Letters

The entire 19 April issue of Science *was devoted to energy. Extra copies were printed and more than 14,000 have been ordered by colleges and universities, government agencies, environmental action groups, industrial and engineering firms, and oil, chemical, and power companies. Here is a selection of the many comments we have received.*

Energy-Induced Inflation

Science has demonstrated excellent awareness of the situation developing in the energy economy by its special issue of 19 April. One aspect that was not specifically analyzed is the effect of the rising costs of basic energy supplies on inflation. The steadily decreasing value of the dollar is assuming greater and greater national importance, and currency stabilization is now the subject of one frenzied idea after another on the part of the Administration.

Over the years, and on the basis of cheap energy, we have developed an economy wherein energy is a necessary ingredient in essentially every product and service. As the cost of these energy inputs becomes greater, the energy demand decreases only slightly because there are no alternative methods which can be readily substituted. The inelasticity of the energy demand with its increasing cost is further assured by the tremendous capital investment in equipment inherent in the means for using energy to provide the desired goods and services.

Recently we have seen the average price per barrel of imported oil increase to four times that of a year ago. Imported oil is now providing approximately 20 percent of our total energy requirements, and that fraction is increasing. This factor alone has accounted for an increase in the total cost of our primary energy supplies during the past year of more than 50 percent. Similar but smaller fractional increases in the costs of domestically produced oil, gas, coal, and even uranium are having additional effects in forcing upward the total cost of fuels used in the United States.

At the present time the cost of all raw fuels available at the mine, wellhead, or port of entry is equivalent to 5 percent of the gross national product. A doubling in the total cost of these raw energy supplies can be expected to produce an inflationary effect of an equivalent percentage. While this is obviously an appreciable factor in today's inflation, the effects are likely to be even more serious in the future.

We are caught for the first time in a situation where the limitations of earth resources are inevitably forcing a decrease in the purchasing power of the dollar.

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The Promises of Technology

The energy issue (19 Apr.) and the recent spate of other writings on this subject suggest to me several fundamental questions that need to be asked. Let us assume that the pressures caused by our demands for increased energy sources will result in the technological development of significant new forms of energy production, for example, from nuclear fusion or direct solar conversion. What then? Will the energy demands of the world be met? Or will the exponential growth of energy use merely be further kindled and soon obliterate any new gain? And, what happens to our other natural resources and ourselves when energy supplies are vastly increased? Won't the pressures on our ecosystems be magnified and our resources be utilized even faster than before? Hasn't this always accompanied the introduction of new energy forms? It seems that the success of our modern technology is dependent on ever more rapacious use of raw materials. At the same time, the benefits to humanity have been mixed. For example, does it make sense to indulge ourselves with endless gadgetry designed to save human labor much to the frustration of our minds and the detriment of our physical well-being? What is the real price of this tradeoff of costly resources for the sake of man's leisure?

On the other hand, with new and highly productive, low-cost energy sources and with planning, could we actually afford to obliterate less of nature, preserve more of man's natural domain, and make his habitations more livable? Might recycling become more economical, resulting in less exploitation of raw materials? To make this happen, it seems to me, would require ingenious efforts, both to reduce excessive use of resources and to become more efficient in using what we must. It would take quite different commitments from those of most present societies. Change to more simple lifestyles would likely be necessary, resulting, ironically, in a real improvement in the human living condition, as opposed to the present drive to ever "higher" but at the same time more "mechanical" living standards. Without direction, great strides forward on the energy supply scene may only hasten our pace of material consumption and human deference to mechanical living, resulting in exhaustion of natural resources, further environmental degradation, and, finally, the virtual dehumanization of man. Must the promises of technology be so shortlived and of such mixed blessing? Can, or should, a free society give no positive guidance to its own destiny? Must a society be so preoccupied with present crises as to ignore its future? Is the decivilization of modern man irreversible?

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Solar Power

In his article "Low-cost, abundant energy: Paradise lost?" (19 Apr., p. 247) Hans H. Landsberg makes the following assertion:

> For good reason, solar energy has drawn increasing attention. At least on a global basis, its use would essentially free us of the thermal discharge penalty. It would thus get around atmospheric and climate problems and obviate limitations of energy use as an ultimate "limit to growth."

Table 1. Inputs to the environment before and after installation of desert solar energy farm with 30 percent conversion efficiency [see (*1*)].

Solar energy flux	Before instal-lation (%)	After instal-lation (%)
Reflected to space	35	5
Desert heating	65	65
Utilized in metropolitan industrial centers	0	30
Additional global heat burden		~ 30
Total	100	100

This assertion would not be correct for an economically competitive solar power system.

