

THE WHITE HOUSE
WASHINGTON

STAFF SECRETARY

TODD STERN

April 30, 1998

MEMORANDUM FOR RECORDS MANAGEMENT

FROM: JONATHAN ADASHEK 

The attached three boxes contain the following material relating to climate change:

- Box 1: UNFCCC - COP - 3 Briefing Book; Agency Papers for Climate Change-Analysis Workshop (6/27); Congressional Information Notebook; PCAST Report Release, 11/5/97; Five Labs Study Information; The March of the Jolly; Global Warming (The Complete Briefing); WHCA East Room Remarks (Audio); Microcassettes of White House Conference;
- Box 2: President's Advisory Committee - USTR Briefing Book (9/25/97); Administration Documents on Climate Change; October 22 Cabinet Briefing Materials; Draft- Climate Change Report; PCAST Report (11/5/97); Global Competitiveness Report- 1997; U.S. Submission Under UNFCCC- 1997; Argonne Report; White House Conference Transcript;
- Box 3: Talking Points- Stern; Stern Speeches; Meetings- Todd; Todd's Speech- 10/14/97; Research; Talking Points- Q & A; White House Conference Materials; International Utility; Climate Change Background; National Security; Oversight/ Working Group; International Actions; Congressional Record (10/22-23/97); Asphalt Nation; Kyoto: Diplomatic Reports, Press, Vice President, State Department Policy Papers, Miscellaneous.

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Todd -

HERE IS A SAMPLER OF INFORMATION
ON CLIMATE CHANGE. HOPE IT GIVES
YOU THE BACKGROUND YOU NEED

| CALL IF I CAN BE OF FURTHER
| ASSISTANCE .

- DIRK FORRISTER

343-1060

1072 (Direct)

Climate Change

Key Findings of the Second Assessment Report of the Intergovernmental Panel on Climate Change

The U.S. Government finds the IPCC Second Assessment Report to be an extremely useful document. It has achieved the goals of being scientifically credible and policy relevant, without being policy prescriptive.

The key findings of the IPCC can be simply summarized:

Regional and global climate and sea level

- Human activities are increasing the atmospheric concentrations of carbon dioxide and other greenhouse gases that tend to warm the atmosphere and, in some regions, of aerosols that tend to cool the atmosphere.
- The Earth's climate is changing. The surface temperature this century is as warm or warmer than any other century since at least 1400 AD; the temperature has increased by 0.3 to 0.6°C (about 0.5 to 1°F) over the last century; the last few decades have been the warmest this century; sea level has risen 10 to 25 cm (about 4 to 10 inches); and mountain glaciers have retreated world-wide this century.
- Models that account for the observed increases in the atmospheric concentrations of greenhouse gases and sulfate aerosols are simulating the recent history of observed changes in surface temperature and its vertical distribution with increasing realism.
- The balance of evidence suggests that there is a discernible human influence on global climate.
- Without specific policies that reduce the growth of greenhouse gas emissions, the Earth's average surface temperature is projected to increase by about 1 to 3.5°C (about 2 to 6.5°F) by 2100, a rate faster than anything observed over the last 10,000 years.

- The reliability of regional-scale predictions is still low, and the degree to which climate variability may change is uncertain.
- Sea level is projected to rise by 15-95 cm (6-38 inches) by 2100.
- The long atmospheric lifetime of many greenhouse gases, coupled with the thermal inertia of the oceans, means that the warming effect of anthropogenic emissions will be long-lived.
- Even with a stabilization of greenhouse gas concentrations in the year 2100, temperatures would continue to increase for several decades, and sea level would continue to rise for centuries.

Potential health and environmental consequences of climate change

- Human-induced regional and global changes in temperature, precipitation, soil moisture, and sea level add important new stresses on ecological and socio-economic systems that are already affected by pollution, increasing resource extraction, and non-sustainable management practices.
- Most systems are sensitive to both the magnitude and rate of climate change.
- The projected changes in climate include potentially disruptive effects that will affect the economy and the quality of life for this and future generations:
 - Human Health will be adversely affected through an increase in the rate of heat-related mortality and in the potential for the spread of vector-borne diseases such as malaria, dengue, yellow fever, and encephalitis and non-vector-borne diseases such as cholera and salmonellosis.
 - Food Security will be threatened in some regions of the world, especially in the tropics and subtropics, where many of the world's poorest people live, even though the effects of

climate change on total global food production may be small to moderate in comparison to the effects of population change and increasing nutrition demands.

- Water Resources will be increasingly stressed, leading to substantial economic, social, and environmental costs, especially in regions that are already water-limited and where there is strong competition among users.
- Human Habitat Loss will occur in regions where small islands and coastal plain and river areas are particularly vulnerable to sea level rise.
- Natural Ecosystems will be degraded because the composition, geographic distribution, and productivity of many ecosystems, such as forests, will shift as individual species respond to changes in climate. This will likely lead to reductions in biological diversity and in the goods and services ecosystems can provide for society.
- Developing countries are more vulnerable than developed countries to climate change because of their socio-economic conditions.
- Impacts will be hard to quantify with certainty because of uncertainties in regional climate projections, the complicating effects of multiple stresses, and a lack of understanding of some key processes.

Approaches to mitigate or adapt to climate change

- Adaptation, which involves adjustments in practices, processes, or structures of systems, can be helpful either in reducing adverse impacts or in preparing to take advantage of potential beneficial changes in climate.
- Options such as migration corridors to assist adaptation of natural ecosystems to new climate conditions are limited and their effectiveness is generally unproven.
- Successful adaptation will depend upon technological advances, institutional arrangements, availability of financing, technology transfer, information exchange, and incorporation of climate change concerns into resource use and development decisions. Potential adaptation options for many developing countries are extremely limited due to the limited availability of technological and economic capabilities.

- Stabilization of the atmospheric concentrations of carbon dioxide at three times the pre-industrial concentration or less will eventually require global emissions to be cut well below today's levels.
- Gains in energy efficiency of 10-30% above present levels are feasible at little or no cost in many parts of the world through conservation measures, development of new energy supply technologies, and improved land management practices over the next 2 to 3 decades.
- Significant reductions in net greenhouse gas emissions can be achieved utilizing an extensive array of technologies, and policy measures that accelerate technology development, diffusion, and transfer in all sectors.
- Flexible, cost-effective policies relying on economic incentives and instruments, as well as internationally coordinated instruments, can considerably reduce mitigation and adaptation costs.
- International and intergenerational equity issues are critical for policy formulation.
- There is justification for going beyond a no-regrets strategy.

Implications for Policymakers

The IPCC has clearly demonstrated that the actions currently being taken under the Framework Convention on Climate Change to address the threat of global warming are inadequate. They have shown that there are many cost-effective approaches to reduce net emissions in all parts of the world, which if implemented would provide significant environmental benefits. In all countries, including non-Annex I countries, many of these options will improve prospects for sustainable development and management of resources. While we are clearly not technology-limited in making some initial progress in reducing projected greenhouse gas emissions, deep long-term cost-effective reductions will require intensive R&D and significant improvements in energy, industrial and crop technologies. Therefore, it is clear that we collectively must redouble our efforts in identifying the most cost-effective global approaches to reduce emissions in both the near- and long-term utilizing a broad portfolio of actions. Further, we must enhance support for cooperative national and international efforts to understand the socio-economic consequences of climate change, regional variations, and the efficacy of adaptation and mitigation options.

Climate Change

July
1996

State of Knowledge

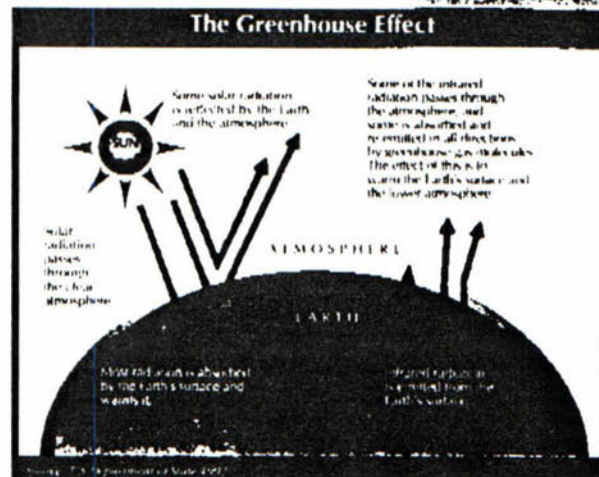
The Earth's climate is predicted to change because human activities are altering the chemical composition of the atmosphere. The buildup of greenhouse gases—primarily carbon dioxide, methane, nitrous oxide and chlorofluorocarbons—is changing the radiation balance of the planet. The basic heat-trapping property of these greenhouse gases is essentially undisputed. Although there is considerable scientific uncertainty about exactly how and when the Earth's climate will respond to enhanced greenhouse gases in the future, observations indicate that detectable changes are underway. The direct effects of climate change will include changes in temperature, precipitation, soil moisture and sea level. Such changes could have adverse effects on ecological systems, human health and socio-economic sectors.

Human-induced climate change is a complex problem, which can impact the economy and the quality of life for this and future generations. The lag time between emission of the gases and their impact is on the order of decades to centuries; so too is the time needed to reverse any effects. Thus, policy decisions in the near term will have long-term consequences.

The Climate System

A natural greenhouse effect keeps the Earth about 33°C (60°F) warmer than it otherwise would be. Without this greenhouse effect, life as we know it would not be possible. Water vapor, carbon dioxide and other trace gases trap heat as it is re-radiated from the Earth back to space. However, since pre-industrial times, human activities have added to the natural greenhouse effect by releasing additional greenhouse gases to the atmosphere. The burning of fossil fuels (coal, oil and gas) for energy is the primary source of emissions; changing land-use patterns through agriculture and deforestation also contribute a significant share. Current global emissions of carbon dioxide from energy use are approximately 6 gigatons of carbon (GtC) per year.

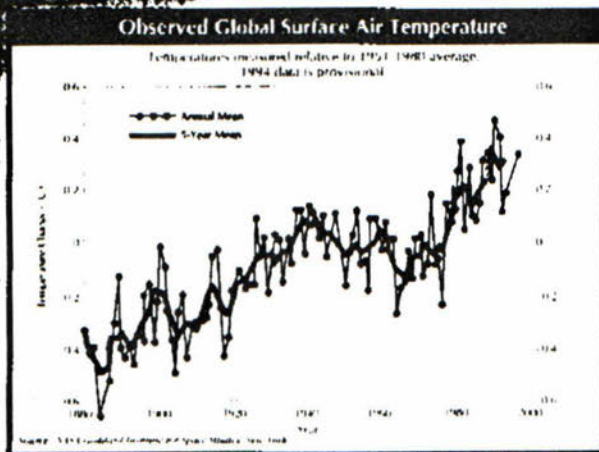
Future greenhouse gas emissions are sensitive to changes in demographic, economic, technological, policy and institutional developments. By the year 2025, world emissions could range from 8 to 15 GtC per year. In the year 2100, world emissions are projected to range from 5 to 36 GtC per year, depending on energy use, populations, technologies and other factors. The United States and the rest of the OECD countries currently



contribute about 40 percent of global carbon dioxide emissions. Future growth in emissions from OECD countries is predicted to be significantly smaller than growth in developing countries and countries with economies in transition.

Since the pre-industrial era, atmospheric concentrations of carbon dioxide have increased by nearly 30 percent, methane concentrations have doubled and nitrous oxide concentrations have risen by 15 percent. These increases result in a radiative forcing or heat-trapping of energy equivalent to about 2.8 watts per square meter (Wm^{-2}). About half of the radiative forcing may have been masked by increased levels of traditional air pollutants—sulfates and carbonaceous aerosols, particularly in the northern hemisphere—which cool the atmosphere by reflecting incoming solar radiation and altering the reflective properties of clouds. Aerosols are short-lived and vary regionally, hence they should not be regarded as a simple offset to greenhouse gas forcing. In addition, due to their health effects, buildup will likely be limited. Calculations suggest that the projected increases in atmospheric concentrations of greenhouse gases alone will result in an additional radiative forcing of about 3-8 Wm^{-2} by 2100. For a given concentration of greenhouse gases, the resulting increase in radiation can be predicted with precision, but the resulting impact on climate is more uncertain.

Model calculations, based on plausible ranges of future emissions and climate sensitivities, suggest that the global surface temperature could increase an average of 1.0 - 3.5°C (1.8-6.3°F) by 2100, with significant variation by region. This estimate accounts for the offset from aerosols, which has lowered earlier estimates somewhat. Global-average temperature changes of this magnitude would be greater than



recent natural fluctuations and would occur at a rate significantly faster than any observed changes in the last 10,000 years. The United States and high latitudes are projected to warm more than the global average, especially as sulfate aerosol loading is decreased.

Model calculations also suggest that the rate of evaporation will increase as the climate warms, leading to an increase in average global precipitation. Although precipitation at high latitudes is expected to increase, much of the precipitation increase may fall over the oceans. The models also suggest that the frequency of intense rainfall will increase and there will be a marked decrease in soil moisture over some mid-latitude continental regions during the summer.

Sea level is projected to increase by 15 to 95 centimeters (6 to 38 inches) by the end of the next century, due primarily to the thermal expansion of the oceans and the melting of glaciers.

Calculations of climate change at the regional scale are significantly less reliable than average global values, and it is unclear whether climate will become more variable. The frequency and intensity of some extreme weather events of critical importance to ecological systems (droughts, floods, frosts, cloudiness, the frequency of hot or cold spells, and the intensity of associated fire and pest outbreaks) could increase.

Global mean surface temperatures have increased between 0.3 and 0.6°C (0.54 and 1.08°F) since the late 19th century, despite marked regional, seasonal and diurnal differences, raising the decade global temperatures to the highest level in this century.

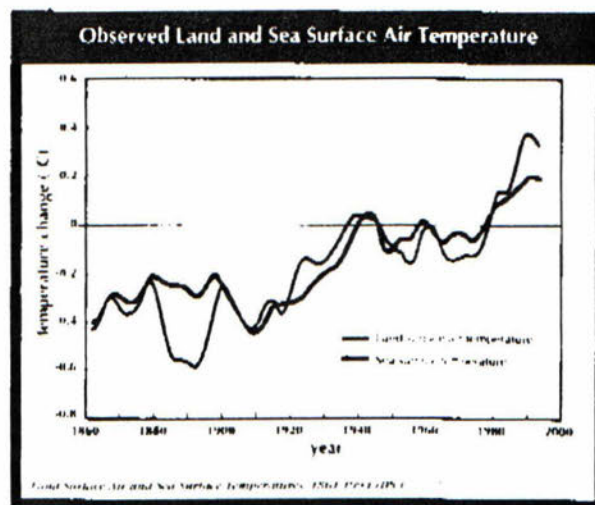
The ten warmest years this century have all occurred since 1980. 1995 was the warmest year on record, suggesting the atmosphere has rebounded from the transient cooling of 0.5°C (0.9°F) caused by the eruption of Mt. Pinatubo and simulated by the models.

Several ancillary pieces of evidence consistent with warming, such as a decrease in Northern Hemisphere snow cover, a simultaneous decrease in Arctic sea ice, continued melting of alpine glaciers and a rise of sea level have been corroborated. The frequency of extreme rainfall events also has increased throughout much of the country, suggestive of an intensification of the hydrologic cycle.

There is consistency between the observed global average temperature trend over this period and model simulations of the warming due to greenhouse gases if allowance is made for the increasing evidence of a cooling effect due to anthropogenic aerosols and stratospheric ozone depletion. Analyses of the geographical and vertical patterns of change give us more confidence that we are beginning to detect a human-induced signal despite natural climate variability. The IPCC concludes "the balance of evidence suggests a discernible human influence on global climate."

Carbon cycle models imply that limiting atmospheric concentrations of carbon dioxide to any level below 750 parts per million by volume (ppmv), about three times the pre industrial level, would require emissions worldwide to eventually drop below 1990 levels. The longer emissions continue to increase, the greater the eventual reductions would have to be in order to stabilize concentrations at a given level.

Although much is already known about the greenhouse effect, substantial reduction of key uncertainties (detailed quantification of the timing, magnitude and regional patterns of climate change) may require a decade or more. Accurate predictions are limited by our knowledge of the future emissions and atmospheric concentrations of carbon dioxide, aerosols and other greenhouse gases, the role of clouds and water vapor, and the role of the oceans and land ecosystems.



Projected Impacts of Climate Change

Climate change poses threats to resources both domestically and internationally. These threats could have significant, but uncertain, socioeconomic consequences. Changes in temperature, precipitation and sea level driven by climate change can add to existing stresses on resources caused by other influences such as population growth, land-use changes and pollution. Developing countries are more vulnerable than developed countries to climate change because of their socioeconomic conditions.

Overall, various strategies for coping with climate change can be identified for "intensively managed" systems (such as agriculture, water resources and developed coastlines). For these systems, technological and management options exist to some extent today, although they may be costly to implement. With time, more efficient responses can be developed for these sectors. By comparison, fewer options can be identified for natural systems (such as wetlands and wilderness areas).

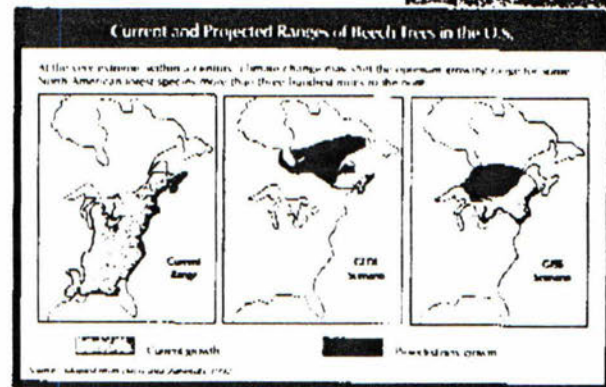
Natural ecosystems will be degraded because the composition, geographic distribution and productivity of many ecosystems will change as individual species respond to changing climate. This will likely lead to reductions in biological diversity and in the goods and services ecosystems can provide for society.

Temperature changes of the magnitude expected from the enhanced greenhouse effect have occurred in the past, but the previous changes took place over centuries or millennia instead of decades. Rates of natural migration and adaptation of species and communities appear to be much slower than the predicted rate of climate change.

One of the consequences of global climate change may be increases in the frequency of some extreme weather events, particularly droughts and floods. Of course, we cannot unambiguously relate climate change to specific events. However, these events, when they do occur, can be costly. For example:

- Since 1992, 15 weather related disasters in the United States have cost \$70 billion in damages and several hundred deaths from floods, heat waves, hurricanes, blizzards and hail storms.
- Damages from the Mississippi River flooding in 1993 are estimated to range from \$10 billion to \$20 billion.
- Almost \$4 billion in federal payments went to farmers suffering crop losses during the 1988 drought.

Examples of the kinds of effects that may result from climate change include:



Health

Human health will be adversely affected through an increase in the rate of heat-related mortality and in the potential for the spread of vector-borne diseases such as malaria, dengue fever, yellow fever and encephalitis and non-vector borne-diseases such as cholera and salmonellosis.

There will likely be increased risk of malaria and dengue fever in the United States. Changing temperatures and precipitation patterns may produce new breeding sites for pests and pathogens.

Climate change may increase heat-stress mortality, particularly in the very young and very old.

Water Resources

Changes in precipitation and increased evaporation from higher temperatures can affect water supplies and water quality, posing threats to hydropower, irrigation, fisheries and drinking water.

Floods are more likely because the frequency of intense rainfall is predicted to increase.

Droughts are likely to be more severe because warmer temperatures increase evaporation rates and thereby lead to drier soils during periods of little or no rain.

Climate change would be likely to add to the stress in several United States river basins such as the Great Basin, California, Missouri, Arkansas, Texas Gulf, Rio Grande and Lower Colorado.

Water scarcity in Middle Eastern and African countries also is likely to be exacerbated by climate change.

Coastal Resources

A 50 centimeters (20 inches) rise in sea level by the year 2100, which is within the range projected by the IPCC, could inundate more than 5,000 square miles of dryland and an additional 4,000 square miles of wetlands in the United States if no protective actions are taken.

Areas at highest risk from sea level rise are areas currently experiencing high erosion rates and those with very low elevations, such as parts of the United States Atlantic and Gulf coasts.

Internationally, many low-lying areas such as parts of the Maldives, Egypt and Bangladesh would be completely inundated and uninhabitable by a similar sea level rise. This would create large numbers of environmental refugees which would put stress on governments and social structures.

Agriculture

Large areas of the eastern and central United States face moderate to severe drying. Drought could become more frequent, particularly in the Great Plains.

Agriculture production in developing countries is likely to be more vulnerable to climate change, given that these countries have relatively fewer economic resources.

Food scarcity is threatened in some regions of the world, especially in the tropics and subtropics, where many of the world's poorest people live, even though the effects of climate change on total global food production may be small to moderate compared with the effects of population growth and increasing nutrition demands.

Forests

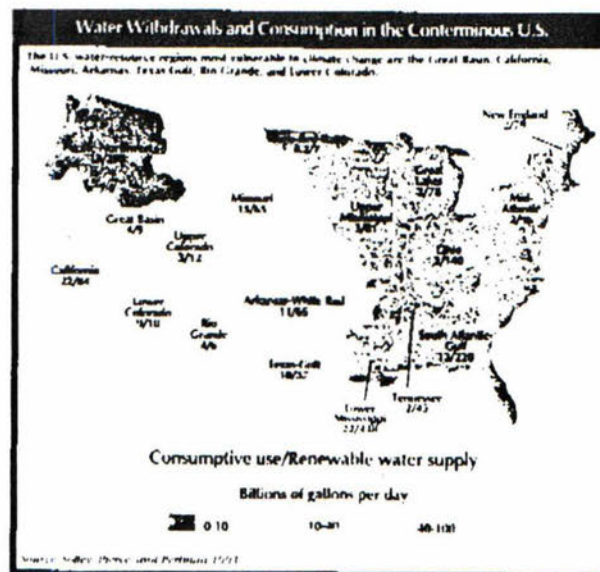
Climate change over the next several decades might shift the ideal range for some North American forest species by as much as 300 miles to the north, exceeding the ability of forests and other ecological communities to migrate.

Forest damage from fire and diebacks driven by drought, insects and disease could increase.

The most vulnerable forest resources are those in regions subject to increased moisture stress, as in the dry continental interiors.

