FINANCING THE NUCLEAR FUEL REQUIREMENTS OF PUBLIC UTILITIES

ABSTRACT

A major portion of new electric generating capacity will be nuclear powered. The change to nuclear power will require large outlays of capital not required with conventional fuels to finance nuclear fuel inventories. Nuclear fuel financing requirements are unique because nuclear fuel is not consumed in the same manner as conventional fuels. Financing has not been a problem to date because nuclear fuel can be obtained only through lease from the Atomic Energy Commission. This arrangement will be terminated by June 30, 1973 and from that date on all nuclear fuel must be privately owned. Electric utilities have shown an interest in continuing leasing arrangements with the government's role as lessor being assumed by private suppliers. Leasing and other financing alternatives available to the utilities are compared using the Minimum Revenue Requirements Discipline. It is shown that the alternatives for leasing nuclear fuel produce higher revenue requirements than does ownership by the utility. A financing plan is proposed that can be tailored to the specific requirements of the utility. Legal and accounting uncertainties that presently surround the financing of nuclear fuel are presented to show how these intangible factors may have a greater influence on the decision to lease than the long-range economic advantage of fuel ownership.

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BY

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FINANCING THE NUCLEAR FUEL REQUIREMENTS OF PUBLIC UTILITIES

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PREFACE

The 100th order for a commercial, nuclear powered electricity generating unit, is expected to be committed early in 1969.[1] When this unit is placed in service, sometime in 1974 or 1975, the United States will have installed 72,000 megawatts (Mw) of nuclear powered generating capacity. This is more capacity than the total installed generating capacity of the United States in 1950.

Growth in the use of electricity in the United States has averaged 7.7 per cent over the last five years and is expected to average at least 7.2 per cent through the early 1970's.[2] This increase in use will require a doubling of the nation's installed generating capacity every decade for the next 20 to 30 years. The capacity to be installed will be made up of hydro, fossil-fueled and nuclear powered units, with the relative proportion of hydro power additions declining and the proportion of nuclear powered capacity increasing. It is expected that by 1980 approximately 65 per cent of all new thermal plant additions will use

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[1] Electrical World, November 18, 1968, p. 59

[2] Joseph C. Swidler, "A Look at National Power Survey Projections" Public Utilities Fortnightly, December 7, 1967, p. 16

nuclear fuel and that the total nuclear capacity will constitute 25-30 per cent of the total United States generating capacity. The cost of nuclear fuel consumed by 1980 is estimated to be $15 billion.[3]

The cost of nuclear fuel has not presented legal, accounting or financial problems up to this time because there has been only one source of uranium for fueling nuclear reactors, the United States Government.

> Companies now operating nuclear power plants obtain their uranium for fuel by leasing it from the Atomic Energy Commission instead of owning it themselves. Under amendments to the Atomic Energy Act in 1964, however, which provided for private ownership of special nuclear material, no additional quantities of enriched uranium will be leased after December 31, 1970, and all leases will terminate by June 30, 1973.
>
> Because of the availability of leasing, the present operators of nuclear power plants presumably have not had any serious problems with financing their fuel inventories. But by July 1, 1973, the financing requirements for nuclear fuel could be substantial. Their magnitude can be appreciated by comparing the high cost of a nuclear fuel inventory with the cost of fuel for conventional power plants. As a percentage of total cost, the initial fuel inventory ranges from zero per cent, in the case of gas-fueled or hydro generating plants, to approximately 3 per cent for a coal-fueled plant. By contrast, the cost of the initial fuel inventory for a nuclear generating plant is presently about 20 per cent of the total cost of the plant, due, in part, to the expensive nature

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[3] Ralph W. Deuster and John D. McDaniels, Jr., "Nuclear Fuel Management: Factors to Consider" _Electrical World_, November 11, 1968, p. 27

> of nuclear fuel material and to the necessity for a large quantity which will not be consumed to be present in the reactor for continuation of the power-producing nuclear reaction.[4]

The purpose of this thesis is to compare the relative merits of owning and leasing nuclear fuel. A long-range economic comparison will be made using the Minimum Revenue Requirements Discipline. A financing plan is developed that is suitable for the specific needs generated by substantial investment in intermediate-term assets. The legal and accounting uncertainties that presently surround the financing of nuclear fuel are presented to show how these intangible factors can have a greater influence on the lease versus own decision than the long-range cost of one alternative over another.

The author acknowledges the contribution of Leonard Van Nimwegen of the Engineering Economist's Division, Public Service Electric and Gas Company for the preparation of the computer program used to calculate the revenue requirements for the nuclear fuel ownership plans investigated, and thanks him for his invaluable discussions on the costs of money. The author wishes to thank Elizabeth A. Maguire for typing, proofreading and suggesting changes to the manuscript.

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[4] C. D. French and R. C. Woodbury, "Mortgage Financing of Nuclear Fuel," <u>Public Utilities Fortnightly</u>, March 28, 1968, pp. 23, 24

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NUCLEAR FUEL--HOW DOES IT DIFFER FROM OTHER FUELS?

To provide background information relevant to the understanding of nuclear fuel financing and how nuclear financing differs from ordinary utility financing for other purposes, this chapter will deal briefly with the growth of the electric utility industry, describe the fuel requirements of conventional and nuclear power plants and include a description of the nuclear fuel cycle. Since it is not the purpose of this thesis to deal with the technical aspects of nuclear fuel management, the description of the nuclear fuel cycle will not go into a great deal of detail. However, because of the unique nature of the legal, accounting and financing problems generated by the use of nuclear fuels to produce electricity, some understanding of the nuclear fuel cycle is a necessary prerequisite to the analysis and evaluation of these non-technical problems.

ELECTRIC UTILITY GROWTH

Along with the automobile, aircraft and electronic industries, the electric power industry is one of the youngest industries. It is also the nation's largest industry, having a total net plant investment in 1966 of some $62 billion. While most manufacturing industries have a plant investment of approximately fifty cents for every dollar of revenue, the electric power industry has an average plant investment of more than four dollars for every dollar of revenue.[5]

Early Development

The first application of electricity for commercial purposes occurred in 1879 when the California Electric Company of San Francisco was established to provide electric arc-lighting service to local businesses. This company used the arc-lighting system developed by Charles Brush two years earlier. The primary use for arc-lighting was to provide lighting for streets and town squares that was more intense than could be obtained from the gas lamps that were then in use.

Also in 1879, Thomas A. Edison demonstrated the first practical incandescent electric light bulb. Between 1879 and 1882 Edison continued the development of his incandescent bulb and also worked on plans for an electrical distribution system and a central generating station to supply the electrical energy requirements of many lighting customers. On September 4, 1882, the first of Edison's central stations began operation at its Pearl Street location in downtown New York City. This station had six "large" generators with a capacity of 120 kilowatts (Kw) each. The source of power

[5] Federal Power Commission, "Statistics of Privately Owned Electric Utilities in the United States 1966" September, 1967, p. XX, and "Statistics of Publicly Owned Electric Utilities in the United States 1966" November, 1967, p. X

for these generators was steam. Later the same month, the second Edison station began operation at Appleton, Wisconsin. This station used generators driven by hydraulic turbines.

The earliest generating stations supplied direct current electricity, and direct current, at the then available voltages was uneconomical when transmitted over long distances.

> Edison's system was the first to make house-to-house distribution of electric power practicable. But it had serious drawbacks. For example, the distribution system required such an expensive investment in copper cables that the area a generating station could serve was severely limited. The stations had to be located in the immediate area where the electricity was to be used. Better, more economic methods of producing and transmitting energy had to be developed before electricity could be brought to any but the largest, most densely populated cities.[6]

Developments were not long in coming. The efficiency of Edison's lamps was improved so that the consumption of electricity was reduced from 6.5 watts per candle in 1882 to 3.1 watts per candle in 1890. The development of the steam turbine brought about the replacement of the steam engine as the primary source of power and made it possible to generate a watt of power with fewer pounds of coal. In 1886, William Stanley, under the sponsorship of George Westinghouse, demonstrated the first alternating

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[6] Edwin Vennard, The Electric Power Business, McGraw-Hill Book Company, Inc., New York, 1962, p. 8

current system in America. This system was placed in service in Great Barrington, Massachusetts, and the initial customers were composed of "...13 stores, 2 hotels, 2 doctors' offices, one barber shop and the telephone and post offices."[7] With the introduction of alternating current it was no longer necessary to generate, transmit, and utilize electricity all at the same voltage level. With alternating current it was possible to select the best voltage at which to generate electricity, transform the voltage to the optimum level for transmission to the load center, and again transform the voltage to a level suitable for use by the customer. The use of the alternating current system reduced the amount of power lost during transmission with the result that central stations no longer had to be located in the areas where electricity was being used.

As the use of electricity grew central stations began to appear in most cities and towns. Usually these early power systems were owned by one individual or a small group of individuals. Since the central station usually served only one town and the surrounding area, transmission lines were used only for the local needs. Central stations were small with only one or two generators available to serve

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[7] Electrical Transmission and Distribution Reference Book, Central Station Engineers, Westinghouse Electric Corporation, East Pittsburgh, Pennsylvania, 1950, p. 1

the entire load. Service interruptions were frequent because an outage of any major component of the system meant that the entire system had to be shut down while repairs were being made. After 1900 the trend was toward consolidation of the small individually owned companies into larger systems.

Development of Interconnected Systems

As the demand for electricity continued to grow during the early 1900's, the individual company owners found that it became increasingly difficult to raise the capital necessary to expand their plant facilities. It was during this period that many of the owners began to interconnect their individual distribution systems in an effort to reduce the frequency of service interruptions. This joining of the small companies' facilities into larger systems resulted in savings to the owners by eliminating unnecessary duplication of equipment. Increased quality of service and reduced cost produced further growth. With the electrical facilities of the small companies joined together it was a natural step for the companies to merge completely into a common corporate structure.

> Corporate organization, with its greater facility for attracting investment and financing, came slowly. By 1902, however, 73 per cent of the 2,805 investor-owned central stations were owned by companies, and the percentage increased year by year.

> By 1910 electric utility men were able to see a pattern in the growth of their industry. Like any new business, the companies had first served the market that was immediately available and promised the surest return: the thickly populated centers. Experience in producing and selling electricity, coupled with technical advances, then made it possible for the companies to serve smaller population centers. With further technical advances it became possible to bring electricity to even small towns and villages. In this way, electric service moved step by step from the large cities, to the towns, to the small villages and rural areas, until today, only about eighty years after Edison developed his light bulb, electric service is available to virtually everyone in the country.[8]

Technical developments in high voltage transmission made it possible to build long transmission lines between major load centers, and between load centers and sources of low cost energy. A well integrated transmission system made it possible to install larger generating units than could be installed on any one isolated system because the interconnected systems provide emergency back-up and spinning reserve for the time when the large unit is forced out of service. Larger more efficient generating units were developed, permitting the utilities to take advantage of the economies of scale. As a direct result of these economies, which were brought about by advances in turbine technology, the average rate of fuel consumption for the production of one kilowatt-hour of electricity was reduced from about 8 pounds in 1892, to approximately 0.85 pounds today. This

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[8] Edwin Vennard, The Electric Power Business, McGraw-Hill Book Company Inc., New York, 1962, p. 12

reduction is shown graphically in Figure 1. Although the amount of coal required to produce one kilowatt-hour of electricity has been decreasing, the cost of one pound of coal has been increasing. This increase in coal cost in recent years is due primarily to the rising cost of labor in both the mining of the coal and in the shipment of the coal to the point of use, and has generally offset the savings obtained through increased efficiencies in production.

> Recent technological advances in extra-high voltage (EHV) transmission lines have made it more economical to transport energy over wires than to transport coal by rail in certain cases. Consequently, the so-called "mine-mouth power plant" is used in many parts of the country when the available water supply in the coal fields is adequate. To illustrate: Public Service Electric & Gas Company of New Jersey estimated in 1963 that coal at the mine head cost 17 cents per million Btu., while transportation to the company's generators in New Jersey cost an additional 17 cents--a total of 34 cents per million Btu. In contrast, since it cost but 8 cents to ship electricity over EHV lines, mine-mouth power cost a total of only 25 cents per million Btu., representing a difference of 9 cents.[9]

Present steam turbine technology has produced turbines that can produce about as much electricity from a pound of coal as is economically feasible. The point of diminishing returns has been reached in achieving greater efficiencies

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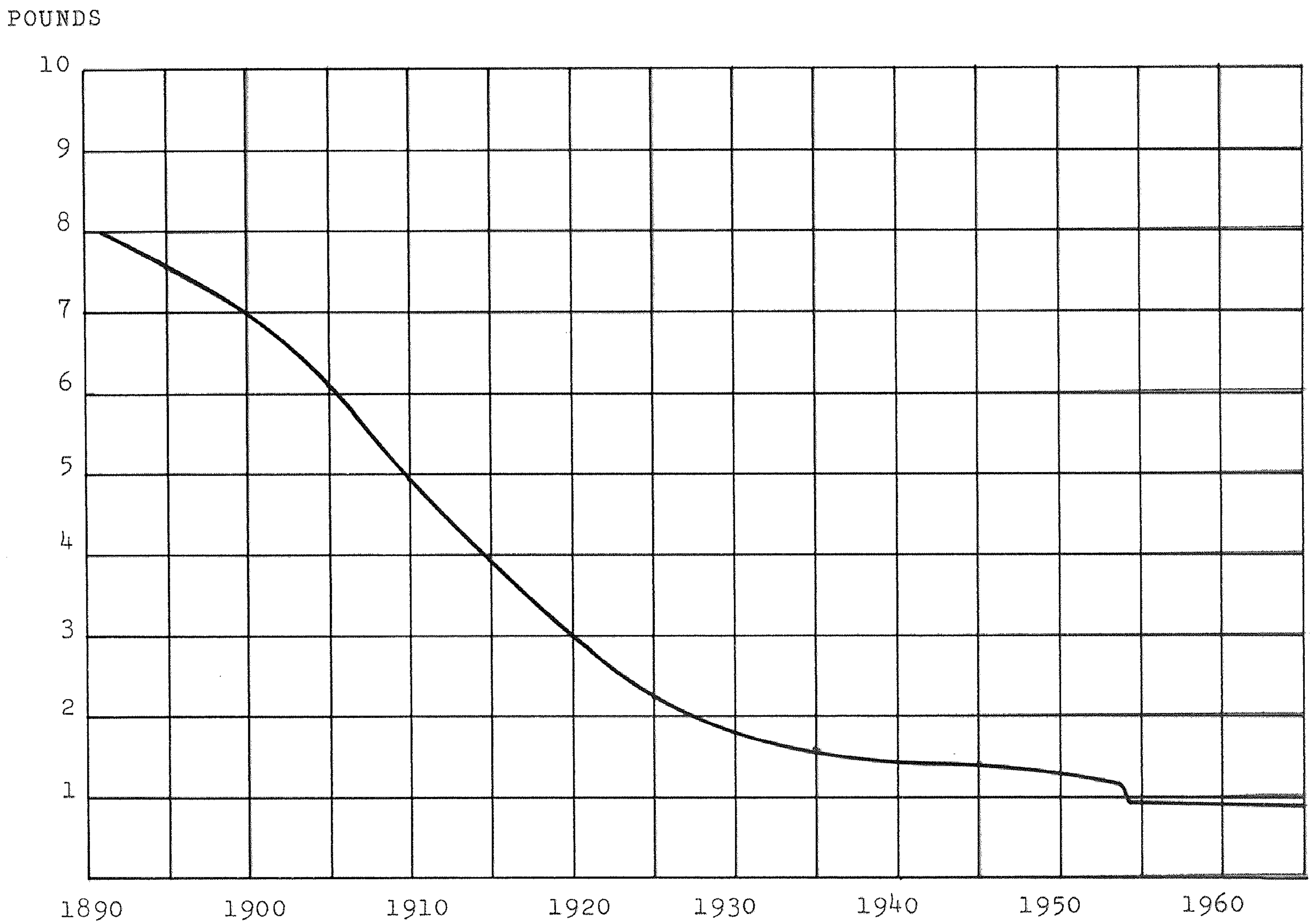
[9] Charles F. Phillips, Jr., The Economics of Regulation, Richard D. Irwin, Inc., Homewood, Illinois, 1965, pp. 568-70

SOURCE: Edwin Vennard, *The Electric Power Business*, McGraw-Hill Book Co. Inc., New York, 1962, p. 117



EQUIVALENT POUNDS OF COAL TO PRODUCE ONE KILOWATT-HOUR

FIGURE 1

in the steam cycle. Fortunately the electric utility industry is now in an era where savings can be realized in the production of electricity through the use of a new energy source. That source is nuclear energy.

