UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
CONSUMERS POWER COMPANY	)	Docket Nos. 50-329
	)	50-330
(Midland Plant, Units 1 & 2)	)	
	)	

NRC STAFF SUPPLEMENTAL DIRECT TESTIMONY
OF JACK ROBERTS - NUCLEAR FUEL COST
ANALYSIS

INTRODUCTION

In this analyses, the nuclear fuel costs used by the NRC Staff in the testimony in the proceeding[1] and the revised nuclear fuel costs presented by the licensee[2] at the hearing, (the original and revised testimony follow TR 3638) are examined and compared to the nuclear fuel cycle costs calculated based on the cost components in the "Final Generic Environmental Statement on the Use of Recycle Plutonium on Mixed Oxide Fuel in Light Water Cooled Reactors" (GESMO), NUREG-0002. This analysis was prompted by the substantial increase in nuclear fuel costs presented in the revised testimony of G. S. Keeley. As can be seen from the original and Revised Exhibits No. 17, nuclear fuel costs for the Midland Facility increased from $840,000,000 to $1,600,000,000, or nearly a doubling. The levelized value of 10.3 mills/kWhre presented in the DES[3] increased to 19.2 mills/kWhre.

Nuclear Fuel Cost for PWR'S

The nuclear fuel cycle costs employed in this analysis were based on the general procedures outlined in "Guide for Economic Evaluations of Nuclear Reactor Plant Designs" NUS-531. The reference fuel cycle cost components as developed in the "Final Generic Environmental Statement on the Use of Recycle Plutonium in Mixed Oxide Fuel in Light Water Cooled Reactors" (GESMO), NUREG-0002, were used. The low, reference, and high values used are summarized in Table 1.

TABLE 1
MATERIAL AND SERVICE UNIT COSTS, 1975 DOLLARS

Parameter	Low	Reference	High
Mining and Milling, average $/lb U_3O_8*	14	28	56
Conversion to UF_6, $/kg U	3	3.5	4
Uranium Enrichment, $/SWU	60	75	110
UO_2 Fabrication, $/kg HM	85	95	105
MOX Fabrication, $/kg HM**	150	200	300
Spent Fuel Transportation, $/kg HM	5	15	30
Spent Fuel Storage, $/kg HM-yr	2	5	10
Reprocessing, $/kg HM***	110	150	190
Waste Disposal, $/kg HM+	30	50	70
Plutonium Transportation, $/g	0.02	0.04	0.06
Plutonium Storage, $/g-yr	1	2	3
Spent Fuel Disposal, $/kg	50	100	150

*Use-weighted average cost (1975-2000), varies with consumption.
**Includes MOX shipping to reactor.
***Includes waste solidification.
+Includes waste shipment to Federal repository.

The fuel cycle calculations were based on equilibrium conditions. Two conditions were considered. One where the spent fuel is stored for 5 years and then shipped to a repository for disposal, the other was chemical reprocessing of the spent fuel to recover the plutonium (Pu) and remaining U-235 for recycle. The value for recovered plutonium and enriched U-235 was determined by making the cost of enriched fuel using Pu and/or recovered U-235 equal to the cost of a fuel using natural uranium. In other words the fuel cycle cost would be the same whether the recovered Pu and U-235 was recycled or sold at the calculated value for Pu and U-235. The assumptions used in the fuel cycle calculations are summarized in Table 2.

Cost for the various components of the fuel cycle were calculated in terms of dollars per kilogram of heavy metal ($/kg HM) and converted to mills/kWh based on an irradiation level of 32,600 MWD/MTHM. The costs were calculated in terms of 1975 dollars and the total fuel cycle cost then escalated at 8% per year to 1981. The 1981 present value for the 30 year life of the plant was calculated by escalating the 1981 cost at 5% per year and discounting at 10% per year. The present value for the 30 year period was then amortized over 30 years.

It should be noted that the 28 $/lb for U_3O_8 under the reference scenario is a use-weighted average cost (1975-2000) and takes account of the increasing cost of U_3O_8 due to depletion of high grade ores.

The fuel cycle cost excluding carrying charges is summarized in Table 3 for the no recycle case and for the recycle of plutonium and spent uranium case.

Carrying charges on the funds required to support the fuel cycle were calculated based on the following set of assumptions:

- 1 year from U_3O_8 purchase through conversion to UF_6, enrichment and fabrication.
- Resident time in the reactor based on capacity factors, 50%, 60%, 70% and 32,600 MWD/MTHM exposure.
- For the throw away fuel (no recycle case) a 5 year storage is included before final disposal.

