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TECH-96-532
7/15/96

TO: AIAM Technical Committee

FROM: Gregory J. Dana
Vice President and Technical Director

RE: **GLOBAL CLIMATE COALITION (GCC) - Science and Technology Assessment Committee - Minutes of the June 20, 1996 Meeting**

Enclosed is a copy of the minutes of the June 20, 1996 meeting of the Science and Technology Assessment Committee (STAC) of the GCC along with the handouts from the meeting.

GJD:lfz

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American Petroleum Institute

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Howard J. Feldman
Research Program
Coordinator -Air

July 2, 1996

To: GLOBAL CLIMATE COALITION -
SCIENCE AND TECHNOLOGY ASSESSMENT COMMITTEE

Enclosed are the minutes of the GCC STAC meeting of June 20, 1996. In the interest of avoiding massive deforestation, attachments which were distributed at the meeting are provided only for those of you who did not attend the meeting. Attendees missing a particular attachment should contact my assistant, Ms. Kobayashi at 202-682-8334.

Please contact me if you have any questions.

Sincerely,

Howard J. Feldman

Enclosure
cc: J. Shaw
T. Kirlin
M. Baer
R. Jones

GLOBAL CLIMATE COALITION
SCIENCE AND TECHNOLOGY ASSESSMENT COMMITTEE (STAC)
MEETING OF JUNE 20, 1996

The June 20, 1996 meeting of the STAC was held at the American Petroleum Institute from 11 AM to 3 PM. A copy of the attendance sheet is Attachment 1 and a copy of the agenda is Attachment 2.

Minutes from Previous Meeting

No comments were noted on the previous minutes.

Preparations for COP-2 - Bernstein

Preparations for COP-2 are underway. Mr. Montgomery and Ms. Holmes are scheduled for briefings and a NERA report will be released. Mr. Bernstein indicated that a presentation by MIT researchers was also being scheduled. Attachment 3 is a paper from the MIT Global Change program. (The recent Climate Forum at MIT was discussed, including the keynote address, the MIT economics model, and technical reservations by MIT researchers regarding the IPCC techniques.)

GCC report - Shlaes

Mr. Shlaes brought five journal articles in Science to the attention of the attendees: a) Overpeck(3/29/96); b) Robock and c) Haigh (5/17/96); and d) Research News and e) Schwartz and Andreae (5/24/96).

Also, Mr. Shlaes indicated that:

- At a recent economics conference many organizations were supporting our position;
- An economics model showing little cost due to greenhouse gas reductions has been challenged;
- In two meetings with Ms. Claussen, the concept of targets and timetables was challenged;
- The GCC position was one of no need for rushing into any controls;
- COP-2 will be active with a GCC delegation of 19-20;
- A lot of recent effort has been expended questioning and challenging the IPCC Working Group I report Chapter 8 changes;
- The following IPCC technical papers are now scheduled:
    - simple climate models
    - modeling of greenhouse gas stabilization
    - implications of emissions limitations
    - policies and measures
    - regional impacts of climate change
    - technology transfer;

- Testimonies from D. Albritton and R. Pomerance were distributed (Attachments 4 and 5).

IPCC Response to GCC Criticism of their Process - Gardner

Publications which have joined in questioning the IPCC approach to conforming technical reports to summaries include the NYTimes, Wall St. Journal, Energy Daily, and Nature. Dr. Bolin and the GCC have also exchanged correspondence. Internet posting of the correspondence is unlikely.

Review of Papers

Measuring Changes in Sea Level (Rasmussen) - This paper was approved by the STAC with minor changes for approval by the Operating Committee for internal use by the GCC and its members.

Quantification of human and natural effects (Gardner) - The Operating Committee will be queried regarding its needs regarding this paper.

Intermodel Comparisons (Gardner) - This paper was being forwarded to the Operating Committee for review and approval.

Definitions of Key Phrases (Gardner) - This paper will be modified to incorporate changes to "broadly consistent" and discernible human influence" sections.

Argonne Lab Research on Paleoclimate

Argonne researchers would be invited to attend a STAC meeting but notified that funding is not available from STAC for attendance or research.

Other

A chart questioning the statement that 1995 was the hottest year was distributed (Attachment 6).

Plans for future meetings

The next meeting is planned for August 1, 1996 at the National Mining Association.

Minutes prepared by

Howard J. Feldman

GCC STAC mtg 6/20

			Fax
Howard Feldman	API	202 682-8340	x8270
George Lauer	ARCO	213 486-0777	x 2021
Jim Smithson	Ill. Power	217-362-7979	x 7649
Roger Nelson	EPRI	415-774-2297	x 2028
Bronson Gardner	GCC	216-475-9674 (ph/fax)	
John Shiller	Ford Motor Co.	313-845-5702	313 594-427.
Tom Rasmussen	NMA	202 463-9796	202 833-9636
Fred Starheim	Ohio Edison Co.	(330) 384-5891	-5433
Chuck Sharp	AAMA	(616)533-8127 (ph/fax)	
Porter Womeldorff	Wom Assoc for IL Power	(217) 422-9174 (phone/fax)	
Lenny Bernstein	Mobil	703-846-3530	703-846-2912
John Kinsman	EEI	202 508 5711	202 508 5150
Eric Kuhn	Cinergy	513-287-4061	513-287-3499
John Holt	NRECA	703 907 5805	5517
John Shlaes	GCC	202-637-3162	202-638-104[illegible]

GCC SCIENCE AND TECHNOLOGY ASSESSMENT COMMITTEE

June 20, 1996
11:00 a.m.
American Petroleum Institute
Room 1273, 1220 L Street, N.W.
Washington, DC

DRAFT AGENDA

1.	Approval of the Minutes	
2.	GCC Report	Shlaes/Holdsworth
3.	Preparations for COP-2	Bernstein/Gardner
4.	IPCC Response to GCC Criticism of their Process	Gardner
5.	Approval of Papers	
	• Sea Level Change	Rasmussen
	• Temperature Record	Reiner
	• Topics Not Adequately Addressed by IPCC	Gardner
6.	Argonne Lab Research on Paleoclimate	Bernstein
7.	Next Meeting	
8.	Any Other Business	
9.	Adjourn	

QELRO Impacts: Domestic Markets, Trade and Distribution of Burdens, and Climate Change

by

H. D. Jacoby, R.S. Eckaus, A.D. Ellerman, R.G. Prinn, D.M. Reiner, and Z. Yang

Joint Program on the Science and Policy of Global Change
Massachusetts Institute of Technology

Workshop on Analysis of Issues Related to Next Steps on Climate Change

Hosted by

U.S. Departments of Agriculture, Commerce, Energy and State, and the Environmental Protection Agency

Springfield, Virginia

6-7 June 1996

AIAM-051236

QELRO Impacts: Domestic Markets, Trade and Distribution of Burdens, and Climate Change

by
H. D. Jacoby, R.S. Eckaus, A.D. Ellerman, R.G. Prinn, D.M. Reiner, and Z. Yang

Joint Program on the Science and Policy of Global Change
Massachusetts Institute of Technology

1. THE ASSESSMENT TASK

National acceptance of quantified emissions limitation and reduction objectives (QELROs), as suggested under the Berlin Mandate (United Nations, 1995), implies the imposition of constraints on emissions of CO_2 and perhaps other greenhouse gases. Such actions taken by one set of countries can have a number of economic impacts, not only on those adopting the restrictions, but on other regions of the world as well. If controls lead to reductions in economic activity in one set of countries, the changes will affect demands for the exports of other countries, and thus influence their levels of Gross Domestic Product (GDP). The relative prices of different sources of energy will also be changed, with consequent effects on the relative prices of non-energy goods. These changes in relative prices occur both within countries (leading to in-country substitution) and between countries (leading to trade adjustments), and thus further influence economic performance.

As a result of this complex web of adjustments, emissions reductions achieved by one set of countries may be counteracted to some degree by increases in emissions elsewhere, producing so-called carbon "leakage." Also, economic burdens may be imposed on countries that have not accepted obligations under the Framework Convention on Climate Change or its Berlin Mandate. If, in an effort to reduce costs, countries facing emissions restrictions adopt some form of burden-sharing scheme (such as emissions trading) these effects may be moderated. The magnitude of the amelioration depends on precisely which groups of nations participate.

Here we examine one prominent QELRO proposal, in order to explore how the various adjustment mechanisms work to determine leakage and distribute burdens. Further, in order to place the analysis in the context of the larger climate issue, we follow the effects of this proposal through the climate system, to assess its effect on estimates of one indicator of possible climate change. There is unavoidable uncertainty in the magnitudes of the various effects of interest, as illustrated below, but these model exercises can be very useful in forming judgments about why various outcomes are to be expected, and how alternative assumptions about the world can influence estimates of the size of the impacts.

The case chosen for study is a modified version of a proposal by the Alliance of Small Island States (AOSIS) and Germany. Under it, OECD nations[1] agree to stabilize their CO_2 emissions at 1990 levels by the year 2000, and to bring these emissions down to 80% of 1990 levels by 2010.[2] Emissions of other anthropogenic greenhouse gases (methane,

[1] The regional definitions used are appropriate for around 1990. OECD members include the United States, Japan, the 12 members of the European Community, Canada, Australia, New Zealand, EFTA (excluding Switzerland and Iceland), and Turkey. Mexico, a recent addition, is not included in the OECD as defined in this analysis.

[2] This version differs from that proposed by AOSIS and Germany which provides for a reduction by all Annex I countries of their CO_2 emissions to 20% below 1990 levels by the year 2005 (United Nations, 1994).

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nitrous oxide, chlorofluorcarbons) or of aerosol-producing sulfur dioxide may be influenced by this commitment, but they are not a direct object of the control policy in this example.

The hypothesis underlying this analysis of impacts is that the AOSIS protocol is adopted now, and it is sustained as the only climate policy over the next century. Its impacts are then calculated by comparison with a "no policy" case, where no actions are taken to control greenhouse emissions over this period. This "policy scenario" construction allows isolation of the effects of this particular protocol, but care must be taken in interpreting the results. As seen by its proponents, the AOSIS protocol is not a climate policy in itself, but the first step on a path that should lead to subsequent commitments by the OECD countries, and eventually to some level of restraint by all Convention signatories. Also, decisions for the next century are not made once and for all today: we will learn with time, and revisit these choices. For clarity in the study of the impacts of QELROs currently under consideration, however, these potential future adjustments are set aside.

2. THE MIT ANALYSIS SYSTEM

The study is carried out using the Global System Model for analysis of climate change developed by the MIT Joint Program on the Science and Policy of Global Change (Prinn *et al.*, 1996). [3] The Global System Model is comprised of several components, including (1) a model of economic growth and associated anthropogenic emissions of climate-relevant gases, (2) a coupled model of atmospheric chemistry and climate, (3) a model of the effects of climate change on terrestrial ecosystems, and (4) a model of the effects of CO_2 and climate changes on the natural cycles of key greenhouse gases. In these experiments we report only one aspect of the climate consequences predicted in the model, which is the change in global temperature.

2.1 The EPPA Model

The analysis reported here makes primary use of one component of this global analysis model, the MIT Emissions Prediction and Policy Analysis (EPPA) Model (Yang *et al.*, 1996). In interpreting the results below, it is useful to have some idea of the structure of this model. EPPA is a recursive-dynamic computable general equilibrium (CGE) model which is derived from the General Equilibrium Environmental (GREEN) Model developed by the OECD (Burniaux *et al.*, 1992a). In the design of the EPPA model, many changes have been made in the GREEN formulation, but the specification of production, consumption and trade remains much the same, as does a major portion of the underlying data base.

As summarized in Figure 1, a computable general equilibrium model is a mathematical representation of a national or regional economy, with supplies of input factors (e.g., labor, capital, land and other resources), consumer demand functions, and a representation of production technologies. By providing inputs to the production process, consumers earn the income to purchase final goods, and the circular flow of income and expenditure in such a model is captured in a simplified version of a national accounting system. It is an

---

[3] The Model has been developed with the support of a government-industry partnership including the U.S. Department of Energy (901214-HAR; DE-FG02-94ER61937; DE-FG02-93ER61713), U.S. National Science Foundation (9523616-ATM), U.S. National Oceanic and Atmospheric Administration (NA56GP0376), and U.S. Environmental Protection Agency (CR-820662-02), and a group of corporate sponsors from the United States, Europe and Japan.

