as regards planned adaptation, should also be developed to take into account the needs of the developing countries, and how the Community's development aid policy can contribute towards the prevention and the adaptation of the greenhouse effect. In particular :

a) by enhancing the type of projects that can actively contribute to prevention such as those which are directed at reducing deforestation, conserving wetlands, coastal ecosystems and the genetic diversity or arid ecosystems;

b) by taking into account the consequences of the greenhouse effect in medium-term project planning (e.g. agricultural programmes, livestock programmes, fisheries and any projects related to long-term investments on lowlands which may be affected by the forecasted increase of ocean level);

c) by ensuring that base line data being gathered for the purpose of implementing development projects be made accessible to the Community research programme on the greenhouse effect.

IV. CONCLUSIONS OF THE COMMISSION

47. The Community should implement fully the Vienna Convention for the protection of the ozone layer and the Montreal Protocol on substances that deplete the ozone layer. This will involve the adoption and application by all Member states of the proposed Council Decision, Regulation and Resolution agreed to by the Council on 16 June 1988.

48. The Community should participate actively in the efforts toward renegotiation by 1990 of the Montreal Protocol on substances that deplete the ozone layer. The Protocol should be revised so that the CFC's emissions could be almost totally eliminated by the year 2000 as recommended by the Toronto conference.

49. The Commmunity should welcome initiation of discussions on the possibilities of an international agreement for the future protection of the atmosphere. It should be prepared to give an important contribution to the preparation and negotiation of such an agreement which might include the establishment of specific targets for limiting emissions of greenhose gases as well as definition of emission reduction measures and programmes.

50. Therefore, the Commission will take the initiative to launch a substantial policy-options study programme to evaluate the feasibility, costs and likely results of possible measures to limit greenhouse gases emissions. Results of such programme would give useful inputs to the international debate on the issue.

The main areas of such programme should be :

- identification and technical assessment of measures and technologies in various relevant fields capable to reduce greenhouse gases emissions;

- analysis of economic, industrial, energy, social and institutional implications and impacts of the above mentioned possible measures and technologies;

- structuring and evaluating policy scenarios referred in particular to possible strategic targets for CO_2 emission ceilings.

A reliable greenhouse gases emission inventory would be needed in this frame.
The focus of the exercise should be on Europe in a first instance.

- establishing a decision analysis framework in order to link probabilistically policy options and their likely results an benefits.

- identifying and evaluating adaptive policies to cope with unavoidable effects under the different scenarios resulting from the decision analysis exercise.

The Commission has developed several energy-economy and energy-environment models and those models and the experience gained in policy analyses of energy-environment interactions should be fully exploited when starting new work on the greenhouse issue.

The above mentioned work programme should be closely linked to the research and development activities on relevant subjects such as climatology and energy.
Moreover a framework should be created to allow systematic exchange of views and rapid feedbacks among scientists and policy makers.

51. The greenhouse effect is a global problem, the Community should therefore play an important part in the definition of a global policy, involving in particular developing countries, towards a sustainable development.

Community work on the greenhouse issue should be structured and scheduled so to allow synergism and collaboration with international organizations and third countries. In particular the Commission work programme should fully take account of parallel activities in the frame of the panel on climate change of WMO/UNEP and of OECD and IEA.

52. The Community and its Member States should by now take into account in their policy decisions (related to energy or other sectors relevant to the issue) the problem of potential climate changes linked to the greenhouse effect.
Early consideration of such issue could avoid higher costs in future.

53. Moreover the Commission will take urgent action to reinforce and expand efforts in the field of energy savings, energy efficiency improvement, development of new energy sources, use of safe nuclear technology. The accelerated development and promotion of innovative commercial-scale technologies in these fields should be given high priority.
There is no doubt that such action is justified because of both energy and environmental requirements, independent of uncertainties on some scientific aspects of the greenhouse issue.
Of special importance would be the possibility to quantify energy efficiency improvements in terms of CO_2 reductions.

54. The Community should sustain vigorous research programmes on all the relevant aspects of the greenhouse issue and should promote new energy technologies having the potential to limit CO_2 emissions.

