search and development overseas—as well as the attendant reprocessing—places the Administration in an awkward position on domestic reprocessing. As a congressional staff member points out, "If the Carter Administration says it's all right for England, France, and Japan to reprocess fuel, what is the argument for not doing it here? We'd just be denying ourselves the business."

The counterargument advanced by environmentalists is that even with U.S. approval these countries are unlikely to carry out their large-scale reprocessing plans, or in the case of France, to continue for long at prohibitive cost. "While there is no shortage of rhetoric, the reality is that the plutonium industry is collapsing," says Thomas Cochran of NRDC.

The debate will probably begin in the Senate soon. Doubtless ample rhetoric will continue on both sides, up to and even past the point when Carter releases his latest views, which could be delayed until after the November election.

—R. JEFFREY SMITH

Energy Forecasts: Sinking to New Lows

The experts keep revising their forecasts of future energy needs—the fashion is downwards

Although some astute energy watchers predicted early in the 1970's that demand would soon level off, the big institutional forecasters have only begun to consider this a real possibility in the last couple of years. Large outfits move slowly. And their forecasts are slow to change—partly because they often represent a record of investment, not just an analysis of trends. But even the most cautious energy forecasters are making revisions today, for a new reality has forced itself upon them.

Since 1978, actual sales of petroleum in the United States have declined, and electricity demand has grown at unprecedentedly slow rates. While demand for electricity used to increase by 7 percent annually, it is now going up less than 3 percent a year. In 1979, total energy use in the nation declined. Yet economic growth, measured by the gross national product (GNP), has continued to rise.

The most striking indication of change lies in the shifting relation between energy and GNP. Before the oil embargo of 1973–1974, energy use increased each year faster than economic growth. Since then, the trend has reversed, with energy demand growing less rapidly than the economy. It now takes 10 percent less energy to produce a dollar's worth of GNP than it did in 1973. The fact that energy demand is growing more slowly than the economy could wreck the plans of some energy suppliers.

One hears exasperation, for example, in the voice of Michehl R. Gent, executive vice president of the National Electric Reliability Council (NERC). NERC is a cooperative formed by electric utilities after the New York City blackout in 1964; its purpose is to see that power-generating capacity keeps pace with demand. Gent said, "We've gone through the age of laying a straight edge on a piece of graph paper, and we've just gone through all the econometric models [for energy forecasting] and shown they're no good. And so we're back to crystal ball gazing. The effect is so enormous, on our industry anyway, because of the capital requirements. To be wrong is just catastrophic." Is it possible that all the forecasts are wrong? "Absolutely," Gent said. Does that mean the future could be catastrophic for some? "It could be; the worst thing would be if demand is greater than we've predicted."

Like others, NERC has lowered its expectations, and Gent said that some utilities will be canceling orders for coal and nuclear generating plants. But Gent remains firm in his conviction that there cannot be any real growth in the economy without increased demand for energy—and particularly electricity. NERC's decision to lower its forecast, incidentally, has shaken others in the field, even though NERC still is among the high-growth forecasters. The chief forecaster for one very large company that makes electrical appliances said that NERC's forecast for electricity demand upset him this year because, for the first time ever, it was lower than his own. He likes to think that his work is conservative, for it is used in making business decisions. NERC's forecast has served him in the past as a marker of the too-optimistic point of view. Next year, he expects he will scramble down to a lower point on the range in order to stay below NERC. Thus the entire pack of prophets moves downhill.

A graphic illustration of this behavior has been put together by Amory Lovins, British representative for Friends of the Earth and bête noire of the utility industry. He is one of many who argue that enormous efficiency improvements can and will be made in technology in the next two decades, and that these will reduce energy demand far below the present level of 78 quadrillion British thermal units (quads) per year.

