

# FEDERAL EXPENDITURE POLICY FOR ECONOMIC GROWTH AND STABILITY IN THE AREA OF NATURAL-RESOURCE DEVELOPMENT WITH SPECIAL REFERENCE TO THE POTENTIAL IMPACT OF ATOMIC-ENERGY DEVELOPMENTS ON THE ENERGY, FUEL, AND POWER ECONOMIES OF THE COUNTRY

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## THE BROAD OBJECTIVES OF THE UNITED STATES ATOMIC-ENERGY PROGRAM

The broad objectives of the atomic-energy program in the United States can perhaps best be stated by quoting from the declaration of the Atomic Energy Act of 1954:

1. Atomic energy is capable of application for peaceable as well as military purposes. It is, therefore, declared to be the policy of the United States:

(a) The development, use, and control of atomic energy shall be directed so as to make the maximum contribution to the general welfare, subject at all times to the paramount objective of making the maximum contribution to the common defense and security.

(b) The development, use, and control of atomic energy shall be directed so as to promote world peace, improve the general welfare, increase the standard of living, and strengthen free competition in private enterprise.

The purpose of this paper is to examine, in the light of the aforementioned policy statement, the present status of the atomic-energy industry in the United States and the direction in which it is likely to move—keeping in mind the impact of fast or slow rates of atomic-energy growth on the competitive energy, fuel, and power economies of the country.

In the first part of this paper it will be assumed that the speed and direction (as well as the incidence and degree of impact) of the United States atomic-energy industry will essentially be in response to economic forces. In the latter part of this paper certain changes in the rules of the game will be considered and the probable effects of the changes discussed.

## WORK ALREADY DONE IN THE FIELD

A great deal of basic work has already been done (and continues to be done) in the field of inquiry under discussion. Because of the limited amount of time available for the preparation of this paper it was considered necessary to draw heavily on the basic material which has already been gathered and analyzed.

## AN ANALYSIS OF THE UNITED STATES ENERGY ECONOMY

Before discussing the potential growth of atomic-energy use in the United States economy, it will perhaps be desirable to take a brief look at the market for energy sources before the entry of the new fuel.

Very detailed and comprehensive studies are available on energy production and consumption in the United States (see, for example, Barnett, Lyon, and Colby). Data were taken from Barnett, Lyon, and Colby, sources in the Federal Power Commission, the Census Bureau, and from worksheets prepared by the author in order to draw up the rough sketch of energy flow in the United States in 1947. Data for 1954 are still being revised; however, the sketch given as figure 1 in this paper will serve the purposes of the present discussion.

In the preparation of figure 1, from another study, various components of energy consumption were systematically removed from the estimated total production of energy in the United States in 1947 until only that component remained which was consumed by the manufacturing industries for nonpower purposes (please see the bar on the extreme right).

