

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.

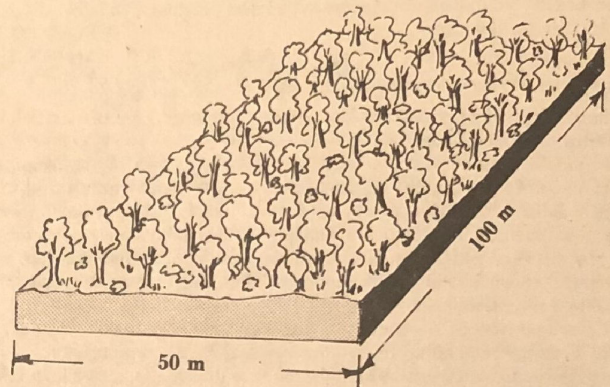
CO₂ Newsletter

Volume 2 Number 4 April - May, 1981

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

Atmospheric CO₂ Equivalents:

CO₂ from one U.S. auto = CO₂ stored in 0.5 hectare new wood growth



Reforestation to remove man-made CO₂ from the atmosphere has been suggested from time to time. The CO₂ which accumulates in the atmosphere each year—after about 50% has been taken up by the oceans—from the average automobile in the U.S. is approximately equal to the carbon removed from the atmosphere by new wood growth on 0.5 hectare of land each year.

The forest used for this example is a mesic hardwood forest ecosystem dominated by the tulip poplar, as studied at the Oak Ridge National Laboratory, Tennessee. The belowground crop in this particular forest is small because the rooting depth does not exceed 60 cm in the study area. The wood considered here consists of the trunks (boles) and branches.

These wood growth figures are derived from 'Carbon Flow and Storage in a Forest Ecosystem' by D.E. Reichle, B.E. Dinger, N.T. Edwards, W.F. Harris and P. Sollins, contained in 'Carbon and the Biosphere—Proceedings of the 24th Brookhaven Symposium on Biology at Upton, NY on May 16-18, 1972', published by the U.S. Atomic Energy Commission August 1973.

An average gasoline consumption of 2200 liters per car per year was used in this comparison, which gives off 4.5 tonnes of CO₂ per year on combustion. Because the energy content of carbon-based fuels is largely a function of the percentage of carbon in the fuel molecules, the amount of CO₂ produced per kilometer of travel in a given vehicle is similar for operation on propane, gasoline and diesel.

10 pellets of enriched uranium = 10 tonnes of CO₂ spared from the atmosphere from coal combustion



Energy produced by nuclear fission from 10 typical pellets of slightly enriched uranium is equivalent to the coal energy (30,000 kilowatt-hours thermal) that gives off 20 tonnes of CO₂ to the atmosphere, half of which is normally taken up by the oceans. The residence time of a man-caused CO₂ buildup may be measured in centuries.

(Photo by Linea SPN, from Agip Nucleare brochure)

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For all European subscriptions and for issues of back copies, contact Rudolf Trüb, CUMULUS FACHBUCHHANDLUNG, 5000 Aarau, Switzerland,

Telephones 064 22 50 20 or 22 37 98.

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"... unless we can progress in this direction, we remain in the Cave, the home of illusion and error, with accordingly, no notion of the good life for ourselves and others, and thence no hope for bringing order into a distracted world."

— Plato

In place of the usual editorial and final article discussing social, political and economic aspects of the CO₂ problem, we are publishing some recent correspondence.

Feedback

"Dear Bill:

"... One thing which I have not gleaned from the various issues of the Newsletter that you have sent me is what is your stand on carbon dioxide? What is your thesis? What are you advocating? I might be able to supply some material for you if I know what you are driving at. In other words, I must be missing some issues because I'm sure you spelled this out somewhere..."

— Art

(A.A. Meyerhoff, March 24, 1981)

Dear Art

Thanks for your perceptive letter, which prompts me to clarify a still-evolving thesis on CO₂:

- Scientific opinion seems to agree that a continued CO₂ buildup poses a serious threat to coastal habitations through polar ice melt and to the world's food productivity, at least temporarily if not permanently. However, opinion seems to be sharply divided between complacency and alarmism over timing. Our studied view is alarmist, and we advocate corrective actions which do not in themselves create worse social and economic problems.

- Complacency is favored by the numerically small estimates of global average warming from increased CO₂. Alarmism results from noting geologic analogs which show very large changes in global climate corresponding to global average temperature changes of very small numerical magnitude.

- Complacency toward polar ice melt has resulted from noting that protective ice shelves border the least stable icecap (West Antarctic); from emphasizing the oceans' thermal inertia; and by expecting CO₂ warming to increase the snowfall on icecaps. Hughes and Denton recently noted a major unprotected West Antarctic ice escape route along the Amundsen Sea. The Southern Hemisphere has most of the oceans' thermal inertia, so temperatures there have climbed generally in lock step with the CO₂ increase with little climate 'noise'. In the Northern Hemisphere natural oscillatory cooling overrode CO₂ warming from about 1940 until recently, but now strongly additive warming from such oscillatory noise is anticipated. Reinforced Northern Hemisphere warming and small ocean thermal inertia might destabilize the Greenland icecap first through increased warm rainfall rather than increased snowfall. Complacency, then, is not a valid substitute for assurance, and our view is that we should allow for the worst possible case.

- Complacency is favored by using only warm climate analogs from recent interglacial ages which were only slightly warmer than now. During the relatively recent Eocene epoch, when no icecaps existed, warmth-loving animals lived on Ellesmere Island above the Arctic Circle.

- Also fostering a lack of urgency is the lack of any comprehensive study of all warm paleoclimates from compilations such as yours, to gain a qualitative idea of what to expect from unrestrained CO₂ production. If greater warming has resulted in ever-widening desert belts, this differs from the model results which infer that continued warming may cause an overall increase in precipitation.

- Still another factor in complacency is an absence of reports about the effect of the 1930s warmth on the food productivity of Russia and China, which countries are presently large food importers. China's current drought parallels the U.S. drought.

- The complacent outlook favors a decade more study before countermeasures are considered justified. The alarmist outlook favors instituting countermeasures immediately to attain as low a ceiling concentration of CO₂ as is reasonably achievable.

- All variables considered, the U.S. snow droughts of 1980-1981 and the summer heatwave-drought of 1980 might actually be ushering in a new dustbowl era that could last for many centuries. The meager ice core data available suggest that the 1930s' abnormal warmth exceeded all other warm ages for the last several thousand years, and thus appears to have been the CO₂ signal showing through. The recently begun warming trend might soon exceed the same background noise level. A decade of dustbowl-causing warmth might be needed to make alarmists of today's skeptics.

