Title: Evaluation of Decommissioning Costs for a Nuclear Power Pl

Course:
Year: 1992
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Report No: P92002

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EVALUATION OF DECOMMISIONING COSTS

FOR A NUCLEAR POWER PLANT

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EMP-P9202

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ENGINEERING MANAGEMENT 535

Portland State University

March 13, 1992

INTRODUCTION

The federal laws governing the commercial use of nuclear energy for the production of electricity are codified and published in the United States Code of Federal Regulations, Title 10, Part 50 (10CFR50, Reference 1). 10CFR50 Sections 50.33(k), 50.75, and 50.82 contain the requirements for decommissioning of nuclear power plants after their operating licenses expire. These requirements include filing a decommissioning report and certifying that funds will be available for decommissioning. Alternatives provided for assuring availability of funds are: the use of a prepayment trust; an external sinking fund; a surety bond or other guarantee; or, for agencies of the Federal government, a "statement of intent".

10CFR50 presents a formula for calculating minimum funds needed for decommissioning but also allows for preparation of decommissioning cost estimates.

The objective of this paper is to prepare cost estimates for decommissioning the Trojan Nuclear Plant and compare the results with the estimates submitted by the majority owner and operator, Portland General Electric Company (PGE).

U. S. NRC Requirements

The United States Nuclear Regulatory Commission (NRC) has authority over commercial use of nuclear energy and has provided guidance on meeting the above requirements in a series of published and draft NRC Regulatory Guides. Regulatory Guide 1.159 (Reference 2) has the following definition: "Decommissioning means to safely remove nuclear facilities from service and reduce residual radioactivity to a level that permits release of the property for unrestricted use and termination of the [operating] license." Three main methods for decommissioning are described: immediate decontamination; safe storage with decontamination after a period of years has elapsed; and entombment in place. The Regulatory Guide states that the purpose of the utilities decommissioning report is "to provide reasonable assurance that licensees have a viable plan to accumulate funds in the certification amount, adjusted for inflation, by the projected time of permanent cessation of operations."

PUC Requirements

The Public Utility Commission of Oregon has statutory authority to review and approve the rates that PGE charges its customers for electricity. The PUC has reviewed PGE's cost estimates and, after a series of negotiations, PGE and the PUC have agreed on a financing plan (References 3 and 4).

COST ESTIMATES

The standard reference for preparing decommissioning cost estimates for nuclear plants is a series of reports prepared by Battelle, Pacific Northwest Laboratories (References 5 through 8). These reports were used as guidance in developing cost estimates for Trojan

Alternatives for Decommissioning

Regulatory Guide 1.159 (Reference 2) provides the following definitions for alternatives:

> Decontamination is the method in which the equipment, structures, and portions of a facility and site containing radioactive contaminants are removed or decontaminated to a level that permits the property to be released for unrestricted use shortly after cessation of operations.
>
> Safe storage is the method in which the nuclear facility is placed and maintained in a condition that allows the nuclear facility to be safely stored and subsequently decontaminated (deferred decontamination) to levels that permit release for unrestricted use.
>
> Entombment is the method in which radioactive contaminants are encased in a structurally long-lived material, such as concrete. The entombed structure is appropriately maintained, and continued surveillance is carried out until the radioactivity decays to a level permitting unrestricted release of the property.

PGE, in Reference 3, explains why the only alternative now being considered is decontamination (immediate dismantlement). The reason given by PGE is that the NRC "no longer allows utilities to assume that decommissioning funds will earn at a rate higher than the general rate of inflation after plant operations cease." Another reason may be because this alternative would meet the least political opposition.

Calculation of Costs

The costs developed in Battelle References 5 through 8 were extracted, modified slightly, and are presented in Table I. The published costs were modified to make them more comparable. References 5 through 8 were modeled on a composite nuclear plant that was in turn partly based upon Trojan facilities. The model in the references was compared with the current basis for Trojan as described in Reference 9. Three reference dates are included to illustrate the increase in costs (January 1978, January 1984, and January 1986). The following discussion address specific categories of costs:

Disposal of Radioactive Materials.

This is the largest group of cost categories. The cost of spent fuel disposal was dropped after 1978 because the Nuclear Waste Policy Act of 1982 requires the federal government to take title to spent fuel at the plant. Disposal costs have grown much faster than the general rate of inflation. PGE, in Reference 3, assumes that costs will continue to grow at the inflation rate plus one per cent. This assumption was used in this paper.