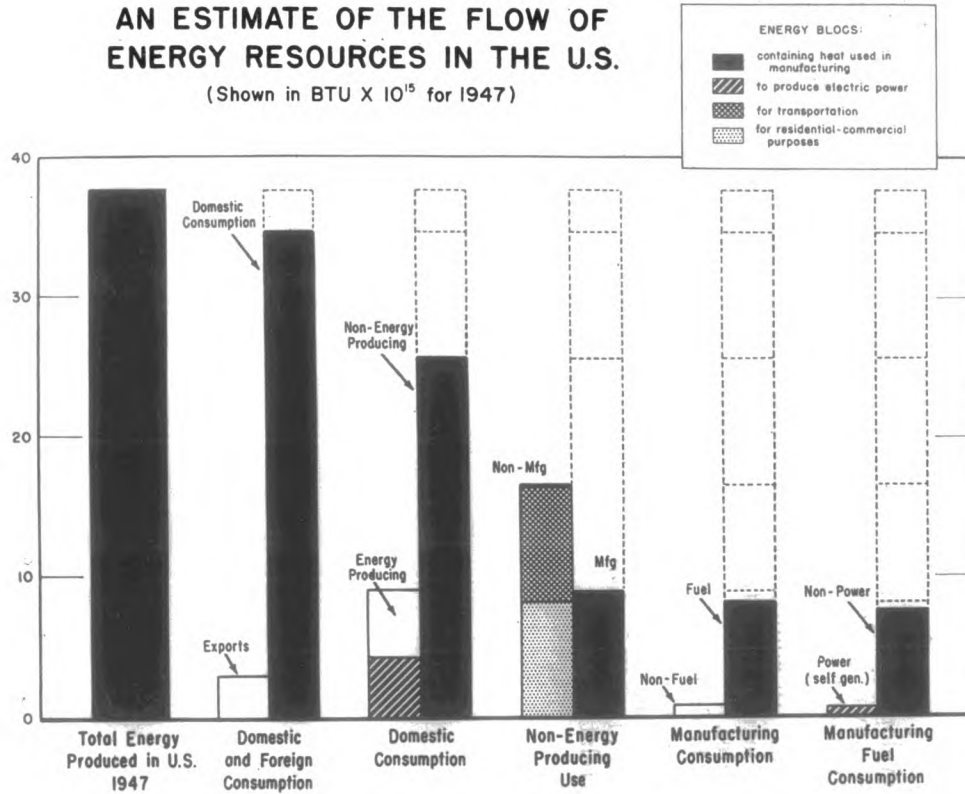
The key or legend indicates those components of the energy market which may feel a more direct impact in the years ahead. The order in which the components are listed (power, industrial heat, transportation, and residential-commercial) are roughly ordered according to the amount of study to which each component has been subjected as a potential market for atomic energy. At one time it was generally held that the above-mentioned order also ranked the various component markets according to the degree of attractiveness (from the standpoint of atomic energy); however, there are many people in the field who now feel that this is not true.

In this paper the component markets will be discussed in the order indicated by the legend of figure 1.

FIGURE 1

# AN ESTIMATE OF THE FLOW OF ENERGY RESOURCES IN THE U.S.

(Shown in BTU X 10<sup>15</sup> for 1947)



