Research Department
Federal Reserve
Bank of
San Francisco

November 12, 1976

Unleashing Nuclear Power

The electorate made an important decision last week in the field of energy economics. Following the example set by their California counterparts last June, voters in Arizona, Colorado, Montana, Ohio, Oregon and Washington all voted by wide margins—2 to 1 in most cases—to defeat ballot initiatives which would have severely restricted the growth of the nuclear-power industry. In all of these cases, the controversy was over safety—storage of nuclear wastes and prevention of radioactive leakage from atomic plants. Yet in deciding the safety issue, the voters also made an implicit decision about the economics of alternative energy sources.

Opposing views

During a sometimes heated election-year controversy, opponents of nuclear power argued that nuclear-fission reactors are unnecessary—even assuming the disappearance of current reserves of petroleum and natural gas—because of the nation's possession of huge reserves of coal, and because of the future potential of such alternatives as fusion power or solar power. (Some advocated a major reduction in energy usage, pointing out that the major nations of Western Europe use less than half as much energy per capita as the U.S. does.) Opponents also claimed that nuclear reactors are unreliable and unsafe, in view of the small but important possibility of reactor failure. They pointed to the problem of disposing of radioactive wastes for thousands of years, as well as the possibility of sabotage of reactors or theft of fissionable material. Some opponents, fearful about these safety problems, demanded the termination of the nation's entire nuclear-development program; this would have meant phasing-out about 80 powerplants now operating or under construction, and cancelling about 100 plants with existing or impending construction permits.

In rebuttal, supporters of nuclear power argued that alternative sources of energy cannot be relied upon, and that many foreign countries (especially those without coal reserves) are already acting upon that conviction. These supporters also pointed to the unique safety record of atomic energy, and argued that deaths due to producing electricity by coal are likely to be 100 times the deaths due to production by nuclear power, even assuming the possibility of occasional catastrophic failure of nuclear reactors. They claimed that the problems of theft and sabotage are under control, and that the problem of waste disposal was irrevocably accepted with the adoption of a nuclear-weapons program a generation ago.

Growing industry

This year's voting on the nuclear issue has confirmed the view of most businessmen, that nuclear (light-water) reactors will be the next generation's most economically

(continued on page 2)

Research Department
Federal Reserve
Bank of
San Francisco

---

attractive technology for generating base-load electricity. Consequently, many billions of dollars (or equivalent) have already been committed to the construction of several hundred reactors in this country, Western Europe and Japan. Industry sources expect nuclear power's share of U.S. electricity production to rise from less than 9 percent today to 50 percent by 1990, replacing fast-disappearing supplies of oil and natural gas. About 60 nuclear plants with total capacity of 45,000 megawatts are scheduled to be in operation in the U.S. in 1977.

An MIT study team led by Irvin Bupp recently analyzed the economic argument for nuclear power by studying the cost experience of the plants now operating or under construction in this country (February 1975 *Technology Review*). Fuel-cycle (variable) costs of nuclear power have turned out to be quite low—about 24 cents/million BTUs, closely in line with earlier predictions. In contrast, fossil-fuel costs in the past decade have jumped from 24 cents/million BTUs to more than $2.00 for oil and $1.00 or more for coal. In many areas of the nation, notably New England and the Middle Atlantic states, light-water reactors provide the most economically attractive technology for generating base-load electricity.

However, the crucial factor is capital costs—total costs (including interest) during construction. From the outset of the Atomic Age, it has been evident that the key to economic success was to prevent a virtually certain fuel-cost advantage from being wiped out by high construction costs. A certain amount of fragmentary evidence suggests that the nuclear industry could lose part of its cost advantage on this score.

The evidence is incomplete because the industry has had less than ten years' experience in constructing large reactors on a completely commercial basis. Government subsidies created the nuclear-power industry in the 1950s and early 1960s, and reactor-manufacturer subsidies later supported the industry, under a "turnkey" type of contract which stipulated that the nuclear plant would generate base-load power at a lower cost to the purchasing utility than an equivalent coal- or oil-fired plant could produce. In addition, not enough commercial plants have been built in the past decade to provide sufficient cost data for evaluation. Despite an estimated completion time of six years for the average nuclear plant, in 1973 only 6 of the 30 plants ordered six years before had entered operation.

Increasing cost?

Nonetheless, the MIT economists concluded that the nuclear-power industry is operating in an increasing-cost situation. Based on their analysis, the capital cost of a light-water reactor ordered in 1974 for delivery in 1982-83 would probably be 50 percent higher (perhaps even double) the $455/kw (in 1974 dollars) estimated by the Federal Energy Administration in its Project Independence report.