- Conscientious CO₂ scientists have ethically restrained sensationalism for more than a decade. Possibly too much restraint was used. Meanwhile the public has become saturated with dire environmental warnings (often trivial by comparison) from other directions. Now that the CO₂ problem is becoming disturbingly clear, the popular press finds the complacent view less discomfiting—and more acceptable for publication—than alarming views. Enlightenment of the public about all views on CO₂ is necessary to develop an effective response.

- Two basically different strategies are being advanced to halt CO₂ outpourings from fossil fuels, one sociopolitical and the other industrial. The sociopolitical strategy seeks to change people's attitudes, desires and demands for energy consumption to allow for much lower energy usage. Such advocates often seek to replace all conventional energy systems except hydroelectric (which is highly vulnerable to drought) with solar, wind and biomass energy.

During the pursuit of the soft energy strategy over the last few years, the U.S. has somehow acquired a de facto pro-CO₂ policy which has created economic disincentives for nuclear and new economic incentives for fossil synfuels, that produce the greatest amount of CO₂ per unit of energy output.

- The industrial strategy involves converting the world's basic energy source from fossil to nuclear. Merely removing economic disincentives may allow nuclear to supplant fossil fuels rapidly in fixed-station generation. Subsidies may be needed for nuclear synfuels, battery-operated vehicles and non-fossil-based mass transit to penetrate the market rapidly. High fuel taxes may be needed to halt profligate non-utilitarian use of fossil fuel, such as in vehicles that carry whole living rooms (campers, vans) or vehicles used solely for pleasure (motor boats, off-road vehicles). The purpose of averting CO₂ impacts is to minimize social and economic disruption, so we advocate a transition to non-fossil energy with as little economic and social disruption as practical.

- The capital requirements of various industrial-substitution scenarios have yet to be addressed squarely in scientific or public fora. Our view is that the speed at which the industry could halt the CO₂ buildup is likely to be controlled by the rate of capital formation in the private sector, which rate is presently very low in the U.S.

- Since the mid-1960s the U.S. energy industries had been converting to nuclear at a fast clip until they ran into massive opposition from anti-nuclear activists who comprise a minority of the public. Unfortunately, nuclear was chosen as a symbolic environmental archvillain. Industry's choice of nuclear was not so much for altruistic reasons or for consciously halting the CO₂ buildup, but for practical and economic reasons. Nuclear companies are now trying to mitigate heavy financial losses and reduce their exposure to possible future losses, and they express virtually no hope that the country will regain its lost nuclear momentum. We advocate that governmental regulations be changed to reflect the need for nuclear profitability, that tax laws be changed to increase capital formation, and that every company which so desires be allowed to enter the nuclear industry.

- Your geologic background and international consulting experience may help fill some gaps concerning past warm climates, such as the general expectation of what to expect globally from continued warming, the Eocene paleoclimate, and Russia's and China's climate of the 1930s.

— Bill

(Art Meyerhoff has since conveyed to us the information that the Antarctic continent also had warmth-loving animals in the Eocene and that Russia experienced dustbowl conditions in the 1930s.)

More feedback on Page 7.

Fourier on the Greenhouse Effect

The greenhouse effect of the earth's atmosphere was recognized early in the 19th century by the French physicist and mathematician, Jean Baptiste Joseph Fourier although CO₂ was not identified as the source of this heat-retaining effect until mid century. Fourier did not refer directly to a hothouse for raising plants, but to a demonstration by de Saussure using multiple glass plates that trapped air and also blocked transmission of infrared. (Glass is opaque to infrared in the range of wavelengths at earth's temperatures.)

In 1896 Svante Arrhenius referred to Fourier's early memoir and used the term 'hot house' in reference to the heat retaining capacity of CO₂ in the atmosphere. Where the term was changed to 'greenhouse effect' has not yet been determined.

Following are excerpts from Fourier's 1824 **Memoirs on the Temperatures of the Terrestrial Globe and Planetary Spaces**. T.M.L. Wigley, Director of the Climatic Research Unit, University of East Anglia, kindly provided the reference. Eliane Hayn graciously translated the memoir to English.

"... The heat from the sun, arriving as light, has the property of penetrating transparent solids or liquids, and it is almost entirely lost by converting itself, by its communication with the body of the earth, into obscure radiant heat...

"The presence of clouds intercepting those rays temper the cold of nights..."

"... there exists a physical cause, always present, moderating the surface of the terrestrial globe, and giving to this planet a fundamentally independent heat from the action of the sun, and from the heat that

the interior mass had kept. . .

"It is difficult to know to what extent the atmosphere influences the average temperature of the globe, and we cease to be guided in this examination by a mathematically regular theory. We owe to the famous traveler M. de Saussure an experiment which seems appropriate to clarify this question. It consists of exposing a covered dish, covered by one or several layers of transparent glass, to the rays of the sun, the layers placed at some distance one above the other. The interior of the dish is lined with a thick covering of blackened cork, ready to receive and keep the heat. The warmed air is everywhere, either in the interior of the box or in each interval between two plates. Some thermometers placed in this dish and in the superior intervals indicate the degree of heat in each of these spaces. That instrument has been exposed to the sun about noon, and we have noticed, in diverse experiences, the dish's thermometer raising to 70, 80, 110 degrees and above (eightieth divisions). The thermometers placed in the layers got degrees of heat less intense, and which were decreasing from the bottom of the box to the highest interval.

"The effects of the solar heat on the air obtained by the transparent chambers had been observed long ago. The apparatus just described has the purpose to bring the acquired heat to its maximum, and especially to compare the solar effect on a very elevated mountain to one from an inferior plane. This observation is principally remarkable by the correct and extensive consequence that the inventor obtained: it was repeated many times in Paris and in Edinburgh, and has given similar results."

Excerpts from recent reports

From 'Greenhouse Effect - Act now, not later', by Wendy Barnaby. NATURE 19 February 1981:

"Stockholm

"The theme that the time has come for policy-makers to take account of carbon dioxide when drawing up energy policies ran through an Earthscan meeting on carbon dioxide, climate and energy last week. But speakers' conviction that action should be taken now was matched by their caution in predicting exactly what would happen if carbon dioxide emissions continue to increase.

"... The reality of the greenhouse effect was also common ground between the speakers. Predictions about specific climatic changes in specific parts of the globe were, however, more equivocal.