According to Aden Meinel and Marjorie Meinel (*1*), the only likely candidate for an economically competitive solar power system is high-temperature thermal conversion interfaced with state-of-the-art, high-pressure steam turbine systems. The goal of such a system would be to operate at 30 percent efficiency rather than at the 2 to 4 percent attainable at the present time. To attain this efficiency, 85 percent of the solar farm energy now reflected back to space would be utilized (see Table 1). If care were exercised in the manner of discharge, there would be no net thermal problem in desert regions. However, the industrial-metropolitan and global heat burden would be increased by the extent to which the ordinarily reflected light is captured and converted to solar power.

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References

1. A. A. Meinel and M. P. Meinel, *Univ. Ariz. Opt. Sci. Cent. Newsl.* **6**, 68 (1972).

Solar Heating and Cooling

Allen Hammond (19 Apr., p. 278) omits any reference to the work of Harold Hay of California in his discussion of solar-heated houses. Hammond gives good coverage to Harry Thomason's commendable work in Washington, D.C., but the only residence which has been constructed and operated up to this time that derives all its heat from the sun and gets all its cooling from night sky radiation and evaporation is the Hay "Skytherm" system, tested for 18 months in Phoenix, Arizona, in 1967–1968. The "Skytherm" system is now in operation as a full-scale house at Atascadero, California.

Many other companies are now becoming active in the solar heating and cooling field, primarily as a result of the three contracts given by the National Science Foundation to General Electric with the University of Pennsylvania; Westinghouse with Carnegie-Mellon University and Colorado State University; and TRW Systems with Arizona State University. The reports on these three projects are available from the National Science Foundation (*1*).

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Notes

1. A limited number of copies is available from the RANN Documents Center, Room 601, National Science Foundation, 1800 G Street, NW, Washington, D.C. 20550.

Wind Power

Martin Wolf (19 Apr., p. 382) comments on wind power and states that "A conceptual design with aeroturbines stationed off the Atlantic coast to produce 160 billion kilowatt-hours of electricity a year has been completed for the New England region." It is possible to estimate the cost and magnitude of such a wind-power project.

A megawatt of power can be extracted from the air with a very efficient wind turbine if the wind is blowing at 20 knots and the diameter of the turbine is about 60 meters. The Putnam wind generator installed at Granpa's Knob, Vermont, in the 1940's was about that size. The cost of building similar generators today is estimated to be at least $1 million if they are mass produced (*1*). To produce 160 billion kilowatt-hours a year (assuming an average wind of 20 knots) would require more than 15,000 wind generating units. The cost of installation of the units alone, not counting the cost of the offshore platforms, would thus be in excess of $15 billion. If these wind generators were placed in a line on platforms 100 meters apart, the line would stretch for 1500 kilometers, which is about the length of the entire New England coast.

Only 15 modern coal- or nuclear-fueled power plants will supply the same amount of electricity as 15,000 wind turbines, and their cost of installation is at least five times less. Also, electricity can be produced at will at conventional power plants, whereas the wind is undependable.

There is no doubt that there is plenty of power in the wind. The real problem is in economically extracting this power, and since the fundamental technology for building wind machines has already been developed, reasonable estimates of the cost of extracting wind power can be made. My analysis indicates that large-scale generation of electricity by harnessing the wind, even as a supplemental source of power, is not feasible economically.

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References

1. E. W. Hewson, "Wind power potential in selected areas of Oregon" (Technical Report, Department of Atmospheric Sciences, Oregon State University, Corvallis, 1973).

Industrial Energy Conservation: Dual Incentives

Charles A. Berg, in his article on industrial energy conservation (19 Apr., p. 264), mentions that industry has not felt obliged to conserve energy in the past. There are two major reasons for industry to save energy: economic (it pays) and patriotism (joining in a common effort to meet a common objective). However, without the first incentive, the second will not be able to go very far or be maintained for very long.

Industries measure their efficiency in the rate of return on capital investment (*1*) and use this same gauge to determine the advisability of current investments. Suppose a company has a current rate of return on capital of $r = P/K$, where P is the profit at the current level of sales and K is the capital invested. If an additional investment in energy-conserving alterations and equipment ΔK produces reduction of operating expenses, which in turn produces an increased profit ΔP, the company will be inclined to make the investment if $r \leqq \Delta P/\Delta K$ (for simplicity, the cost of capital is included in ΔK). Typically r is in the range of 15 to 20 percent per year (*2*).

There are a number of reasons why companies hesitate to make energy-saving investments, even those which will return r on the investment.

1) There is always some amount of