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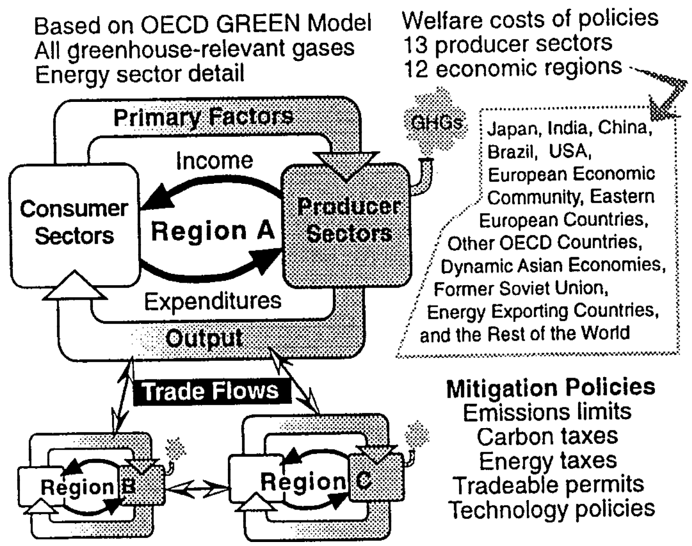

Figure 1. Features of the EPPA Model

"equilibrium" model because it finds a set of product and factor prices that balance supplies and demands in each period. It is "general" in that it clears *all* markets and not just one or two; it is called "computable" because, while such models have been formulated analytically for many decades, only with the advent of modern digital computers could an application of any size be solved in practice. The EPPA model is "recursive," meaning that it is solved by stepping forward in time without an ability to anticipate possible future changes in relative prices, or the imposition of new constraints. It is "dynamic" in the sense that the capital stocks available in any period are an inheritance from decisions in previous periods.

The model covers the period 1985 to 2100 in five-year steps. The world is divided into 12 regions, as shown in Table 1, which are linked by multilateral trade. The economic structure of each region consists of eight fully elaborated production sectors (3 non-energy and 5 energy) and four consumption sectors, all shown in the table, plus one government sector and one investment sector (not shown). The detail of the production sectors is designed to highlight sub-components of the energy sector because of their importance in the emissions of greenhouse-relevant gases.

The current version of the model also incorporates two future energy supply or "backstop" production sectors, represented as linear functions of their inputs of labor and capital. One of the backstops represents heavy oils, tar sands and shale, and it produces a perfect substitute for refined oil. Because of extensive processing requirements, substantial CO_2 is emitted by the production of this backstop (and is credited to its regions of origin) as well as at the place where the refined oil is consumed. The other backstop sector is a non-carbon electricity source, which represents the possible expansion of technologies like advanced nuclear and solar power. The non-carbon electric backstop is available in all regions. However, the carbon-liquids backstop are assumed to be produced in only three regions which are now known to have substantial amounts of the necessary resources: The Energy Exporting Countries (e.g., Venezuelan tars and heavy oils), the Other OECD (e.g., Canadian and Australian tar sands) and the United States (e.g., Western oil shales). The location of this carbon-liquids potential will prove important in interpreting the results below.

Table 1. Key dimensions of the EPPA model

Production sectors	
Non-Energy	
1.	Agriculture
2.	Energy-intensive industries
3.	Other industries and services
Energy	
4.	Crude oil
5.	Natural gas
6.	Refined oil
7.	Coal
8.	Electricity, gas and water
Future Supply Technology	
9.	Carbon liquids backstop[1]
10.	Carbon-free electric backstop[2]

Consumer sectors	
1.	Food and beverages
2.	Fuel and power
3.	Transport and communication
4.	Other goods and services

Primary Factors	
1.	Labor
2.	Capital (by vintage)
3.	Fixed factors for each fuel, and for land in agriculture

Regions (and abbreviations)		
1.	United States	USA
2.	Japan	JPN
3.	European Community	EEC
4.	Other OECD[3]	OOE
5.	Central and Eastern Europe[4]	EET
6.	The former Soviet Union	FSU
7.	Energy-exporting LDCs[5]	EEX
8.	China	CHN
9.	India	IND
10.	Dynamic Asian Economies[6]	DAE
11.	Brazil	BRA
12.	Rest of the World	ROW

Gases (and chemical formulae)		
1.	Carbon Dioxide	CO_2
2.	Methane	CH_4
3.	Nitrous Oxide	N_2O
4.	Chlorofluorocarbons	CFC
5.	Nitrogen Oxides	NO_x
6.	Carbon Monoxide	CO
7.	Sulfur Oxides	SOx

[1] Liquid fuel derived from tars, oil sands, and oil shale
[2] Carbon-free electricity derived from advanced nuclear, solar, or wind
[3] Australia, Canada, New Zealand, EFTA (excluding Switzerland and Iceland), and Turkey
[4] Bulgaria, Czechoslovakia, Hungary, Poland, Romania, and Yugoslavia
[5] OPEC countries as well as other oil-exporting, gas-exporting, and coal-exporting countries. See Burniaux *et al.*, 1992b
[6] Hong Kong, Philippines, Singapore, South Korea, Taiwan, and Thailand

Each of the eight producer sectors is modeled by a nested set of production functions which allows a flexible representation of the degree of substitution between inputs to the production processes. The output of each sector results from the combination of energy and intermediate goods (provided by other production sectors), and three primary factors: capital, labor, and a fixed factor. The fixed factor represents land in agriculture, reserves in the production of oil, gas and coal, and the supply of nuclear and hydro power to the electric sector. It also is assumed, in the model solutions described here, that there are multiple vintages of capital, each with characteristics fixed at the time of investment.

All goods are traded among regions. With the exception of two of these, imported goods are imperfect substitutes for the equivalent domestic ones, and goods imported from

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alternative foreign regions are imperfect substitutes for one another. The two exceptions are crude oil and natural gas: imported and domestic supplies of each are treated as perfect substitutes. Calculated within the model are all relative prices, including the wage rate and the return to capital. The returns to capital, along with the level aggregate income, determine the level of savings (and thus of investment and capital formation). The model is calibrated with 1985 data, with a data set consisting of Social Accounting Matrices (SAMs) for each of the 12 regions, and a bilateral trade matrix. The data set now in use was compiled by the OECD (Burniaux *et al.*, 1992b).

Energy use in production and consumption produces varying amounts of CO_2, CH_4, N_2O, SO_2, CO and NO_x, depending on the fossil source and the policies assumed to be in place. (Emissions of CO_2 from deforestation are exogenous to the EPPA model.) Similarly, trace gas emissions result from non-energy-consuming activities included in the model (e.g., a component of anthropogenic CH_4 is driven by the level of activity in the agriculture sector). Emissions by region are then converted to emissions by latitude, which are the necessary inputs to the model of atmospheric chemistry and climate described below.

The major driving factors in the model are population change, the rate of productivity growth (stated in terms of labor productivity and denoted LPG), and a rate of Autonomous Energy Efficiency Improvement (AEEI) which reflects the effect of non-price-driven technical change on the energy intensity of economic activity. Another important influence on economic growth, the rate of capital formulation, is endogenous to the model. Finally, a key determinant of the carbon intensity of economic growth, which also has an important influence on the distribution of burdens of a policy of carbon restriction, is the assumed costs of the backstop technologies (production sectors 9 and 10 in Table 1) relative to conventional sources.

Policies implemented in the EPPA model may take the form of either price instruments (taxes or subsidies) or quantitative measures (quotas). The quantitative instruments are CO_2 emission quotas imposed on individual regions or blocks of regions (e.g., the OECD), and quotas can be tradable among regions. Carbon quotas depress the demand for output from the energy sectors, particularly the more carbon-intensive ones, and shift the equilibria in the economy away from the no-policy baseline. The adjustments are complex and may include:

- Substitution among fuels,
- Substitution in production among inputs of energy, capital, labor, and fixed factor.
- Changes in the mix of goods consumed, and
- Shifts in international trade, both in energy and non-energy goods.

As a result of the economic adjustments to a carbon constraint imposed in a particular country, there is, in general, a reduction in GDP and consumption levels, although the effect may be the opposite. The latter occurs when the tax or quota has the effect of offsetting the distortion from an existing subsidy. The effect on other countries also may be either positive or negative, depending on the interaction of trade effects. In describing the overall effects of the emissions constraints, a measure of economic welfare is used which is related to aggregate consumption within a region, discounted over time in most cases.

2.2 Climate Component of the MIT Integrated Framework

To illustrate the climate consequences of the AOSIS protocol, use is made of a coupled model of atmospheric chemistry and climate dynamics, which also is part of the larger MIT Global System Model (Prinn *et al.*, 1966). A two dimensional (2D) land- and ocean-

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resolving statistical-dynamical model is used to address climate dynamics (Sokolov and Stone, 1994). It is a modified version of a model developed at the NASA Goddard Institute for Space Studies or GISS. The model's numerics and parameterizations of physical processes (radiation, convection, etc.) are closely parallel to those of the GISS general circulation model (GCM). The grid used in the model consists of 24 points in latitude, corresponding to a resolution of 7.826°. The model has nine layers in the vertical: two in the planetary boundary layer, five in the troposphere, and two in the stratosphere. The important feature of the model, from the point of view of coupling chemistry and climate dynamics, is the radiation code of the GISS GCM that it incorporates. This code includes all significant greenhouse gases (H_2O, CO_2, CH_4, N_2O, CFCs, etc.), and twelve types of aerosols. Many revisions have been made to the model at MIT, including the incorporation of a real land-ocean distribution, and a capacity to handle alternative formulations of cloud dynamics. In climate simulations, the 2D atmospheric model is coupled to an ocean model with parameterized horizontal and vertical transports.

For predictions of atmospheric composition, a 2D atmospheric chemistry model is used which is run interactively with the climate model and has the same horizontal and vertical grid points. It incorporates 25 chemical species, including CO_2, CH_4, N_2O, O_3, CO, H_2O, NO_x, HO_x, SO_2, sulfate aerosol, and chlorofluorocarbons. The coupled atmospheric chemistry and climate model computes the longitudinal means of trace gas and aerosol concentrations over land and ocean.

Other capabilities of the MIT Global System Model—such as estimation of the impacts of increased CO_2 and climate change on the state of terrestrial ecosystems and the rate of ocean uptake of carbon, and effects of climate change on the natural cycles of other greenhouse gases—are not applied in the calculations shown here.

3. SENSITIVITY OF RESULTS TO ECONOMIC ASSUMPTIONS

In this paper we emphasize the point that the magnitude of the various effects of this policy measure are sensitive to underlying assumptions about economic conditions over the next century. As noted earlier, four input assumptions have the greatest influence on future emissions trajectories: population growth, the rate of labor productivity growth, the rate of non-price induced improvement in energy efficiency, and the relative costs of the backstop technologies. The values of all these parameters are subject to substantial uncertainty. To test the consequences of this fact, three of the four parameters were subjected to an uncertainty analysis, applying a probabilistic collocation method under development at MIT (Webster, Tatang and McRae, 1996; Webster, 1996). The judgment of EPPA model developers was applied to the estimation of probability distributions for all but the rates of population growth, and the resulting dispersion of key model outputs was calculated (Webster, 1996).

Figure 2 shows the results for the prediction of global carbon emissions in specific years. With predictions beginning in 1985, the variance of the estimate in 2020 is relatively small. As time progresses, however, the variance increases, as shown by distributions for the years 2050 and 2100. Indeed, in terms of relative likelihood there is very little basis to distinguish between an emissions forecast anywhere in the range of 13 GtC to 22 GtC per year in 2100. Thus, when considering the results presented below, it should be remembered that a prediction anywhere in the central part of the distribution in Figure 2 is of near equal likelihood, and therefore the choice of the Reference Case (whose end-point is indicated "R" in Figure 2) is arbitrary within this range.

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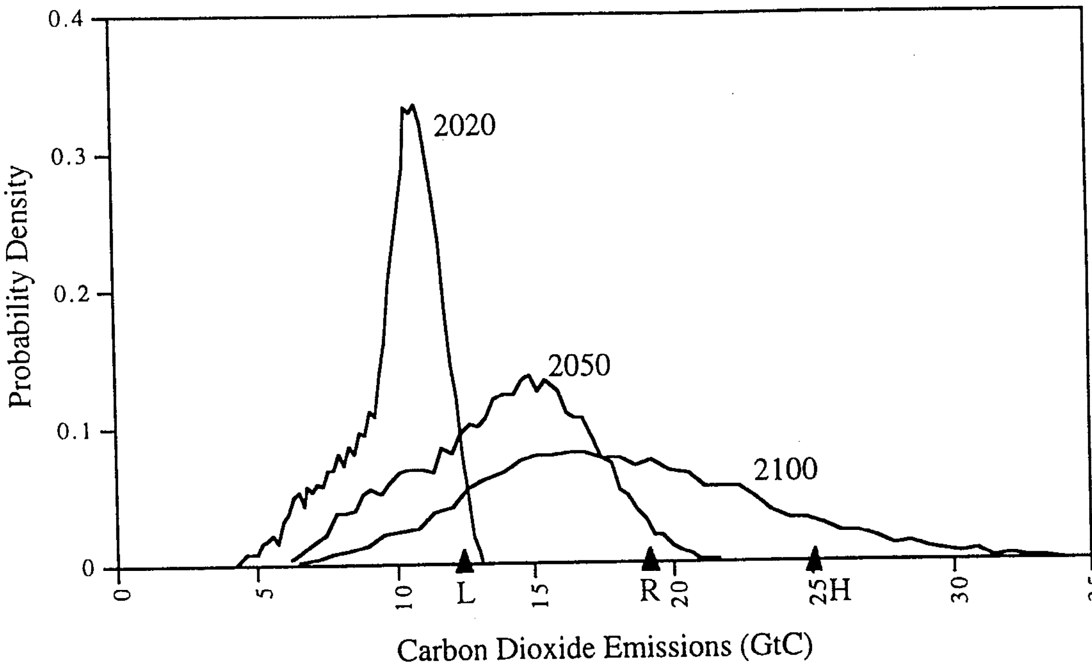

Figure 2. Distribution of CO_2 emissions in 2020, 2050 and 2100 calculated by the EPPA model. The points R, L, and H indicate emissions for the reference, and higher and lower scenarios in 2100.

