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REPORT BY THE

Comptroller General

OF THE UNITED STATES

10,517

Nuclear Power Costs And Subsidies

On October 23, 1978, Senator John Melcher asked GAO to identify, to the extent possible, the "full" cost of nuclear power. Such a cost mainly includes not only industry's costs, but also those borne by the Federal Government to promote or regulate the nuclear power industry.

GAO found that the average commercial cost of electricity generated by nuclear powerplants in the United States during 1978 was reported to be about 1.5 cents per kilowatt-hour, about the same as it was in 1977.

Major Federal nuclear-related costs and subsidies for research and development, uranium enrichment, uranium exploration, and regulation totaled about $1.7 billion during fiscal year 1978, an increase of about $274 million from fiscal year 1977. These costs, based on assumptions described in the report, were equal to 0.62 cents per kilowatt-hour during fiscal year 1978, and 0.57 cents during fiscal year 1977. Other Federal contributions to the nuclear industry described in the report were not quantifiable.

EMD-79-52
JUNE 13, 1979

COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-164105

The Honorable John Melcher
United States Senate

Dear Senator Melcher:

On October 23, 1978, you asked us a number of questions about the cost of nuclear power. Taken together, these questions were aimed at determining--to the extent possible --the "full" cost of the electricity generated by nuclear powerplants. Such cost mainly includes not only industry's costs but also those borne by the Federal Government to promote or regulate the nuclear power industry.

Therefore, in response to your request, this report primarily addresses

--the current and projected costs of nuclear-generated electricity borne directly by the Nation's electric utilities, and

--the past and current Federal costs and financial incentives attributable to the Government's interest in promoting and regulating nuclear power.

Other related questions you asked are also discussed in the report.

As arranged with your staff, the report will be available for unrestricted distribution in 7 days unless you publicly announce its contents earlier.

Sincerely yours,

Comptroller General
of the United States

COMPTROLLER GENERAL'S REPORT
TO THE HONORABLE JOHN MELCHER
UNITED STATES SENATE

NUCLEAR POWER COSTS
AND SUBSIDIES

D I G E S T

On October 23, 1978, Senator John Melcher asked GAO a number of questions about nuclear power costs. Taken together, these questions were aimed at determining--to the extent possible--the "full" cost of nuclear-generated electricity. Such cost would mainly include not only the electric utilities' costs, which are passed on to the consumers in their electric bills, but would also include the costs borne by the Federal Government. The Federal costs, many of which could be considered as apparent subsidies or incentives to the nuclear power industry, would not be passed on to the consumer through the utility, but would generally be financed through tax revenues. (See p. 1.)

In response to Senator Melcher's request, this report primarily addresses

--the current and projected costs of nuclear-generated electricity borne directly by the Nation's electric utilities (see ch. 2) and

--the past and current Federal costs and apparent financial incentives attributable to the Government's interest in promoting and regulating nuclear power. (See ch. 3.)

THE COMMERCIAL COSTS OF NUCLEAR POWER

As of January 31, 1979, 70 nuclear powerplants were licensed to operate in the United States. These plants, having a total capacity of about 50,000 megawatts, provided about 13 percent of the Nation's electricity. An additional 126 powerplants are either under construction or planned. (See p. 4.)

While the cost of generating electricity at nuclear powerplants varies, depending on plant size, age, and location, GAO found various organizations that keep records of average costs for the electricity generated at all nuclear powerplants throughout the United States. For instance, in June 1978 the Department of Energy estimated that the average cost of nuclear-generated electricity was 1.46 cents per kilowatt-hour in 1976, and 1.45 cents per kilowatt-hour in 1977. (See p. 6.)

The Department of Energy's costs are very close to those reported by the Atomic Industrial Forum--an international association of more than 600 organizations interested in the peaceful uses of nuclear energy. While the figures for 1978 were not available from the Department of Energy at the time of our review, the Forum reported that the weighted average cost of nuclear-generated electricity during 1978 was 1.5 cents per kilowatt-hour. (See p. 7.)

Two future areas of increased costs will be waste management and decommissioning. Because actual procedures for both waste management and decommissioning are not known, the costs for these activities can only be estimated. (See p. 9.)

THE FEDERAL COSTS OF NUCLEAR POWER

The large financial risks involved with developing commercial nuclear power in the United States required Federal participation and cooperation with industry. This cooperation resulted in the Nation's first Power Reactor Demonstration Program in 1955. Under this program, the former Atomic Energy Commission offered large financial incentives such as research and development technology, waivers of fuel-leasing charges, fuel fabrication, and training to cooperating electric utilities. (See p. 12.)

The Government's objective was to eventually transfer all federally-developed reactor and fuel cycle technology to a

self-sustaining private industry. Federal participation in meeting this objective has cost the taxpayer an estimated $12.1 billion since 1950. (See p. 12.)

While the Federal Government has been active in a large number of nuclear areas, its major support to the commercial nuclear industry has been in the following areas.

--Nuclear research, development, and demonstration.

--Nuclear regulation to protect the public's health and safety.

--Enriching uranium so that it is usable in commercial nuclear powerplants.

--Stimulating mining of domestic uranium.

--Indemnifying powerplant owners and others in the industry against nuclear accidents. (See p. 12.)

From its inception, the Atomic Energy Commission supported a large nuclear reactor research, development, and demonstration program. This program--perhaps the most visible of the Federal Government's commercial nuclear efforts--was subsequently carried out by the Energy Research and Development Administration and then by the Department of Energy. According to the Department of Energy, it totaled $8.6 billion for fiscal years 1950 through 1978. These costs, however, may be about $1.1 billion higher. A 1978 Battelle Memorial Institute analysis indicated that the Department excluded (a) $0.6 billion for such efforts as the Biology and Environmental Sciences program and the Education Information and Training program and (b) $0.5 billion for program management and administrative costs. (See p. 13.)

