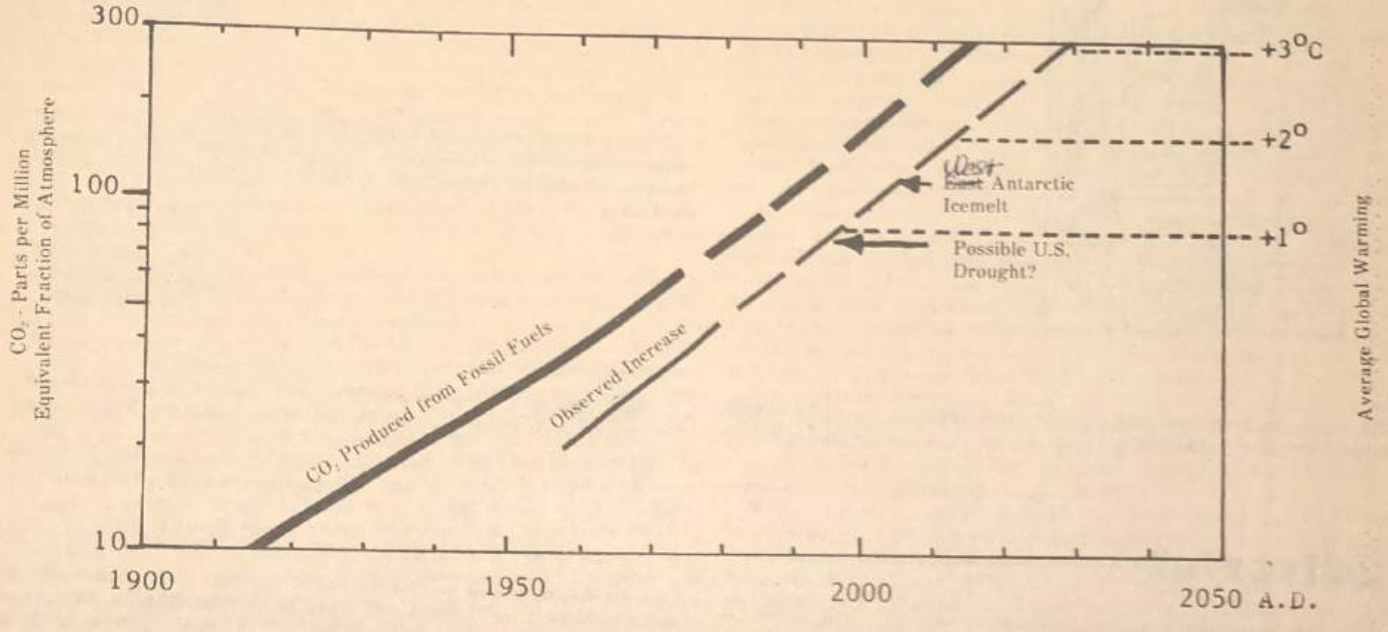
The CO2 Newsletter, created, published, and edited by William N. Barbat, ran from 1979 to 1982.

In 2025, the family of Mr. Barbat donated an original set of all issues to Dr. Marc Hudson, and agreed that these could be digitised and placed online as a resource for anyone who wants to understand how long we've known about the carbon dioxide and global warming problem.

CO_2 Newsletter

Volume 1 - number 2 **December, 1979 - January, 1980**

A bimonthly summary of advances in knowledge of the CO2-greenhouse problem, and of the social, political, and economic implications.



Exponential projections of the worldwide production of CO_2 from fossil-fuels combustion and the observed increase in atmospheric CO_2, which amounts to about half the CO_2 from fossil fuels. The estimated global warming is based on a 3 degree centrigrade rise for a doubling of atmospheric CO_2 (see article below) which is expected to occur about 2030 if fossil-fuel CO_2 continues to increase at 4% per year. The 'Possible U.S. Drought' threshold is based on SRI Project EGU 6375 (unpublished DoE report of July 1, 1977, prepared by JASON group, G. MacDonald, Chairman) and the 'West Antarctic Icemelt' threshold is approximated from the work of J.H. Mercer (Nature, January 1978).

Cumulative CO_2 production is based on the work of R.M. Rotty, and observed CO_2 on the work of C.D. Keeling and associates.

Report to president's adviser: CO_2 buildup can change climate

The introduction of the CO_2 issue into U.S. energy policy moved a step closer in November as a scientific advisory panel reported, "If the CO_2 concentration of the atmosphere is indeed doubled . . . our best estimate is that changes in global average temperature of the order of 3 degrees C will occur and that this will be accompanied by significant changes in regional climatic patterns."

At the request of Frank Press, science adviser to the President, the National Academy of Sciences had convened this group of experts who had little previous involvement in CO_2 studies to make an impartial examination of the validity of CO_2 forecasts.

The group stated in its report that the basic model relating CO_2 to global warming is correct, so far as they can see. "We have tried but have been unable to find any overlooked or underestimated physical effects that could reduce the currently estimated global warmings due to a doubling of atmospheric CO_2 to negligible proportions or reverse them altogether."

The report is summarized in *Science* 23 November 1979 under the title, 'CO_2 in Climate: Gloomsday Predictions Have No Fault'. The panel was chaired by Jule G. Charney, MIT.