Socio-Economic Analyses

Socio-economic analyses of climate change also are making important contributions. A key insight is that a portfolio of actions aimed at mitigation, adaptation and improving our knowledge would be a prudent way to deal with climate change. It is important to allow activities to be adjusted periodically in light of new information. Another insight is that policy analysis and development must carefully consider both the potential costs of inaction in terms of impacts, as described in the previous section, and the potential economic



costs associated with measures to reduce greenhouse gas emissions.

From the practitioners' perspective, qualitative insights from mitigation cost modeling studies are more important than the absolute numerical results. For example, specific approaches, designs and strategies may emerge as superior when evaluated using a variety of modeling frameworks. Several distinct methodologies are among the tools available to assist policy-makers in evaluating the potential costs associated with reductions in greenhouse gas emissions. These include: technology costing studies, economy-wide macroeconomic models and computable general equilibrium models. The various models each have strengths and weaknesses, and none by themselves can adequately portray the potential economic impacts associated with reductions in greenhouse gas emissions.

Analyses to date highlight the key role of technology innovation, capital stock turnover and capital productivity and their influence on mitigation costs. In addition, recent analyses also suggest that flexible approaches, including the possibility of optimizing reductions across countries and over time, have the potential to significantly reduce the costs of achieving any given mitigation objective.

Source: Office of Science and Technology Policy, 1996

EXCERPTS ON CLIMATE CHANGE
Remarks by the President to Business Roundtable
Washington, D.C.
June 12, 1997

...Finally, let me say on an issue that I know is a concern to some of you because I read your ad in the paper -- (laughter) -- I think that we have to prove that we can grow the economy while not only preserving, but actually enhancing, the environment. And I believe most of you think we can do that. And I think the message you were trying to get across in the ad is, don't wreck the economy without knowing what you're doing. I understand that.

But let me say, I was very moved by the speech recently given by the Chairman of British Petroleum on the issue of climate change. I don't know how many of you read it, but essentially what he said is, look, nobody knows exactly what the impact of climate change is, but let's not deny anymore that the climate is changing and that it can't be good, and that no harm will be done if we take sensible steps to try to reduce greenhouse gas emissions and to do other things which will help us to preserve the environment.

We've had more extreme weather conditions in the United States in the last five years than we had in the previous 30. And we know from all the scientific studies what is happening to the temperature of the globe. What I ask you to do is to work with me in good faith to give our children a world worth living in.

A lot of you have made a good deal of money in your corporations by technologies which improve the environment. And if we have the strongest economy in the world, we will find a sensible way to grow that economy in a way that fulfills our responsibilities.

Today, with 4 percent of the world's population, we produce over 20 percent of the greenhouse gases. We're up 13 percent since 1990 when President Bush and his administration said we would try to hold constant through the year 2000.

I had an interesting conversation with Jiang Zemin in New York about a year ago, when he said, I don't want you to have a containment policy toward China. I said, I'm not sure -- I said, I don't want to have a containment policy towards China. I said, my biggest worry about you is that you'll get rich the same way we did. And if you do that, you might burn the air up because you've got 1.2 billion people. And we need to find an environmentally responsible way for China to grow.

So I ask you to join with us in this partnership. There is no secret plan. There is no scheme here to try to put thousands of Americans out of business. I have devoted my passion and the best ideas I could come up with to try to get this country in good shape economically and socially. But I do believe it is folly for us to believe that we can go into the next century without a strategy that says we're going to be responsible and we're going to do our part and lead the world on the environmental issues -- because we all know what the evidence is. We don't know what the consequences are, and we don't want to go off and do something that we're not sure makes sense. But we can do this. We can do it together. We can do it in a way that makes sense.

And I ask you not to ever ask us to back away from that, but instead join hands with us and do what we've done for the last four and a half years. Let's find a way to preserve the environment, to meet our international responsibilities, to meet our responsibilities to our children, and grow the economy at the same time. I know we can do it. Look at the evidence of the last four years. We can do anything if we put our minds to it...

Everett M. Ehrlich

A Common-Sense Approach to Global Change

A leading business group a week ago advertised its desire for a national debate on climate change policy. All power to them: Such a debate is sorely needed.

But a debate needs to start somewhere, which means asking ourselves what we understand about climate change policy. Economists have thought about this issue—the administration's among them—and their thinking provides a set of "common sense" precepts about climate change that form a worthwhile basis for the discussion our nation needs to have. Before we debate, let's remind ourselves of what we already know.

(1) **The science is compelling.** Carbon dioxide warms the planet and by pumping more of it into the atmosphere, humankind is changing its climate. It's hard to say by how much, and it will affect different places in different ways, but the net effect is unlikely to be good. And as is too often the case for "system changes," the shift in temperature is likely to be more abrupt than we'd like it to be.

(2) **The economic costs are small.** Abating carbon dioxide and other greenhouse gases will entail economic

costs, but these are small and transitional. The economic literature suggests that we could roll back our CO₂ emissions to their 1990 levels by 2010 for the equivalent of a 25 cent gas tax. It's not free, but it's not the end of the world. Catastrophic climate change, if it occurs, could be.

(3) **Price signals matter.** Would that we could mandate that all refrigerators run on hamster power and that banana peels fuel automobiles. We can't. Broad price signals—perhaps the product of emissions permits that polluters could trade—send everybody the right message. They're not a whole policy, but a requisite basis for one.

(4) **Waiting won't work.** As serious as it is, climate change is not some sci-fi terror that requires immediate mobilization and massive sacrifice. But deferring action will raise the cost of stabilizing the world's atmos-

"The longer we wait, the further we have to catch up."

pheric concentrations of greenhouse gases, our ultimate goal. That's because our emissions (both the United States' and the world's) are growing faster than any imminent technology can abate them. The longer we wait, the further we have to catch up. On the other hand, the sooner we give ourselves some lead time, the easier all of this will be.

(5) **Capital incentives are important.** The faster we invest, the faster we turn over our capital stock, and the faster we achieve emissions reductions. That's because new investment embodies the latest technologies for reducing emissions. Experience across a wide range of industries shows that well-designed processes reduce both emissions and total business costs. Investment incentives must be considered as part of climate change strategy, because

pro-investment policy is pro-environment policy.

(6) **Allow cross-border trading.** It's all one atmosphere, whether it's polluted by U.S. utilities, German steel plants or Korean traffic jams. If we let polluters in one country search for cheaper pollution offsets in others, then we lower the cost of the entire process. The former Soviet bloc, China, India and others will offer such opportunities, at least for the next few decades. The question is: How do you make such a system work? That's something worth debating.

(7) **Technology is the key.** The economic effects of climate change policies occur over periods so long that even Alan Greenspan can't manage them—decades, even generations. We must have a far-sighted technology program that aims our most formidable economic weapon—new ideas—at this pressing problem. Let's sidestep the yammering about "corporate welfare," sit down with the business leaders who have expressed their concern and work out a shared program to innovate our way through this problem.

(8) **The whole world must be in-**

involved. The current negotiating framework would require the leading industrial economies and the former Soviet bloc to sign up to firm commitments now while the newly industrializing nations of Asia and Latin America catch up, somehow, later. Will this lead to a massive out-migration of capital from the United States and the other developed nations as firms flee the burden climate change policies impose? Probably not, given that there are already sizable differences in energy costs and environmental stringency between these two groups. But that's no reason to let them persist. Any climate treaty has to show how all of the world's nations are brought into the process.

(9) **Compensate the losers.** The fact that the economic costs are small in general does not mean that everyone escapes unharmed. It would be high-handed in the extreme to speak of climate change policy as an abstract "transition" without addressing the losses it imposes on men and women who work hard and support their families through jobs such as coal-

mining. Fairness demands nothing less.

(10) **The United States must lead.** The business leaders are right when they call for a debate that allows our entire nation to understand the climate issue. But there are also international negotiations underway. The United States can't walk away from the table. To date, it has done a good job of pushing for greater flexibility for our private sectors as a general principle, even while not agreeing to any specific targets. If the United States falls back from a leadership role in these negotiations, then the vacuum will only be filled by thinking and directions that will disserve us later. We must stay involved, even as we build consensus at home.

It's time to have a climate change debate. But the debate should concern itself with how best to take these "common sense" precepts and turn them into a policy that preserves both our prosperity and our quality of life for generations to come.

The writer was undersecretary of commerce for economic affairs until this month.

Washington Post

Sunday, June 15, 1997

U.S. CLIMATE CHANGE PROPOSAL FACT SHEET

January 17, 1997

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EMISSIONS TRADING AND JOINT IMPLEMENTATION

LONG-TERM EFFORTS UNDER THE CONVENTION

In July, 1996 the United States outlined a broad framework for negotiation of next steps under the Framework Convention on Climate Change. In December, 1996 the U.S. further elaborated its ideas by describing the key elements that should be discussed for inclusion in a protocol to guide greenhouse gas emissions reduction efforts in the post-2000 period. The attached document represents further elaboration of the proposed framework. Today, the United States will present to the Convention's Secretariat draft text for consideration in international negotiations that will occur throughout 1997. Consistent with previous U.S. statements and proposals, the U.S. submission addresses the following key topics:

EMISSIONS TARGETS

- A new concept is set forth to guide the establishment of developed country emissions targets. Building on the concept of cumulative and averaged emissions, the U.S. proposes creation of an "emissions budget". Multiple emissions budget periods are proposed, including a second period in which emissions are equal to or less than the first period, thus assuring continued progress toward achievement of the Convention's objective.
 - For a given period, each developed country Party would be allocated an emissions budget.
 - The submission does not identify either the size of the budgets or the duration of the periods.
 - Parties would be allowed to bank for future use emissions not used during a given period; to borrow a limited amount of emissions (with a penalty) from a subsequent period; and to trade emissions.
 - A new category is proposed to encourage rapidly developing countries to voluntarily adopt emissions budgets.

REPORTING AND COMPLIANCE

- The proposal establishes procedures to ensure adequate reporting, measurement, review and compliance.

- Countries would have to set national systems for measuring emissions accurately, achieving compliance and ensuring enforcement.
- Annual reports on measurement, compliance and enforcement efforts for the relevant budget period would be required and made available to the public.
- Implementation efforts would be reviewed under the Convention by expert teams and discussed at appropriate meetings of the Parties.
- The Parties would be assigned responsibility for determining the consequences of non-compliance, for example: denial of emissions trading/joint implementation rights; loss of voting and other decision-making rights.

ADVANCING DEVELOPING COUNTRY EFFORTS

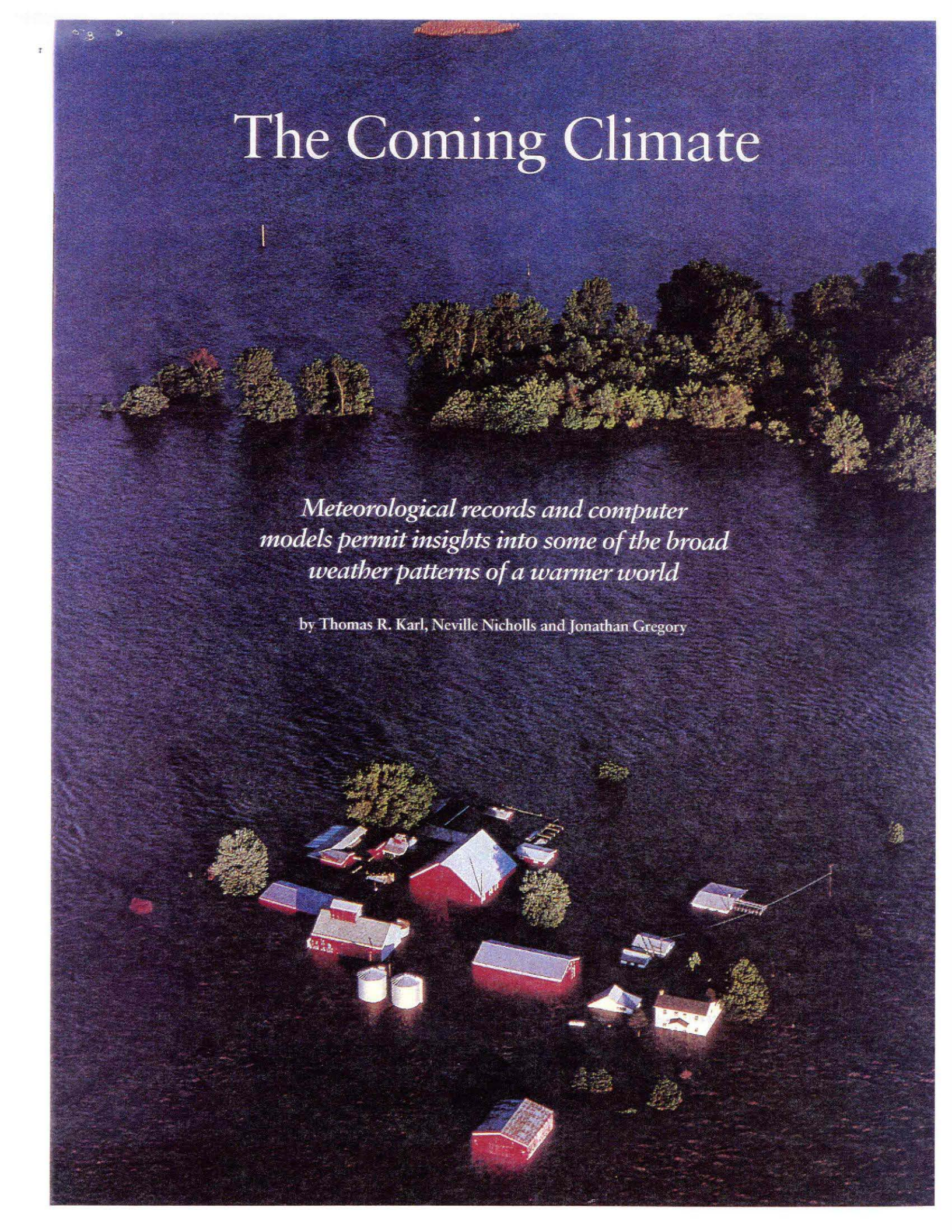
- The proposal advances implementation of developing country commitments under the Convention by:
 - Requiring developing countries to identify and adopt "no-regrets" measures to mitigate net greenhouse gas emissions.
 - Requiring developing countries to prepare annual emissions inventories and report on steps taken to reduce emissions.
 - Establishing a process for reviewing developing country reports and improving emissions reduction strategies.

EMISSIONS TRADING AND JOINT IMPLEMENTATION

- The U.S. submission provides for full emissions trading among countries with emissions budgets (provided they are in compliance with all obligations under the agreement); it also provides for "joint implementation", through which countries without emissions budgets could create and transfer emissions reduction credits achieved by qualified projects.

LONG-TERM EFFORTS UNDER THE CONVENTION

- The proposal calls for periodic review of the agreement as scientific knowledge and information grow; it also requires the Parties to seek establishment of a long-term goal for atmospheric greenhouse gas concentrations.
- The proposal calls for establishment of a date certain for negotiation of emissions obligations for all Parties, and calls for development of graduation mechanisms to strengthen the obligations of developing nations.

An aerial photograph showing a farmstead completely submerged in water. Several red barns and white houses are visible, surrounded by water. In the background, a large island of trees is also partially submerged. The sky is a deep blue, suggesting dusk or dawn.

The Coming Climate

Meteorological records and computer models permit insights into some of the broad weather patterns of a warmer world

by Thomas R. Karl, Neville Nicholls and Jonathan Gregory

Human beings have in recent years discovered that they may have succeeded in achieving a momentous but rather unwanted accomplishment. Because of our numbers and our technology, it now seems likely that we have begun altering the climate of our planet.

Climatologists are confident that over the past century, the global average temperature has increased by about half a degree Celsius. This warming is thought to be at least partly the result of human activity, such as the burning of fossil fuels in electric power plants and automobiles. Moreover, because populations, national economies and the use of technology are all growing, the global average temperature is expected to continue increasing, by an additional 1.0 to 3.5 degrees C by the year 2100.

Such warming is just one of many consequences that climate change can have. Nevertheless, the ways that warming might affect the planet's environment—and, therefore, its life—are among the most compelling issues in earth science. Unfortunately, they are also among the most difficult to predict. The effects will be complex and vary considerably from place to place. Of particular interest are the changes in regional climate and local weather and especially extreme events—record temperatures, heat waves, very heavy rainfall, or drought, for example—which could very well have staggering effects on societies, agriculture and ecosystems.

Based on studies of how the earth's weather has changed over the past century as global temperatures edged upward, as well as on sophisticated computer models of climate, it now seems probable that warming will accompany changes in regional weather. For example, longer and more intense heat waves—a likely consequence of an increase in either the mean temperature or in the variability of daily temperatures—would result in public health threats and even unprecedented levels of mortality, as well as in such costly inconveniences as road buckling and high cooling loads, the latter possibly leading to electrical brownouts or blackouts.

FLOODED FARM near the Mississippi River in 1996 illustrates one likely consequence of warming trends. Rainfall will not only increase overall, but individual events will become more intense.

Climate change would also affect the patterns of rainfall and other precipitation, with some areas getting more and others less, changing global patterns and occurrences of droughts and floods. Similarly, increased variability and extremes in precipitation can exacerbate existing problems in water quality and sewage treatment and in erosion and urban storm-water routing, among others. Such possibilities underscore the need to understand the consequences of humankind's effect on global climate.

Two Prongs

Researchers have two main—and complementary—methods of investigating these climate changes. Detailed meteorological records go back about a century, which coincides with the period during which the global average temperature increased by half a degree. By examining these measurements and records, climatologists are beginning to get a picture of how and where extremes of weather and climate have occurred.

It is the relation between these extremes and the overall temperature increase that really interests scientists. This is where another critical research tool—global ocean-atmosphere climate models—comes in. These high-performance computer programs simulate the important processes of the atmosphere and oceans, giving researchers insights into the links between human activities and major weather and climate events.

The combustion of fossil fuels, for example, increases the concentration in the atmosphere of certain greenhouse gases, the fundamental agents of the global warming that may be attributable to humans. These gases, which include carbon dioxide, methane, ozone, halocarbons and nitrous oxide, let in sunlight but tend to insulate the planet against the loss of heat, not unlike the glass of a greenhouse. Thus, a higher concentration means a warmer climate.

Of all the human-caused (anthropogenic) greenhouse gases, carbon dioxide has by far the greatest impact on the global heat budget (calculated as the amount of heat absorbed by the planet less the amount radiated back into space). Contributing to carbon dioxide's greenhouse potency is its persistence: as much as 40 percent of it tends to remain in the atmosphere for centuries. Accumulation of atmospheric carbon dioxide is promoted not only by combus-

tion but also by tropical deforestation.

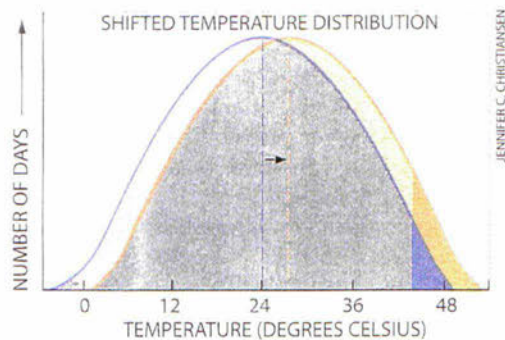
The second most influential human-caused effect on the earth's radiation budget is probably that of aerosols, which are minute solid particles, sometimes covered by a liquid film, finely dispersed in the atmosphere. They, too, are produced by combustion, but they also come from natural sources, primarily volcanoes. By blocking or reflecting light, aerosols tend to mitigate global warming on regional and global scales. In contrast to carbon dioxide, aerosols have short atmospheric residence times (less than a week) and consequently are concentrated near their sources. At present, scientists are less certain about the radiative effects of aerosols than those of greenhouse gases.

By taking increases in greenhouse gases into account, global ocean-atmosphere climate models can provide some general indications of what we might anticipate regarding changes in weather events and extremes. Unfortunately, however, the capabilities of even the fastest computers and our limited understanding of the linkages among various atmospheric, climatic, terrestrial and oceanic phenomena limit our ability to model important details on the scales at which they occur. For example, clouds are of great significance in the atmospheric heat budget, but the physical processes that form clouds and determine their characteristics operate on scales too small to be accounted for directly in global-scale simulations.

How Hot, and How Often?

The deficiencies in computer models become rather apparent in efforts to reproduce or predict the frequency of climate and weather extremes of all kinds. Of these extremes, temperature is one of the most closely studied, because of its effect on humanity, through health and mortality, as well as cooling loads and other factors. Fortunately, researchers have been able to garner some insights about these extremes by analyzing decades of weather data. For statistical reasons, even slight increases in the average temperature can result in big jumps in the number of very warm days [see top illustration on next page].

One of the reasons temperature extremes are so difficult to model is that they are particularly sensitive to unusual circulation patterns and air masses, which can occasionally cause them to



SMALL SHIFTS in the most common daily temperature cause disproportionate increases in the number of extremely hot days. The reason is that temperature distributions are roughly Gaussian. So when the highest point in the Gaussian "bell" curve moves to the right (*above*), the result is a relatively large increase (*yellow area*) in the probability of exceeding extremely high temperature thresholds. A greater probability of high temperature increases the likelihood of heat waves (*right*).



follow a trend in the direction opposite that of the mean temperature. For example, in the former Soviet Union, the annual extreme minimum temperature has increased by a degree and a half, whereas the annual extreme maximum showed no change.