The Atomic Energy Commission was solely responsible for regulating the nuclear industry to protect the public's health and safety from 1946 through 1974. The Energy Reorganization Act of 1974 (Public Law

93-438) separated nuclear power development and promotional functions from regulatory functions and created the Nuclear Regulatory Commission. Today, the Nuclear Regulatory Commission regulates the design, construction, and operation of all commercial nuclear powerplants and plays a major role in regulating all commercial fuel cycle phases except mining and enrichment. This regulatory function has cost $1.2 billion from fiscal years 1960 through 1978. (See p. 14.)

Uranium enrichment is a process which helps prepare uranium for use as a nuclear reactor fuel. The Federal Government's three large enrichment facilities--Oak Ridge, Tennessee; Paducah, Kentucky; and Portsmouth, Ohio--represent the major source of free world enriched uranium. Originally these enrichment plants were used to enrich uranium for the Nation's nuclear weapons program. Today, they provide enrichment services mainly to domestic and foreign utilities. (See p. 15.)

The Atomic Energy Act of 1954 (Public Law 83-703), as amended, requires the Department of Energy to price its uranium enrichment services to recover all Federal costs over a reasonable period of time. The Federal Government, however, has incurred costs, and provided what could be considered as subsidies, for uranium enrichment that have not yet been repaid by private industry. These costs and apparent subsidies, which totaled $1.2 billion through fiscal year 1978, include

--a price difference between the Government's current enriching charge and what it would cost if a commercial enriching facility provided the service and

--imputed interest on the Government's investment in uranium feed. (See p. 16.)

During fiscal years 1976, 1977, and 1978, quantifiable Federal costs for nuclear power--in addition to those borne by industry--were equal, based on assumptions described

in the report, to 0.51 cents, 0.57 cents, and 0.62 cents per kilowatt-hour, respectively.

Federal subsidies in the mining and indemnification areas surely stimulated the nuclear industry but, to our knowledge, no one has attempted to fully quantify these subsidies. (See p. 19.)

It is important to note that, while this report addresses only the costs--both apparent and hidden--of nuclear power, other energy sources receive Federal subsidies. Therefore, before one can compare the full cost of nuclear power to other energy sources, such as coal or oil, the full cost of other sources should also be calculated. Such a comparison is beyond the scope of this report.

AGENCY COMMENT

GAO submitted this report for comment to the Department of Energy and the Nuclear Regulatory Commission. The Department of Energy officials indicated general agreement with the report except where it (1) includes Federal expenditures for the liquid metal fast breeder reactor as a cost of nuclear power and (2) shows the Federal cost of nuclear power in terms of cents per kilowatt-hour.

GAO believes that the fast breeder reactor is widely regarded as a nuclear fission technology, and although it has not been commercialized, expenditures for its research and development should be included in the total Federal cost of nuclear energy. GAO also recognizes that its method of calculating the Federal cost of nuclear energy per kilowatt-hour has a disadvantage as noted by the officials. (See p. 18.)

The NRC staff also commented on a draft of this report. Their comments were generally similar to DOE's.

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ABBREVIATIONS

DOE	Department of Energy
GAO	General Accounting Office
NRC	Nuclear Regulatory Commission

CHAPTER 1

INTRODUCTION

Whether nuclear powerplants should be relied on as a significant future energy source is one of the most controversial energy issues in the United States. The issue is highly complex.

One of the most complex facets of this controversy relates to the cost of nuclear power. Nuclear power proponents often maintain that the electricity generated at nuclear powerplants is significantly less costly than alternative energy sources, such as coal and oil. On the other hand, nuclear power opponents often contend that this advantage is the result of various Federal incentives, like the cost of the Department of Energy's (DOE's) nuclear-related research and development. Accordingly, the opponents contend that eliminating these incentives would place nuclear power in an uneconomic position.

On October 23, 1978, Senator John Melcher asked GAO to help resolve this issue. Senator Melcher asked GAO a number of questions about nuclear power costs. Taken together, these questions were aimed at determining--to the extent possible--the "full" cost of nuclear-generated electricity. Such cost would include not only those electric utility costs which are passed on to the consumers in their electric bills, but would also include those borne by the Federal Government. The Federal costs, many of which could be considered as subsidies or incentives to the nuclear power industry, would not be passed on to the consumer through the utility, but would generally be paid for through tax revenues. The two costs together could roughly be considered the "full" cost of nuclear power.

In response to Senator Melcher's request, this report primarily addresses

--the current and projected costs of nuclear-generated electricity borne directly by the Nation's electric utilities (see ch. 2) and

--the past and current Federal costs and financial incentives attributable to the Government's interest in promoting and regulating nuclear power (see ch. 3.)

Other questions asked by Senator Melcher are also discussed in the report. A copy of Senator Melcher's request is included as appendix 1 of this report.

SCOPE OF REVIEW

We obtained the information contained in this report by reviewing key documents, studies, reports, correspondence, and other records. We also interviewed officials at the

--Atomic Industrial Forum, Inc., Washington, D.C.;

--Commonwealth Edison Company, Chicago, Illinois;

--DOE headquarters, Washington, D.C., and Germantown, Maryland;

--Edison Electric Institute, New York, New York;

--National Economic Research Associates, New York, New York;

--Nuclear Regulatory Commission (NRC) headquarters, Bethesda, Maryland;

--Philadelphia Electric Company, Philadelphia, Pennsylvania; and

--United Engineers and Constructors, Inc., Philadelphia, Pennsylvania.

It is important to note that, while this report addresses only the costs--both apparent and hidden--of nuclear power, other energy sources receive Federal subsidies. Therefore, before one can compare the full cost of nuclear power to other energy sources, such as coal or oil, the full cost of other sources should also be calculated. Such a comparison is beyond the scope of this report.

