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RESOURCES, COMMUNITY,  
AND ECONOMIC DEVELOPMENT  
DIVISION

April 15, 1983

B-207463

The Honorable Gordon J. Humphrey  
Chairman, Subcommittee on Regional  
and Community Development  
Committee on Environment and Public  
Works  
United States Senate



Dear Mr. Chairman:

Subject: Data on DOE's Uranium Enrichment Program  
(GAO/RCED-83-143)

Your letter of February 28, 1983, expressed concern about the Department of Energy's (DOE's) plans for providing uranium enrichment services and their potential effect on the Tennessee Valley Authority (TVA) and its customers. In that letter you asked us to answer a series of questions concerning these issues, and to report back to you with the answers to some of the questions by April 18, 1983.

This letter contains the answers to the following questions:

- What were DOE's expenditures for uranium enrichment research and development and pilot plant operations from 1970 to the present?
- What were DOE's expenditures for enrichment-related construction from 1970 to the present?
- What was the depreciation component of DOE's enrichment services price from 1970 to the present?
- What are DOE's plans for recovering projected enrichment capital investments over the next 20 years?

Since your request indicates that our response to the questions dealing with the price TVA charges DOE for its electric power is not as time critical and can be provided at a later date, we will provide that information in a subsequent report.

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## ENRICHMENT PROGRAM OVERVIEW

Uranium enrichment is the process by which uranium is prepared for use as fuel for nuclear reactors. At present, DOE enriches uranium for its domestic and foreign customers at three enrichment plants located at Oak Ridge, Tennessee; Paducah, Kentucky; and Portsmouth, Ohio. These plants use an electric power-intensive technology known as gaseous diffusion. Although the three plants were built in the 1940s and 1950s, DOE is nearing completion of a 10-year, \$1.5 billion program to improve their efficiency and increase their production capacity by about 60 percent.

In addition to the gaseous diffusion enrichment technology, DOE has developed a different type of enrichment technology which it believes will be more economical and thus result in lower enrichment prices. A project employing this technology, known as gas centrifuge, is currently being constructed at Portsmouth, Ohio. By the end of fiscal year 1984, DOE expects to have spent about \$2.4 billion on the gas centrifuge project. It currently expects the project to be completed in 1994 at a total cost of \$7.4 billion (fiscal year 1984 dollars).

Finally, DOE is developing two other enrichment technologies--advanced gas centrifuge and advanced isotope separation--which, according to recent DOE congressional testimony, have the potential of reducing enrichment prices to a level substantially below that possible from either the existing gaseous diffusion technology or the gas centrifuge technology now under construction.<sup>1</sup> If successful, DOE expects to be able to utilize an advanced technology for production of enriched uranium in the early 1990's.

## OBJECTIVES, SCOPE, AND METHODOLOGY

The objective of our work was to obtain answers to the specific questions asked by your office. To answer these questions, we interviewed DOE uranium enrichment program officials and requested them to provide us with specific data. We utilized this data to compute the depreciation component of DOE's enrichment services price and to compile the tables in the

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<sup>1</sup>The impact of advanced enrichment technologies on DOE's gas centrifuge plant construction plans is discussed in our report entitled "Issues Concerning The Department of Energy's Justification For Building The Gas Centrifuge Enrichment Plant," GAO/EMD-82-88, May 25, 1982.

enclosures to this letter. As agreed with your office, to report this information to you in the time requested, we did not audit or verify the data provided by DOE. With that exception, however, we performed our work in accordance with generally accepted government auditing standards.