"Current models, according to Bert Bolin of the University of Stockholm, are inadequate but 'they are all we have'...Dr. Tom Wigley of the University of East Anglia pointed out the difficulties of distinguishing the signal from the noise: knowing when variations in regional climates stem from a particular factor such as carbon dioxide and when they are simply a part of continual natural variation.

"Professor S.K. Sinha from the Indian Agricultural Research Institute in New Delhi was the only speaker daring to be at all optimistic, and even his belief that agriculture could adapt to climate changes was conditional on fruitful research being done on water management, the identification of new genotypes more tolerant of temperatures 3-4° greater than at present and on higher crop yields with a smaller input of fossil fuels.

"The most eloquent plea for energy policies to take account of carbon dioxide came from Gus Speth, chairman of President Carter's Council on Environmental Quality. In the last days of the Carter presidency, the council urged that 'full consideration' should be given to carbon dioxide in the development of United States and global energy policy.

"One of the first priorities in a preventative strategy would be to decide 'what level of atmospheric carbon dioxide should be considered a prudent upper bound'...

"Dr. Thomas B Johansson of the University of Lund could offer little encouragement in that the sorts of energy policies desirable from a carbon dioxide point of view were also becoming increasingly necessary, in Sweden at least, for economic reasons."

From 'Weather forecast: The lull Before the Storm', by Robert Jastrow (director of NASA's Goddard Institute for Space Studies), FAMILY WEEKLY, March 15, 1981:

"Last summer, scorching heat blistered the South. Now, drought parches the East and Midwest. A noted scientist contends this is but a taste of what lies ahead.

"The world has seen many changes in climate, and each one has worked a profound effect on the history of life and the history of man. The fate of America depends on questions that have to do with climate: Is the earth growing colder - or warmer? What will conditions be like for American farmers in 20 years? How much water will be available for the expanding population of the Sun Belt in the 21st century?

"Some recent progress by climate experts suggests the answers: Drought is the specter that hovers over America; the hot, dry summer of 1980 is a foretaste of our future..."

"...a new factor has entered the picture. Man has been burning coal, oil and gas at prodigious rates for the last 30 years or so, releasing vast amounts of carbon dioxide into the atmosphere...If the present trends in the burning of coal, oil and gas continue for another 50 to 100 years, the carbon dioxide effect will be sufficient to drive the temperature of the earth up to the very warm levels of 4000 B.C. (global temperatures of three to four degrees F. warmer).

"All this has been known to climate experts for some time. Until recently, however, measurements of the earth's temperature failed to reveal the predicted warming effect, which left the experts somewhat puzzled...The newest studies of the world's temperatures, brought up to date as of January 1980 by James Hansen of the National Aeronautics and Space Administration, finally show a temperature increase of exactly the amount predicted due to the burning of coal, oil and gas. The warming effect is real.

"The main reason why the warming failed to appear in the earlier temperature records is that it was masked by a temporary cooling of the earth, resulting from the ejection of mammoth amounts of sulphur and dust into the stratosphere during the explosion of two Indonesian volcanoes in the 1960's..."

"Now that the existence of the warming effect has finally been confirmed, we can predict its course during the next 100 years with some confidence. Allowing for the normal ups and downs of climate from year to year, conditions in the U.S. from now to the end of the century will be a little on the warmer side. And if coal and oil burning continue, the 21st century will be very warm: in this country, perhaps 10 degrees F. warmer year-around.

"What will that mean in practical terms, especially for farmers? Dr. William W. Kellogg of the National Center for Atmospheric Research has reconstructed the climate of the fourth millennium B.C. by studying geological evidence and has arrived at an interesting answer.

"For farmers in the Soviet Union, Dr. Kellogg's news is very good. At various times in the past decade or so, Soviet wheat production has been badly hit by drought as well as by short growing seasons due to cold weather. A return to the conditions of 4000 B.C. would produce wetter and warmer weather in a vast belt of Soviet territory stretching from the Ukrainian breadbasket to the wheat-producing New Lands

east of the Ural Mountains.

"For American farmers, the news is bad. They can expect hot, dry weather in the central and western states. The states of the farm belt will see year after year of sustained drought, with dust bowl conditions that could persist for more than a century. As for the Sun Belt, the outlook there is also discouraging because decreased rain and snowfall in the western mountains will mean less runoff feeding into western rivers.

"...According to the calculations of the climate experts, the temperature in the Antarctic will rise about eight to ten degrees F., which is enough to melt the West Antarctic ice sheet. The ice could melt in as short a time as a few decades, and the runoff from the melted ice could raise the level of the world's oceans by about 15 feet, flooding 25 percent of Louisiana and Florida and 10 percent of New Jersey.

"...Only one-third of the man-made carbon dioxide in the atmosphere comes from America, but if we could control even that part, we would be able to postpone the heat catastrophe for a few decades - probably sufficient to find another technological fix. Whatever we do, it should be done fairly soon because these climate changes, once set in motion, are irreversible.

"American options are limited...Solar and hydroelectric power...could not supply more than a fraction of America's energy needs. Fusion power...is very promising for the long run if scientists can ever get it to work...until they do, an energy policy based on fusion power will be too risky to chance.

"That leaves nuclear power, which releases no carbon dioxide and could supply a large part of the energy needs of the United States without heating up the atmosphere. Nuclear power is unpopular today, but it could turn out to be America's best option. It may seem foolish to contemplate a trade-off between this difficult technology and the threat of a temperature rise that will not become important until the 21st century, but our grandchildren may think differently about the matter, as the water rises above their ankles."

From 'The New Zealand Temperature Series', by M.J. Salinger, CLIMATE MONITOR (published by the Climatic Research Unit, University of East Anglia, Norwich UK), Sept.-Nov. 1980:

"...Conclusions

"Analysis of temperature records show that warming and cooling anomalies are synchronous throughout the entire New Zealand area. This makes it possible (and sensible) to calculate a New Zealand temperature series which depicts regional variations. This composite temperature curve has been calculated after careful selection and adjustment of climatological station records. The temperature trends suggest considerable climatic amelioration since the 1850's, punctuated by two cold periods in the early 1860s and in the years around 1910. The last 25 years have been particularly warm. All seasons show similar overall trends, however the transitions seasons of spring and autumn show the best agreement with the annual trend. The warming is strongest in summer and weakest in winter. All air masses that affect New Zealand are oceanic either in origin or passage to the country... The mean air flow trajectory... is from the west-southwest in all seasons, so the warming may reflect warming in the seas around New Zealand."