AGENCY COMMENTS

We submitted this report for comment to DOE and NRC. DOE officials indicated that they generally agreed with the report except where it (1) includes Federal expenditures for the liquid metal fast breeder reactor as a cost of nuclear power and (2) shows the Federal cost of nuclear power in terms of cents per kilowatt-hour. These officials believe that fast breeder reactor expenditures are not directly related to the present generation of nuclear power, and that the cents per kilowatt-hour calculation is misleading because it allocates all Federal costs and subsidies in a given year to the total kilowatt-hour generation of nuclear plants during that year. We believe that the fast breeder reactor is widely regarded as a nuclear fission technology, and although it has not been commercialized, expenditures

for its research and development should be included in the total Federal cost of nuclear energy. We also recognize that our method of calculating the Federal cost of nuclear energy per kilowatt-hour has a disadvantage as noted by the officials. While we noted this disadvantage, we left the calculation in the report, however, to be responsive to Senator Melcher's request.

The NRC staff also commented on a draft of this report. Their comments which were generally similar to DOE's are reflected, where appropriate, in the body of this report.

CHAPTER 2

THE COMMERCIAL COSTS OF NUCLEAR POWER

The generation of electricity is a process whereby a primary energy source (such as coal, oil, gas, or uranium) is converted into another form--electricity--which is generally more convenient to use. While fossil fuels can be converted directly to other sources of energy, nuclear fuel is currently used in the private sector mainly for conversion to electricity. This conversion takes place at nuclear powerplants.

The first civilian nuclear powerplant began operation in 1957 in Shippingport, Pennsylvania. This 60-megawatt prototype reactor was Government-owned, but contractor-operated by the Duquesne Light Company under a cooperative agreement with the former Atomic Energy Commission. 1/

As of January 31, 1979, 70 nuclear powerplants were licensed to operate by NRC. These 70 plants, having a capacity of about 50,000 megawatts, provided about 13 percent of the Nation's electricity. In addition, DOE operates two reactors with a capacity of 940 megawatts, which are not licensed by NRC. NRC recently reported that an additional 126 powerplants, representing almost 140,000 megawatts, are either under construction or planned.

CURRENT COSTS OF NUCLEAR POWER GENERATION

Before a utility decides to construct a powerplant--usually coal or nuclear--it will compare the costs of one to the other. This comparison is usually based on three major factors:

--Capital costs.

--Fuel costs.

--Operation and maintenance costs.

1/In October 1974 the Energy Reorganization Act of 1974 (Public Law 93-438) abolished the Atomic Energy Commission and created NRC and the Energy Research and Development Administration. On October 1, 1977, pursuant to the Department of Energy Organization Act (Public Law 95-91), the Energy Research and Development Administration's responsibilities were transferred to DOE.

Together, these equal the cost--often called the "bus-bar" cost--to produce electricity at the powerplant and do not include transmission, distribution, and overhead charges common to all sources of electricity. In discussing costs in this chapter, we will be concerned mainly with the bus-bar costs to generate electricity.

Capital costs

Capital costs, the largest of the three factors, can be viewed as either the actual dollar investment in the facility or the fixed charges associated with this investment. In developing bus-bar electric production costs, utilities use the fixed-charge rate.

The annual fixed-charge rate consists of (1) depreciation, (2) property insurance, (3) property taxes, (4) an interim replacement allowance, and (5) return on investment. The fixed rate will vary from utility to utility with the major variable being the utility's capitalization structure.

The capitalization structure of a utility determines the cost of money for new generating capacity. For publicly owned (municipal) utilities, this cost equals the interest rate on new bond issues. Investor-owned utilities, however, have an established allowable rate of return based, in part, on their capital structure, i.e., a combination of common stock, preferred stock, and bonds. Other variables among utilities include different credit ratings, various rates of return, and State and local taxes.

Fuel costs

A utility's fuel cost includes the cost of the present nuclear fuel cycle, namely, uranium mining and milling, production, enrichment, fuel fabrication, and interim storage of the used fuel assemblies. 1/ All of these steps, except uranium enrichment, which is run by the Federal Government on a cost recovery basis, are handled by industry.

Fuel costs vary from utility to utility due mainly to two factors--the cost of uranium ore and the price paid for enriching services. For example, one utility owns a mining and milling company which may allow it to acquire uranium at a lower cost than the current price of the ore. Further, DOE provides enriching services under three types of

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1/A brief description of the nuclear fuel cycle is included as app. II of this report.

contracts: (1) requirements contracts, (2) long-term fixed-commitment contracts, and (3) adjustable fixed-commitment contracts. (See page 15.) The contract price for the enriching service may vary, depending on the type of contract negotiated.

Operation and maintenance costs

Operation and maintenance costs consist mainly of salaries and benefits for the powerplant's operation and maintenance staff, fixed and variable costs for maintenance materials, insurance and licensing costs, and the cost of administration. These costs vary, of course, depending on the requirements for staff and the size and age of the plant.

Total bus-bar costs

The preceding discussion of the three types of costs leads to the question--what does nuclear-generated electricity cost at the bus-bar?

In June 1978 DOE estimated the actual cost at the bus-bar for the years 1976 and 1977. This estimate was based on the annual reports of both privately owned and publicly owned utilities submitted to DOE's Energy Information Administration. These estimates are shown in the following table.

Estimated Actual Cost at the Bus-bar, 1976-77

Cost factor	Average unit costs 1976	1977
	(cents/kilowatt-hour)	
Fuel (actual)	0.27	0.28
Operation and maintenance (actual)	0.23	0.25
Capital (estimated) (note a)	0.96	b/0.92
Generation cost (estimated)	1.46	1.45

a/Capital costs are based on an estimated constant fixed-charge rate of 17 percent. Actual fixed-charge rates are not submitted and vary from utility to utility based on tax rates, return on equity, etc.

b/Reduction due to averaging prior years capital investments.

DOE's estimates were very close to those kept by the nuclear industry. For example, each year the Atomic Industrial Forum--an international association of more than 600 organizations interested in the peaceful uses of nuclear energy--requests that all utilities with nuclear powerplants, as well as those purchasing substantial amounts of nuclear power, compute the total actual cost of producing a kilowatt-hour via the nuclear option. The Forum then accumulates this data and develops a weighted average cost. For both 1976 and 1977, the Forum reported that the weighted average cost of electricity from the Nation's nuclear powerplants was 1.5 cents per kilowatt-hour.

