THE WHITE HOUSE

WASHINGTON

May 5, 1980

Pres-President

MEMORANDUM TO THE PRESIDENT

FROM: Frank Press FP

SUBJECT: Carbon Dioxide Increases

Chancellor Schmidt and others have raised with you the possibility of a CO_2-induced climatic change in the next century and its impact on our energy policy. At my request, the National Academy of Sciences has examined the social and economic consequences of the increase in atmospheric carbon dioxide. A copy of their report is attached as TAB A.

The report emphasizes the following points:

- The carbon dioxide issue is clouded by critical uncertainties as to the sources of carbon dioxide, the airborne concentrations, the climate response, the likelihood and timing of sea-level increases, and the socio-economic impact. Even in agriculture, which will be one of the most affected areas, there could be both positive effects (e.g., enhancement of photosynthesis) and negative effects (e.g., reduced rainfall in some regions).

- The changes and the costs and benefits are likely to be very unevenly distributed across the globe. The biggest problems may result from changed patterns in the distribution of rainfall -- the semitropical arid belt may expand, severely affecting agriculture in primarily the poorer countries with reduced capacity to adapt.

- Although carbon dioxide increase is inherently an international issue, it will be intensely divisive because of the uneven distribution of costs and benefits and because of the overlay of other issues: nuclear power, preservation of the environment, central economic planning, and "north versus south."

- The NAS believes that better understanding of the climatic consequences will emerge in 5-10 years. The Nation's principal efforts in the near term, therefore, must be focused on research to acquire this improved knowledge, but with as low a political profile as possible until we reduce the uncertainty. Meanwhile, the Nation would be well advised to keep open all relevant policy and technological options.

bcc: Henry Owen

NATIONAL RESEARCH COUNCIL
ASSEMBLY OF MATHEMATICAL AND PHYSICAL SCIENCES

2101 Constitution Avenue Washington, D. C. 20418

CLIMATE RESEARCH BOARD

April 18, 1980

Dr. Philip Handler
President
National Academy of Sciences
2101 Constitution Avenue
Washington, D.C. 20418

Dear Dr. Handler:

In a letter dated January 2, 1980, Dr. Press requested that the Academy assess for him, as promptly as possible, the likely foreseeable social and economic consequences of an increasing concentration of atmospheric carbon dioxide. He also requested a judgment on any implications for policy.

We were appointed members of a panel under the Climate Research Board and asked to provide such an assessment. It was understood that we would have to base our conclusions on what is currently understood about the likely increases in atmospheric carbon dioxide and the relation of carbon dioxide to climate. We took as a basis for our discussions the scientific consensus on the climatic effects of increased atmospheric carbon dioxide as presented, for example, in the 1977 Geophysics Study Committee report, Energy and Climate, and the 1979 report of an ad hoc Climate Research Board panel, Carbon Dioxide and Climate: A Scientific Assessment. We were aware that questions had recently been raised about the magnitude of

the projected climate changes.* We acknowledge that the range of uncertainty in estimates of future influences on climate is indeed wide. However, we have accepted the judgments of qualified members of the panel and other experts we consulted that these recent estimates of extremely small effects are based on incomplete assessments that unrealistically omit important feedback processes. Starting from these premises, we undertook to use our best judgment about the social and economic context on which any climate changes would impinge during a period that is half a century or more in the future. We did not undertake new research. Most of what we report must therefore be recognized as a collective judgment rather than as a scientific finding.

Society has developed in a relatively stable global pattern of climate. We face the possibility of a markedly different climate in 50 years in consequence of the continuing buildup of atmospheric carbon dioxide. Furthermore:

> This issue is inherently and inescapably international in character. The phenomenon is global: different countries will be affected differently, but none will be immune. No single nation can forestall undesirable consequences by its own actions alone.
>
> It is linked to other intensely controversial problems: energy, environment, population, economic growth, north-south conflict, unequal distribution of resources and wealth, pollution across boundaries, migration.
>
> Its implications are inherently divisive. Climate change will benefit some and harm others. Advanced countries will be major carbon users but may suffer the least. Adverse changes in climate are usually felt in the increasing frequency and severity of familiar extremes, such as drought; whether carbon dioxide is the cause and who is to blame will be inherently difficult questions to resolve.