The implications of this uncertainty for the choice of a reference or base case are illustrated in Table 2, which presents climate and cost predictions for the Reference Case we use below, and for Higher and Lower predictions chosen from the distribution in Figure 2 (where they are indicated as H and L). In the calculation of climate effects, a "reference" version of the coupled chemistry-climate model is used in all cases. Although this component of the analysis also is subject to many uncertainties (Jacoby and Prinn, 1994), these are not explored in this paper. Results of a study using the MIT model of the sensitivity of climate-change predictions to uncertainty in key aspects of the science is provided in Prinn *et al.* (1966).

As can be seen in Table 2, over this range of (nearly indistinguishable) economic predictions, global CO_2 concentrations by the end of the next century range between 539 ppm and 770 ppm, and forecast temperature change ranges from 1.55 °C to 3.36 °C. With this perspective established, we now proceed to study the details of the AOSIS protocol, using the Reference Case prediction shown in Figures 2 and Table 2 as a standard.

Table 2. Sensitivity of the climate and effects of the AOSIS protocol to uncertainty in the factors driving emissions, in the Reference Case and Higher and Lower alternatives.

Policy case	Emissions Case		
	Lower	Reference	Higher
No Policy			
CO_2 Emissions in 2100 (GtC)	12.4	19.0	25.1
CO_2 Conc. in 2100 (ppm)	539	668	770
ΔT, 1990 to 2100 (°C)	1.92	2.53	3.36
AOSIS Protocol			
CO_2 Emissions in 2100 (GtC)	10.5	14.1	17.8
CO_2 Conc. in 2100 (ppm)	507	575	635
ΔT, 1990 to 2100 (°C)	1.55	2.11	2.82

4. DISTRIBUTION OF THE BURDENS OF POLICY

When a carbon constraint is accepted by some regions, the overall system of production, consumption and trade adapts, and the effects are felt both in those countries that are taking direct action to reduce emissions and in countries that are taking no direct action. The consequences for each region, measured in terms of the consumption-based welfare index, are shown in Figure 3. The EPPA model distinguishes four OECD regions: the United States (USA), the European Community (EEC), Japan (JPN) and the rest of the OECD (OOE). Under the AOSIS conditions imposed here, each of these OECD regions meets the AOSIS target independently (the implications of intra-OECD trading are considered later). The depressing effect on the regional economies of the AOSIS CO_2 constraints, which force adjustments to less efficient production and a less desirable composition of output, are clearly shown.[4]

Also striking are the differences in welfare losses among the sub-regions of the OECD. The costs to the United States and the Other OECD are relatively small. This occurs because, in the Reference run, both regions use the carbon-liquids backstop, which is a relatively carbon-intensive technology. If AOSIS were in effect it would be relatively easy to avoid emissions growth by forgoing the development of this non-conventional carbon fuels industry. The EC fares worse than its companion regions. Because it does not have the natural resource base to produce the backstop carbon fuels, they are not present under Reference conditions with no policy. As a result, reductions in their carbon emissions are achieved only with more distorting changes in resource allocation and consumption patterns. The relatively light burden of the AOSIS protocol on Japan is explained by another phenomenon related to the backstop technologies. The *current* cost of electric power in Japan is relatively high by world standards, so that the non-carbon electric backstop enters earlier than in other OECD regions. If the AOSIS restrictions are in place,

[4] Note that the consumption-based welfare index used here (or a companion GDP measure) does not take account of any economic gains from having less CO_2 in the atmosphere. Also, no account is taken of possible environmental benefits from the reduction of other pollutants associated with energy production.

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the development of the non-carbon backstop can be pushed more aggressively because the structure of the Japanese economy makes a shift toward electric power easier than in, say, the United States or Europe.

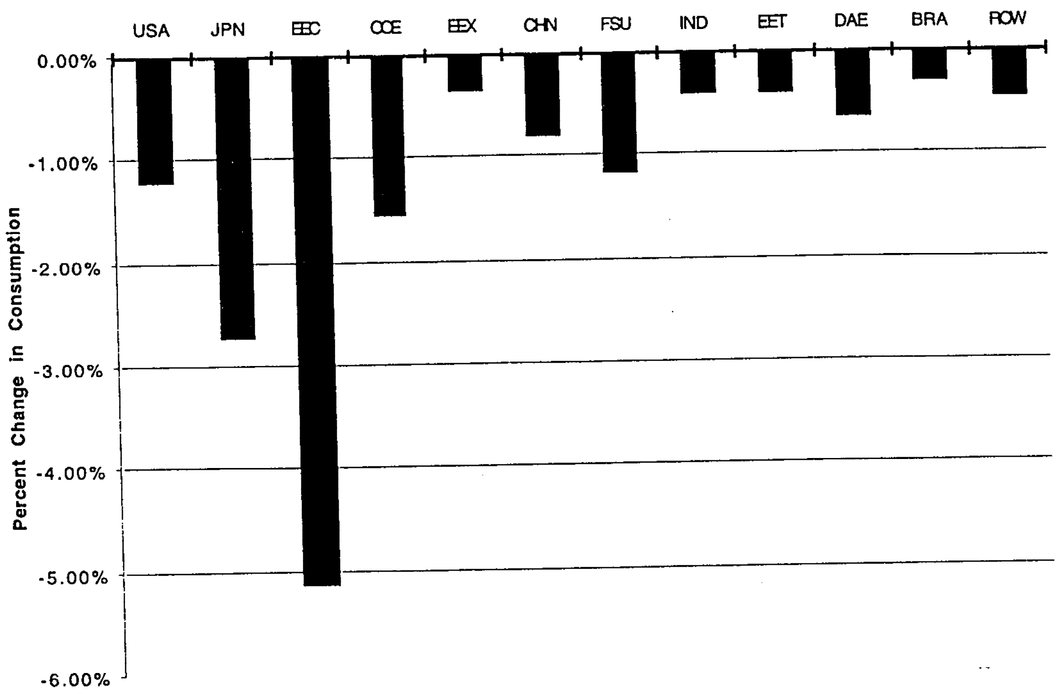

Figure 3. Regional economic impacts of a version of the AOSIS Protocol (impacts expressed as the cumulative percentage loss in consumption between 2000 and 2100, discounted at 5% as computed from the differences between two runs of the EPPA model). See Table 1 for regional abbreviations.

These calculations indicate the important role of these backstop assumptions in the predictions. To illustrate this point in more detail, their effects will be is tested further in Section 5.

Although their losses are smaller than those in the OECD, other world regions also bear a portion of the burden of the AOSIS restraint. Under the conditions of the Reference Case, every region suffers some degree of welfare loss as a result of the reduced demand in the industrialized world, and the consequent adjustments in international trade. The changes projected for the Energy Exporting Countries (EEX), where the burden is relatively light in relation to other non-OECD regions, are particularly noteworthy. Many adjustments contribute to this effect, but the main one concerns the net exports of crude oil and refined oil by EEX countries. Under the model of resource depletion incorporated in the EPPA model, crude oil production in the EEX does not change much when comparing the Reference Case to the AOSIS protocol. Furthermore, the EEX also has the resources to produce exportable refined oil from the carbon-liquids backstop technology. With the AOSIS protocol, which does not restrain emissions in the EEX region, net exports of these liquids (with their carbon emissions at the point of supply) are larger than under the no-policy case. That is because EEX production substitutes for the cutback in carbon liquids production in the two OECD regions that can produce the carbon-fluids technology (USA and OOE).[5] This picture changes substantially under the hypothesis of a world with no backstops, as discussed below.

5. THE MECHANISM OF CARBON LEAKAGE

If one set of world regions constrains activities that produce CO_2, then adjustments through changes in relative prices and shifts in trade patterns may cause increases in carbon emissions elsewhere which would partially offset the gains achieved. This phenomenon is often referred to as the carbon "leakage" associated with a policy applied to a subset of world regions. Taking the AOSIS protocol as defined here as an example, carbon leakage can be defined as that increase in CO_2 emissions under AOSIS (compared to the Reference Case without restraint) stated as a percentage of the reduction in emissions in the OECD. Under this definition, the leakage from the AOSIS protocol under the Reference Case is 6.8% for the period 2000 to 2100.

The magnitude of carbon leakage is, of course, a function of the details of the economic assumptions (as illustrated below), but the primary mechanisms producing it can be illustrated using Figures 4 and 5. Figure 4 shows the percentage change in carbon emissions, by region, resulting from the AOSIS protocol, and separates this net change into two components: one related to GDP loss and another which can be attributed to the many substitution possibilities, between goods and across countries. As a rough approximation of the GDP loss effect, an estimate is made of the change in CO_2 emissions

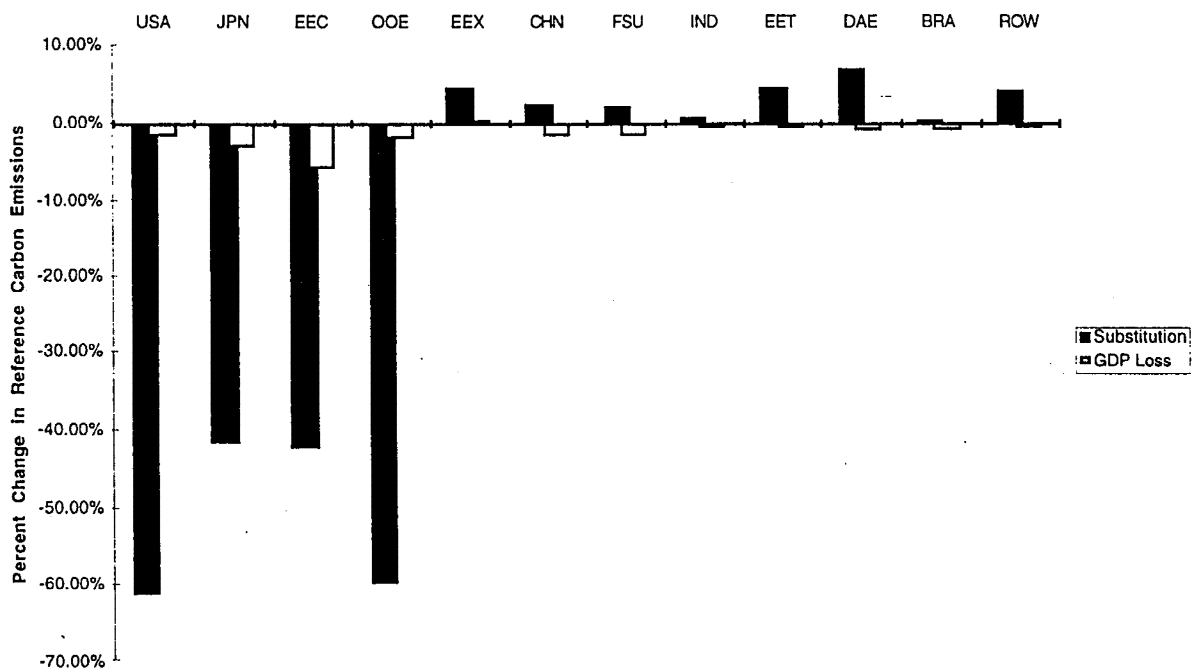

Figure 4. Percentage change in carbon emissions between 2000 and 2100 due to substitution effects and GDP loss resulting from AOSIS Protocol as computed from the differences between two runs of the EPPA model. See Table 1 for regional abbreviations.