The National Climatic Data Center, which is part of the U.S. National Oceanic and Atmospheric Administration (NOAA), has developed a statistical

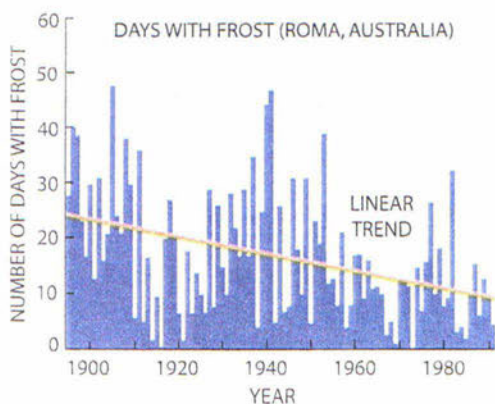
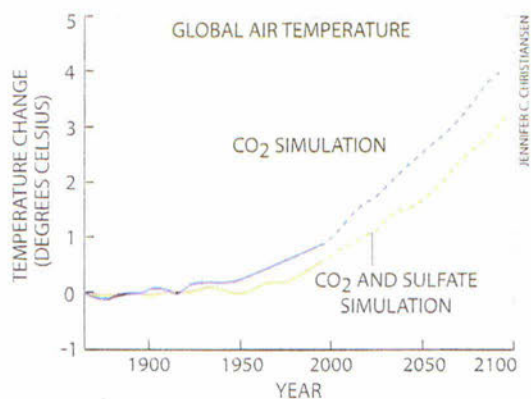
model that simulates the daily maximum and minimum temperatures from three properties of a plot of temperature against time. These three properties are the mean, its daily variance and its day-to-day correlation (the correlation is an indication of how temperatures persist—for example, how often a hot day is followed by another hot day). Given new values of mean, variance and persistence, the model will project the duration and severity of extremes of temperature.

Some of its predictions are surprising. For example, Chicago exhibits considerable variability of temperature from week to week. Even if the mean January temperature went up by four degrees C (an occurrence that may actually take place late in the next century) while the other two properties remained constant, days with minimum temperatures less than -17.8 de-

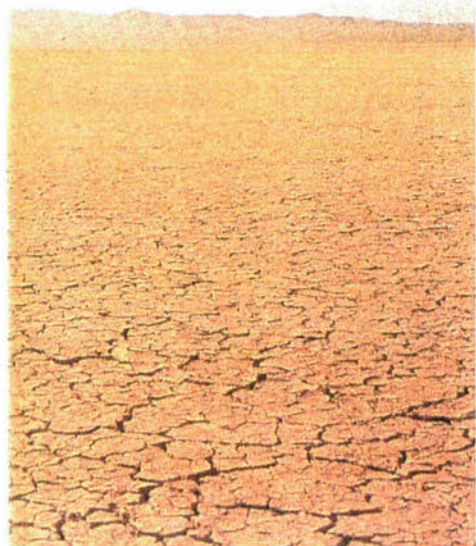
grees C (zero degrees Fahrenheit) would still occur. They might even persist for several days in a row. There should also be a significant reduction in the number of early- and late-season freezes. And, not surprisingly, during the summer, uncomfortably hot spells, including so-called killer heat waves, would become more frequent. With just a three degree C increase in the average July temperature, the probability that the heat index (a measure that includes humidity and measures overall discomfort) will exceed 49 degrees C (120 degrees F) sometime during the month increases from one in 20 to one in four.

Because of their effects on agriculture, increases in the minimum are quite significant. Observations over land areas during the latter half of this century indicate that the minimum temperature has increased at a rate more than 50 percent greater than that of the maximum. This increase has lengthened the frost-free season in many parts of the U.S.; in the Northeast, for example, the frost-free season now begins an average of 11 days earlier than it did during the 1950s. A longer frost-free season can be beneficial for many crops grown in places where frost is not very common, but it also affects the growth and development of perennial plants and pests.

The reasons minimum temperatures are going up so much more rapidly than maximums remain somewhat elusive. One possible explanation revolves around cloud cover and evaporative cooling, which have increased in many areas. Clouds tend to keep the days



GLOBAL AIR TEMPERATURE rise was simulated (*above, left*) by a climate model at the U.K. Meteorological Office's Hadley Center. The blue line is from a simulation based on carbon dioxide only; the yellow line also takes into account sulfate. As the global temperature has increased, the number of days with minimums below zero degrees Celsius has gone down. This example (*left*) shows the annual number of days with frost in Roma, Queensland, in Australia.



WARREN MARK/Panorama Images

temperature is complex. In a warmer world, the difference of temperature between the tropics and the poles would most likely cover a smaller range, because greater warming is expected near the poles. This factor would tend to weaken storms. On the other hand, high in the atmosphere this difference would be reversed, having the opposite influence. Changes in storms could also happen if anthropogenic aerosols continue to cool the surface regionally, altering the horizontal temperature contrasts that control the location of the storm tracks.

More Precipitation

The relation between storms and temperature patterns is one of the reasons it is so difficult to simulate climate changes. The major aspects of climate—temperature, precipitation and storms—are so interrelated that it is impossible to understand one independently of the others. In the global climate system, for example, the familiar cycle of evaporation and precipitation transfers not only water from one place to another but also heat. The heat used at the surface by evaporation of the water is released high in the atmosphere when the water condenses again into clouds and precipitation, warming the surrounding air. The atmosphere then loses this heat by radiating it out into space.

With or without additional greenhouse gases, the earth takes in the same amount of solar energy and radiates the same amount back out into space. With a greater concentration of greenhouse gases, however, the surface is better insulated and can radiate less heat *directly* from the ground to space. The efficiency with which the planet radiates heat to space goes down, which means that

the temperature must go up in order for the same amount of heat to be radiated. And as the temperature increases, more evaporation takes place, leading to more precipitation, averaged across the globe.

Precipitation will not increase everywhere and throughout the year, however. (In contrast, all areas of the globe should have warmer temperatures by the end of the next century.) The distribution of precipitation is determined not only by local processes but also by the rates of evaporation and the atmospheric circulations that transport moisture.

For instance, most models predict reduced precipitation in southern Europe in summer as a result of increased greenhouse gases. A significant part of the rainfall in this region comes from local evaporation, with the water not precipitated locally being exported to other areas. Thus, in a warmer climate, increased evaporation in the spring would dry out the soil and lead to less water being available for evaporation and rainfall in the summer.

On a larger scale, most models predict an increase in average precipitation in winter at high latitudes because of greater poleward transport of moisture derived from increased evaporation at low latitudes. Since the turn of the century, precipitation has indeed increased in the high latitudes of the Northern Hemisphere, primarily during the cold season, as temperatures have increased. But for tropical and subtropical land areas, precipitation has actually decreased over the past few decades. This is especially apparent over the Sahel and eastward to Indonesia.

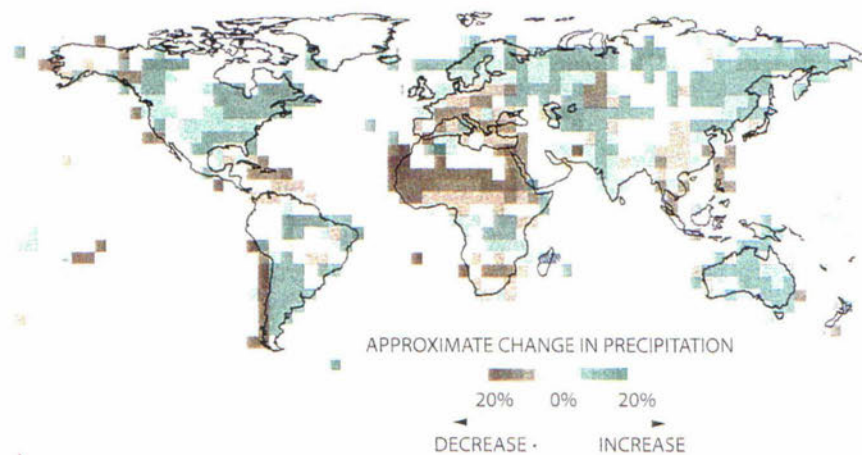
In northernmost North America (north of 55 degrees) and Eurasia, where conditions are normally far below freezing for much of the year, the amount of

cooler by reflecting sunlight and the nights warmer by inhibiting loss of heat from the surface. Greater amounts of moisture in the soil from additional precipitation and cloudiness inhibit daytime temperature increases because part of the solar energy goes into evaporating this moisture. More conclusive answers, as well as a prediction about whether the asymmetry in daytime and nighttime warming will continue, await better computer models.

Projections of the day-to-day changes in temperature are less certain than those of the mean, but observations have suggested that this variability in much of the Northern Hemisphere's midlatitudes has decreased as the climate has become warmer. Some computer models also project decreases in variability. The variability depends on season and location and is also tied to surface characteristics, such as snow on the ground or moisture in the soil. In midlatitudes, changes in the daily variability of temperature have also been linked to changes in the frequency and intensity of storms and in the location of the paths commonly taken by storms. These storm tracks are, in effect, a succession of eastward-moving midlatitude depressions whose passage dominates the weather.

The relation between these storms and

PRECIPITATION TRENDS between 1900 and 1994 reveal a general tendency toward more precipitation at higher latitudes and less precipitation at lower ones. Green indicates more rain; brown less.



LAURE GRACE

snowfall has increased over the past several decades. Further increases in snowfall are likely in these areas. Farther south, in southern Canada and the northern U.S., the ratio of snow to rain has decreased, but because of the increase in total precipitation there has been little overall change in the amount of snowfall. In the snow transition belts, where snow is intermittent throughout the cold season, the average snowfall will tend to diminish as the climate warms, before vanishing altogether in some places. Interestingly, areal snow cover during spring and summer abruptly diminished by nearly 10 percent after 1986. This decrease in snow cover has contributed to the rise of spring temperatures in the middle and high latitudes.

Besides the overall amounts of precipitation, scientists are particularly interested in the frequency of heavy downpours or rapid accumulations because of the major practical implications. Intense precipitation can result in flooding, soil erosion and even loss of life. What change do we expect in this frequency?

Whether precipitation occurs is largely determined by the relative humidity, which is the ratio of the concentration of water vapor to its maximum saturation value. When the relative humidity reaches 100 percent, water condenses into clouds, making precipitation possible. Computer models suggest that the distribution of relative humidity will not change much as the climate changes.

The concentration of water vapor needed to reach saturation in the air rises rapidly with temperature, however, at about 6 percent per degree Celsius. So in a warmer climate, the frequency of precipitation (which is related to how often the relative humidity reaches 100 percent) will change less than the amount of precipitation (related to how much water vapor there is in the air). In addition, not only will a warmer world be likely to have more precipitation, but the average precipitation event is likely to be heavier.

Various analyses already support the notion of increased intensity. In the U.S., for example, an average of about 10 percent of the total annual precipitation that falls does so during very heavy downpours in which at least 50 millimeters falls in a single day. This proportion was less than 8 percent at the beginning of this century.

As incredible as it may seem with all this precipitation, the soil in North America, southern Europe and in sever-

HURRICANES, a kind of tropical cyclone, will probably occur in different global patterns as a result of warming; their overall incidence, however, may not change. Hurricane Andrew, shown raging here in Miami, struck the southeast coastal U.S. in 1992, causing \$30-billion worth of damage.

al other places is actually expected to become drier in the coming decades. Dry soil is of particular concern because of its far-reaching effects, for instance, on crop yields, groundwater resources, lake and river ecosystems and even on down to the foundations of buildings. Higher temperatures dry the soil by boosting the rates of evaporation and transpiration through plants. Several models now project significant increases in the severity of drought. Tempering these predictions, however, are studies of drought frequency and intensity during this century, which suggest that at least during the early stages of global warming other factors have overwhelmed the drying effects of warmer weather. For example, in the U.S. and the former U.S.S.R., increases in cloud cover during the past several decades have led to reduced evaporation. In western Russia, in fact, soil moisture has increased.

Stormy Weather

Great as they are, the costs of droughts and heat waves are less obvious than those of another kind of weather extreme: tropical cyclones. These storms, known as hurricanes in the Atlantic and as typhoons in the western North Pacific, can do enormous damage to coastal areas and tropical islands. As the climate warms, scientists anticipate changes in tropical cyclone activity that would vary by region. Not all the consequences would be negative; in some rather arid regions the contribution of tropical cyclones to rainfall is crucial. In northwest Australia, for example, 20 to 50 percent of the annual rainfall is associated with tropical cyclones. Yet the damage done by a single powerful cyclone can be truly spectacular. In August 1992 Hurricane Andrew killed 54 people, left 250,000 homeless



and caused \$30-billion worth of damage in the Caribbean and in the southeast coastal U.S.

Early discussions of the possible impacts of an enhanced greenhouse effect often suggested more frequent and more intense tropical cyclones. Because these storms depend on a warm surface with unlimited moisture supply, they form only over oceans with a surface temperature of at least 26 degrees C. Therefore, the reasoning goes, global warming will lead to increased ocean temperatures and, presumably, more tropical cyclones.

Yet recent work with climate models and historical data suggests that this scenario is overly simplistic. Other factors, such as atmospheric buoyancy, instabilities in the wind flow, and the differences in wind speed at various heights (vertical wind shear), also play a role in the storms' development. Beyond enabling this rather broad insight, though, climate models have proved of limited use in predicting changes in cyclone activity. Part of the problem is that the simulations are not yet detailed enough to model the very intense inner core of a cyclone.

The historical data are only slightly more useful because they, too, are im-



perfect. It has been impossible to establish a reliable global record of variability of tropical cyclones through the 20th century because of changes in observing systems (such as the introduction of satellites in the late 1960s) and population changes in tropical areas. Nevertheless, there are good records of cyclone activity in the North Atlantic, where weather aircraft have reconnoitered since the 1940s. Christopher W. Landsea of the NOAA Atlantic Oceanographic and Meteorological Laboratory has documented a decrease in the inten-

sity of hurricanes, and the total number of hurricanes has also followed suit. The years 1991 through 1994 were extremely quiet in terms of the frequency of storms, hurricanes and strong hurricanes; even the unusually intense 1995 season was not enough to reverse this downward trend. It should be noted, too, that the number of typhoons in the northwestern Pacific appears to have gone up.

Overall, it seems unlikely that tropical cyclones will increase significantly on a global scale. In some regions, activity may escalate; in others, it will lessen. And these changes will take place against a backdrop of large, natural variations from year to year and decade to decade.

Midlatitude cyclones accompanied by heavy rainfall, known as extratropical storms, generally extend over a larger area than tropical cyclones and so are more readily modeled. A few studies have been done. A recent one by Ruth Carnell and her colleagues at the Hadley Center of the U.K.

Meteorological Office found fewer but more intense storms in the North Atlantic under enhanced greenhouse conditions. But the models do not all agree.

Analyses of historical data also do not give a clear conclusion. Some studies suggest that since the late 1980s, North Atlantic winter storm activity has been more extreme than it ever was in the previous century. Over the past few decades, there has also been a trend toward increasing winds and wave heights in the northern half of the North Atlantic Ocean. Other analyses by Hans von

Storch and his colleagues at the Max Planck Institute for Meteorology in Hamburg, Germany, found no evidence of changes in storm numbers in the North Sea. In general, as with the tropical cyclones, the available information suggests that there is little cause to anticipate global increases in extratropical storms but that regional changes cannot be ruled out.

The Future

Although these kinds of gaps mean that our understanding of the climate system is incomplete, the balance of evidence suggests that human activities have already had a discernible influence on global climate. In the future, to reduce the uncertainty regarding anthropogenic climate change, especially on the small scales, it will be necessary to improve our computer modeling capabilities, while continuing to make detailed climatic observations.

New initiatives, such as the Global Climate Observing System, and detailed studies of various important climatic processes will help, as will increasingly powerful supercomputers. But the climate system is complex, and the chance always remains that surprises will come about. North Atlantic currents could suddenly change, for example, causing fairly rapid climate change in Europe and eastern North America.

Among the factors affecting our predictions of anthropogenic climate change, and one of our greatest uncertainties, is the amount of future global emissions of greenhouse gases, aerosols and other relevant agents. Determining these emissions is much more than a task for scientists: it is a matter of choice for humankind. ■

The Authors

THOMAS R. KARL, NEVILLE NICHOLLS and JONATHAN GREGORY were all members of the Intergovernmental Panel on Climate Change, which assessed and reported on the human impact on global climate. Karl is a senior scientist at the National Oceanic and Atmospheric Administration's National Climatic Data Center. Nicholls is a senior principal research scientist at the Australian Bureau of Meteorology Research Center. Gregory is a climate modeler at the Hadley Center of the U.K. Meteorological Office.

Further Reading

CHANGING BY DEGREES: STEPS TO REDUCE GREENHOUSE GASES. U.S. Congress, Office of Technology Assessment, 1991.
POLICY IMPLEMENTATION OF GREENHOUSE WARMING: MITIGATION, ADAPTATION, AND THE SCIENCE BASE. National Academy of Sciences. National Academy Press, 1992.
GLOBAL WARMING DEBATE. Special issue of *Research and Exploration: A Scholarly Publication* of the National Geographic Society, Vol. 9, No. 2; Spring 1993.
GLOBAL WARMING: THE COMPLETE BRIEFING. John T. Houghton. Lion Press, 1994.
CLIMATE CHANGE 1995: THE SCIENCE OF CLIMATE CHANGE. Contribution of Working Group I to the *Second Assessment Report of the Intergovernmental Panel on Climate Change*. Edited by J. T. Houghton, L. G. Meira Filho, B. A. Callendar and N. Harris. Cambridge University Press, 1996.
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Climate Change: An Overview



DIRK FORRISTER
CHAIRMAN
WHITE HOUSE CLIMATE CHANGE TASK FORCE

734 JACKSON PLACE, NW
WASHINGTON, D.C. 20503

(202) 343-1060
FAX (202) 343-1162

Presentation by Dr. Jonathan C. Pershing
Office of Global Change (OES/EGC)
ESTOC -- March 10, 1997

Climate Change: An Overview

- Chronology
- Science
- Negotiations
- Other Country Positions
- U.S. Objectives

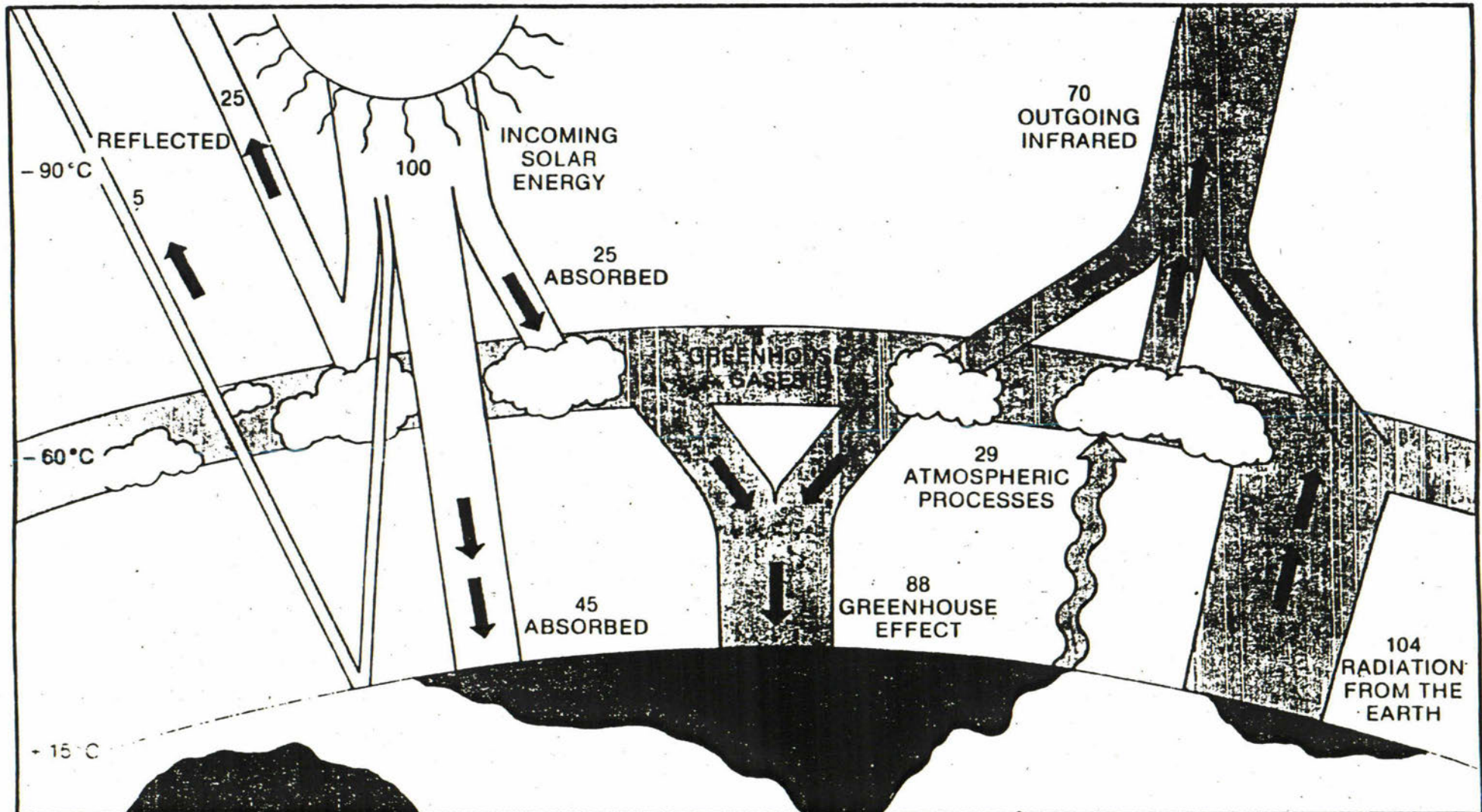
History

- Arrhenius; Late 1800's -- scientific statement of problem
- Keeling; 1959 -- monitoring of atmospheric CO₂
- Toronto; 1987 -- political statement of possible solution: 20% reduction from 1987 levels by 2005
- UNGA; 1990 -- formal initiation of negotiations
- Rio; June, 1992 -- UN Framework Convention
- Berlin; March, 1995 -- new negotiating mandate

Physical Science

- Radiative forcing: global warming theory
- Modeling v. empirical data
 - Satellite data
 - Computer analysis
- Uncertainty in the science
- Science “skeptics”

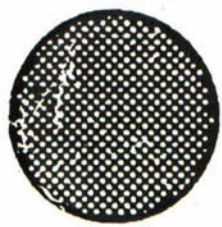
The Greenhouse Effect (radiation flows expressed as a percent of total incoming or outgoing energy)



Incoming solar radiation is partially reflected back into space (30 percent) and partially absorbed by the atmosphere, ice, oceans, land, and biomass of the Earth (70 percent). The Earth then emits radiant energy back into space. The "Greenhouse Effect" refers to the trapping of some of the radiant energy the Earth emits by atmospheric gases, both natural and anthropogenic. As a result of this effect, the Earth's surface and lower atmosphere warms.

SOURCE: Office of Technology Assessment, 1991.