SUMMARY OF INFORMATION OBTAINED

The detailed data we obtained from DOE in response to your questions are included as enclosures to this letter. The information shows that

- for fiscal years 1970 through 1984, DOE anticipates it will have spent about \$1.6 billion on uranium enrichment research and development and pilot plant operations for its existing and advanced enrichment technologies (see enc. I);
- for fiscal years 1970 through 1984, DOE anticipates it will have spent about \$2.4 and \$2.0 billion, respectively, in constructing the gas centrifuge facility and making improvements to the gaseous diffusion enrichment facilities (see enc. II); and
- from fiscal year 1970 to 1984 the depreciation component of DOE's enrichment services price is expected to increase from \$3.65 to \$8.05 per separative work unit (SWU)<sup>2</sup> while, due to a large increase in the overall price for enrichment services, depreciation as a percentage of the SWU price will decrease from 14.0 percent to 5.8 percent (see enc. III).

With respect to your fourth question concerning DOE's plans for recovering its projected enrichment capital investment, DOE program officials told us that at this time, for planning purposes, they expect that the primary capital investments to be recovered will consist of those expenditures which have been and will be made to construct the gas centrifuge enrichment facility, and those expenditures which have been and will be made to improve and maintain the gaseous diffusion enrichment facilities. The amount of capital investment to be recovered by DOE could change, however, if the advanced isotope separation technology, now under development, proves to be successful and is

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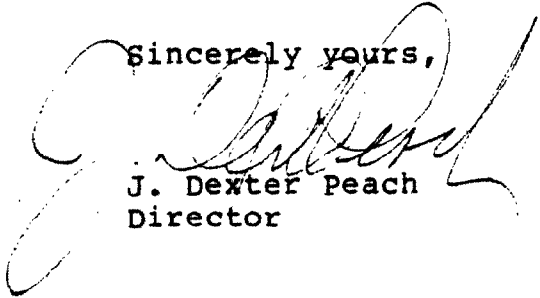
<sup>2</sup>The production capacity of enrichment plants is defined in terms of Separative Work Units. This is a measure of the amount of effort expended to separate a given amount of natural uranium into two components--one having a higher concentration and one having a lower concentration of fissionable uranium-235.

substituted for, or built in combination with, the gas centrifuge facility.

DOE recovers its capital investments by depreciating its capital items and factoring these costs into the price the customer is charged for enrichment services. Enclosure IV shows that the amount DOE plans to depreciate each year through 2003 ranges from \$109 million in 1984 to \$429 million in 2003. Enclosure V shows each year's depreciation as a component of the overall enrichment price. Between 1984 and 2003, the depreciation component as a percentage of the overall price is expected to increase from 5.8 to 16.4 percent, or from \$8.05 to \$15.65.

We did not obtain official agency comments on this letter. We did, however, discuss the matters presented with DOE program officials and have incorporated their views where appropriate. As arranged with your office, unless you publicly announce its contents earlier, we plan no further distribution of this letter until 3 days from the date it is issued. At that time we will send copies to the Secretary of Energy and make copies available to others upon request.

Sincerely yours,



J. Dexter Peach  
Director

Enclosures - 5

Uranium Enrichment Research and Development  
Costs From 1970 through 1984

Fiscal year	Gaseous diffusion Operating costs (note a)	Gas centrifuge/ advanced gas centrifuge		Total	Advanced isotope separation (note c)			Total uranium enrichment research and development costs
		Operating costs (note a)	Construction and equipment cost (note b)		Operating costs (note a)	Construction and equipment cost (note b)	Total	
------(in millions)-----								
1970	\$ 8.9	\$ 6.4	\$ 1.0	\$ 7.4				\$ 16.4
1971	8.4	8.2	3.4	11.6				20.0
1972	8.5	12.0	3.5	15.5				23.9
1973	8.4	15.9	11.1	27.0	.6	\$ .2	\$ .8	36.2
1974	9.1	24.3	25.9	50.1	2.8	.2	3.0	62.3
1975	9.6	27.1	25.5	52.6	13.6	1.6	15.2	77.3
1976	11.0	35.0	11.7	46.7	28.6	3.7	32.3	90.0
TQ (note d)	4.4	13.2	2.3	15.5	-	-	-	19.8
1977	16.1	50.3	12.6	62.8	33.2	5.0	38.2	117.1
1978	16.7	56.6	20.5	77.0	38.1	7.8	45.9	139.6
1979	17.1	57.1	27.7	84.7	44.7	7.0	51.7	153.5
1980	15.6	61.7	37.9	99.6	44.2	10.5	54.7	169.9
1981	15.2	61.8	27.7	89.5	67.7	8.8	76.6	181.3
1982	16.2	63.1	15.7	78.8	81.9	8.8	90.7	185.7
1983	18.0	69.5	6.7	76.2	45.5	1.4	46.9	141.1
(estimated)								
1984	17.9	71.9	7.4	79.3	60.5	10.1	70.6	167.7
(estimated)								
Total (note e)	<u>\$201.1</u>	<u>\$633.9</u>	<u>\$240.6</u>	<u>\$874.3</u>	<u>\$461.4</u>	<u>\$ 65.1</u>	<u>\$526.6</u>	<u>\$1,602.0</u>