## THE MARKET POTENTIAL OF NUCLEAR ENERGY IN THE UNITED STATES

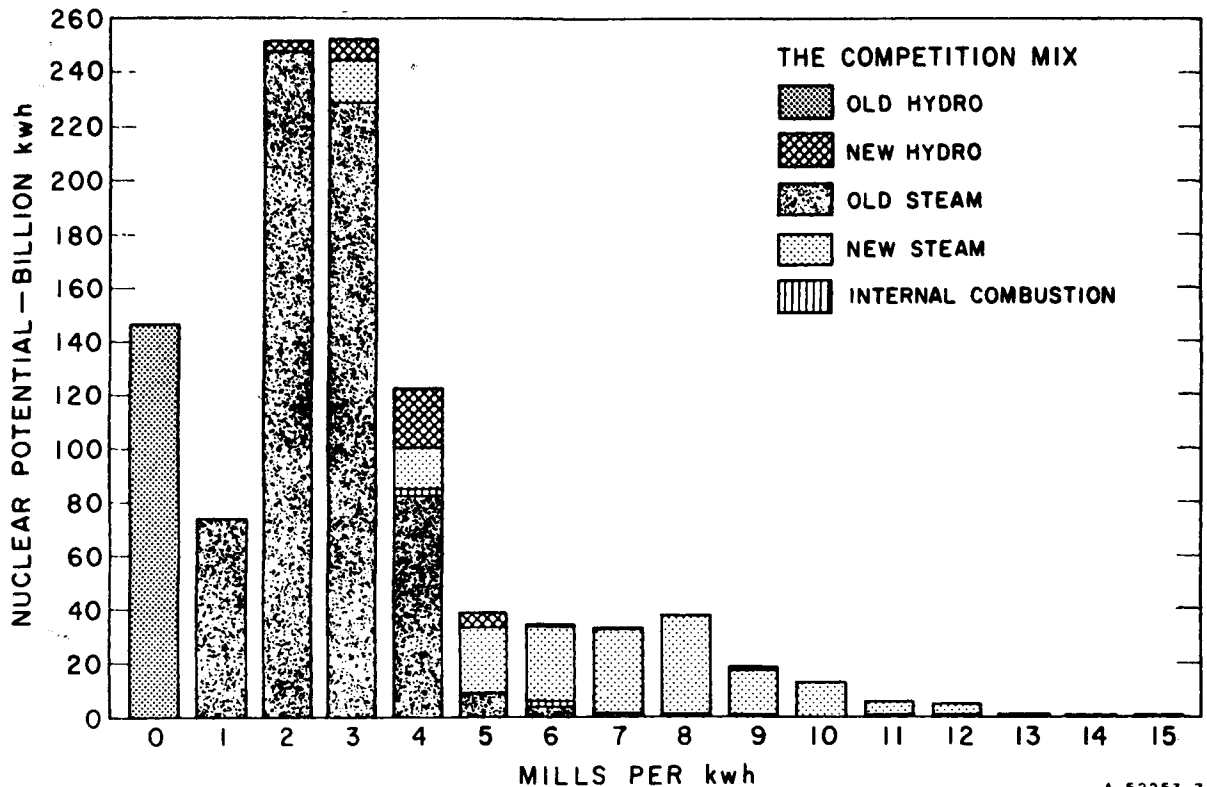
*Power*

The data given in figure 2 (taken from another study) illustrate the economic setting within which nuclear power finds itself now and will find itself in the years immediately ahead in the United States. In other words, if nuclear power can be generated only at costs in excess of 10 or 12 mills per kilowatt-hour, such power is of little economic interest in the United States.

If nuclear-power costs can be reduced over time, roughly as illustrated by the line given in figure 3, then one can derive a projected development of nuclear power shaped primarily by economic forces, as shown in figure 4. Note that only a very slow growth can be expected before 1970. Most of the growth will take place at the expense of steam-electric plants which would otherwise have been built. In addition, the bulk of the fuel which will be displaced, as nuclear power enters the market, will be bituminous coal in the United States.

The data given in figures 5 and 6 indicate the existing and projected differences between the power-market situation in the United States and other areas. Whereas there is a large and immediate market for 12- to 15-mill nuclear power in Europe, the market in the United States is relatively small.