SUN



Some solar radiation
is reflected by the Earth
and the Atmosphere

ATMOSPHERE

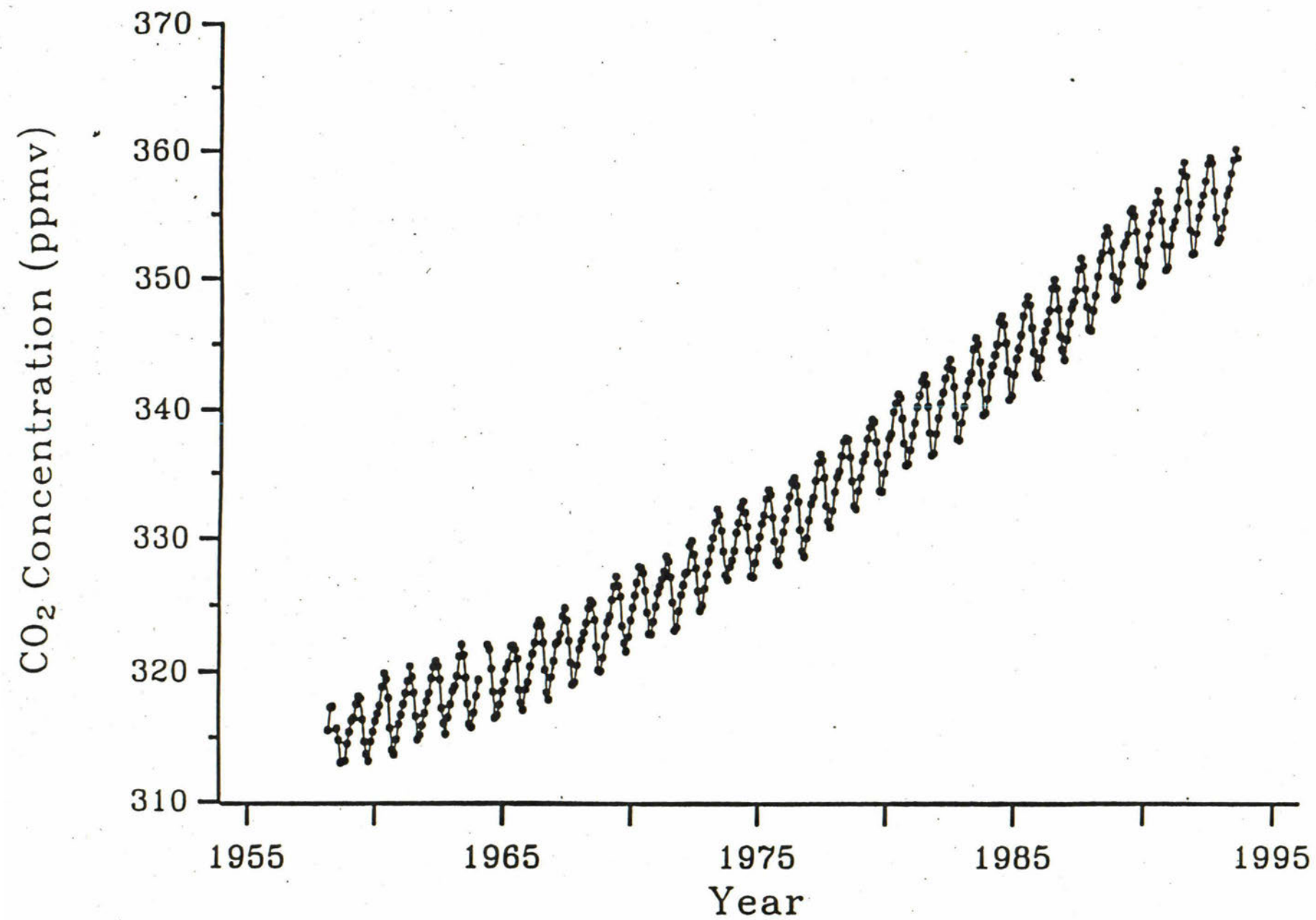
Some of the
infrared radiation
is absorbed by
the greenhouse
gases. The effect
is to warm the
surface and the
lower atmosphere

EARTH

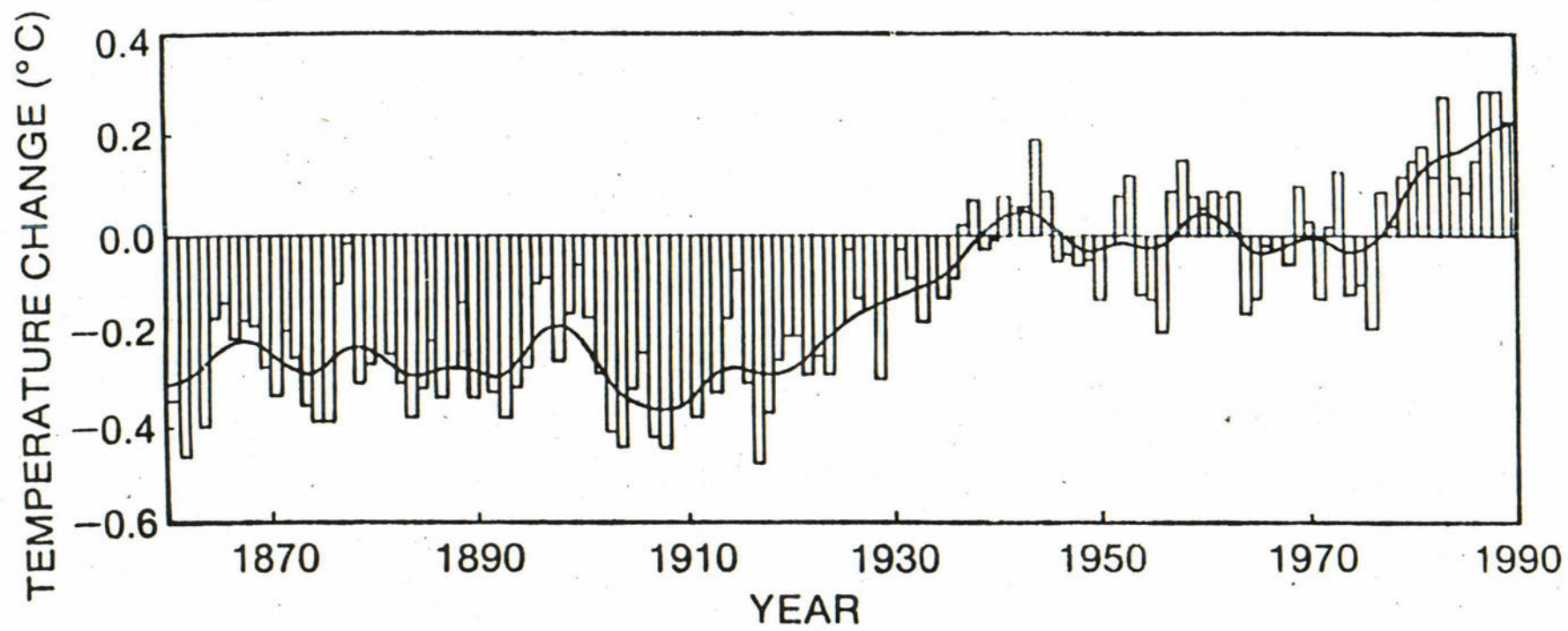
Most solar radiation passes
through the clear atmosphere,
is absorbed by the Earth's
surface, and warms it

Infrared radiation
is emitted from the
Earth's surface

A simplified diagram illustrating the greenhouse effect



Monthly atmospheric CO₂ concentrations at Mauna Loa.



IPCC: The Science

1

Atmospheric concentrations of greenhouse gases and aerosols are increasing because of human activities

There is clear evidence of a discernible human influence on the Earth's climate, remaining uncertainties notwithstanding

Without global efforts to reduce emissions, the Earth's temperature is projected to increase between 0.8° and 3.5° C by the year 2100, a faster rate than anything observed during the last 10,000 years

These projected changes in climate will result in adverse effects on human health, many ecological systems and socio-economic sectors

A range of cost-effective technologies and policies can be used in both developed and developing countries to markedly reduce net emissions of greenhouse gases

There is a justification for going beyond a “no regrets” strategy

Impacts

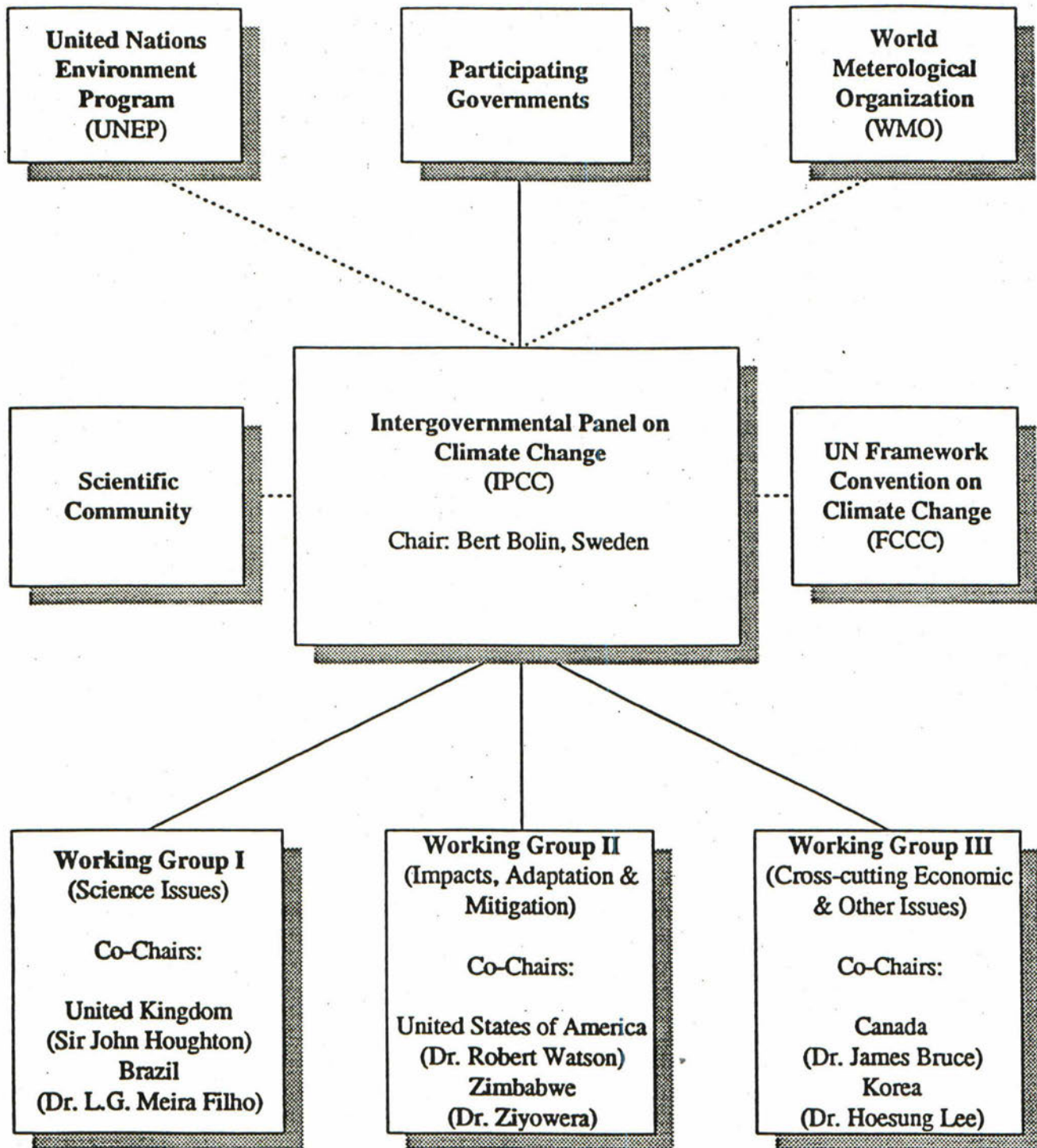
- Temperature change
- Change in hydrologic cycle
- Sea level
- Disease vectors
- Biodiversity/managed and unmanaged ecosystems

Response Options

- Costs and cost-benefit analysis to determine level of appropriate action
- Sectoral Responses
 - Technology development/diffusion
- Change in behavior patterns induced through:
 - economic instruments
 - legislation
 - public relations

The Intergovernmental Panel on Climate Change (IPCC)

- Origins: WMO and UNEP
- Structure -- organization of Panel
 - Scientific structure: Working Groups on Science, Impacts, Response Options
 - Governing structure
- First and Second Assessment Reports
- Influence on Process
- IPCC's future



Negotiations

- UNGA Resolution 45/212
- Intergovernmental Negotiating Committee (INC)
 - Establishing the negotiating structure
 - Conducting a multilateral negotiation
 - Concluding an agreement

Climate Change Convention Status

Signed by 160 Countries

As of July 1, 1996, Convention had been ratified by 159 countries, including the United States (which was the 4th country to ratify in October 1992)

Convention “Entered into Force” on March 21, 1993

The United Nations Framework Convention on Climate Change

- Objective
- Principles
- Commitments
 - All Parties (Article 4.1)
 - Developed Country (Annex I) Parties
- Institutional Structure

FCCC OBJECTIVE

“The ultimate objective of this convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gases in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a timeframe sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.”

Commitments

For all Parties:

- **Develop national inventories of greenhouse gases**
- **formulate and implement programs of measures to mitigate and facilitate adaptation to climate change**
- **promote technology development, application, diffusion and transfer**
- **promote research and information exchange**
- **report on actions**

COMMITMENTS FOR DEVELOPED COUNTRY PARTIES:

- **adopt policies and take corresponding measures on mitigating climate change by limiting anthropogenic emissions of greenhouse gases and protecting and enhancing sinks and reservoirs**
- **take the lead in modifying longer-term trends of emissions, recognizing that return by the end of the present decade to earlier levels of anthropogenic emissions of greenhouse gases would contribute to such modification.**
- **coordinate with other such parties relevant economic and administrative instruments necessary to achieve the convention's objectives**
- **provide new and additional financial resources to meet the agreed full costs incurred by developing country Parties in complying with their obligations.**
- **report on actions to meetings of the Conference of the Parties**

REPORTING

- national inventories
- description of steps taken to implement convention
 - for developed country, quantifying projected results of actions
- first report due:
 - for developed countries, within six months of entry into force
 - others, within three years or when financial resources become available
- Parties may make report jointly

Operation of the Convention

- International process
 - Inventorying
 - Reporting
- Domestic obligations
 - The U.S. Climate Action Report
 - Country studies
 - Consideration of next steps

**U.N. Framework Convention on Climate Change
(FCCC)**

Convention Secretariat
Michael Zammit Cutajar, Executive Secretary
(Malta)

Signed in Rio de Janeiro-June 1992

Ratified by U.S.-Oct. 15, 1992

Entered into force-March 21 1994

First Conference of the Parties-March/April 1995

Second Conference of the Parties-July 8-19 1995

Conference of the Parties (COP)

Chair: Environment Minister Merkel
(Germany)

COP 2 will be chaired by the
Environment Minister of Zimbabwe

March/April 1995

July 8-19 1995

**Intergovernmental Panel on
Climate Change (IPCC)**

Chair: Bert Bolin
(Sweden)

**Ad Hoc Group on the
Berlin Mandate (AGBM)**

Chair: Ambassador Estrada
(Argentina)

Vice-Chairs:
Daniel Riefsnyder
(United States)
and Thailand.

**Subsidiary Body
for Implementation (SBI)**

Chair: Mr. Mahmoud Ould
El Ghaouth
(Mauritania)

Vice-Chair: Mr Soobaraj
Nayroo Sok Appadu
(Mauritius)

**Subsidiary Body for
Scientific and
Technological Advice
(SBSTA)**

Chair: Mr. Tabor Farago
(Hungary)
Vice-Chair: Mr. Bert Metz
(Netherlands)

Decisions at COP-1: Post-2000 Action

For Developing Country Parties:

- Not introduce any new commitments
- Reaffirm and continue to advance the implementation of existing commitments

Decisions at COP-1: Post-2000 Action

For Developed Country Parties, aim to:

- **Elaborate Policies and Measures**
- **Set quantified limitation and reductions objectives within specified timeframes, such as 2005, 2010 and 2020 for their anthropogenic emissions by sources and removals by sinks**

Decisions at COP-1: Post-2000 Action

Process to be carried out in light of best available scientific evidence, and include, in its early stages, analysis and assessment to identify possible policies and measures

Process to take place in open-ended ad hoc group

Sessions of group should be scheduled to complete work as early as possible in 1997, with a view toward adopting results at 3rd Session of COP

JOINT IMPLEMENTATION

- **What is it?**
- **What problems do countries see in it?**
 - **North-South debate**
 - **Criteria**
- **What is the U.S. doing?**
 - **U.S. Initiative on Joint Implementation (USIJI)**

Decisions at COP-1: Joint Implementation

Establish a pilot phase, to include both Annex I and non-Annex I Parties on a voluntary basis, and review progress of pilot on an annual basis

Allow no credits to accrue to any Party during pilot phase activities

Take conclusive decision on pilot phase and progression beyond it no later than end of the present decade

Decisions at COP-1: Other Issues

Reporting (including from developed and developing country Parties)

Technology transfer

Financial assistance to developing country Parties

Technical advisory panels

NGO input

Developing Country Participation

- Non-Annex I represents a growing proportion of global emissions
- Equity issues and domestic priorities limit willingness to act:
 - Per capita income disparities between developed and developing countries
 - Health, local pollution, economic growth, etc.
- FCCC call for “common but differentiated responsibilities”

Domestic policy making

- Interagency working group
 - chaired by DOS (Climate Negotiator, Amb. Hambley)
- Assistant Secretaries' Group
 - chaired by DOS (A/S Claussen)
- Deputies Committee
 - co-chaired by NSC and CEQ (D. Tarullo and K. McGinty)

Berlin Mandate called for Parties:

- To elaborate policies and measures and set quantified limitation and reductions objectives within specified timeframes;
- Not to introduce new commitments for Parties not included in Annex I, but to continue to advance the implementation of existing commitments.

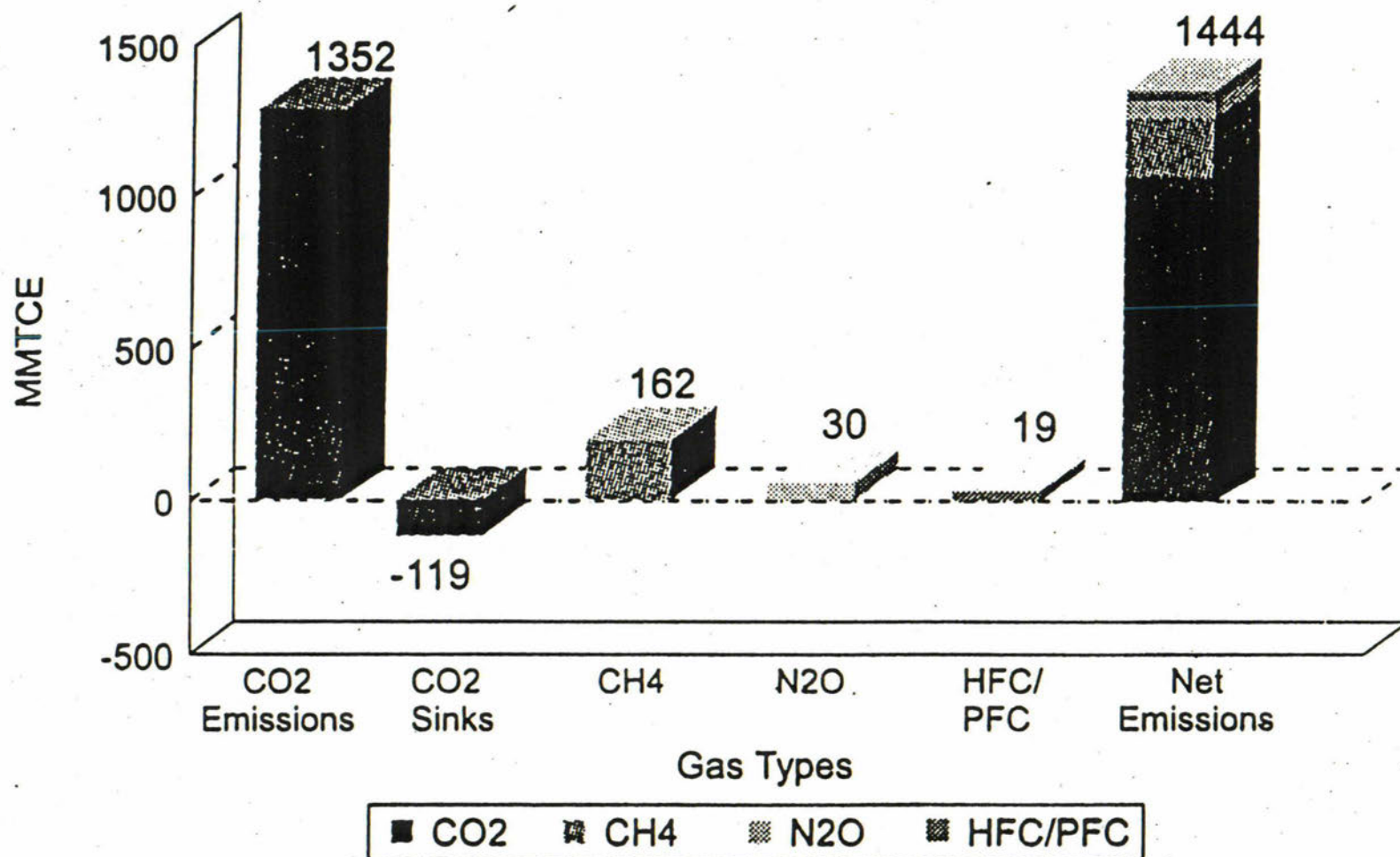
Congress and Local Government

- Ratification will be necessary for new agreement; SFR committee has jurisdiction.
- Implementing legislation will also be required; multiple House and Senate committees with jurisdiction
- Many state and local governments already have climate programs in effect (e.g., CA, MA, MN, WI, etc.).