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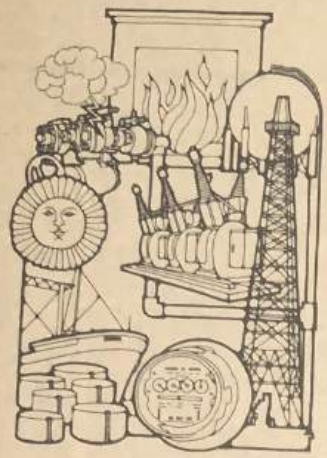

"Human history becomes more and more a race between education and catastrophe." — H.G. Wells

Editorial

The CO_2 Newsletter's editorial goals are to aid enlightment on the CO_2 problem, to promote constructive and timely solutions, to reduce disagreement and to encourage cooperation.

The many persons who continue to send articles are to be thanked for their contribution toward enlightenment. Ideas for constructive solutions are just now being formed as the CO_2 issue emerges from scientific laboratories to reach the political and industrial worlds. While scientific disagreement is declining with the acquisition of new data, much disagreement exists in the political world over what national energy policy should be and what should be the role of industrial establishments in carrying it out. The revolutionary energy policies which are now being considered by the scientific community to bring the CO_2 buildup to an early halt would require much more cooperation between government and business than appears to exist. Unwarranted hostility and intolerance directed towards energy companies for political gain make it difficult to address the CO_2 problem effectively and early.

American businesses have not been wholly oblivious to the CO_2 problem in the past. In a well-researched comprehensive report on the environmental aspects of energy production published nearly a decade ago (May 1970) in the Westinghouse Engineer *James H. Wright noted that the CO_2 buildup should be given consideration as a serious environmental concern.*

Corporations which have diverted income from oil revenues to the production of nuclear fuels have come under political attack for attempting to monopolize energy production, when that is the least likely motive. The costly Barnwell nuclear-fuel reprocessing plant has not been allowed to operate after apparently receiving governmental approval while the investments were being made. Well-meaning detractors have been able to delay construction of nuclear plants, and rate commissions often have shifted the heavy financial burden of the delays solely to the utility owners.

At this stage, recriminations would be counterproductive. We would be wise to learn from past mistakes and close ranks to prepare for the difficult task of halting the CO_2 buildup.

From our readers

"Congratulations on the *CO_2 Newsletter*. It's a tightly edited and focused report, and I'm sure it will be a useful guide, especially to the non-technical or those who are not able to follow this complex issue on a daily basis. . . ."

David M. Burns, Director, Climate Project
American Association for the
Advancement of Science
Washington, D.C.

"I am very much impressed by your '*CO_2 Newsletter*. I will not comment on the details of what is in it, but I do think you have addressed a great many important issues very convincingly. I hope your newsletter finds a wide audience. . . ."

William W. Kellogg,
Senior Scientist
National Center for
Atmospheric Research
Boulder, Colorado

"Thank you very much for providing me with a copy of the October-November *CO_2 Newsletter*. I look forward to reading in-depth the CO_2 problems. . . ."

Larry R. McDonald
Member, House of Representatives

"I would like to thank you for sending me the first issue of your publication, *CO_2 Newsletter*. It seems well organized and thoughtful. A publication of this type will be useful in pointing out that all energy systems can have harmful effects on the public. . . ."

Herbert Inhaber, Scientific Adviser
Technology Impact Division
Atomic Energy Control Board of Canada

"Thank you for sending me a copy of your *CO_2 Newsletter*. It seems an important and worthwhile endeavor, and one which will serve a vital educational function over the coming years. . . .

"From your newsletter I was not entire clear what you perceive your audience to be. Whom do you hope to reach? What other activities does your organization participate in, and how does it impact on your interest in CO_2 and climate? . . ."

Henry D.I. Abarbanel
Lawrence-Berkeley Laboratory
University of California

(William N. Barbat is an entrepreneur and geological consultant in minerals exploration and production, and is informally affiliated with other business consultants in three states. Wm. N. Barbat Associates is presently engaged both in fossil fuels projects and uranium. Mr. Barbat published a comprehensive report on energy systems and the overriding concern for the CO_2 buildup in 1973, and he has actively followed the subject ever since. The newsletter is intended to be informative of an impending revolutionary change to leaders in government and industry. Hence, the newsletter reaches a broad spectrum of subscribers, as the U.S. Nuclear Regulatory Commission, Old Ben Coal Co. (Sohio), Rocky Mountain Energy Co. (uranium subsidiary of Union Pacific R.R.), and thermodynamics consultant (solar thermal) R.M. Krudener. Complimentary subscriptions are made available to CO_2 researchers who are contributors. —Editor)

Will impacts remain for one generation or thirty?

'Tropical Deforestation' issue seeks the answer

How fast can the ocean waters and other natural sinks take up the CO_2 produced by man? This question has been the center of heated controversy which occupied a large share of the Dahlem (Berlin) Conference on 'Global Chemical Cycles' in 1976 and ERDA's Miami Beach Workshop on the 'Global Effects of Carbon Dioxide from Fossil Fuels Combustion' in 1977.

One school of thought holds that man-created CO_2 would be removed from the atmosphere at a rapid rate—possibly as high as 6% per year—once man's outpourings of CO_2 have ceased. If so, any legacy of a CO_2-induced climate change would be short lived except possibly for any destruction of icecaps that has taken place before a CO_2-induced warming ended. Natural uptake of CO_2 this fast would essentially relegate the CO_2 problem to a reversible status, similar in certain respects to smoke pollution and acid rain. Also, the contributions to the CO_2 buildup due to fossil-fuel consumption by people in the United States (which comprise 5% of the world's total population) in such a case figures to be 12% of the overall atmospheric buildup rather than 24%.