From 'Climate and CO₂', by David M. Burns (director of AAAS Climate Project), Op-Ed page of THE NEW YORK TIMES, April 17, 1981:

"... We fear that if the theoreticians of climate are correct, sometime in the next 100 years there will be a virtually irreversible shift in the Earth's climatic pattern; it would be on a scale unprecedented in human history. Such a 'greenhouse effect' could lead to great disruption; there might be benefits, but also costs, such as widespread hunger.

"... Climatologists say that it may be several decades before we can detect, through the statistical 'noise' of normal fluctuations, carbon dioxide-induced climate changes. Such changes are likely to be incremental and barely perceptible from year to year. Energy experts remind us that historically it has required 50 years to switch from one energy source to another... Given scientific uncertainties, long lags required for proof or prevention, and public-policy overload, carbon dioxide-induced climate change may be an issue that politicians choose to ignore.

"If the (climate) change brought a permanent drought, for example, to regions near the productive limit of their agricultural productivity, famine or migration could result.

"There is no global policy of mutually assured survival..."

"Even if there were no critical gaps in the data, implementing a global carbon-dioxide policy would still be difficult. The current uncertainties are not likely to be quickly resolved, but uncertainty does not

relieve us of the burden of decision. Are there reasonable and prudent actions that buy time or protection? I think there are.

"The issue cannot be safely ignored in setting energy and natural-resource policies, but it probably will be. We do not know enough to say what amount of increase of carbon dioxide is safe, and would be unsuccessful if we tried to enforce any such global limit. By the time we were certain that a carbon dioxide-induced climate change was occurring, it would be too late to prevent it.

"But it is possible to slow the rate of CO₂ buildup. Energy conservation and renewable and nonfossil sources—for example, biomass and solar power—make sense for economic and national security reasons, even if a climate change does not occur..."

"It is possible to improve our understanding of the connections between physical, biological, and social systems, all of which contribute to the carbon cycle and all of which would be affected by climate change. This will require time, commitment by the world's scholarly community, and sustained funding. We need such understanding—even if climate change does not occur."

From 'Carbon dioxide and climate: ice and ocean', by Starley L. Thompson and Stephen H. Schneider, NATURE 5 March 1981:

"... The present rate of growth of atmospheric CO₂ concentration due to fossil fuel burning will result in a doubling of the CO₂ level sometime in the next century and this may produce a global surface temperature increase of between 1.5 and 4°C. Since this temperature change is as large or larger than any natural change in the past few millennia, the increasing interest in the connection between CO₂ and climate is not surprising. Recently new ground has been broken in two relatively unexplored areas—the measurement of natural CO₂ variations on long time scales and the role of the ocean in modulating climatic response to the anthropogenic CO₂ increase.

"... A correlation between levels of CO₂ and palaeoclimatic temperature data would constitute the first clear empirical evidence of CO₂-induced climatic change..."

"Two features stand out in the (analyses of CO₂ trapped in large ice sheets) from Berner *et al.* First their data show a CO₂ concentration of as little as 200 p.p.m. by volume 10-30 (X 10³) years ago compared to the present-day value of around 340 p.p.m. Second, there appears to have been more atmospheric CO₂ in the mid-Holocene (about 5000 years ago) than at present..."

"Should these large CO₂ variations prove to be reasonably accurate, the implications for palaeoclimatic theory would be enormous. One of the most difficult problems in palaeoclimatic modelling has been the determination of the feedback processes which must exist to cause the large-amplitude glacial to interglacial transitions... A feedback including natural CO₂ variations... could explain as much as half the surface temperature amplitude of the ice age/interglacial climate changes. However, it does not appear that the CO₂ variations initiate these large climate changes as the minimum and maximum concentrations do not appear to lead the respective glacial and interglacial extremes of 18,000 and 6-8,000 years ago. Therefore CO₂ changes may act only to amplify changes that are initiated by other means.

"... because of its large heat capacity, the ocean acts as a thermal buffer by delaying the response of the atmospheric temperature—an effect that has been neglected or undervalued in most equilibrium studies.