Other Domestic Players

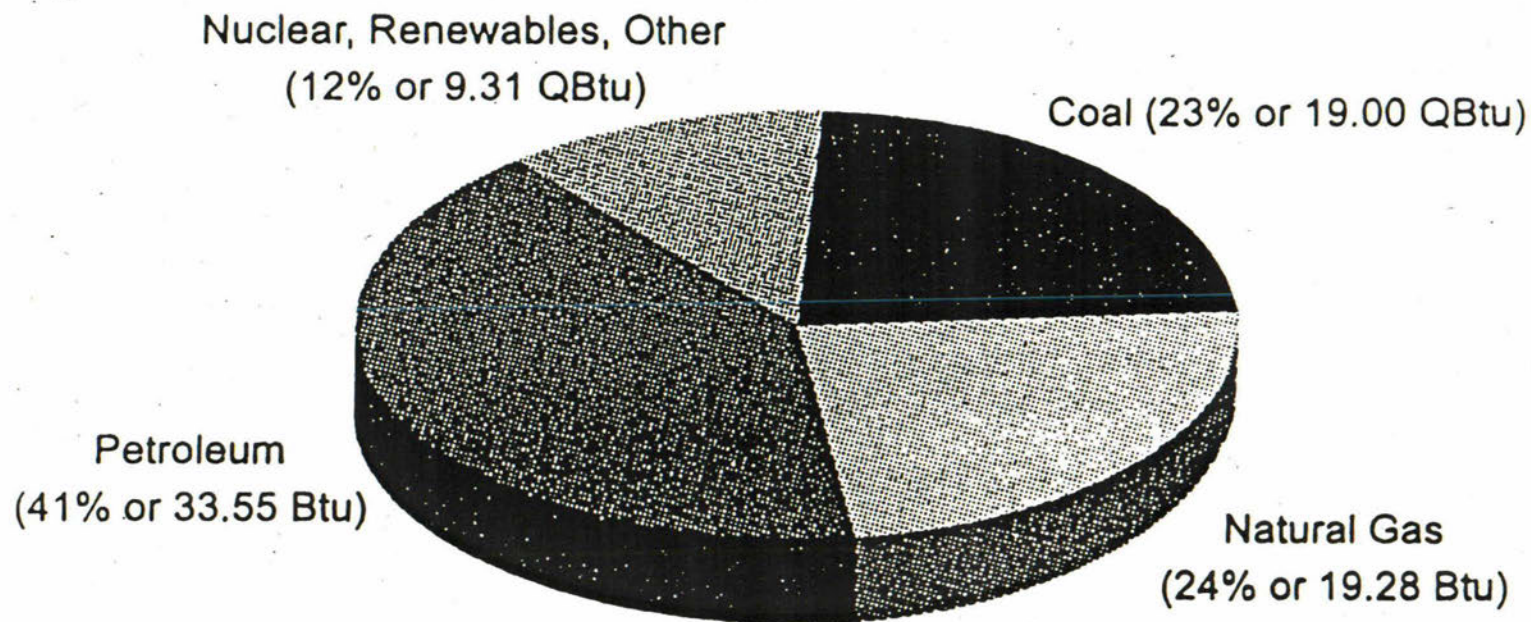
- Industry
 - Business Council for Sustainable Energy (renewable energy companies, some electric utilities)
 - International Climate Change Partnership (ICCP; chemicals, appliances, natural gas, etc.)
 - Global Climate Coalition (GCC; coal, oil, utilities, primary industry, etc.)
- Environmental NGOs
 - CAN, EDF, NRDC, Sierra Club, WWF, UCS, etc.
- Labor
 - AFL-CIO, Mineworkers, etc

Figure ES-1
Total U.S. Greenhouse Gas Emissions: 1990



Largely because of fossil fuel consumption, CO₂ emissions accounted for the largest share of U.S. emissions in 1990.

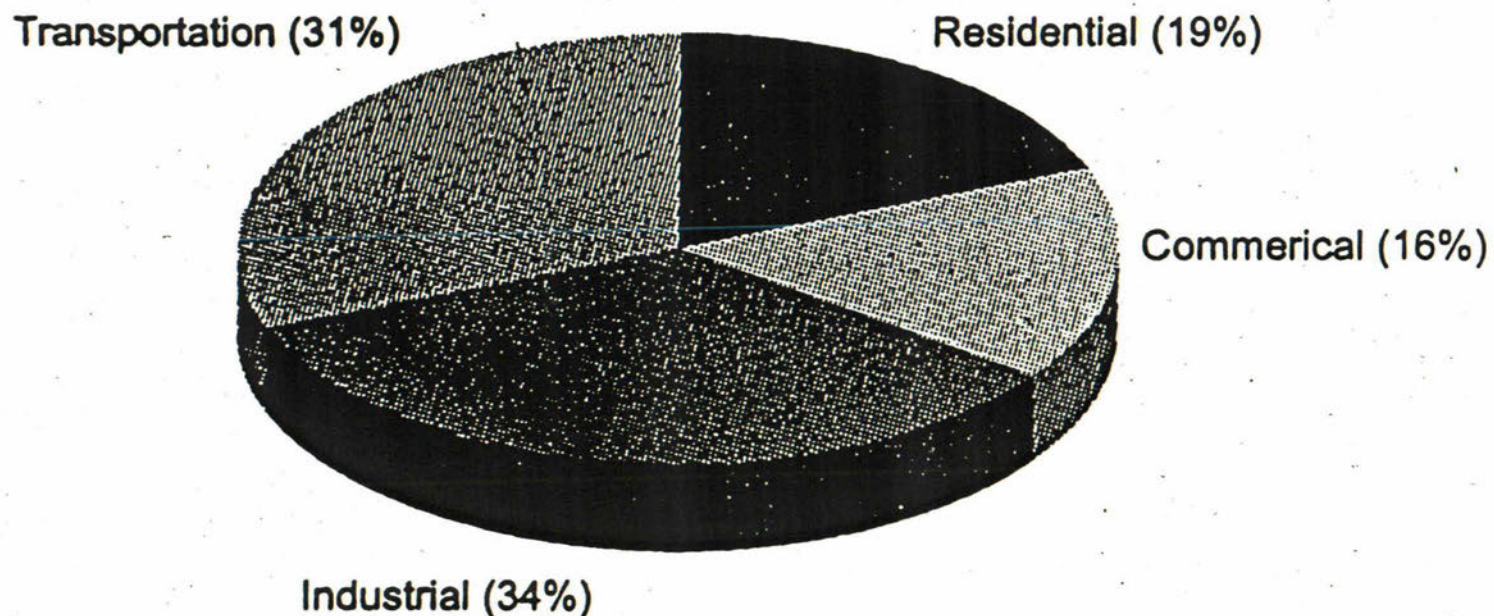
Figure ES-2
Types of Energy Consumed in the U.S.: 1990



1 QBtu = 1 quadrillion Btu = 1×10^{15} Btu

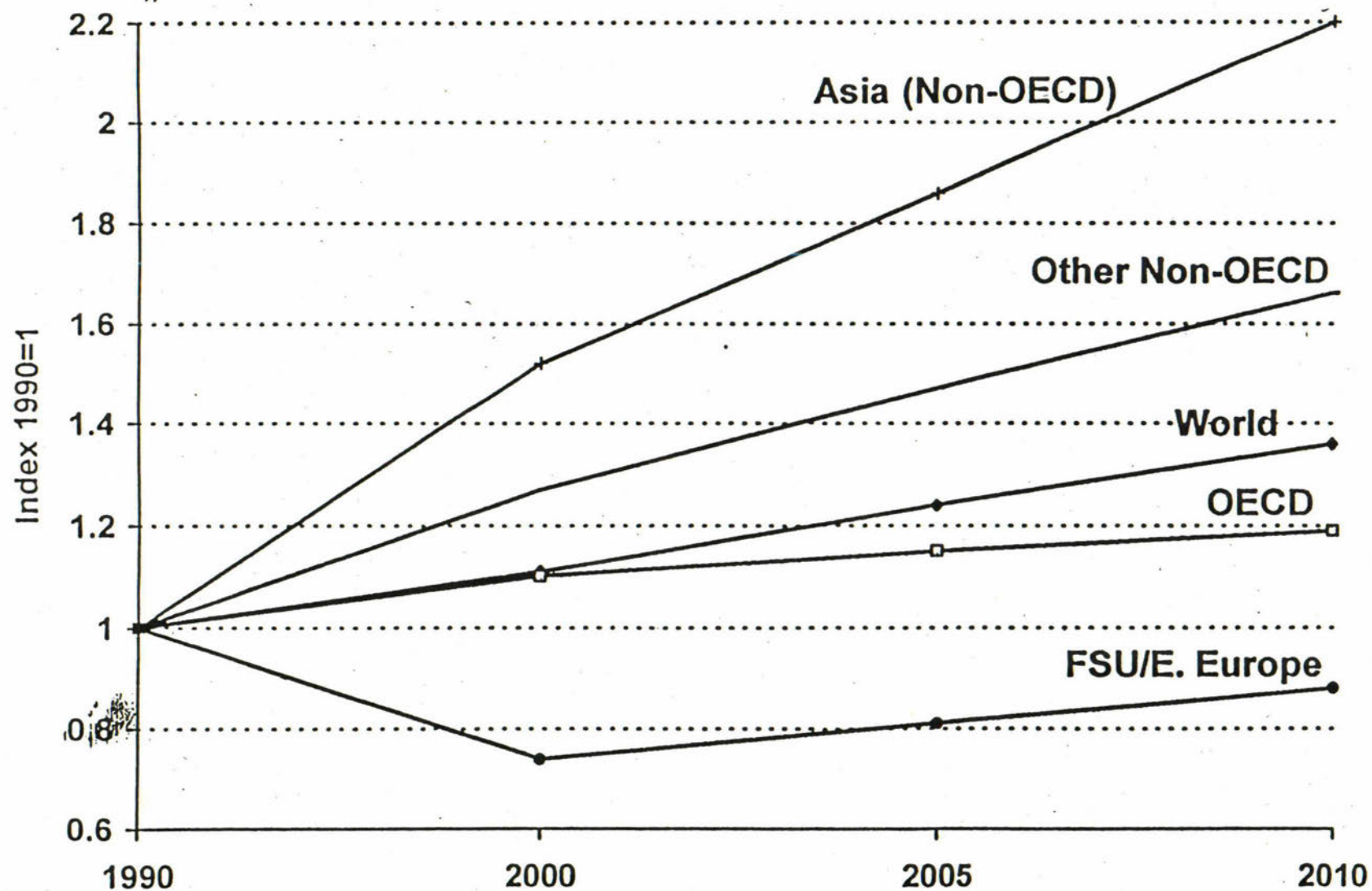
Approximately 88 percent of U.S. energy is produced through the combustion of fossil fuels.

Figure ES-3
Carbon Dioxide Emissions by End Use Sector: 1990



In this graph, emissions generated by electric utilities are allocated to each end-use sector according to each sector's share of electricity consumption;...

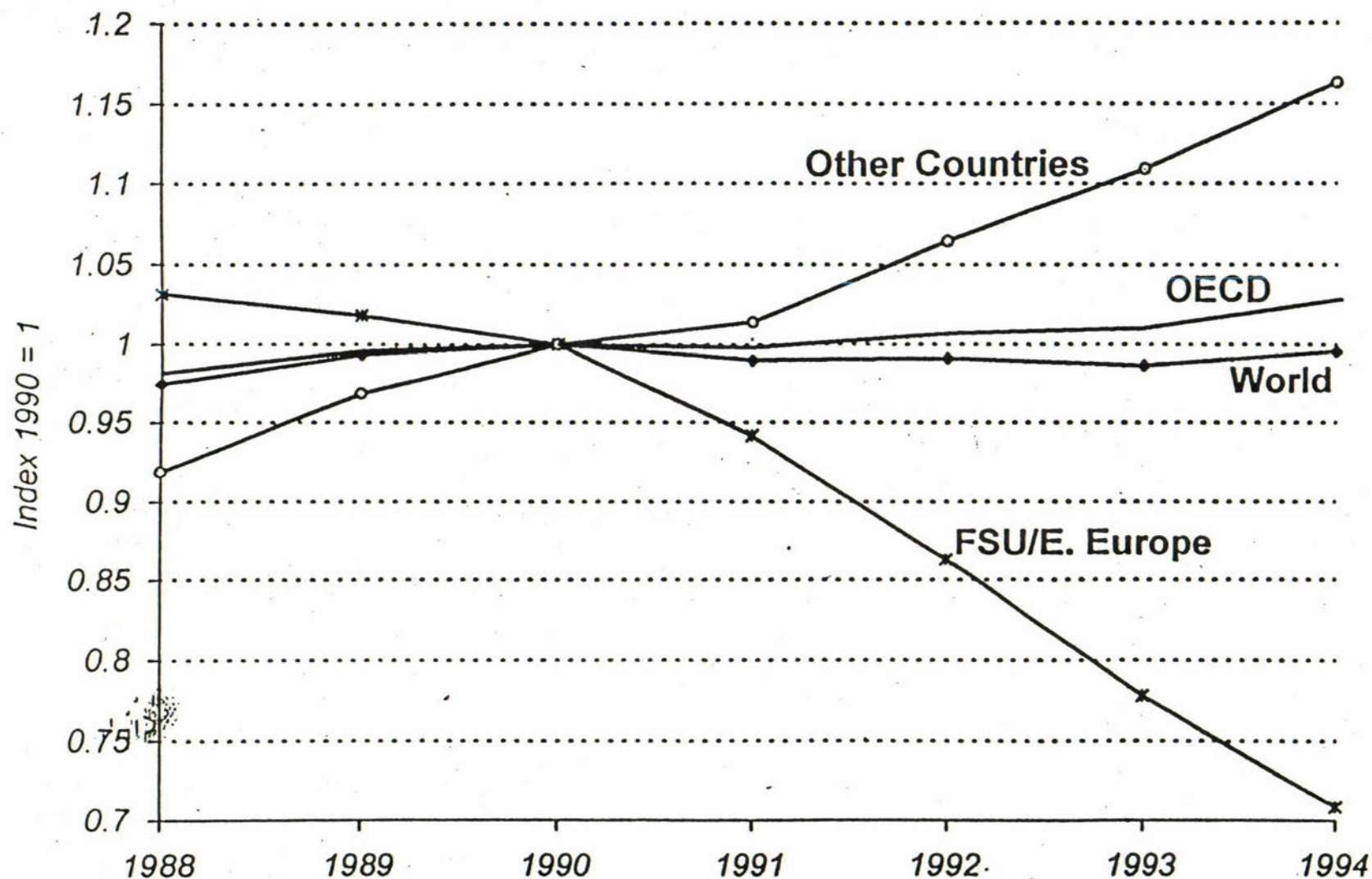
Energy-Related Carbon Emissions Forecasts: Major World Groupings



Source: An average of the forecasts from the International Energy Outlook (IEA), World Energy Outlook (IEA), and DRI (only for U.S. and Europe)

Energy-Related Carbon Emissions

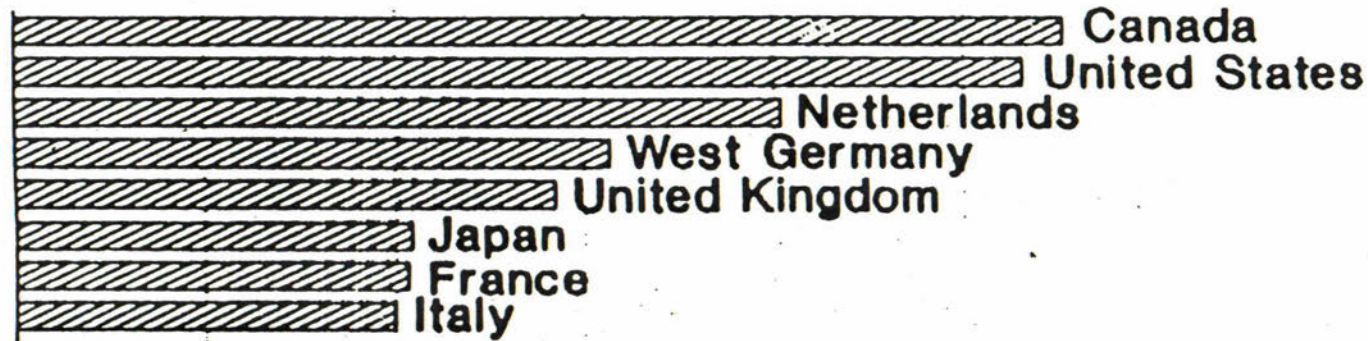
Major World Groupings



Source: BP Statistical Review of World Energy, British Petroleum, June 1995

Per Capita Energy Consumption

OECD



E. Europe/U.S.S.R.



Developing



0 50 100 150 200 250 300 350
Million Btu's per person per year

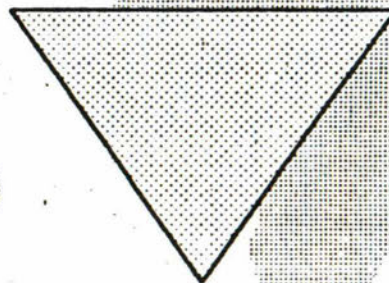
SOURCES: U.S. Congress, Office of Technology Assessment, *Energy in Developing Countries*, OTA-E-486 (Washington, DC: U.S. Government Printing Office, January 1991).

Principles for Kyoto Agreement

Compliance with Binding Targets

**Maximum
Flexibility**

**National
Implementation**



Realistic & Achievable

+ Steps towards a longer term solution

Key Elements of U.S. Protocol Proposal

- ◆ Multi-Year Emissions Budgets
- ◆ Tools for Flexible, Cost-Effective Implementation
- ◆ National Accountability
- ◆ Fair and Equitable Participation by All Parties

Emissions Budgets

Principles:

- ◆ Legally binding
- ◆ Medium-term
- ◆ Realistic and Achievable Levels
- ◆ Flexibility in implementation

Emissions Budgets

Proposal:

- ◆ Multi-year emissions budgets for Annex A (Annex 1) Parties
- ◆ Establish budgets for at least two periods
- ◆ Second budget equal to or smaller than the first
- ◆ Banking and limited borrowing
- ◆ International emissions trading, joint implementation

Emissions Budgets

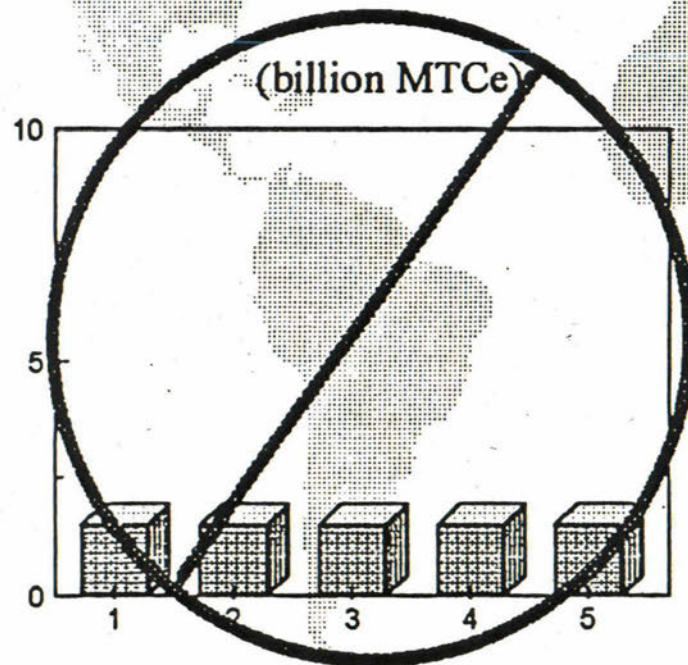
A Party's emissions budget equals:

- ◆ The Party's initial allocation
 - *plus* any amounts banked
 - *plus* any amounts borrowed
 - *plus* any amounts acquired through international emissions trading or JI
 - *minus* any amounts transferred to other Parties through international emissions trading

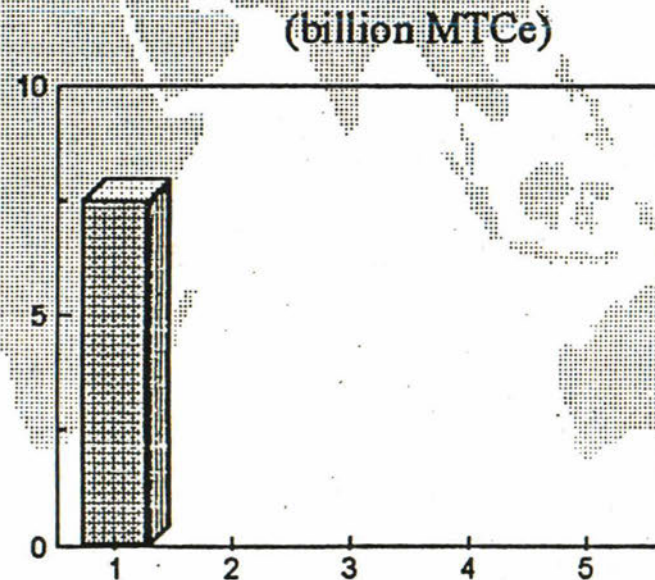
Initial Budget Allocation

Example: 5-year budget period (period could be 3-10 years)