[5] Resources of tars, oil sands and oil shale are unevenly distributed among the countries that make up the EEX, and analysis disaggregating this region likely would reveal a diverse pattern of economic impacts.

if the energy intensity of GDP were to remain constant under the GDP changes implied in Figure 4. This component is shown in Figure 4 by the white bars, and it can be seen that there is some reduction in carbon emissions over the period 2000-2100 in each region. The rest of the net change in carbon emissions with the AOSIS protocol is then attributed to the many substitution effects. (The net change in CO_2 emissions over the century in each region is the sum of the black and white bars.)

Several aspects of these results are worth noting. First, the overwhelming factor in OECD adjustments to the AOSIS constraint is the substitution effect, including substitutions among fuels, among means of production of particular output goods, among sectors of consumption, and among goods imported and exported. Second, the depressing effect of OECD restriction on non-OECD economies is to produce a small reduction in their CO_2 emissions. It is the much larger substitution effects which lead to leakage.

Two substitution phenomena are the key contributors to this result. First, the development of tars, tar sand and shale oil resources (the carbon-fluids backstop) in the Energy Exporting Countries makes them a large source of leakage. AOSIS commitments would restrain the expansion of this emerging industry in the two OECD regions that have the needed resources (USA and OOE), but there is no restraint on the EEX, and its carbon-fluids industry grows faster, with a resultant increase in carbon emissions. Second, OECD regions become less competitive, relative to selected non-OECD regions, in the production of the products of the Energy-Intensive Industries sector. This adjustment is most significant in the Dynamic Asian Economies (DAE), which increase their production of

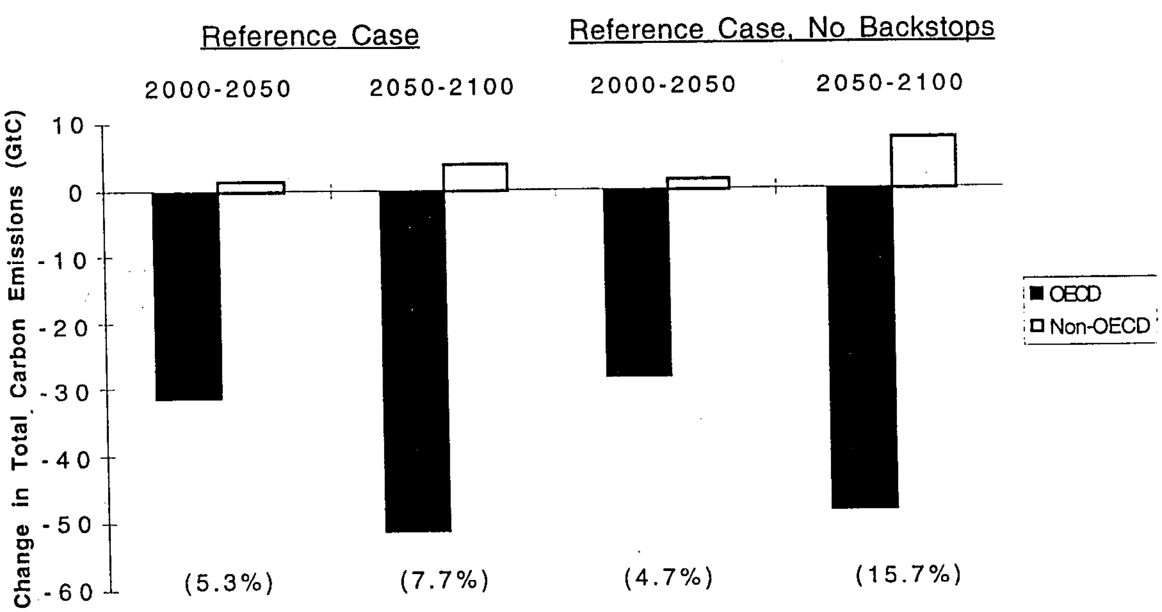

Figure 5. Carbon leakage under the AOSIS protocol, for 2000 to 2050 and 2050 to 2100, under different assumptions about the availability of backstop technologies, computed from differences between runs of the EPPA model. Leakage rates are shown in parentheses.

energy-intensive goods (which they export to the OECD countries in the main) and import additional energy (e.g., coal from OECD sources) to fuel the process. This adjustment through goods trade is most clearly seen when the carbon-fluids backstop, with its large leakage effect, is not present. We illustrate this case below.

For the Reference Case considered here, the pattern of leakage over time is shown on the left-hand side of Figure 5. (The bars on the graph show the net change in carbon emissions, over the periods shown, comparing a world under the AOSIS protocol with one that has no policy of carbon restraint.) In the period 2000 to 2050, the leakage is 5.3%, with the EEX production of the carbon-intensive backstop being a primary cause. In the second half of the century, the carbon-liquids backstop continues to grow in the EEX, and substitution through goods markets intensifies, so the leakage rate rises to 7.7% under AOSIS compared to a no-policy world.

6. SIGNIFICANCE OF THE BACKSTOP ASSUMPTION

As suggested by the previous results, assumptions about the availability and relative cost of the two backstop technologies have a significant effect both on the distribution of burdens of the AOSIS protocol, and on leakage. To demonstrate this point more clearly, we have formulated a dramatically different case. We hypothesize a world where all the conditions in the Reference Case remain the same, except the backstop technologies do not exist. The stark comparison is particularly useful in illuminating the mechanisms that distribute the economic burden among regions, and determine the levels of leakage. By

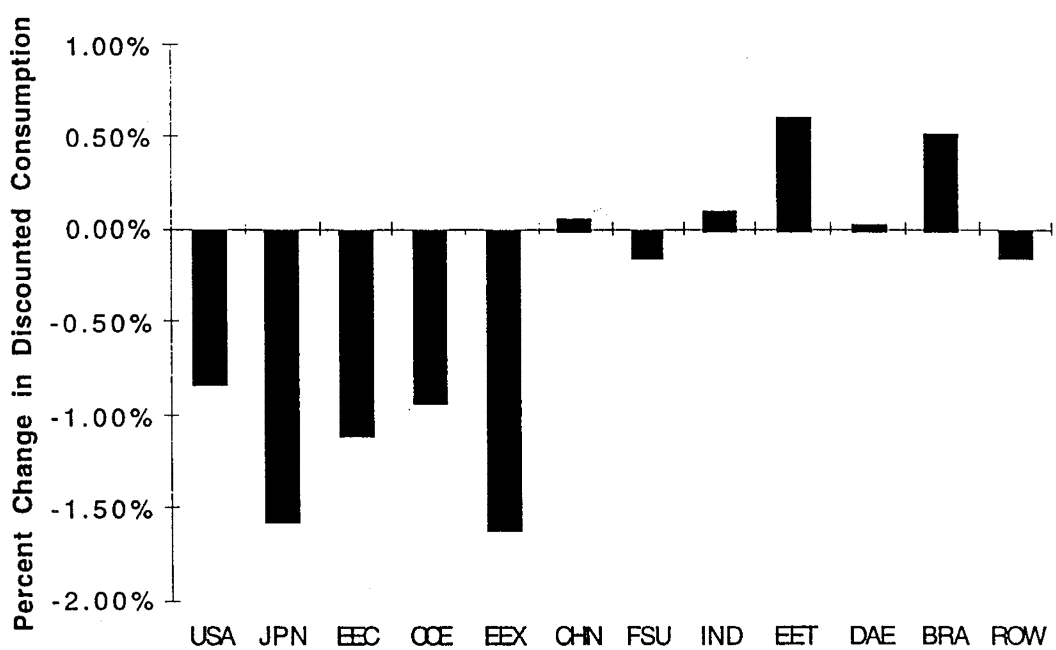

Figure 6. Regional economic impacts of a version of the AOSIS Protocol, for the Reference Case with no backstop technologies (definitions as in Figure 3).

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coincidence, the Reference Case with no backstops implies total carbon emissions that are very close to the Reference with backstops. In effect, for the relative costs assumed, the low-carbon and high-carbon alternatives roughly balance one another, so that total emissions over the period are only 4% higher in the "no backstops" world. The pattern of regional emissions is very different between the two, however.

The economic burden in this case is shown in Figure 6, which again presents the percent welfare loss over the period 2000 to 2100, for each of the model regions. Note that gains and losses shown in Figure 6 are *not* comparable with those in Figure 3 for the case with backstops. These are two different worlds: in particular, the GDP and consumption levels in the "no-policy" version are not the same with and without backstops, and so the levels of burden and gain associated with the two cases do not have a common basis. What is important is the change in the *distribution* of burdens among regions.

The region which is most affected is the Energy Exporting Countries (EEX). The imposition of the AOSIS restriction tends to lower the price of oil relative to other goods. Without the production of backstop fuels to offset this effect, the economic losses in the EEX region are large relative to other regions. Japan also is relatively strongly affected, compared to the with-backstops case, mainly because of the absence of the non-carbon backstop.

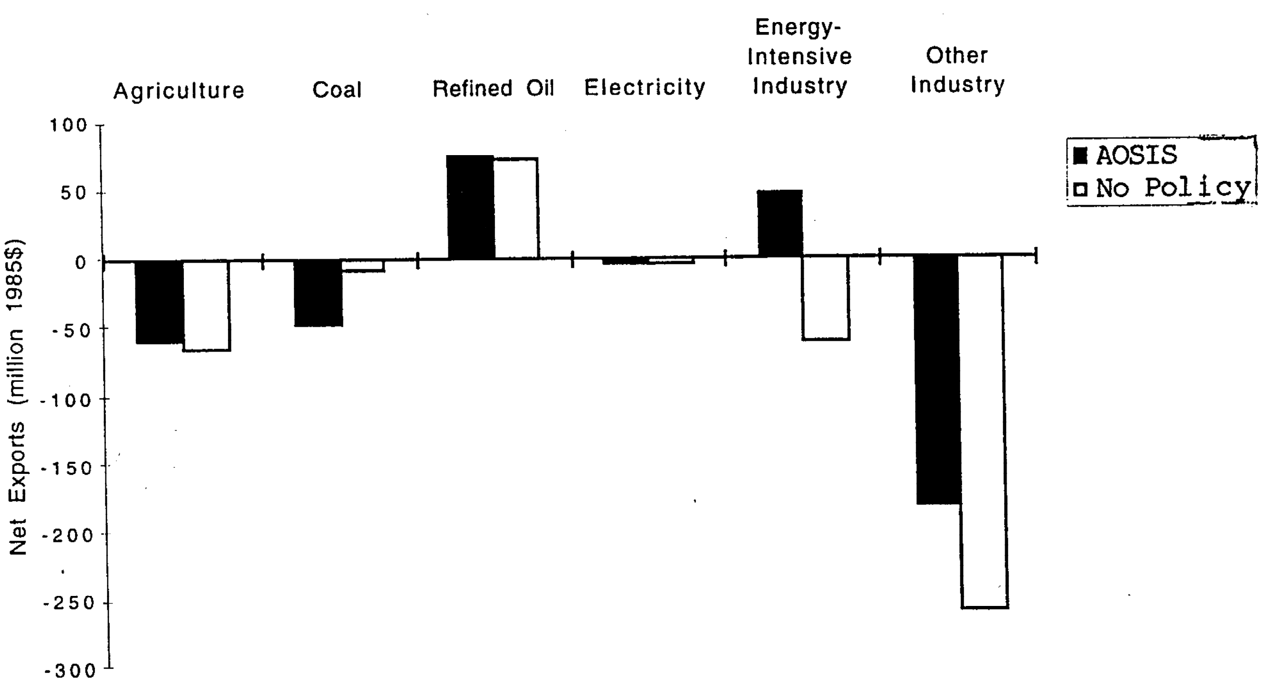

Figure 7. Trade of the non-OECD regions in 2050, with and without the AOSIS protocol, calculated from runs of the EPPA model without backstop technologies. Numbers greater than zero are net exports, those less than zero are net imports.

The leakage rate is roughly the same as in the "with backstops" world for the period 2000 to 2050, as shown in Figure 5. As growth proceeds into the 2050 to 2100 period, however, the AOSIS restrictions bind more tightly and the leakage goes up. An important contributor to this effect is the shifting pattern of competitiveness between OECD and non-OECD regions. Figure 7 illustrates the phenomenon for a single period, 2050. The results are trade values in constant 1985 $US (in effect, a quantity index). The net exports of some sectors (Agriculture, Refined Oil, Crude Oil and Natural Gas) differ little between the "no-policy" and the Reference cases. As can be seen in the figure, however, under AOSIS conditions (in contrast to the no-policy case) the non-OECD regions are exporters rather than importers of energy-intensive goods, and their imports of products of the Other Industry sector are reduced. To fuel this shift, coal imports from the OECD are higher.

7. THE ROLE OF EMISSIONS TRADING

Achieving commitments to reduced emissions purely domestically can be difficult for some regions depending on the structure of their energy economies. Countries will seek efficiencies by exploiting the cheapest opportunities for reducing carbon emissions, wherever they may be available. One approach is to engage in individual bilateral agreements that allow countries facing a constraint to undertake or fund CO_2 reduction measures in other countries. On a project-by-project basis such programs fall under the rubric of Joint Implementation (JI) or Activities Implemented Jointly (AIJ).