Lovins points out that, no matter what the bias of the forecaster, all energy pre-

Year of forecast	Beyond the pale	Heresy	Conventional wisdom	Superstition
1972	125 (Lovins)	140 (Sierra)	160 (AEC)	190 (FPC)
1974	100 (Ford zeg)	124 (Ford tf)	140 (ERDA)	160 (EEI)
1976	75 (Lovins)	89–95 (Von Hippel)	124 (ERDA)	140 (EEI)
1977–78	33 (Steinhart)	67–77 (NAS I, II)	96–101 (NAS III, AW)	124 (Lapp)

Abbreviations: Sierra, Sierra Club; AEC, Atomic Energy Commission; FPC, Federal Power Commission; Ford zeg, Ford Foundation zero energy growth scenario; Ford tf, Ford Foundation technical fix scenario; Von Hippel, Frank Von Hippel and Robert Williams of the Princeton Center for Environmental Studies; ERDA, the Energy Research and Development Administration; EEI, Edison Electric Institute; Steinhart, 2050 forecast by John Steinhart of the University of Wisconsin; NAS I, II, III, the spread of the National Academy of Sciences Committee on Nuclear and Alternative Energy Systems (CONAES); AW, Alvin Weinberg study done at the Institute for Energy Analysis, Oak Ridge; Lapp, energy consultant Ralph Lapp.

Amory Lovins put together this table showing the downward drift in forecasts. Figures represent total U.S. energy demand in year 2000 or 2010.

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dictions for the year 2000 have been dropping at about the same speed since the oil embargo (see table). He divides the prophecies into four groups: beyond the pale (made by low-growth advocates like himself), heresy (put out by moderate conservationists), conventional wisdom (this includes government scenarios), and superstition (the work of high-growth advocates). Lovins notes that what was beyond the pale in 1972—an expected 125 quads of demand at the end of the century—became mere heresy in 1974, conventional wisdom in 1976, and superstition in 1978. Publication of the table, he says, has speeded up the process, for at least one branch of the Department of Energy (DOE) is about to publish a low-growth plan this year that goes almost beyond the pale, estimating we may need only 57 quads in year 2000. This report is being prepared for DOE Under Secretary John Sawhill, and its summary chapter is due to be completed this month.

The Lovins table amuses Lincoln Moses, head of the DOE's Energy Information Administration, and, in Lovins's sense, the spokesman of conventional wisdom. More than anything else, says Moses, the table illustrates the hazard of extrapolating from the historical record. It suggests that all one need do is wait 8 or 10 years and "our forecasted energy needs will have gotten down to the point where we have nothing to worry about." That, he thinks, is a "ridiculous result." He agrees, however, that he has seen signs that a "sea change may be taking place in energy using habits." His own agency's forecast (part of its 1979 annual report) will not be out until August. Meanwhile, it undergoes continuous revision.

Those who believe a sea change has occurred received a vote of confidence this year from several conservative institutional forecasters. Exxon's World Energy Outlook, published last December before the latest OPEC oil price increases, predicted that energy demand would grow in the United States by less than 1 percent a year through 1990, and by 1.6 percent after 1990. Before the oil embargo, the rate of demand growth was about 4.3 percent a year. Petroleum demand in America has passed its peak forever, Exxon concluded. The report also estimated that the recent pattern of efficiency improvement will continue, so that the already achieved 10 percent decline in energy needed per dollar of GNP will fall to 22 percent by 1990 and 30 percent by the end of the century. This represents radical change.

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Spy Ship Got No Warning

On the afternoon of 8 June 1967, the U.S.S. *Liberty* cruised some 12 miles off the Sinai Peninsula, eavesdropping on battlefield communications in the 1967 Arab-Israeli war. During the previous 13 hours, six urgent messages had been sent to the ship by U.S. command forces, messages ordering the *Liberty* out of the area, telling it to pull 100 miles offshore.

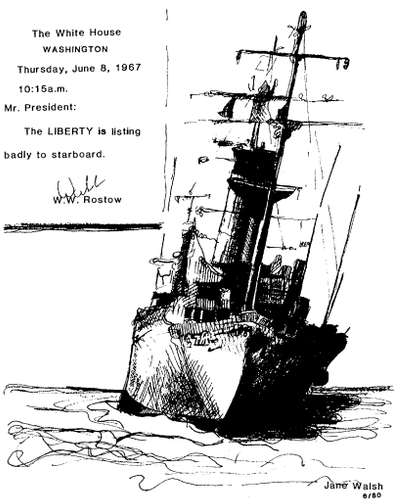
Due to a series of human and computer errors, however, none of the messages reached the ship in time. Two were misrouted to a U.S. communications station in the Philippines and one went to Greece. One was never addressed to the *Liberty*. One was lost in the electronic labyrinth at the Army Communications Station at Pirmasens, Germany. The final message, marked urgent and "Top Secret" by the Joint Chiefs of Staff, spent the morning of 8 June passing from ship to ship in the U.S. Mediterranean fleet, never reaching the *Liberty* at all. The Joint Chiefs, it turns out, had overlooked the fact that the *Liberty* could not receive Top Secret messages.