55. Activities should be reinforced and expanded in the frame of existing cooperation agreements of the EC with mediterranean countries with the aim both of promoting sustainable development in those countries and of helping them to prevent likely impacts of the greenhouse issue on their environment.

56. The Commission will also prepare urgent action in the field of aid to developing countries both as regards preventive and as regards adaptation measures.

In particular :

- An attempt should be made to classify and map geographical areas which are particularly vulnerable to the greenhouse effect (such as, for instance, islands whose mean altitude above sea level is precariously low, coastal states, etc. Such maping would form a reference basis against which policies could be evaluated. It would certainly be a first step towards adapting policy as regards aid to developing countries.

- The greenhouse effect should as much as possible be taken into account in considering the feasibility of major projects such as, for instance, dams, agricultural projects which involve major modifications to the environment and in being particularly cautious in evaluating any project which may have a negative input on

tropical forests, wetlands, coastal ecosystems or mountain ecosystems. Instruments should be developed to assess the long-term sensitivity of development projects to the greenhouse effect. Preparedness against natural disaster also at some stage have to be increased, in respect of the type of calamities which the greenhouse effect may make more likely. (For example the strength of tropical storms which is expected to increase.) In preparing national regional conservation strategies one should ensure that adequate account is taken of the greenhouse effect.

57. In parallel to the work needed to evaluate possible policy options, existing research programmes should be strenghten to better understand the potential impacts of the greenhouse effect on European regions. These programmes should consider both the physical and the socio-economic direct and indirect impacts.

In this frame the risks for the coastline regions of the Community related to possible sea level rise should be assessed so that information useful for land use planning is available to developers and competent authorities.

58. Finally, the Commission will set up a Committee to exchange information on all the aspects of the greenhouse issue. Member States and the Commission should be represented in this Committee.

ANNEX

Recent major events on the greenhouse issue

A. The "VILLACH" Conference (International conference on the assessment and the rate of CO_2 and of other greenhouse gases in climate variations and associated impacts (Villach - Austria, 9-15 October 1985))

This conference was jointly convened by UNEP, WMO and ICSU with participation of scientists from twenty nine developed and developing countries.

The following sentences appear in the statement adopted by this conference :

"Many important economic and social decisions are being made today on long-term projects - major water resource management activities such as irrigation and hydro-power; drought relief; agricultural land use; structural designs and coastal engineering projects; and energy planning - all based on the assumption that past climatic data, without modification, are a reliable guide to the future. This is no longer a good assumption since the increasing concentrations of greenhouse gases are expected to cause a significant warming of the global climate in the next century."

.....

"While some warming of climate now appears inevitable due to past actions, the rate and degree of future warming could be profoundly affected by governmental policies on energy conservation, use of fossil fuels, and the emission of some greenhouse gases."

.....

"Based on evidence of effects of past climatic changes, there is little doubt that a future change in climate of the order of magnitude obtained from climate models for a doubling of the atmospheric CO_2 concentration could have profound effects on global ecosystems, agriculture, water resources and sea ice."

.....

"Governments and regional inter-governmental organizations should take into account the results of this assessment (Villach 1985) in their policies on social and economic development, environmental programmes, and control of emissions of radiatively active gases."

.....

"Public information efforts should be increased by international agencies and governments on the issues of greenhouse gases, climate change and sea level, including wide distribution of the documents of this Conference (Villach 1985)."

.....

"Major uncertainties remain in predictions of changes in global and regional precipitation and temperature patterns. Ecosystem responses are also imperfectly known. Nevertheless, the understanding of the greenhouse question is sufficiently developed that scientists and policy-makers should begin an active collaboration to explore the effectiveness of alternative policies and adjustments. Efforts should be made to design methods necessary for such collaboration."

B. The EEC Symposium on "CO2 and other greenhouse gases : climatic and associated impacts (Brussels, 3-5 November 1986)

Upon the initiative of Dr. K.H. Narjes, Vice-President of the Commission of European Communities, a Symposium organised by the CEC, DG XII, was held in Brussels from 3 - 5 November 1986. It was attended by about 60 leading European and US scientists, who reviewed the whole issue of the climate change that will take place as a consequence of the accummulation of the atmospheric CO_2 and other greenhouse gases.