While figures for 1978 were not available from DOE at the time of this report, the Atomic Industrial Forum reported that 1978 generating costs were 1.5 cents per kilowatt-hour, about the same as they were in 1977 and 1976. A list of the Nation's nuclear utilities showing their reported costs for 1976 through 1978 is included as appendix III.

FUTURE COSTS OF NUCLEAR POWER GENERATION

This report concentrates on the most recent historical costs of generating electrical power via the nuclear option. However, in the future these costs will likely change in two ways. First, the existing cost factors may increase and second, other currently noncritical cost factors will receive more emphasis.

Projection of costs of current factors

Many estimates are available for the future cost of nuclear-generated electricity. For example, DOE projected that the cost of nuclear power beginning operation in 1985 will be:

	Cents/kilowatt-hour (note a)
Capital costs	1.€
Fuel costs	0.7
Operation and maintenance costs (note b)	0.1
Total costs	2.4

a/Based on GAO escalation of 1975 dollars at 6.5 percent per annum.

b/Minimal operating and maintenance costs during initial operating year.

Another example is the following NRC October 1978 cost projection of nuclear power coming on line in 1990 for various regions of the country.

Projected costs for 1990
initial year operation (note a)

Region	Capital	Fuel	Operation and maintenance	Total
	(cents/kilowatt-hour)			
New England	4.4	1.5	0.3	6.2
New York/New Jersey	4.6	1.5	0.3	6.4
Middle Atlantic	4.0	1.5	0.3	5.8
South Atlantic	4.0	1.5	0.3	5.8
Midwest	4.4	1.5	0.3	6.2
Southwest	3.9	1.5	0.3	5.7
Central	4.3	1.5	0.3	6.1
North Central	4.2	1.5	0.3	6.0
West	4.5	1.5	0.3	6.3
Northwest	4.4	1.5	0.3	6.2
National average	4.3	1.5	0.3	6.1

a/All estimates are in 1990 dollars to account for inflation.

Other cost factors

While much of the increased cost shown in the previous projections can be attributed to inflation, two new costs will be for waste management and decommissioning. Because actual procedures for both waste management and decommissioning are not known, the costs for these activities can only be estimated. While these costs will generally be added as factors to the bus-bar cost of producing electricity via the nuclear option, some utilities already include components for these activities.

Waste management

The Nation's nuclear waste management policies are constantly evolving. Today DOE expects that, in general, nuclear fuel--once discharged from the reactor--will pass

from the utility to a temporary storage facility, often called an "away from reactor" storage facility. If a final decision is made to discard the fuel, it could then be transported to a geologic repository where it will be permanently disposed. Considerable Federal research and development will be necessary, however, before these disposal facilities will be available to take the utilities' used fuel.

The Federal Government proposes to eventually offer to take title to and store spent nuclear fuel from privately owned power reactors. In keeping with this policy, DOE expects that there will be a one-time charge for the storage and disposal services provided by the Government. DOE also expects this charge to recover all Government costs. In July 1978 DOE published a report titled "Preliminary Estimates of the Charge for Spent-Fuel Storage and Disposal Services," which estimates that the one-time charge for storage and disposal would be approximately 0.1 cents per kilowatt-hour. It should be pointed out that this is only an estimate and it could change significantly if the procedures change.

As mentioned, the 0.1 cents per kilowatt-hour charge is based on estimates of full cost recovery by the Government. The following schedule shows all of the costs which DOE believes will need to be recovered in the one-time charge.

Facility or service	Costs to be recovered (note a) (millions)
Away from reactor storage	$ 275
Transportation to repository	100
Encapsulation facility	1,325
Geologic repository	2,141
Research and development	560
Government overhead	234
Total	$4,635

a/1978 dollars.

Decommissioning

Decommissioning can be defined as all of the measures taken at the end of a nuclear facility's operating life to

assure the continued protection of the public from any residual radioactivity or other potential hazards present in the facility. In a 1978 study prepared for NRC by Battelle Pacific Northwest Laboratory, two approaches to nuclear powerplant decommissioning were considered--immediate dismantlement and safe storage with deferred dismantlement.

Immediate dismantlement is the removal of radioactive materials with disassembly and decontamination during a 4-year period following final operation of a powerplant. The process known as safe storage with deferred dismantlement involves two steps. First, radioactive materials and contaminated areas are controlled to assure that the public is protected from residual radioactivity. Second, dismantlement is delayed until radioactivity has decayed to considerably lower levels.

The Battelle study estimated these methods to cost $42.1 million and $50.2 million, respectively, for a 1,175-megawatt powerplant. The costs of decommissioning are expected to be borne by the utility. Commonwealth Edison Company, the largest generator of nuclear power in the United States, estimated that these expenses translate into 0.02 cents per kilowatt-hour.

CHAPTER 3

THE FEDERAL COSTS OF NUCLEAR POWER

All commercial nuclear power technology can be traced directly or indirectly to the Federal Government's military program, namely, the development of nuclear weapons and reactors. The Atomic Energy Act of 1946 (Public Law 79-585) transferred these military nuclear programs to civilian control and charged the Atomic Energy Commission to develop the non-military aspects of nuclear energy. Later, the Atomic Energy Act of 1954 (Public Law 83-703) paved the way for industrial participation in the nuclear power development program. This law provided for declassification of considerable amounts of restricted information and permitted private ownership and operation of civilian nuclear powerplants.

Developing commercial nuclear power required large financial resources. Financial risks of this nature required Federal Government and industry cooperation which resulted in the Nation's first Power Reactor Demonstration Program in 1955. Under this program, the Atomic Energy Commission offered large financial incentives, such as research and development technology, fuel-lease waivers, fuel fabrication, and training to cooperating electric utilities.

The Government's objective was to eventually transfer all federally developed commercial reactor and fuel-cycle technology to a self-sustaining private industry. All steps in the fuel cycle--except uranium enrichment and waste management--are now handled by private industry. (See app. II.) Through 1978, Federal participation 1/ in developing the Nation's commercial nuclear power industry has cost the taxpayer an estimated $12.1 billion since 1950. This represents research, development, and demonstration incentives totaling $9.7 billion; regulatory costs of $1.2 billion; and enriching incentives totaling $1.2 billion.