FIGURE 2

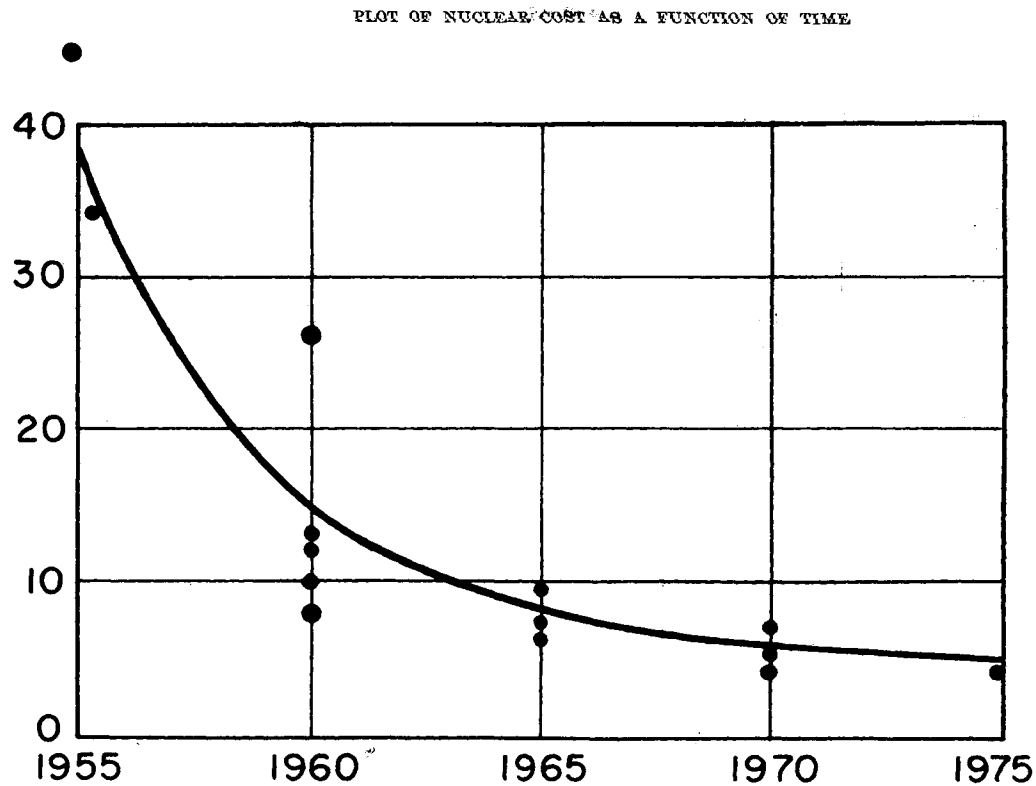


THE MARKET POTENTIAL FOR NUCLEAR POWER AT VARIOUS COSTS OF GENERATION, 1965

A-52253-7

GENERATING COST OF NUCLEAR POWER

mills / kwh



A-52140-5-9