The fault does not lie with the cost of manufactured components, because this cost has been falling in constant-dollar terms. Despite significant design changes and scale modifications, there has evidently been a learning process in this area, especially in the manufacture of turbine generators. On the other hand, some fault does lie with sharply increasing labor costs, because of wage increases, manpower shortages and declines in labor productivity. Thus, reactors going into operation in the 1970s required about 3.5 manhours per kilowatt to build, while those slated for the 1980s will require about 8.5 manhours per kilowatt. However, this problem has affected all major construction projects, and so fails to explain why nuclear-construction costs have far outdistanced both fossil-plant and oil-refinery costs.

The nuclear industry's increasing-cost situation instead is attributable to the procedural delays and design changes arising out of the nuclear-safety issue. For example, stricter design criteria caused a reversal in the late 1960s of an earlier trend toward decreased use of steel and concrete per kilowatt, despite the growing size of reactors and consequent increasing economies of scale. More importantly, reactor construction times have increased, from an average of 85 months for reactors ordered in 1965 to 115 months for those ordered in 1969. (In the last half of 1974 alone, construction was deferred on 94 plants and cancelled completely in the case of 14 plants.) These delays have caused extra construction costs and extra borrowing costs, in addition to unexpected inflationary effects.

The MIT study underlines the strong correlation between plant costs and total project length. For a given project length, the longer the licensing period arising from procedural delays, the higher the total cost. According to the MIT group, "Present trends in nuclear reactor costs can be interpreted as the economic result of a fundamental debate on nuclear power within the U.S. community."

The MIT economists thus suggest that engineering estimates of reactor capital costs are insufficient guides for predicting actual future costs, because of the noneconomic factors forcing construction delays and design changes. Another consequence is the increased potential competitiveness of coal-fueled plants, since the present trends in reactor capital costs are significantly narrowing the economic gap between the two technologies. Construction costs for coal-fueled power plants have been rising also, but less than half as fast as for nuclear.

But a different conclusion could be reached now that one-fifth of the nation's voters have decided strongly in favor of nuclear-power development, since this suggests some reduction of the delays involved in debate and litigation. The nuclear industry's obvious advantage in fuel-cycle costs henceforth might not be offset by any capital-cost differential in coal's favor.

William Burke

Research Department
Federal Reserve
Bank of
San Francisco
Alaska • Arizona • California • Hawaii
Idaho • Nevada • Oregon • Utah • Washington

BANKING DATA—TWELFTH FEDERAL RESERVE DISTRICT

(Dollar amounts in millions)

Selected Assets and Liabilities Large Commercial Banks	Amount Outstanding 10/27/76	Change from 10/20/76	Change from year ago Dollar	Change from year ago Percent
Loans (gross, adjusted) and investments*	90,170	− 42	+ 4,732	+ 5.54
Loans (gross, adjusted)—total	68,828	+ 12	+ 4,912	+ 7.69
Security loans	1,471	− 117	+ 688	+ 87.87
Commercial and industrial	22,450	+ 94	− 208	− 0.92
Real estate	20,954	+ 53	+ 1,295	+ 6.59
Consumer instalment	11,590	+ 37	+ 1,285	+ 12.47
U.S. Treasury securities	8,879	+ 121	+ 192	+ 2.21
Other securities	12,463	− 175	− 372	− 2.90
Deposits (less cash items)—total*	90,068	+ 0	+ 3,364	+ 3.88
Demand deposits (adjusted)	25,847	+ 38	+ 1,824	+ 7.59
U.S. Government deposits	383	− 63	+ 58	+ 17.85
Time deposits—total*	62,177	− 187	+ 1,466	+ 2.41
States and political subdivisions	4,978	− 89	− 857	− 14.69
Savings deposits	28,375	+ 151	+ 7,032	+ 32.95
Other time deposits‡	26,589	− 156	− 3,423	− 11.41
Large negotiable CD's	10,490	− 324	− 5,198	− 33.13

Weekly Averages of Daily Figures	Week ended 10/27/76	Week ended 10/20/76	Comparable year-ago period
Member Bank Reserve Position			
Excess Reserves	+ 7	− 37	+ 31
Borrowings	54	1	1
Net free(+)/Net borrowed (−)	− 47	− 38	+ 30
Federal Funds—Seven Large Banks			
Interbank Federal fund transactions			
Net purchases (+)/Net sales (−)	+ 223	+ 12	+ 301
Transactions of U.S. security dealers			
Net loans (+)/Net borrowings (−)	+ 270	+ 114	+ 213

*Includes items not shown separately. ‡Individuals, partnerships and corporations.

Editorial comments may be addressed to the editor (William Burke) or to the author. . . .
Information on this and other publications can be obtained by calling or writing the Public Information Section, Federal Reserve Bank of San Francisco, P.O. Box 7702, San Francisco 94120. Phone (415) 544-2184.