Staff.

This category has increased due to changes in NRC regulations governing radiation exposure. This paper assumed that the trend will continue, and used as a basis an allowable exposure per employee of 3 rem per year. (The current allowable is 5 rem per year.)

Contractors.

PGE has tended to rely heavily on contractors for specialized work, so the cost estimates were based on the assumption that this will continue.

Demolition.

Demolition of nun-nuclear structures and facilities if not required by the NRC. However, these costs were included because of the presumption that political pressures will require that the site be restored to a "natural" condition. Salvage values were included in Reference 5 and serve to reduce demolition costs slightly.

Summary.

Published cost estimate, as modified for this paper have increased from 41.5 million dollars in 1978 to 135 million dollars in 1986. See the last line in Table I.

Inflation

United States Bureau of Labor Statistics for the Consumer Price Index (CPI) were used to adjust costs to October 1991. The CPI for the last 20 years was assumed to apply for the next 20 years and used to calculate prices at the end of the year 2011.

Risks and Uncertainties

The uncertainty in this evaluation concerns future inflation rates. The risks in this evaluation are that costs of decommissioning may increase faster than the CPI due to increase government regulation.

FINANCING

In References 3 and 4, PGE describes establishing a sinking fund to provide for the needed decommissioning funds when needed in 2011. PGE assumes a 4.5% interest rate and a mix of interest rates: 6.45% for tax exempt bonds, 8% for treasury bonds, and 9.25% for corporate bonds. As of the end of 1990, the fund had only 8.6 million dollars. Because in July, 1990 the NRC changed the regulations for such funds, PGE will need to collect approximately 14 million dollars annually. These funds will be invested in a trust and the funds plus earned interest collected until 2011. For information, PGE's projected fund is attached as Table III.

CONCLUSIONS

This paper estimates a decommissioning fund of 619 million dollars will be needed in 2012. PGE used a different method based on comparisons with a study done for the Wolf Creek Generating Station. PGE estimated that 723 million dollars will be needed in 2011. PGE's share at the end of 2010 will be 445 million dollars.

The conclusion is that PGE's estimate is reasonable. Costs will need to be reviewed periodically to correct for changing requirement, inflation rates, and interest rates. If the plant is shut down before 2011, there will be a large shortfall in funds, which will need to be made up by ratepayers or stockholders.

REFERENCES

1. United States Code of Federal Regulations, Title 10, Part 50, "Domestic Licensing of Production and Utilization Facilities," (10CFR 50), U.S Government Printing Office, Washington, D.C., 1991.

2. United States Nuclear Regulatory Commission, Assuring the Availability of Funds for Decommissioning Nuclear Reactors, Regulatory Guide 1.159, Revision 0, August 1990.

3. Public Utility Commission of Oregon, General Rate Increase, Case UE 79, Issues S-27 and S-28, including PGE Exhibit 3D, dated March 22, 1990, PUC Staff Exhibits 35 and 36, dated August 29, 1990, and PGE Exhibit 3R, dated November 19, 1990.

4. Portland General Electric Company letter to Oregon Department of Energy, Report of Decommissioning Funding Plan Pursuant to Oregon Administration Rule (OAR) 345-26-096, dated December 31, 1991.

5. R. I. Smith, G. J. Konzek and W. E. Kennedy, Jr., Technology, Safety and Costs of Decommissioning a Reference pressurized Water Reactor Power Station, NUREG/CR-130, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, WA, June 1978.

6. R. I Smith and L. M. Polentz, Technology, Safety and Costs of Decommissioning a Reference pressurized Water Reactor Power Station, NUREG/CR-130, Addendum 1, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, WA, August 1979.

7. I. Smith, G. J. Konzek, E. S. Murphy, H. K. Elder, Updated Costs for Decommissioning Nuclear Power Facilities, NP-4012, Electric Power Research Institute Report by Pacific Northwest Laboratories, May 1985.

8. J. Konzek and R. I. Smith, Technology, Safety and Costs of Decommissioning a Reference pressurized Water Reactor Power Station, NUREG/CR-130, Addendum 4, U.S. Nuclear Regulatory Commission Report by Pacific Northwest Laboratory, Richland, WA, July 1988.

9. Trojan Final Safety Analysis Report, Portland General Electric Co., Portland, Or, December, 1991.

10. Bureau of Labor Statistics, "Consumer Price Index, All Items," U.S Government Printing Office, Washington, D.C., November, 1991.