The leading advocate of this rapid-uptake hypothesis is biologist George Woodwell of Woods Hole. Woodwell's position is based on his estimate that the cutting and burning of forests (essentially for farm-clearing in the tropics) is currently a major source of CO_2—possibly as much as 20 to 100 percent of that released by the burning of fossil fuels. Woodwell's estimate of the deforestation rate is not based on hard data, but is projected from very limited statistical samplings, which statistics have also been interpreted by some others as showing a slight **increase** in forest biomass.

The opposing school of thought holds that uptake by the oceans is very slow and depends on the turnover rate of undersaturated deep ocean waters, which is of the order of 1000 years. If true, then as man's cumulative output of CO_2 exceeds certain threshold values to cause impacts such as a decrease in agricultural productivity, a decrease in marine habitat, or to cause icecaps to become unstable, these impacts would become irreversible for many generations to come. Also the slow uptake carries the implication that the highly industrialized nations bear most of the responsibility for the CO_2 buildup rather than sharing it almost equally with farmers in the tropics.

The slow uptake view is shared by the geophysicists, geochemists and ocean scientists who have made extensive studies of the world's overall carbon budget. Notable among this group are Wallace S. Broecker, Taro Takahashi, and associates of Lamont-Doherty Geological Observatory and Columbia University, C.D. Keeling and associates of Scripps Institution of Oceanography, Minze Stuiver of University of Washington, and H. Oeschger and U. Siegenthaler of Switzerland.

An article published in *Science* 26 October 1979 by Broecker and his associates notes that "several versions of recent atmosphere-ocean models appear to give reliable and mutually consistent estimates for carbon dioxide uptake by the oceans . . . calling for a modest increase in the size of the terrestrial biosphere in order to achieve a balance in the carbon budget." These workers further provide hard data on the distribution of carbon isotopes between various carbon reservoirs which provide constraints on the size of the known carbon reservoirs. The authors also note that Woodwell's rapid-uptake hypothesis and deforestation estimate demands that between one-third and one-half of all the tropical forest would have disappeared in the last two decades, which should be more readily apparent if true. (Projected at a constant rate per year rather than at the exponential rate of growth exhibited by the CO_2 buildup, one notes that Woodwell's hypothesized deforestation rate would result in complete elimination of tropical forest cover in two or three more decades.) In resolving the apparent carbon budget contradiction, Broecker's group concluded that "regrowths of previously cut forests and enhancement of forest growth resulting from excess CO_2 in the atmosphere have probably roughly balanced the rate of forest destruction during the past few decades."

While the controversy over deforestation and ocean uptake is not yet settled to everyone's satisfaction, majority scientific opinion seems to strongly favor the slow-uptake school of thought. With slow uptake by oceans, there is no safe allowable *rate* of CO2 output which could prevent temperature thresholds from being reached. Rather every single contribution of CO_2 is likely to have a long-lasting effect. Acceptance of the slow-uptake theory shifts the social concern from *slowing* the rate of CO_2 production to *limiting* the total amount of CO_2 produced from the combustion of fossil fuels.

Excerpts from recent reports

From 'Fuel Combustion Adds to Anxiety over CO_2 Buildup', by David Sleeper, Conservation Foundation Letter, August 1979 (1717 Massachusetts Ave. NW, Washington, D.C. 20036):

"The amount of atmospheric CO_2 has been increasing rapidly since the onset of the Industrial Revolution. And in the past 20 years, the annual rate of increase has grown sharply.

"All this has caused a mild panic in the scientific community. . . .

"For the past decade, debate in the scientific community has been sharply divided between those who thought the earth was heading into a cooling period—perhaps even a new ice age—and those who forecast a global warming. This 'fire and ice' controversy still continues, but recently the weight of scientific opinion has shifted toward the warming thesis. The current belief is that rising levels of carbon dioxide will simply overwhelm any cooling brought on by sunspot activity, increases in air-borne particles, or other phenomena that might cause long-term cyclic changes. . . .

"The names of the institutions currently working on the CO_2 problem suggest how seriously it is taken. In the U.S., they include the National Center for Atmospheric Research, the Marine Biology Laboratory at Woods Hole, the MITRE Corporation, SRI International, the National Academy of Sciences, the Oak Ridge National Laboratory, and at least two dozen universities. Most of the government work is being handled by NOAA and the Department of Energy's Carbon Dioxide and Climate Research Program, set up in 1977. (Until recently, CEQ and EPA have not paid much attention to CO_2. Among private environmental groups, only Friends of the Earth seems to have followed the issue.) . . .

"At a time when scientists finally seem to be reaching agreement that a global warming is in the cards the world's energy planners are calling for greatly increased use of coal and coal-based synthetic fuels—the two worst contributors to carbon dioxide pollution. . . .

"A report by SRI International lists mass migrations, political changes, economic chaos, and agricultural disruptions, among other effects of climate change. 'You can see why people are not totally able to emotionally accept this,' says David Slade, manager of DOE's carbon dioxide program.

"According to a group of researchers at the Oak Ridge National Laboratory, 'Any rapid change in a regional climate is more likely to produce detrimental effects that far outweigh the beneficial ones.' . . .

"Precipitation and warm temperatures might shift northward in the U.S. returning Kansas, Oklahoma, and surrounding states to drought conditions of the 1930s and seriously diminishing the corn, wheat, and soybean crops of the central part of the country. . . .

"The major Atlantic fisheries, already overfished, might be further weakened by shifting ocean currents and decreased nutrient replenishment. . . .

"Because of higher temperatures, inland lakes and waterways might dry up, causing severe transportation and water-supply problems. Among the hardest hit might be the Colorado River system. . . .