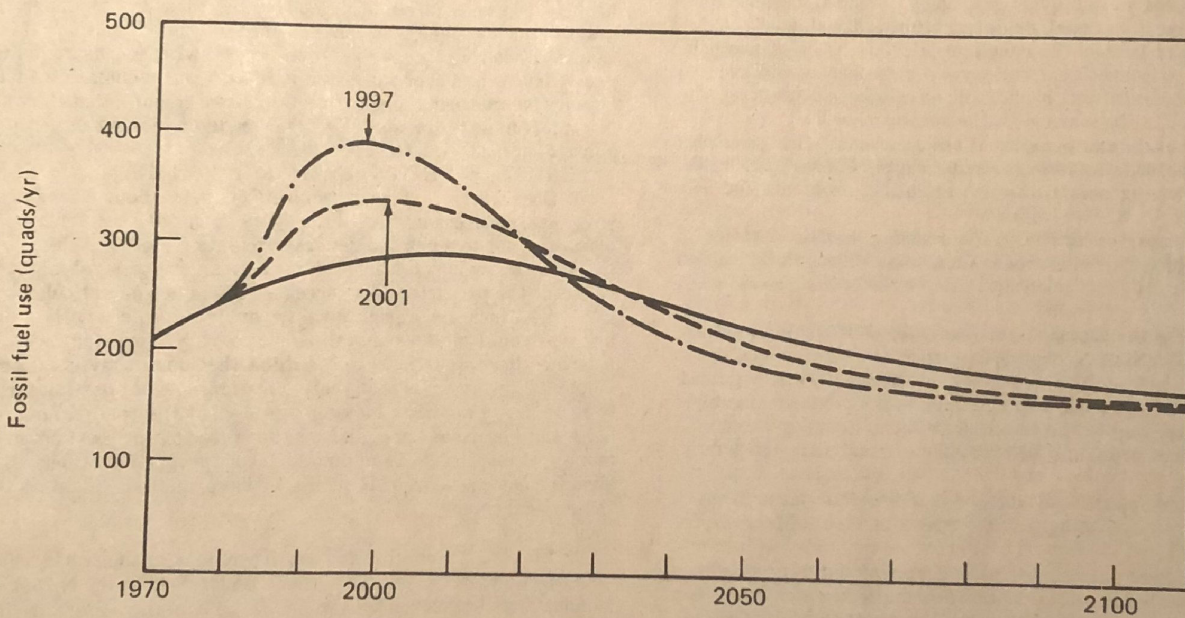
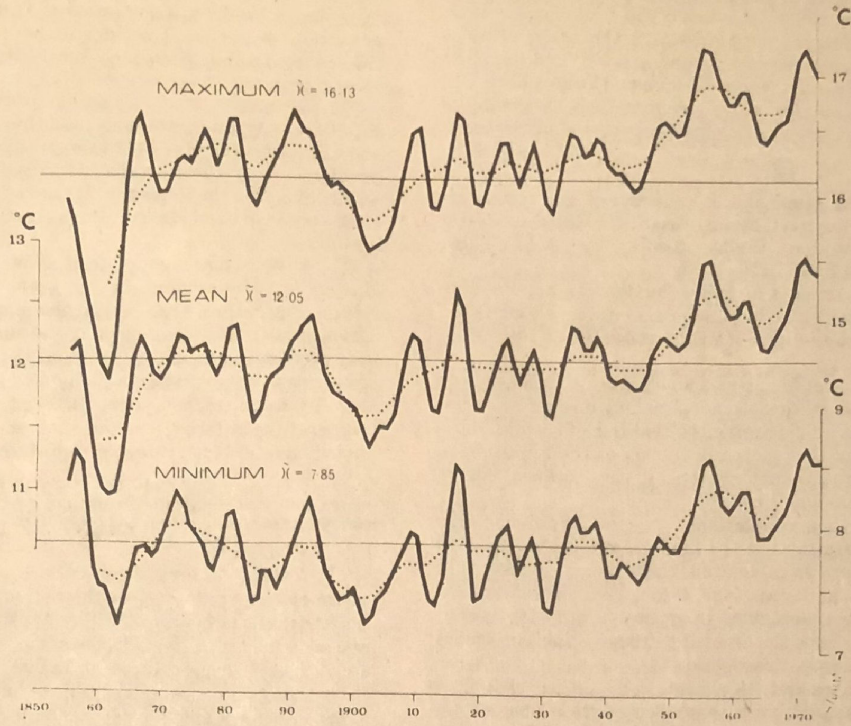
"In order to simulate adequately the climatic response to the actual time-dependent CO₂ increase one must account for oceanic heat capacity, which means that one must determine how the ocean mixes the excess CO₂ heating at its surface... When Hoffert *et al.* simulated the heat capacity of the entire ocean in an ocean model with vertical diffusion and specified upwelling, they found that the response of the global temperature to the CO₂ increase would be delayed by 10 to 20 years by the year 2000. Even longer lags would occur in the next century.

"... We may not be able to extract a detectable CO₂ 'signal' from the climatic 'noise'... until several decades after the date estimated from equilibrium calculation. Thus the absence of unambiguous warming during the remainder of this century would not serve to disprove the validity of our current equilibrium estimates of the effect of CO₂ on global temperature..."

From 'The Effect of Ocean Heat Capacity Upon Global Warming Due to Increasing Atmospheric Carbon Dioxide', by Robert D. Cess and Steven D. Goldenberg, Journal of Geophysical Research, January 20, 1981:

"Time-dependent global warming due to increasing levels of atmospheric carbon dioxide has been estimated by employing an ocean-land global climate model. Ocean heat capacity is incorporated by means of a

New Zealand Temperature 1853 - 1975 from 'The New Zealand Temperature Series' by M.J. Salinger, CLIMATE MONITOR, September - November 1980.



Alternative production curves leading to a 50% increase in atmospheric CO₂ levels. The solid line represents an immediate but gradual response. The middle curve (- -) represents a 2.5% growth in fossil fuel use from 1980 to 1990. The high curve (- · -) represents a 4% growth from 1980 to 1990. From 'Global Energy Futures and the Carbon Dioxide Problem', U.S. Council on Environmental Quality, January 1981.

global ocean model having a 70 m deep mixed layer, with heat being transported from the mixed layer to deeper waters by eddy diffusion. The time-dependent increase in atmospheric CO₂ from 1860 to 2025, is taken from carbon-cycle models. The model results suggest that ocean heat capacity will produce a lag in CO₂-induced global warming of about 2 decades. For example, without inclusion of ocean heat capacity the model predicts that an increase in global surface temperature of 1°C, relative to 1860, will occur by 1988. But when ocean heat capacity is included, the 1°C warming is delayed until 2006-2012, this range of times corresponding to no land-ocean advective coupling (2006) and complete land-ocean coupling (2012). By 2025, when the assumed atmospheric CO₂ content is twice the 1860 value, the model predicts global warming of 1.5-1.8°C, in contrast to 3.1°C when ocean heat capacity is neglected." - Abstract.

From Book Review of 'The atmosphere: endangered and endangering', (W.W. Kellogg and Margaret Mead, Scientific Editors, Castle House Publications, Tunbridge Wells, Kent), by A.F. Tuck, METEOROLOGICAL MAGAZINE, 109, 1980:

"... The vagaries of the process of title selection can be, one supposes squarely blamed on the publishers, who also deserve a brickbat for publishing in 1980 the proceedings of a conference which took place over four years ago ...

"... The Preface (by Margaret Mead) as a whole calls for scientists to connect science effectively to political decision-making on a global scale, without however explicitly acknowledging the realities of a world of nation states. It is not obvious that global problems of the atmosphere cannot be solved within the present system; if they cannot, one is tempted to observe that they won't be.

"Part 1: Summary and recommendations ... even if doubled CO₂ does increase surface temperatures in the models, and the effect does operate in the real atmosphere as calculated, there is no certainty that it will not be lost in the natural fluctuations. If long-range planning on a time-scale of decades is to be undertaken, then the concept of predicted effects being unequivocally above the level of natural variability should see more use than is apparent in this book.

"In Part 2: The atmosphere and its climate, this difficulty is again returned to: one school of thought holds that calculations which predict 'great societal risk' should be acted upon, even if the calculations are incomplete, because there is no way of dismissing the possibility that the calculated effect will prevail. On the other hand, the position as stated by Smagorinsky 'If current physically comprehensive models are inadequate to answer some of our questions, then certainly we should be wary of basing broad national or international decisions on hand-waving arguments or back-of-the-envelope calculations' is characterized as extremely conservative. While your reviewer would replace 'hand-waving arguments or back-of-the-envelope calculations' by 'incomplete models' ... he sides with the second view.

"Part 3: Human costs and benefits of environmental change covers now familiar ground, with human usage and supply of energy and food considered from varying points of view: scientific, economic and ecological ...