Further to the conclusions on the scientific aspects of the greenhouse issue, mentioned in the relevant sections of this document, the following recommendations were presented as a conclusion of this Symposium :

"- The time has come for taking a decisive step toward converting the dialogue between scientists and decision makers from a remote, intermittent and casual reading of reports of the other party to a closer and more interactive exchange of views.

- It is recommended that a means be established for obtaining the necessary exchange of information between policy analysts, decision makers and the scientific community involved in the issue."

C. The workshops on "Developing policies for responding to climatic change" (Villach - Austria, 28 September-2 October 1987 and Bellagio - Italy, 9-13 November 1987)

These meetings were called following the scientific consensus reached at the Villach conference in order to "start policy analysis to identify the widest possible range of social responses for limiting or adapting to climatic changes".

Apart from the statement mentioned in paragraph 28 of this document, the following conclusions/recommendations were presented :

"Immediate steps to limit greenhouse gas emissions

(1) Ozone Protocol Immediate approval and implementation of the Protocol on Substances that Deplete the Ozone Layer (thereby reducing CFC emissions). Recommend that it be ratified urgently and that after expedited scientific review the parties consider acceleration of the schedule for reductions in CFCs and eventual elimination of emissions not only for ozone layer protection but particularly for greenhouse gas limitation.

(2) Energy Policies

Governments should immediately begin to reexamine their long-term energy strategies with the goals of achieving high end-use efficiency, reducing multiple forms of air pollution and reducing CO_2 emissions. Research and development on alternative (non-fossil) energy systems must be greatly intensified.

(3) Deforestation Policies

Recommend support for increased measures to reduce deforestation, e.g. locally appropriate actions along the lines of the Tropical Forest Action Plan, 1987. Such measures are currently necessary because of the effects of tropical deforestation on agriculture,

energy, soil erosion, flooding and drought, etc. The contribution of deforestation to greenhouse gas induced climatic change is a powerful additional reason for measures to reduce deforestation.

(4) Other Trace Gases

Measures should be taken to avoid industrial and societal actions in the future which unduly contribute to emissions of greenhouse gases to the atmosphere. Examples include landfills that emit methane; N_2O reduction strategies; agricultural practices, etc.

Immediate steps to limit the impact of sea-level rise

(5) River and Coastal Zone Policies

International unions of geographic, coastal and geodetic and soil sciences and/or government agencies should develop maps to identify coastal areas vulnerable to sea-level rise, river regulation and intensifying land-use. Planning for large new industrial, tourist and urban installations near the sea should allow for the risks of possible sea-level rise.

Immediate steps to improve understanding of the greenhouse effect and options for dealing with it

(6) Management tools

Policy and scientific research should investigate further the utility of particular goals as management tools. An environmental goal expressed in terms of a rate of change of temperature or sea-level is easy to relate to observed historic rates of change. Such an environmental goal is related to the ambient concentration of greenhouse gases (expressed in terms of CO_2 equivalence) and thus to the emissions and for each of these, regulatory targets can be set in line with the long-term environmental goal.

(7) Monitoring

The problem of significant climate warming may call for a considerable increase in existing available monitoring activities, both with regard to global climate and its variability and sea-level changes, atmospheric chemistry and rainfall chemistry, as well as the consequences for the environment of any significant warming.

It is therefore recommended that WMO/WCP (World Meteorological Organization / World Climate Programme) and UNEP/GEMS (Unite Nations Environment Programme / Global Environmental Monitoring System) carry out a joint study of :

- what new climate observing system activites are required for monitoring the changing climate;
- what activities are required for monitoring the consequences of the changing climate.

The IOC through the Global Sea Level Observing System should give urgent attention to strengthening the monitoring of sea-level changes worldwide.

(8) Research

ICSU, UNEP and WMO jointly support the World Climate Programme (WCP), which is the focus for the further study of both basic research issues concerning global climatic change and questions about climatic impact. The World Climate Research Programme (WCRP) is an important component of the WCP, as the assessment of possible or likely future climatic changes rests on a comprehensive understanding of the global climate system.