Annual Allocation

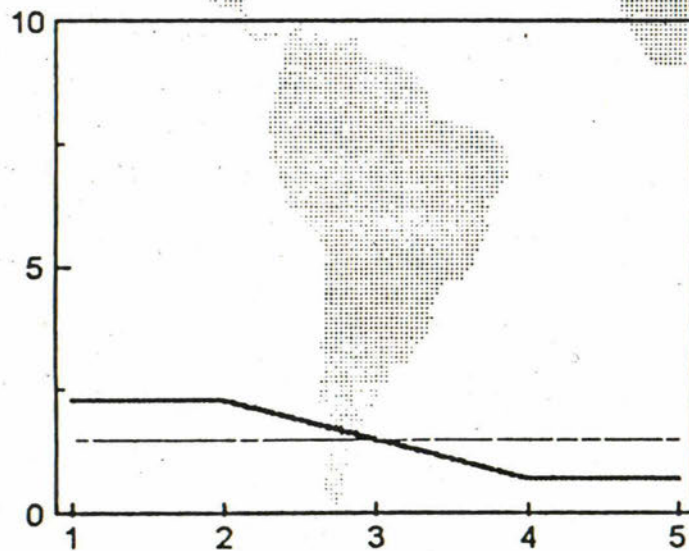


Budget Allocation

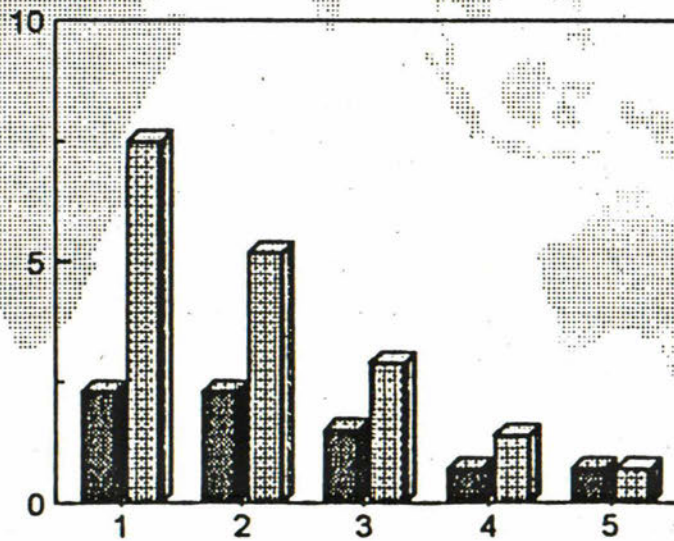


Basic Compliance Strategy

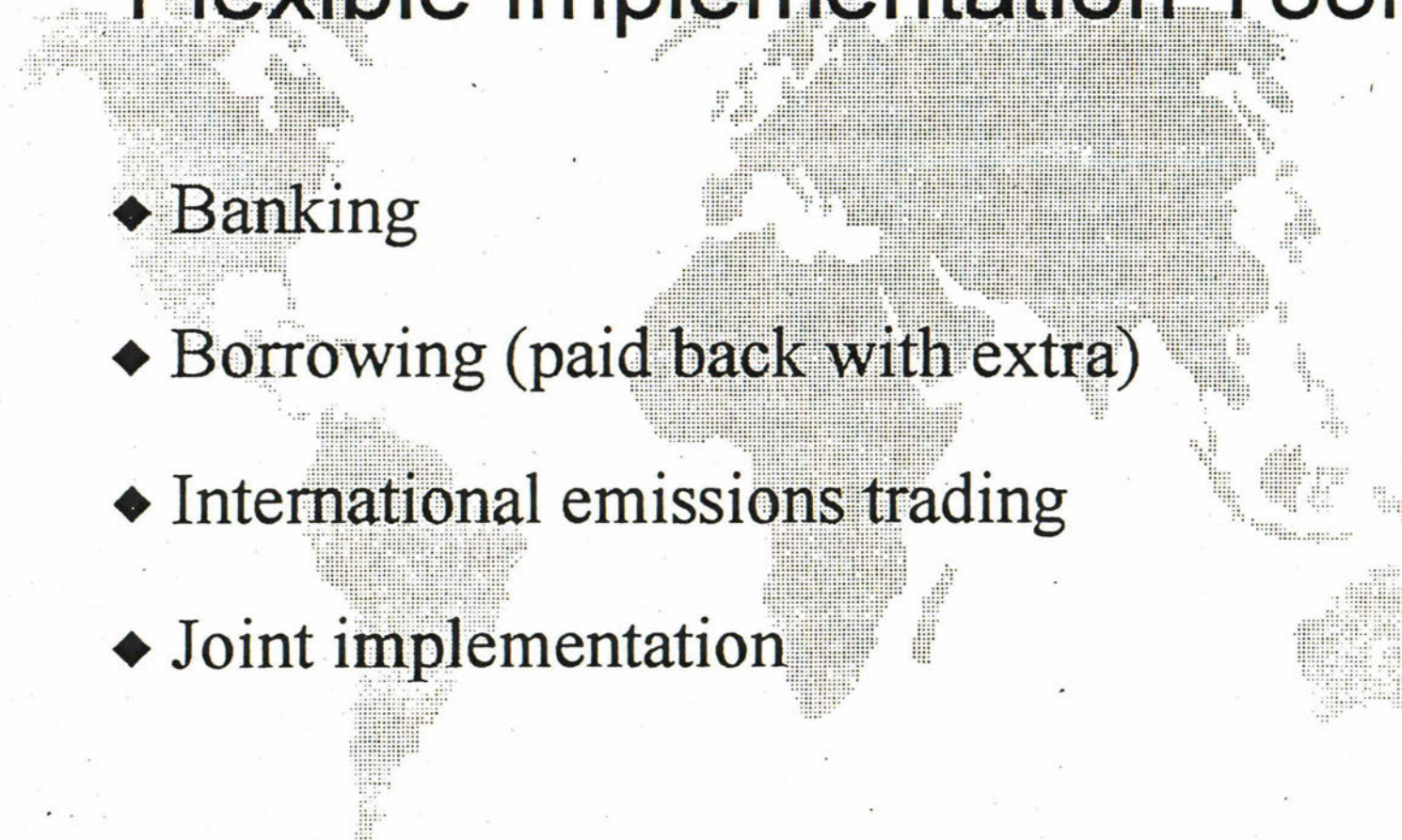
Emissions Path



Budget Balances



Flexible Implementation Tools



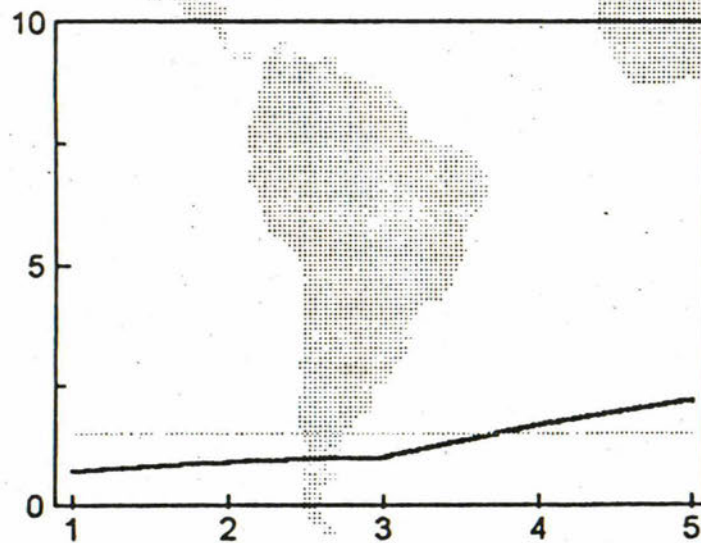
- ◆ Banking
- ◆ Borrowing (paid back with extra)
- ◆ International emissions trading
- ◆ Joint implementation

Banking

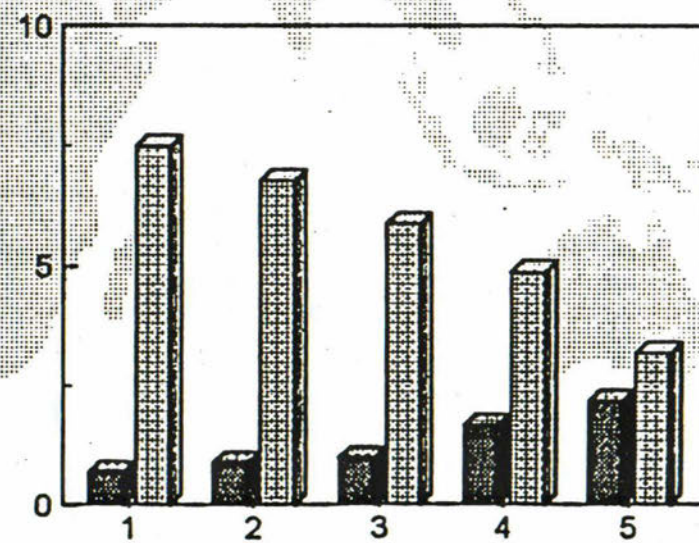
- ◆ A Party that does not use up its entire emissions budget may carry over the unused “tonnes allowed” to the next budget period
- ◆ The banked amount is added to the next period’s budget

Banking Compliance Strategy

Emissions Path



Budget Balances

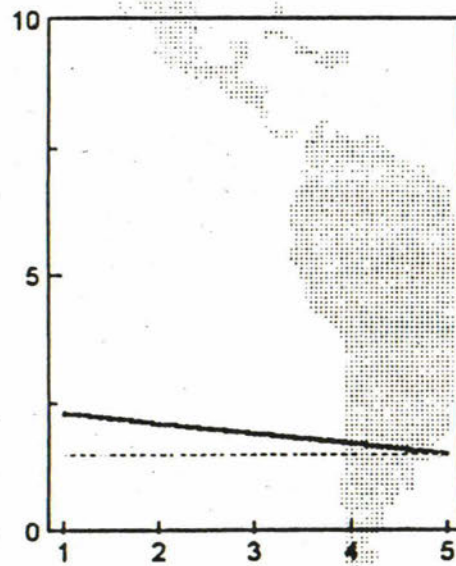


Borrowing

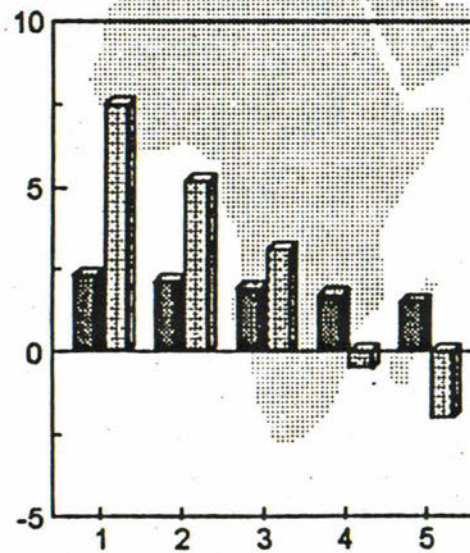
- ◆ A Party may borrow a limited amount of “tonnes allowed” from the next budget period
- ◆ The borrowed amount, plus “extra,” is subtracted from the Party’s next budget

Borrowing Compliance Strategy

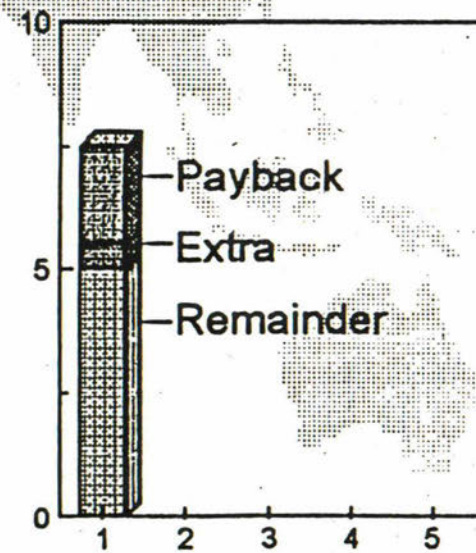
Emissions Path



Budget Balances
Budget Period #1



Budget Allocation
Budget Period #2



International Emissions Trading

- ◆ Parties with emissions budgets may buy or sell “tonnes allowed”
 - “High-cost” Parties will have incentives to buy
 - “Low-cost” Parties will have incentives to sell
- ◆ Parties report purchases or sales each year, adding to or subtracting from their budgets
- ◆ Private sector can facilitate trades
- ◆ No new international organization needed

Joint Implementation

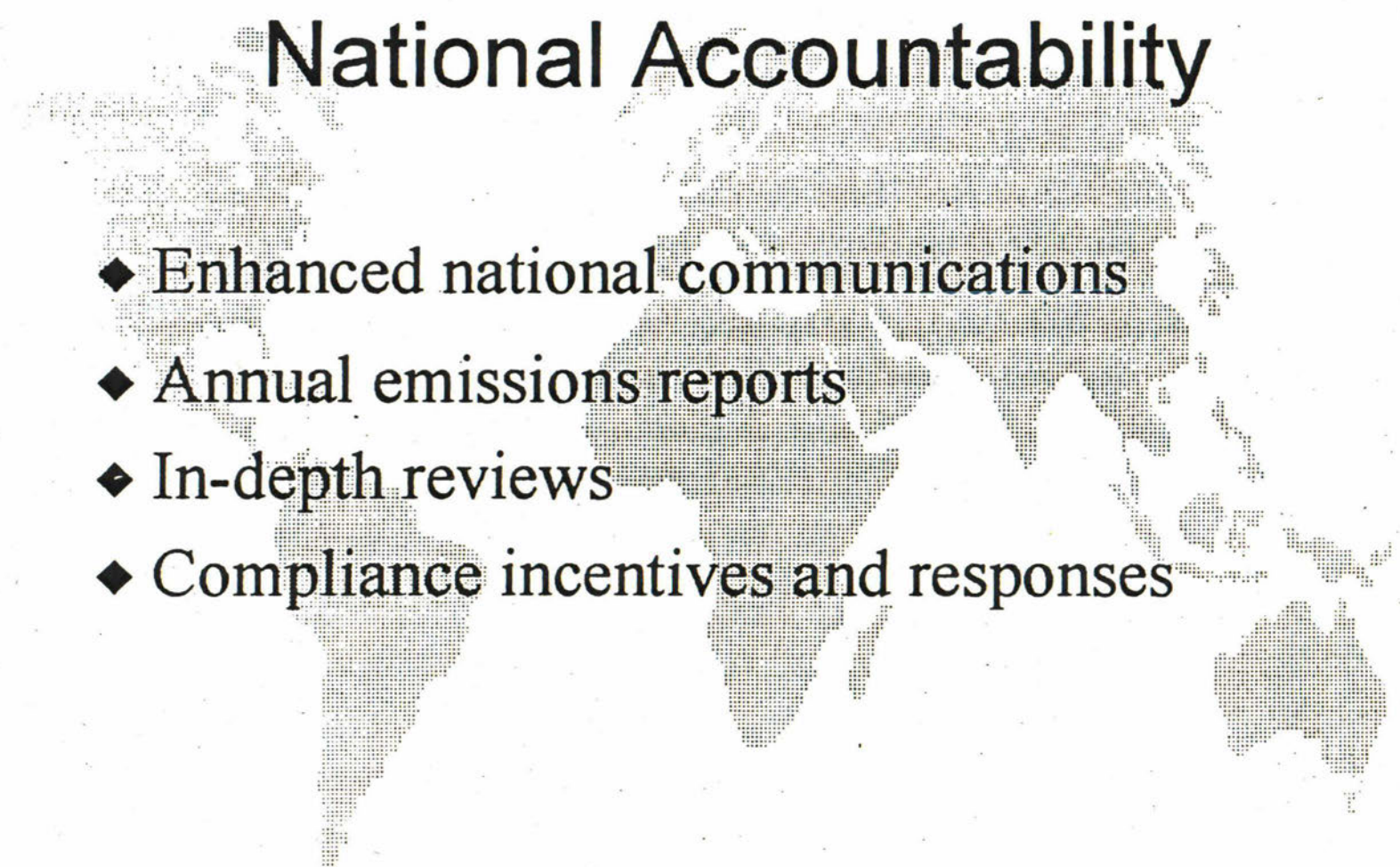
- ◆ Project-based, not budget-based
- ◆ Developing countries may undertake projects that generate new “tonnes allowed”
 - eligible projects: supporting national environment and development strategies, providing additional reductions
 - provisions for measurement, verification, review, etc.
- ◆ Party may keep the credits, or transfer them in return for investment and development resources
- ◆ Developed countries, private sector can facilitate JI projects

National Accountability

Compliance linkages:

- ◆ Parties wanting to engage in international emissions trading must be in compliance with their measurement and reporting obligations
- ◆ Parties that do not meet their emissions budgets may lose right to sell “tonnes allowed,” may lose voting rights
- ◆ Other responses

National Accountability



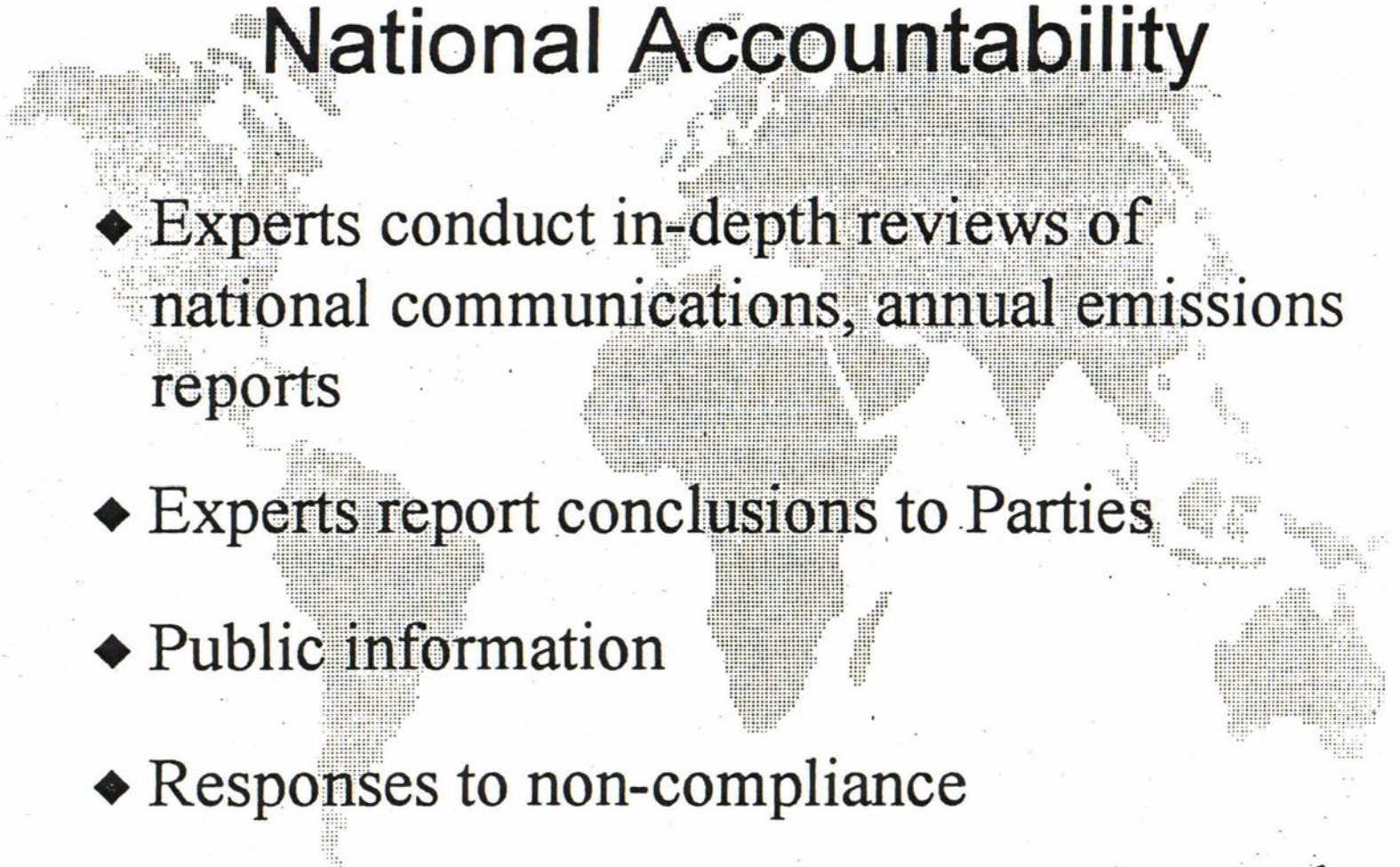
- ◆ Enhanced national communications
- ◆ Annual emissions reports
- ◆ In-depth reviews
- ◆ Compliance incentives and responses

National Accountability

Parties with emissions budgets must:

- ◆ Adopt national systems for accurate emissions measurement
- ◆ Adopt national compliance and enforcement programs
- ◆ Report on policies and measures employed to meet budgets
- ◆ Report annually on emissions and budget consumption

National Accountability



- ◆ Experts conduct in-depth reviews of national communications, annual emissions reports
- ◆ Experts report conclusions to Parties
- ◆ Public information
- ◆ Responses to non-compliance

Fair and Equitable Participation

- ◆ Developing countries adopt and report on “no regrets” measures, with assistance and cooperation from developed countries
- ◆ Voluntary participation in Annex B
 - opt-in to emissions budgets, emissions trading
- ◆ Evolution

The International Players

- European Union
- JUSCANZ (Non-EU OECD countries)
- NIS/Eastern Europe
- Big Developing Countries (China, India, Brazil)
- OPEC
- Alliance of Small Island States
- Other Developing Countries

European Union

- “Bubble”
- 15% below 1990 levels by 2010
- Differentiated commitments within EU; call for flat rate for others
- Opposed to JI with developing countries
- “Light” on developing country commitments

Emissions Reductions in 2010: EU Council Distribution

Austria	-25	Belgium	-10
Denmark	-25	Finland	0
France	0	Germany	-25
Greece	+30	Ireland	+15
Italy	-7	Luxembourg	-30
Netherlands	-10	Portugal	+40
Spain	+17	Sweden	+5
United Kingdom	-10		

Emissions Projected in 2010: USDOE - DRI/McGraw Hill Projections

Austria	+15	Belgium	+15
Denmark	+22	Finland	+37
France	+25	Germany	-2
Greece	+36	Ireland	+44
Italy	+28	Luxembourg	---
Netherlands	+34	Portugal	+53
Spain	+59	Sweden	+29
United Kingdom	+12		

Key Players in EU

- Germany: strong Green Party; calls for aggressive commitments; considerable reductions from former East Germany
- Netherlands: EU president; limited domestic ability to reduce emissions; strong rhetoric; most actions include significant domestic exemptions

More Key EU Players

- UK: removal of coal subsidies; strong on developing country action; often U.S. ally in EU council
- Italy: little domestic action on issue; opposed to Northern Europe's "too-aggressive" approach; generally supportive of JI

Still more on the EU

- Denmark: the green end of the spectrum; opposes JI; opposes developing country action at this time; rhetoric very strong
- France: with high reliance on nuclear, has low per capita emissions; relatively unengaged in AGBM debate.