Development of Nuclear Power

In 1953, Congress authorized funds for construction of the country's first nuclear reactor to supply steam to a turbogenerator that would be connected to a commercial power system. This nuclear power plant was placed in operation at Shippingport, Pennsylvania in 1957 with an initial capacity of 60 Mw. The reactor for this plant is owned by the Atomic Energy Commission (AEC) because the Atomic Energy Act of 1946, prior to its 1954 amendment, did not permit private ownership of nuclear facilities.[10] The electrical portion of the plant is owned by the Duquesne Light Company at Pittsburgh, Pennsylvania. The plant was built at a cost of $120 million, of which Duquesne provided $15 million for the generating equipment and contributed $5 million toward the cost of the reactor, and the government supplied the remaining $100 million.[11] Based on the initial capacity of

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[10] The Atomic Energy Act of 1946 (the McMahon Act) and its amendments will be discussed in more detail in Chapter II.

[11] Charles F. Phillips, Jr., op. cit., p. 610

60 Mw, the investment of $120 million results in a construction cost per kilowatt of $2,000. This high plant construction cost can be compared with current plant investments for nuclear and conventional thermal power plants that fall in a range between $100-$200/Kw, depending on site conditions and the area in which the plant is being built. It is rather ironic to note that this first nuclear power plant, with production costs of some 60 mills per kilowatt-hour,[12] was built in the heart of the coal fields of western Pennsylvania where conventional power plants are now producing electricity at a cost of less than 3 mills per kilowatt-hour. Since this plant was built for development purposes, it was not intended that the cost of the power produced be competitive with that produced by conventional means.

Subsequent to passage of laws amending the McMahon Act, additional developmental nuclear power plants were built by several investor-owned utilities, and although most of these plants were built in relatively high fuel cost areas, the cost of the power produced (approximately 10 mills/Kw-hr) was still not competitive with conventional power. In 1962 the AEC reported that plants being placed in service during the mid 1960's would be capable of generating power at an

[12] Joint Committee on Atomic Energy, Congress of the United States, Nuclear Power Economics--1962 through 1967, U.S. Government Printing Office, Washington, D.C., February, 1968, p. 86

estimated cost of 5.5-6 mills per kilowatt-hour, and concluded "...that nuclear power is on the threshold of economic competitiveness and can soon be made competitive in areas consuming a significant fraction of the nation's electrical energy; relatively modest assistance by the AEC will assure the crossing of that threshold and bring about widespread acceptance by the utility industry."[13]

In February, 1964, Jersey Central Power & Light Company announced plans to construct the Oyster Creek Nuclear Electric Generating Station at a site near Toms River, New Jersey and that the nuclear plant had a clear-cut economic advantage over a conventional plant at the same site.[14] This announcement touched-off a series of debates as to whether or not the Jersey Central results were valid. The Jersey Central report on "Economic Analysis for Oyster Creek Nuclear Electric Generating Station" dated February 17, 1964, was intensively reviewed by other electric utilities, the AEC, power plant equipment manufacturers, the Federal Power Commission and representatives of the coal industry. The results of these appraisals are contained in Nuclear Power Economics--1962 through 1967, a report of the Joint

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[13] Atomic Energy Commission, Civilian Nuclear Power--A Report to the President--1962, Washington, D. C., November, 1962, p. 34

[14] "Commercial Uranium Market Seen by 70's" C&EN, July 4, 1966, p. 18

Committee on Atomic Energy, Congress of the United States, February, 1968. Although the opinions expressed in this report conflict on the basic question of nuclear plant economics it can be concluded that in areas with fuel costs as high as 28-30 cents per million Btu., nuclear plants are competitive. This conclusion has been justified by the rush to place orders for nuclear generating capacity that has occurred since 1964.

FUEL REQUIREMENTS

There are three major types of generating plants being used by electric utilities today--steam, hydroelectric, and internal combustion. Plants that use internal combustion engines, either diesel or gas turbine, are usually small plants designed to provide emergency power or peaking power. There are also steam and hydroelectric plants that are designed to provide only peaking power. The fuel requirements discussed in this section will be those of base load units only and will not include the requirements of units designed to supply peaking power since they are not pertinent to the discussion of nuclear fuel requirements.

Conventional Plant Fuel Requirements

Hydroelectric power plants have no fuel requirements per se, since they produce electricity through the action of falling water which is used to turn turbines connected to generators. However, to get the water to fall there must be a dam and a reservoir behind the dam to store water. It is usually not feasible to build a dam large enough to provide sufficient water to run the turbines continuously. Because of seasonal variations in stream flow and pondage restrictions of reservoirs, the energy output of hydroelectric plants is generally limited during the summer months when the demand for electricity is greatest. In areas that are supplied by hydroelectric power there must also be steam plants to firm up the power supply.

> At first glance it may seem that hydroelectric power should always be cheaper, because one has to buy fuel for a steam plant, whereas the water is free. However, this overlooks the fact that variable costs, such as fuel cost, are not nearly as important as fixed costs. The fixed costs of a hydro plant are likely to be much higher than for a steam plant.
>
> In the early years of the power business hydroelectric power was generally cheaper than steam power. However, designers and manufacturers have been able to raise the efficiency of steam generation and hold to a minimum the increase in the unit cost of the machines. There has been less opportunity for raising the efficiency of hydro plants. As a result there has been a shift in the relative economy of the two over the years.[15]

Table I shows a comparison of hydro and steam costs for the years 1920 and 1960 that indicates how increases in hydro construction costs and decreases in steam production costs have acted to bring about this shift.

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[15] Edwin Vennard, The Electric Power Business, McGraw-Hill Book Company Inc., New York, 1962, pp. 265-67

TABLE I

COMPARISON OF STEAM AND HYDRO COSTS

	1920	1960
(a) Hydro: Investment in plant (including 20% for transmission) per kilowatt	$240	$336
Fixed Charges: Return on investment	8.0%	6.0%
Depreciation	1.5	1.6
Taxes	1.4	1.8
Total	10.9%	9.4%
(b) Steam: Investment in plant per kilowatt	$140	$135
Fixed Charges: Return on investment	8.0%	6.0%
Depreciation	2.5	2.7
Taxes	2.0	2.5
Total	12.5%	11.2%
Economy: Btu per kilowatt-hour	30,000	9,300
Coal: Pounds coal (of 14,000 Btu per lb)	2.14	0.66
Cost per ton	$4.50	$7.00
(c) Load characteristics: (55% load factor) kilowatt-hours per kilowatt per year	4,820	4,820

Costs
Mills per kilowatt-hour

	1920	1960
(a) Hydro		
Fixed Charges	5.43	6.55
Fuel	0.00	0.00
Labor and Maintenance (including transmission)	0.35	0.89
Total	5.78	7.44
(b) Steam		
Fixed Charges	3.63	3.14
Fuel	4.82	2.31
Labor and Maintenance	1.40	1.01
Total	9.85	6.46

Source: Edwin Vennard, The Electric Power Business, McGraw-Hill Book Company Inc., New York, 1962, p. 267.

During 1966, electric utilities in the United States produced some 1.144 trillion kilowatt-hours of electrical energy. Approximately 17 per cent of this energy was produced by hydroelectric plants and 0.6 per cent was produced by internal combustion units. The remaining 82.4 per cent was produced by steam plants. Of the 942.8 billion kilowatt-hours produced by steam plants, approximately 4.8 billion kilowatt-hours or 6 per cent was generated in nuclear powered plants and the major portion of 94 per cent was produced through the combustion of gas, oil, and coal. Fossil fuel reserves were depleted by 2.6 trillion cubic feet of gas, 141 million barrels of oil and 266 million tons of coal for the production of electricity in 1966.[16] In addition to the fuel actually consumed in production, there is a generally accepted policy throughout the industry that a 60 day fuel reserve will be maintained at those plants that burn coal and oil. Since gas is piped directly to the boilers, no on site reserves are maintained, however reserves are maintained by the gas pipeline companies. Oil and coal reserves are maintained on site to provide for possible interruptions in deliveries that may be caused by strikes in the coal producing regions, railroads or barge lines. Since fuel reserves are not used in the production

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[16] Federal Power Commission, Annual Report, Fiscal Year 1967, Washington, D. C., January 15, 1968, p. 12

of electricity, the cost of these reserves is not recovered as an operating expense and the investment remains in an asset account which is included in the rate base.

To put conventional fuel requirements on an easy to understand base, the requirements for a 1000 Mw, coal-fueled unit will be developed. Assuming a unit heat rate of 9000 Btu/Kw-hr and fuel with a heating value of approximately 10600 Btu/lb, a 1000 Mw unit will require approximately 425 tons of coal every hour. If we further assume that the coal has a delivered cost of 30 cents per million Btu, then the cost of one hour's coal is $2,700. A 60 day fuel reserve for this unit, assuming 85 per cent plant factor, will require storage of 520,000 tons of coal and an investment of $3.3 million, or $3.3 per Kw.

Nuclear Plant Fuel Requirements

Unlike the conventional steam power plant, where fuel is added to the furnace as electricity is being produced, a nuclear steam power plant requires that all the fuel necessary for one year's electrical output be placed in the reactor vessel during the annual maintenance and fueling period. For a nuclear plant with the same electrical output as the plant discussed above (1000 Mw) the initial fuel requirement consists of approximately 90,000 kilograms (99 tons) of uranium fuel. This amount of fuel represents an initial investment of about $30 million, ($30 per kilowatt) or nine times the investment required for the 60 day fuel reserves of a conventional power plant.

The fuel for a typical light-water reactor of this size is contained in a core of three zones. Each zone of the core is made up of fuel assemblies arranged as shown in Figure 2. When the reactor is first placed in operation, the three regions in the core contain fuel with different degrees of enrichment to improve the distribution of heat release within the core. The first refueling operation takes place after about 18 months of operation. At this time the Region 1 fuel assemblies in the central zone are removed from the core and placed in storage to cool. Region 2 is then moved to the space left vacant by the removal of Region 1, and Region 3 is transferred to the intermediate zone. A new region, Region 4 is then placed in the outer zone of the core formerly occupied by Region 3. After another 12 months of operation, Region 2, now in the central zone, is removed, Regions 3 and 4 are moved inward, and Region 5 is installed in the outer zone. This process continues at intervals of 12 months with a new region being added to the outer zone of the core at every refueling. With this refueling pattern, Region 1 operates for 18 months, Region 2 for 30 months, and Region 3 for 42 months. Equilibrium is reached with Region 4 which remains in the core for 36 months, as do all subsequent regions. The investment required for replacement regions is about $10.2 million.

THREE ZONE
NUCLEAR REACTOR CORE

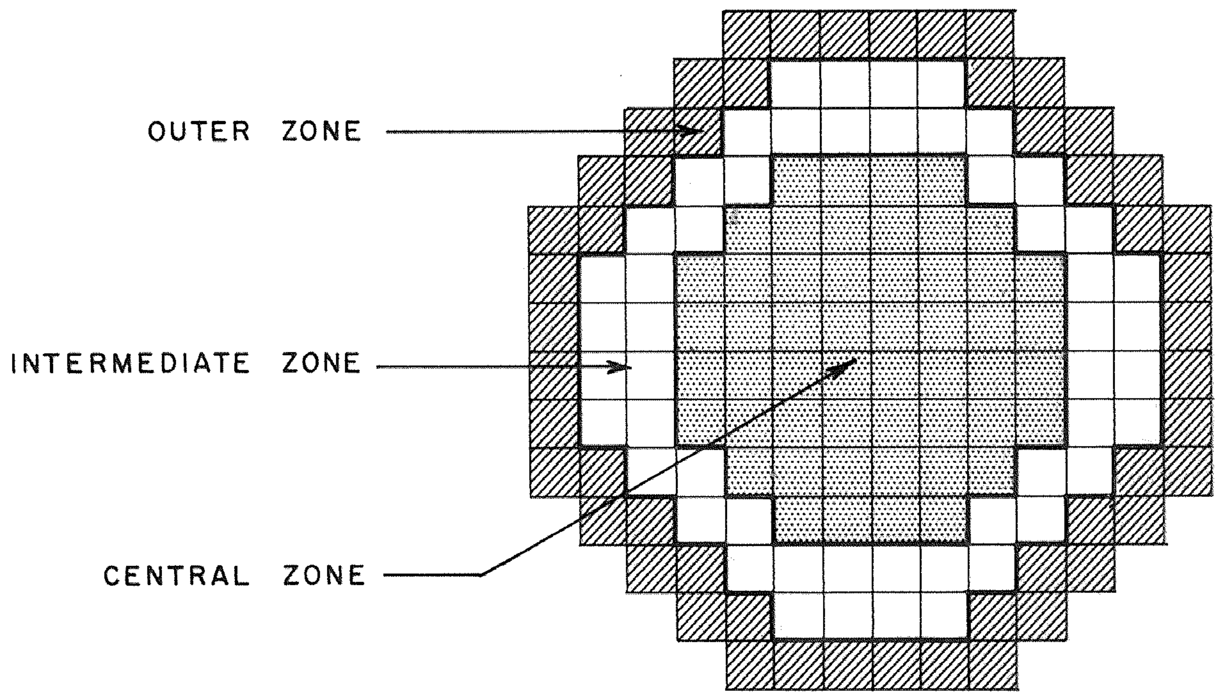

FIGURE 2.

