

tal protection for conservationists; exciting technologies for the secular; a rebirth of spiritual values for the religious; world order and equity for globalists; energy independence for isolationists; radical reforms for the young; traditional virtues for the old; civil rights for liberals; and states' rights for conservatives.

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Dialogue on Energy: Reply

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Amory Lovins has rendered a service in highlighting the fact that we cannot go on indefinitely building as many electric power plants every ten years as we have in the preceding years. This requirement, a result of the historic 7% per year growth rate in electric energy use since World War II, has indeed failed to be noticed by

a number of proponents of "business as usual" in energy generation.

However, Lovins has done a marked disservice in arguing that instead of instituting a policy of conservation of energy stiff enough to reduce the growth rate of energy usage to a level which can be sustained indefinitely, we should embark instead on his "soft path." The appeal of this argument to technically unsophisticated policy-makers has caused some of them to postpone action on the required conservation efforts, and we are paying and will continue to pay a very high price in dollars for this delay.

One can dismiss out of hand the numbers on costs of various alternatives put forth by Lovins and others. There are simply too many imponderables to allow meaningful calculation of future costs of such major technological changes. For example, the most important thing to know is the time scale on which a given development will occur. As Lovins points out, unknown future interest rates, inflation rates, and regulatory requirements can wreak havoc with cost projections. While Lovins asserts that his "soft path" has shorter lead-times than conventional projects, this is the most difficult thing to determine. The fault in his analysis is to cite prototypes as examples of technology ready to be put in place on known timetables and at known costs.

As I teach in my classes at Fletcher, there are four steps required for any technological development to become widely adopted. First, there must be the

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scientific discovery of the relevant laws of nature; second, the invention based on these laws; third, the development of a prototype, model, or device which successfully performs the technological function; and fourth, production of the device in sufficient quantity and at a price which allows it to become a successful commercial product. The fourth step is nearly always the most difficult and time-consuming part of the process. Thus, one must view prototypes as only possibilities, but not as certainties which can be relied on.

A few faltering steps in this direction are readily brought to mind. Massachusetts Electric, Granite State Electric, and Narragansett Electric recently conducted a program to determine whether solar home hot water heaters are commercially available at acceptable cost and with acceptable reliability in New England, and the results are that they most decidedly are not. To quote from the Arthur D. Little interim report on the program,

Interim findings indicate that solar energy is a victim of unreasonably high expectations. Up to now, projections of cost and reliability have tended to be optimistic. There has been little recognition given to the fact that the solar water heater industry is in its infancy in northern climates and few manufacturers have had experience with real-life installation problems. Under actual operating conditions in the field, solar hot water installations have encountered many of the same difficulties faced by other mechanical systems in the early years of product development. Those problems must be resolved if solar water heaters are to become economically viable.

The point is that the existence of working prototypes does not necessarily imply a technology is ready to be widely adopted.

It is my further thesis that the changes in life style required by Lovins' soft path would be much more severe than those required by conservation and a manageable growth rate in energy usage. I well remember making trips to visit my grandfather who lived in a small town served by a diesel electric generator in the next block. In spite of the best efforts of the man who tended the plant day and night, the reliability of the service left much to be desired. Imagine additional problems in this age in which no one wants to take responsibility for anything outside of the prescribed working hours and established procedures!

Harvard University has for some time been trying to build a cogeneration facility in the Boston area for its hospital complex. Opposition has come from local residents who do not want such a plant — efficient though it may be — built in their neighborhood.

As Arthur Kanfrowitz eloquently points out, ours is a time of technological timidity, and this includes small-scale technology as well as large-scale. No technology is risk-free, but a vocal segment of our society wishes to require that anything we do be guaranteed to be without risk. Thus, at the moment there is