While the Federal Government has been active in a large number of nuclear areas, its major support to the nuclear industry has been in the following areas:

--Nuclear research, development, and demonstration.

1/Defined to include direct or indirect payments, economic concessions, and privileges or benefits provided to any enterprise by the Government to promote its nuclear policies.

--Nuclear regulation to protect the public's health and safety.

--Enriching uranium so that it is usable in commercial nuclear powerplants.

--Stimulating mining of domestic uranium.

--Indemnifying powerplant owners and others in the industry against nuclear accidents.

NUCLEAR RESEARCH, DEVELOPMENT, AND DEMONSTRATION

From its inception, the Atomic Energy Commission supported a large nuclear reactor research, development, and demonstration program through contracts with national laboratories, industrial concerns, and private and public institutions. This program--perhaps the most visible of the Federal Government's nuclear efforts--was subsequently carried out by the Energy Research and Development Administration and then by DOE. These programs were aimed at promoting basic research and development and, with industry support, building demonstration plants.

According to DOE, the cost of Federal nuclear research, development, and demonstration totaled $8.6 billion. This represents program funds expended from fiscal years 1950 through 1978 on one or more of the following programs:

--Nuclear materials.

--Civilian reactor development.

--Advanced isotope separations.

--Waste management.

--Reactor safety research.

--Uranium resource assessment.

A table of the Federal Government's expenditures from 1950 through 1978 for each of these programs is included as appendix IV of this report.

Eighty-one percent, or $7.0 billion, of these Federal research and development funds were spent for the so-called civilian reactor development program, including $4.4 billion for the Liquid Metal Fast Breeder Reactor--once the Nation's highest priority energy research and development program.

In the early 1950s, the Atomic Energy Commission contributed only about 1 percent of its budget to commercial nuclear power research and development. In 1978 that contribution represented 17 percent of the DOE budget.

A 1978 analysis by the Battelle Memorial Institute indicated that DOE's cost figures for research, development, and demonstration excluded nuclear-oriented costs for such efforts as the Biology and Environmental Sciences Program, and the Education Information and Training Program. These programs were related to many programs, not only the civilian nuclear power program. Battelle estimated that the portion of these programs attributable to commercial nuclear energy cost about $0.6 billion.

Battelle also estimated the portion of the Government's program management, or administrative costs attributable to nuclear power programs, by assuming that in any one year, program management costs allocated to nuclear power should be the same as the total percentage spent in that area. Thus, an additional $0.5 billion could be included as a cost of commercial nuclear power development.

The total Federal commercial contribution for nuclear-related research, development, and demonstration--including DOE's "mixed" program contributions and administrative costs--totaled $9.7 billion through fiscal year 1978.

NUCLEAR REGULATION

The Atomic Energy Commission was solely responsible for regulating the nuclear industry to protect the public's health and safety from 1946 through 1974. The Energy Reorganization Act of 1974 (Public Law 93-438) separated nuclear power development and promotional functions from regulatory functions and created NRC. Today NRC regulates the design, construction, and operation of commercial nuclear powerplants and associated facilities and plays a major role in regulating all commercial fuel cycle phases except mining and enrichment. 1/

The NRC regulatory program's basic purpose is to carry out the Commission's statutory responsibilities to assure that the possession, use, and disposal of radioactive facilities and materials are conducted not only in a manner consistent with the public's health and safety and the Nation's

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1/Mining is controlled by individual States; enrichment is regulated by DOE.

defense and security, but also with the proper regard for environmental quality. Regulatory control was relatively simple when all nuclear materials were Government-owned, but became more difficult with the passage of the 1964 Private Ownership of Special Nuclear Materials Act (Public Law 88-489). This act allowed many private organizations to own nuclear materials.

The Federal Government has spent $1.2 billion from fiscal years 1960 through 1978 regulating the commercial nuclear power industry. Offsetting these costs, NRC collects various fees from its licensees. According to an NRC official, the fees represent only 20 percent of the actual licensing costs. Through fiscal year 1978, these fees have produced $74.3 million in revenues for NRC.

A table of yearly expenditures for nuclear regulation is found in appendix V.

URANIUM ENRICHMENT

Uranium enrichment is a process which prepares uranium for use as a nuclear reactor fuel. Basically, it converts natural uranium into a mixture with enough of the isotope uranium-235 to sustain a nuclear reaction.

The Federal Government has built three large enrichment plants at Oak Ridge, Tennessee; Paducah, Kentucky; and Portsmouth, Ohio. These facilities, representing the major source of free world enriched uranium, are currently capable of annually servicing about 200 large nuclear powerplants.

Originally these enrichment plants were used to produce enriched uranium for the Nation's nuclear weapons program. Today, they provide enrichment services mainly for sale to domestic and foreign utilities. These domestic and foreign customers are supplied under

- --requirements contracts where DOE agrees to supply the enriched uranium needed to fuel a specific reactor;
- --long-term, fixed-commitment contracts where DOE agrees to provide fixed amounts of enriched uranium for a certain time period; or
- --adjustable fixed-commitment contracts which allow the purchasers more flexibility than with the long-term, fixed-commitment contract.

The adjustable fixed-commitment contract became available in 1978 and is the only type of contract available to new customers.

The Atomic Energy Act of 1954, subsection 161B, (Public Law 83-703), as amended, requires DOE to price its uranium enrichment services provided under the above contracts to recover all Federal costs over a reasonable period of time. However, the Federal Government has incurred costs, or provided apparent subsidies to the nuclear power industry that have not yet been paid for by industry. The Federal incentives provided the commercial nuclear power industry in the enrichment area include:

--A price difference between the Government's current enriching charge and what it would cost if a commercial enriching facility provided the services.

--Imputed interest on the Government's investment in uranium feed.