The fuel used in conventional steam plants is a natural fuel (coal, oil or gas) and requires very little processing prior to being consumed. Nuclear fuel however, is extensively processed, refined and fabricated into fuel assemblies before it is placed in a reactor core. The kinds of raw material required and the refining and fabricating processes are identical for all regions of the core. For this reason it is convenient to explain the physical and financial aspects of the fuel cycle by tracing the history and cost development of one region only. Some cost changes result from differences in enrichments and processing times for the various regions, however, the basic procedure used to develop the total cost is the same for all regions.[17]

In describing the physical aspects of the fuel cycle, the quantities of uranium required at each step will be referred to one kilogram (kg) of 3% enriched fuel as it is loaded into one region of the reactor. It should be remembered that each region of a 1000 Mw reactor requires about 30,000 kg. The costs associated with each fuel cycle step will also be referred to the one kg base quantity.

The nuclear fuel cycle can be divided into seven steps. These steps are shown in Figure 3. The cycle begins with

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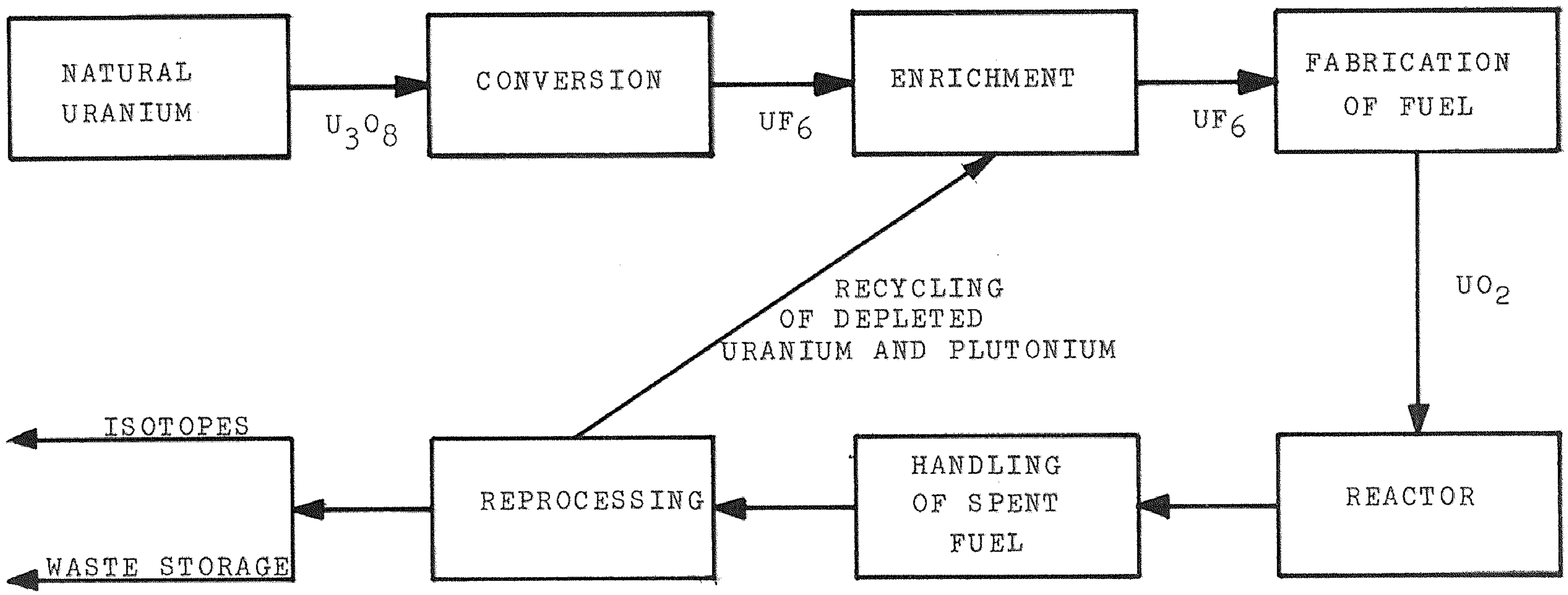
[17] D. J. Povejsil, R. L. Witzke, C. A. De Salvo, "Financial Aspects of the Nuclear Fuel Cycle," Proceedings of the American Power Conference, Vol. XXIX, Chicago, Illinois, 1967, pp. 237-49



NUCLEAR FUEL CYCLE

FIGURE 3

exploration, mining and milling of uranium ore. Uranium is located by the usual exploration techniques supplemented by detection of its radioactivity. The ore is recovered using conventional strip and underground mining methods. The ore is then milled and leached with acid to extract a concentrate known commercially as "yellowcake." This concentrate contains about 85% by weight of U_3O_8. To obtain one kg of fuel requires 6.633 kg of uranium in the form of 7.84 kg (17.25 pounds) of U_3O_8. At a cost of $8 per pound of U_3O_8, the cost associated with Step 1 is $138.

The second step is conversion of the U_3O_8 to gaseous uranium hexafluoride (UF_6). There is a loss of about ½% in the conversion process resulting in an output of 6.6 kg of uranium. Conversion costs about $2.30 per kilogram converted, resulting in a cost for Step 2 of $15.28.

Gaseous UF_6 is required as input to the third step. In its natural state, uranium consists of a small amount of highly fissionable U-235 and the predominant isotope, U-238. Gaseous diffusion (sometimes called isotope separation) raises the concentration of U-235 from the 0.711% found in natural uranium to 2-4%, the level required by light-water reactors currently being built in the U.S. The enrichment process requires 6.6 kg of feed material to produce 1.1 kg of enriched output. The cost of this process varies with the degree of enrichment required and prices are quoted in terms of dollars per kilogram-unit of separative work required. For a 3% enrichment, a total of 3.785 kilogram units of work are required. Enrichment is carried out exclusively by the Atomic Energy Commission at a price in the range of $26-40 per kg-unit of separative work. Based on a price of $30 for 3% enriched uranium, the cost of processing 1.1 kg is $124.90.

Fabrication of the fuel assemblies takes place in Step 4. This step includes conversion of the enriched UF_6 to uranium dioxide (UO_2), compacting the powdered UO_2 into pellets, sintering and grinding the pellets to size and encapsulating the pellets in stainless steel or zirconium rods. The rods containing the nuclear fuel are then fastened together to form the fuel assemblies. The fabrication process involves a loss of nuclear material due to chipped pellets, grinding waste, etc. of approximately 10% of every kilogram of fuel manufactured. The cost of fabricating 1.0 kg of fuel is $90.00. The losses are paid for by the fabricator and result in a credit of $27.82 at the time the fuel is delivered to the power plant.

The fifth step in the fuel cycle is the installation of the nuclear fuel assemblies and operation of the nuclear power plant to produce electricity. Up to this point the fuel cycle has incurred costs, less a credit for excess uranium and excluding financing charges, of about $340 per kg of uranium fuel installed in the reactor core. Since one region of a three region, 1000 Mw reactor requires about 30,000 kg, the cost of fuel at this point is $10.2 million. This is the cost of one "equilibrium" replacement region.

After irradiation in the reactor core for a period of about 36 months, the fuel assemblies are removed from the central zone and transferred to a storage area to cool. Since the irradiated fuel assemblies are highly radioactive they must remain in storage at the plant for a period of 3-4 months and then the spent fuel is placed in heavy lead casks for shipment to the fuel reprocessing plant. Step 6, transportation of the spent fuel involves a cost of $5.00 per kg of uranium initially placed in the reactor.

At the reprocessing plant, Step 7, the spent fuel is chemically treated to separate the uranium, plutonium, other useful fission products and the radioactive waste products. The reclaimed uranium can be returned to the fuel cycle at the enrichment step and the plutonium can be fabricated into new fuel for recycle through the reactor. The other useful fission products are potentially saleable for use in medicine and research, and the radioactive wastes are consigned to a storage area to be buried. The cost of reprocessing one kg of uranium is $33.00. Out of the re-processing step, credits are obtained for the uranium and plutonium recovered. In the case of this one kilogram of fuel, the credits amount to $44.40 for the uranium and $57.92 for the plutonium. The fuel cycle is complete after reprocessing and has produced costs of $406.18 and credits of $130.14, excluding financing charges. These results are summarized in Tables II and III.[18,19]

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[18] D. J. Povejsil, R. L. Witzke, C. A. De Salvo, op. cit.

[19] "A Hard Look at Nuclear Fuel Financing," Nuclear Industry, October, 1968, p. 11

TABLE II

NUCLEAR FUEL CYCLE COSTS AND STEP DURATION

Component	Product	Quantity Kg	Quantity Pounds	Material Cost	Fuel Cycle Step Cost	Fuel Cycle Step Duration
1. Mine and Mill	U_3O_8	7.84	17.25	\$ 8.00/lb of U_3O_8	\$138.00	
2. Conversion	UF_6	6.6	14.55	1.05/lb of U	15.28	3 Months
3. Enrichment	Enriched UF_6	1.1	2.43	30.00/Kg-Unit[1]	124.90	3 Months
4. Fabrication[2] (Loading & Testing)	Fabricated UO	1.0	2.205	90.00/Kg of U	90.00	10 Months 1 Month
5. Reactor Operation (Cooling)	Irradiated Fuel	.958	2.1			36 Months 3-4 Months
6. Spent Fuel Transport		.958	2.1	5.25/Kg of U	5.00	
7. Reprocessing[3]	Uranium, Plutonium, Fission Products	.958	2.1	34.50/Kg of U	33.00	2-3 Months

1) For 3% enrichment, 3.785 Kg-Units of separative work are required
2) Does not include excess uranium credit of \$27.82
3) Plutonium Credit @ \$9.00/gm = \$57.92, Uranium Credit = \$44.40 plus miscellaneous Isotope Credits whose value is not determined.

TABLE III

FUEL CYCLE COSTS EXCLUDING FINANCING COST

1.	Mine and Mill	$138.00/Kg
2.	Conversion	15.28
3.	Enrichment	124.90
4.	Fabrication	90.00
	Excess Uranium (Credit)	(27.82)
		$340.36/Kg
6.	Spent Fuel Transport	$ 5.00/Kg
7.	Reprocessing	$ 33.00
		$ 38.00
CREDITS		
Uranium		$ 44.40/Kg
Plutonium		57.92
		$102.32/Kg

Cost Per Region 30,000 Kg X $340.36/Kg = $10,200,000

SUMMARY

The majority of new generating capacity installed in the years to come will be nuclear powered. The problem of financing nuclear fuel inventory is unique because of the time it takes to process and consume the fuel. Nuclear fuel isn't consumable like fossil fuels and it doesn't depreciate in value in the same way that a plant does.[20] At present all nuclear fuel is classified as a current asset. This has not been a problem to date because; 1) nuclear fuel costs have been a minor fraction of any utility's expenses, and 2) all nuclear fuel to date has been leased from the Atomic Energy Commission.

The following chapter will describe nuclear fuel financing under government ownership, and the alternative methods of financing available to electric utilities under private ownership. Subsequent chapters will evaluate these alternative financing methods and propose a plan for financing utility nuclear fuel requirements.

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[20] Jack H. Morris, "Utilities' Embrace of Nuclear Fuel Stalled by its Classification as a Current Asset," The Wall Street Journal, November 12, 1968, p. 4

CHAPTER 2

NUCLEAR FUEL OWNERSHIP

The development of nuclear energy as an economic source of electricity is largely the result of the timely passage of legislation affecting the production of nuclear materials and control of the facilities for this production. The nuclear industry was born during World War II. During the war and for a short period thereafter the Manhattan District completely monopolized the industry it created, from the mining of uranium ore to the ultimate enrichment of nuclear materials and the fabrication of nuclear weapons. Although large industrial concerns and private research institutions built and operated the nuclear plants which the government owned, the Manhattan District, under the War Department, managed the entire operation. Since shortly after the war legislation has been enacted and amended in progressive stages so that by the early 1970's private enterprise will be able to enter into almost all phases of nuclear material production.

GOVERNMENT OWNERSHIP

Congress passed as Public Law 79-585, The Atomic Energy Act of 1946 (McMahon Act), the first major piece of legislation concerned with national policy toward the crisis born nuclear industry. In writing this Act, Congress recognized that the effect of the use of nuclear energy for civilian purposes could not then be determined and that nuclear energy was a field in which many unknown factors were involved. For these reasons the Act specifically states that any legislation will necessarily be subject to revision from time to time.

> It is reasonable to anticipate, however, that tapping this new source of energy will cause profound changes in our present way of life. Accordingly, it is hereby declared to be the policy of the people of the United States that, subject at all times to the paramount objective of assuring the common defense and security, the development of utilization of atomic energy shall, so far as practicable, be directed toward improving the public welfare, increasing standard of living, strengthening free competition in private enterprise, and promoting world peace.[21]

In spite of the language used in the Declaration of Policy, the McMahon Act actually did very little toward "strengthening free competition in private enterprise" in the development of nuclear energy. The most significant change brought about by the Act was the creation of a civilian agency to replace the Army as manager and administrator of the U.S. nuclear program. The Government, through the Atomic Energy Commission, continued to own the plants, laboratories, and materials used in nuclear production and research. The AEC continued the work started by the Manhattan District, built up a stockpile of atomic weapons, developed and perfected a family of new weapons and thermo-

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[21] Herbert S. Marks and George F. Trowbridge, Framework for Atomic Industry, BNA Incorporated, Washington, D.C., 1955 Appendix B, The Atomic Energy Act of 1946, p. B-1

nuclear bombs, started research into the use of radioisotopes, and conducted experimental work with reactors for marine propulsion, aircraft, and civilian power production. Private research in the area of reactor development was hampered by the intense security precautions required in all matters relating to the nuclear program and by the provisions of the McMahon Act which required that the AEC, as agent of the United States, be the exclusive owner of all facilities for the production of fissionable material except for very small research facilities, and that the Commission should retain ownership of all fissionable material then in existence or produced in the future. Since the production of electricity using nuclear energy requires the use of facilities that produce fissionable material and substantial quantities of fissionable material must be present to generate the heat required to produce steam, it was impossible for private enterprise to contribute substantially to the reactor development program. This limitation of the McMahon Act was recognized as experience was acquired in the new field of atomic energy and the technological problems that needed to be attacked before atomic energy could be put to useful, peaceful purposes were identified.

In 1949 the exclusive possession of atomic weapons by the United States was lost. This fact, and the accumulation by degrees of a stockpile of atomic weapons made it possible to give more attention to nuclear development for nonmilitary purposes. In 1953, hearings were conducted by the Congressional Joint Committee on Atomic Energy which led to the passage of Public Law 83-703, The Atomic Energy Act of 1954. This law amended the McMahon Act and by removing some of the restrictions of that Act, encouraged private enterprise to actively participate in the development of commercial nuclear reactors.