JUSCANZ

- Australia: heavy coal/industry lobby strongly opposed to action; proposes differentiated commitments to reduce target; favors market mechanisms
- Japan: host of COP-3 (in Kyoto); favors differentiation; opposes JI, emissions trading
- Mexico: Only developing country member of JUSCANZ; relatively silent in AGBM, emissions growth projected to nearly double by 2010

More on JUSCANZ

- Canada: domestic process makes policymaking difficult; high emissions growth projected, favors JI, emissions trading
- New Zealand: closest to US in approach to next steps; emissions largely from logging, methane from sheep.
- Norway: along with Switzerland and Iceland are in favor of European style targets; Norway is strong proponent of JI, and also of differentiated commitments

JUSCANZ Emissions in 2010: USDOE - DRI/McGraw Hill Projections

Australia	+58	Canada	+32
Japan	+35	Mexico	+68
New Zealand	+33	Norway	+18
Switzerland	+8	USA	+24

JUSCANZ: Acronym stands for Japan, United States, Canada, Australia, New Zealand; includes all non-EU OECD members

NIS/Eastern Europe

- Russia: Supports JI/trading; favors (as do all in this group) “flexibility” for meeting targets; has protocol proposal combining flat targets with differentiated commitment
- Eastern Europeans: positions often taken on the basis of their impact on future membership in the EU; favor trading; favor flexibility.
- Total emissions in this group projected to decrease by about 10% by 2010

Big Developing Countries

- China: Plays the leading developing country role in AGBM process; adamantly opposes new commitments at Kyoto; publicly opposes JI; world's second largest emitter (after U.S.)
- India: only erratically a player in AGBM; no consistent position; has in past been (along with China) a key spokesperson for developing countries

Big Developing Countries

- Brazil: Only JI opponent in South America; exerts enormous influence in southern hemisphere, position often driven by individuals -- current head of delegation is from space agency and has technical focus/orientation
- DOE/DRI-McGraw Hill 2010 Emissions Projections (percent growth)
 - China 134%
 - India 140%

OPEC

- Fearful of substantial reductions in global oil consumption with mitigation efforts.
- Does not believe science has demonstrated climate change is a credible problem.
- Uses procedural maneuvers to block progress in AGBM
 - Currently holding up resolution on “Rules of Procedure”, including how final legal agreement is to be adopted.
- Seeks “compensation” for any economic losses associated with emissions reductions.
- With more than 20 countries in the group, exerts considerable influence during debate.

Other Developing Countries

- Largely silent during negotiations
- Climate change concerns are low domestic priorities compared to economic growth health and regional stability
- Principle focus in negotiations is to obtain preferential transfer of technology and additional financial development assistance

Alliance of Small Island States (AOSIS)

- Composed of more than 35 island countries and countries with low lying coastal areas.
- Provides “left” end to OPEC’s right
- First group to table a protocol proposal; it calls for a 20% reduction of CO₂ emissions below their 1990 levels by 2000 by developed country Parties

Negotiating Blocs

- JUSCANZ (non-EU OECD countries)
- EU
- Eastern Europe/Countries in Transition
- Large developing countries (China, India, Brazil)
- AOSIS
- OPEC
- Other developing countries

Next Steps to the Future

- First meeting of the Conference of the Parties: COP-1, Berlin: A call to action
- The Berlin Mandate
 - Policies and measures
 - QELROs
 - Developing countries
 - Timing
- The Ad Hoc Group on the Berlin Mandate (AGBM)

The Future

- Who cuts the deal?
- New inputs
- The long term
 - Environment
 - Politics
 - Negotiations

Calendar

- April 1 -- Due date for any additional proposals to meet “six month rule”
- July 28-August 7: AGBM 7 (Bonn)
- October 20 - 31: AGBM 8 (Germany? TBA)
- December 1-12: COP-3 (Kyoto, Japan)

WE NEED HELP

- Presentation of US positions
- Persuasion to U.S. view
- Reporting on host government concerns/ideas

THE WHITE HOUSE
WASHINGTON

Todd -

Appendix D is a good
Summary. Lots more paper
available, if you like -

Daniel Sandalan
x66543

Clinton Presidential Records Digital Records Marker

This is not a presidential record. This is used as an administrative marker by the William J. Clinton Presidential Library Staff.

This marker identifies the place of a publication.

Publications have not been scanned in their entirety for the purpose of digitization. To see the full publication please search online or visit the Clinton Presidential Library's Research Room.

Climate Change Principals

Decision Memorandum



June 2, 1997

STORM WARNINGS RATTLE INSURERS

Global warming may lead to violent weather—and hefty insurance claims—resulting in calls for government action

Bette Hileman
C&EN Washington

On April 1, a blizzard roared through the Northeast, dumping nearly three feet of snow from New Jersey to Massachusetts, shutting down airports, closing schools, and knocking out electricity to hundreds of thousands of people. The 24 inches of snow that fell on Boston was a record for April. Winds reached 70 mph, and the atmosphere was so unstable it spawned frequent thunderstorms. A week later, another spring blizzard buried parts of the north central U.S., exacerbating already miserable conditions brought on by huge snowmelt.

Extreme weather events like this—many of them far more damaging—have become increasingly frequent in many countries over the past six years. At the same time, global warming research is giving more indications—although certainly not proof—that highly volatile weather patterns are one of the consequences of rising atmospheric concentrations of greenhouse gases.

Despite this, the U.S. appears to be backing away from the idea of supporting the development of a strong treaty that might eventually control greenhouse gases. "I am concerned that the Administration may support the most minimal approach it can get away with politically and sneak through Congress without too much complaint," says Daniel A. Lashof, senior scientist at the Washington, D.C.-based Natural Resources Defense Council.

The Administration, however, has taken a number of other steps that may help slow down climate change, or help society prepare for and adapt to the severe weather events that do occur. The most recent step is the formation of a White House task force to communicate global warming issues to Congress and the public.

Since 1990, the area of the U.S. affected by extreme precipitation events—

blizzards and heavy rainstorms—has jumped about 20%. Last year, the nation as a whole experienced its fifth wettest period since records began to be kept in 1895, and in January, for the third consecutive year, the West Coast was hit with severe flooding.

Recently, only a few areas of the country have escaped 100-year events—weather events so rare in the past that they occurred only once in 100 years. Precipitation is so much more extreme that the statistics for 100-year events "in many parts of the country are no longer reliable," says Thomas R. Karl, director of the National Climatic Data Center at the National Oceanic & Atmospheric Administration (NOAA).

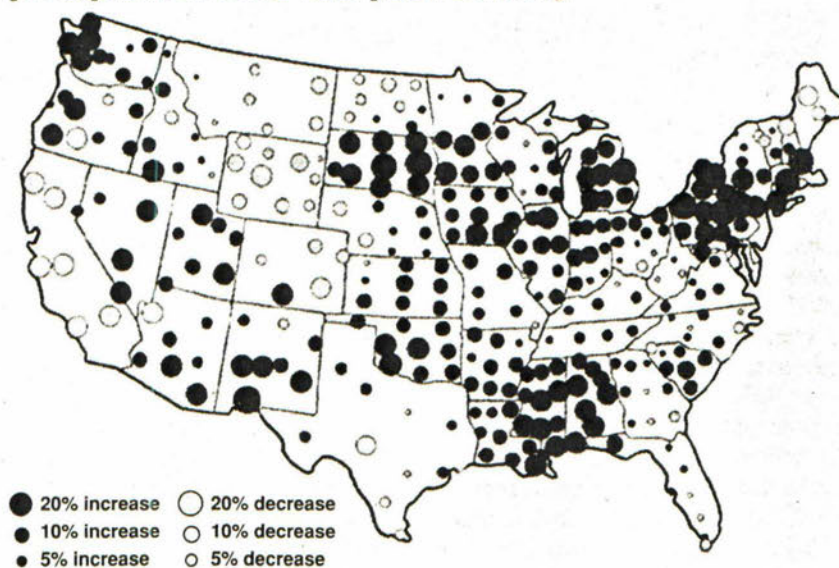
Another measure of the increase in extreme weather events is the rising tide of insurance claims around the world. In constant dollars and using the 1960s as the baseline, annual economic losses from natural catastrophic events worldwide in the

past decade have risen eight times, and insured losses 15 times, says Munich Reinsurance in a new report. (Reinsurance companies are those that provide insurance coverage for insurance companies around the world.) About 600 natural disasters—more than half of them storms or floods—caused economic losses of \$60 billion in 1996 and cost the insurance industry \$9 billion.

Many reinsurance industry leaders in Europe and Japan and one in the U.S. have decided that their rising costs probably result from human-induced climate change as well as from the increased concentration of populations in cities and on coastlines. They have been very active at United Nations meetings on climate change to try to persuade the international community to establish limits on greenhouse gases. They believe that if nothing is done, the insurance industry worldwide could well collapse, and other sectors of the economy could be jeopardized on a global scale as well.

"Global climatic change is probably the single most important issue facing the world today," insists Kaj Ahlmann, president of Employers Reinsurance Corp. in Overland Park, Kan. "If we don't do something about the climatic changes on a global level, we will see some changes that will alter the lifestyle of our children and grandchildren," he adds. "Global climate change is here. It is happening right now." It certainly has a major impact on the reinsurance business, he says.

Most of the U.S. has experienced increased precipitation over the past century



Source: National Climatic Data Center of the National Oceanic & Atmospheric Administration

Billion-dollar U.S. weather disasters in 1996

Southern Plains Severe Drought. Fall 1995 through summer 1996. More than \$4 billion estimated damage.

Blizzard of 1996—in Appalachians, Mid-Atlantic, and Northeast—Followed by Flooding. January 1996. \$3 billion estimated damage; 187 deaths.

Pacific Northwest Severe Flooding. February 1996. \$1 billion estimated damage; 9 deaths.

Hurricane Fran. September 1996. At least \$5 billion damage; 36 deaths.

West Coast Flooding. December 1996–January 1997. \$2 billion to \$3 billion estimated damage; 36 deaths.

Source: National Oceanic & Atmospheric Administration

"If we do not take strong measures to control greenhouse gases within the next century, we can expect temperatures and other climatic conditions Earth has not experienced in over 1 million years," says Gerhard Berz, head of the geoscientific research group at Munich Reinsurance. "We will be confronted with a massive increase in extreme meteorological events that will frequently result in catastrophes because society will no longer be able to adapt quickly enough. Therefore, wait-and-see tactics could prove extremely costly."

Similarly, some government leaders have come to believe that rising levels of greenhouse gases have already caused, or eventually will cause, a more extreme climate and other adverse global changes. The intensification of the natural greenhouse effect could lead to "widespread, uncontrolled harmful global change," says Sen. John H. Chafee (R-R.I.), chairman of the Environment & Public Works Committee. He is particularly concerned that man-made emissions of carbon dioxide could upset the "natural patternlike flow of oceanic currents" that influence the climate in many parts of the world dependent on stable ocean currents.

For this reason, and because of the conclusions of the 1995 report of the UN Intergovernmental Panel on Climate Change—that human beings have already had a discernible effect on climate—Chafee advocates a global treaty to reduce greenhouse gas emissions. Many European leaders share his view. At the last negotiating session on climate change in Bonn, the Eu-

ropean Union proposed that greenhouse gas emissions be reduced 15% from 1990 levels by 2010.

But the Clinton Administration, although it basically shares these views, seems to be waffling on the issue. It announced last July that it would push for specific targets and timetables in a treaty to limit greenhouse gas emissions. But with only two negotiating sessions left before the final meeting in Kyoto in December—where a treaty will be negotiated at a climate summit—the U.S. still has not proposed specific targets or timetables. It apparently does not plan to do so until a few weeks before the Kyoto meeting.

Slow action in one arena does not mean the U.S. is not taking steps to protect its citizens from severe weather events. The U.S. government is taking its cues from analyses of 20th-century data by Karl, who finds that annual precipitation has increased 6% since 1900—about equal to one-half the yearly discharge of the Mississippi River. Annual precipitation in the cold season (October–April) has risen 8% and in the warm season (May–September), 4%. At the same time, the proportion of precipitation falling in extreme events—more than 2 inches of rain in 24 hours—has risen while the proportion coming in gentle showers—less than one inch in 24 hours—has declined.

Australia, Canada, Mexico, and South Africa show similar precipitation trends, Karl says. Only China and Russia show no change—but for Russia, the data are scant; and for China, data for the 1990s have not been analyzed.

Over this century, drought indexes for the U.S. indicate no overall systematic trend. But "during the past few decades, there has been a tendency for a greater portion of the country to be either in a severe drought or severe moisture excess," Karl says. Between 1960 and 1995, both the frequency and intensity of hurricanes that make landfall in the U.S. were relatively low, compared with the peaks that occurred in the 1940s and 1950s. However, 1995 and 1996 brought hurricanes that were the strongest, or tied for the strongest, of the century.

The climatic data for the U.S. over the century is quite consistent with the projections of global climate models for rising levels of greenhouse gases, Karl explains. Models project that precipitation would increase, especially during the cold season; more of the warm season rainfall would come in heavy convective storms—showers or thunderstorms—rather than gentler, longer lasting rainfall;

droughts would be more severe and longer lasting; and if other factors stayed constant, the frequency and/or severity of hurricanes would increase.

Karl folded all the climate changes that have occurred together into an index and compared it statistically with the changes that are expected with global warming. This superimposition led him to conclude that there is only about a 1-in-20 probability that the changes in climate seen during the 20th century could be explained by natural variation alone.

"But it is unlikely that all the changes in climate we have seen result from rising levels of greenhouse gases," Karl says. Natural variations of climate are caused by changes in ocean circulation that affect air temperatures, feedback from changes in land surface (snow cover and plant cover), volcanic eruptions, and variations in solar radiation. However, ocean circulation and land cover are not independent variables. They, too, are affected by rising levels of greenhouse gases.

In contrast, John M. Wallace, professor of atmospheric science at the University of Washington, says the extreme weather events seen recently may be simply natural variability. "The climate system has exhibited huge natural variability over the millennia," he explains. "It just goes against my intuition to believe that the system would be so sensitive that the small amount of [global average] warming [1 °F] seen over the century would be responsible for the large increase in extreme weather events," he says. The global increase in rainfall could well result from the 1 °F increase in temperatures, he notes. But air pollution may be responsible for the fact that a greater proportion is coming in heavy downpours.

Increases in precipitation and drought are inevitable in a warmer world, explains Kevin E. Trenberth, head of the climate analysis section at the National Center for Atmospheric Research in Boulder. According to the laws of physics, the increase in greenhouse gases makes more heat available to the climate system. "Some of that heat goes into raising temperatures, some of it goes into evaporating moisture," he explains. As a result, there is more moisture in the atmosphere to get rained out. And, inevitably, in a warmer world when it doesn't rain for some time, the land dries out faster and drought is more severe.

Hurricanes capture peoples' imaginations and lead them to believe that greenhouse gases are having an effect on climate. But rising levels of greenhouse gases

could have two opposing effects on hurricanes, Trenberth says. Hurricanes feed upon the energy that comes from the ocean. With the higher sea temperatures associated with global warming, the area of ocean that would be warm enough to spawn hurricanes would be larger.

At the same time, higher levels of greenhouse gases, which produce more heating above Earth's surface than at the surface, would give the atmosphere more stability. A more stable atmosphere would be less likely to produce hurricanes. As a result, "we do not have a clear understanding of how [the frequency and severity of] hurricanes are going to change," Trenberth says.

Another problem is that if global warming does affect the frequency or intensity of hurricanes, the trend would be very hard to detect because hurricanes show an enormous natural variability. "Almost any trend you find will not be significant," Trenberth insists.

Researchers are now beginning to use special modeling techniques to project greenhouse-gas-induced climate changes in much smaller regions than past models could handle. Because these new techniques better represent storms and circulation, this research could cast light on the question of whether greenhouse gases are having an effect on weather extremes, particularly on rainfall.

Traditional global climate models, called general circulation models, project changes with rising levels of greenhouse gases for large areas of Earth—squares generally 350 miles on a side. Such models are not useful for projecting the climate of much smaller regions like New York's and Pennsylvania's Susquehanna Valley, for example.

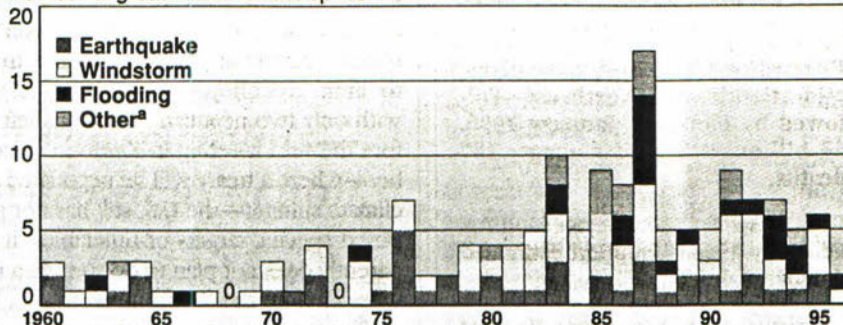
For smaller regions, Eric J. Barron, director of the Earth System Science Center at Pennsylvania State University, uses a modeling technique called "nesting." It involves embedding a high-resolution, limited-area climate model into a global-scale general circulation model.

The nesting method is an improvement over using general circulation models alone because it describes the physics of precipitation better and includes the topography, Barron explains. With nesting, model results closely simulate the observed precipitation and water flow in small regions over past years, he says.

Barron used the nesting technique to project what the precipitation for a number of regions of the U.S. would be if carbon dioxide levels rose to 560 ppm, or about two times the preindustrial level.

Since 1960, the number of weather-related great natural catastrophes has increased worldwide

Number of great natural catastrophes



Note: A great natural catastrophe is one that overtaxes the ability of a region to help itself, making outside assistance necessary. ^a Includes volcanic eruptions, landslides, forest fires, frost and heat waves, droughts, and hail. Source: Munich Reinsurance

(The current level is about 360 ppm, and without curbs on greenhouse gases, carbon dioxide levels are expected to rise to 560 ppm sometime between 2050 and 2100.) He found that precipitation in the northeastern U.S. in winter would rise from its current average of 1 to 2 mm per day to 2 to 4 mm per day, and that the southwestern U.S. would be substantially drier.

Robert G. Crane, professor of geography at Penn State, used a set of mathematical expressions along with circulation and humidity results from a general circulation model to project precipitation for the Susquehanna River Basin. When he raised carbon dioxide levels to 560 ppm in his model, he found that precipitation in spring and summer would rise 32% over current levels. "Such increases would have dramatic effects on river flow, on valley communities, and on the Chesapeake Bay," he says.

Although Barron's and Crane's methods are different, they reinforce each other and have a great potential for helping develop policy responses to global warming, Barron says.

The U.S. government is not yet responding to the global warming issue as if it were a crisis—as many reinsurance companies advocate. But it is taking steps that eventually could lead to a reduction in greenhouse gases, and, possibly, the mitigation of severe weather events.

The Environmental Protection Agency and Democratic members of Congress are pushing for a change in the tax code that would require employers to offer cash in lieu of free parking. In large cities, this might induce more people to take public transportation, thereby reducing carbon dioxide emissions.

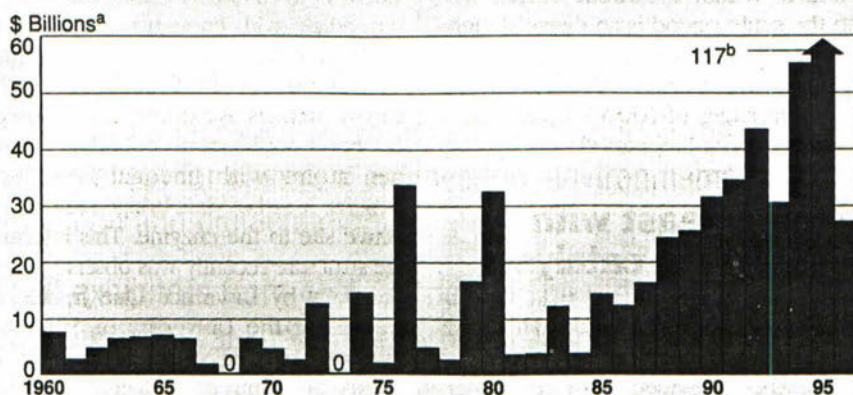
The bill the Administration is crafting on electricity deregulation will undoubtedly include some mandates for renewable energy, which will reduce greenhouse gases. And the proposed fiscal 1998 budget of \$699 million for research on energy efficiency and renewable energy at the Department of Energy is an increase of 20% over the 1997 level. A number of new ways to generate energy without producing much carbon dioxide will likely come from this research.

The Clinton Administration has started an outreach effort to lay the groundwork for convincing the Senate to eventually approve a climate-change treaty. A few weeks ago, it set up a White House Climate Change Task Force to communicate global warming science and policy options to Congress and to the many constituency groups that have a stake in the issue. The task force will have a staff of six and will report jointly to the White House's Council on Environmental Quality and National Economic Council.

"We're working with a variety of constituency groups, and Congress, and the public to make sure that the domestic implications of the issue are understood," says task force member Tom Peterson, a representative from EPA who until recently was on a Brookings legislative fellowship with Sen. Joseph I. Lieberman (D-Conn.). "We also want to make sure that the concerns, ideas, and needs of these groups are adequately considered in the policy process. We are trying to involve Congress as much as we can" in developing policy.

Most members of Congress now are fairly indifferent to climate-change issues. House Science Committee and Senate En-

Worldwide economic losses from great natural catastrophes have escalated since the mid-1970s



Note: A great natural catastrophe is defined as one that overtaxes the ability of a region to help itself, making outside assistance necessary. More than half the costs of these catastrophes are weather related. ^a Constant 1995 dollars. ^b High value largely due to a huge earthquake in Japan. Source: Munich Reinsurance

vironment & Public Works Committee staff say the vast majority of the members of Congress have not focused on climate change at all and have little knowledge of the subject. Only a very small fraction are actively working for initiatives that might eventually reduce greenhouse gases.

Several other new or ongoing government initiatives might help society prepare for or adapt to extreme weather events. On Feb. 20, Franklin D. Raines, director of the Office of Management & Budget, and Kathleen A. McGinty, chairman of the Council on Environmental Quality, issued a policy that aims to reduce the risk of future flooding.

In the past, the response to flooding has been to rebuild levees and hand out relief checks that are often used to rebuild structures on their original flood-plain locations. When considering levee repair, the policy says, the relevant agencies should factor in design modifications that would reduce future flood damages. And agencies should consider "buyout" of properties on flood plains, rather than providing money to rebuild structures.

William H. Hooke of the Office of Oceanic & Atmospheric Research at NOAA is coordinating a similar response to natural disasters from extreme weather and other causes. He chairs the White House National Science & Technology Council's Subcommittee for Natural Disaster Reduction. This is a 10-year-old interagency research program on measures communities can take to guard against damage from natural disasters. Under the committee's direction, federal agencies are trying to put together a package of initiatives to minimize impacts.