"The problem facing us today is this: When should the studying stop and political action begin:

"Stephen Schneider, a scientist at the National Center for Atmospheric Research, puts it this way: 'The dilemma rests, metaphorically, in our need to gaze into a very dirty crystal ball; but the tough judgment to be made here is precisely how long we should clean the glass before acting on what we believe we see inside.' . . . .

"According to a comprehensive research plan proposed by the Department of Energy (some portions of which were severely criticized by the JASON study), reports representing 'an international consensus of the perceived costs or benefits' of the carbon dioxide problem will be issued in 1983 and 1988."

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From 'Influences of mankind on climate', by William W. Kellogg, Annual Review of Earth and Planetary Sciences, 7:63-92:

"A more significant influence (than heat pollution), and one which can be more easily quantified, is the change of atmospheric composition as we add carbon dioxide, smoke and smog, and a variety of relatively stable trace gases such as chlorofluoromethanes, methane, nitrous oxide, carbon disulfide, and so forth. . . .

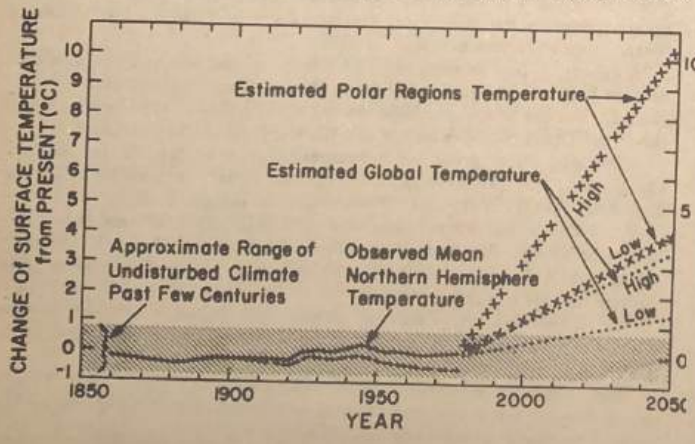
"When we compare the magnitudes of the various human effects on climate it seems that the largest single influence is that of adding carbon dioxide. . . .

"Several studies in the past have concluded that if these aerosols (smoke from coal, oil, wood and sulfur dioxide, unburned gasoline, photochemical smog) were distributed uniformly over the earth they would increase the earth's overall albedo by scattering sunlight and thereby cause a general cooling. . . .The reasons why this is almost surely **not** the case . . . are briefly restated. First, such industrial aerosols (and the same would apply to slash-and-burn smoke) do not remain airborne in the lower levels of the atmosphere for more than about five days on the average. . . . That means that they are a regional phenomenon and are limited for the most part to the land areas where they were created. Second, they are now known to be fairly highly absorbing in the visible, apparently because they contain small particles of carbon or black organic substances, and therefore they absorb solar radiation as well as scatter it . . . . Detailed calculations taking account of their size distribution, optical properties, and the albedo of the underlying surface . . . show that low-lying aerosols will lower the albedo of a typical land surface, thereby causing a warming of the lower atmosphere. (Over a dark ocean surface this is not true, and they may cause an increase in albedo, but most anthropogenic aerosols are over land.) This theoretical conclusion that aerosols over land cause a warming has been verified by actual observations in aerosol-laden air . . . .

"It has been suggested (Boeck 1976) that the addition of radioactive Krypton-85 from the extensive use and reprocessing of nuclear fuels could change the conductivity of the atmosphere, and that this might in turn influence the formation of thunderstorms. . . . This effect might turn out to be a real one, but we know too little about the interactions between the earth's electric field and thunderstorms to be able to say at this time what the final effect on climate might be. . . .

"We turn now to the single influence that appears to be the most significant, the addition of carbon dioxide to the atmosphere. . . .

"The best estimate of the 'greenhouse effect' due to a doubling of carbon dioxide lies between 2 and 3.5 degrees C increase in average surface temperature . . . , and both the models and record of the behavior of the real climate show that the change in the polar regions will be greater than this by a factor of from 3 to 5, especially in winter. . . .



"We can predict that a warmer earth will also have smaller equator-to-pole temperature contrast. Thus the atmospheric heat engine, with a relatively warmer 'condenser' at the polar end, will run more slowly. In meterological terms, there will be less available potential energy in the system to convert to kinetic energy. . . .

"Our coupled general circulation models are just getting to the point where they are capable of throwing light on the regional changes that would accompany a general warming. . . . we can probably look forward to some preliminary results in a very few years. . . .

"If the scenario presented here turns out to be correct, more or less, and climatic change becomes an accepted reality, what will we decide to do about it? The countries of the world must act together, since the effect is global in character and the cause, primarily the burning of fossil fuels, is an international activity."

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From 'An inquiry into man's impact on climate', by Walter Orr Roberts, The Food & Climate Forum Distinguished Lecture 1978, Aspen Institute for Humanistic Studies:

"Let us now take a look at the predominant view of the influence of carbon dioxide and the 'greenhouse' effect. If this occurs, sometime within the next 30 to 50 years (which is an extremely short time period in terms of climatic fluctuations), we will see a much warmer Earth that will perhaps resemble a period that occurred in the Earth's history between 4,000 and 8,000 years ago, usually called the altithermal period. This period resulted in a very different distribution of vegetation, a very different distribution of rainfall and temperature, and in particular, as William Kellogg and others have pointed out, it resulted in quite a difference in patterns of where one would optimally grow various crops. The Sahara Desert was vegetated, at least lightly, during that time, and from the Rockies some distance to the east, it was probably almost a sandy desert. If this were to recur we would probably have sand dunes not just around Alamosa, Colorado, but probably for about 800 miles east of Boulder in regions now important for agriculture.