TABLE I ESTIMATED TROJAN DECOMMISSIONING COSTS

	Costs, in Millions of Dollars				
Date, month and year:	Jan-78	Jan-84	Jan-86	Oct-91	Jan-12
Reference source:	Ref. 5	Ref. 7	Ref. 8		
Category of Cost					
Spent Fuel Disposal	2.5	0.0	0.0	0.0	0.0
Activated Materials Disposal	2.7	6.0	6.4	8.5	34.6
Containment Internals Disposal	1.0	2.9	4.0	5.3	21.6
Other Building Internals Disposal	4.2	12.5	19.0	25.2	102.7
Waste Disposal	0.7	1.6	2.1	2.8	11.4
Staff Labor	9.0	14.4	14.4	18.1	60.9
Electrical Power	3.5	9.1	6.7	8.4	28.4
Special Equipment	0.8	1.2	1.3	1.6	5.5
Miscellaneous Supplies	1.6	2.3	2.5	3.1	10.6
Specialty Contractors	0.4	0.6	0.6	0.8	2.6
Nuclear Insurance	0.8	1.1	1.5	1.9	6.3
Environmental Surveillance	0.2	0.2	0.3	0.3	1.1
License Fees	NA	0.1	0.1	0.2	0.7
Additional Staff (<5 rem/year)	NA	5.9	6.0	7.5	25.4
Additional Staff (<3 rem/year)	NA	12.8	12.9	16.2	54.6
External Decom. Contractor	NA	10.2	10.3	12.9	43.6
Predecommissioning Eng'ing	NA	5.8	5.9	7.4	25.0
Supplies for Extra Staff (<3 r/yr)	NA	3.1	3.2	4.0	13.5
Post-TMI2 Impacts	NA	NA	0.7	0.9	3.0
Subtotal, nuclear costs	27.3	89.9	97.9	125.0	451.5
25% Contingency	6.2	22.5	24.5	31.3	112.9
TOTAL NUCLEAR COSTS	33.5	112.3	122.4	156.3	564.4
Demolition of Containment Bldg	2.3	NA	NA	NA	NA
Demolition of Cooling Tower	1.4	NA	NA	NA	NA
Demolition of Other Facilities	2.7	NA	NA	NA	NA
25% Contingency	1.6	NA	NA	NA	NA
TOTAL NON-NUCLEAR COSTS	8.0	NA	12.8	16.0	54.2
GRAND TOTAL	41.5	NA	135.2	172.3	618.6

NA = Not Applicable

TABLE II INFLATION FACTORS AND RATES

	General	RadWaste
	Ref. 10	
Inflation Factor Oct 1991/Jan 1986	1.25	1.32
Inflation Factor Oct 1991/Jul 1971	3.38	4.08
Inflation Rate, 1986-1991	0.040	0.050
Inflation Rate, 1971-1991	0.062	0.072

TABLE III

YEAR-END PROJECTED ACCUMULATED AMOUNTS
FOR THE TROJAN NUCLEAR PLANT DECOMMISSIONING
(THOUSANDS OF DOLLARS)

Year	PGE	EWEB	PP&L	Total
1991	18,524	7,168	1,875	27,567
1992	28,995	9,601	2,000	40,596
1993	40,101	12,257	2,473	54,831
1994	51,879	15,153	2,979	70,011
1995	64,370	17,008	3,521	84,899
1996	79,020	19,043	4,100	102,163
1997	94,558	21,274	4,720	120,552
1998	111,037	23,720	5,384	140,141
1999	128,516	26,398	6,093	161,007
2000	147,053	29,329	6,853	183,235
2001	168,462	32,462	7,666	208,604
2002	191,169	36,043	8,535	235,474
2003	215,252	29,875	9,466	264,593
2004	240,796	44,061	10,461	295,318
2005	267,890	48,633	11,527	328,050
2006	298,804	53,622	12,666	365,092
2007	331,594	59,065	13,886	404,545
2008	366,373	65,001	15,191	446,565
2009	403,263	71,472	16,587	491,322
2010	444,514	78,325	18,075	541,114

NOTE: The annual amounts indicated are estimates and may differ from the actual values. The annual report of decommissioning funding will provide current values.

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Source: Copied from PGE to Oregon DOE letter Dated December 31, 1991 (Ref. 4)