A more comprehensive approach to the goals of JI and/or AIJ would be to set up a market for carbon emissions by allocating emissions quotas and allowing countries to engage in trading for those rights. Alternative versions of these arrangements may allow such carbon trading to be concluded only with countries facing the same constraints, with some other subset, or with all other countries. We have explored the implications of these forms of agreement for the cost of meeting the AOSIS constraint and for the distribution of burdens and leakage. Figure 8 shows the result for the cost to the OECD, over several decades of meeting the AOSIS protocol. Again the comparison is made using the Reference Case, and the same consumption-based index is used to measure welfare loss. Four regimes are shown: (1) no trading, (2) trading among the four OECD regions only, (3) extension of OECD trading to all Annex I countries by including the Former Soviet Union and the Economies in Transition of Central and Eastern Europe, and (4) full global trading.

Trading limited to OECD regions does not yield very great reductions in cost: the economies of the sub-regions are simply too similar to one another in structure and in opportunities for carbon reduction.[6] Full global trading, on the other hand, yields very large reductions in cost to the OECD regions of meeting the AOSIS commitment. It benefits the non-OECD regions as well. It also is interesting to note that not all non-OECD regions need participate in order for real gains to be achieved from a trading regime. With the addition of the Former Soviet Union and the Economies in Transition, a large fraction of the benefits to the OECD of full global trading are gained, as shown in the figure.

The definition of a leakage rate used above (i.e., the increase in non-OECD emissions as a percentage of the OECD reduction) no longer holds if trading is allowed. In the cases with trading, our calculation procedure gives non-OECD countries an annual quota which is equal to the amount they would have emitted under AOSIS (with leakage) if there were

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[6] Analysis treating the OECD at the country level (disaggregating the EEC and Other OECD), where the economic circumstances would be more diverse, likely would show greater gains from trade than the four-region version applied here.

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no trading. This quota is fully utilized, and thus the global emissions over the century is the same with trading and without it. Other definitions of the quota scheme that underlies the trading will yield differing amounts of total carbon and thus of implied leakage.

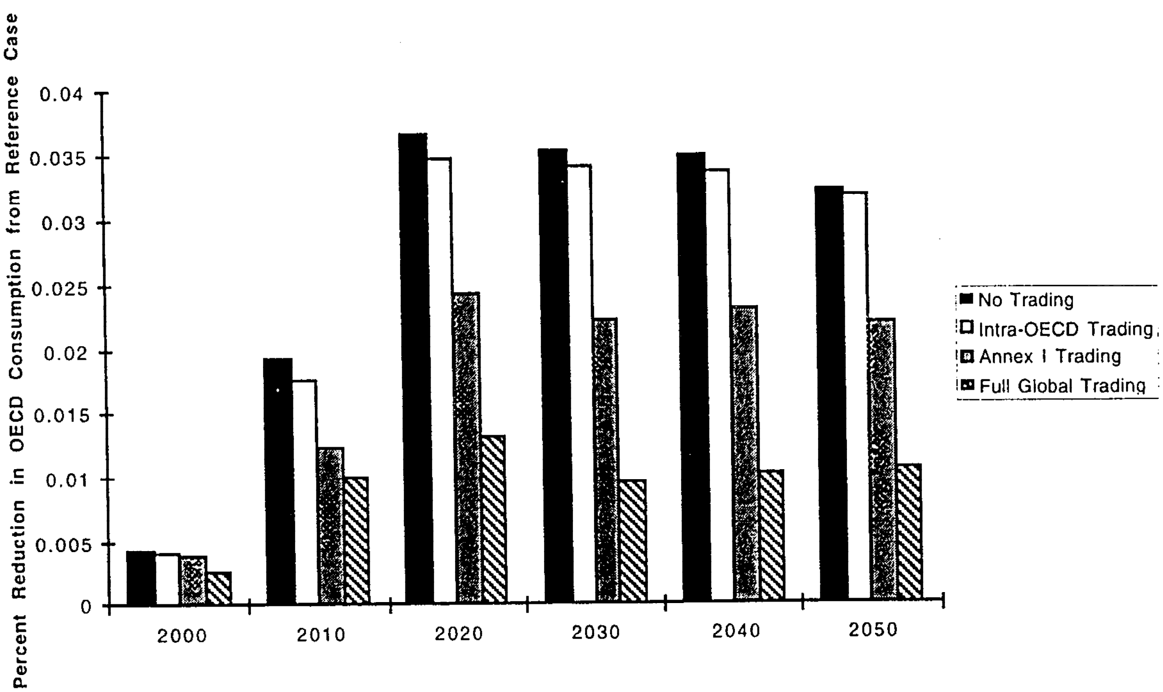

Figure 8. Costs to the OECD of meeting the AOSIS protocol under no trading and three definitions of a regime of emissions trading, for selected decades, calculated from runs of the EPPA model.

8. CONCLUDING OBSERVATIONS

Any attempt to assess the impacts of a QELRO policy, if followed for a century, must be pursued with due attention to the very large uncertainties in predictions. Nonetheless, an exercise like this does contribute some useful insights.

- If emissions limits are applied independently to a subset of world regions, then the burden of meeting these emissions reduction targets will fall not only on the parties to the agreement but on others as well, because of changes that are mediated through international trade. Not all non-participating regions need lose, but many will.
- Leakage is a real phenomenon. Policy restriction that applies only to some regions will shift comparative advantage in particular energy and non-energy goods. Specifically, countries outside the region of constraint become more competitive in the production of highly carbon emitting energy sources, and in the production and export of energy-intensive goods.
- If large-scale expansion of the existing (but small) carbon-intensive fuels industry is a realistic prospect, then it can have large implications not only for total carbon emissions but for the distribution of burdens, and for leakage.
- The differences in economic conditions and opportunities for carbon reduction between the OECD and non-OECD nations are great, so the benefit from trading is very large, with much room for bargaining over compensation. Further, it is not necessary

for all regions to participate in the trading for a substantial fraction of the potential gains to be realized.

Beyond the issues of economic impact and leakage that are the focus of this paper, these results have another implication for current QELRO proposals. By itself, the effort required by the AOSIS protocol has only a small impact on the threat of global warming. The reduction in predicted temperature change, shown in Table 2, is greater in the higher carbon case, where it may matter more, and vice versa, but the probabilities of these outcomes are hard to distinguish, so we do not know which world we are entering. In these circumstances, assessments of QELROs proposed for agreement now need to consider how these policies can be designed to be adaptive over time, and how mechanisms can be developed to gain participation of all world regions.

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AIAM-051252

FAX MEMO

To: Lenny S. Bernstein	Pages Sent: 4
From : Bronson Gardner	Phone / Fax Number : 216-475-9674
Subject : 1995--The Hottest Year on Record ?	Internet Address: gardnerb@ix.netcom.com

Attached is a chart which questions the statement that 1995 was the hottest year on record.

L.S. BERNSTEIN
JUN 11 1996
RECEIVED

Copied to:

Jim Pinto
Don Rheem
Lenny Bernstein
John Shlaes
Connie Holmes

Bronson Gardner
13965 Milo Road
Garfield Heights, Ohio 44125

To: Jim Pinto
From: Bronson Gardner
Re: 1995 Global Temperature Data

The issue which Clem probably would like to challenge is whether or not 1995 was *really* that much hotter than normal, or whether the data were "blown out of proportion". After experimenting with different ways of looking at the data, I decided that one way to answer this question is to cmpare the 1995/96 observed data (global mean temperatures) with the record high for each month. This comparison shows that, infact, most of 1995 and all of 1996 (so far) was well below the record high value, with the exception of July-Oct period in 1996 (the only period where the temperatures were a "record". In short, the summer of 1996 was hot, but the remainder of the year was cool. My conclusion is that 1996 should not be considered "the hottest year on record" but should simply be remembered for having had a rather warm summer. The data I used to prepared this chart are also attached. I hope this is useful.

Bronson

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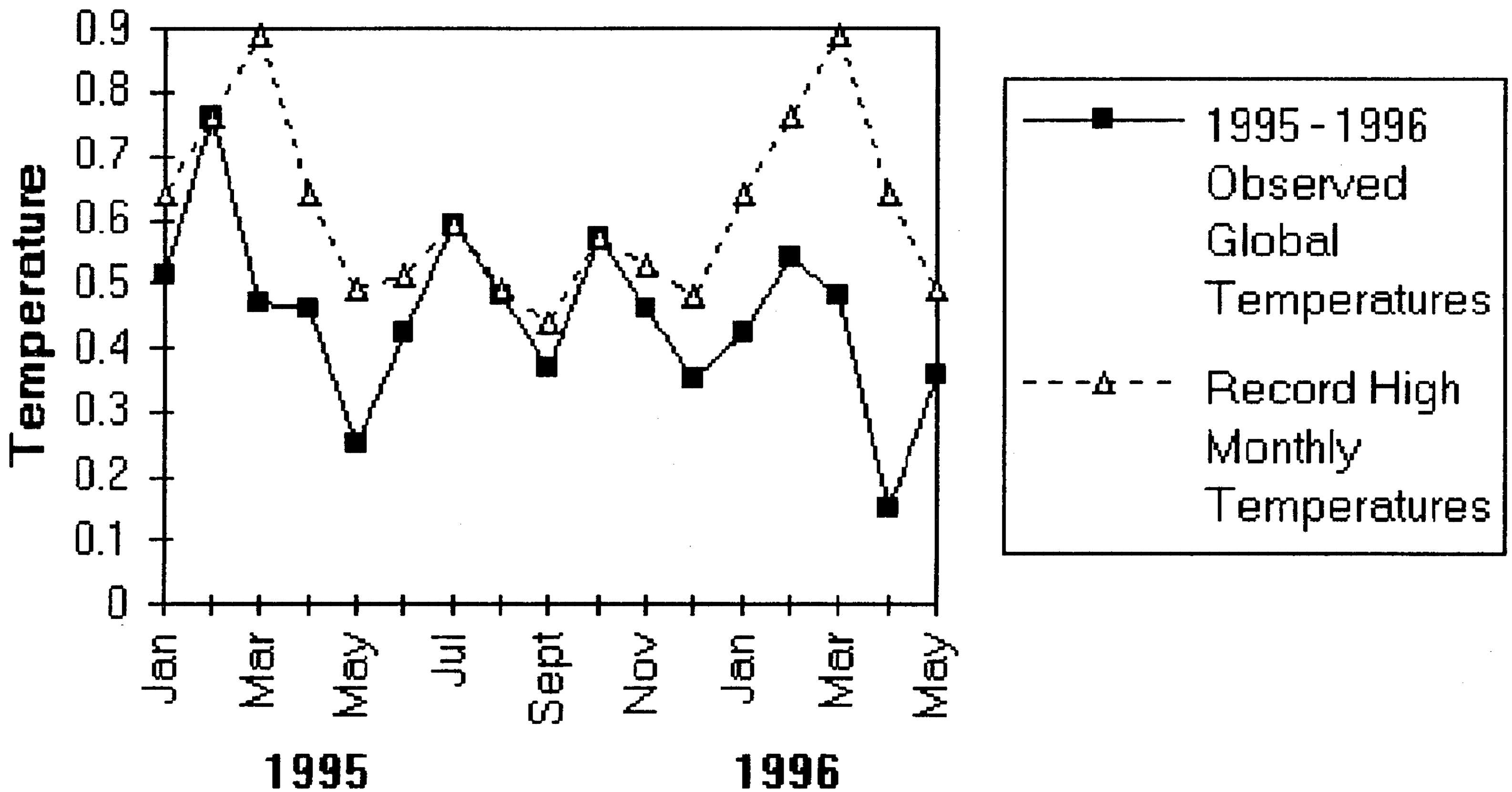
1995—Hottest Year on Record ?



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	1995/96	Record
Jan	0.51	0.64
Feb	0.76	0.76
Mar	0.47	0.89
Apr	0.46	0.64
May	0.25	0.49
Jun	0.42	0.51
Jul	0.59	0.59
Aug	0.48	0.49
Sept	0.37	0.44
Oct	0.57	0.57
Nov	0.46	0.53
Dec	0.35	0.48
Jan	0.42	0.64
Feb	0.54	0.76
Mar	0.48	0.89
Apr	0.15	0.64
May	0.36	0.49

source: NASA Goddard Institute for Space Studies

Statement of Mr. Rafe Pomerance
Deputy Assistant Secretary for
Environment and Development

Subcomittee on Energy and Power
of the Committee on Commerce
U.S. House of Representatives

June 19, 1996

Good morning Chairman Schaefer and Members of the Subcommittee.