*R. E. Newell and T. G. Dopplick (1979). Questions concerning the possible influence of anthropogenic carbon dioxide on atmospheric temperature. J. Appl. Meteorol. 18, 822-825.
S. B. Idso (1980). The climatological significance of a doubling of earth's atmospheric carbon dioxide concentration. Science 207, 1462-1463.

Critical Uncertainties

The credible range of effects is extremely broad. By the middle of the next century, we may have a climate almost as different from today's as today's is from the peak of the last major glaciation. At the other extreme, we may only experience noticeable but not necessarily unfavorable effects around mid-century or later.

Uncertainties lie in four principal areas:

1. Sources of carbon dioxide. The magnitude of future injections of carbon dioxide will depend on how the world's population obtains its energy and, to some extent, uses its land. Projections based on today's technology may prove irrelevant if new energy sources and ways of life compete successfully against coal burning.

2. Airborne concentrations. Carbon dioxide in the atmosphere is part of a complex carbon cycle. The nonatmospheric reservoirs of carbon are in the aggregate much larger than the atmospheric. Projections of future airborne concentrations depend on the uncertain partitioning of carbon dioxide among the reservoirs.

3. Climate response. Increases in atmospheric concentrations affect the energy exchange of the climate system. Changes in climate must be estimated from models of the entire system--the atmosphere, oceans, ice and snow, and land surface. There is uncertainty about the magnitude, timing, and global distribution of climate changes even for a given change in carbon dioxide concentration.

4. Socioeconomic impact. Even in agriculture, which will be one of the most affected activities, there would be both positive effects (e.g., of enhanced carbon dioxide on photosynthesis) and negative effects (e.g., of reduced rainfall in some regions), and there are uncertainties about genetic adaptation of crops, irrigation techniques, and dietary developments. Other impacts are similarly uncertain if only because they are decades into the future.

There is assuredly enough economically accessible fossil fuel--primarily coal--to inject into the atmosphere several times as much carbon dioxide as it now holds. That is not in dispute. But it is not certain how much will be burned or how rapidly. Once established, elevated carbon dioxide levels would then almost certainly persist for many centuries.

In addition to problems of adjusting to a gradually changing climate, there may be thresholds or discontinuities. At some point within the range of carbon dioxide increases that known reserves of fuels could produce, the floating Arctic Ocean sea ice would disappear in summer, radically altering the meteorology of the northern hemisphere, with consequences that are not now predictable. Another concern is the West Antarctic Ice Sheet. A warmer climate with warmer oceans might cause it to disintegrate over a period of a decade to centuries, raising sea levels by about 15 to 20 feet, enough to jeopardize many of the world's cities. We have not examined any of the protective measures--whatever they may be--that might be considered, nor have we assessed the plausibility of the contingency itself.

It is also possible that the required rate of adjustment to changes in climate will be very great. Fossil-fuel consumption may indeed increase steadily; increments of carbon dioxide may become harder to absorb in the biosphere and ocean, an increasing proportion remaining airborne; whatever the climatic response, the pace of adaptation required could well accelerate.

There is a further point that is not adequately suggested by the term "climate change." Food production is not just a function of average rainfall or temperature; changes in the variability of climate would affect food production.

