UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

April 22, 1977

MEMORANDUM FOR: Dino C. Scaletti, Environmental Projects Branch #2, DSE

FROM: Darrel A. Nash, Section Leader, Technology Assessment Section, CBAB, ET, DSE

SUBJECT: DES INPUT

PLANT NAME: Yellow Creek Nuclear Plant Units 1 & 2
LICENSING STAGE: CP
DOCKET NOS. 50-566/567
RESPONSIBLE BRANCH: EPB-2
PROJECT MANAGER: D. C. Scaletti
REQUESTED COMPLETION DATE: April 11, 1977

Enclosed is our review summary for use i the DES. As you requested, we have addressed the economic costs of coal and nuclear power generation alternatives. The summary was prepared by S. M. Coplan of the Cost-Benefit Analysis Branch (492-7906).

Darrel A. Nash

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Enclosure: As stated

cc: W. H. Regan
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ECONOMIC COMPARISON OF COMPETITIVE SOURCES
YELLOW CREEK NUCLEAR STATION, UNITS 1 & 2
DOCKET NOS. 50-566/567

9.1.2.2 Competitive Sources - Economic Costs

After reviewing both the conventional and potential future energy sources, the staff concluded that only coal is a viable alternative source of energy for the proposed nuclear power generating station. Costs for a power generating station that uses coal are compared with those for the proposed nuclear station in the following paragraphs. The comparison is based on the proposed 2600 MWe two-unit nuclear station and a high-sulfur coal-fired station comprised of three units, each with a rated capacity of 800 MWe with a total generating capacity of 2400 MWe.

The staff's economic cost estimates for the alternative coal and nuclear stations are presented in Table 9.1. The assumptions and methods used in making the comparison are discussed in the following paragraphs.

Capital Cost for Generating Units

The staff used capital cost estimates obtained from the CONCEPT computer code by Oak Ridge National Laboratory (ORNL). The CONCEPT code is in the process of being updated. A new cost model is now available for PWR's. However, only an older model is available for estimating costs of coal facilities.

Using the new cost model, CONCEPT estimated the cost of a two-unit, 2600 MWe PWR with mechanical draft cooling towers at $893/KW. CONCEPT estimated the cost of a three-unit 2400 MWe coal fueled station with scrubbers at $643/KW. Based upon experience with CONCEPT and after review of a number of studies by consultants and architect/engineers there is a correlation between the costs of nuclear plants and coal plants. This is because many of the unit costs, i.e., labor, and materials are the same for both. The staff therefore adjusted the coal cost and by simple proportion to make it compatible with the new PWR cost model. The adjusted figure is $761/KW.

TABLE 1
CAPITAL COST AND UNIT GENERATION COST COMPARISON FOR NUCLEAR AND COAL-FIRED GENERATING STATIONS [1/]

	NUCLEAR			COAL		
Capital Cost, $/KW net	893			761		
(capacity factor, %)	50	60	70	50	60	70
Unit Cost: mills/KWh						
Charges on Capital (9.4%):	19.1	15.9	13.7	16.3	13.6	11.7
Operation and Maintenance:						
Fixed	3.3	2.7	2.3	5.9	4.9	4.2
Variable	0.1	0.1	0.1	3.9	3.9	3.9
Fuel Cost:	13.0	13.0	13.0	21.0	21.0	21.0
Carrying charge on Fuel Working Capital:	2.4	2.1	1.8	0.3	0.3	0.3
Decommissioning:	0.3	0.3	0.2	--	--	--
TOTAL	38.2	34.1	31.1	47.4	43.7	41.1

1/ Unit generating costs are 30-year levelized values.

Fixed Charge Rate

The Tennessee Valley Authority (TVA) will be the sole owner and operator of the proposed Yellow Creek Station. Based on interest rates to be paid on TVA's 1975 bond issues, the staff estimated TVA's cost of money at 8.5%. Using the 8.5% interest rate as the discount factor, the staff calculated a sinking fund factor for depreciation of 0.81%.