Because carbon dioxide has such a long atmospheric lifetime, it may take 100 years for people to see the results of reducing greenhouse gas emissions, Hooke says. But if governments try to make every community more resilient—for example, by denying federal flood insurance for new buildings on flood plains—"the payoff is very much up front," he says. (Residences on flood plains are generally insured by the federal government; businesses, by private insurers.)

In contrast, the government has taken some actions that may make it more difficult for people to prepare for extreme weather events. The National Weather Service (NWS) has a \$27.5 million shortfall in its operating budget for fiscal 1997 because of various rescissions and additions that were made to that budget.

To make up the deficit, NWS will lay off up to 200 employees, including some at the National Hurricane Center in Miami; cancel service contracts for weather radio transmitters; reduce training for meteorologists; and cancel the public toll-free phone numbers for weather information. Unrepairable operational equipment will not be replaced during this fiscal year. These steps may impede NWS's ability to predict storms, hurricanes, and other potential disasters. If Congress approves the fiscal 1998 budget request without substantial cuts, some of these steps will be reversed next year, but some will be permanent. A citizens group called Americans United is trying to reverse these cutbacks in NWS services.

Because of its concern over the rising number of extreme weather events, two years ago the reinsurance and insurance

industry established a program to fund research to help predict the risks of hurricanes and windstorms. The program, called the Risk Prediction Initiative (RPI), is administered by the Atlantic Global Change Institute, which is located in the Bermuda Biological Station for Research.

Funding for RPI, at about \$3 million annually, is supplied by 13 global reinsurance and insurance companies based in Europe, Bermuda, and the U.S. Most of this money is used to finance research by independent scientists.

RPI is attempting to address one central question: Is the record of past weather events no longer a guide to the future? Traditionally, insurers have determined the probability of natural catastrophes by assessing their historical monetary losses from similar events. But if human activities are perturbing global climate, monetary losses from past events may no longer be sufficient for predicting future costs.

RPI also aims to enhance communication between scientists and insurers. It convenes meetings attended by insurance experts and climate scientists from around the world.

Last July, 47 reinsurance and insurance companies created a position paper that they presented to the UN. Called the UN Environment Program Insurance Initiative, it "insists" that international negotiations "achieve early substantial reductions in greenhouse gases." The paper further concludes that "man-made climate change" will increase the likelihood of extreme weather events and that "such effects carry the risk of dramatically increased property damage." So far, only one U.S. firm, Employers Reinsurance Corp., has signed the position paper.

For self-preservation reasons, many reinsurance and insurance companies are willing to go out on a limb, insisting on near-term action before the costs of not taking action can be quantified. Most scientists, on the other hand, express much less certainty about the risks of climate change.

"One of the things we face is that the traditional scientific community is looking for high levels of certainty," says Michael C. MacCracken, head of the U.S. Global Change Research Program. But the insurance community doesn't usually wait until it has 20-to-1 odds on something before it makes a decision, he explains. The industry is used to making decisions based on more subtle trends—small changes in risk. "This whole issue of decision-making under uncertainty is a very challenging one for the scientific community to interface with," he says. ◀

The Role of Technology Policies in Limiting Greenhouse Gas Emissions

"Economics studies have found that there are many potential policies to reduce greenhouse gas emissions for which the total benefits outweigh the total costs. For the United States in particular, sound economic analysis shows that there are policy options that would slow climate change without harming American living standards, and these measures may in fact improve U.S. productivity in the long run."

-- The Economists' Statement on Climate Change, Feb. 13, 1997 (signed by more than 2,400 economists, including eight Nobel Laureates)

A strategy to accelerate the diffusion of existing technologies and the research, development and deployment of more advanced technologies is a critical component of any U.S. policy to stabilize greenhouse gas emissions. Any emissions control program — without such a technology strategy — would result in higher prices for carbon allowances than would otherwise be the case. Analysis suggests that an accelerated technology effort has a large potential for bringing down this price, and thus the cost to the economy.

In addition to major studies in the early 1990s¹, forthcoming analysis by five leading National Laboratories finds that a large potential remains for reducing U.S. energy consumption and greenhouse gas emissions while meeting the full energy needs of U.S. businesses and families. In the long term, stabilizing concentrations at even twice pre-industrial levels, which will likely still have severe national and global environmental impact, poses an unprecedented challenge that can only be met with superior technology brought about by aggressive diffusion and significantly higher levels of R&D.

Two types of technology provide significant opportunities to reduce greenhouse gas emissions in the near- to mid-term while providing our full energy needs. First, energy-efficient technologies are currently underutilized in all sectors of the economy. These technologies allow us to do more while consuming less energy and reducing pollution. Through increased energy efficiency, we can maintain GDP growth while cutting energy usage and associated greenhouse gas and other air pollution. Second, a variety of low- and zero-carbon technologies, such as solar, wind and biomass power, advanced industrial processes and highly efficient fuel cells, are becoming increasingly competitive. These technologies can supply energy or produce energy services with little or no carbon emissions, allowing us to further sever the link between GDP and greenhouse gas emissions and other air pollution. Working together, energy efficiency and low-to-zero carbon technologies provide the means of sustaining economic growth while meeting medium- and long-term limits on greenhouse gas emissions. In the longer term, greater technology opportunities exist - including a variety of advanced low-to-zero carbon technologies and carbon sequestration.

In addition to reducing greenhouse gas emissions, these technologies provide other benefits to the nation that have long been the basis of national policy, including: achieving major reductions in criteria air pollutants, decreasing dependence on foreign oil, increasing productivity of domestic

¹See National Academy of Sciences, Policy Implications of Greenhouse Warming (1991) and Office of Technology Assessment, Changing by Degrees: Steps to Reduce Greenhouse Gases (1991).

industries, and promoting U.S. leadership in the large and growing international market for advanced technologies. Greater penetration of today's energy-efficient technologies can also enhance economic productivity through more efficient use of our energy resources. Shifting capital from energy expenditures to new investments elsewhere in the economy will help drive economic growth, employment and consumer income.

A clear policy on limiting U.S. greenhouse gas emissions would help to focus attention on energy consumption and will provide important incentives for the diffusion of existing technologies and the development of even more advanced technologies. The technological response to past environmental policies, such as acid rain controls and the ban on CFCs, has been dramatic. In both cases, the actual cost of control has been substantially less than early projections.

Unfortunately, even with a clearer market signal, the technology response to a greenhouse gas policy will continue to be restrained. A host of market barriers contribute to today's large energy efficiency gap — the significant underutilization of existing, cost-effective, energy-efficient technologies. Many federal programs, many of which were launched in the President's Climate Change Action Plan, are successfully overcoming market barriers to key energy-efficient technologies through partnerships with the private sector. These programs need to be fully supported, and additional initiatives need to be put in place to target the remaining barriers to the use of energy efficiency and low-to-zero carbon technologies.

Additional barriers lead to systematic under investment in important research and development of new technologies. To achieve a sustainable emissions pathway through the year 2010 and beyond, there is an unavoidable need for advances in low-to-zero carbon energy technologies. As global population and energy demand continue to rise, technological advances provide the key to stabilizing global concentrations of greenhouse gases at safe levels without jeopardizing our quality of life. In order to stabilize greenhouse gas concentrations at safe levels, new technologies will have to reduce emissions by more than a factor of ten during the next few decades and be competitive enough to achieve deployment throughout the world. This need for major and continual advancements can only be met through a strong commitment to Federal RD&D.

Existing Technologies Offer Significant Potential to Control Emissions

There is clear evidence that the full potential of existing, profitable technologies is not being realized. Many of these energy-efficient technologies have relatively small market shares and low rates of technology diffusion. Their penetration is restrained because of a number of institutional, organizational, and other barriers that work against the diffusion of existing, energy-efficient technologies and the development of advanced technologies. Consumers and decision makers in business are often not aware of the availability of reliable, energy efficient equipment, nor the significant cost savings this equipment can offer. Even if they are aware, they may lack the information needed to make important investment decisions, or access to reasonable finance terms.

A number of federal, voluntary programs are currently enhancing markets by overcoming the barriers to energy efficiency. The Administration's Climate Change Action Plan (CCAP) launched over 40

initiatives in 1993. Building on other DOE and EPA programs, the CCAP's goal was to return U.S. greenhouse gas emissions to 1990 levels by the year 2000. Despite large Congressional funding cuts,² the CCAP programs are successfully overcoming market barriers and are currently expected to deliver approximately 70% of the emissions reductions originally projected. With continued support beyond the year 2000, these programs will significantly restrain growth in U.S. greenhouse gases through 2010 and beyond. Even at current funding levels, Administration projections indicate that these programs will eliminate 1/4 of total emissions growth through the year 2010, resulting in annual energy bill savings of approximately \$30 billion (in 1995 dollars). A sustained commitment to these programs beyond the year 2000 is needed to achieve these results, and restored full funding of CCAP programs will further cut the growth in greenhouse gas emissions. Some examples of CCAP programs include:

- DOE's Rebuild America program and EPA's Green Lights and ENERGY STAR Buildings programs are demonstrating that many of the barriers to energy efficiency in the commercial buildings sector can be overcome. By providing valuable information (no subsidies are provided), these programs have formed over 2500 partnerships to improve energy efficiency in buildings. Partners can reduce their energy use by up to 40% through technology investments with annual rates of return of 20-50%. This potential is significant because total greenhouse gas emissions from energy use in commercial and industrial buildings is equal to all emissions from U.S. light duty vehicles. Program partners have already invested over \$1 billion dollars in energy efficiency improvements, and partners are saving over \$280 million per year on their energy bills.
- EPA and DOE's ENERGY STAR Consumer Labeling programs are removing barriers that consumers have faced in purchasing energy-efficient home products, such as heating and cooling equipment and appliances. The programs have already transformed a number of markets, including cutting the energy used by computers, monitors, and printers by 50% at virtually no incremental cost to the customer. Other energy-efficient technologies, such as heating and cooling equipment, do have higher initial price tags. The programs are providing important information to consumers through a national education campaign on the highly profitable opportunities that efficient equipment offers when energy bills are considered. Manufacturers of home products are partnering with the federal government and labeling their more efficient products with the Energy Star logo. Through 1996, this program has seen thousands of products labeled and billions of dollars invested in ENERGY STAR products. Consumers are savings over \$500 million per year on their energy bills.

Because the CCAP's focus on the year 2000 limited the options that were implemented, a longer term goal provides significant new opportunities to overcome remaining market barriers and develop key technologies.

² Total expenditures on CCAP programs in 1997 is \$183 million, 40% million below the President's requested budget of \$305 million.

Research, Development, and Deployment of Clean Technologies

A strategy of continued diffusion of energy efficient and low-carbon technologies and accelerated development of key new low-carbon technologies during the next decade sets the stage for development and diffusion of a number of longer term low-to-zero carbon technologies that may begin to see limited penetration by 2010, but will have substantial impacts after 2010. The accelerated technology development effort must focus on four strategic thrusts: (1) clean power generation, (2) energy efficiency, (3) carbon sequestration accompanying a transition to a hydrogen-based economy, and (4) basic and very advanced research. Responding to the climate problem may require breakthroughs in all of these areas, and in any case the high-risk nature of R&D requires the pursuit of multiple pathways.

Increasing the probability of achieving these desirable outcomes will require expanding the government's current R&D spending in these areas, which is roughly \$1.3 billion per year. Also, the policies described in the previous section, including partnerships with industry, market pull deployment initiatives, and improved regulatory processes, will be required to ensure technological success and accelerated market penetration. The benefits could be enormous. A 1997 study by Pacific Northwest Laboratory found that developing and deploying advanced technologies over the next 15 to 30 years could substantially lower the cost to the U.S. and global economy of achieving major reductions in emissions of greenhouse gases.

Clean Power Generation

Natural gas technologies now set the benchmark for low cost, cleaner power generation. Further advances in natural gas turbines could yield overall energy conversion efficiencies of 60% or more in the next decade, double conventional plants. High temperature fuel-cells, such as molten carbonate and solid oxide, may have significant application in power generation with further R&D, promising high efficiency and low emissions. Molten carbonate fuel cells could eventually cut greenhouse gas emissions by as much as 50%. Continued advances in high efficiency coal power plants, such as integrated gasification combined cycle, could approach 50%, allowing some continued use of abundant U.S. coal even in a greenhouse gas constrained world while helping the U.S. realize domestic and global market opportunities for these superior technologies.

While electricity from fossil fuels continue to become cleaner and cheaper, expanded R&D and deployment could make a number of renewable technologies competitive on purely economic grounds in the next two decades: wind power, PV, biomass power, solar thermal, and geothermal. In a greenhouse-gas constrained world, these zero-carbon emitting sources of power would be even more competitive. Royal/Dutch Shell projects these technologies to be the dominant global source of energy by the middle of the next century.

Renewable technologies are becoming more economically competitive over time. Both wind and PV are experiencing a 20% cost reduction for every doubling of cumulative production. Photovoltaic (PV) cells, which convert sunlight into electricity, have dropped from 90 cents per kilowatt-hour in 1980 to under 20 cents today while wind power has dropped from 25 cents per kWh to 5 cents. These cost reductions will continue to occur not just because of R&D, such as advances in thin film

PV, but also through economies of scale and improvements in manufacturing that come with increased production. A number of different PV technologies are being pursued, providing multiple opportunities for breakthroughs. Accelerated RD&D for wind could potentially have an impact on CO₂ emissions in 2010.

Finally, life extension of nuclear power plants could provide substantial carbon reductions, so technology R&D to provide safe and economic extension of at least some nuclear plants is a vital component of the technology strategy.

Energy Efficiency

Technology R&D in transportation is essential because the sector produces one third of U.S. CO₂, and large reductions are unlikely without major regulatory changes or substantial technology advances. Also, two other major national problems — urban air pollution and dependence on foreign oil — stem largely from the transportation sector. The current federal strategy is to develop cars and trucks that are highly fuel-efficient as well as ones that run on fuels other than petroleum, including natural gas, electricity, and biofuels (ethanol). An aggressive RD&D strategy could result in significant penetration of much more efficient vehicles and biofuels in the next two decades.

The Partnership for a New Generation of Vehicle (PNGV) with the U.S. auto industry is pursuing multiple technology pathways for both advanced engines and energy storage. These vehicles could be commercially available just prior to 2010 and be 3 times more efficient than today's - providing large potential to reduce greenhouse gas emissions. In the slightly longer term, vehicles powered by proton exchange membrane (PEM) fuel cells have perhaps the greatest long-term potential for reducing transportation CO₂. To ensure that the R&D leads to commercially viable vehicles, a number of programs are needed to guarantee that the infrastructure is available to support vehicles that run on non-traditional fuels.

Federal RD&D into buildings technologies has been remarkably successful. Consider just five technologies developed or advanced by the national laboratories in the past two decades at a cost of roughly \$40 million — building design software and advanced lighting, windows, oil burners, and refrigerator compressors. These have provided cumulative net savings of more than \$28 billion to consumers and businesses, exceeding the \$8 billion spent on all energy efficiency R&D since 1978. They now provide 16 million metric tons of annual CO₂ savings.

Continued RD&D in the buildings sector is likely to prove just as cost-effective. Key near-term technologies include improvements in lighting, superwindows, advanced design software, high-efficiency appliances, heat-pump water heaters, gas heat pumps, improved insulation and duct systems, more efficient cooling including gas cooling. Longer term R&D could result in electrochromic glazings for windows, building-integrated PV systems, and building fuel cells, all of which could see some market share before 2010 and make a large impact in the following decade.

The Industries of the Future visions and technology roadmaps identify the best R&D opportunities for increasing energy efficiency and reducing emissions in the industrial sector while increasing productivity. These include advanced materials development, separation technology, catalysis,

bioprocessing, renewable feedstocks, sensors and controls, and industrial cogeneration. All of these industries hope to dramatically improve their environmental performance while increasing their competitiveness. The pulp and paper industry, for example, sees the possibility of becoming a no-net-CO₂ industry, through a combination of efficient use of energy and biomass cogeneration.

Carbon Sequestration

In addition to the portfolio of R&D options related to less CO₂ intensive technologies for energy supply and use, capture and disposal of CO₂ offers an additional alternative for reducing atmospheric concentrations of CO₂. If major reductions in CO₂ emissions are necessary, and global reliance on fossil fuels continues beyond the middle of the next century, then some form of CO₂ sequestration will almost certainly be needed. A long-term R&D strategy would include demonstration of a number of sequestration options and research into their possible environmental impacts; converting CO₂ into an industrial chemical feedstocks; other novel sequestration options, such as CO₂ fixation by micro-algae; selectively permeable membranes for CO₂ capture; processes for converting fossil fuels and biomass into CO₂ and hydrogen; development of hydrogen infrastructure technology, including transportation and storage; and PEM fuel cells.

Basic and Advanced Research

A number of areas of basic research could prove crucial to responding to climate change, including biotechnology, fermentation microbiology, combustion research, polymer and ceramic science, process engineering, supercritical CO₂, new materials synthesis, and nanotechnology. We need to better understand the underlying biochemistry of the bioconversion of carbon dioxide to methane or to other potential fuels and feedstocks. This new research includes the ability to sequence the genetic material of microorganisms and plants, to develop new molecular genetic engineering techniques, and to understand biophysical and biochemical pathways of photosynthesis.

New and Expanded Efforts to Accelerate Diffusion and the Development of Clean Technologies

New initiatives are currently being designed to take advantage of the many areas of opportunity. All initiatives described are very preliminary.

Residential/Commercial Sectors

- *Split Incentives* — An initiative to overcome the unique split incentive barriers of landlord/tenant and builder/buyer relationships. In these cases, the people who make investment decisions (i.e., the builder of new buildings, or the landlord) do not pay the energy bills.
- *Energy Information* — An initiative to empower consumers and businesses by providing better information in their monthly energy bills, including benchmark comparisons to efficient homes.
- *Advanced Buildings Technology Development* -- Accelerated development of a portfolio of buildings technologies - such as fuel cells in buildings, reflective surfaces and materials, and advanced windows.

Industrial Sector

- *Acceleration of Industries of the Future* -- The Industries of the Future process for the seven most energy intensive industries will be accelerated, resulting in successful development of new technologies sooner. These investments will be targeted on those elements of industry's Technology Road Maps which will have the greatest potential to reduce emissions.
- *Cogeneration and Biomass Gasification* -- The development of advanced industrial turbines and biomass gasification technologies will be accelerated to provide many industries with not only inexpensive electricity, but also a means to reduce fossil-based electricity generation.
- *Industrial Partnerships* -- The federal government will work more aggressively with other major industries to achieve significant emissions reductions by 2010.

Transportation

- *Accelerated PNGV Initiative* -- The PNGV initiative will be expanded to accelerate the vehicle development and decrease the costs -making these vehicles even more attractive to consumers.
- *Light Truck Diesel R&D* -- The light truck diesel R&D initiative will increase light truck fuel economy by 40% - cutting emissions from the fast-growing sport-utility vehicles, light truck and minivans market.
- *Increased Ethanol Fuel R&D* -- Increased ethanol R&D will accelerate commercial competitiveness of biofuels by supporting greater feedstock work and accelerating completion of production facilities - bringing ethanol costs down faster than anticipated.

Cross-Cutting Opportunities

- *Financing for Energy Efficiency Investments* — Programs to improve access to financing for energy efficiency investments.
- *"Set Aside" for Clean and Efficient Technologies* — A new U.S. climate change policy would provide unique opportunities to provide further incentives to improve the penetration and innovation of energy efficiency and renewable technologies. For example, under a domestic trading system with a cap on greenhouse gas emissions, a reserve of allowances or a portion of auction revenues could be set aside to spur new R&D investment and production and use of energy efficiency and low-to-zero carbon technologies.
- *Business Accounting Practices* — An initiative to work with businesses to develop new practices that more accurately reflect energy liabilities.
- *Government Procurement* — An initiative to harness the combined purchasing power of all levels of government and provide large markets for efficient and clean technologies. efficient.

Electric Utility Sector

- *Biomass Co-firing with Coal* -- Biomass, particularly waste biomass, has been co-fired with coal for over 10 years. This initiative will continue technology development to allow greater fractions of biomass to be co-fired and sponsor technology demonstrations at coal plants and offer technical assistance to plant operators, suppliers, farmers and others.
- *Expanded Renewable Energy Technology Development and Deployment* -- This initiative will expand technology development efforts on key renewable energy technologies such as photovoltaics, wind and biomass while aggressively working with power companies, States and communities to accelerate their use.
- *CO₂ Sequestration and Hydrogen Production* -- This initiative would include demonstration of a number of sequestration options and research into their possible environmental impacts; converting CO₂ into an industrial chemical feedstocks; and other other novel sequestration options - such as converting fossil fuels and biomass into CO₂ and hydrogen.

Clinton Presidential Records Digital Records Marker

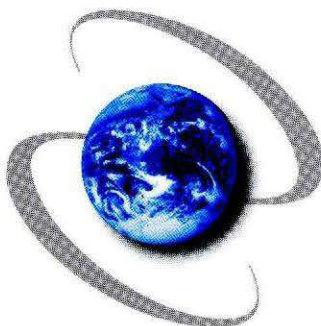
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CONSEQUENCES

THE NATURE & IMPLICATIONS OF ENVIRONMENTAL CHANGE



T*rends in U.S. Climate during the Twentieth Century* 2

The last several decades of weather records for the United States reveal trends that are consistent with the specific expectations of greenhouse warming, although even were they to persist, these documented changes in the American record could not be taken as conclusive evidence for a global effect.

A*merica's Water Supply: Status and Prospects for the Future* 13

Over 1300 gallons of freshwater are withdrawn each day for each person living in America, counting direct and indirect uses such as irrigation and the production of electric power. Although the U.S. has seemingly abundant supplies, the infrastructure of storage and delivery is growing old, while new factors, including the value of water left in the stream, now weigh heavily in apportioning it.

P*ast and Present Land Use and Land Cover in the USA* 24

In 1850, old growth trees still grew on nearly half of America; forest cover of all kinds reached a low point in about 1920, rising to 31% today. Cropland now covers some 22% of the conterminous U.S., and urban development about 4%. Roughly half of our original wetlands have disappeared. Changes in how the land is used are closely coupled with other aspects of the environment.

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