Potential Impacts of Climate Change

Economic impacts of changing climate would certainly be felt in agriculture. Changes in precipitation would be most significant and most conspicuous, but changes in temperature and growing seasons, sunlight, and the frequency of storms would also be important. Shifts in climate zones and in the loci of agricultural activity may create new combinations of soil and climate to which existing crops and farming practices would be imperfectly adapted. Marine resources, including fisheries, are also sensitive to changes in ocean chemistry and climate. The increased concentration of carbon dioxide should, up to a point, directly increase the rate of photosynthesis and improve water utilization and nitrogen fixation by plants in agriculture. (Artificially enhanced carbon dioxide is now used to increase productivity in commercial greenhouses.) The net effect on aggregate food production, which depends on many complex factors, is uncertain and would depend greatly on the rate of climate change and the ability of different peoples to adapt; the most serious consequences are likely to be in the distribution of gains and losses among areas of the world.

What is certain is that established patterns of agriculture would have to change, and in some areas might be disrupted.

Other direct effects of climate change, e.g., on energy demand, navigation, tourism, appear of lesser significance than food production, but we cannot say they will be negligible. Second-order effects may prove important, e.g., conversion of stable permafrost to impassable bog. Our welfare is linked to the stable functioning of many ecosystems; disturbances can have unexpected consequences. For example, outbreaks of agricultural pests or certain human diseases may be triggered by changes in climatic conditions.

It is worth remarking that the major foreseeable effects of carbon dioxide will be a different distribution of climate, not the creation of entirely new kinds of climate. The present climates of the globe span an exceedingly wide range from the Arctic to the desert. Indeed, the migration to and throughout the new world subjected large numbers of people--together with their livestock, food crops, and culture--to drastically changed climate.

The overall economic cost (or benefit) of the sort of climate change associated with a doubling of carbon dioxide may be no more than a few percent of world gross national product (GNP). But the seriousness cannot be assessed in GNP alone. The geographical pattern of climate change may produce a drastically unequal distribution of impacts. For example, northern countries might benefit, despite disruption, from a general warming; on the other hand, an expansion of subtropical arid regions would affect primarily the poorer countries. Developed countries with advanced and diverse agriculture, and in which agriculture accounts for a relatively small proportion of the GNP, would probably be better able to adapt to change than would less-developed ones, which are strongly dependent on agriculture. It seems that climate change might well tend to make the already poor still poorer and increase the differences between north and south, rich and poor, developed and developing. We emphasize again the uncertainties: substantial changes could occur within forty or fifty years and be accelerating in mid-century, or could be delayed many decades beyond.

Responses to Change in Climate

Although climate change would certainly affect agriculture, technologically advanced agriculture has proved to be quite resilient under climate change. Modest changes have been

accommodated in this century, and the ability of crops to prosper under a range of climatic conditions has been greatly extended through genetic improvements. Further advances may aid agricultural adaptation to climate changes.

Changes in availability of water are the single most significant consequence of climate change that we foresee through the next century. Present use of water for agriculture is highly inefficient in most countries. Improvements in irrigation and water delivery could increase production even in the face of declining precipitation. The obstacles are as much legal and institutional as technological. Changes in water supply also affect the availability of water of adequate quality for industrial and human consumption. However, large-scale, long-distance transfers of water currently seem unlikely; most opportunities for large-scale, gravity-fed transfer have already been exploited, and rising energy costs will discourage pumped long-range water transfers. For the most part, regional water needs will have to be met by regional resources. While modest precipitation decreases in areas well supplied at present could be accommodated, similar decreases in some currently marginal semiarid regions and increases in the frequency of drought could have serious impacts.

Migration has historically been the principal means of adapting to climate change. But today's political barriers hamper migration, and national boundaries are not likely to be more open in the future. If migration out of climatically impoverished areas is not feasible, transfer payments and other technology and capital to aid local adaptation to climatic change may have to be considered for such areas.

Preventing or delaying the increase in carbon dioxide would have to be done mainly by restricting the use of fossil fuels, although management of land and forests could also contribute. Only coal is likely to be economically available in the quantities required to double or more than double the airborne carbon dioxide. Known coal reserves are mainly concentrated in a few major countries: the United States, the Soviet Union, and China together hold most of the known reserves. Emissions can therefore be controlled only if these countries, which agree on little at present, agree in the future not to exploit for their own use or make available to other countries without restriction this part of their natural wealth, or if most of the consuming countries can agree to restrict their imports. Moreover, in our judgment the Soviet Union and the United States--because of their geographical extent and general economic development--are

likely to be among the nations most able to adapt to, or even benefit from, climate change.