Nuclear liability insurance and interim replacement costs are included in the Operating and Maintenance costs. TVA is self-insured with respect to property. The staff estimated the cost to TVA of underwriting its own risks to be about 0.07%

TVA,being a Federal agency, pays no federal income tax. It pays in lieu of taxes to state and local governments. The in lieu of taxes are not based on capital investment and would be the same for either a coal or a nuclear unit which generates the same amount of energy. Therefore, the staff has not included taxes in the fixed charge rate.

The cost of money, depreciation, and property insurance total 9.38%. The staff used a fixed charge rate of 9.4%.

Escalation and Discount Rates

Forecasting electricity generating cost changes over a 40-year period (i.e., from 1976 to the end of the reactor life), obviously is subject to much uncertainty. There are likely to be significant fluctuations in these costs during the period. Nevertheless, the staff believes that over the long term, a reasonable assumption is that generating costs will not vary substantially from general inflation levels. An escalation rate of 5% per year is assumed for general inflation. Coal and nuclear fuel and operation and maintenance (O&M) costs are therefore escalated at 5% per year. Before escalating nuclear fuel costs certain upward adjustments are made to current costs. In the case of uranium, the base price is adjusted upward from current production costs to reflect the continual depletion of higher grade ores and need to open new

mining areas. Enrichment costs are adjusted upward from current charges to the charge likely to exist on a full cost recovery basis, i.e., $75 per SWU. These adjusted nuclear fuel costs are then escalated at 5% per year. Coal fuel costs are likewise escalated at 5% per year, although transportation costs, in particular, may well exceed this rate. Note is also made that no allowance is given to depletion of high yielding coal areas even though this may well occur over a 30-year period.

The discount rate used by the staff is the weighted cost of money to the utility. In TVA's case the average cost of recent bond issues best represents the cost of money. Thus, a value of 8.5% was used.

Operation and Maintenance

The operation and maintenance cost were obtained from the OMCST computer program* by ORNL. The OMCST code is designed to assist in examining average trends in costs, in determining sensitivity to technical and economic factors and in providing cost projections. The OMCST code provides the annual cost for operation and maintenance staff, the fixed and variable cost for maintenance materials, the fixed and variable cost for supplies and expenses, the cost for insurance and fees (including nuclear liability insurance) and the cost of administration and general expenses. The fixed and variable annual cost are totaled and converted to unit cost (mills/KWh) for the selected capacity factor. Costs are escalated to the year of initial operation, 1985 for Yellow Creek 1 & 2. The O&M cost estimates are summarized in Table 2.

TABLE 2. FIXED AND VARIABLE PORTIONS OF O&M COST

	Nuclear			Coal		
Capacity Factor, %	70	60	50	70	60	50
1985 O&M Cost						
Fixed, M/KWh	1.33	1.55	1.86	2.40	2.80	3.36
Variable M/KWh	.06	.06	.06	2.22	2.22	2.22

* A Procedure for Estimating Non-fuel Operation and Maintenance Costs for Large Steam-Electric Power Plants, ERDA 76-37.

Fuel Cost - Nuclear

The nuclear fuel cycle cost calculations were based on the general procedures outlined in "Guide for Economic Evaluations of Nuclear Reactor Plant Designs" NUS-531. The no-recycle case 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 after extending them to the year 2020. The values used are summarized in Table 3.

TABLE 3. MATERIAL AND SERVICE UNIT COSTS, 1975 DOLLARS

Mining and Milling, \$/lb U_3O_8*	25
Conversion to UF_6, \$/kg U	3.5
Uranium Enrichment, \$/SWU	75
UO_2 Fabrication, \$/kg HM	95
Spent Fuel Transportation, \$/kg HM	15
Spent Fuel Storage, \$/kg HM-yr	5
Spent Fuel Disposal, \$/kg	100

*First year cost.