The Atomic Energy Act of 1954 amended the McMahon Act in areas relating to the control of nuclear materials and the production facilities for nuclear materials, information concerning nuclear technology, patents, and direct government aid for research. The amended act made possible private ownership of nuclear reactors under license from the AEC. The licenses that can be issued are divided into two categories, commercial and non-commercial. The nuclear power plants in operation today are licensed under Section 104 of the Act which provides for non-commercial licenses "...for utilization and production facilities involved in the conduct of research and development activities leading to the demonstration of the practical value of such facilities for industrial or commercial purposes."[22] The Act also provided in Section 53 for the distribution of special nuclear materials needed to fuel the privately owned nuclear reactors used in the production of electric power. Although

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[22] Ibid, Appendix A, The Atomic Energy Act of 1954, p. A-13

the use of nuclear fuel in privately owned reactors was permitted under license from the AEC, the government retained ownership of the fuel and was permitted to make a reasonable charge for it's use.

When the McMahon Act was passed in 1946 the only prior use of atomic energy had been for military purposes. Consequently, a shroud of secrecy was placed around all information relating to nuclear research and development. The Atomic Energy Act of 1954 provided for the orderly declassification of restricted data and thus opened the door for the dissemination of scientific and technical information relating to atomic energy. Along these same lines, the amended Act also permitted the restoration of conventional patent rights in the nuclear field (with the exception of inventions and discoveries which are useful solely in nuclear weapons) which had been set aside by the McMahon Act. The patent incentive, coupled with the relaxed requirements for control of nuclear information contributed much to the rapid development of nuclear energy for peaceful purposes.

The first nuclear power reactor was built at Shippingport, Pennsylvania under the provisions of the McMahon Act. This precluded ownership of the reactor by anyone other than the government. In this case the steam plant was owned by the government and the electric generating station was privately owned. The Atomic Energy Act of 1954 prohibits direct government subsidies for the construction of privately owned nuclear plants but it does provide for indirect subsidies in the form of research contracts for private developmental projects. All subsequent power reactors have been licensed under these provisions. Nuclear fuel for private reactors, although owned by the government, was to be provided at a reasonable and fair price. In establishing what constitutes a fair price, it was the intent of the Joint Committee on Atomic Energy that the price should be based "...primarily on the value to the United States of the intended use..." and only secondarily on the actual cost of production.[23] This provides a means for indirectly subsidizing the cost of nuclear power during the early phases of nuclear power development by having nuclear fuel supplied at less than the actual cost of production in order to create an incentive for private participation in the nuclear program.

Through the experience gained after passage of the Atomic Energy Act of 1954, the AEC has been able to establish standard prices for the use of "special nuclear materials" as fuel for nuclear power plants. It has also developed a standard Lease Agreement that some nuclear plant operators would like to see adopted as a model for future private lease arrangements.[24] The basic provisions of the AEC lease are:

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[23] Ibid., p. 55

[24] J. E. Tribble, "AEC Leasing as a Model for Private Lease Arrangements," Presented at the Atomic Industrial Forum Conference on Financing Nuclear Fuel, Cherry Hill, New Jersey, September 25-27, 1968

1. The user can withdraw enriched uranium from the AEC at any time, although there is usually a period of sixty days prior notification required.

2. After submitting a request for the enriched uranium to the AEC Office of Safeguards and Material Management in Washington the request is followed by a Purchase Order to the AEC Leasing Office in Oak Ridge.

3. Standard prices are quoted for the cost of the raw materials ($8.00 per pound of U_3O_8) and the enrichment operation ($26.00 per unit of separative work).

4. Lease charges are incurred from the date of withdrawal at an established rate (4 3/4 to 5 1/2% per year).

5. Payments for fuel leasing and fuel burnup must be made at least every six months.

6. Fuel burnup may be prepaid if the user wishes. Prepayment reduces the value of the fuel on the lease account and also reduces the lease charges. This provides a flexible means for the user to utilize short-term cash surpluses at the interest rate quoted in the lease.

7. Procedures are specified for maintaining accurate fuel accountability records.

8. Based on periodic material status reports and AEC records, the Commission issues invoices which cover lease charges for a specified period, and charges for burnup and losses.

The AEC Lease Agreement was developed out of necessity during a period in which there was only one supplier of nuclear fuel. In addition to the role of fuel supplier, the government was also in the position of encouraging greater private participation in the development of nuclear energy while still maintaining direct control of nuclear materials. The result of this has been the development of a lease agreement with terms that are quite liberal to the lessee, with well defined and documented procedures to control accountability for the special nuclear materials being leased.

The standard lease provides a good starting point for the negotiation of future lease terms between private users of nuclear fuel and competitive suppliers that will enter the field when the ownership of nuclear fuel is opened to private enterprise.

PRIVATE OWNERSHIP

Additional major legislation affecting the use of nuclear energy was passed in August 1964. Passed as Public Law 88-489, the Private Ownership of Special Nuclear Materials Act amended the Atomic Energy Act of 1954. The most significant changes were in Subsection 53c which, prior to amendment dealt with the determination of a reasonable charge for the leasing of special nuclear materials. The amended subsection is expanded to provide authorization for the Commission to "...distribute special nuclear material licensed under this section by sale, lease, lease with option to buy, grant, or through the provision of production or enrichment services."[25] In addition to the provision for private ownership of special nuclear materials, the amendment further provides for a gradual transition from the condition where the government is the sole supplier to private users through a lease agreement, to the condition where private users will be able to obtain special nuclear materials only from private suppliers through either purchase or lease. Beginning January 1, 1971, the Commission will no longer be permitted to enter into new lease agreements for the distribution of special nuclear materials, and no lease will continue in effect after June 30, 1973. The Commission is permitted to continue

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[25] Joint Committee on Atomic Energy, Congress of the United States, <u>Atomic Energy Legislation Through 90th Congress</u>, 1st Session, U.S. Government Printing Office, Washington, D.C., December 1967, p. 21

providing the service of enriching uranium on a "toll" basis for private owners of nuclear fuel and may establish reasonable rates for this service. Uranium enriching is now the only major step in the nuclear fuel cycle which is dependent on the government.

The transfer of ownership of special nuclear materials from government to private ownership produces several financial options that electric utilities must evaluate to achieve maximum utilization of available sources of capital. Should the nuclear fuel be owned by the utility company or should it be leased from a supplier or other third party lessor? Utility ownership of nuclear fuel will require a capital investment that is approximately 20% of the investment in the generating station itself. Since utility companies also require large quantities of new capital for general system expansion, placing transmission and distribution facilities underground and increasing overall system reliability, the additional burden of raising capital for nuclear fuel could be avoided by turning to other means of financing. The decision concerning owning or leasing will vary from company to company depending on such factors as the cost of money, capitalization ratio, timing of future investments, flexibility and the desirability of including the fuel inventory in the rate base.

There are other options to consider within the framework of both owning and leasing. If the fuel is owned, should it be from the issuance of additional debt? If the fuel is leased, should the lessor be the reactor manufacturer? a fuel service company? a bank or other financial institution? or perhaps even an agency of state government? These options must be evaluated by utility company managements, not only in terms of their long range impact on corporate financial structure and earnings, but they must also be evaluated in terms of risk, the accounting classification assigned to nuclear fuel, the legality of issuing additional bonds for intermediate term "consumable" assets using the existing mortgage indenture, and the financial flexibility inherent in leasing.

CHAPTER 3

METHOD OF ANALYSIS

The question of whether an electric utility should own or lease nuclear fuel is basically a problem of comparing an increase in capital expenditures with an increase in expenses. Capital outlays are disbursements of money, belonging to the stockholders or owners of the firm, to obtain assets. The money to do this is obtained by the sale of the company's securities to investors, by borrowing, or by the use of retained earnings. Retained earnings are derived from revenues after being classified as earnings by the subtraction of revenue deductions (expenses) from revenues. Earings belong to the owners of the business. Expense outlays, on the other hand, make use of funds obtained from revenues before being classified as earnings. Expense outlays purchase services and materials, not assets. When applied to the leasing of nuclear fuel, the lease expense assumes that the agreement between the lessor and the lessee is a true lease and not a deferred purchase.

The analysis used to compare the merits of owning versus leasing nuclear fuel is based on the Minimum Revenue Requirements Discipline (MRRD). Minimum Revenue Requirements "...are strictly defined as the revenues which must be obtained in order to cover all expenses incurred, associated with and including the company's minimum acceptable return (MAR) on investors' committed capital, no more and no less."[26]

MRRD does not attempt to estimate actual revenues. In the case we are studying, options for financing nuclear fuel, the actual revenues are independent of the proposal that may be selected. In fact, over short and intermediate time periods, revenue is dependent only on the electric power requirements of the customers and the tariff then in existence, and is independent of the means used to supply the demands of the customers. Over long periods, the means of supply will influence the rates charged for service, which in turn will have an effect on the customer's demand. This study, however, is limited to conditions as they exist prior to rate changes.

The cost of capital used in MRRD calculations is the company's minimum acceptable return (MAR). MAR is not the return actually earned by the company or paid to the investors, nor is it the return allowed by the various utility regulating agencies. "MAR is not an attractive rate. It is the lowest rate at which capital can be obtained for reinvestment at some higher attractive rate."[27] MAR is

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[26] Paul H. Jeynes, Profitability and Economic Choice, The Iowa State University Press, Ames, Iowa, 1968, p. 62

[27] Ibid, p. 29

used in the determination of revenue requirements for return, depreciation and taxes. The difference between the revenue requirement based on MAR and the actual revenue is the profit incentive, and of course, the inescapable tax on profit incentive. This is shown diagramatically in Figure 4.

The intent of this study is to show how the economic choice between owning and leasing nuclear fuel may be determined. Since the revenue earned by a utility company during the period of the study is assumed to be the same regardless of the type of financing adopted, the study will not be concerned with profitability. It has been shown that the financing plan that has the minimum revenue requirements will contribute the most to the profitability of the corporation as reflected in the earnings per share.[28]

Many utilities involved in the construction of nuclear power plants are presently negotiating fuel leasing terms with prospective lessors. To date no lease agreements with private fuel suppliers have been consumated and consequently the detailed conditions of nuclear fuel leases are not readily available for study. It has been reported that the terms of commercial nuclear fuel leases being offered differ

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[28] Ibid, Chapter 4

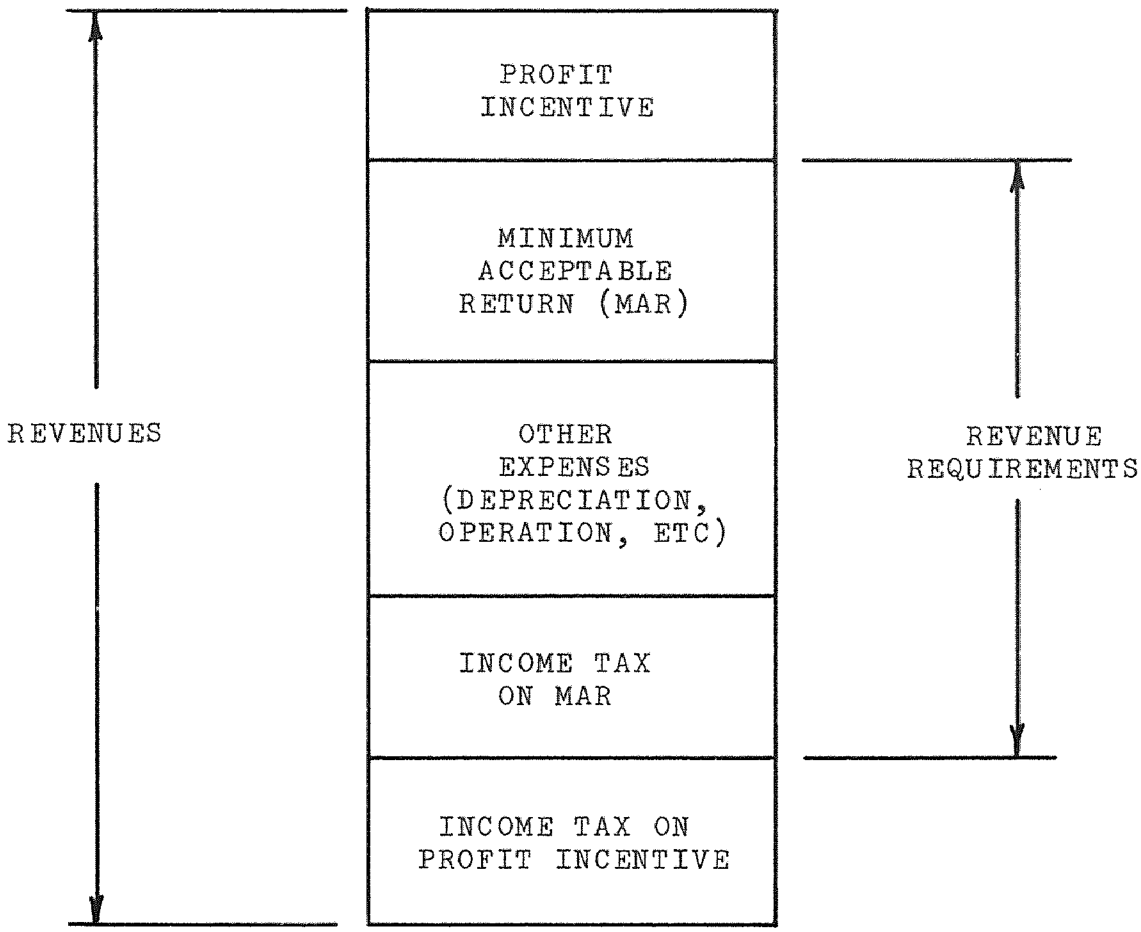

DIAGRAM OF INTENT

FIGURE 4

Source: Paul H. Jeynes, Profitability and Economic Choice, The Iowa State University Press, Ames, Iowa, 1968, p. 64

widely in details and that they will change as negotiations continue.[29] To determine the economic advantage (or disadvantage) of owning nuclear fuel compared with leasing, it is necessary to first develop a method for evaluating leasing terms.

Using the Minimum Revenue Requirements Discipline the author will determine the life-time revenue requirements for financing the fuel inventory for a 1000 Mw nuclear power reactor. This will first be done assuming that the utility company intends to own all the nuclear fuel during the useful life of the reactor, including the initial fuel loading. The series of cash outlays to which the revenue requirements will be applied is shown in Figure 5. These cash outlays are based on the calculated fuel costs given in Chapter 1 with adjustments for the differences in enrichment required for the first three regions of the initial core loading.