FIGURE 3

FIGURE 4

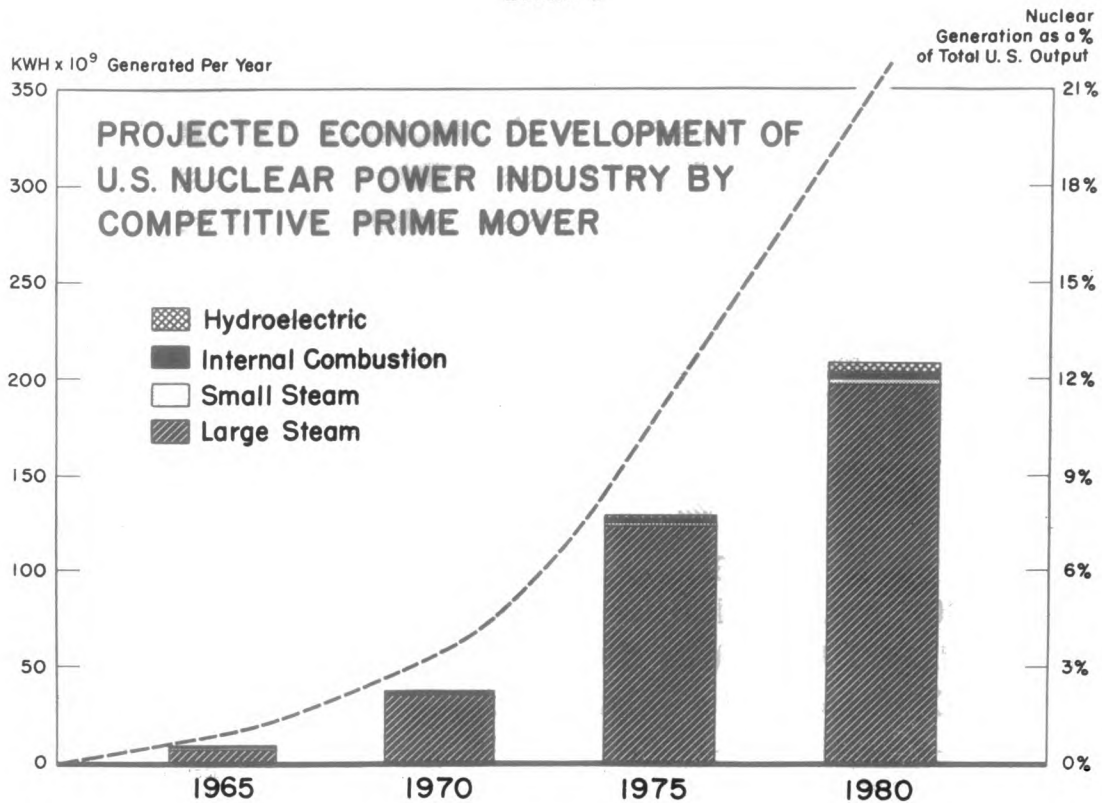


FIGURE 5

Potentials Shown in  
KWH x 10<sup>9</sup> Per Year

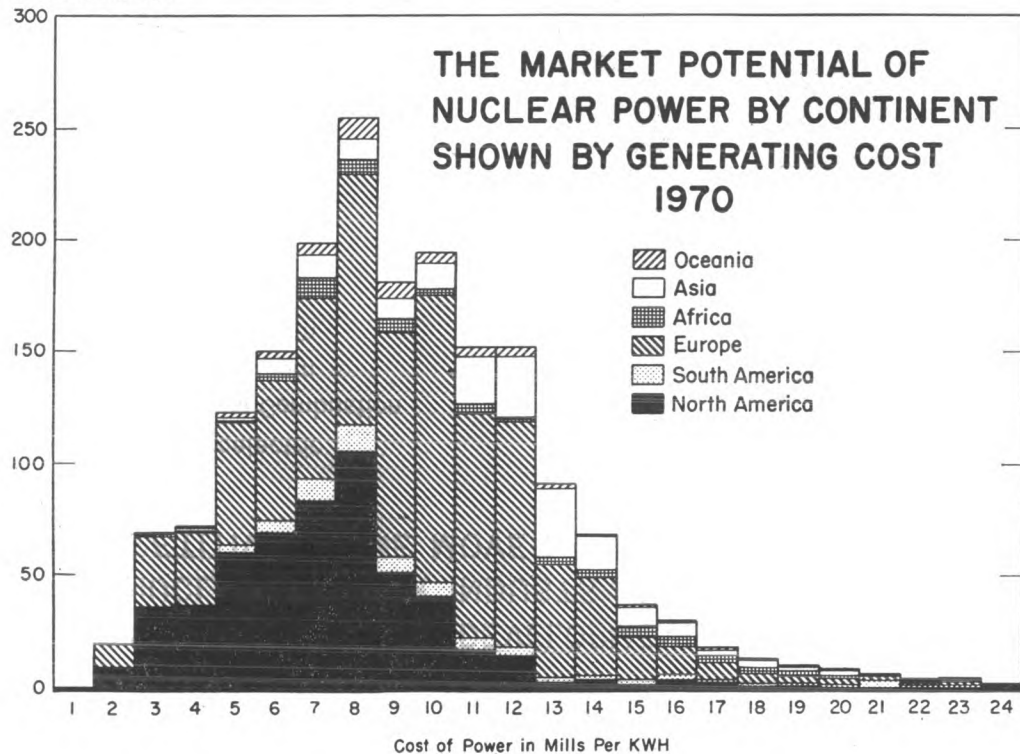
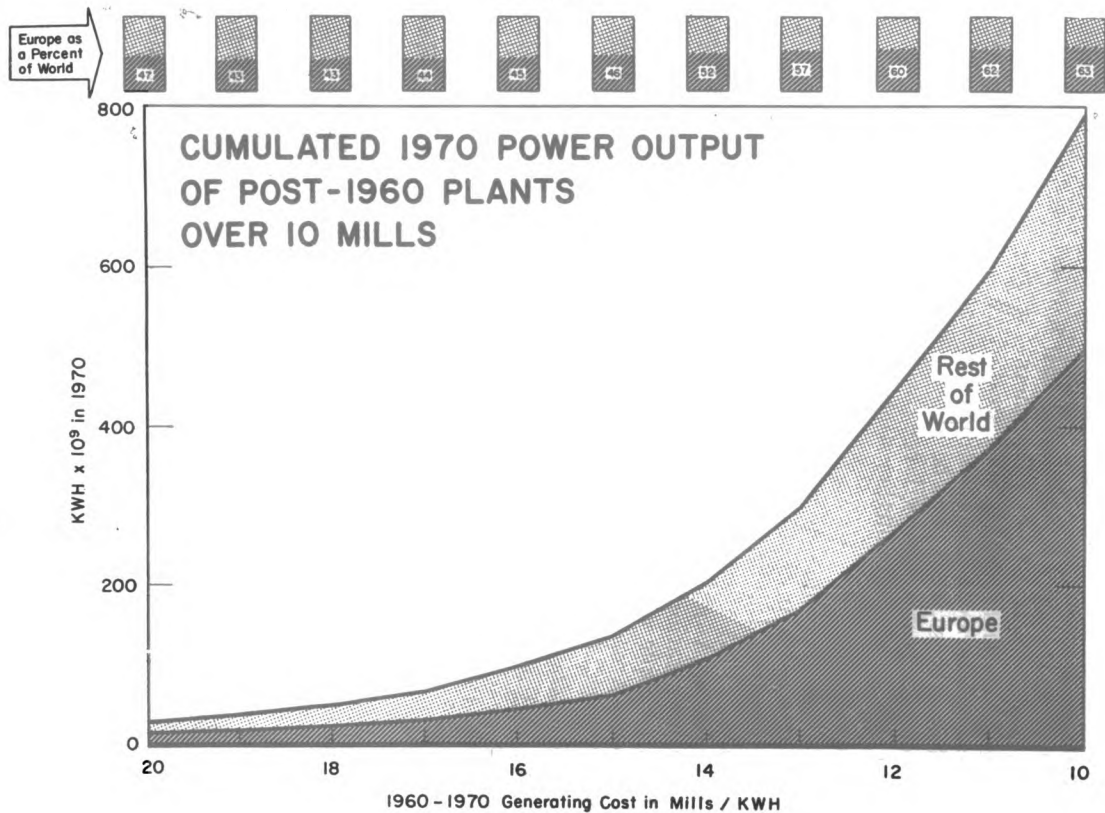




