Solar Energy Development

Christian B. Anfinsen's comment (Letters, 16 Apr., p. 202) that a major solar energy effort might unburden us of dependency on nuclear power is appropriate. Analyses in the Project Independence task force report on solar energy (*1*)—to which more than 100 professionals from government, industry, and academia contributed—suggest that by the end of the century the nation could be obtaining about four times as much total energy, and about twice as much electricity, from the sun (*1*, p. I-7) as is expected from nuclear fission (*2*, pp. V-5, VI-2, and VIII-6). Each of four individual solar technologies has the potential to deliver more power sooner than, and at least as cheaply as, the liquid metal fast breeder reactor (LMFBR).

Incomprehensibly, the Administration is deliberately moving slowly in developing this potential. The definition report of the National Solar Energy Research, Development, and Demonstration Program issued by ERDA (Energy Research and Development Administration) projects outputs of solar electricity that are 22 to 27 times less in 1985 and 5 to 13 times less in the year 2000 (*3*, pp. I-4, V-5, and V-6) than those projected in the Project Independence report. In contrast to the heavy documentation of the latter, the ERDA report gives no details about the derivation of its estimates. Of the goal set for solar energy production, it acknowledges that "Significantly higher levels are possible . . . ," and describes the goal as ". . . *a modest and highly attainable impact for solar energy in deference to conventional fossil fuel and nuclear sources* [italics mine]" (*3*, p. V-6).

The final environmental statement on the LMFBR (*4*) recently released by ERDA treats the solar alternatives superficially and, like the definition report, makes no reference to the Project Independence report, which is still the most comprehensive analysis of the solar energy potential.

Although more than 60 percent of the mail sent to ERDA is said to be concerned with solar energy (*5*), as of 20 February, only 72 of ERDA's 8000-odd employees were assigned to the Division of Solar Energy. Even its Office of Public Affairs, with 92 employees, had more.

ERDA recently created a new administrative division for the LMFBR, while its Division of Solar Energy continues to be responsible for varied technologies, some of which have no more in common with each other than with hydropower or coal, which are also forms of "solar" energy.

Nuclear advocates say that solar power is too costly. But they do not acknowledge that government promotion and subsidy give nuclear power an artificial competitive advantage. Certainly, the characterization by Zebroski and Minnick (Letters, 26 Mar., p. 1214) of nuclear power as "highly attractive as a source of long-term, low-cost power" should not go unchallenged. The cumulative direct cost to the federal government of supporting nuclear power through the end of 1975 was about $8.15 billion (1975 dollars). This is equivalent to 15.9 mills for every kilowatt-hour of commercial nuclear power ever generated in the nation. It is equivalent to about 85 percent of the total capital that industry had invested in all commercial nuclear plants operating at the end of 1975 (*6*). During 1975, the federal government spent about 10 percent more supporting fission power than the nuclear industry spent to generate power (if we assume a high estimate of 5 mills per kilowatt-hour as the industry's production cost) (*6*, p. XV). During the coming fiscal year, the federal cost of nuclear power is due to increase 35 percent, but the nation's licensed nuclear capacity will increase during 1976 by only 13 percent. The budget of the Nuclear Regulatory Commission alone averages well over $6 million for each 1000 megawatts of nuclear capacity (the size of a large reactor) licensed at the end of 1975. Indirect federal costs, state government costs, and other externalities have not been estimated.

Moreover, costs of nuclear power to taxpayers are due to sharply increase. The cumulative federal cost of the LMFBR program, "[u]ntil the time that the option is made available to utilities to buy a commercially viable breeder" (*7*), is now expected to be $12.88 billion (1975 dollars). Before the prototype commercial large breeder is completed, the cumulative federal cost of civilian fission power could easily exceed $25 billion (1976 dollars). This does not include the expenditures made through the Tennessee Valley Authority, the world's largest purchaser of nuclear reactors; it plans to spend $9.4 billion to increase its nuclear generating capacity by 1984.

Moreover, it is not a foregone conclusion either that it will be possible to overcome the technical obstacles to building a commercial LMFBR or that it will be possible to make it economical (*4*). ERDA's National Plan says, "Because the technical risks are too great and the financial pay-offs so far in the future, ERDA will develop the fuels, materials, and components technology to support the construction and operation of large-scale LMFBR's by industry" (*2*, vol. 2, p. 89). Nuclear proponents Hans Bethe and Alvin Weinberg have said, respectively, "Nobody can predict the price of a fast breeder" (*8*), and "Whether LMFBR's can be the basis for a truly commercial industry still remains to be seen" (*4*, vol. 1, p. 1-C-8).

Federal budgets, both present and recommended, for all solar technologies combined are less than one-tenth those related to civilian fission power, and the budget for the LMFBR alone is almost five times as great. The proposed fiscal year 1977 budget for ERDA's commercial radioactive waste program amounts to more than half the projected outlay for solar energy. Although improved energy storage is essential for optimal solar technology implementation, less than 1.5 percent as much is budgeted for this as is budgeted in support of nuclear fission power. (Only $2 million is allotted for improving the storage of hydrogen, one of the most likely fuels of the future.) ERDA's senior solar energy administrator recently resigned, protesting the low priority given to harvesting the sun.