"Part 4 summarizes the first day's discussion, and is a series of paragraphs describing the views of a succession of people identified mainly as 'a participant', 'one scientist', 'another scientist', 'a conferee', etc. ...

"Part 5: Managing the atmospheric resource: Will mankind behave rationally? is mainly about neither management nor behaviour, but is rather concerned largely with the way international law and organizations, such as the UN agencies, impinge upon national governments. ... The reader is ... treated to the revelation that national governments react to international problems on the basis of maximizing benefit to themselves ...

"Part 6: The atmosphere and society is a position paper written before the conference by Kellogg, and defines the areas of interest for the participants ...

"This book has added yet another to the growing list of proceedings of international conferences on environmental matters which have been published in the last decade. It is a good deal worse than most of its predecessors, which in themselves were no great monuments to scientific insight or literary skill. The most effective course of action will be publication of the scientific work in journals, with national governments taking the best scientific advice available to them and acting as they see fit ..."

From 'Discussion Period on Past Climates', Michael C. McCracken, PROCEEDINGS OF THE CARBON DIOXIDE AND CLIMATE RESEARCH PROGRAM CONFERENCE, WASHINGTON, DC, APRIL 24-25, 1980, published as CONF-8004110 by U.S. Department of Energy, December 1980:

"PAST CO₂ CONCENTRATIONS AND TEMPERATURE CHANGES IN THE EQUATORIAL PACIFIC

"R. Newell: Am I right that the temperature change from 0 to 18,000 years before present (BP) in the subtropical gyres in the western Pacific is almost zero? It has been claimed from ice core data that there was a CO₂ decrease from 300 to 200 ppm during that time period, and so we have an experimental verification of the actual CO₂-induced change in temperature of a water mass that is not influenced by upwelling, advection, or mixing. I wonder if there is any explanation of this: the CO₂ concentration decreased by 50%, therefore the radiation must have changed with a corresponding change in temperature?

"W. Broecker: There is another problem, however. Climate: Long-Range Investigation, Mapping, and Prediction (CLIMAP) temperatures show almost no change over this same period, but the ice expanded to a great extent on the Hawaiian Islands. Thus there is a paradox: at the same time that there seemed to be essentially no temperature change in the ocean around Hawaii, Hawaii had a major expansion of mountain glaciers.

"T. Webb: The evidence from New Guinea is similar to that from Hawaii ... The evidence would seem to indicate that we are dealing with temperature changes in the upper atmosphere that differ in magnitude from the changes at the surface. With a drier atmosphere over the continents in the tropics at 18,000 years BP, somewhat steeper lapse rates could exist than today, and thus the temperature difference aloft between 18,000 years BP and today can be more than the temperature difference at the surface. It is very likely that the actual environmental lapse rates were different from those recorded today.

"T. Webb: The overall decrease in sea-surface temperatures 18,000 years ago was small in the subtropics.

"THRUST OF DEPARTMENT OF ENERGY (DOE) STUDIES ON PAST CLIMATE

"T. Webb: ... I myself am working ... now to reconstruct the hemisphere climatic patterns for the period 5000 to 7000 years ago ... This time period has been called the 'hypothermal', and yet ... we may be biased in using this term in the same way that we were when we talked about global temperatures at 18,000 years BP being 10°C lower than those today. I keep wondering if we haven't looked at just a few records in mid-latitudes and said 'Gee, the period from 5000 to 7000 years ago seems a lot warmer here' and then projected that inference over the entire world ...

"M. McCracken: ... I think that the argument for studying past climates was intended to try to develop scenarios. I realize that Kutzbach is urging studies of paleoclimates in order to understand the system, not to develop scenarios based on past climate ... It is a question whether we can use past information, whether instrumental ... or paleoclimatic and then make the jump to a warm-climate scenario as an alternative method of projecting the future climate; that is, as a method to complement the modeling efforts to determine what a future warm climate might look like ...

"THRUST OF THE CO₂ RESEARCH PROGRAM

"W. Broecker: ... I went before Congress about 2 weeks ago, and what the congressmen are interested in is not so much the CO₂ problem, and not so much the general circulation models. What they'd really like to know is something about how much sea level might rise as a result of the predicted CO₂ increase, how much a particular buildup of CO₂ might increase agricultural productivity, and whether the Arctic ice cap would melt as a result. We're very, very far away from answering these questions, and I think that one of my criticisms of the whole CO₂ program is that these questions are not getting pushed really hard ... Is anybody looking to see what the really important problems and key issues are, and making sure that at least some of DOE's money, at least 10%, should go toward a program on these issues, with 90% for basic research? It seems we have a moral obligation to address the critical issues.

"D. Slade: ... I would say that, if you look at the world 'community', you will find that about 90% of the dollars are in the carbon cycle and climate modeling research and maybe 10% of the dollars are in the area that you might call effects ... About 2 years ago, the CO₂ and Climate Division at DOE began to look into this area of effects. The problem that we faced then was that there was no community interested in this kind of question. There were people interested in climate variation on agriculture, or climate variation on biotic distribution, but in not applying this knowledge to the consequences of a climate change ... The difficulty is that one has to first develop a community of interested and knowledgeable people ... and then bend them into a consideration of these specific question. Working with the American Association for the Advancement of Science, we now have almost 200 environmental and social scientists developing into such a community and helping us to construct the 'effects' plans.

"C. Cooper: . . . If we are successful . . . in recreating past climate at a temperature was 2.5°C or more warmer than now, then would we have a basis for constructing a scenario?

"W. Broecker: There may never have been a time as warm (at least in the last few million years).

"T. Webb: . . . A lot of people have said that this period (5000 to 7000 years ago) was that much warmer, by 2° to 5°C . . . This time period is that much proposed warming. The next time period that we might look will find that 120,000 years ago was not much warmer than today. I mean, the more I look at it, the more I think that we are just biased by a . . . If these periods were not much warmer than today, we should really be impressed at the fact that, if we are projecting a 2°C to 3°C warming from CO₂-induced changes, we are predicting a big change for the earth's climatic system. That may help impress us about the magnitude of the disaster we may be looking at. An increase of 2° to 4°C in the global mean temperature is a big change in climate; it is equivalent to an ice age change; it is in the opposite direction, but it is of that level of magnitude . . .

"PAST WARMING AND COOLING OF OCEANS

"J. Hays: . . . Our evidence suggests that, during the last million years, at least in terms of the Antarctic, the temperatures of the Antarctic surface water have never warmed or cooled off much more than today's temperatures because they are so close to freezing . . .