Fair value pricing

Three times in the past 5 years, DOE has submitted a proposal to the Congress to revise the current uranium enrichment price structure. The proposed legislation would have established a "fair value" for pricing services by eliminating or reducing the difference between lower Government charges and those of potential domestic private enrichment projects.

DOE's current price, by law, excludes a return on equity, insurance, and taxes which a commercial supplier would pass on to the customer. This difference represented $220 million from fiscal year 1976 through fiscal year 1978. In a recent report 1/ addressing proposed legislation, we stated that a fair value pricing policy would generate additional revenues to the Federal Government of $1.5 billion for fiscal years 1979 through 1983.

This proposed legislation did not gain congressional approval, and DOE does not intend, at least in the near future, to resubmit a fair value pricing proposal.

1/"Fair Value Enrichment Pricing: Is It Fair?" (EMD-78-66, Apr. 19, 1978).

Imputed interest

Another cost of enrichment not charged to utilities is the imputed interest on the Government's investment in uranium feed stock--the uranium material that will eventually be processed through the enrichment plants. DOE's enriching prices must, by law, reflect the Government's enriching services cost.

Excluding imputed interest on feed stock represents a loss to the Government. If such funds are not so disbursed, they could repay or reduce Government borrowings and, therefore, reduce interest charges.

DOE recognizes imputed interest on uranium needed to provide enrichment services as a recoverable cost. However, it is our understanding that although DOE plans to initiate recovery of this lost interest in fiscal year 1979, the Department does not intend to recover this cost for fiscal years 1969-1978, which we estimate to be $1 billion.

DOE officials told us that they believe that the failure to recover the imputed interest is a Federal cost of nuclear power. However, they tentatively believe that it should not be called a cost of enrichment. They believe that it might be more appropriate to include it in the section of this report on uranium mining. At the time of this report, both DOE and GAO were studying this issue in more detail. On March 8, 1979, we sent a letter of inquiry to DOE addressing various aspects of this issue. As of the date of this report, however, DOE had not responded to this inquiry.

FEDERAL COSTS IN TERMS OF CENTS PER KILOWATT-HOUR

In his request, Senator Melcher asked us to show, in cents per kilowatt-hour, the Federal nuclear costs exceeding those incurred by private utility companies. The following table shows this by allocating the various Federal costs and incentives in a given year--1976, 1977, and 1978--to the total kilowatt-hours generated by nuclear plants in that year.

Fiscal year	R&D (note a)	Enrichment	Regulation	Total	Billion kilowatt-hours gen.	Cents/ kilowatt-hour
	(millions)					
b/1976	$ 936	$120	$221	$1,277	228	0.51
1977	989	180	213	1,382	243	0.57
1978	1,196	220	240	1,656	265	0.62

a/Includes $81.2 million for uranium resource assessment discussed on p. 18.

b/1976 figures include the 3-month transition quarter.

It is important to note that, in making this calculation, we had to assume that the costs in each year were to be "matched" with the kilowatt-hours generated during that year. Unfortunately, our method has a disadvantage in that the costs incurred in any one year--1976, 1977, or 1978--may benefit the nuclear industry during future years. This is particularly true for research and development costs. On the other hand, costs incurred prior to 1976 may benefit the industry during the 1976-1978 period. It should be noted that some sizable Federal contributions to the nuclear power program are not easily quantifiable. These contributions are discussed below.

URANIUM MINING

The U.S. war effort needs for uranium prior to the mid-1940s were supplied from a Belgian Congo mine, a Canadian mine, and a few scattered U.S. deposits. Eventually, the former Atomic Energy Commission recognized the Nation's dependence on foreign ore and established a uranium ore procurement program to stimulate domestic production. As a result, the Commission entered into long-term contracts with the following incentives:

--A 10-year guaranteed minimum price for certain high grade ore.

--A $10,000 discovery and production bonus.

--A guaranteed 3-year minimum price for Colorado Plateau ores.

The program's success required the eventual elimination of these benefits to avoid an excessive stockpile of uranium ore. The only benefits remaining, following the 1971

Federal termination of the uranium purchase program, are a restriction on foreign ore imports and DOE's National Uranium Resource Evaluation program.

The 1964 Private Ownership of Special Nuclear Materials Act in lieu therefore, directed that, to the extent possible these enrichment plants should not enrich foreign ores intended for use in the United States. This provision, which is not quantifiable, protected the domestic uranium industry from less expensive foreign uranium. A Notice of Modification of Restriction on Enrichment of Foreign Uranium for Domestic Use was published in the Federal Register and became effective on October 25, 1974. Under this plan, in 1977 up to 10 percent of the uranium furnished for enrichment by a domestic customer may come from a foreign source. The amount allowed would increase until 1984 when there will be no restriction on enrichment of foreign uranium for use in domestic reactors.

DOE's National Uranium Resource Evaluation program researches and estimates the potential domestic uranium reserves at various mining and milling costs. Program data, based on topographic and geological analysis, provides input to our national energy policy. According to DOE estimates, $116.2 million has been spent on this program through fiscal year 1978. This will provide information to both the Federal Government and the commercial nuclear industry. (See app. IV.)

NUCLEAR INDEMNIFICATION

The 1954 Atomic Energy Act permitted private ownership and operation of nuclear powerplants. Private ownership, however, raised an important question--who was to be financially liable in the event of a catastrophic nuclear accident? Nuclear facility suppliers and operators were generally unwilling to risk solvency on a budding industry. Further, the insurance industry was unwilling to fully insure these plants because no loss experience existed. The solution, a 1957 amendment to the Atomic Energy Act of 1954, provided the public, AEC licensees, and contractors financial protection against a nuclear accident.

This amendment--often called the Price-Anderson Act--effectively limited liability for any nuclear incident to $560 million and was to remain in effect for 10 years. The liability amount represented a maximum $500-million Government indemnity for each nuclear incident in addition to the maximum private liability insurance available in 1957--$60 million. The act was amended in 1965 by extending the Federal indemnity for an additional 10 years, as well as specifically limiting the $560 million for each accident. In

1966 it was again amended to provide for a "no-fault" clause, meaning that proof of negligence was not a requirement for compensating the injured party.