FIGURE 6



*Industrial heat*

The bulk of the boilers sold to the manufacturing industries in the United States are used to generate heat rather than electric power. Of course, some boilers are used to make steam which in turn generates power and later gives up additional energy to supply heat to industrial processes.

The characteristics of industrial-heat boilers may be somewhat discouraging to nuclear-reactor designers since they must be cheap, small, and generate small amounts of steam at low pressure. However, if nuclear reactors can generate steam of the same quality and quantity at a lower price, they will be able to invade a large and expanding market. Estimates of how large the industrial-heat market is at each price level must await further study.

*Transportation*

A technical-economic study of the potential of nuclear energy in the field of marine propulsion is currently being undertaken by Stanford Research Institute and the American Standard atomic-energy division. This work is being sponsored by the Maritime Commission and the Atomic Energy Commission. Studies in other branches of transportation have been undertaken by several other groups. Among people working in this field are Dr. Lyle Borst, of New York University, who has done work in the possible application of nuclear energy to rail transportation.

*Residential-commercial applications*

A relatively small amount of work has been done in this field. However, Schurr and Marschak did give the subject some attention in their study, *Economic Aspects of Atomic Energy*.

## CONCLUSIONS REGARDING THE MARKET POTENTIAL OF NUCLEAR ENERGY

The conclusions, regardless of application, will, of course, always be the same. In a greatly simplified form, one can always say that it is merely a matter of cost. At this point a great deal of the simplicity disappears.

The energy-cost structure varies from area to area, so that nuclear energy for a particular application is likely to be competitive in certain areas sooner than in others. The energy-cost structure in the United States is such that, although the total market (at all price levels) is large, the size of the market at higher price levels is very small. For this reason, the atomic-energy industry in the United States is likely to grow less rapidly than in other areas if the development of the industry is determined by economic forces alone. Stated somewhat differently, the likely penetration of nuclear energy into markets now held by other sources of energy, fossil fuels, and conventional generating equipment will tend to be smaller in the United States than in other areas of the world.

In Geneva paper P/475, the author concluded that nuclear-energy costs will have to be reduced—nuclear energy cannot expect the costs of conventional sources of energy to rise substantially in the United States in the years ahead. In the paragraphs which follow, some general consideration will be given to the prospects for reducing nuclear-energy costs.