Similarly, the new research programme IGBP (International Geosphere Biosphere Programme), initiated by ICSU, addresses the scientific problems that we are now confronting when trying to understand the biological and geochemical interactions that contribute to future climatic change and are of importance for understanding climatic impacts.

Increased support for scientific research for both the WCRP and IGBP should be given high priority."

D. The Brundtland Commission's report

The World Commission on environment and Development has been created on the basis of an UN General Assembly resolution in 1983 as an independent body to formulate and present proposals and recommandations concerning the critical environment and development problems with the aim of promoting a sustainable development.

Its report was presented to the General Assembly of UN during its 42nd Session in the fall of 1987.

This report asks for a urgent start of negotiating procedures to develop international agreement on strategies to cope with the greenhouse issue. It is suggested to consider :

"- improved monitoring and assessment of the evolving phenomena;
- increased research to improve knowledge about the origins, mechanisms, and effects of the phenomena;
- the development of internationally agreed policies for the reduction of the causative gases; and
- adoption of strategies needed to minimize damage and cope with the climate changes and rising sea level."

The report also suggests that such negotiations should aim at an international convention on "management policies for all environmentally reactive chemicals released into the atmosphere".

E. The European Parliament resolution

The European Parliament has adopted on 12th September 1986 the following resolution on measures to counteract the rising concentration of CO_2 in the atmosphere :

" The European Parliament

- having regard to the motion for a resolution tabled by Mr. Linkohr on research and policy measures to counteract the rising concentration of carbon dioxide in the atmosphere ('greenhouse effect') (Doc. B2-1430/84).

- having regard to the report of the Committee on Energy, Research and Technology and to the opinion of the Committee on the Environment, Public Health and Consumer Protection (Doc. A2-68/86).

A. noting the growing scientific certainty that the earth's average temperature s rising as a result of non-natural releases into the atmosphere of carbon-dioxide and propellants from fossil-fuel burning, intensive farming and industrial activities and deforestation respectively.

B. noting that an increasing temperature build-up, which is greater at the poles than at the equator, will bring about a shift in the earth's climatic zones, resulting in radical and, in some cases, disastrous changes in economic-activity patterns.

C. pointing out that the only scientifically established facts about global temperature build-up are the scale thereof and thus the number of years remaining until its effects become apparent, assuming no change in human-activity patterns.

D. pointing out the need to obtain essential scientific data on the slow but perceptible changes in the environment of the world in order to establish the extent of the changes taking place, and the measures to be taken to avoid or reduce their unfavourable effects and to exploit beneficial consequences.

1. Stresses that it is imperative to make more-reaching countermeasures than those currently implemented to combat pollution, provided such measures are directed at releases of both carbon dioxide and propellants, since, contrary to earlier assumption, the latter are just as significant a cause of temperature build-up as the former;

2. Calls upon the Commission, in future activities in the field of agricultural, industrial and energy policy and in negotiations with both national and international authorities, to put forward measures with a view to a substantial reduction of harmful discharges, thus benefiting the environment too;

3. Emphasizes in this connection the automatic benefit to be gained from large-scale energy-saving and rational use of energy, possibly in tandem with exploitation of cleaner energy sources and flue-gas purification respectively;

4. Calls for a worldwide policy of reafforestation, for which the Community should provide an example with its own forestry policy;

5. Calls for financial Community development policy measures to help put an end to the deforestation of rain forests in Third World countries;

6. Calls on the Council when drawing up the new framework programme for research to allocate more resources to the area of climatology, especially relating to changing temperature gradients including ocean-atmosphere interaction;

7. Stresses that preventing pollution of the world's seas is an essential requirement for climatic stability;

8. Recalls that it is incumbent upon the industrialized countries of the Northern hemisphere, which are largely responsible for jeopardizing climate, to ensure that the developing nations are given access to the latest technological know-how;

9. Instructs its Members, in collaboration with the relevant scientific quarters, to inform the public - and particularly the operators directly responsible - about the implications of the human activities in question, while explaining the need for effective measures;

10. Instructs its committee responsible to include in their opinions a climatic-impact assessment of future Community-level activities with a view to reducing the current temperature build-up;

11. Instructs its President to forward this resolution and the report of its committee to the Council and the Commission."