TABLE 2

Reactor Type	PWR
Net thermal efficiency, %	33
Specific power MWT/MTHM	38*
Irradiation level, MWDT/MTHM	32,600*
Fresh fuel enrichment % U-235	3.21*
Spent fuel enrichment % U-235	0.90*
Fissile Pu recovered, Kg/MTHM (after losses)	7.0*
Tails assay, % U-235	0.3**
Pu replacement value, g. of U-235/g. Pu	.8**
U-236 penalty - the quality of recovered U-235 is reduced by multiplying by 0.904**	
Increased separative work, because of the presence of U-236 in recycled uranium, is 0.138 Kg for each kilogram of recycled uranium.**	
Losses in conversion to UF_6%	.5
Losses in fabrication, %	1.5
Losses in chemical reprocessing, %	1.0

*WASH-1139 (74), Nuclear Power Growth.

**GESMO.

- For the recycle case a one year storage of spent fuel is included before reprocessing.
- The credit for Pu and spent uranium is taken on the next succeeding fuel cycle.
- A 10% interest charge on invested funds required to support the fuel cycle.

The carrying charges for the two fuel cycle cases are summarized in Table 4 for capacity factors of 50%, 60% and 70%.

The levelized cost for the reference case of 10.88 mills/kWh (9.52 mills/kWh, plus 1.36 mills/kWh for fuel cycle carrying charges) agrees with the 11.8 mills/kWh used in NRC testimony (Reference 1). While the applicants estimate of 19.2 mills/kWh appears high when compared to the reference case it does not appear unreasonable when compared to the high case of 17.49 mills/kWh (15.23 mills/kWh plus 2.26 mills/kWh carrying charges.)

CONCLUSION

In the nuclear fuel cost analysis presented above, I conclude that the levelized fuel cost used by the NRC staff of 11.8 mills/kWh is reasonable and in good agreement with my reference value of 10.88 mills/kWhre. The licensee's new levelized fuel cost of 19.2 mills/kWhre appears high but is not unreasonable when compared to my high case value of 17.49 mills/kWhre.

TABLE 3

SUMMARY OF NUCLEAR FUEL CYCLE COST

	No Recycle			Pu & U Recycle		
	Mills/kWh			Mills/kWh		
	Low	Ref.	High	Low	Ref.	High
U_3O_8 Cost as UF_6	.95	2.13	4.19	.95	2.13	4.19
Enrichment	.91	1.14	1.68	.91	1.14	1.68
Fabrication	.33	.37	.41	.38	.46	.57
Spent Fuel Disposal:						
Storage, 5 yr/1year	.04	.10	.19	.01	.02	.04
Shipping	.02	.06	.12	.02	.06	.12
Disposal	.19	.39	.58			
Reprocessing				.43	.58	.74
Waste disposal				.12	.19	.27
Spent U-235 Credit				(.19)	(.41)	(.79)
Pu Credit				(.38)	(.65)	(1.17)
Pu Storage, 1 yr				.03	.05	.08
Sub total (1975 $)	2.44	4.19	7.17	2.28	3.57	5.73
Escalated to 1981 at 8%	3.87	6.65	11.38	3.61	5.69	9.09
Present value 1981, 5% escalation and 10% discount	61.14	105.06	179.79	56.97	89.70	143.61
Present value amortized over 30 years at 10%	6.49	11.14	19.07	6.04	9.52	15.23

TABLE 4

FUEL CARRYING CHARGES

		No Recycle Mills/kWh			Pu & U Recycle Mills/kWh		
Capacity Factor		50	60	70	50	60	70
1975	Low Case	.56	.48	.43	.35	.31	.28
	Ref.	.85	.73	.64	.58	.51	.46
	High	1.49	1.28	1.13	1.07	.94	.85
Escalated to 1981 @ 8%							
	Low Case	.89	.77	.68	.56	.50	.45
	Ref.	1.34	1.15	1.01	.92	.81	.73
	High	2.37	2.04	1.80	1.70	1.49	1.35
Present Value 1981 5% Escalation 10% discount - 30 years							
	Low case	14.02	12.12	10.75	8.89	7.84	7.08
	Ref.	21.24	18.20	16.02	14.53	12.79	11.55
	High	37.44	32.16	28.39	26.79	23.60	21.33
Present Value Amortized over 30 years @ 10%							
	Low case	1.48	1.29	1.14	.94	.83	.75
	Ref.	2.25	1.93	1.70	1.54	1.36	1.23
	High	3.97	3.41	3.01	2.84	2.50	2.26

REFERENCES

1. NRC Staff Testimony of Sidney E. Feld on Cost of Replacement Power Resulting from Suspension, Midland Plant, Units 1 and 2.

2. G. S. Keeley Testimony.

3. Consumers Power Company - Midland Units 1 and 2 - Environmental Report Supplement - October 1976.