The rest is history. At 2:00 in the afternoon, Israeli planes and boats began a coordinated 1-hour-and-20-minute attack on the *Liberty* with gunfire, torpedoes, rockets, and napalm. At the end of the attack, 34 American sailors were dead and 171 wounded.

Details of the communications mixup that paved the way for the attack come from a new book, *Assault on the Liberty,* by James M. Ennis, a recently retired Navy officer who served as cryptographic specialist on the *Liberty* and was wounded in the action. His report of communication and computer errors helps explain why the Pentagon in 1970 decided to overhaul its World Wide Military Command and Control System (WWMCCS)—a computerized system the Joint Chiefs use to coordinate U.S. military activity around the world. Some experts claim that WWMCCS is still so bogged down in technical and administrative problems that its effectiveness is open to doubt (*Science*, 14 March).

Ennis accuses U.S. officials of trying to cover up facts surrounding the incident in an effort to avoid public protest over the Pentagon's failure to protect the ship and its men. He says, for instance, that the House Armed Services investigations subcommittee, which studied the affair in detail, was never told of the final, misguided, Top Secret message sent to the *Liberty* by the Joint Chiefs.

Ennis says the Administration also covered up facts in a effort to avoid embarrassing any ally. Since 1967, for instance, the Israelis have claimed



that their pilots reported that the *Liberty* was not flying the American flag and that the ship was attacked on the assumption it was Egyptian. But Ennis, who stood watch on the bridge of the *Liberty* on the morning of 8 June, had a new, oversized flag raised to replace the sooty one the *Liberty* was flying. The new flag was put up because "we were operating in a dangerous area and could afford to fly only our clearest, brightest colors," Ennis writes. The flag stood out in an 8-knot wind while Israeli reconnaissance planes flew over the ship at low level six times.

Academy Says Curb on Cholesterol Not Needed

"Good food should not be regarded as a poison, a medicine, or a talisman. It should be eaten and enjoyed." That rather lighthearted advice comes from the Food and Nutrition Board of the National Academy of Sciences (NAS). On 28 May, the board issued a report on the public's preoccupation with the links between diet and chron-

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The National Petroleum Council (NPC), which looks into the future for the major oil companies, also predicts that petroleum demand in the United States will never again be as high as it was in 1978. The NPC made two surveys of 32 petroleum forecasters, one in the spring of 1979, and one in early 1980. According to coordinator Joan Cassedy, the NPC found a considerable drop in demand forecasts between the two dates, and "the feeling is that a third survey would have come out even lower."

John Lichtblau's Petroleum Industry Research Foundation, a private consulting group, predicts in a May publication that U.S. oil demand will drop 5 percent in the 1980's, and that gasoline demand will drop by 20 percent. Energy demand may grow by 1.4 percent a year. Unlike Exxon, it predicts that gains in conservation will be accomplished more slowly in the 1980's than in the last 6 years, but it noted: "U.S. primary energy consumption has changed radically since 1973." The fastest growing major energy sector, according to this report, will be nuclear power. This conclusion is reached simply by assuming that only those nuclear plants "in an advanced stage of construction by the end of 1979 will be in operation by 1985," and only those 20 percent completed by the end of 1979 would be in operation by 1990. Coal supplies will outstrip demand, and so on. The study assumes an annual GNP growth rate of 2.3 percent in the 1980's; a lower actual rate would, of course, imply less energy demand.

In reports like these, it seems to be taken as obvious that petroleum demand is on the decline. What is not agreed, but is hotly disputed, is what will happen to electricity. The utilities are in a difficult spot because they have made long-term financial commitments to build new plants, commitments which they justified at the time by reference to their own rising demand forecasts. But the forecasts were wrong. Demand has slowed, costs have increased, and many utilities have been forced to increase the rates charged to consumers—putting an additional damper on demand. Some nonindustry analysts think that the utilities may be caught in a quicksand of stagnant demand and rising costs from which they will not easily escape.