In 1952, noting the danger of becoming dependent on Middle Eastern oil (*9*, vol. 3, p. 9), President Truman's Materials Policy Commission said, "We must look to solar energy . . . it is time for aggressive research in the whole field of solar energy—an effort in which the United States could make an immense contribution to the welfare of the free world" (*9*, vol. 4, p. 213). That advice was not followed. Nuclear fission, in 1975, after a quarter of a century of federal promotion and support, provided barely more than half as much electricity as that provided by hydropower—1 percent of the energy used for the nation's work. One solar technology alone—wind generators equipped with 6 days' storage capacity—might deliver this much power as cheaply by 1985 (*1*, pp. I-B-10 and I-7).

Can we afford to continue marking time on implementing the solar technologies and betting so heavily on an exotic unknown such as nuclear fission power?

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Breast Cancer and Chemotherapy

In her article of 12 March (News and Comment, p. 1029), Barbara J. Culliton discusses a study by Bonadonna *et al.* (*1*), in which chemotherapy was used as an adjuvant to radical mastectomy, and criticizes as "greatly exaggerated" my characterization of the study as a work of "monumental importance" (*2*).

Appearance of clinically manifest breast cancer after the initial resection predictably leads to death despite temporary remission. Axillary node metastases at the time of mastectomy are sentinel lesions indicative of a high probability of micrometastases in other body sites. Without chemotherapy, only 23.9 percent of 163 women with one or more positive axillary nodes and 13.8 percent of 87 women with four or more positive nodes at the time of surgery were alive 10 years later (*3*).

Modeling from combination chemotherapy of acute leukemia, Cooper (*4*) described a chemotherapeutic program for metastatic breast cancer using five drugs—vincristine (V), prednisone (P), cyclophosphamide (C), methotrexate (M), and 5-fluorouracil (F). In terms of remission induction, this regimen was superior to any single drug therapy previously employed; nonetheless, half the patients in a group treated with the five-drug therapy were dead in 1 year and 75 percent in 2 years (*5*). Others studied components of Cooper's five-drug regimen by omitting one or two drugs. A three-drug combination (CMF) was found more effective than a single oral drug, L-phenylalanine mustard (L-PAM), in suppressing metastatic breast cancer (*6*). Both treatments were then tested immediately after surgery in women who had axillary node metastases. The L-PAM study, conducted in the United States, was published (*7*) as a report of early findings at a time when significant delay in appearance of recrudescent cancer ($P = 0.2$) was seen only in premenopausal women.

Bonadonna *et al.* (*1*) reported a controlled, randomized trial in 386 women in which 12 monthly courses of CMF were administered to one group after surgery; a control group received no postoperative treatment. After 27 months, there were 11 relapses in 207 patients (5.3 percent) in the CMF group and 43 in 179 patients (24.0 percent) in the control group ($P = < .000001$). Furthermore, CMF was significantly superior for patients in *every* subset of the study classified by age, ovarian function, number of nodes involved, and extent of mastectomy. This was also true for the 90 percent of patients with the commonest pathologic type of tumor and the 89 percent whose tumors were more than 2 centimeters in diameter. Bonadonna *et al.* presented their relapse data in the form of life-table plots, the most effective way to describe the events that occurred. These events, in turn, give the best indication of how the entire group, of which the early members are a subset, will behave. Treatment failure distributions after 27 months were projected to be 10 percent for the CMF group and 43 percent for the control group ($P = .00002$). No patient treated with the full CMF regimen had relapsed after the drug therapy was ended. For the subset of 122 patients with the worst prognosis—those with four or more metastatic nodes—the projected treatment failures by life-table plot are 19 percent for the CMF group and 76 percent for the control group ($P = .001$). All relapsed patients are expected to die. Like many experimental neoplasms, disseminated human cancer can in some instances be cured by drugs when micrometastatic, but rarely when clinically evident. This principle, adopted from experience with experimental and clinical acute leukemia, has also been demonstrated in Wilm's tumor, osteogenic sarcoma, embryonal rhabdomyosarcoma, Ewing's tumor, and Hodgkin's disease. The Italian data and the experience with micrometastatic cancer as a biologic phenomenon rather than a unique characteristic of breast cancer support the proposition that some patients in the CMF treatment group have been cured. Mortality data after 32 months show a difference: 11 of 179 patients in the control group have died, compared with only 4 of the 207 patients treated with CMF ($P = .03$) (*8*).

Culliton and Costanza (*9*) assert that postoperative chemotherapy is still an experimental method not to be undertaken outside the research setting because of unknown late effects. The drugs have been in use singly for 18 years or more, and in combination for half that time. The risks are reasonably well un-