## PROSPECTS FOR NUCLEAR ENERGY COST REDUCTION

Nuclear-energy use in the United States can be expected to grow faster than a rate such as suggested by figure 4 if costs are reduced at a rate faster than given in figure 3. The effective costs of nuclear energy can be reduced by (1) research and technical progress, or by (2) administrative action. Examples of both methods are suggested in the paragraphs which follow.

From the standpoint of the powerplant operator, the cost of nuclear power is composed of elements which are similar to those which constitute the cost of generating power by conventional means. In order to illustrate the similarities (as well as the differences), an analysis of the cost of power from a large (100–150 megawatt) nuclear powerplant built in the 1960–70 period is given in table 1. The figures given in table 1 are given for illustrative purposes only; however, the magnitudes of the figures are not unreasonable.

TABLE 1.—*An analysis of the cost of nuclear power produced by a 100–150-megawatt plant in the 1960–70 period*

<i>Cost component</i>	<i>Estimated cost in mills per kilowatt-hour</i>
Plant <sup>1</sup> .....	6.0
Operation and maintenance .....	1.0
Fuel:	
Uranium consumption .....	1.0
Fuel fabrication .....	1.5
Fuel reprocessing .....	2.0
Fuel-inventory charge .....	.5
Gross cost of production .....	12.0
Plutonium credit .....	2.0
Incentive credit .....	(2)
Byproduct credit .....	(2)
Net cost of production .....	10.0

<sup>1</sup> At about \$200 per kilowatt of plant capacity, 13.5 percent overall investment charge, and 50 percent lifetime plant factor.

<sup>2</sup> Not known.

A plant cost of around \$200 per kilowatt of capacity does not seem unreasonable in view of the estimates made by such reactor builders as General Electric, Babcock & Wilcox, and North American Aviation Corporation. A good estimate of operation charges must await the actual operation of a commercial nuclear powerplant for some period of time. It is possible, of course, to design a nuclear-power station in such a manner as to reduce plant costs at the expense of higher fuel and operating costs, or the other way round. Even the fuel cost components can be varied by the design of the plant. Uranium consumption can be reduced at the expense of high-cost fabrication and fuel reprocessing; it may be possible to eliminate fuel-reprocessing costs (and also plutonium credits) and reduce uranium consumption per kilowatt-hour through the use of very expensive fuel fabrication techniques, and by discarding long irradiated fuel elements. The optimum cycle and the final level of costs reached by each component will be determined through a whole series of cost-balancing and cost-trading activities between cost components, as reflected by a design and development program.

## COMPETITIVE POSITION OF NUCLEAR POWER

For purposes of discussion, let it be assumed that nuclear power could be produced at a given place for 10 mills per kilowatt-hour. Assume, also, that a comparable amount of power could be produced by conventional means at the same time and place for 7 mills per kilowatt-hour. Faced with such alternatives, the powerplant executive would, in all probability, elect to build the conventional plant.<sup>1</sup>

But let it be assumed that the Government would like to encourage the construction of the nuclear plant as a means toward fulfilling a Government objective. The nuclear plant can be built by the Government with public funds, or the Government can provide an incentive credit to encourage the construction of the nuclear plant, and thereby make nuclear power competitive in the eyes of the powerplant operator. The incentive credit can be given directly by a capital subsidy or an outright operating grant, or indirectly by one of a number of means, including the following:

1. Waiving of fuel charges.
2. Interest-free or low-interest-bearing loans.
3. Low charges for use of Government goods and services.
4. Reduction in price of fuel.
5. Increase in the credit for plutonium.
6. Purchase of nuclear powerplant operating reports.

## SIGNIFICANCE OF INCENTIVE CREDITS

Direct subsidies can be designed to encourage nuclear powerplant construction without affecting powerplant design. However, the effects of indirect subsidies are much harder to control. If a government wishes to encourage a reactor operating by reducing chemical processing charges, it discourages entry into the processing field by the chemical industry. If the price of fuel is reduced, then designers will be encouraged to waste fuel and save expensive plant. If the price of plutonium is raised, then plant designs and operating cycles will be shifted accordingly.