I wish to express my appreciation to you for giving me this opportunity to discuss the issue of global climate change and the Administration's preparations for the ongoing international negotiations under the United Nations Framework Convention on Climate Change. As indicated by Secretary Christopher in his major speech on the environment at Stanford University on April 9th, this is a very important topic and one in which he pledged continued U.S. leadership in "safeguarding the global environment on which prosperity and peace ultimately depend."

Today's hearing, Mr. Chairman, comes at an important time for consideration of this topic. There are four basic reasons for this assertion which will form the framework for my remarks this morning:

- First, new and more extensive scientific information has been released in recent months that further underscores the seriousness with which the world's leading experts view the issue of global climate change and humankind's role in it.
- Second, we are approaching an important new phase in the international negotiations that are underway pursuant to the so-called "Berlin Mandate" which was established at the first Conference of the Parties in Berlin in April 1995.
- Third, the month of June has a full schedule of events here in the United States and around the world that will help advance the analysis and assessment that we have insisted be a major component of the early stages of this round of negotiation.

- And fourth, we are in the midst of the budget season, and it goes without saying that the decisions that are made during the budgetary process will have an important impact not only on our ability to achieve our national plans to reduce greenhouse gas emissions, but also on our credibility and leverage in the international dialogue on these matters.

Let me begin, Mr. Chairman, with some statements about the science which has formed the foundation for action by both the United States and the international community with regard to the difficult and complex challenge of climate change.

As you know, the Intergovernmental Panel on Climate Change (IPCC) -- a partnership of the World Meteorological Organization and the United Nations Environment Program -- is the world's preeminent scientific and technical assessment body concerned with the threat of global climate change. The IPCC, which involves more than 2000 scientists from more than 100 countries, was established largely at the urging of the United States during the Bush Administration for the expressed purpose of assessing this issue and providing policymakers with the best possible scientific information.

In December of last year, the IPCC finalized its Second Assessment Report -- which represents the most recent, authoritative and comprehensive scientific analysis we have available to us on this issue. This report is the result of years of effort, extensive peer review, and exhaustive analysis and consultation.

These recent findings have underscored and amplified the IPCC's initial work -- refining estimates and revealing new understandings that continue to ring the alarm bells first sounded in the 1990 IPCC review. From our perspective, the most salient of these scientific findings are as follows:

- Human activities are altering the chemical composition of the atmosphere. The so-called "greenhouse" gases" -- primarily carbon dioxide, methane and nitrous oxide -- are building up in the atmosphere. The essential heat-trapping property of these gases is undisputed.

- Carbon dioxide, the most important gas, has increased 30 percent since pre-industrial times.

- There is certainty that the continued build-up of these gases will enhance the natural greenhouse effect and is predicted to cause the global climate to change significantly compared to natural variations.

- Global average surface temperature has increased, and the period since 1980 has been the warmest of the past century.
- The most recent IPCC assessment reports that sea level has been rising over the past 100 years; similarly, mountain glaciers are retreating worldwide.
- Based on these facts and additional underlying science, the second assessment reported that "the balance of evidence suggests that there is a discernible human influence on global climate."

All of these points underscore one, inescapable conclusion: Human beings are altering the Earth's natural climate system. Although there has been some criticism in the press recently complaining about alleged procedural errors in finalizing the IPCC's final report (to which I will turn in a moment), there is no dispute about the scientists' compelling conclusion. We note that the scientific community cannot yet tell us precisely how much, when or at what rate the Earth's climate will respond to greenhouse gas buildup. However, making the best possible estimate based on what is known about the complex climate system, the scientific community believes that current emissions trends (resulting from the effective doubling from pre-industrial concentrations of carbon dioxide in the atmosphere over the next several decades) will lead to global temperatures which, on average, are 2 to 6.5 degrees Fahrenheit warmer than today, rising at a rate of increase greater than that seen over the past 10,000 years. And the warming will not stop there: Without action, concentrations of greenhouse gases will continue to grow and warming will continue to increase, as the IPCC has demonstrated in its extensive carbon cycle work.

The IPCC report supports the view of the Administration that action must be taken to address this challenge and that, as agreed in Berlin, more needs to be done. This problem cannot be wished away. Our obligation, to respond with the same thoughtfulness that has characterized the work of the world's scientific community, is one which we must take with the utmost seriousness.

I note that over the past several weeks there has been a significant -- albeit one-sided -- series of allegations in the press over the IPCC's procedures in the development and acceptance of the Second Assessment Report. I say one-sided, because to my knowledge, not a single critic of the IPCC bothered to consult either with the chapter lead authors -- or with the officers of the IPCC Working Group prior to airing their allegations in public and in the popular press.

The criticism focuses on the fact that the draft report detailing some of the conclusions was changed to reflect concerns raised at the Plenary Meeting of Working Group I of the IPCC (on the science) in Madrid in November 1995. Was the draft report modified? Of course; that is the purpose of a draft -- drafts are intended for modification to reflect various legitimate concerns. Was there an attempt to modify scientific findings to reflect a political agenda? Most certainly not.

The modifications and editorial changes to the underlying chapter were made by the lead authors following the Madrid plenary to clarify the agreed views (agreed on the basis of a line-by-line reading and approval by the full plenary, including some of the world's foremost scientific experts on these issues). The chapter concerned, even in its earliest draft forms, always contained the same scientific findings, including the concept that there is a discernible human influence on the climate system.

A second concern raised is that the revised text does not adequately describe the uncertainties surrounding the detection of climate change. I suggest this claim is absurd: of the six sections in the final text of the chapter (which includes the introductory section), two focus exclusively on issues related to uncertainties (one related to uncertainties in model projections and the second related to uncertainties in estimating natural variability) while the remaining four each discuss uncertainties at some length as well.

Mr. Chairman, I am extremely disappointed that we are engaged in a process in which, without a full understanding of the issues, we pillory Working Group I scientists -- and by implication, the work of thousands of others involved in the process -- on the basis of unfounded information. And, as we are all too well aware, it is much easier to tear down a reputation than to rebuild one falsely implicated. I hope that with this clarification of the issue, we can return to the much more fundamental question: "How do we act in light of the new and disturbing evidence from the scientific community about climate change?"

Mr. Chairman, let me now turn to the second area I would like to cover in my testimony, and that is the state of the international negotiations on actions to fulfill that obligation.

As you know, climate change negotiations have been underway, almost uninterrupted, for more than seven years. We are now entering an important new phase under the Framewrok Convention. This framework includes the obligation of the United States and other developed economies to aim toward reducing greenhouse gas emissions to 1990 levels by the year 2000.

At the Berlin conference in April 1995, the Parties to the climate convention decided that these provisions were not adequate to address the long-term challenges of climate change, agreeing that the current convention commitments are only a first step -- they are silent about goals after the year 2000. As a result of the Berlin mandate, the Parties agreed to launch a process to define actions in the post-2000 period and to advance implementation of commitments by all nations. This process is taking place through a series of negotiations that are scheduled to conclude at a conference to be held in Japan sometime during the second half of 1997.

As suggested by the United States, the process has included in its early stages analysis and assessment of strategies, policies and measures to deal with climate change -- information that will help shape the search for agreement on actions for the period after the year 2000. Already, three negotiating sessions have been held and a great deal of analysis and assessment is underway internationally, and domestically -- as I will discuss in a moment.

In July, Mr. Chairman, we will meet again in Geneva at the Second Conference of the Parties to the climate convention. While that meeting will not resolve any of the issues set forth in the Berlin mandate, we expect that the July meeting will mark the beginning of an important new stage in the negotiations leading to the commencement in December of much more concrete and critical discussions.

Many parties have begun to lay out their vision for the resolution of the critical issues before us. The Europeans have been pushing the negotiations toward consideration of some ambitious near-term targets and goals, along with mandatory, internationally coordinated policies and measures. In our view, the significant differences in national circumstances and individual national approaches to these matters suggest that few, if any individual measures are likely to be applicable to all countries.

The issue of targets and timetables is, as always, very much in consideration in these negotiations. And indeed, some very specific, ambitious, some might even say unrealistic short-term targets have been proposed, for example in the protocol suggested by the Alliance of Small Island States.

Another key area, called for under the Berlin Mandate, relates to the actions developing countries will take to advance their commitments under the Convention. This has always been and will remain a difficult component of the negotiations, but it is essential to respond to it, if we are to make progress over the long-term in preventing harmful climate changes.

The Clinton Administration has formulated a broad, multifaceted framework to assist developing countries to reduce their greenhouse gas emissions. In this connection, I would note that some of the potential incentives with regard to additional developing country participation in this process -- such as financial support by the Global Environment Facility for various climate-related projects and activities and climate-friendly loan portfolios -- threaten to be seriously undermined by Congress' decision to sharply reduce GEF funding.

This leads me to the third area I would like to discuss this morning, namely, the on-going analysis and assessment effort we have embarked upon and the ambitious calendar that has been on-going during recent weeks, both here and abroad, and which will continue throughout the rest of this year.

First of all, I would like to underscore that the Administration is currently engaged in developing, through analysis of options, the best way to approach this issue over the short and the long term, and therefore has not finalized our positions for Geneva and beyond. Nonetheless, our ongoing work has made clear four basic foundations for the U.S. approach, which I want to share with the Committee today.

- First, we are not interested in grand rhetorical goals that are impossible to realize. We want the negotiations to focus on outcomes that are real and achievable.

- Second, the United States will continue to seek solutions that are flexible and cost-effective, as we have throughout the negotiations.

- Third, while developed countries must take the lead, we believe that this is ultimately a global problem requiring global solutions as agreed at the Berlin Conference of the Parties.

- And finally, a response to climate change requires both significant actions over the long term and sensible policies and investments in the public and private sectors in the short term.

Our public efforts with regard to analysis and assessment has been one in which we have been forthcoming and have welcomed -- and continue to welcome -- inputs from the business, academic, and NGO communities. Earlier this month, the Administratioin hosted a major, two-day workshop on analysis and assessment at which presentations, from more than 50 experts from inside and outside of government about technical issues associated with our emissions trends and capability to reduce emissions in the next century, were submitted. This workshop provided the opening round of discussions on the economic analysis which we are undertaking.

An array of analytic work has also been undertaken at the international level. The Organization for Economic Cooperation and Development (OECD) has developed a technical analysis of a series of policies and measures that might be undertaken by Annex I countries in a common manner. Notwithstanding some concerns about the rapid turn-around of the OECD analysis, this work has yielded some important insights. The OECD's preliminary conclusions seem to indicate that few, if any, individual actions could be taken by all Annex I countries in common, given the wide differences in their national circumstances, although the studies also conclude that a wide array of options exist at the national level. The U.S. does not believe the OECD papers have made a good case for mandating the harmonization of any of these policies and measures.

Additional information on both policies and measures, and on possible quantified emission limitation and reduction objectives, has been the focus of international roundtables (such as those held on the margins of the third AGBM session in Geneva in March 1996), workshops, and informal technical sessions. We continue to believe that this analytic process is a valuable step toward ensuring a full airing of information about the challenges we face, as well as opportunities that may be available to us.

We have also held three informal roundtable discussions among governmental experts, private sector and non-governmental specialists as part of our ongoing effort to interact with, and to obtain input from, a broad range of interested parties in the United States. These roundtables complemented the material and opinions received and expressed at the earlier analysis and assessment workshop and have, we believe, given important stakeholders, and other interested parties, an opportunity to share their views and insights on the challenge of global warming with both ourselves and with others.

Yesterday, the State Department co-hosted a conference for business and the public about the export market opportunities that are emerging as nations begin to tackle the challenge of reducing greenhouse gas emissions. No matter what we do under the Convention on the issue of climate change, there are a range of technologies and business interests that American firms are superbly positioned to take advantage of, as nations all over the world seek to enhance efficiency and deploy new technology in service of economic and environmental goals. We want to stay at the forefront of this drive. This conference provided an initial opportunity for us to explore this issue with interested U.S. corporate executives and managers and to solicit their ideas and suggestions for additional joint and cooperative action.

This is only a partial listing of a very full calendar, which also includes a high-level meeting of the International Energy Agency (IEA) that will address the issue of climate change; ongoing workshops on joint implementation; and a variety of other meetings and initiatives by various independent organizations.

Turning to my fourth and final point, this hearing comes at an important time because this is the budget season. The funding decisions that are made by the Congress will have significant implications for the American people, the agencies of the government that serve them, and for the international dialogue in which we are engaged.

We have heard loud and clear the view from Congress about the importance of developing countries undertaking steps to reduce their share of emissions. Therefore, as I have already suggested, we believe that it is imperative that we work together to ensure that we meet the modest funding requirements for the international institution responsible for assisting developing countries in this process, the Global Environment Facility (GEF).