It also was reasonably clear that during the altithermal there was considerably greater rainfall in East Africa, and that in the Siberian lands where wheat is grown (marginally at the present time because of the shortness of the growing season), there was something like a two, three, or possibly even four week longer growing season. If this were to recur it would extend significantly the range of the growth of wheat. It seems to me not totally unreasonable to expect that if this change were to occur, we would find the Soviet Union as a major wheat export nation and the United States as a substantial wheat import nation. But, of course, this is a speculation.

●

From 'Environmental and Societal Consequences of an Increase in Atmospheric CO_2', a summary by Roger Revelle of the DoE-AAAS Workshop held at Annapolis, Maryland on April 2-6, 1979:

"The dominant concerns of the panel on the ocean and the cryosphere were the impacts on fisheries of a global atmospheric warming and a possible disintegration of the West Antarctic ice cap. . . . A slackening in average wind speeds could be expected . . . with a concomitant larger decrease in wind stress on the surface ocean waters. This could result in a diminution in upwelling and vertical convection and correspondingly in nutrient recycling and primary organic production in the ocean. At the same time, the pH of the waters near the surface might become significantly lower, with pronounced effects on the ecology and species composition of plankton communities. . . .

"Major changes in the distribution and species composition of terrestrial and fresh-water ecosystems could occur. . . .

"Changes in the distribution of food resources on a global scale are to be expected, with significant social, institutional, economic, and political ramifications."

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From *Newsweek* November 19, 1979:

"Then there is the question on ecological instability. I would expect to get clear signals in the '80s of impending and irreversible climatic changes because of carbon dioxide in the air."

— Theodore Taylor,
Nuclear physicist, weapons designer

Human activities influencing climate

Activity	Climatic effect	Scale and importance of the effect
Release of carbon dioxide by burning fossil fuels	Increases the atmospheric absorption and emission of terrestrial infrared radiation (greenhouse effect) resulting in warming of lower atmosphere and cooling of the stratosphere	Global; potentially a major influence on climate
Release of chlorofluoromethanes, nitrous oxide, carbon tetrachloride, carbon disulfide, etc	Same effect as that of carbon dioxide since these, too, are infrared-absorbing and chemically stable trace gases	Global; potentially significant
Release of particles (aerosols) from industry and slash-and-burn practices	These sunlight-absorbing particles probably decrease albedo over land, causing a warming; they also change stability of lower atmosphere	Regional, since aerosols have an average lifetime of only a few days; stability increase may suppress convective rainfall
Release of heat (thermal pollution)	Warms the lower atmosphere directly	Locally important now; will become significant regionally; could modify large-scale circulation
Release of aerosols that act as condensation and freezing nuclei	Influences growth of cloud droplets and ice crystals; may affect precipitation in either direction	Local or (at most) regional influence on precipitation
Upward transport of chlorofluoromethanes and nitrous oxide into the stratosphere	Photochemical reaction of their dissociation products reduces stratospheric ozone	Global; probably small influences on climate; allows more solar ultraviolet radiation to reach the surface
Patterns of land use, e.g. urbanization, agriculture, overgrazing, deforestation, etc	Changes surface albedo and evapotranspiration	Regional; global importance speculative
Release of radioactive Krypton-85 from nuclear reactors and fuel reprocessing plants	Increases conductivity of lower atmosphere, with implications for electric field and precipitation from convective clouds	Global; importance of influence is highly speculative

From 'Influences of mankind on climate', by William W. Kellogg, Annual Review of Earth and Planetary Sciences.

"Our most important environmental problem, certainly the most urgent, is the burning of fossil fuels, which has significantly increased the carbon dioxide in the atmosphere. . . . If we increase the CO_2 in the atmosphere at the rate it's been going, atmospheric warming has been predicted to be as much as a degree and a half or so over the next ten to fifteen years. This will have major consequences for the climate, and could start to melt the icecaps. . . .

"If we start to produce rain where there has been no rain, and take away the rain where there has been rain, man cannot respond with his agriculture fast enough to adjust.

"President Carter's stress on the use of coal resources, and the rate at which we are burning fossil fuels in this country and in the Western world, are very serious problems. I think we should put more stress on nuclear, solar, and geothermal power."

Derek Spencer,
Research Director
Woods Hole Oceanographic Institution

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From 'The long term effects of CO_2 on the climate: general prospects and the role of synthetic fuels', presented by Henry D.I. Abarbanel at a conference in Chicago sponsored by The Energy Bureau Inc., Dec. 3-4, 1979:

"The atmospheric CO_2 amount due to human activity has been increasing at 4.3 percent/year for the past 20 years. This translates into four billion metric tons of CO_2 entering the atmosphere in 1978. At 4.3 percent increase each year the amount of CO_2 put into the atmosphere by people doubles every 16½ years. If we continue to increase our carbon based fuel consumption at this rate, then by 2030 we will have doubled the CO_2 concentration in the atmosphere compared to its 1978 value. . . .

"No one disputes that the CO_2 greenhouse effect will eventually occur. . . . A variety of climate models agree on the following consequences of doubling the atmospheric CO_2:

"A. There will be an average global temperature increase of 3-4 degrees C (5.5 to 7.2 degrees F).

"B. The increase in temperature in the . . . polar regions will be much larger; probably as much as 5.5 degrees C (9.9 degrees F) or more near the poles.

