Letters

The CO_2 Question

In his editorial "Carbon dioxide emissions" (25 Nov., p. 879), Philip H. Abelson states that "[d]uring the past decade the rate of [fossil fuel] burning has been static. If present trends continue, the doubling time for CO_2 will be 220 years." In fact, studies on historical emissions cited in recent reports by the National Research Council (NRC) (*1*) and the Environmental Protection Agency (EPA) (*2*) show that the rate of carbon release from fossil fuel burning has been increasing at an average rate of 1.9 percent per year over the last decade (*3*). Continuation of this trend would result in a "doubled" atmospheric concentration of CO_2 (that is, 600 parts per million by volume) in about 90 years (*4*). The median estimate for actual doubling time according to the NRC and EPA reports is about 70 years.

Abelson asserts that "One method for decreasing net emission of CO_2 is close to commercial feasibility. . . . Following the combustion of fuel gases, the CO_2, being present in high concentration, could easily be removed. Later it would have a market value for injection underground to promote tertiary recovery of oil." Our very rough estimate (*5*) has been that 0.42 ton of carbon dioxide could be "consumed" in the unreleased oil and in the gas space of the field for each barrel of enhanced oil recovered. Burning of that barrel of oil will release about 0.42 ton of carbon dioxide. In essence, this use of CO_2 allows us to recover some additional oil, and there is no net CO_2 release for the increment of oil that is produced by CO_2 floods. Easy removal of CO_2 from power plants generally is not suggested by published studies of the problem. Analyses have shown that some of the specific removal-disposal technologies that have been proposed are not physically feasible; others are net energy losers; and the rest are tremendously expensive (*5*). The EPA report concludes that "controlling CO_2 emissions appears to be marginally effective and prohibitively expensive." The NRC report notes that, for pumping CO_2 into the deep ocean, "The benefits with any currently conceived technology would be small compared to the cost."

Abelson writes that biomass energy strategies can play a significant role in reducing CO_2 emissions and in removing excess CO_2 from the atmosphere. The detailed energy forecasts made by the Institute for Energy Analysis form the basis of the EPA study and are consistent with the NRC results (*6*). They suggest that, even under the most generous assumptions, less than 10 percent of the world's primary energy production will come from biomass by the middle of the next century. The possibility of storing significant quantities of CO_2 in biomass was explored. Dyson and Marland (*7*) envisioned a heroic project that might be undertaken as a short-term response to a threat of a CO_2 catastrophe. The EPA study reviewed and updated this work and agreed that "sequestering atmosphere CO_2 by trees is an extremely expensive, essentially infeasible option for controlling CO_2." The NRC writes, "One conclusion is inescapable, irrespective of a hundred years' technological change: 'sweeping' the atmosphere with trees can be no great part of any solution to the CO_2 problem."

Abelson implies that the advent of fusion energy could "drastically" affect the CO_2 question. In the very long run, this may be possible, but we cannot find a single quantitative analysis that gives a significant world energy share to fusion before the time in the next century when atmospheric CO_2 would already have reached its "doubling" concentration. Fission (including breeder) technologies have much greater (although still limited) potential for reducing CO_2 emissions in the foreseeable future.

The CO_2 issue is extremely complex; little can be said with much certainty about its implications and the options for dealing with them. But careful study over the last decade has moved a few of the relevant issues from the realm of arm-waving to a point where the range of possibilities is constrained by facts. Ignoring these facts adds only confusion to an important current debate.

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References and Notes

1. National Research Council, *Changing Climate* (National Academy Press, Washington, D.C., 1983).
2. *Can We Delay a Greenhouse Warming?* (Environmental Protection Agency, Washington, D.C., 1983).
3. G. Marland and R. M. Rotty, "Carbon dioxide emissions from fossil fuels" (DOE/NBB-0036, Department of Energy, Washington, D.C., 1983). Analyses still in press will suggest that the current growth rate is nearer 1.5 percent per year.
4. W. C. Clark, Ed., *Carbon Dioxide Review: 1982* (Oxford Univ. Press, New York, 1982), p. 16.
5. C. F. Baes, Jr., *et al.*, "Options for the collection and disposal of carbon dioxide" (ORNL-5657, Oak Ridge National Laboratory, Oak Ridge, Tenn., 1980); A. S. Albanese and M. Steinberg, "Environmental control technology for CO_2" (BNL-5116, Brookhaven National Laboratory, Upton, N.Y., 1979).
6. J. Edmonds and J. Reilley, *Energy Econ.* **5**, 74 (1983); *Energy* **8**, 419 (1983); *Energy J.* **4**, 21 (1983).
7. F. J. Dyson and G. Marland, in *Workshop on the Global Effects of CO_2 from Fossil Fuels*, W. P. Elliott and L. Machta, Eds. (CONF-77038, Department of Energy, Washington, D.C., 1979), p. 111.

Argentina's Capital: Buenos Aires

"Argentina formulates a nuclear New Deal" (News and Comment, 17 Feb., p. 669), true, but it intends to keep Buenos Aires as its capital! Pilcaniyeu is indeed 600 miles from Buenos Aires and more than three times as far from Rio de Janeiro. I recommend *National Geographic Atlas of the World.*

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Parapsychology

Christopher H. Dodge (Letters, 3 Feb., p. 440) states that "psi in various forms has been around for a long time and has already been applied. . . ." From our reading of *Science* and other sources, we conclude that the world is still waiting for a replicable demonstration of "psi." In what forms has it been around, and where has it been applied?

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Erratum: In the report "Prenatal exposure to carbon monoxide: Learning and memory deficits" by C. F. Mactutus and L. D. Fechter (27 Jan., p. 409), the second sentence of the second full paragraph in column 3 of page 410 should have read, "A 2 by 2 analysis of covariance on the number of avoidance responses with covariates of number of avoidance responses in acquisition and number of adaptation and intertrial responses during reacquisition revealed significant effects of training contingency [$F(1, 57) = 23.8$, $P < 0.001$] and an interaction of CO exposure with training contingency [$F(1, 57) = 7.6$, $P < 0.008$].