The FY-97 House level of $30 million for the GEF is a cut of over two-thirds from the President's request for $100 million. This decision, if it stands, will have a serious impact on our ability to interface with developing countries on the climate change challenge in a meaningful and credible manner.

Similarly, many have suggested that we should pursue voluntary, as opposed to regulatory, programs in the United States to address this problem. Yet, the funding for the President's Climate Change Action Plan is far short of what is needed, and we are off course in terms of returning emissions to 1990 levels by the year 2000.

The most important and most cost-effective long-term strategies for reducing greenhouse gas emissions will require research and development and significant improvements in energy, industrial and crop technologies. To be successful, investment by both the public and private sectors will be required. It is disturbing, therefore, to learn of proposals contained in the House budget proposal which, if enacted, would remove DOE funding for energy efficiency programs within two years, and phase out all DOE funding for renewable programs within three.

Mr. Chairman, the Clinton Administration remains committed to the international climate change process. As I indicated today, the science is increasingly convincing: It is evident that concern about global warming is real, and that we must continue to take steps to address this problem consistent with our political realities.

The on-going negotiations under the climate convention represent the global effort to limit this damaging trend, and the United States must and will continue to work in support of these negotiations. We need to find ways to reduce our emissions of greenhouse gases, just as we urge all nations to join us in thinking creatively and acting aggressively to confront this major challenge in a manner that is fair and certain. In this regard, we will continue to attempt to make our contribution through thoughtful, cost-effective policies that will help prepare us -- economically and environmentally -- for the next century.

Thank you.

SEOESB 1210-VI

Climate Change Roundtable: Recent IPCC Science Findings

11 June 1996

Senate Dirksen Office Building

Evidence of Global Warming and its Geographic Consequences

"An Overview of Climate Change: Observations and Understanding"

Dan Albritton
National Oceanic and Atmospheric Administration
U. S. Department of Commerce

Introduction

Senator Lieberman and colleagues: I am the Director of NOAA's Aeronomy Laboratory in Boulder, Colorado, which studies the chemistry and dynamics of the Earth's atmosphere. Further,

- I served as one of the Lead Authors for the 1994 and 1995 scientific assessments of the Intergovernmental Panel on Climate Change (IPCC), which provides scientific input to the United Nations Framework Convention on Climate Change.

- I am also Cochair, along with Dr. Robert Watson (USA), who is here today, and Dr. Piet Aucamp (South Africa) of the Ozone Science Assessment Panel of the United Nations Environment Programme, which provides scientific input to the Montreal Protocol on Substances that Deplete the Ozone Layer.

In these capacities, I appreciate this opportunity to participate in your Climate Change Roundtable and to summarize the IPCC findings.

Context

In short: The global climate system and humankind are "co-involved".

Specifically, there are a number of "agents" that can cause global climate change. We (and our emissions of greenhouse gases) are one of them. There are also natural climate-forcing agents, such as changes in the amount of solar energy reaching the Earth. All of these forcing agents "nudge" the Earth's climate into some new patterns via numerous Earth-system processes, such as more or less heat exchange between the

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atmosphere and oceans. The result is that the planet will have a slightly new climate, for example, changed temperatures or rainfall. These physical changes will cause, in turn, biological changes, such as more or less vegetation. Many of these biological changes would directly impact the welfare of humankind, such as loss of coastal habitation due to rising sea level. These impacts bring the process full circle; namely, human lifestyles can change the climate, and climate changes can impact human lifestyles.

This co-involvement of humans and the climate of their planet raises important questions that relate to choices about action or inaction regarding the possibility of causing future climate changes. Indeed: there are three overarching questions that decisionmakers are posing to the scientific, technical, and economic communities:

- How well do we understand the climate system and our role in changing it?
- How well can we characterize the impacts of climate change?
- What are our future options?

This Roundtable addresses the first two questions. My summary addresses the first question: *"How well do we understand the climate system and our role in changing it?"* I draw upon the recent 1995 IPCC assessment report for answers. The answers are arranged here in the order of the confidence that science currently can provide them.

(1) Greenhouse gases are increasing in the atmosphere because of human activities, and they are increasingly trapping more heat within the atmosphere. *(A "certainty")* Basic physics demonstrates that greenhouse gases, such as carbon dioxide (CO_2), trap within the atmosphere part of the heat radiation from the Earth's surface that would otherwise escape to space. Impeccable measurements show that the atmospheric abundances of many greenhouse gases are increasing. It is clear from worldwide emissions data that those increases are due to human activities, such as the burning of fossil fuel and the resulting emission of CO_2.

(2) A continued future growth in greenhouse gases is predicted to lead to very significant global climate changes. *(Application of our best tools)* Given the central role of fossil fuels to the global economy, it is likely that the levels of CO_2 in the atmosphere will double sometime in the next century. Current models of the climate system predict that the result of this doubling would be a 3.5 degree F increase in the average temperature of the globe. Based on indirect indications of distant-past temparatures, such an increase would be larger that the natural swings in temperature that have occurred over the past 10,000 years. Lastly, because of the large thermal inertia of the oceans, such a warming, if it occurs, would only be very slowly reversed.

(3) Global-average temperatures have warmed over the past century, and the balance of evidence suggests a discernable human influence. *(A first indication)*

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Direct temperature measurements demonstrate that the Earth (on the average) has warmed 0.5 - 1.0 degree F over the past 100 years. Slow, natural swings in temperature since the last Ice Age are not dissimilar in size; therefore, it has been very difficulty to determine what portion of that warming is natural change and which portion could be due to human-influenced greenhouse gases. However, in the recent IPCC report, scientist state that the current warming is unlikely to be entirely natural. The evidence for this statement lies in the similarity of the spatial and temporal patterns of the temperature changes to those predicted for greenhouse gases.

(4) However, it is a complex planet, and we have imperfect knowledge about it; therefore, prediction of some important details cannot yet be done with significant confidence. *(Current unknowns)* Exactly what climate changes could happen in particular places and for which particular years cannot be predicted reliably. There is insufficient knowledge to yet say whether hurricanes or other such extreme events will be more or less frequent in a greenhouse-warmer world. Because of the complexity of the planet, the probability of the occurrence of future "surprises" (pleasant or unpleasant) is significant, since we are likely to be entering a new climatic regime that we have not experienced in the past and because some climate changes can be rather abrupt.

Summary

The key points associated with the most up-to-date assessment of the understanding of the climate by the world scientific community are the following:

- The issue is a real one.
- Some human-induced climate changes appear to be inevitable.
- Discernible first signs are suggested now.
- Exactly where, when, or how much change will occur in the future is harder to predict.
- Human-induced climate change would be slow to reverse.

In conclusion, I would like to re-emphasis that this summary is based not purely upon one person's views, but rather upon the recent IPCC assessment, which has several key and important features that are relevant to its high credibility:

- *It is strong single concise statement from the large majority of the climate scientific community.* In the assessment, the major representatives of the climate research community speak at one time and one place regarding the current understanding of climate change. The report, therefore, is a common reference point for decision

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makers, in contrast to sporadic and separate statements reflecting the opinions of one person or a few individuals.

- *It is an international scientific assessment.* With it, all nations have a common basis of scientific input for their decision making, as opposed to several national statements. Where appropriate, scientists from developing countries are involved in preparing the assessment to the fullest extent possible.

- *The scientific scope is comprehensive.* With the report, decision makers have available a single, homogeneous summary of the current scientific understanding of the whole climate-change phenomenon, ranging from the agents that cause change to the climate-system responses. This is more useful than separate reviews of components of the phenomenon done at different times and perhaps for different purposes.

- *Both natural and human-induced climate changes are considered.* In contrast to considering only the perturbation of the climate system by human activities, the assessment places that human-induced change in the context of the observed and predicted changes that are a natural part of climate variations. The comparison of the two affords immediate and straightforward insight into the significance of the human-induced perturbations relative to the natural variations.

These characteristics show that, while the "The Science of Climate Change: 1995" is a scientific document, its value to decision makers such as yourselves is considerable. Thank you for the invitation to be part of this Roundtable.

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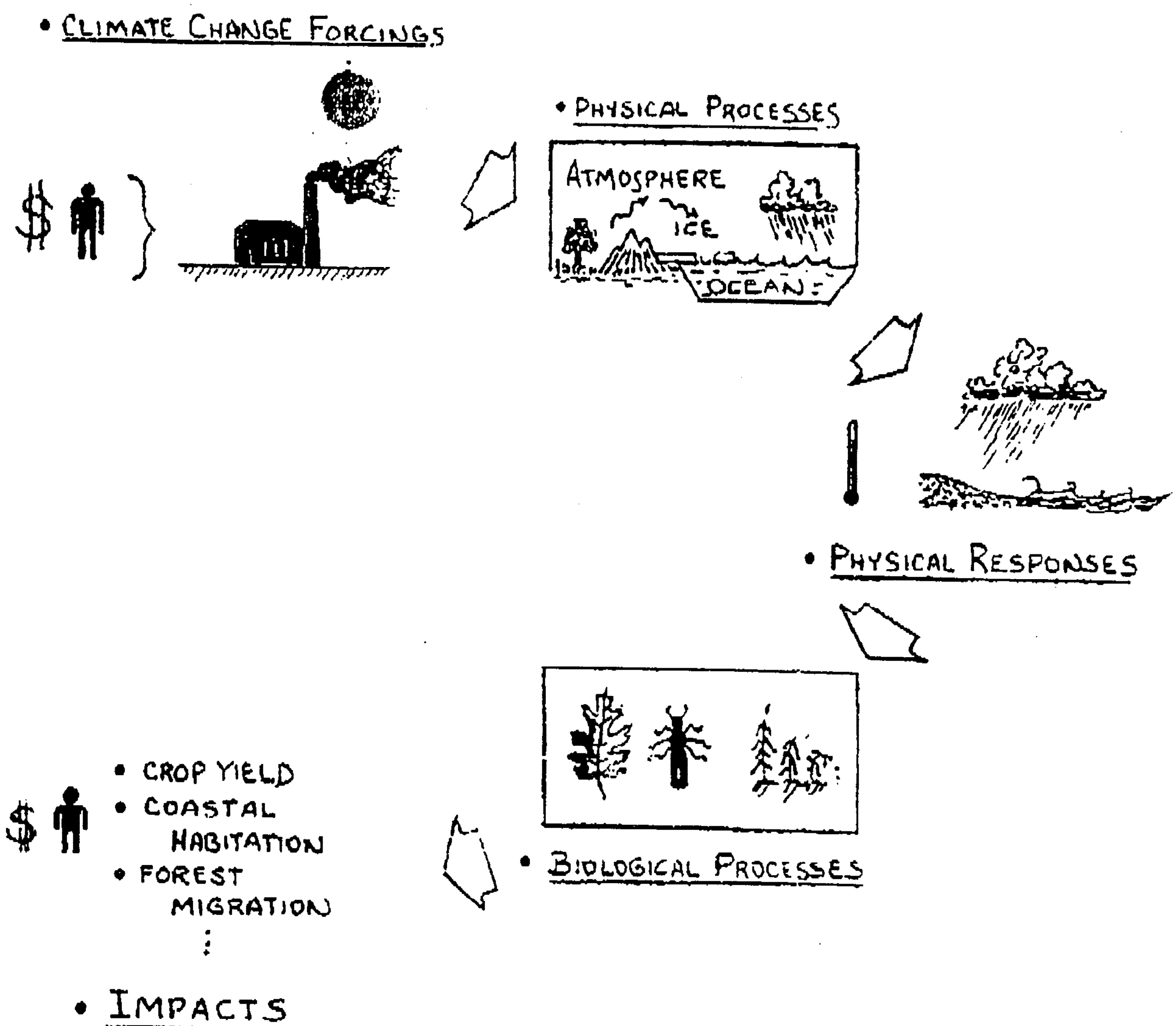
Evidence of Global Warming & Its Geographic Effects