In 1975, the act was amended once again. This last amendment will eventually phase out Government indemnification for commercial reactors. It will not, however, phase out the $500-million indemnification for non-profit educational reactors.

The phase-out legislation will eventually eliminate Federal liability. The legislation shifts the financial risk from the Government to the nuclear industry. Insurance companies are currently providing $140 million of insurance and each commercial reactor must pay a retrospective premium or deferred premium of $5 million per reactor per incident. As a result, the Government indemnification stands at $70 million. The indemnification will be phased out as more private insurance becomes available and the number of operating reactors increase. To date no claims have been filed against the Federal Government.

The Price-Anderson Act provided an impetus needed to develop the nuclear industry without jeopardizing the industry's financial stability. However, quantifying that impetus was not feasible.

In a 1975 report 1/, we estimated an annual indemnity subsidy for a utility with one or two on-site reactors. Applying these figures annually to each operating reactor does not reflect the coverage provided fuel fabricators, suppliers, engineers, valve producers, and the general public. To our knowledge, no one has attempted to quantify this portion of the subsidy.

1/"Selected Aspects of Nuclear Powerplant Reliability and Economics" (RED-76-7, Aug. 15, 1975).

United States Senate

October 23, 1978

Honorable Elmer B. Staats
Comptroller General of
the United States
General Accounting Office
441 G Street, N. W.
Washington, D. C. 20548

Dear Mr. Staats:

The cost of nuclear waste disposal has for a number of years been reviewed by a number of sources in the private sector and in government. The latest is a study being conducted by the Department of Energy, headed by Dr. John Deutch.

There is a great deal of confusion among the Members of Congress, not only on the methods of storage but also on the cost. Coupled with the costs of processing nuclear fuels, the cost of disposing of the radioactive waste from the nuclear activities appears to be quite high, estimated to be over $568 million for Fiscal Year 1979. In addition, there are a number of localities where radioactive dust or other radioactive wastes from earlier nuclear fuel processing plants have created a federal responsibility that is quite costly.

It appears to me that it is time to have a major study outside of the Department of Energy and which is completely independent of the utility companies that have nuclear electrical generating plants. The General Accounting Office could, I believe, conduct a major, independent investigation of the total costs to the government of obtaining and processing or enriching the nuclear fuels and the present and projected costs of handling nuclear waste from nuclear electrical generating plants. I am aware that, generally, the utilities currently store spent fuel rods in pools at reactor sites and, therefore, despite the federal responsibilities for waste disposal, the utilities are bearing this cost in the short-run. However, there remains the away-from-reactor storage costs as well as costs for decontaminating and decommissioning currently used facilities. Until all of the costs are factored in, including those federal government costs attributed to licensing and regulating as well as waste management, it will be completely impossible to determine the actual kilowatt cost of the power produced from the nuclear electrical generating plants owned by

private utilities. The President has made some preliminary moves to recommend what utilities should be charged for federal waste disposal, but my questions seek an independent "audit" of federal costs that can reasonably be attributed to non-military nuclear activities.

I hereby request the GAO to undertake such a study and report to me and other Members of Congress on:

(a) The total federal government costs in nuclear fuels including costs and liabilities incurred from radioactive dust or other materials that require settlement by the U.S. attributable to non-military nuclear activities;

(b) Costs incurred by the U.S. in licensing and regulating of privately owned nuclear electrical generating plants;

(c) Costs incurred by the federal government for nuclear research and development that directly benefits the utilities using nuclear generating plants;

(d) Costs to the federal government for disposal and management of domestic nuclear waste from such funds both in current and projected expenditures, including expenditures for decontaminating and decommissioning nuclear installations; and,

(e) The current and projected federal costs defined in terms of electrical kilowatt costs that are in addition to the regular kilowatt cost for private utility companies from their nuclear electrical generating plants.

Please advise me if such a study could be conducted promptly and the report available by January 20, 1979.

Kindest personal regards.

Sincerely,

John Melcher

STEPS IN THE NUCLEAR FUEL CYCLE

Step	Description	Institution involved
Mining	Underground and surface mining of uranium ore.	Independent mining and large resource companies.
Milling	Mechanical and chemical refining of ore to "yellow cake." Usually done near mines.	Mining and chemical companies.
Production of uranium hexafluoride (UF6)	Conversion of "yellow cake" to gas for enrichment.	Chemical companies and resource companies.
Enrichment	Changing the concentration of natural uranium content of uranium-235 at 0.7 percent to between 2 and 4 percent. Current technology is being upgraded and new techniques are being tested.	Federal Government.
Fuel fabrication	The conversion of enriched UF6 gas to solid form and its assembly in fuel.	Nuclear steam system suppliers, large resource companies, and others.
Utility powerplant	Converts energy in uranium to electricity.	Investor-owned, public-, and federally-owned utilities.
Spent fuel storage	The storage of "burned" fuel bundles which no longer sustain the power output of the reactor.	Utilities and the Federal Government.
Fuel reprocessing (note a)	The recovery of usable uranium and plutonium from nuclear wastes.	Chemical and nuclear service companies.
Waste management	The safe disposal of radioactive waste essentially forever.	Federal and State governments and private industry.

a/On Apr. 7, 1977, the President decided to indefinitely defer commercial reprocessing in the United States because the process could be used by other nations to obtain materials usable in nuclear weapons.