In the absence of attractive alternative energy sources, voluntary control of coal use and coal exportation by any of the three major coal-holding nations would be unlikely unless it were clear that the unfavorable consequences of climate change significantly outweighed the benefits of coal exploitation. Similarly, self-imposed restrictions on energy demand by countries without coal would hardly find ready acceptance unless this self-denial was obviously in their own best interests; for each nation individually it would not be. Technological aid to fuel-poor developing nations for development of alternative energy sources is therefore an attractive policy to the extent that it can reduce their fossil-fuel needs. In summary, restraint on fossil fuel will require global cooperation, reductions in energy demand, and the widespread introduction of alternative energy sources.

Policy Choices under Uncertainty

Carbon dioxide and climate are not the only uncertainties in our future. In the next half century, world population will probably double and global GNP will, one hopes, increase by a larger multiple. Comparable changes took place between the early years of this century and today. If we had attempted in 1900 to predict the world of 1980, we might well not have foreseen air travel, nuclear energy, space exploration, recombinant DNA, and digital computers. Future technology may overshadow, in both benefits and damages and their differential impacts among peoples, the effects of carbon dioxide. Significant progress in weather modification, water management, development of alternative energy sources, or agricultural technology would change our assessment of the problem.

Some implications of increased concentration of carbon dioxide, however, are clear:

1. Our immediate problem is uncertainty itself. We must reduce that uncertainty through research. We discuss this further below.

2. Research notwithstanding, uncertainty will persist. Even as the dimensions of the problem become clearer, it may be necessary to base preventive and adaptive policies on uncertain predictions.

3. We must recognize now that increases in energy consumption using fossil fuels will have increasingly undesirable climatic effects.

4. We and the main energy-consuming countries must keep open a number of options for energy and not become committed to an extended period of unrestricted fossil-fuel use.

5. Agriculture would be most certainly affected, especially through changes in the availability of water. We should enhance the resilience of agriculture to changing climate, through research in the adaptability and diversity of species, irrigation techniques, and water conservation and transport.

6. Climate changes will produce increased pressures in some parts of the world for migration within and across national boundaries, a potential source of conflict.

7. Climate changes, and measures to prevent them as well, would constitute for some countries an adverse redistribution of resources and could generate demands for compensation.

8. Current capabilities give no grounds for hoping that controlled weather modification could compensate for global changes in climate. Breakthroughs in climate control could alter this assessment, but there is no assurance that any breakthroughs would be less divisive in their effects than the climate changes that would occur in their absence.

9. Slowing the growth in fossil-fuel combustion will make adaptation to climate change easier and may permit more absorption of carbon into nonatmospheric sinks. It will also permit conversion to alternative energy sources at a lower cumulative carbon dioxide concentration, and it is likely that the sooner we begin the transition from fossil fuels the easier the transition will be.

10. Carbon dioxide is but one of a class of "global commons" issues that includes chlorofluoromethanes and acid rain. The precedents we set in dealing internationally with any of these issues, in regulation or research, will influence how we deal with carbon dioxide.

11. There is an intricate linkage of carbon dioxide with other intensely divisive issues: nuclear power and preservation of the environment, markets and central economic planning,

"north versus south" and the gap between developed and developing nations, and even OPEC and the demand for oil.