Climate Change Roundtable: Recent IPCC Scientific Findings

11 June 1996
Senate Dirksen Office Building

▶ Context: The Climate System & Humankind

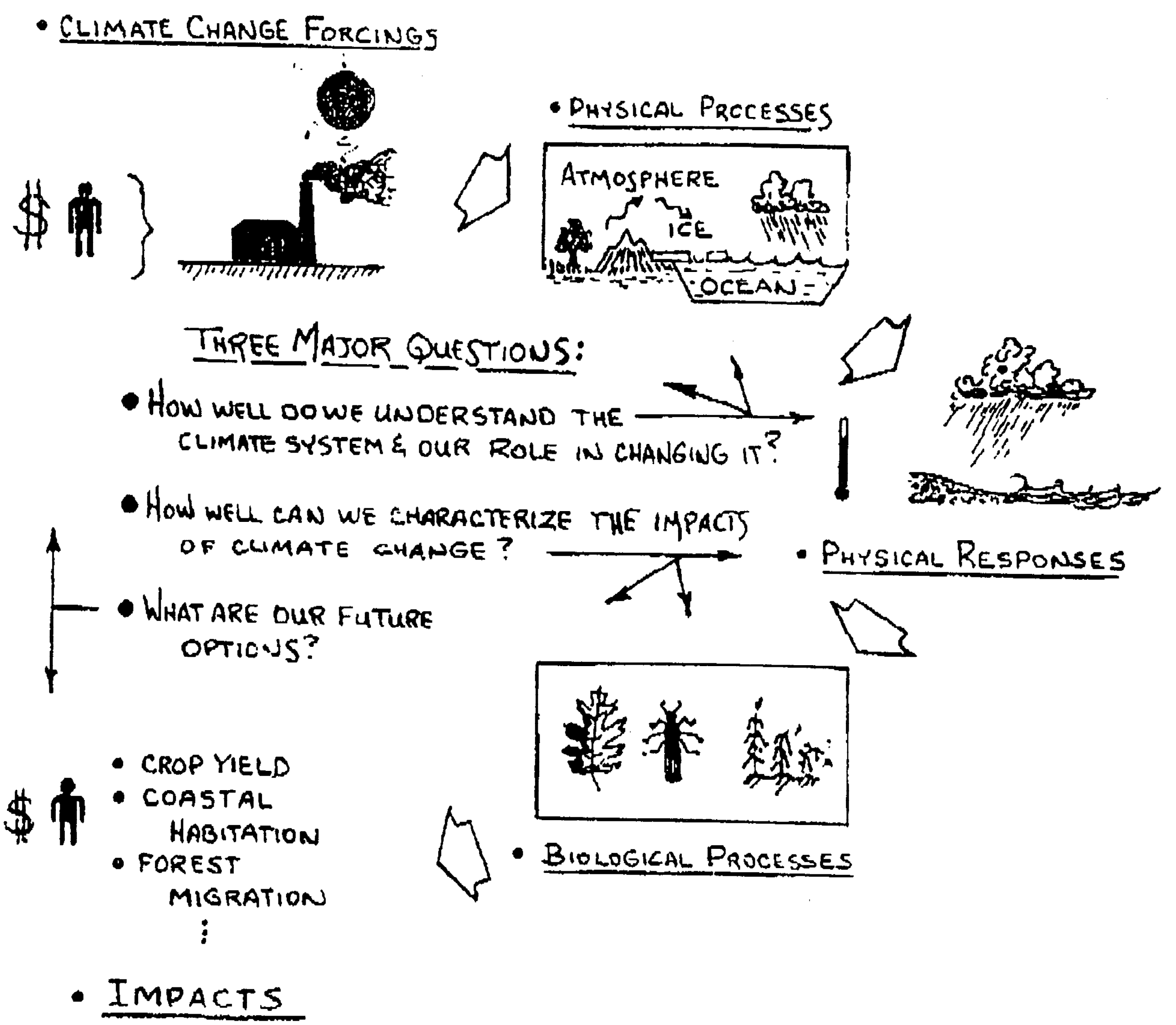


EVIDENCE OF GLOBAL WARMING & ITS GEOGRAPHIC EFFECTS

CLIMATE CHANGE ROUNDTABLE: RECENT IPCC SCIENTIFIC FINDINGS

11 JUNE 1996
SENATE DIRKSEN OFFICE BUILDING

▶ CONTEXT: THE CLIMATE SYSTEM & HUMANKIND



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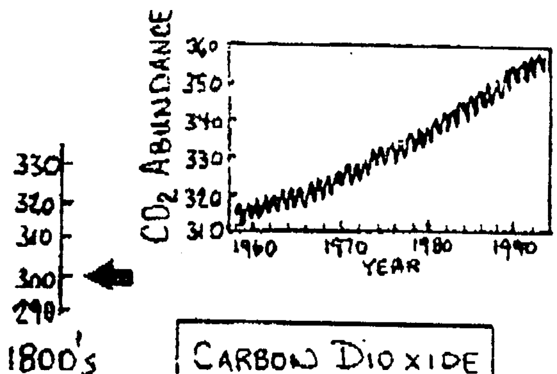
②

(A) A Scientific Status Report:

➡ Greenhouse Gases are Increasing in the Atmosphere Because of Human Activities, and They are Increasingly Trapping More Heat:

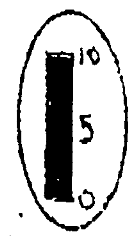
Points:

- Impeccable Scientific Measurements



Carbon Dioxide

30% increase since pre-industrial times



"Confidence Index"

- Other Gases Are Increasing Too

Methane, for example

- The Sources are Human-Caused

CO_2 ~ All
Methane ~ Most

Q: So... What could happen?

A CONTINUED FUTURE GROWTH IN GREENHOUSE GASES IS PREDICTED TO LEAD TO VERY SIGNIFICANT CLIMATE CHANGES.

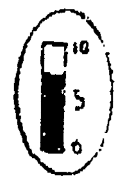
POINTS...

- CO_2 ABUNDANCE WILL VERY LIKELY DOUBLE BEFORE 2100

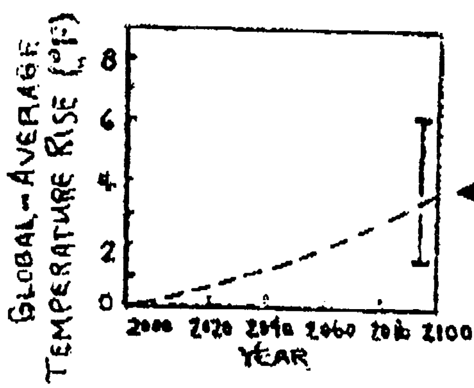
  INDEED... TO STABILIZE AT DOUBLED → [illegible]

  TO RETURN TO TODAY'S → [illegible]

- PREDICTED CLIMATE RESPONSES.



CONFIDENCE [illegible]

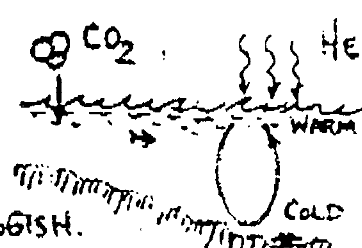


"BEST ESTIMATE": 3½ °F INCREASE IN TEMPERATURES AVERAGED OVER THE GLOBE.

> IF SO, THIS WOULD EXCEED THE NATURAL CHANGES OVER THE PAST 10,000 YEARS.

> CORRESPONDING SEA LEVEL RISE: ~20 INCHES.

- A GREENHOUSE WARMING COULD ONLY BE REVERSED VERY SLOWLY.



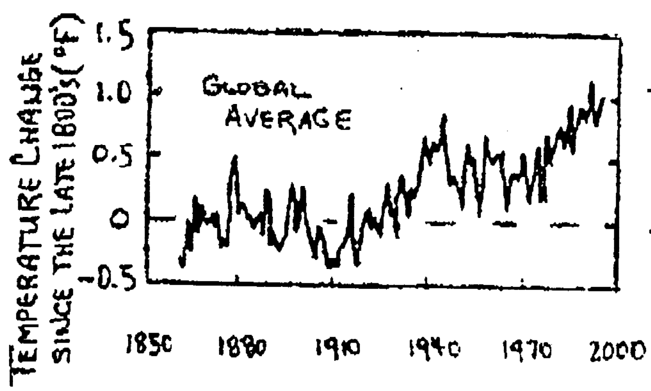
REASON: THE OCEANS ARE SLUGGISH.

[illegible]: HAVE WE SEEN ANY WARMING YET?

GLOBAL TEMPERATURES HAVE WARMED OVER THE PAST CENTURY & THE BALANCE OF EVIDENCE SUGGESTS A DISCERNABLE HUMAN INFLUENCE

POINTS...

- GLOBAL TEMPERATURE MEASUREMENTS



THE EARTH (ON THE AVERAGE) HAS WARMED 0.5 − 1.0 °F OVER THE PAST 100+ YEARS.

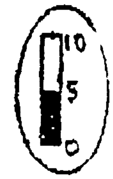
> SLOW, NATURAL SWINGS IN TEMPERATURE SINCE THE LAST ICE AGE ARE NOT DISSIMILAR IN SIZE.

- THE OBSERVERED WARMING IS UNLIKELY TO BE ENTIRELY NATURAL

REASONS: COMPARISONS OF TEMPERATURE-CHANGE PATTERNS: PREDICTIONS ⟷ OBSERVATIONS

☑ REGIONAL, SEASONAL, VERTICAL } PATTERN OF CHANGES • PREDICTIONS • OBSERVATIONS TEND TO CORRESPOND

☑ CORRESPONDENCES INCREASE WITH TIME



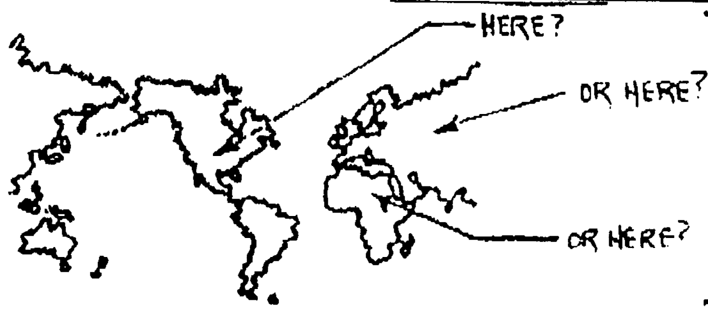
☑ PROBABILITY IS LOW THAT A "NATURAL-ONLY" EARTH WOULD HAVE SUCH CORRESPONDENCES

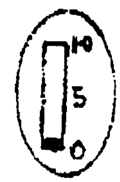
Q: BEYOND "GLOBAL AVERAGES"?

➡ IT IS A COMPLEX PLANET & WE HAVE IMPERFECT KNOWLEDGE, SO, PREDICTION OF FURTHER DETAILS SUFFERS

POINTS...

- WHAT WILL HAPPEN IN PARTICULAR PLACES?





- REGIONAL CHANGES CANNOT YET BE PREDICTED RELIABLY.

- INDICATIONS ARE: • LAND WARMS MORE THAN OCEANS } WINTER
  • MAX N. HI-LATITUDE WARMING } WINTER
- TEMPERATURES BETTER PREDICTED THAN RAINFALL.

- HOW ABOUT "EXTREME EVENTS"?

  > A WARMER WORLD → A MORE-VIGOROUS HYDROLOGICAL CYCLE

  PERHAPS MORE VARIATION → FLOODS/DROUGHTS: MORE OR LESS SEVERE, FROM REGION-TO-REGION.

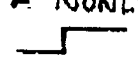
  > HURRICANES: MORE/LESS FREQUENT? INSUFFICIENT KNOWLEDGE

- SURPRISES?

  > ABRUPT CLIMATE SHIFTS?

  > CURRENTLY UNKNOWN GEOPHYSICAL PROCESSES ACTIVATED?

  } POSSIBLE HERE'S WHY:

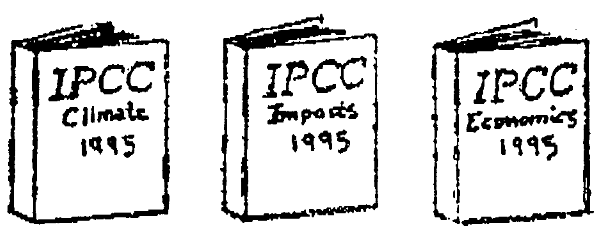
  - ENTERING A NEW REGIME OF CLIMATE PERBATION
  - CLIMATE IS A NONLINEAR SYSTEM : 

CONCLUDING COMMENTS

- BOTTOM LINES ➔ THE VAST-MAJORITY SCIENTIFIC VIEWPOINT:
  - THE ISSUE IS A REAL ONE
  - SOME HUMAN-INDUCED CLIMATE CHANGE APPEARS INEVITABLE
  - DISCERNABLE "FIRST SIGNS" ARE SUGGESTED NOW.
  - EXACTLY WHERE (REGIONS) / WHEN (RATE OF CHANGE) / HOW MUCH (MAGNITUDE) IS HARD TO PREDICT.
  - HUMAN-INDUCED CLIMATE CHANGE WOULD BE SLOW TO REVERSE.

- BASIS OF THIS INFORMATION

INTERGOVERNMENT PANEL ON CLIMATE CHANGE



OFF THE PRESS: APR/MAY '96

ASSESSMENTS:

- PREPARED BY EXPERT COMMUNITIES.
- INTERNATIONALLY BASED.
- "ONE-STOP SHOPPING" FOR THE ISSUE.

THE LAST BOTTOM LINE: KEY INPUT TO POLICY DECISIONS