a/Operating costs consist only of the amount of money DOE spent on research and development salaries, related items, and pilot plant operations.

b/Construction and equipment costs consist only of the amount of money DOE spent on research and development test facilities and equipment.

c/There were no DOE research and development expenditures for advanced isotope separation until the program was begun in fiscal year 1973.

d/"TQ" stands for "transition quarter." In 1976 the Federal Government converted its fiscal year from the 12-month period ending June 30 to the 12-month period ending September 30. The transition quarter consists of July, August, and September 1976, which are not included in either fiscal years 1976 or 1977.

e/Totals may not add due to rounding.

SOURCE: "Research and Development Costs," March 1983, and other documents, Office of Uranium Enrichment and Assessment, Department of Energy.

<u>Uranium Enrichment</u> <u>Construction Costs</u>			
<u>Fiscal year</u>	Gas centrifuge (note a)	Gaseous diffusion (note b)	Total (note c)
------(in millions)-----			
1970	\$	\$ 11.5	\$ 11.5
1971		8.7	8.7
1972		19.1	19.1
1973		43.8	43.8
1974		84.2	84.2
1975		128.9	128.9
1976		200.4	200.4
TQ	2.2	63.5	65.7
1977	18.9	307.9	326.8
1978	45.7	288.1	333.8
1979	126.3	227.1	353.4
1980	238.1	178.3	416.4
1981	336.3	161.0	497.3
1982	444.0	75.6	519.6
1983 (estimate)	600.0	110.8	710.8
1984 (estimate)	601.6	77.0	678.6
Totals (note c)	<u>\$2,413.1</u>	<u>\$1,985.9</u>	<u>\$4,399.0</u>

a/DOE did not begin construction activity for its gas centrifuge enrichment plant until the fiscal year 1976 transition quarter.

b/These construction costs primarily represent expenditures to improve the existing gaseous diffusion plants (see p.2 ).

c/Totals may not add due to rounding.

SOURCE: "Construction: Gas Centrifuge/Gaseous Diffusion," March 1983, Office of Uranium Enrichment and Assessment, Department of Energy.

Depreciation Component of DOE's  
Price Per SWU of Enrichment Services (note a)

<u>Effective date of price</u>	<u>DOE enrichment services price (note b)</u>	<u>Depreciation component of price (note c)</u>	<u>Depreciation component as a percentage of price</u>  (in percentages)
Jan. 1, 1970 (note d)	\$ 26.00	\$3.65	14.0
Feb. 22, 1971	28.70	4.20	14.6
Nov. 14, 1971	32.00	4.59	14.3
Aug. 14, 1973	36.00	4.63	12.9
Dec. 18, 1974	42.10	5.60	13.3
Aug. 20, 1975	53.35	5.23	9.8
Apr. 27, 1976	59.05	5.39	9.1
Oct. 1, 1976	61.30	5.74	9.4
Nov. 29, 1977	74.85	4.32	5.8
Dec. 30, 1978	88.65	5.51	6.2
Dec. 31, 1979	98.95	5.25	5.3
Nov. 29, 1980	110.00	5.64	5.1
Oct. 1, 1981	130.75	5.93	4.5
Aug. 21, 1982	138.65	6.28	4.5
FY 1984	138.65	8.05	5.8

a/The production capacity of enrichment plants is defined in terms of Separative Work Units (SWU). This is a measure of the amount of effort expended to separate a given amount of natural uranium into two components--one having a higher concentration and one having a lower concentration of fissionable uranium-235.