"C. There will be severe effects on the distribution of precipitation, the growing season and probably the cloudiness in the temperate zone.

"D. The stability of the great ice sheets of Greenland and the Antarctic will be reduced. On a time scale of perhaps several hundred years the West Antarctic Ice Sheet will disintegrate raising average sea level by five to six meters (16-19 feet). On a much longer time scale (probably thousands of years) all the ice sheets will disappear: this will raise sea level by as much as 100 meters (325 feet).

"There are good arguments to believe that the temperature rise will be greater in the summer than the winter. Calculations based on the principle of energy conservation indicate that the summer temperature rise in August in, say, Washington, D.C. will be as large as 8 degrees C (14½ degrees F). In February, the rise will only be 2 degrees C (3½ degrees F).

"Temperature changes of this magnitude should be compared with the temperature record of the past 100 years which show changes from averages taken over ten year intervals of only plus or minus ½ degree F. So the changes in global temperature we are talking about are about ten times the mean changes seen in the last century. In polar regions the expected changes are 15 times the natural variation over the last century.

"When should we expect these changes to occur? When the CO_2 concentration increases by 20 percent, the global temperature change should be about 0.8 degrees C (1.4 degrees F). At the present rate of consumption of C based fuels this would occur in the year 2000. When the CO_2 concentration rises by 50 percent (in 2016 at the present rates of C fuel consumption), the global temperature increase should have reached 2 degrees C (3½ degrees F). When the CO_2 concentration rises by 80 percent (in 2025), the temperature increase will be 3 degrees C (5½ degrees F).

"People who have studied this problem more or less agree about the magnitude of temperature increases for given increases in atmospheric CO_2. There is no general agreement on the very important questions of local precipitation changes, wind changes, and soil moisture changes. Everyone does agree that over the time scale of CO_2 doubling, measurable changes in these factors will occur—especially in the temperate zones. . .

"A turn to synthetic fuels will result in putting carbon into the atmosphere at a rate about twice that of our present input. Turning to a methane or natural gas based economy would reduce by 1/3 the amount of C we put into the atmosphere. . . .

"These (changes in precipitation, soil moisture, winds and the like which would result from double CO_2) coupled with the projected temperature rise will surely affect the growing season in the temperate zones. The Great Plains of the U.S. and the vast wheat growing regions of the Ukraine will be affected. Perhaps the only result will be to move the major growing zones north to Canada, Siberia, and Northern China. Even the most benign scenario I have imagined or have heard is full of major human and economic dislocations."

(Dr. Abarbanel participated in the 1978 JASON report and in the follow-up study of 1979. The 1979 study is expected to be released by SRI-International through the Department of Energy in January of 1980.)

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From 'CO_2 and the Biosphere', R.S. Loomis, an invited paper in 'Workshop on the Global Effects of Carbon Dioxide from Fossil Fuels', U.S. Department of Energy, published May 1979:

"Woodwell and Houghton (1977) presented an argument that the biosphereis currently a net source of as much as 5 to 10 X 10^{15} metric tons of carbon as CO_2. Their case rests on man's disturbance of the tropical forests and wet soils. Soil disturbance is taken as a corollary of forest-cutting.

"Much of the evidence of cutting is drawn from Hamilton's (1976) study of the Western Llanos region of Venezuela, where cutting was estimated at about 1.3% per year. That rate is derived from Viellon's appendix to Hamilton's report, which gives 21% as the forested area of that region in 1825, 45% in 1950, and 30% in 1975. This is a populated region, and the mixed vegetation (tall grass-galleria forest) apparently has long been subject to cutting and regrowth. The report notes that if proposed cutting is carried out, a similar rate might apply in the future to much of South America. Woodwell and Houghton apparently use that statement as a basis to suggest that the worldwide cutting rate *is* 1 to 2%. That such has not yet happened in Venezuela is revealed by examining Hamilton's report in more detail: 85% of Venezuela's forests lie in other provinces south of the Orinoco River, and Hamilton observes that no one knows how fast those forests are being altered because of lack of commercial and scientific contacts. Those provinces are essentially unpopulated, and logging and shifting agriculture are far less intense.

"Woodwell and Houghton's 1 to 2% rate also does not apply to the Amazon basin. Zinke (personal communication) finds from radar maps that less than 0.5% of that basin has been disturbed during the past ten years. Brazilian agricultural development is centered mostly on the cerrado vegetation south of the basin. Muthoo (1977) provides data for all Brazilian forest lands, 1958 and 1973, from which Wadsworth . . . estimates that (0.3% of the biomass) has been cut in that 15-year period. . . . Correction for regrowth of forest or pasture and for remaining stumps (a large fraction) would reduce that rate."

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From 'Status Report Carbon Dioxide Effects Research and Assessment Program', U.S. Department of Energy, July 1979:

"A conference of Experts on Climate and Mankind was held in Geneva during February 1979. . . . The focus of the (World Meterological Organization) sponsored meeting was interaction of climate and society. . . . Approximately 400 individuals from 50 countries attended.

"The CO_2 question was used as a common example of a potential human-induced effect on climate. There was much interest and discussion concerning this issue, ranging from serious concern to sentiments that concern now is premature. . . . The major concerns about the CO_2 issue were expressed by scientists from energy-intensive countries. . . .

"While few countries outside of the USA have an organized research and assessment program, specifically related to the CO_2 issue, concerns were expressed by many. Several international efforts on this issue are being planned. They include efforts within the United Nations Environmental Program, the World Meterological Program, and the International Council of Scientific Unions."