From the standpoint of the equipment suppliers and powerplant operators, it will be extremely difficult to make plans for the future if indirect incentive credits are used and frequently changed.

Unexpected changes in prices due to policy shifts could cause a great deal of hardship to the individual manufacturer. However, no business enterprise is wholly immune from such hazards; most businesses are affected to some degree by changes in taxes, tariffs, tolls, and regulations resulting from Government policy decisions.

## RELATIONSHIP OF PRICE TO COST

Some have suggested that Government prices for goods and services should be made equal to their costs—but to which costs? Let it be

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<sup>1</sup>The author recently conducted a survey among leading powerplant executives of power-producing organizations in the southern United States. It was found that the power executives were of the opinion that: (1) Nuclear and conventional power generation costs should be figured on the same basis (13-15 percent overall investment charge; 50-60 percent lifetime plant factor, etc.). (2) Nuclear plants should be installed only when and if the cost of nuclear power is equal to or less than the cost of conventional power on a comparable basis.

assumed that irradiated fuel from many nuclear powerplants will be reprocessed in a Central Government chemical reprocessing plant. The basis for pricing could be any one of the following costs:

1. Average cost at present plant throughput.
2. Average cost at optimum plant throughput.
3. Average cost at maximum plant throughput.
4. Marginal cost at present plant throughput.
5. Marginal cost at maximum plant throughput.

Each price would have different advantages and disadvantages, and a different set of impacts. It is important, therefore, that each manufacturer become familiar with the pricing policies and bases of the Government before becoming heavily committed in any particular direction (or with any particular reactor type) in the nuclear-power field.

### CONCLUSIONS

On the basis of facts developed by studies mentioned in this paper and by other studies in the field it is most difficult to prove an economic need for nuclear energy in the United States.

If one seeks to prove a need for nuclear energy now in order to conserve valuable, limited fossil fuels, he must in turn prove that the fossil fuel saved now will be more valuable in the future than the uranium, stainless steel, and zirconium used now—and thereby effectively not available in the future. Stated somewhat differently, one must prove that the higher fuel cost or expenditure now will be more than offset by even higher fuel revenues in the future.

It might be easier to show that nuclear-power development should be encouraged because the additional cost associated with nuclear-power generation will be more than offset by the additional non-power-economic benefits brought to the country or to a particular region. For example, the presence of a nuclear-power industry in a particular State (or in the country as a whole) might attract sufficient ancillary economic activity to justify the payment of a subsidy by the shareholders of the company, by the ratepayers of the system, or by the taxpayers of the State.

It might, on the other hand, be easier to prove a future economic need for nuclear energy in terms of the economic benefits which will accrue to the American economy should the United States become a nuclear workshop supplying reactors to all parts of the world as nuclear power becomes competitive with power generated from local, conventional resources. In this case it might be held that the dollars invested today in the nuclear-energy field will be returned many times over in the future. Persons holding this position would, in the final analysis, also have to hold that public or private dollars invested in this direction will show a greater social or private return than an equivalent sum invested in any other available direction.

If one determines that there is a noneconomic need (such as international prestige) to encourage or expand the use of nuclear energy, then there is a cost involved and either or both of two action courses are suggested: Government construction and/or subsidies for private construction. It is beyond the scope of this paper to discuss the relative merits of either of these courses of action; however, it is clear that some concrete aid (other than the removal of restrictive rules,

regulations, and laws) is called for if the industry is to be encouraged. Subsidies for encouragement can come from such groups as shareholders, ratepayers, or taxpayers.

If the subsidy rather than the public construction course is taken, then there are many economic arguments which tend to favor the use of a direct subsidy or capital grant even though such action may be politically difficult to take. In the end, it will produce the same effect at a lower overall cost.

The amount of direct subsidy or capital grant needed to encourage a given, desired amount of activity in the nuclear-energy field is directly proportional to the competitive gap between nuclear and non-nuclear-fuel costs. This suggests that consideration might be given to the granting of subsidies to United States firms engaged in nuclear-energy activities in high-fuel-cost areas overseas.