"ANALYSIS OF CLIMATE DATA FROM THE HISTORIC PAST

"J. Namias: . . . there have been numerous conferences including the (NATO) Sicily Climate Conference . . . wherein there was an expressed need for evidence in the paleoclimatic records. Although we want to get results from modeling, there is relatively little effort going into studying the period of historical records, in which all sorts of data are available that are relatively unmined . . . this whole procedure of using historical data and dreaming up scenarios and trying to determine cause and effect is being underplayed . . .

"M. McCracken: J. Namias is right, but there have been very few researchers coming forward to do the work.

"NATURAL CLIMATE VARIATION, EVIDENCE OF CO₂-INDUCED CHANGE, AND THE DOE PROGRAM

More Feedback

"Dear Bill,

"Thanks for sending your Dec./Jan. issue with the abstract of my Muenster paper published last year by Reidel in *Interactions of Energy and Climate*. I hope people interested in the potential of soft energy paths . . . will read what I wrote, not your garbled editorial version of it on p. 8. Meanwhile your readers may want corrected some basic errors of fact that you introduced.

"My analysis does not assume 150-200 mpg cars, but only identifies them as a technical limit. The efficiency I assume, around 60-80 mpg, is not 'extrapolated' but empirically demonstrated by VW and others two years ago using prototypes bigger than a Rabbit. (I do not assume a modal shift to motorbikes or mass transit as you suggest.) Corresponding efficiency improvements already demonstrated for other vehicles suffice to reduce transport-liquids demand from about 19 to 5-6 q/y—straightforward to meet with present farm and forestry wastes

"J. Hays: . . . If we have to worry that, in fact, the CO₂ effect is already occurring, then W. Broecker isn't going to get his model done in time to help us, nor will other modelers. What we really need to know is what is this natural background change so that we can recognize it and differentiate between a natural climatic change and whatever might be an aberration caused by CO₂ . . . I think that we will probably not know whether it is the CO₂ effect until it gets so warm that it can't be anything else but that . . .

"RELATING PAST CLIMATE AND MODEL RESULTS

"A. Arking: . . . very often the direct effect of an external forcing is not what causes the model response, but that there are a lot of indirect effects. For example, you can change the solar constant or you can double the CO₂ concentration, and, if you look at the response of the model, it is pretty much the same. The reason for this, as I think was pointed out by R.T. Wetherald and S. Manabe . . . is that there are secondary effects. The increase in temperature initially caused by a slight increase in solar constant or by a doubling of the CO₂ concentration increases the water vapor in the atmosphere or melts some of the polar ice, or both of these. There are a lot of amplifications and positive feedbacks to take place.

"And thus model simulations suggest that there are feedback mechanisms and that, whatever the external forcing, it is the collection of feedback mechanisms that really determines the response. . . . Let's find typical scenarios that have occurred in the past, regardless of what caused them. We don't really have to understand the past. There will be a lot of information to suggest what the climate might look like in the future, regardless of the nature of the forcing. Maybe this is what W. Broecker was trying to bring out, that we do want to use past data to learn directly what might take place without having to go through complicated modeling.

"USE OF THE HYPsITHERMAL AS AN ANALOG

"W. Broecker: I think it is very unlikely that we have an analog. The middle of this interglacial (the Hypsithermal) may be only 0.5°C warmer than present . . . Can you make a projection of the error in this global temperature change between 6000 years ago and today? What is the accuracy likely to be?

"T. Webb: I think we are dealing with a change that is on the order, when we average it out, of 1°C or so . . . The standard errors for our current calibration equations are on the order of 0.5°C . . . Past climates differ from today's climate more in terms of spatial patterns of temperature and atmospheric circulation than in terms of the global mean temperature . . . When we refer to a 2°C increase in the global mean temperature, if that were to occur (as a result of doubling of CO₂), we are talking about a very large change . . ."

without special 'fuel crops'. (Municipal wastes are 3x smaller.)

"I have never proposed mandated constraints on building temperature, motor size, electricity demand, etc., but only economically efficient investment to supply desired energy services at least private internal cost. It is the empirical verdict of the capital marketplace, not my own preference, that has rightly sealed the fate of nuclear power. Purchasers would likewise choose the economically proper scale for each wind machine, not be restricted to an 'individualized' scale as you state. Soft technologies are more 'labor-intensive' than hard technologies in terms of total factor inputs, but not in the sense of requiring more labor or trouble for their users. I do not assume substitution of human for inanimate labor, nor any loss of convenience, but rather economically optimal use of *all* resources to power a dynamic economy.

"The roughly fourfold average efficiency improvement I cite for household appliances is neither 'extrapolated' nor implausible, but care-

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fully derived by J.S. Norgaard in *Energy Policy* 7:43-56 (March 1979). The Saskatchewan Conservation House achieved its thermal-efficiency design targets *despite* the net loss caused by the thousand visitors per week, and *deliberately* used as much electricity as an average Regina house in order to control the 'free heat' variable while varying the shell efficiency, not because that much electricity was actually required. Most electricity demand is highly price-elastic (at least -1.0), not 'quite inelastic' as you state, and your alleged correlation between electric demand growth rates and unemployment is a spurious surrogate for other macroeconomic variables. The industrial motor retrofits I cite do not affect versatility and are simple and cheap (3-4 y payback). Gains in U.S. energy (and electrical) efficiency are almost entirely due to improved domestic end-use energy productivity, not to shifts in embodied energy as you assert. It is simply untrue that solar process heat systems, *sensibly designed*, consume 'much more structural metal by weight than fossil or nuclear [complete systems] per unit of energy output', or are 'about 15 to 30 times' as labor-intensive (the correct ratios are 1 and 2.3 respectively). Your TVA example ignores interties (which I did not) and again confuses efficiency with curtailment. Your British example forgets that *any* kind of new thermal power station is grossly uneconomic: the real competitor is not other power stations (at say 8 cents/kW-h delivered) but efficiency gains (0-1.5 cents). In short: please don't mar a useful CO₂ Newsletter by not doing your homework in less familiar fields! . . ."