Energy alternatives to meet projected demands

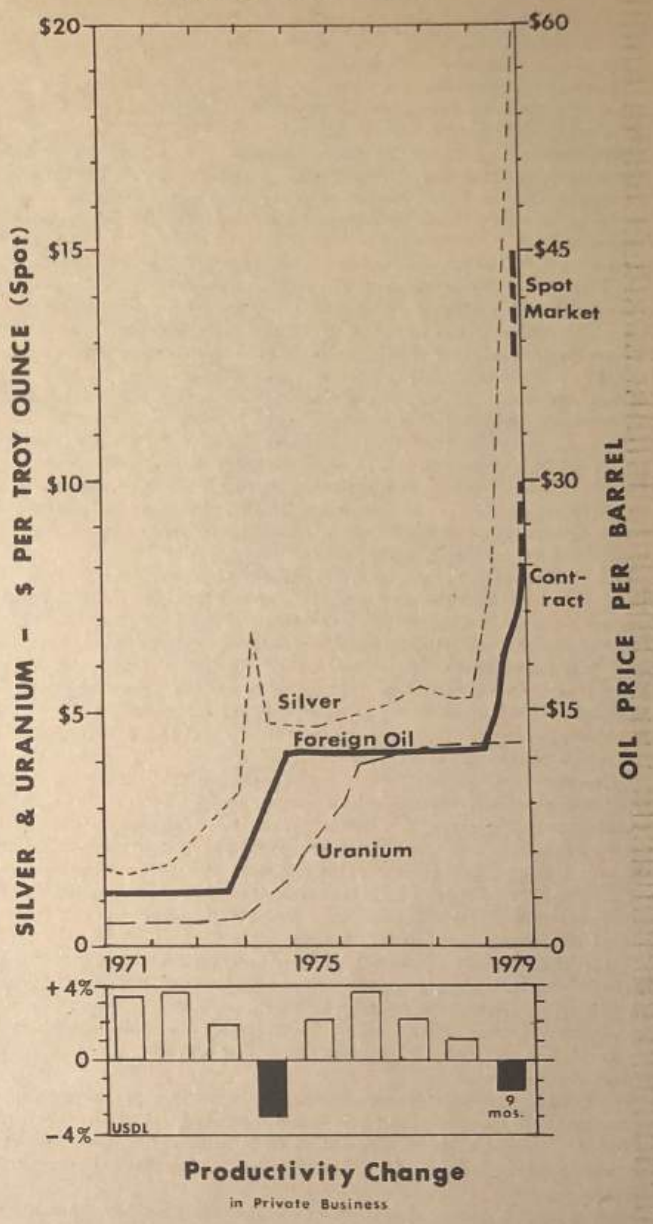
If an enlightened public chooses to halt the CO_2 buildup, reality must be faced squarely in choosing an energy strategy to accomplish this. Demand, supply capability, resource availability, and price are all bounded by certain constraints:

- The primary purpose of manufactured energy is to supplant physical labor. Any source that is labor-intensive falls short of this objective. The basic measure of energy efficiency (or magnification of human labor) is price. Shifting the high price of harnessing diffuse energy (wind, solar, ocean thermal and biomass) to tax monies does not hide the cost in terms of human labor.
- Like food, the demand for utilitarian energy (which provides food, refrigeration, cooking, clothing, shelter, bodily comfort, illumination, basic transportation, water supplies, sewage treatment, and medical care) is relatively inelastic to changes in price. Large price increases would decrease demand significantly only where there is an inability to pay. Incentives for people to use more utilitarian energy are to make more leisure time available, to experience less physical fatigue, and to experience increased comfort and well-being. Demand is restricted by satiation, increased efficiency, decreased obsolescence and declining birthrates.
- The demand for pleasure-giving energy (traveling for leisure pursuits, non-pooled commuiting, and driving large vehicles and motorized living quarters) is limited only by affordability. The price of gasoline in the U.S. would probably have to exceed $3 per gallon to severely restrict the use of personal vehicles for pleasure.
- All energy supply systems consume mineral resources, even the 'renewable' energy sources.
- The supply of conventional forms of energy is generally responsive to price (with a lag of several years) barring political constraints and barring the control of prices by a few nations which dominate the supply.

Worldwide, the exponentially rising demand for oil will probably not be constrained for several decades by the depletion of supplies, and may be affected only little by price rises as recently witnessed. Domestic supplies of oil are being depleted apparently because the average replacement cost of new deposits in the ground has exceeded revenues from production. Therefore, OPEC has been able to peg the price of their oil to precious metals.

When overall productivity has declined in the U.S. and the spendable money supply has continued to grow, high rates of inflation have resulted. As shown by the accompanying graph, the price of silver (compared to the dollar) has responded convulsively to high inflation, and the price of OPEC oil has responded similarly a short time later. Between surges of inflation, foreign oil has generally declined in terms of constant dollars, yet the world's total oil reserves have actually continued to **increase** during periods when the real price declined.

OPEC oil has not been immune to economic substitution, however. Shortly after the Arab oil embargo of 1973, utilities turned heavily to nuclear as a long-term economy measure. The increase in demand for uranium caused by a rush to cover unfilled requirements resulted in a convulsive jump in the



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uranium price similar to the jumps in silver and OPEC oil. A second cycle may be in the making for similar economic reasons.

Practical energy strategies to halt the CO_2 buildup must look beyond these short-term fluctuations in price and demand, which essentially are caused by wild fluctuations in the buying power of the U.S. dollar.