The utility revenue requirements for owned nuclear fuel will be calculated using a computer program written for this purpose by Leonard Van Nimwegen of the Engineering Economist's Division, Public Service Electric and Gas Company. The program was written for use on a time-sharing computer and is relatively easy to use with a

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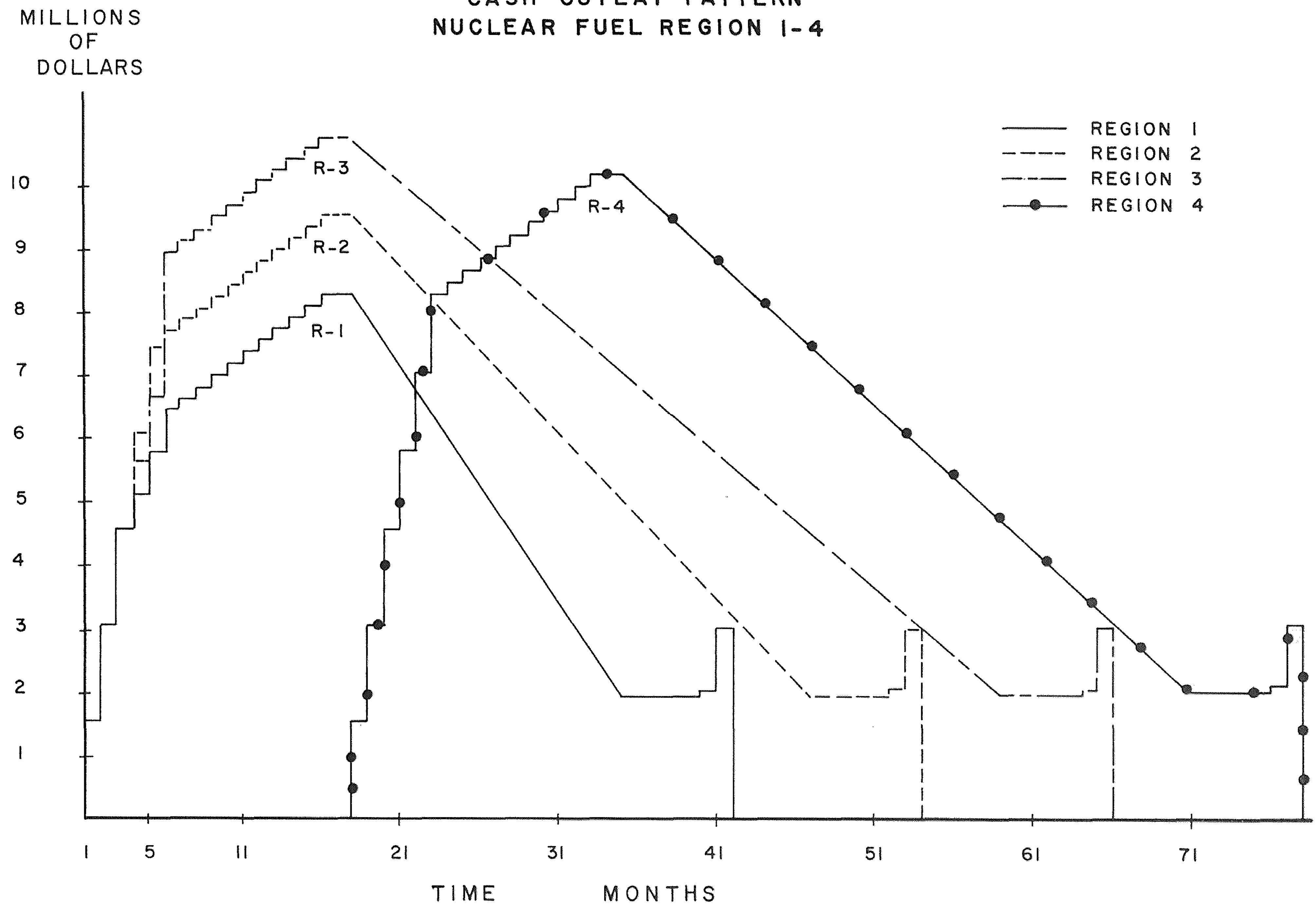
[29] "Fuel Leasing Activities," Nuclear Industry, August 1968, p. 6

FIGURE 5.
CASH OUTLAY PATTERN
NUCLEAR FUEL REGION 1-4



minimum of data preparation. The program provides as output, the monthly present worth of revenue requirements for a nuclear fuel region and also the total present worth of revenue requirements for the region. The data required as input to the program consists of:

1. Designation of the fuel region being studied

2. Definition of the region life characteristics divided into four periods:
   a. total period of expenditures and returns
   b. the pre-operational period
   c. the period of operation in the nuclear reactor
   d. the post-operational period.

3. Monthly cash outlays for the purchase and processing of nuclear fuel during the pre-operation and post-operation periods.

4. Interest rates for:
   a. minimum acceptable return
   b. interest during construction

5. Rates for special taxes such as the utility Gross Receipts and Franchise Tax.

The program was written assuming that during the period of operation there are no additional cash outlays, that is, all cash transactions associated with a nuclear fuel region are accomplished either before the region is installed or after the region has been removed from service. This assumption is valid since expenses incurred in moving the region from one core zone to another during the annual refueling operation will be charged to conventional operation and maintenance (O&M) accounts for the nuclear reactor. The present worth of revenue requirements for each month are calculated based on monthly cash outlays, current utility money costs (MAR), amortization of the fuel cost including interest during construction (IDC) during the operational period, and taxes on the revenue requirements.

The cash outlays for nuclear fuel by the fuel owner are the same regardless of whether the fuel is to be owned by a utility or a lessor. The revenue requirements for these cash outlays can be substantially different however, because of the differences in money costs, capitalization, accounting procedures and tax provisions between the utility and the potential lessors. Having established the present worth of revenue requirements (PWRR) for utility owned nuclear fuel, it is then necessary to determine the PWRR for the various classes of potential nuclear fuel lessors. This can be done by modifying the program used to determine the utility PWRR for nuclear fuel, to reflect the differences mentioned above. The economic choice between utility ownership and leasing is based on which plan results in the least PWRR.

The method of financing determined to be the most economical may not be the preferred method due to the legal and accounting uncertainties that exist in the area of nuclear fuel financing. These uncertainties will be discussed in the chapter following the economic evaluation. The final chapter will present a plan for financing the nuclear fuel requirements of public utilities.

CHAPTER 4

QUANTITATIVE EVALUATION OF OWNING VERSUS LEASING

Using the digital computer program described in Chapter 3, the author has calculated the present worth of revenue requirements for four typical nuclear fuel regions. These regions are:

a. Region 1, in-core for 18 months
b. Region 2, in-core for 30 months
c. Region 3, in-core for 42 months
d. Region 4, the equilibrium region which is in-core for a period of 36 months.

The life-time fuel requirement for a nuclear reactor was assumed to consist of an initial core loading of Regions 1, 2, and 3; replacement regions with characteristics similar to Region 4 being installed starting with the 18th month after initial operation and every 12 months thereafter for 25 years; and a final loading consisting of three regions, starting during the 26th year with the installation of a region similar to Region 3, a region similar to Region 2 being installed during the 27th year and the last region, similar to Region 1, being installed during the 28th year. The last three regions (numbered 29, 30, and 31) are removed from the reactor after irradiation at the end of the 30th year of operation.

CASH OUTLAYS

The present worth calculations are referred to the month of the first cash outlay by the utility. For the purpose of this comparison this cash outlay was assumed to occur 17 months prior to initial operation of the nuclear reactor. The cash outlays during the 17 months prior to initial operation are made up of the procurement of the uranium in the oxide form and conversion to uranium hexafloride, enrichment, fabrication of the fuel assemblies and shipment to the reactor site for installation. The payments for the purchase of "yellowcake" or U_3O_8 and it's conversion to UF_6 were assumed to be distributed over a period of three months with equal payments each month. Enrichment of the UF_6 is a process that takes about three months to complete so it was again assumed that payments for this part of the cycle would be made in three equal monthly installments. Fabrication of the fuel assemblies is a longer process, taking about ten months, and at the end of the period there is generally a credit for excess uranium not used during fabrication. Cash outlays assumed during the fabrication period were based on the net outlay after receiving the credit, and were distributed equally over the ten month period. The final month of the 17 month pre-operation period is used for shipment of the finished fuel assemblies and installation in the nuclear reactor core. Payment for the shipment is assumed to be included in the cost of fabrication. During the pre-operation period, interest on the money paid for utility plant not yet in service is charged to construction at the simple rate of 6 per cent. This interest during construction is accounted for in the revenue requirements program and is amortized with the other fuel expense charges during the period of operation when the fuel is in-core. Replacement regions follow the same general time sequence and pattern of cash outlays, however the date of payment is displaced in time 18 months, 30 months, 42 months, etc. This pattern of cash outlays was shown diagramatically in Figure 5, Chapter 3.

REVENUE REQUIREMENTS

The present worth of revenue requirements for utility owned nuclear fuel was compared with the PWRR for three nuclear fuel leasing plans. The revenue requirements consist of revenue requirements for:

a. Return, or the use of investment money.
b. Taxes, including federal income tax and local taxes, such as the gross receipts and franchise tax.
c. Depreciation, or in this case, amortization of the nuclear fuel expense during operation.

In all of the plans being evaluated the revenue requirements are those of the utility company, that is, they are based on the cash outlays of the utility company for fuel in the utility ownership plan, and the cash outlays for lease payments to the lessor in the case of the lease plans. The predominent variable used in the determination of the revenue requirements is the cost of money assumed for each of the plans. With utility ownership, the cost of money was assumed to be a typical electric utility minimum acceptable return of 6 per cent. This cost of money is based on a capitalization of 60 per cent debt at an average rate of 5 per cent, and 40 per cent equity at a rate of about 7.5 per cent. The money costs assumed for the leasing plans were 4.5 per cent for fuel leased from a government agency using tax exempt bonds, 7.5 per cent for fuel leased from banks or insurance companies and 10 per cent for fuel supplied by a reactor manufacturer or nuclear fuel supply service. These rates are undoubtedly subject to question when related to specific leasing organizations, however, it is felt that they generally fall into the range of rates of return anticipated by each of the institutions considered as a potential lessor of nuclear fuel.

Federal income taxes were assumed at a rate of 48 per cent with the expectation that the 10 per cent surtax will in fact be a temporary tax. The effects of tax benefits under leasing programs were not investigated because it is generally felt that such benefits will not be available to the lessors of nuclear fuel in the same manner in which they are available to lessors of other types of equipment. Since these comparisons are based on an average useful life for each nuclear fuel region of three years, it was assumed that there will be no investment tax credit.

The revenue requirement for depreciation is based on the amortization of the nuclear fuel expenses over the period during which the region is actively producing power in the nuclear reactor. Although the power output of the nuclear reactor may vary from time to time, for the purpose of this study it was assumed that fuel would be consumed linearly with time (ie., straight line depreciation). This assumption is generally valid for the early years of operation but could introduce some errors during the latter part of the useful life of the nuclear reactor. Since the present worths of revenue requirements for all fuel regions are being referred to the month of initial cash outlay for the first region, the effect of errors in the revenue requirement for depreciation of the latter regions will be small.

PRESENT WORTH OF REVENUE REQUIREMENTS COMPARISON

Table IV shows a comparison of the present worth of revenue requirements for nuclear fuel cash outlays for utility ownership of nuclear fuel with three leasing plans outlined in previous sections of this chapter. The PWRR are listed for each of the three regions contained in the initial core loading and for a typical replacement region, with the revenue requirements referred to the present value

TABLE IV

ECONOMICS OF NUCLEAR FUEL FINANCING FOR PUBLIC UTILITIES
PRESENT WORTH OF REVENUE REQUIREMENTS FOR NUCLEAR FUEL CASH OUTLAYS

Source of Fuel	Money Cost - %	Region 1	Region 2	Region 3	Equilibrium Region 4	30 Year Requirement
Utility Ownership	6.0	$8,196,000	$ 9,937,000	$11,668,000	$10,836,000	$170,270,000
Government Lease	4.5	7,956,000	9,598,000	11,219,000	10,442,000	164,151,000
Bank Lease	7.5	8,434,000	10,272,000	12,110,000	11,224,000	176,434,000
Supplier Lease	10.0	8,823,000	10,821,000	12,835,000	11,860,000	186,206,000

at the month of initial cash outlay for the regions shown. In addition, the PWRR for a complete life-time nuclear fuel supply for a 1000 Mw nuclear reactor is given for each of the financing plans based on a 30 year reactor life. The revenue requirements for the complete fuel supply are referred to the month of first cash outlay for the initial core loading.

From this comparison it can be seen that only one of the leasing plans has an economic advantage over utility ownership of nuclear fuel. This leasing plan is based on financing using tax exempt bonds issued by a government agency. This plan is being considered in only one state and is not generally available to all electric utilities. The apparent savings that would be available to the utility under such an arrangement over the life of the reactor have a present value of about $6,000,000. The present value of the first core saving amounts to about $1,000,000 out of a total present value investment of approximately $30,000,000. The social cost of this leasing plan and the indirect cost of lost tax revenues that will have to be provided from other sources have not been included in these calculations. The intangible disadvantages to leasing through a government agency will be discussed in detail in the next chapter.

The life-time economic penalties associated with leasing plans financed using money obtained from more conventional sources amount to about $6,000,000 for the bank or insurance company lease and $16,000,000 for the nuclear fuel supplier lease. On a short range basis, the economic penalty associated with the first core fuel requirements is about $1,000,000 for the bank lease and $2,700,000 for the fuel supplier lease. These figures are probably conservative (too low) because in determining the respective revenue requirements for the two leasing plans, no allowance was made for inclusion of profit incentive over and above the potential lessors cost of money. This will be discussed in more detail along with special leasing inducements provided in nuclear fuel supplier leases in the next chapter.

Based on a purely economic criterion, ownership of nuclear fuel by the utility has the advantage over most leasing plans. There are however, other aspects of leasing that cannot be evaluated using simple financial mathematics, that to some, would be considered as playing a more important role in the final decision making process than the economics of the problem. At a recent conference on fuel procurement and financing, David Springsteen, vice president of New York's Chase Manhattan Bank's Energy Division, listed 12 factors that could be used in evaluating nuclear fuel leases. Of the 12 factors he listed, he put the effective rate last.

> I seriously question whether effective rate is a valid basis for comparison of lease proposals containing materially different terms. A far

> more valid basis would be to try to compare lease proposals on the basis of 'which alternatives are most likely to result in the greatest long term benefit to the stockholder'?[30]

In contrast to Mr. Springsteen's viewpoint, the author feels that the financing plan that results in the least present worth of revenue requirements[31] is "most likely to result in the greatest long term benefit to the stockholder," and therefore the effective rate is a valid basis for comparison of lease proposals in so much as it affects the revenue requirements. If other features of leasing are considered as desirable to the utility investigating leasing alternatives, then these features should be evaluated in terms of how much the utility is willing to pay to obtain the benefits provided by these features.