Programme de travail de la Commission concernant l'analyse des options politiques permettant de faire face aux risques associés à l'"effet de serre"

I. CONTENU DU PROGRAMME

Le présent programme de travail devrait apporter toutes données utiles permettant de déterminer le rôle que la Communauté et ses Etats membres pourraient jouer dans la définition et la promotion, au sein d'un contexte international approprié, des mesures nécessaires pour faire face aux risques associés à l'effet de serre.

A cette fin, il portera sur les points suivants :

A. Identification des actions permettant de prévenir ou de réduire les émissions de gaz entraînant un effet de serre

Les mesures nécessaires pour réduire conformément aux objectifs stratégiques fixés en la matière, les émissions des différents gaz entraînant un effet de serre seront identifiées. Pour chacun de ces gaz, il sera procédé à une évaluation détaillée des méthodes de réduction existantes et du niveau de réduction associé à chaque méthode. Les possibilités de réduction ou de prévention des émissions seront étudiées dans les secteurs suivants :

- la production d'énergie;
- la consommation d'énergie (y compris les transports);
- la production industrielle;
- l'utilisation de produits;
- l'agriculture.

L'approche choisie devra tenir compte des différences spécifiques existant entre pays ou groupes de pays. Elle devra notamment prendre en considération :

- le stade de développement économique,
- la politique énergétique,
- la géographie.

B. Implications des méthodes de réduction des émissions

Les méthodes de réduction des émissions seront évaluées quant à :

- leurs implications techniques et industrielles,
- leurs implications financières et économiques,
- leurs implications politiques, institutionnelles et sociales.

C. Mise au point d'un cadre d'analyse de la décision

Ce cadre permettra de structurer les informations disponibles sur tous les aspects de l'effet de serre et, partant, d'identifier les avantages probables (en termes de diminution des risques de modification climatique, etc.) des différentes méthodes envisageables. Il tiendra compte :

- des émissions et des réductions d'émission,
- des implications de ces réductions,
- des données scientifiques disponibles sur les avantages potentiels des différents modes de réduction des émissions.

Il sera conçu de manière à intégrer le facteur d'incertitude attaché aux émissions, à l'efficacité des contrôles, aux changements climatiques et à leurs effets et permettra d'identifier les résultats les plus probables des différentes actions.

Ce cadre permettra également d'étudier les implications d'un report éventuel de l'action. En structurant le problème et en identifiant les principaux facteurs d'incertitude qui influencent le plus les résultats, il fournira un outil majeur pour évaluer les actions et focaliser la recherche future sur des domaines clés.

D. Evaluation, à l'aide du cadre d'analyse de la décision, des avantages probables des différentes méthodes de réduction des émissions et établissement des scénarios climatiques et d'impact résultant de la mise en oeuvre de ces méthodes

Le cadre sera utilisé pour déterminer les résultats possibles des diverses méthodes de réduction des émissions et de leur calendrier d'exécution (scénarios). Il indiquera également la probabilité relative des résultats qui seraient atteints.

E. Identification et évaluation des mesures d'adaptation nécessaires dans le cadre des différents scénarios élaborés conformément au point D ci-dessus

La mise en oeuvre des mesures de réduction des émissions ne fera pas disparaître complètement les risques résiduels associés aux émissions passées et aux émissions futures qui ne peuvent être supprimées. Des mesures d'adaptation (actions visant à protéger la population, les biens, l'agriculture et les ressources naturelles et économiques) devront donc être prises. L'importance et la localisation des risques résiduels majeurs seront définies, les coûts en argent et en temps des différentes mesures d'adaptation évalués. Les mesures d'adaptation devront être classées par ordre de priorité en vue de garantir que les ressources disponibles soient exploitées au mieux et que l'accent soit placé sur les principaux domaines de préoccupation.