The utilities respond by saying the economy must grow at a rate of more than 2 percent a year to maintain such things as "reasonable social balance." And demand for electricity will grow slightly faster than the economy because "electricity will prove increasingly attractive relative to other forms of energy." For one thing, prices are likely to climb more slowly than those for oil or natural gas. These are the views of the Edison Electric Institute (EEI), an association of investor-owned utilities. EEI releases a report this month (*Economic Growth in the Future II*) predicting that if the GNP grows at roughly 3 percent a year—EEI's "preferred rate"—total energy demand will grow by 1.9 percent a year, and installed electric capacity will grow by 3.8 percent a year.

An earlier forecast of sorts by EEI President William McCollam used stronger language. He told the New York Society of Security Analysts early this year that the industry was being constrained by the antinuclear lobby, and that electricity shortages might appear in the 1980's as a result. These might drive companies to find substitutes for electric power that could "downgrade productive efficiency, move the U.S. toward economic decline, weaken its ability to compete on the international scene, and, with rising unemployment and declining living standards, set the stage for the eclipse of American civilization as we know it. . . . This is an objective of a well-financed, well-organized political movement which has as its goal the restructuring of the society, and which has chosen the destruction of nuclear power as its focal point."

Both the forecast and the fiery words seem laughable to Roger Sant, the former chief of conservation policy for the Ford Administration and current director of the Mellon Institute's Energy Productivity Center. The EEI, Sant thinks, is one of the worst offenders in forecasting in that it clings to an old paradigm that is based on low-cost energy. "They're living in a dream world," he says. The utilities, according to Sant, "continue to make us feel like the world won't work without them, but maybe it won't work with them." If the utilities are to survive, he thinks, they must become peddlers of energy services, not raw electricity. In his vision of the future, the utilities will compete with other companies to provide customers with the most efficient lighting, heating, cooking, and refrigeration services. If the utilities fail to take advantage of new markets for energy-saving technologies, others will. Thus Sant thinks it is "totally feasible" for the economy to shift into a long-term pattern of declining energy use.

Sant's own study (*The Least-Cost Energy Strategy*) led him to conclude that the United States could have improved energy efficiency by 32 percent in the years since 1973, rather than the actual 10 percent, if the government had encouraged an all-out investment in new energy-saving technology. Sant bases his argument in part on the work done by the National Academy of Sciences' Committee on Nuclear and Alternative Energy Systems (CONAES), which "illustrated how incredibly flexible the system is." The CONAES study found that with continued high energy prices and low growth in GNP (less than 3 percent annually), the United States could, if it wished, decrease energy consumption from the present 78 quads to 58 quads by 2010 (see *Science*, 25 January 1980).

Richard Holt, a policy analyst in DOE's solar energy office, is another forecast watcher who thinks most of the studies done before CONAES were inadequate because they simply extrapolated from historical trends. Like Sant, he thinks it makes more sense to look at the "end-uses" of energy and ask whether those patterns of use will continue as prices rise. After reading many papers of this sort, Holt concludes that industry forecasters are off target. For example, he is certain that the electric utilities are wrong in predicting that more consumers will choose electric heat.

Holt has just finished reviewing 10 major studies of the potential for a low energy economy (including CONAES). He found that all agree the United States could lower its demand for primary energy in the next 20 years while population and GNP increase. They agree as well that pursuing efficiency would be cheaper for the nation and individual energy buyers than expanding "conventional" supply systems. They disagree on the potential contribution of solar and renewable forms of energy, and on the relative importance of electricity, particularly as it applies to transportation. If these forecasts have any salient flaw, Holt says, it is that they may have underestimated the rate at which energy prices will increase. Oil prices, for example, have nearly jumped above the highest rate of increase projected in these studies. This suggests that conservation may occur more rapidly, too.

It is plain that what was once considered a utopian vision—the possibility of improving the economy with "zero energy growth"—is becoming accepted among forecasters as a plausible way out of the current energy bind. That does not mean that the new trend in energy prophecy, the scramble for low demand estimates, will produce more accurate information than the old trend. But the abrupt reversal does suggest that a radical change is working its way through the economy.—ELIOT MARSHALL