The fuel cycle calculations were based on equilibrium conditions. After removal from the reactor the fuel is stored for five years and then shipped to a repository for disposal. The staff's assumptions concerning the reactor and other elements of the fuel cycle appear in Table 4.

TABLE 4. ASSUMPTIONS USED IN THE FUEL CYCLE CALCULATIONS

Reactor size and type	1300 MWe	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*
Tails assay, % U-235		0.3**
Losses in conversion to UF_6%		0.5
Losses in fabrication, %		1.5

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

** GESMO

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 escalated at 5% per year to 1984. The 1985 present value for the 30-year life of the plant was calculated by escalating the 1984 cost at 5% per year and discounting at 8.5% per year. The present value for the 30-year period was them amortized over 30 years.

It should be noted that in addition to the 5% per year escalation, U_3O_8 prices were further increased to account for depletion of the resource. The additional increase is based on an assumption of 507 GWe of nuclear capacity in the year 2000 with no new construction after that date. The fuel cycle cost is summarized in Table 5.

TABLE 5. SUMMARY OF NUCLEAR FUEL CYCLE COST
(30-YEAR LEVELIZED)

	$/KG-U*	Mills/KWh
U_3O_8	1875	7.26
Conversion to UF_6	68	0.26
Enrichment	786	3.04
Fabrication	258	1.00
Storage	68	0.26
Transportation	41	0.16
Disposal	271	1.05
	3367	13.04**

*Contained in fuel.
**In the U and Pu recycle case this figure would be 10.28 mills/KWh.

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% and 70% and 32,600 MWD/MTHM exposure.
- A 5-year storage period before final disposal.
- An 8.5% interest charge on invested funds required to support the fuel cycle.

The carrying charges are summarized in Table 6.

TABLE 6. CARRYING CHARGES FOR NUCLEAR FUEL
(30-YEAR LEVELIZED)

Capacity Factor	50%	60%	70%
Carrying charge (Mills/KWh)*	2.42	2.08	1.84

*In the U and Pu recycle case, these figures would be 1.50, 1.32 and 1.19 respectively.

Fuel Cost - Coal

The staff based its estimated coal price on prices for 1975 contract deliveries as reported in the Federal Power Commission publication "Annual Summary of Cost and Quality of Steam Electric Plant Fuels, 1975." Since the Yellow Creek Site is near the Tennessee, Mississippi, Alabama border, the use weighted average for those three states was used. Its 1975 value was 84.5 $¢/10^6$ BTU. The thirty-year levelized value is 229.1 $¢/10^6$ BTU or 21.0 mills/KWh, based on 5% escalation, an 8.5% discount rate, and a heat rate of 9150 BTU/KWh.

The staff assumed that a 3 months supply of coal would be stockpiled at the generating station. Also it is assumed that if it is necessary to use this coal at any time the stockpile would be credited at the then current price for coal and the amount used would be replaced at the same price. The carrying charge for the coal stockpile is based on 8.5% interest, 1985 price for coal and a three months coal supply. The cost of the coal stockpile and carrying charges are summarized in Table 6.

TABLE 6. CARRYING CHARGES FOR COAL STOCKPILE

Capacity Factor	50%	60%	70%
Cost of 3 month stockpile, $\$10^6$	31.5	37.8	44.2
Unit cost of carrying charges, mills/KWh	0.25	0.25	0.25

Decommissioning Cost

The staff's estimate of decommissioning cost assumes complete restoration of the site. The 1975 cost for such restoration would have been about $70 million for a two-unit site.

At the end of plant life (2014) this figure would escalate to $469 million. The sinking fund payment required over 30 years at 8.5% is $2.85 million. The resultant unit costs are displayed in Table 7.

TABLE 7. DECOMMISSIONING COST

Capacity Factor	50%	60%	70%
Unit Cost, Mills/KWh	0.31	0.26	0.22