II. LISTE DETAILLEE DES ACTIVITES

L'exécution du présent programme nécessitera entre autres les activités suivantes :

A. Analyse des émissions et méthodes de réduction des émissions

I) Etablissement d'analyses d'émissions pour chaque gaz entraînant un effet de serre. Ces émissions devraient être analysées par (a) régions, (b) par groupes politiques, stratégiques et économiques.

II) Définition des facteurs (autres que les mesures de réduction) susceptibles d'influencer les émissions futures. Evaluation de leur probabilité et établissement des divers scénarios d'émissions correspondants.

III) Identification des méthodes de réduction des émissions applicables pour chaque gaz entraînant un effet de serre. Evaluation des réductions potentielles dans le cadre des différents scénarios d'émissions.

B. Evaluation des implications des méthodes de réduction des émissions

I) Définition de la faisabilité, du coût et du calendrier d'exécution de chaque mesure de réduction des émissions.

II) Evaluation des effets sociaux et économiques.

III) Evaluation des effets sur la distribution (a) au sein de chaque pays, (b) entre pays, (c) entre groupes politiques et stratégiques.

C. Etablissement d'un cadre permettant d'intégrer les informations obtenues au cours du programme de travail

Ce cadre devrait être conçu de manière à :

- montrer les implications des différentes actions, y compris les coûts et les avantages potentiels;

- indiquer les implications des reports éventuels de l'action;

- indiquer le bien-fondé des décisions possibles (en ce qui concerne les stratégies de réduction ou d'adaptation) compte tenu du caractère incertain des prévisions et des données scientifiques disponibles;

- mettre en lumière les recherches ultérieures nécessaires pour pouvoir prendre les décisions qui s'imposent.

D. Evaluation des stratégies de réduction des émissions

I) Détermination des avantages potentiels qui résulteraient de l'application des stratégies de réduction des émissions. Ce travail nécessitera un examen critique des liens existant entre les concentrations de gaz provoquant un effet de serre et le réchauffement global, portant notamment sur les systèmes de rétroaction, le calendrier d'exécution et les implications pour les climats régionaux.

II) Evaluation, fondée sur l'examen critique précité, de la vraisemblance des différentes prévisions et de leurs implications. Ce travail devrait intégrer les avis des principaux experts et, si possible, déboucher sur l'établissement de taux de probabilité reflétant le degré d'incertitude des différents résultats.

III) A partir de ces informations, et des informations obtenues sur les réductions d'émissions (A) et leurs implications (B), utilisation du cadre de décision visé au point C) en vue d'évaluer les coûts, les avantages et les autres implications des différentes méthodes de réduction des émissions.

E. Evaluation des mesures d'adaptation

i) Etude des implications des différents niveaux de réchauffement notamment sur l'infrastructure et les ressources alimentaires européennes; identification d'autres conséquences majeures. Evaluation des effets sur d'autres groupes politiques et économiques de pays.

ii) Examen des méthodes qui pourraient être mises en oeuvre pour faire face aux changements potentiels (i) (exemple : nouvelles variétés de plantes cultivées, nouvelles méthodes de planification, etc.)

iii) Détermination, grâce à l'évaluation visée sous (D) et au cadre de décision visé sous (C), des coûts et avantages des différentes mesures d'adaptation; évaluation de l'efficacité probable de ces mesures d'adaptation à la lumière des effets prévus.

III. LIGNES DIRECTRICES POUR L'EXECUTION DU PROGRAMME

A. La Commission tiendra compte, dans l'exécution du présent programme, des autres activités pertinentes menées aux niveaux communautaire et mondial, telles que :

- le programme de recherche de la CE en matière de climatologie et de risques naturels;
- les programmes du Centre Commun de Recherche concernant l'économie d'énergie, l'énergie solaire et la conversion thermique, la sécurité nucléaire, etc.;
- les conférences internationales (telle la récente conférence sur les modifications de l'atmosphère, Toronto, juin 1988);
- les activités du groupe de travail PNUE/OMS sur les modifications climatiques;

etc.

A cette fin, la Commission établira une coopération appropriée avec les organisations concernées par ces activités.