An activist movement in the U.S. has made a strong effort to replace the nuclear energy option with diffuse ('soft') energy sources. Few of these advocates realize the magnitude of the physical resources and human labor needed to sustain the soft energy systems, which are mistakenly termed 'renewable'.

Five bushels of corn (maize) are needed to yield 12 gallons of ethanol, which has the energy equivalent of 8 gallons of gasoline. If all the gasoline energy consumed in the U.S. each year were to be replaced with energy from corn—which is one of the most efficient sunlight converting plants of the temperate zone— **400 times** the annual U.S. corn crop would be needed to provide this much ethanol. Such a supply is an absurdity, but it brings biomass into focus. Even a limited amount of biomass substitution of fossil fuels would require the continual replacement of essential plant nutrients—phosphate and potassium—of which the world has limited reserves. ("The depletion of U.S. reserves of phosphate rock, particularly from Florida and Tennessee, is projected to occur before or shortly after the end of this century." - W.F. Stowasser, U.S. Bureau of Mines Bulletin 667, 1976.) The use of these mineral fertilizers to provide automotive fuel precludes their use for growing food.

Herbert Inhaber has been attacked repeatedly in print for attempting to analyze the comparative industrial risks of soft and conventional energy sources. Inhaber has rated soft sources as relatively high overall in industrial accidents because soft systems would require very large amounts of steel and other metals per unit of energy output. Inhaber's detractors criticize severely his estimates of comparative risks in their attempts to defend soft systems. However, these detractors overlook completely the magnitude of the resources consumed and labor spent on soft energy production, which provide narrow constraints.

To supplant just the natural gas used to heat buildings in the U.S. for 30 years with solar-thermal energy is shown to use as much steel as could be produced from the entire U.S. iron ore reserves. Wind energy is shown to use 3 times as much steel per unit of energy output as solar thermal. To supplant the electrical energy used in the U.S. with solar-photovoltaic is shown to require about 5% of the entire U.S. work force just to supply the materials on a sustained basis (and possibly a comparable number of workers to construct and maintain them).

Large inaccuracies could be admitted in these figures without altering an obvious conclusion: Until the resource and labor demands are reduced greatly, such systems could not possibly supplant fossil fuels for the 4½ billion people in the world today. Until such soft systems become competitive in price and resource consumption, such systems at best will be limited to supplementary supplies.

The remaining energy sources which could feasibly supplant fossil fuels on a major scale over the next few decades are nuclear and hydroelectric. (Geothermal from natural waters and natural steam also releases CO_2 from the lithosphere). Hydroelectric is restricted by the limited number of available sites and by the vulnerability to droughts.

By elimination, nuclear fission energy is the lone candidate to carry the burden of halting the CO_2 buildup relatively soon. This conclusion has been apparent to many workers on the CO_2 problem for some time, but so far the nuclear controversy has not taken the CO_2 factor into account. The American Nuclear Society has published only brief mentions of the CO_2 problem, and the Nuclear Legislative Advisory Service has declined to introduce this issue after giving it serious consideration. Many energy companies now realize a much better financial return on their non-nuclear investments, and some have taken baths in red ink trying to promote nuclear.

Thus the CO_2 problem has no outspoken champions and no legislative lobby. Nor does the CO_2 issue serve conveniently as a rallying cause for activism.

Fortunately, though, the CO_2 problem has not become an adversary issue. This issue is being treated rationally in the scientific community, in the news media, and in politics. Apathy has been the real problem.

The key to making nuclear energy attractive to the public and highly competitive with all fossil fuels may be to treat environmental problems generically rather than specifically. If prevention of cancer is the objective, then **all** exposures to cancer-causing substances should bear the same cost-to-risk burden. Presently regulatory agencies are not charged with preventing cancer per se but are charged with regulating some potential cancer hazard. An example of the generic approach would be to provide people who crave nicotine with nicotine tablets so that they would no longer be exposed to hydrogen carcinogens in tobacco smoke. The cost to reduce cancer statistics noticeably in this manner may be very small in contrast to the very high costs of attempting to reduce potential carcinogens from nuclear energy where the incidence is already so low that it is difficult to detect statistically.

Generically treated, the radium-226 from coal smoke and ash (and as a natural constituent of virtually all drinking waters and many foods) would be controlled as strictly as the much-feared plutonium-239. In animal experiments, radium-226 was shown to be about 2½ times as potent a carcinogen in soft tissues as plutonium-239, but slightly less than half as potent in a bone dose. Generically treated, the chance of a reactor core melting clear through the earth would rank with the chance of concentrated fuel oil, burning at 6 barrels per hour, melting through the earth.

A generic conservation ethic could also help reduce demand and aid substitution for petroleum. Advertising by utilities to promote small scale utilitarian uses has been censured vigorously in the past, while the widespread advertising of vehicles for sport and leisure enjoyment has received no censure whatsoever.

At present only battery-powered cars could utilize non-fossil energy economically in competition with petroleum. Little research is being devoted to naturally recycled chemical fuels for autos, trucks, and airplanes using a non-fossil electric source. While battery power can now barely compete in personalized forms of local transportation, it presently offers no real match to petroleum for speed, weight, and distance.

The drain of U.S. capital for foreign oil purchases is partly responsible for the shortage of industrial capital and for high interest rates, which have severely hindered nuclear construction. If U.S. gasoline consumption were reduced by one-half through higher prices and taxes, levied at the gasoline pumps—rather than on domestic oil production to subsidize oil imports—this would save enough money in this country in 3 years to build as many nuclear plants as are now operating in the U.S.

These are some possible revolutionary changes in energy policy which may result when the CO_2 problem becomes a public issue.

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