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[30] "Leasing Concepts Refined," Nuclear Industry, February, 1969, p. 8

[31] Adopting the financing plan that has the least PWRR does not insure that there will be savings over the present cost of operation that can be passed along to the owners in the form of increased earnings. Adopting the least PWRR financing plan means that there will be expected savings over the other plans considered, and that the utility will have the greatest opportunity for benefitting the stockholder. The resulting benefit may be direct, in the form of an increase in earnings or a continuation of present earnings, or it may be an indirect benefit in the form of a rate reduction that is passed along to the customers with the hope that in the long term there will be an increase in utilization that will result in an increase in earnings for the owners.

CHAPTER 5

QUALITATIVE EVALUATION OF FINANCING ALTERNATIVES

The quantitative analysis of nuclear fuel financing alternatives contained in the preceeding chapter indicates that, except for the case where fuel can be leased from some branch of government permitted to issue tax free bonds expressly for this purpose, there is no economic advantage to leasing over ownership by the utility. Provided this analysis is accurate, then why is there so much interest within the utility industry concerning the leasing of nuclear fuel? The answer to this question may lie in a qualitative evaluation of the "...imponderables, intangibles, or irreducibles" associated with both owning and leasing, and the various financial options under each alternative.[32]

This evaluation will consider those factors which are difficult to reduce to dollars.

UTILITY OWNERSHIP

Ownership of nuclear fuel assemblies by the operating electric utility companies has an advantage in that regulatory agencies may permit inclusion of the cost of the fuel in the rate base. This could be particularly desirable in

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32 Paul H. Jeynes, Profitability and Economic Choice, The Iowa State University Press, Ames, Iowa, 1968, p. 236

the case where a company is earning a return that is close to the maximum allowed under existing rules. Whether or not the nuclear fuel can be included in the rate base is somewhat uncertain at this time because the Federal Power Commission (FPC) system of accounts includes nuclear fuel as part of current assets. Recent indications are that nuclear fuel is being recognized as a fixed asset and changes in accounting procedures have been proposed to the FPC that would include nuclear fuel investment in a separate account listed on the balance sheet immediately following net utility plant.[33]

The major disadvantage to utility ownership is that a large incremental capital investment is required for nuclear fuel financing. This capital must come from the pool of utility capital which is generally made up of about 50-60 per cent debt and 50-40 per cent equity. Since the capital required to finance the nuclear fuel inventory is approximately 20 per cent of the cost of the nuclear plant, and may be 10 per cent of the utility company's total new project investment, over a long period, the investment in nuclear fuel alone can approach a value that is 10 per cent of total plant investment. The magnitude of investment in nuclear fuel can have an effect on decisions made concerning methods

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33 "How Do You Account For Nuclear Fuel?" <u>Electrical World</u>, February 5, 1968, pp. 113-116

of current financing and future borrowing ability for other purposes, if secured financing is to be used for these purposes.

Mortgage Financing

Utility companies today issue mortgage bonds under open-end mortgage indentures. Secured financing of nuclear fuel could be accomplished either through the issuance of additional bonds under the mortgage indenture, or the issuance of new securities secured by a lien separate from the mortgage indenture. The customary method of secured financing under the mortgage indenture raises questions as to the status of the nuclear fuel inventory using this type of secured financing. Would the nuclear fuel inventory be excluded from the coverage of the mortgage lien under existing indentures?

> A typical clause excludes "fuel and other materials and supplies consumable in the operation of the company's business." The legal reason for this exclusion is mainly a historical one. Fuel is a current asset, which is consumed and replenished over short periods of time and over which the debtor or user must, as a practical matter, have high control.[34]

The theory of the law has been that the debtor who has possession and control of readily disposible assets is

[34] Carroll D. French and Robert C. Woodbury, "Mortgage Financing of Nuclear Fuel," Public Utilities Fortnightly, March 28, 1968, p. 24

entitled to those assets free and clear. In cases where a claim was made on such assets in favor of a particular creditor, the purported lien jeopardized the entire indenture by including in the indenture those items considered as current assets. Today, the Uniform Commercial Code permits liens on personal property even though the debtor maintains possession and control of the property, and permits the lien to cover after-acquired property. With the passage of the Uniform Commercial Code there is no legal reason why the mortgage indenture could not be revised to include nuclear fuel inventories.

There are however, practical considerations that must be evaluated. To include the nuclear fuel inventory as collateral under existing mortgage indentures will, in most cases, require revision of the indenture. This is because most indentures were drafted before enactment of the Uniform Commercial Code. The process of amending the indenture usually requires the approval of some proportion of the utility company's bondholders. Although this is possible, it is a very difficult process because many of the bondholders are anonymous holders of bearer bonds, and others may be widely distributed throughout the world. In addition, consent to an indenture amendment may only be obtained by offering some inducement such as an increase in interest rate. This could be an expensive process for the utility company.

If bondholder consent to amend the indenture can be obtained, there are three areas that present mainly mechanical drafting problems:

1. Provision must be made to include the nuclear fuel inventory in the lien.

2. The type of fuel to be included must be limited to nuclear fuel and conventional fuels should continue to be excluded.

3. Procedures must be established to permit the periodic removal and replacement of the nuclear reactor fuel assemblies covered by the indenture.

In addition to the amendment provisions mentioned above that involve primarily drafting changes, the amended indenture must provide assurance to the bondholders "...that the company's properties are maintained or replaced over the period of their estimated economic lives."[35] This may be accomplished by writing into the indenture provisions for maintenance and replacement (M&R) funds. Existing provisions of this type are generally related to retirement from service and maintenance and replacement of a company's continuing plant and related fixed assets. Most utility plant has a fairly long average useful life of about 35 to

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[35] Ibid., p. 25

45 years. Bondholder's investment in nuclear fuel should be given the same protection as the investment in more conventional types of utility plant. Nuclear fuel however, is not the same type of asset as conventional plant and does not involve the same type of risk. Conventional plant is generally kept in service for the entire plant life-time and is then retired all at once. Nuclear fuel is not subject to the long-deferred retirement of utility plant equipment, but must be replaced as it is consumed in the production of electricity.

The two basic formulae used to establish annual M&R requirements cannot readily be applied to the calculation of M&R funds for nuclear fuel. The net plant formula is used to establish the annual requirement at a fixed percentage based on average life. The difference in average life between nuclear fuel and other types of plant, and the fact that nuclear fuel is now classified as a current asset means that little or no account would be taken of nuclear fuel inventory in the calculation of annual M&R requirements. The second formula, based on a fixed percentage of annual gross revenues is more flexible, but may require bondholder approval for amendments to the formula if the nuclear fuel inventory becomes an appreciable factor in the determination of annual M&R requirements. The gross revenue formula appears to provide some degree of stockholder protection since the annual M&R fund would increase as revenues increased, and this increase would be somewhat related to the increase in nuclear fuel inventory.[36]

The difficulties encountered in developing an adequate M&R formula for nuclear fuel inventory point out that perhaps the most effective financial treatment of nuclear fuel would be to capitalize the initial core loading and expense the subsequent replacement regions. This procedure would provide for the normal retirement of the initial core capital investment over the life of the nuclear plant, while permitting replacement of the consumed regions on a current basis. The only accounting change required would be to include the cost of the initial core as a fixed asset in one of the utility plant accounts. This change may also permit an investment tax credit for the initial core investment. The cost of replacement regions could continue to be classified as current assets.

The eligibility of nuclear fuel for secured financing is somewhat uncertain at this time because of accounting and mortgage provisions that were established with fossil fuel in mind. As more experience is gained in the operation of nuclear plants and in the manufacturing of nuclear components, including fuel assemblies, accounting procedures

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[36] Ibid., p. 27

and legal precedants will be established. Until these things are accomplished it may be necessary for utility companies to issue additional debt secured by presently unbonded company properties to obtain funds for the purchase of nuclear fuel.

Separate Lien Financing

Another method for financing utility ownership of nuclear fuel is the assumption of additional debt outside the existing mortgage indenture under a separate lien. This type of financing may be popular because the separate lien could be tailored to the special requirements needed for financing nuclear fuel without going through the complex procedures for amending the existing indenture. The separate lien also offers the utility company flexibility in the timing of the issue and in the refunding or retirement. This could be of particular importance if technological advances bring about changes in core design that also affect the core financing requirements. The advantages do not come without some penalty however. This type of financing would probably involve higher charges for executive, legal and administrative expenses than would a similar issue under the existing indenture. In addition, the interest cost may be slightly higher than current rates for debt secured under the mortgage indenture because the separate lien may be considered as subordinate to the indenture.

A special type of separate lien financing would be the use of nuclear fuel trust certificates. These trust certificates would be similar to those in use for railroad and aircraft equipment trust financing. The problem with this type of financing is that the nuclear fuel assemblies that would be used for collateral, have not reached the same degree of standardization as railroad rolling stock and aircraft. Nuclear fuel cores are generally custom designed for use in one specific reactor whereas railroad cars and airplanes can be used by any railroad or airline in the country. This lack of standardization has raised some doubt as to the collateral value of nuclear fuel assemblies.[37]

Convertibles and Warrants for Financing

Two types of securities that have not been put to much use by utility companies are the convertible bond and the bond or common stock offering with a warrant option. In an address to the Rocky Mountain Electrical League, Paul Hallingby, Jr. of White Weld & Company referred to the vast amounts of capital that must be raised by the utility industry at high interest rates and "...urged utilities to depart from classic financing techniques and go to private placement, longer periods of non-refundability, cash sinking

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[37] Ibid., p. 28

funds, warrants, negotiated bond offerings, and convertible securities."[38] Utility companies in general, are reluctant to make new issues of common stock. This is because earnings grow at a fairly constant rate and to reflect this growth on an earnings per share basis the number of outstanding shares must remain constant. Debt financing appears to be the more attractive alternative despite the present high cost of long-term debt. In the long run continued earnings growth may permit a gradual increase in the number of shares outstanding without adversely affecting the market price of the common stock. This gradual increase could be accomplished with either convertibles or warrants.

Convertible bonds are a particularly attractive form of debt financing during periods of high interest rates. These bonds are generally convertible at a price above the market price for the common stock at the time of issuance, and consequently downward pressure on the price of the common stock is avoided. In addition, convertible bonds can be sold at yields substantially lower than yields on similar non-convertible issues. The company can therefore obtain economical, tax deductible interest rates by selling future equity.[39]

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[38] "Utilities Urged to Invest Outside Regulated Areas," Electrical World, November 11, 1968, p. 68

[39] "Should Utilities Switch to Convertibles?" Electrical World, April 22, 1968, p. 58

> The characteristics of the convertible debenture encourage rather prompt conversion into the common, thus supplementing the equity base for future borrowing. The equity option cannot be sold separately and can be exercised only by surrendering the debt. Consequently, the usual call provision gives the company a tool to force conversion within a few years.[40]

When properly drafted, the conversion privilege is likely to be exercised at a time favorable to the company (and also favorable to the bondholder and potential stockholder or it would not be exercised). Since the bonds are convertible at a price above market at the time of issue, conversion won't take place until the market price exceeds the conversion price. This would generally be after several years growth and at a time when additional outstanding shares will not be detrimental to the earnings per share. This may also be at a time when additional debt financing is required for supplying replacement fuel in the nuclear reactor core. Conversion is also likely to occur at a time when interest rates are lower than they were at the time of issue. This results in the retirement of a relatively high cost issue during a period when it is possible to obtain additional debt without conversion features, at lower cost, while at the same time decreasing

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[40] Samuel L. Hayes, III and Henry B. Reiling, "Sophisticated Financing Tool: The Warrant," Harvard Business Review, January-February, 1969, p. 141

the debt/equity ratio. With constant leverage it would be possible to increase both the debt and equity portions of capitalization simultaneously, thereby building on the new equity base.

The use of warrants could also provide a means for raising capital to finance nuclear fuel inventories. "A stock purchase warrant is a certificate representing an option (that is a contractual right) to purchase stock, typically common stock."[41] Unlike the convertible bond, the warrant does not offer the company the same degree of flexibility in determining when the option will be exercised. Warrants tend to remain outstanding for longer periods than convertible securities. This is because the debt and equity portions can be separated and the investor can obtain the debt portion while either exercising the option or selling the warrant. This lack of control over when a warrant is converted to new equity has been viewed as a barrier to future financings.[42] An advantage to using the warrant is that the amount of ultimate dilution that will take place can be influenced to a greater degree than with convertible bonds. The dilution resulting from convertibles is based on a compromise between the conversion

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[41] Ibid., p. 137

[42] Ibid., p. 142

price of the stock and the face value of the bond. Some flexibility is allowed but it is limited by the price determined for conversion. The warrant transformation on the other hand, is relatively independent of the face value of the bond or other security with which the warrant was initially issued.

LEASING

The interest utilities have shown in leasing nuclear fuel rather than owning it can be attributed to two factors:

1. Large outlays of capital to finance the initial nuclear reactor fuel inventory can be avoided through leasing.

2. Financial flexibility can be maintained by avoiding present uncertainties in conventional financing of nuclear fuel and by permitting timely entry into capital markets for overall utility needs.

The large amounts of capital required for nuclear fuel financing are needed during a period when most utilities are seeking an unusually large amount of capital for other purposes. There is a great deal of emphasis being placed on making the facilities used to supply electric service more socially acceptable.[43] Additional capital, over and above normal growth requirements, is needed to place transmission and distribution facilities underground instead of overhead as in the past, to provide generating stations with additional air filtering equipment to reduce air pollution, and to provide generating stations with supplemental water cooling facilities to avoid thermal pollution of lakes and rivers. With these large demands for capital, it is only natural that the utilities are looking to other possible sources of funds and continuing their efforts to obtain the funds that must be borrowed at the lowest possible interest rate. Since nuclear fuel can currently be obtained only by leasing it from the AEC, the precedent for leasing nuclear fuel is well established. Many utilities would like to see the concept of nuclear fuel leasing continue into the era of private ownership of special nuclear materials.