b/Between 1970 and 1982, DOE had three different types of enrichment contracts. In 1983, it expects to have a fourth type. The enrichment service prices in this schedule are the prices for the type of contract DOE offered its customers as of the particular date shown.

c/Section 161V of the Atomic Energy Act of 1954 (42 U.S.C. 2011) as amended, requires DOE to price its enrichment services in a way that it will recover the Government's cost of providing those services over a reasonable period of time. Thus, in determining the price for its enrichment services, DOE accounts for a number of different cost components, one of which is depreciation.

d/This price became effective January 1, 1968.

SOURCE: "Depreciation Component of SWU Price," March 1983, Office of Uranium Enrichment and Assessment, DOE.

DOE Uranium Enrichment Program's Planned  
Depreciation Schedule for Fiscal Year 1984 Through 2003

<u>Fiscal year</u>	Annual Depreciation expense (note a)  (in millions)
1984	\$109
1985	113
1986	117
1987	118
1988	129
1989	146
1990	192
1991	240
1992	288
1993	340
1994	388
1995	418
1996	421
1997	424
1998	424
1999	425
2000	426
2001	426
2002	429
2003	429

a/DOE plans to build the gas centrifuge facility in increments. Therefore, that facility's capital costs are incrementally added to the depreciation schedule as they are scheduled to come on-line.

SOURCE: "Uranium Enrichment Cash Flow/Pricing Tool Depreciation Schedule Output Data Values," Feb. 7, 1983, Office of Uranium Enrichment and Assessment, DOE.



Estimated Depreciation Component of DOE's  
Projected Price Per SWU of Enrichment Services (note a)

<u>Fiscal year</u>	<u>DOE enrichment services price</u>	<u>Depreciation component of price (note b)</u>	<u>Depreciation component as a percentage of price</u>  (in percentages)
1984	\$138.65	\$ 8.05	5.8
1985	135.95	8.97	6.6
1986	132.69	10.08	7.6
1987	129.60	11.15	8.6
1988	126.72	12.04	9.5
1989	123.93	12.76	10.3
1990	121.27	13.46	11.1
1991	119.19	14.18	11.9
1992	116.75	14.83	12.7
1993	114.38	15.33	13.4
1994	112.13	15.36	13.7
1995	110.02	15.29	13.9
1996	107.99	15.23	14.1
1997	106.05	15.27	14.4
1998	104.18	15.31	14.7
1999	102.37	15.46	15.1
2000	100.61	15.59	15.5
2001	98.89	15.52	15.7
2002	97.17	15.55	16.0
2003	95.45	15.65	16.4

a/The production capacity of enrichment plants is defined in terms of Separative Work Units (SWU). This is a measure of the amount of effort expended to separate a given amount of natural uranium into two components--one having a higher concentration and one having a lower concentration of fissionable uranium-235.

b/Section 161V of the Atomic Energy Act of 1954 (42 U.S.C. 2011) as amended, requires DOE to price its enrichment services in a way that it will recover the Government's cost of providing those services over a reasonable period of time. Thus, in determining the price for its enrichment services, DOE accounts for a number of different cost components, one of which is depreciation.

SOURCE: "Uranium Enrichment Cash Flow/Pricing Tool Depreciation Schedule Output Data Values," Feb. 7, 1983, Office of Uranium Enrichment and Assessment, DOE.