Implications for Research

Present knowledge is an insufficient basis for international action to prevent climate changes or to adapt to them. Two kinds of knowledge and capability should be improved. First, we need to reduce the uncertainties about future carbon dioxide injections, their climatic effects, and the social and economic implications. It will be important to verify observationally the model predictions of climate change as soon as possible by carefully designed monitoring programs. Continued research in ocean chemistry and dynamics, the biogeochemical cycling of carbon, the myriad processes that influence climate, and the building and validation of climate models will be necessary. We must also learn much more about the impacts of a climate change on human activities, especially agriculture and its complex interaction with society. This first stream of research to clarify the links between our actions and their consequences will enable us to measure the problem and to assess its importance with respect to other societal issues. Second, we need to learn more about how we might adapt to climate change or prevent it. Our discussion above has indicated some of the knowledge needed in agricultural technology, energy production, and management of forests and soils.

Recommendations for Near-Term U.S. Policy

Better understanding will emerge slowly, but knowledge can probably be made to grow faster than the problem. The information needed to choose a balance of adaptation and prevention should be of much better quality in five or ten years. But this information will be of little value if options are not available. We must ensure that options for adaptation and prevention remain open.

The challenge is to progress toward an international consensus on the carbon dioxide issue while minimizing its factious involvement with other issues and its own divisive aspects. The carbon dioxide issue should appear on the international agenda in a context that will maximize cooperation and consensus-building and minimize political manipulation, controversy, and division.

Our understanding of the issue has been developed in the context of research on climate, its changes, and their

interaction with mankind. A World Climate Program, led by the World Meteorological Organization, has been established to improve the world's ability to cope with contemporary climate, natural climate fluctuations, and man-made climate changes. Most of the research necessary to improve our understanding is at least conceptually provided for in this program. Moreover, as part of this program, several international organizations are organizing a sequence of activities to develop a cross-cutting "Plan of Action" specifically relating to the assessment of the carbon dioxide issue. Thus, a relatively nonpolitical and broadly supported framework for international study exists. The effectiveness of these activities is as yet unproven.

In view of the uncertainties, controversies, and complex linkages surrounding the carbon dioxide issue, and the possibility that some of the greatest uncertainties will be reduced within the decade, it seems to most of us that the near-term emphasis should be on research, with as low a political profile as possible. We should emphasize that this is both a technical and a political judgment. Another point of view represented on the panel is that further research will not fundamentally change our perception of the issue; in this view, the need for preventive measures is already apparent and urgent.

Most of the things one would want to do now to prepare for dealing with the carbon dioxide problem are things one would want to do for other reasons. Overdependence on a single energy source has already proven to be unwise; development of alternative energy sources is clearly necessary. Energy production has many troublesome environmental effects, including carbon dioxide; we should study how to alleviate them. Climate variability already causes problems; we want in any event to learn more about climate and its interaction with society. The past teaches us that significant natural climate changes are likely; we should consider how to cope with their impacts, whether induced by nature or man. The carbon dioxide problem increases the urgency of this research; it does not fundamentally change its nature.

The one exception is the novel possibility of elevated ocean levels due to disintegration of the West Antarctic ice sheet. Research bearing directly on the likelihood and timing of such a development is needed, and an exploration of protective and adaptive measures should be initiated. (The problem of "rising" sea levels due to land subsidence and the silting of river bottoms is itself not new, and the first stages should be to assemble what is already known, both in the United States and abroad.)

In all of this, we need to keep in mind that this earth is the only planet we have on which to live. We humans have made major changes in our environment without yet destroying its ability to support us. This may demonstrate great resilience in the earth's life-support systems; but we may just have been lucky. As we grow in numbers and power, we will make ever greater demands on our planet, and there is no guarantee that we will not get into trouble in ways that we have not yet discovered or even imagined.

Conclusion

To sum up, carbon dioxide will pose exceedingly difficult and divisive policy questions for all the world's nations individually and collectively. We do not know enough to address most of these questions right now. We believe we can learn faster than the problem can develop. This learning can be done while we address with increasing urgency the problems of living with changing resources of energy, land, and climate.

Sincerely,

Ad Hoc Study Panel on Economic and Social Aspects of Carbon Dioxide Increase
Thomas C. Schelling, Chairman

McGeorge Bundy	Herman Pollack
Abram J. Chayes	Roger R. Revelle
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