To some, the opportunities for leasing nuclear fuel to utility companies appear to be similar to the situation that existed several years ago with the wide acceptance of the digital computer. At that time, many companies devoted a great deal of manpower to the study of owning versus leasing

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[43] The Electric Utility Industry and the Environment, A Report to the Citizens Advisory Committee on Recreation and Natural Beauty by the Electric Utility Industry Task Force on Environment, Laurance S. Rockefeller, Chairman, 1968

computers. The success of the short-term nonpayout computer-leasing industry resulted from the "...marriage of two young and hopeful segments of the post-World War II American economic boom:

> *Electronic data processing--which itself has grown from a prewar concept to an industry whose current status and projected rate of growth cannot be matched by any other industry in the United States or elsewhere in the world.
>
> *Leasing--which has grown so rapidly that it has become, even for the most sophisticated financial men, one of the accepted means of financing large-volume capital expenditures.[44]

Due to rapid change in the design of computers, they are considered a short-lived asset with little salvage value, with the result that many companies are reluctant to invest large sums of money that could be used for other projects in computers. In this respect, the investment in nuclear fuel is similar to the investment in computer hardware. The advantages to leasing computers result primarily from the liberal accounting procedures used by computer lessors. Most of these firms depreciate computers over ten years while computer owners must write off their investment in about half that time to prepare for the change over to more sophisticated machines.[45] The extended write-

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[44] William A. Armstrong, Computer Leasing: Evaluating Criteria for Decision Making, American Management Association, New York, N.Y., 1968, p. 1

[45] "Computer Lessors Have Problems," Financial World, February 5, 1969, p. 24

off period used by computer lessors is not entirely without merit since the use of a less sophisticated computer can be transferred to a second lessee whose computational needs do not require the most current degree of sophistication offered by computer technology. In this respect there is a major difference between leasing nuclear fuel and leasing computers. Once nuclear fuel has been irradiated in a nuclear reactor for the period of its design life-time it cannot be transferred to another lessee for further irradiation. This basic difference in usage voids the all too common comparison of nuclear fuel leasing with computer leasing.

Nuclear Fuel Lessors

Since there are no major accounting methods that can be used to advantage by potential nuclear fuel lessors, the decision to provide a fuel leasing service must be based on an expected real return on investment. Organizations that have shown an interest in entering the field of nuclear fuel leasing include:

1. Companies that fabricate nuclear fuel
2. Banks
3. Investment banking houses
4. Independent leasing organizations

5. The New York State Atomic and Space Development Authority[46]

The entry of nuclear fuel suppliers into the business of leasing fuel to reactor operators is probably an evolutionary step that will take place during the transition from government to private ownership. The nuclear fuel suppliers have developed a working knowledge of the intricacies of the fuel cycle and the financing requirements at each step. During the early years of private ownership, the suppliers will probably offer fuel leasing terms as part of a larger overall fuel management service. This type of arrangement is particularly attractive to smaller utility companies that do not have the staff required for complete in-house nuclear fuel management. As the nuclear industry continues to grow, the fuel suppliers can be expected to withdraw from the leasing business and concentrate on selling their product. The decision to withdraw from leasing will be influenced by the suppliers need to divert the capital investment in fuel being leased to the utility customers, to investment in fuel processing plant expansion.

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[46] Hugh P. Boylan, "Nuclear Fuel Leasing Programs," Presented at Atomic Industrial Forum Conference on Financing Nuclear Fuel, Cherry Hill, N.J., September 25-27, 1968

Banks, investment banking houses, insurance companies, and other financial institutions are attracted to the field of nuclear fuel leasing by the possibility that it will develop into a high quality, intermediate-term investment with a fixed return. Since each region of nuclear fuel assemblies can be financed separately and each region requires a commitment for a period of only 3-4 years, there is an opportunity to adjust the leasing terms periodically to follow changes in the interest rate. This provides an added degree of flexibility compared with investment in utility bonds which generally involves a commitment for 25-30 years at a fixed rate of interest. The large commitment of the electric utility industry to nuclear energy for the production of electric power makes the investment in nuclear fuel for leasing purposes a fairly low risk investment.

Independent leasing firms have expressed confidence in their ability to provide competitive leasing terms for nuclear fuel. They feel that the lease terms could be based on a low cost of money provided by people who are in high tax brackets. To do this would require leasing arrangements that make the most of investment tax credits and capital gains. In addition, Vincent S. Mullaney of Walnut Leasing feels that there is only limited competition in the nuclear fuel leasing field. "Most banks are not interested now. It would mean that they would own something, which is not their business."[47] Mr. Mullaney may be correct in his assumption that banks would prefer not to own nuclear fuel, however, if the return to the bank is attractive they may be willing to make the ownership sacrifice. The independent leasing organizations are presently figuring on a lease with a cost that is approximately equal to the utility bonding rate plus one quarter of one per cent.[48]

> If a utility can get money as cheap as we can, we can't compete. But, they have $150 million to borrow on their plant. They can't put fuel in their bond issue, and will have to finance it either by debt issue or short-term debt. If you have a $60 million revolving bank credit, you don't want to tie up $30 million in fuel.[49]

Although independent leasing firms have indicated an interest in the leasing of nuclear fuel, it is apparent that they should do more research before entering the field. Nuclear fuel leasing is a new and relatively unknown field. Mr. Mullaney indicates that the independent lessors source of money may be different from the sources available to utility companies. Many utility company common stock dividends offer tax deductions resulting from a return of

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[47] "Fuel Leasing Activities," Nuclear Industry, August, 1968, p. 9

[48] Ibid., p. 10

[49] Ibid., p. 10

capital, and the utility companies can also take advantage of the investment tax credit when applicable. There is some doubt as to whether the investment in nuclear fuel inventory will be eligible for investment tax credit.[50] In addition, the cost of money to a utility is not the current bonding rate but the rate of the total pool of utility capital.[51] Leasing agencies will have to develop an understanding of nuclear fuel requirements to provide financing terms that are competitive with others in the field and also to insure that the optimum use is made of the agencies' investment funds. If nuclear fuel leasing does develop into a substantial industry, the leasing agencies will probably have their best opportunity for breaking into the field at the time when the fuel suppliers want to get out. This timing will permit the leasing agencies to develop a firm nuclear background while some of the accounting and tax uncertainties are being resolved.

A unique approach to nuclear fuel financing is developing in New York State. Established in New York is the state's Atomic and Space Development Authority (ASDA) which, with unlimited bonding capacity, has permission to own and

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[50] "A Hard Look at Fuel Financing," Nuclear Industry, October, 1968, pp. 9, 10

[51] Paul H. Jeynes, Profitability and Economic Choice, The Iowa State University Press, Ames, Iowa, 1968, pp. 497-499

lease to utilities, nuclear plant sites, nuclear fuel, and other facilities. Con Edison, which has a special interest in leasing because of the small return being earned on the existing rate base, has been negotiating with potential fuel lessors for more than a year and has narrowed the field of potential lessors to four organizations including ASDA.

> The contract will probably go to ASDA if it can get a tax exemption from the Internal Revenue Service for the industrial revenue bonds it would issue to pay for the fuel. Such a ruling would make ASDA financing cheaper than from any other source.[52]

This type of financing has implications that go beyond the subject of owning versus leasing. There is some concern within the privately owned sector of the utility industry stemming from apprehension over the potential proliferation of government subsidy. The one advantage to a lease provided through a government agency as opposed to that provided from private sources is the reduction in money costs made possible through the issuance of tax exempt bonds. This type of financing arrangement has been used by several states, primarily in the south, to induce industry to move into the area. Since the electric utilities in New York are regulated companies with established franchise territories, there is little danger that these companies will attempt to

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[52] Ibid., p. 9

relocate unless offered an incentive such as the use of low cost money from tax exempt bonds. Fuel leased from a government agency using tax exempt bonds for financing, should result in lower production costs for electric power. If this reduction in production costs is reflected in a reduction in electric rates there may be some incentive for industries largely dependent on electric power to locate new plants in New York. Other states, in an effort to compete with New York in attracting new industry, would soon pass legislation permitting similar leasing arrangements and may even "go one better" by offering financing of the nuclear plant itself.

> Under the circumstances, then, we do not envy the decision that Con Edison apparently must face. On the one hand if it refuses the state's offer, it will be criticized by customers who fail to appreciate that the basic cost difference between two sources of lease financing is the tax exemption afforded investors by ASDA bonds. On the other hand, if Con Edison accepts state aid it will certainly increase the pressure on sister utilities.
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> We remain convinced, however, that accepting subsidized financing of nuclear fuel, especially if its equivalent is available from conventional commercial sources, is not in the long-term best interest of the utility, the industry, or the consumer.[53]

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53 "New York's Nuclear Fuel Leasing Dilemma," Electrical World, November 18, 1968, p. 41

In summary, it should be noted that on a straight cost basis, a lease provided by a state agency, funded through the issuance of tax exempt bonds, would undoubtedly be the most attractive leasing alternative in those areas where it is available. In other areas, banks, investment banking houses, insurance companies and other finance oriented organizations that can obtain money at rates one to two per cent higher than tax exempt rates, should provide the lowest cost nuclear fuel lease. Leasing organizations and fuel vendors will have the highest money costs of any of the organizations interested in nuclear fuel leasing. In addition, leasing organizations must consider the potential returns from leasing other types of industrial equipment such as computers and vehicles. Due to accounting and tax benefits the returns from equipment leasing may be greater than the returns from fuel leasing. Fuel vendors, while most experienced in the technical and financial aspects of the nuclear fuel cycle, must consider not only the cost of money but also the profit being earned through investment in fuel for leasing compared with what the profit would be if the money were to be invested by some other division of the company. In order to remain competitive with other divisions of the company the nuclear fuels division may be forced to provide leases only as part of a total fuel management service.

The decision concerning which lease is most attractive will be based on more than the cost of money. The utility must evaluate lease terms for flexibility and liability as well as cost. The following section describes the types of leases presently being considered.

Terms of Nuclear Fuel Leases

Nuclear fuel leases, although still in an embryonic stage of development, fall into two general patterns: the region-by-region arrangement and the so-called "evergreen" plan.[54] These descriptive terms refer to the period over which the lease will remain in effect.

In the region-by-region arrangement, the lessor buys the nuclear fuel, owns it during the time it is in the reactor, and continues to own it after it has been removed from the reactor, although ownership after irradiation is one of the variables for negotiation. Rental payments are made by the utility while the fuel is in the reactor. Arrangements to finance future replacement regions are made by the utility. The flexibility offered by this arrangement provides the utility with the options of:

1. continuing the region-by-region lease
2. negotiating a new lease
3. owning future replacement regions.

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[54] "Fuel Leasing Activities," op. cit., p. 6

The region-by-region lease arrangement provides intermediate-term financing of one region for a period of three to four years. A long-term arrangement that will provide financing for the initial core and subsequent replacement regions is the "evergreen" plan. In this plan, the lessor buys the initial core and rents it to the utility. The utility is responsible for purchasing replacement regions which are paid for out of revenues received in part from the sale of power generated by the initial core. Title to the replacement regions is turned over to the lessor and the utility generally has the option of buying back the unspent uranium in the regions being removed from the reactor. Plutonium and other nuclear by-products belong to the utility because they are considered as products manufactured by the utility during operation of the reactor to produce power.

> Under this arrangement, the utility is essentially using this technique to finance the first big jump into nuclear fuel, with the lessor--or lender--always having collateral in the reactor and perhaps a new core at the end of the lease term.[55]

The "evergreen" contract does not provide the utility with the financial flexibility available with the region-by-region arrangement. There is also some doubt as to whether the "evergreen" contract is a true lease or simply

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55 Ibid., p. 7

a deferred purchase. Decisions and opinions concerning the contract status will not be made by the Internal Revenue Service and the various regulatory agencies until an actual arrangement is put together. When these rulings are made they will be based primarily on the buy-back or other provisions for the disposal on the unspent uranium. In drafting the lease agreement, the lessor must avoid going too far in protecting himself on the resale of spent fuel or he will be in danger of having the lease classified as a conditional sale. Provisions for resale of spent uranium at "fair market value" may provide the means for avoiding classification of the lease as a conditional sale.

The "evergreen" contract provides for supply of the initial core by the lessor and supply of the replacement regions by the utility with transfer of title to the lessor. This type of arrangement does not adequately provide for changes in region cost that may result from inflation and general fuel cycle price escalation. The result is that the lease will cover less and less of the total value of fuel in the reactor as the cost of replacement regions increases. One leasing firm has suggested that a fuel amortization provision be included as a feature of the lease. This may accomplish recovery of the added investment but it may also jeopardize the status of the lease. Another way in which the incremental investment could be recovered is to provide liberal buy-back provisions for the spent fuel. Since the "fair market value" of spent uranium will be related (probably directly proportional) to the cost of the uranium in the replacement region, the adjusted buy-back clause may be the most suitable vehicle for recovery of the incremental fuel investment.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

The foregoing chapters have described the growth in the demand for electricity, the introduction and development of nuclear energy for the production of electricity, and the legislative actions that now make possible the change from government to private ownership of nuclear fuel. With the change in ownership of nuclear fuel scheduled to take place between January 1971 and June 1973, many utility companies are now investigating alternate means for financing the new capital requirements. In addition to ownership by the utility, several plans for leasing have been set forth by nuclear fuel suppliers, financial institutions, leasing companies and an agency of state government.

The economic comparison of alternatives generally available to utilities for financing nuclear fuel shows that ownership by the utility will cost less than the leasing proposals. Leasing is economically preferable to owning only when the potential lessor's cost of money is less than the utility's minimum acceptable return. In today's money market, the low cost of money needed to provide favorable leasing terms can be obtained only by government agencies authorized to issue tax exempt bonds. These agencies are not profit motivated and may actually subsidize a bond issue by underwriting the associated administrative and legal expenses using general tax receipts. Only one state government has indicated an interest in entering the nuclear fuel leasing business to date, and whether this interest will spread to other state or local governments is dependent on the outcome of a pending ruling of the Internal Revenue Service concerning the tax-free status of bonds sold to finance nuclear fuel. The possibility that favorable nuclear fuel leases provided by government agencies will become generally available to all electric utilities is remote. Without this source of low cost leases, the utilities can best maximize the low production cost advantage of nuclear powered generation by owning the nuclear fuel. This is the procurement policy that should be followed.

Large amounts of capital will be required for the financing of additions to generation, transmission and distribution plant. This capital can be obtained through the issuance of secured debt, increasing equity ownership in the utility, and from internally generated funds. Obtaining the additional capital required to finance utility owned nuclear fuel will mean that the utility industry will be going to the money market for unusually large amounts of new capital during the early years of large-scale nuclear unit installations. The capital required for nuclear fuel financing will become an increasingly larger portion of the total capital requirements as additional nuclear plants are placed in operation. The need for capital to finance an item that cannot be included in the existing mortgage indenture and is not a long-term asset requires special financing consideration.

Funds for the initial fuel supply should be obtained through the issuance of convertible debentures or convertible preferred stock. This type of issue can be used to maintain the balance between the marginal cost of equity and the marginal cost of debt by drafting the conversion provisions to encourage the investor to exercise his option at about the same time additional capital is required to finance the initial core loading of the next nuclear generating unit. Funds for replacement regions should be obtained from the conventional sources of utility capital. Using convertible issues to finance the initial core capital requirements will permit the utility to obtain funds at a cost less than current bonding rates because of the added feature of the equity sweetener. The convertible issue will also tend to reduce the cost of mortgage bond issues by building the equity base at the time of conversion. An example of the financial effects of a convertible debenture issue on the cost of money and the earnings of the utility is contained in the appendix to this chapter.

