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## Energy Consumption

Bill Keepin and Gregory Kats (Letters, 26 Aug. p. 1027) correctly point out the continued potential of conservation for restraining energy consumption and limiting carbon dioxide emissions. But their dismissal of nuclear power is regrettable because, whatever the success of conservation, massive supplies of energy will continue to be needed. Nuclear power is currently the most practical source, if one wants to minimize the use of fossil fuels.

Consideration of U.S. energy history from 1973 to 1987 (1) shows that total energy use rose 2.7%, the gross national product (in constant dollars) rose 40%, electricity generation by utilities rose 38%, electricity sales rose 43%, and total use of fossil fuels dropped 3%. This combination of near-constant energy demand and continued electrification can serve as a model for the future, at least if the electricity comes from nonfossil sources.

Unfortunately, more of the rise in electricity generation came from coal than from nuclear power (in a ratio of 1.66 to 1), but had greenhouse fears exceeded radiation fears this could have been reversed. Even so, nuclear power now provides about 20% of our electricity, and its increased use since 1973 accounts for the drop in fossil fuel consumption. Nuclear power not only can substitute for fossil fuels in existing electricity generation but can also displace fossil fuels in other sectors by continued electrification of the energy economy. As of 1987, electricity represented 65% of the energy input for the residential and commercial sector and 35% of the input for industry. Both of these fractions

can continue to rise. There are also prospects in transportation.

Solar power, including hydroelectric power, has advantages similar to those of nuclear power along with the additional advantages of providing direct heating and, in some of its forms, of being technologically simple. Thus, although contributions from solar power aside from hydroelectricity are still on a small scale, its development deserves high priority.

The greenhouse problem represents one of the greatest global environmental threats that civilization has faced. The overriding goal of energy policy should therefore be to make fossil fuel use "as low as reasonably achievable" (ALARA, in the radiation protection acronym). Conservation, nuclear power, and solar power can each contribute toward this goal, while reducing the problem of acid rain and the dangers of impending oil shortages. It is beyond our predictive abilities to gauge realistically how much each can eventually contribute and at what cost. Prudence therefore dictates that we now explore and exploit each to the fullest extent practical.

DAVID BODANSKY

*Department of Physics,*

*University of Washington, Seattle, WA 98195*

## REFERENCES

1. Energy Information Administration Report, Monthly Energy Review [DOE/EIA-0035(88/05), Department of Energy, Washington, DC, May 1988].

## Energy Options

David Bodansky (Letters, 21 Oct., p. 348) appears to miss the point of the earlier letter by my colleagues Bill Keepin and Gregory Kats (26 Aug., p. 1027). Energy options are not to be chosen like dishes from a Chinese restaurant menu -- one from column A and one from column B -- but rather by marginal costs and benefits. In this marginalist calculus, whenever nuclear power costs more than efficient end-use of electricity, buying nuclear power instead of efficiency increases carbon emissions and worsens global warming compared to what least-cost investment of the same dollars would have achieved.

Specifically, if displacing a coal-fired kilowatt-hour costs seven times as much with a new nuclear plant as with a new superefficient light, motor, window, and so forth (the actual ratio might arguably be between 2.5 and 25 and is very probably 7+ today), then every dollar spent on the nuclear plant results in releasing six times more carbon than if the same dollar had been spent on efficiency. Bodansky's recommended nuclear exploitation "to the fullest extent practical" is thus not "prudent" but dangerously counterproductive (1).

Efficiency holds the edge in speed as well as cost. During 1973-1986 (1979-1986) inclusive, Bodansky's reference 1 (2) shows that energy savings increased U.S. energy supplies by 7.1 (12.7) times as much as nuclear expansion (3). Merely continuing historic rates of savings would thus yield the same climatic benefits as an order-of-magnitude scale-up of nuclear programs (4) -- yet is much cheaper, safer,

easier, and surer. Again, why keep diverting scarce resources from a winning option to a losing one?

AMORY B. LOVINS  
*Rocky Mountain Institute,  
Old Snowmass, CO 81654-9199*

### REFERENCES AND NOTES

1. A paper by B. Keepin and G. Kats [Energy Policy 16, 538 (1988)] further shows that even if nuclear plants can be built twice as fast as they now can in the United States, then even in a low-energy scenario (a 2025 global primary energy demand of only 1.1 times the 1988 level), the sixfold nuclear expansion required to displace all the coal-fired electricity by 2025 would require 1600 gigawatts (GW) of nuclear plants. These would have to be built at a rate averaging one 1-GW plant per 7.5 days (3.1 times the 1970-1985 global rate), yet they would reduce global warming by only ~15%. This suggests the question, Wouldn't it work even better to invest the nuclear plants' \$1.6-trillion cost (at \$1 per watt, a third the actual U.S. cost today) in efficiency instead?
2. Energy Information Administration Report, *Monthly Energy Review* [DOE/EIA-0035 (88/05), Department of Energy, Washington, DC, May 1988].
3. This comparison generously counts nuclear output at its primary (steam) value; in terms of delivered energy, electricity's speed advantage was about three times larger still. Most of the savings were in oil and gas, not electricity, but for artifactual reasons unrelated to the feasibility, availability, or economic advantages of electric end-use efficiency [A. B. Lovins, "Eleven reasons why we're saving electricity more slowly than direct fuels" (Rocky Mountain Institute, Old Snowmass, CO, 1988); *Negawatts for Arkansas* (Rocky Mountain Institute, Old Snowmass, CO, 1988)].
4. C. K. Komanciff, "Greenhouse effect amelioration -- efficiency vs. nuclear" (Memo, KEA, New York, 24 August 1988).

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