intercontinental range. The arms controllers' response to the second scheme is straightforward. They say the Soviets have never tested the SS-20 at an intercontinental range, and thus cannot assume it will fly the extra 2000 miles, certainly not with any assured accuracy. If the Soviets did test it at longer ranges, the United States would see the tests and classify the SS-20 as a new strategic missile. It is unlikely the Soviets would risk making the SS-20 their one new missile under the treaty, particularly in view of the fact that they have agreed to scrap its nearest cousin, the SS-16. Of course, if there were no treaty, the Soviets would be free to do whatever they pleased with the SS-20 and the SS-16.

The other objection—that the Soviets might produce and stockpile SS-16's in secret—presents a hiding and counting problem of a fundamental kind that applies to missile stockpiling in general, to launchers putatively hidden in warehouses, bombers produced secretly and moved about in the dark, and other flagrant violations of the treaty. Arms controllers agree that if the Soviets wished to devote the time and money to it, they could probably conceal a lot of weapons. But missiles, launchers, weapons factories, and transporters are large objects. It is unlikely that, in the time it would take to build up a massive secret arsenal, the United States would fail to spot clues giving away at least one of the offending items. The Soviet landscape has been thoroughly surveyed by now, and changes are not difficult to see.

A violation of this sort would be taken very seriously, leading perhaps to an abrogation of the treaty and an accelerated arms building campaign in the United States. American officials believe the Soviets understand that the risk of detection outweighs any potential gain that might be won by cheating. As one Soviet watcher put it, the problem is not going to be cheating, but incremental chiseling.

Objections to the treatment of the Soviet Backfire bomber are similarly judgmental. Because this weapon is clearly designed for "theater" warfare, as U.S. intelligence informs us, the SALT negotiators did not try to include it in the treaty. In reciprocation, SALT II makes no mention of U.S. nuclear-armed "forward-based systems" in European and other friendly countries near the Soviet Union. Nor does the treaty limit theater nuclear weapons held by NATO nations. SALT critics are correct, however, in pointing out that U.S. surveillance cannot guarantee that the Backfire will not be adapted to a strategic role. For this reason, the United States extracted a pledge from Leonid Brezhnev that his country would not produce more than 30 Backfires a year—a pledge that can be verified with good confidence through satellite photography. Limited to this rate of production, the Soviets, it is said, will have no incentive to thin the ranks of their peripheral defense force by diverting Backfires from a theater to an intercontinental mission, with all the retraining and new support systems the latter would require.

Last and worst are the mobile missile and the cruise missile. Neither type is fully controlled under the treaty, and both will pose grave problems for verification in the future. SALT II permits the deployment of one type of mobile ICBM launcher on each side, but only after 1981 when the protocol expires. Long-range cruise missiles—ground-hugging, radar-evading drones that travel more than 600 kilometers—are permitted if launched from the air or from underwater. They are banned under the protocol from deployment on sea or land launchers, but they may be tested and developed ad nauseam.

Present surveillance methods are inadequate to certify the range of a cruise missile, although the Soviets would have trouble hiding a 1000-kilometer cruise test flight from our cameras. Once a reliable long-range cruise has been developed, monitors will find it next to impossible to determine whether or not the missile has been MIRVed, and if so, with how many MIRV's. Cruises are easier to conceal than ballistic missiles, although the present generation of Soviet cruises are "huge behemoths" (with a short range) according to an arms control specialist at the Pentagon. They might be stockpiled—when they have reached some future stage of sophistication—for quick deployment and launching. In buying this technology, the United States and the Soviets may be adopting a family of rattlesnakes.

Mobile missiles, designed intentionally to play hide-and-seek with spy satellites, will bring other serious verification problems. They are especially worrisome because the new mobile missiles will be lethally accurate first-strike weapons. The exact dimensions of the verification problem remain unclear because no one has a clear fix on what basing systems will be used. The U.S. mobile missile, the MX, still requires years of testing and development before it will be ready for deployment, and the mode of deployment is still uncertain.

The United States is ahead of the Soviets in mobile missilery and in cruise

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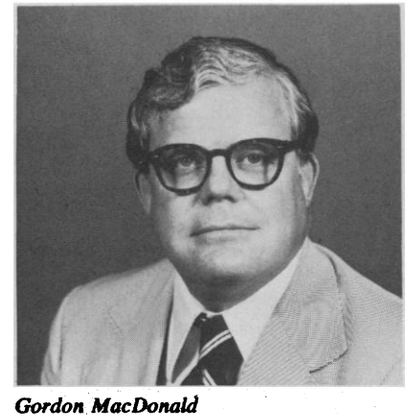
A Warning on Synfuels, CO_2, and the Weather

As President Carter and the Congress move to launch a large synthetic fuels program, four prominent scientists are waving a red flag about synfuels and accelerated use of fossil fuel generally.

In a statement presented recently to the President's Council on Environmental Quality (CEQ), they warn that energy policy makers should consider now—before it is too late—the possibility of a disastrous warming of the atmosphere from the release of carbon dioxide associated with the use of fossil fuels. They note, in particular, that on an energy-equivalent basis a lot more CO_2 is released from production and combustion of synfuels than from the direct burning of coal.