In spite of the unattractive economic picture for nuclear fuel leasing, several electric utilities have indicated an interest in this alternative. This interest stems from the current large demand for new utility capital at a time when the securities market conditions have made conventional debt, preferred stock and common equity financing less attractive than at any time in the past 30 to 40 years. Leasing has advantages in that:

1. leasing defers large investments in nuclear fuel during a transient period of uncertainty brought about by the lack of well established legal and accounting procedures, and

2. leasing will permit the timely entry into capital markets based on future utility capital requirements and changes in the cost of money.

Utilities will find leasing terms most favorable during the next few years. This is because interest rates will remain at fairly high levels and potential lessors will be proposing terms in the initial lease agreements designed to make the leasing alternative appear more attractive than ownership by the utility. The decision to lease should be made only after it has been determined that the benefits obtained through leasing are worth the additional long-range costs that will be incurred. A dependence on long-term fuel leasing programs can bind the utility to an inflexible pattern of financing. Utilities that choose to lease the initial nuclear fuel requirements should avoid fuel procurement contracts with terms and conditions that preclude the flexibility to make future choices between conventional and lease financing.

APPENDIX TO CHAPTER 6

EXAMPLE OF CONVERTIBLE DEBENTURE FINANCING

With current bonding rates for high quality securities averaging between 7.5 and 8 per cent, there is an advantage to issuing convertible securities. The rate for convertibles will fall somewhere between the rate for mortgage bonds and the expected return from utility common stocks. Dividends for utility common stocks are now being paid at a rate in the neighborhood of 5 per cent.

For the purpose of illustrating financing using convertible debentures we will present a four year financing plan for the Hypothetical Electric Utility Company. The company presently has an installed generating capacity of about 8000 Mw and is expected to require an additional 1000 Mw of installed capacity in the next two years. The base year capitalization is assumed to be $2,000,000,000. This is made up of 60 per cent debt and 40 per cent equity with the equity consisting of $480,000,000 of capital stock and $320,000,000 of earned surplus. The company has an established dividend policy that returns about two-thirds of earnings to the common stockholder while retaining the remaining one-third for investment. It is assumed that market conditions are relatively stable and that the market price of the common stock will be in the range of 12 to 13 times current earnings. With the established policy for dividend payments, a new investor can expect the stock to yield a return of about 5.2 per cent.

The need for new capital is expected to increase at an annual rate of about 6 per cent. During the first year the company will require additional capital in the amount of $120,000,000. Retained earnings will supply $42,000,000 and the remaining $78,000,000 will be obtained through the issuance of new debt. The utility has the option of selling mortgage bonds for the entire amount or of selling mortgage bonds for a portion of the requirement and convertible debentures for the remainder. Mortgage bonds are expected to sell at a coupon rate of 7.5 per cent and a convertible debenture issue is expected to sell at a rate about one per cent less, or 6.5 per cent. For the purpose of simplifying the comparison, underwriting costs will be omitted. The two financing plans being considered by HEUC are described in Table 6-1.

The base plan cost of debt is assumed to remain constant over the four year study period. Interest rates for the mortgage bond issues under the alternate plan are assumed to decrease slightly as a result of the anticipated increase in the equity base that will take place when the debenture conversion option is exercised. With the common stock currently selling at a market price of about $40 per share it is planned to have the debentures convertible to

TABLE 6-1

HYPOTHETICAL ELECTRIC UTILITY COMPANY FINANCING PLANS

Base Financing Plan - Mortgage Bonds

Year 1	$78,000,000	at	7.5%
Year 2	82,000,000	at	7.5%
Year 3	88,000,000	at	7.5%
Year 4	96,000,000	at	7.5%

Alternate Financing Plan
Mortgage Bonds and Convertible Debentures

Year 1	$48,000,000	at	7.5%
	30,000,000	at	6.5%
Year 2	82,000,000	at	7.4%
Year 3	88,000,000	at	7.3%
Year 4	56,000,000	at	7.2%
	40,000,000	at	6.2%

21 shares of common stock for each $1000 bond. This should encourage conversion at a market price between $47 and $48 per share. A second issue of convertible debentures is planned to coincide with the installation of a second nuclear powered generator to provide capital for the fuel requirements of that reactor. This pattern of financing is designed to match an intermediate-term source of funds to the intermediate-term requirement for nuclear fuel capital.

A comparison of the interest expenses for each of the financing plans is presented in Table 6-2. Assuming that the revenues will be the same regardless of the financing plan adopted, the increase in income resulting from the decrease in interest expenses of the alternate financing plan will be shared equally by the owners of the company and the federal government. The greatest increase in income will occur in the year in which the convertible debentures are converted to common stock. This addition to income will be used to supply dividend payments for the new outstanding shares of common stock.

Tables 6-3 and 6-4 present condensed financial statistics for each of the financing plans. For each plan the market price of the common stock is expected to appreciate from $40 per share to $50 per share over the study period based on the earnings multiple and the consistent pattern of dividend payments. The discounting of

TABLE 6-2

FINANCING PLANS EFFECT ON INTEREST EXPENSE
(Dollars in Millions)

End of Year	1	2	3	4
Mortgage Bond Plan Interest Expense	5.850	12.000	18.600	25.800
Convertible Debenture Plan Interest Expense	5.550	11.618	18.042	22.604
Reduction in Interest Expense of Convertible Debenture Plan	.300	.382	.558	3.196
Post-Tax Advantage	.150	.191	.279	1.598

TABLE 6-3

FINANCIAL STATISTICS - MORTGAGE BOND FINANCING PLAN
(Dollars in Millions)

End of Year	0	1	2	3	4
Capitalization					
Total	2000	2120	2247	2382	2525
Debt	1200	1278	1360	1448	1542
Capital Stock	480	480	480	480	480
Surplus	320	362	407	454	503
Revenue	700	740	788	834	884
Operating Expense	524	552	590	625	663
Interest Expense	50	53	57	61	65
Income	126	135	141	148	156
Dividends	84	90	94	99	104
Retained Earnings	42	45	47	49	52
Outstanding Shares (X 10^6)	40	40	40	40	40
Earnings Per Share ($)	3.150	3.375	3.525	3.700	3.900
Dividends Per Share ($)	2.100	2.250	2.350	2.475	2.600
Estimated Market Price of Stock ($)	40	43 1/2	45 3/8	47 1/2	50

TABLE 6-4

FINANCIAL STATISTICS - CONVERTIBLE DEBENTURE FINANCING PLAN
(Dollars in Millions)

End of Year	0	1	2	3	4
Capitalization					
Total	2000.00	2120.00	2247.00	2382.00	2525.00
Debt	1200.00	1248.00	1330.00	1418.00	1472.00
Convertible	0	30.00	30.00	30.00	40.00
Capital Stock	480.00	480.00	480.00	480.00	510.00
Surplus	320.00	362.00	407.00	454.00	503.00
Revenue	700.00	740.00	788.00	834.00	884.00
Operating Expense	524.00	552.15	590.19	625.28	664.60
Interest Expense	50.00	52.70	56.62	60.44	61.80
Income	126.00	135.15	141.19	148.28	157.60
Dividends	84.00	90.15	94.19	99.28	105.60
Surplus	42.00	45.00	47.00	49.00	52.00
Outstanding Shares (X 10^6)	40.00	40.00	40.00	40.00	40.61
Earnings Per Share ($)	3.15	3.379	3.529	3.707	3.881
Dividends Per Share ($)	2.10	2.254	2.354	2.482	2.60
Estimated Market Price of Stock ($)	40.00	43 1/2	45 1/2	47 3/4	50.00

the market price of the common stock that should be expected to accompany the alternate financing plan does not materialize because the increase in earnings during the years prior to conversion is passed along to the stockholders in the form of increased dividends. Dividends paid under the alternate financing plan are about one cent per share greater than under the base plan during the first two years and an additional one cent per share greater during the third year. The total increase in money available for dividend payments under the convertible debenture financing plan during the three years prior to conversion amounts to $620,000. To achieve this same increase under the mortgage bond financing plan would require a substantial increase in revenue or reduction in expenses of approximately $1,250,000. During the period prior to conversion downward pressure on the price of the common stock is further avoided because the stock conversion price is greater than the current market price. During the year conversion is expected to take place, the earnings per share is depressed slightly although the total earnings will be greater than in the base plan. The larger earnings of the alternate financing plan will provide the same retained earnings and dividends per share as the plan for financing using mortgage bonds.

This illustration has assumed that the cost of debt for a given capitalization ratio and class of security will remain constant over the period during which the two financing plans are being compared. Variations in the general interest rate will be reflected in the market price of the utility company common stock and will therefore have an influence on the length of time a convertible debenture remains outstanding. An increase in the rate of interest will depress common stock prices and therefore prolong the period before conversion. This conversion delay could be offset to some extent by increasing the dividend payment. With declining interest rates, utility common stock prices will appreciate at a faster rate and the period before conversion will be made shorter. In either case the effect on an intermediate-term convertible issue will be slight unless the change in interest rates is unusually large.

A comparison of the financial statistics in Tables 6-3 and 6-4 indicates two areas in which the financing plan using convertible debentures has a long-range advantage over the more conventional mortgage bond financing plan. In the mortgage bond plan the debt/equity ratio increases from 60/40 per cent to about 61.2/38.8 per cent. This means that future security issues will be considered higher risk securities and will command a higher coupon rate. The convertible debenture financing plan maintains a debt/equity ratio of approximately 60/40 per cent and tends to keep the marginal cost of debt and the marginal cost of equity equal (assuming that the initial capitalization ratio was optimum). The second area in which the long-range advantage of the convertible debenture financing plan is shown is in the area of interest expense. In the example financial statistics, the interest expense for the mortgage bond plan increases from $50,000,000 to $65,000,000 while the interest expense for the convertible debenture plan increases from $50,000,000 to $61,800,000. The difference in these two plans is a saving of $3,200,000 annually in fixed interest expense for the convertible debenture financing plan. This saving in fixed charges will be reflected in the rating assigned to future security issues.

The use of convertible debentures to finance the nuclear fuel requirements of public utilities will provide a low cost source of capital and it will also provide a means for gradually increasing the equity base for anticipated future borrowing.

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C R I T I Q U E S

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May 16, 1969

Mr. Peter A. Lewis
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Dear Pete:

You are to be congratulated on the professional quality of your thesis "Financing the Nuclear Requirements of Public Utilities." I was honored to have the privilege of reviewing it. It is pleasant reading. You have, indeed, covered quite thoroughly a technical and financing problem of considerable magnitude. As your thesis indicates, the mode of financing the nuclear fuel requirements of electric utilities is one of the major problems facing financial managers today.

I am recommending that your thesis be included in the Public Service Nuclear Fuel Library. This library is being maintained by the General Manager - Engineering and provides source material for the work of the Nuclear Fuel Task Force. In one document you have covered in a highly professional manner all of the aspects of the problem.

My review of your thesis indicates only one or two points at which I might suggest some minor improvement in treatment with the idea in mind of eliminating misinterpretation on the part of the readers. These can be classified into three general headings:

1. Corporate Pool of Capital Concept
   If nuclear fuel is to be financed through the normal channels, it may be confusing to attempt to identify the proceeds of a given security issue with a particular project. You understand the situation thoroughly, I know. My point is that at pages 38 and 72 a reader may indulge in the improper interpretation. Convertible debentures are issued on the credit of the entire enterprise and not just because of the nuclear fuel activity. The interest rate which they bear and the conversion pattern which will be generated by the investor reaction are dictated more by the total corporate financial behavior rather than by the nuclear fuel activity.

2. Revenue Requirements
I have found it helpful recently when dealing with the true cost of a project to use the phrases "minimum revenue requirements" and "present worth of all future minimum revenue requirements." While these phrases are cumbersome, it has become necessary to distinguish between the cost of a project and the total revenues required to sustain it. The difference, as you know and point out, is the profit incentive and the taxes thereon. When comparing two alternatives, it is the difference in the "present worth of all future minimum revenue requirements" that represents economic advantage. This economic advantage can then be allocated to either investors or customers as dictated by the thrusts of competition or the requirements of the investing market.

3. Income Taxes
It is desirable to regard all taxes levied on a corporate enterprise as increasing the total requirement for revenue. If taxes are reduced, the requirement for total revenues can be reduced and per unit prices lowered. Following this concept there is no real "sharing" of corporate economies with the federal government. As you point out, the objective of economic studies is to identify courses of action that have minimum costs including taxes. As per unit costs and revenues are reduced, per unit income taxes are also reduced. Adopting the economic alternatives will probably result in reduced per unit revenues.

Again, I would like to extend my sincere congratulations to you on the excellent job that you have done. I know that your thesis reflects the high personal integrity that you possess. These personal characteristics will accompany you on a highly successful personal career.

Yours very truly,

Bert J. Blewitt
Engineering Economist
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May 16, 1969

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Dear Pete:

I was pleased to have the opportunity to read and review your Master's Thesis. It is a comprehensive, well-written statement of the alternate means of financing the nuclear fuel requirements of a privately owned electric utility company.

Your task was an arduous one since the financial treatment of nuclear fuel is in its infancy. As you state, important governmental decisions are pending concerning the financial status of nuclear fuel. Leases have not been finalized whereby tax rulings can be established. Until these uncertainties are resolved, definite conclusions from a financial analysis become virtually impossible.

However, current decisions must be made. In general, you have stated reasonable assumptions on which your analysis is based. I agree with your conclusion that owning nuclear fuel is the most economical way of financing in the long run, barring governmental subsidies. The cost of leases should always be more than the marginal cost of money of a utility.

I don't believe the differences in costs are as great as you indicate in evaluating owning versus leasing. A 6% MAR is fine for engineering studies but the marginal cost of money, now 7-1/2% for utility bonds, should be used in a financial analysis. A more accurate and preferred way of demonstrating differences between alternatives is to use a corporate model. Here the effect on earnings per share, something everyone comprehends, is demonstrated. For example, the effect of classifying nuclear fuel as a fixed asset can better be evaluated. The effect on net plant and the allowable return on such will be different in the owning case. Consequently revenues will probably be different due to a difference in rate structure. This affects profitability which is not easily shown in the revenue requirement discipline.

I do realize corporate models are still developing and not available to most companies, no less individuals. But I do think we should look to the day when corporate models will be used to compare financial alternatives.

For some reason, use of convertible debentures has not been used very much by utilities. Your recommendation to use convertibles to finance nuclear fuel demonstrates a keen insight into the flexibility of such an issue.

Your intent of converting the debenture at the time a new nuclear unit is added should minimize the problem of future dilution of earnings. This type of financing definitely has merit during periods of high interest rates.

I believe your thesis serves as an excellent reference on nuclear fuel and the various possibilities of financing the fuel. My congratulations to you on a difficult job well done.

Very truly yours,

Richard B. Hieber
Associate Engineer

RBH:PA