B. Avec l'assistance du comité visé à l'article 1er de la décision, la Commission définira les modalités et les mesures concrètes d'exécution du présent programme de travail ainsi que les informations que doivent fournir les Etats membres.

Les organisations et ministères compétents des Etats membres seront associés au travail par l'intermédiaire du comité susmentionné.

IV. FINANCEMENT DU PROGRAMME

Les fonds qui sont considérés nécessaires à l'accomplissement du programme s'élèvent à 6 millions d'ECUS.

Projet

de

Résolution du Conseil concernant "l'effet de serre et la Communauté"

Le Conseil des Communautés européennes,

vu le Traité instituant la Communauté économique européenne,

vu le projet de Résolution de la Commission,

considérant que le traité instituant la Communauté économique européenne, modifié par l'acte unique européen, prévoit le développement et la mise en oeuvre d'une politique communautaire en matière d'environnement et que ce même traité prévoit que dans l'élaboration de son action dans ce domaine la Communauté tienne compte notamment des données scientifiques et techniques disponibles et des avantages et des charges qui peuvent résulter de l'action ou de l'absence d'action;

considérant que la présente résolution s'inspire des considérations figurant dans la Résolution du 19 octobre 1987 concernant un programme d'action des Communautés européennes en matière d'environnement[1], à savoir l'opportunité d'agir au niveau approprié, ainsi que la nécessité de coordonner les travaux au niveau international, d'évaluer les avantages et les coûts des actions envisagées et de préparer l'action de façon adéquate du point de vue technique et politique;

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(1) J.O. n° C328 du 7.12.1987, p.1

considérant que les données scientifiques disponibles, notamment les résultats des programmes de recherche en matière d'environnement de la Communauté, indiquent que la composition de l'atmosphère est en train d'être sensiblement modifiée par les activités de l'homme et que, sur la base des modèles climatologiques disponibles, cela pourrait entraîner à terme par un effet dit de serre, des modifications du climat et par cela des impacts importants sur l'environnement, sur l'homme et sur ses activités;

considérant que compte tenu de la nature et des dimensions des risques entraînés par l'effet de serre, il est urgent de procéder à un examen des possibilités d'action visant à prévenir ou à réduire ces risques;

considérant que lors de récentes conférences internationales un très large consensus s'est dégagé concernant la nécessité de considérer d'urgence des mesures visant à réduire les émissions des gaz responsables de l'effet de serre;

considérant que compte tenu de la complexité du sujet "effet de serre", des vastes et multiples implications à la fois de cet effet et des mesures envisageables pour en prévenir ou en mitiger les conséquences, un examen préalable approfondi des options politiques possibles, réalisées par des méthodologies appropriées qui tiennent notamment compte de manière adéquate des incertitudes qui subsistent sur plusieurs aspects du sujet en question, est nécessaire;

considérant qu'il est de la plus haute importance que la Communauté et ses Etats membres soient en mesure de donner une contribution fondamentale à la réflexion et à l'élaboration concernant les décisions politiques éventuelles à prendre dans les enceintes internationales appropriées afin d'agir de la manière la plus efficace contre les risques de modification climatique.

Accueille favorablement la communication de la Commission concernant "l'effet de serre et la Communauté" et approuve les principales conclusions et recommandations qu'elle contient.

Déclare que la Communauté devrait consacrer une attention grandissante aux risques des modifications climatiques possibles associés à l'effet de serre et qu'elle devrait contribuer de façon substantielle à promouvoir la réflexion et la discussion concernant les mesures possibles visant à contrer ces risques.

Accueille favorablement l'initiative de la Commission de lancer un programme de travail concernant l'évaluation des options politiques pour faire face aux risques associés à l'effet de serre et approuve les objectifs de ce programme.

Invite les Etats membres à coopérer activement avec la Commission dans l'exécution du programme de travail susmentionné et à coordonner leurs activités concernées dans le domaine de l'effet de serre, dans le cadre de ce programme.

Invite la Commission à présenter au Conseil et au Parlement Européen un rapport d'avancement à la moitié de 1990 et un rapport final sur les résultats obtenus par ce programme de travail et sur les conclusions tirées à la fin de 1991.