Amory
(Amory B. Lovins, 21 March 1981)

Dear Amory

Any garbling was due to misunderstandings of what I thought you said at your local lecture and seminar of December 12-13, 1980. Your intent of trying to halt the CO₂ buildup with the least consumption of natural resources is very honorable. If your anti-CO₂ strategy is intended to work in harmony with all other strategies to attain the best overall strategy mix, no one will require you to be logically accurate and precise. If instead your strategy excludes all other conventional alternatives, you are obligated to defend every component rigorously and to demonstrate conclusively that the strategy won't collapse because people fail to adopt it voluntarily.

If you totally reject the nuclear anti-CO₂ strategy, as your publications and lectures suggest, you are obligated to present your technical plans in a form that consumers and industrial engineers can clearly visualize rather than as academic abstractions. The nuclear alternative doesn't just exist in academic reports, it is an industrial reality. To abandon nuclear now with no technically advanced replacement would accelerate the CO₂ buildup.

Your published thesis is that the CO₂ buildup can be halted and the entire population of the world can have the present U.S. standard of living on 1/8 the per capita energy now consumed in the U.S. You advocate that this energy be limited to solar, wind, biomass and hydroelectric. Presumably you intend for the per capita U.S. energy consumption to be reduced by 7/8 to eliminate any difference between haves and have-nots. If one sector cannot meet this 7/8 reduction, presumably a greater reduction would be needed in other sectors to make up for it.

My lecture notes erroneously showed that you consider an auto fuel efficiency of 150-200 mpg as "possible". We agree that this is completely impossible. However, even if we generously accept 100 mpg with diesel as maximum efficiency for marketable cars, biomass still appears to fall far short of supplying current auto demands. Due to the different energy content per gallon, 100 mpg with diesel is equivalent to 60 mpg on ethanol.

Biomass (wood) was formerly the world's principal fuel before its natural supply diminished and coal supplanted it for economic reasons. Biomass auto fuel would have to compete for customers with the gasoline business, which is highly mechanized and automated, and in which transportation has reached maximum efficiency by waterways and pipelines. For biomass to offer similar efficiencies in cost and labor expended per unit of energy output, only that biomass which can be gathered by large, efficient machinery, transported by large, efficient equipment, and converted by large, efficient plants could offer an attractive alternative to consumers without great subsidies. In theory the U.S. forest and agricultural wastes could produce ethanol with an energy equivalence of nearly half the liquid automotive fuel consumed in the U.S. today (excluding diesel fuel, aviation fuel and boiler fuel for ships). A reasonable guess is that at least half that biomass could not be gathered with competitive efficiency, at least half the final ethanol product might be consumed in gathering and transporting, and the distillation necessary to make fuel could well consume most or all the remainder of the product. If, instead, much of these forest and agricultural wastes were sequestered by burial, that great mass of carbon would go into a sink rather than the atmosphere.

As to decreasing the energy used in household appliances by four-fold, it is not sufficient to consider only what is theoretically possible,

but what efficiencies would consumers gladly accept? If, for instance, soft-energy advocates willingly have given up all use of energy-intensive clothes driers in favor of solar clothes driers (clothes lines), the human-resistance factor would appear to be less of an obstacle.

Debate about the size, scale, metal consumption, labor consumption, capital consumption and public acceptability of individual solar and wind components of soft systems might be futile and endless. For the public to visualize the whole effect of an exclusively soft strategy, they need to be presented with engineering plans for entire systems operated solely by solar and wind, as a steel mill, a cement plant, a paper mill, a food-processing and canning plant, and an extensive irrigation system from pumped wells. What would a complete soft energy system look like, say, for New York City? How must buildings be altered for soft energy and conservation to maintain temperatures at comfort levels on both cold and hot days so as not to cause detrimental effects on productivity and health, as mandatory temperature controls seem to have caused?

Your cost estimates for future nuclear electricity are unusually high compared to actual costs reported by governments of several countries, including the U.S. Your estimates do not reflect the fact that *each year* the delays and capital erosion imposed on U.S. utilities by the U.S. and state governments cause a financial loss greater than the entire amount invested by the U.S. government to launch the nuclear industry (\$16X10⁹).

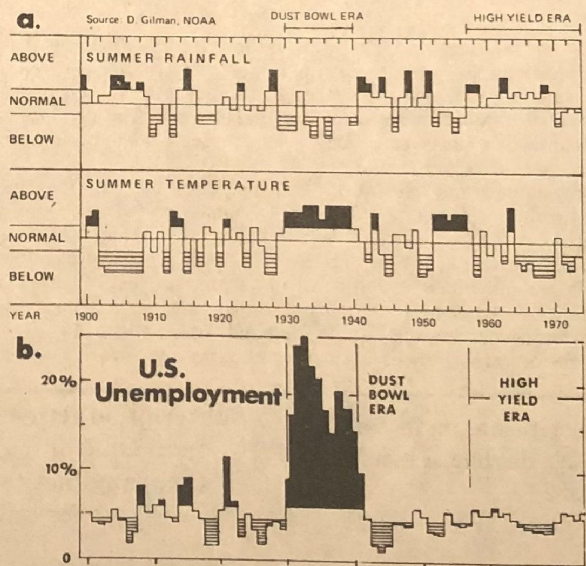
That graphic correlation of mine which you questioned, between annual U.S. electric growth and unemployment, was intended to show only how rising unemployment caused a decline in electric growth, which might be misinterpreted as 'conservation'. The accompanying graph, below, showing U.S. unemployment in the U.S. from 1900-74 illustrates the high, intractable unemployment level caused by the Great Drought of the 1930s, a climatic condition which most economic theories and models fail to recognize in their macroeconomic variables.

Except for the war year 1945, the *only* years in which electric consumption declined were 1921 (a decline of 6% as unemployment rose from 5.2% to 11.7%), 1930 through 1932 (a decline of 15% as unemployment rose from 3.2% to 24.1%), and 1938 (a decline of 3% as unemployment rose from 14.3% to 19.1%). In all other years, electric usage grew.

Nor do such economic models note that almost any economic system could have thrived during the era of very high farm productivity (the 'high yield era' of 1957-74), which may help explain why such models are now seen to lack predictive ability. Only economic systems based on enterprise, thrift and imaginative inventiveness can hope to thrive as widespread drought returns.

The great concern about what would happen to the U.S. economy if (or when) a CO₂ warming causes a return of dustbowl conditions is demonstrated by these graphs.

Bill
(- W.N.B.)



a. Summer Temperature and Rainfall in Five 'Wheat Belt' States (from 'Climate Change to the Year 2000, a Survey of Expert Opinion', published February 1978 by the National Defense University, Washington DC)

b. Unemployed population as a percent of the total civilian work force, data from U.S. Department of Census.