APPENDIX III

U.S. ELECTRICAL GENERATING COSTS VIA THE NUCLEAR OPTION FOR CALENDAR YEARS 1976, 1977, AND 1978

Utilities	Cents per kilowatt-hour (note a) 1976	1977	1978
Alabama Power	N/A	N/A	N/A
American Electric Power	N/A	N/A	N/A
Arkansas Power and Light	1.5	1.3	1.5
Atlantic (City) Electric	1.6	2.6	2.2
Baltimore Gas and Electric	N/A	N/A	N/A
Bangor Hydro Electric, Maine	1.0	1.2	1.3
Boston Edison	2.9	3.0	1.9
Carolina Power and Light	N/A	N/A	1.9
Central Maine Power	1.0	1.3	1.3
Central Vermont Public Service	N/A	1.7	1.7
Commonwealth Edison, Illinois	1.4	1.3	1.3
Consolidated Edison, New York	3.8	1.8	2.4
Consumers Power, Michigan	N/A	N/A	N/A
Dairyland Power Corporation, Wisconsin	2.2	N/A	2.2
Delmarva Power, Delaware	N/A	3.1	N/A
Duke Power, North Carolina	1.2	1.3	1.2
Duquesne Light, Pennsylvania	N/A	1.0	N/A

N/A: Data not available.

a/Utility computation reflecting total actual cost of producing a kilowatt-hour, including cost of equipment, fuel, carrying charges, insurance, operation and maintenance, taxes, etc.

Utilities	Cents per kilowatt-hour (note a) 1976	1977	1978
Eastern Utilities Association, Massachusetts	1.8	1.9	1.8
Florida Power	N/A	N/A	N/A
Florida Power and Light	N/A	N/A	N/A
Green Mountain Power, Vermont	1.7	1.9	2.1
Jersey Central Power and Light	1.5	1.7	1.9
Metropolitan Edison, Pennsylvania	2.9	2.0	1.9
Nebraska Public Power District	1.6	1.3	1.1
New England Electric System, Rhode Island	1.2	1.4	1.4
New England Gas and Electric System, Massachusetts	1.7	1.9	1.6
Niagara Mohawk, New York	1.4	2.4	1.7
Northeast Utilities, Connecticut	1.4	1.5	1.6
Northern States Power, Minnesota	N/A	N/A	1.2
Omaha Public Power District	1.2	1.0	0.9
Philadelphia Electric	1.6	2.8	2.1
Portland General Electric, Oregon	N/A	1.6	6.0
Power Authority of the State of New York	1.3	N/A	N/A
Public Service Company of New Hampshire	1.1	1.4	1.5

N/A: Data not available.

a/Utility computation reflecting total actual cost of producing a kilowatt-hour, including cost of equipment, fuel, carrying charges, insurance, operation and maintenance, taxes, etc.

Utilities	Cents per kilowatt-hour (note a) 1976	1977	1978
Rochester Gas and Electric	1.5	1.5	1.5
Sacramento M.U. Distributor	1.2	1.0	1.1
Southern California, Edison	0.8	N/A	N/A
Tennessee Valley Authority	N/A	N/A	N/A
Toledo Edison Electric	N/A	N/A	1.3
United Illuminating, Connecticut	N/A	N/A	N/A
Virginia Electric & Power	1.3	1.2	1.9
Washington Public Power Supply System	N/A	N/A	0.9
Wisconsin Electric Power	1.0	0.8	0.8
Wisconsin Public Service	1.8	1.8	1.7
Weighted averages	1.5	1.5	1.5

N/A: Data not available.

a/Utility computation reflecting total actual cost of producing a kilowatt-hour, including cost of equipment, fuel, carrying charges, insurance, operation and maintenance, taxes, etc.

Source: Atomic Industrial Forum.

FEDERAL RESEARCH AND DEVELOPMENT EXPENDITURES FOR THE NUCLEAR POWER PROGRAM

Fiscal year	Nuclear materials	Civilian reactor development (fission)	Advanced isotope separation	Waste management	Reactor safety research	Uranium resource assessment	As disbursed dollar total
				(millions)			
1950	$ 3.3	$ 3.9	-	-	-	-	$ 7.2
1951	3.2	11.3	-	-	-	-	14.5
1952	4.1	15.8	-	-	-	-	19.9
1953	4.3	19.1	-	-	-	-	23.4
1954	5.1	31.6	-	-	-	-	36.7
1955	5.1	45.9	-	-	-	-	51.0
1956	6.0	69.2	-	-	-	-	75.2
1957	7.4	116.8	-	-	-	-	124.2
1958	8.3	128.0	-	-	-	-	136.3
1959	8.1	162.5	-	-	-	-	170.6
1960	8.1	219.0	-	-	-	-	227.1
1961	1.0	231.2	-	-	-	-	232.2
1962	8.7	217.7	-	-	-	-	226.4
1963	9.6	218.1	-	-	-	-	227.7
1964	9.5	200.8	-	-	-	-	210.3
1965	9.0	204.6	-	-	-	-	213.6
1966	9.0	196.6	-	-	-	-	205.6
1967	7.6	201.2	-	-	-	-	208.8
1968	7.6	248.6	-	-	-	-	256.2
1969	9.3	234.1	-	-	-	-	243.4
1970	12.6	231.0	-	-	-	-	243.6
1971	19.3	265.6	-	-	-	-	284.9
1972	23.4	324.0	-	-	-	-	347.4
1973	35.5	341.2	$ 0.8	$ 3.6	$ 41.0	-	422.1
1974	80.0	411.9	3.7	12.0	48.0	$ 2.9	558.5
1975	62.0	538.2	18.6	9.8	53.8	6.8	689.2
1976	61.0	521.7	27.6	12.2	86.0	12.8	721.3
Transition quarter	14.4	158.0	8.0	3.6	22.7	8.1	214.8
1977	68.4	684.3	39.2	62.8	103.2	30.8	988.7
1978	a/	729.0	a/	a/	a/	54.8	1,195.8
Total	$510.9	$6,980.9	$97.9	$104.0	$354.7	$116.2	$8,576.6

a/$412 million included in fiscal year 1978 total.

APPENDIX IV

THE COST OF NUCLEAR REGULATION

Year	Amount (millions)
1960	$ 3.1
1961	3.4
1962	3.6
1963	4.0
1964	21.0
1965	23.6
1966	26.5
1967	34.0
1968	39.7
1969	43.0
1970	49.0
1971	51.5
1972	69.5
1973	47.5
1974	55.2
1975	94.3
1976	164.8
TQ	56.2
1977	213.6
1978	240.2
Total	$1,243.7

Source: Nuclear Regulatory Commission.

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