Gordon MacDonald

The four—Gordon J. F. MacDonald, Roger Revelle, George M. Woodwell, and Charles D. Keeling—say that a doubling of the CO_2 concentration may warm the world's climate by as much as 2° to 3°C, with the warming to be greater by a factor of 3 or 4 at the poles than in the tropics. They indicate that such a doubling can be expected sometime during the first half of the next century if worldwide use of fossil fuels continues to grow at the present rate of 4.3 percent a year.

MacDonald, geophysicist, former CEQ member, and environmental studies professor at Dartmouth College, told *Science* that, given this growth rate for fossil fuels, the doubling of the CO_2 concentration will occur by the year 2035 if the present mix of coal, oil, and natural gas remains unchanged. But, he said, if the fuels

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mix changes, with the United States and the Soviet Union each using 2 to 3 million barrels of synfuels a day, the doubling could come as early as the year 2010. Carbon dioxide is released both during the production and the combustion of synfuels; according to MacDonald, on an energy-equivalent basis, the total CO_2 released from synfuels is 1.4 times greater than that from coal and 1.7 and 2.3 times greater than that from oil and natural gas, respectively. The CO_2 produces its warming or "greenhouse" effect by absorbing infrared radiation from the earth that would otherwise escape into space.

"If we wait to prove that the climate is warming before we take steps to alleviate the CO_2 buildup, the effects will be well under way and still more difficult to control," the scientists say in their statement to CEQ. All four are consultants or contractors to the Department of Energy (DOE), which has a study of the CO_2 problem under way, with the first formal assessment due in 1984 and the final one due in 1989.

Frank Press, the President's science adviser, remains to be convinced that the CO_2 problem is such that the use of coal and development of synfuels should be restrained. In an interview with *Science*, Press said, "Everyone agrees that CO_2 is increasing and will have a warming effect. But how great the effect will be, and whether it will be good or bad, is not certain."

Press said that at the end of July, the National Academy of Sciences' Climate Research Board will conduct a 1-week review at Woods Hole of the CO_2 problem. This review, to be led by Jule Charney of the Massachusetts Institute of Technology, will consider all recent studies and assessments of the problem, including the Jason study published in April, which was done for DOE and chaired by MacDonald. "I will suspend judgment until after the Woods Hole study," Press said.

Keeling, of the Scripps Institute of Oceanography, says that the four scientists' urgent warning rests on essentially the same understanding of the CO_2 problem contained in the National Academy of Sciences' 1977 study *Energy and Climate*, which Revelle chaired. What motivated them to act, he explains, is the lack of evidence that "DOE, at the policy levels, is dealing the problem into the mix of policy considerations."

Gus Speth, acting chairman of CEQ, says the scientists' warning is "very important and perhaps historic." He mentioned it to President Carter on 3 July at a White House meeting on energy issues and found him "knowledgeable" on the CO_2 problem. But if Carter is worried about how an accelerated burning and conversion of coal might affect the world's climate, it is not yet evident, although the DOE study of the problem was begun in 1977 as the result of a White House initiative suggested by Frank Press. Speth has said that the CO_2 problem may be the "central problem" that limits the nation's long-term reliance on coal.

Gus Speth Photo by L. J. Carter

Oh, Sweet CONAES, Where Art Thou?

Representative Morris Udall (D-Ariz.), chairman of the House subcommittee on energy and environment, is wondering whatever became of the National Academy of Sciences' long-heralded CONAES study that was begun nearly 4 years ago, and well he might.

The acronym CONAES stands for the Committee on Nuclear and Alternative Energy Systems, which was established in 1975 to conduct a $3.6-million study for what was then the Energy Research and Development Administration (now the Department of Energy). The study was supposed to be completed and the report delivered by June 1977, but the expected completion time slipped to December 1978, then to March of this year, and now, to "late September or early October."

With President Carter at Camp David receiving literally scores of visitors to advise him on how to straighten out the nation's energy policy, this would seem to have been an excellent time for the cochairmen of CONAES, Harvey Brooks of Harvard and Edward L. Ginzton of Varian Associates, to step forward with their report.

In a recent letter to Philip Handler, president of the academy, Udall called for an explanation of all the delay and observed: "With full recognition of the difficulties of conducting a study of this kind, it does appear that the 4 years that have elapsed was a sufficient period to complete as thorough an analysis as is permitted by the uncertainties inherent in the situation."

The executive director of the National Research Council's Assembly of Engineering, Michah H. Naftalin, who has been drafting a reply to Udall's inquiry, attributes recent schedule slippages to essentially the same factor that has been slowing things up all along. That is, there is the sheer difficulty of getting all parts of a very long document (700 to 800 manuscript pages) on a difficult and controversial subject perfected and approved by both CONAES and the Report Review Committee, groups made up of busy professionals who have many other fish to fry.

According to Naftalin, all major substantive issues were disposed of by CONAES at least a year ago, with the members reaching a consensus on some and agreeing to disagree on others. The Three Mile Island accident did not, he says, lead to a reopening of the nuclear safety issue.

The report, minus the summary chapter which CONAES has not signed off on yet, is now with the Report Review Committee, which is chaired by Saunders MacLane, professor of mathematics at the University of Chicago. None of the comments received thus far from the reviewers assigned by this committee have raised substantive problems, so the hope is that the review process is nearly over.

Ginzton says that nobody asked him to the White House or Camp David to talk about the study. Presumably nobody asked Brooks either. He is in Vienna.

Luther J. Carter