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Risk Analysis - An Economic Comparison of Oil and Coal Power Plants

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"RISK ANALYSIS-AN ECONOMIC COMPARISON OF OIL AND COAL POWER PLANTS"

BY

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RESEARCH REPORT

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ABSTRACT

The demand for electric energy increases every year. However, due to recent changes in the U. S. energy supplies, a growing gas shortage forced suppliers to curtail deliveries of natural gas for power generation. Many utilities anticipating supply problems switched to burning more costly light distillate oil. Unfortunately the Arab boycott of 1973 and the following price increases for oil forced again utilities to seek a cheaper source of fuel, namely coal, as a substitute for oil. Even though the U.S. has abandunt supply in coal, the use of coal in power generation was limited in the past because of a higher capital cost associated with installing air pollution control devices. Therefore, current utilities primary concerns are "Does the lower fuel price of the coal power plant really outweigh its disadvantage of higher construction costs as compared to the oil-burning power plant?". Thus, the purpose of this paper is to evaluate the economic preference of the coal burning power plant compared to the oil-burning power plant in suppling base load power. An extensive analytical model accounting for the effects of escalating fuel prices was examined and a computer simulation model was developed to handle risk associated with various input parameters using the SLAM as a simulation language.

To my Father, Haaj Mohammad Reza, who has always inspired an interest in learning and a desire for academic achievements.

ACKNOWLEDGEMENT

I would like to express my sincere thanks to Dr. Chan S. Park, my advisor, for his guidence and encouragement in the preparation of this report. I would also like to express my gratitude to Dr. Gary E. Whitehouse, the Chairman, whom I feel indebted to for his help and understanding.

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CHAPTER 1

INTRODUCTION

Fossil fuels are used to generate ninety percent of the electricity needed in the United States. In particular, coal has been a major contributor to U.S. energy needs for the past several decades. Its growth was limited by the abundance of cheap oil and gas in the past. However, the price increases following the Arab oil embargo of 1973 and the increase in demand for energy have again made coal a competing fuel for energy production. The use of coal faces many challenges because of its environmental impacts, but its ready availability makes it increasingly attractive.

Statement of the Problem

Coal is the most abundant domestic fossil resource with identified reserves sufficient to meet the nation's needs for an estimated 200 years. The combustion of coal produces airborne emissions of particulates, nitrogen and sulfur oxides. These emissions must be reduced to some acceptable levels specified by the environmental protection agency (EPA).

In many cases the flue gas desulfurization method is used to reduce the pollution. Scrubbers are installed to process the limestone which absorbs the sulfur oxides. The cost of pollution control equipments and their installation constitutes a high portion of the total construction cost for a coal power plant. The cost of limestone consumed and also the cost of maintaining the pollution control equipments are high during the operational period.

The pollution resulting from burning oil is relatively minimal. For this reason the construction and operating and maintenance costs of an oil power plant are considerably lower than those of a coal power plant. However, the fuel cost for an oil power plant is much higher than of the coal power plant and it has been escalating during the last several years. Therefore, utilities primary concern is "What ranges for fuel cost of an oil power plant would make coal power plant the more economical alternative?".

Objective of the Report

The primary purpose of this research is to develop a methodology for evaluating economics of power generations under uncertainty. The objective will be accomplished in two steps.

1) Development of an analytical model - Of particular concern is the development of a comprehensive analytical model which incorporates various decision variables into a decision criterion which ultimately measures the desirability of power plant.

2) Simulation Model - Given the lack of available actual

data and the need to examine the performance of the models under a variety of conditions regarding investment settings, the logical alternative is to select a simulated environ ment in which the important parameters generating investment data could be controlled.

Plan of Study

Chapter 2 provides a description of power plants selected for this study. Electricity generation by using fossil fuel is explained, and the environmental effects of burning fuels and method of pollution control are discussed.

In Chapter 3, a comprehensive mathematical model is presented for evaluation of power generation economics. All the cost elements during the construction and operational periods are identified and an algebraic relationship for calculating the total equivalent annual cost is derived.

Chapter 4 describes the risk analysis model for this study. The factors subject to uncertainty are identified and their probability distributions are discussed. SLAM, a FORTRAN based simulation language is selected to simulate the economic model of this study. The SLAM network model is presented and an explanation of this model is given. The program is developed based on the mathematical model presented in Chapter 3.

In Chapter 5 both the data used to develop probability distributions and the data estimated with certainty are explained.

The results of risk analysis are shown in Chapter 6. In this Chapter the expected cost of generating electricity by using coal is compared to the expected cost when using oil. The resulting probability distributions and also the probability distribution of the difference in cost between the two alternatives are shown. By using the distribution of the difference in cost of the two alternatives the probability that the coal power plant is more economical can be determined. The interrelationships and sensitivity of the alternatives to changes in input parameters are then analyzed.

Chapter 7 contains the summary and conclusions of the report along with recommendations for future research.

CHAPTER 2

DESCRIPTION OF POWER PLANTS

In this Chapter electricity generation by using Fossil Fuel is explained. Also the environmental effects of burning fuels and related regulations are discussed.

Power Generation Technique

The essential stages involved in a steam turbine electricity plant are outlined in Figure 1.

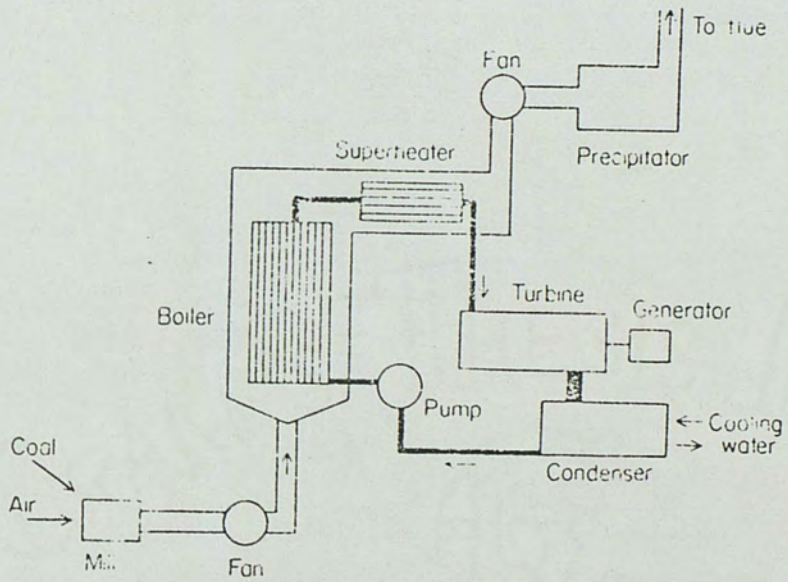


Figure 1. STEAM TURBINE ELECTRICITY GENERATOR
Source: J. T. Mcmullan; R. Morgan; and R. B. Murray. "Electricity Generation and Transmission" Energy Resource and Supply (New York: Wiley-Interscience, 1976): 176.

The fuel, usually coal or oil is burnt in a type of burner. The heat released in combustion is extracted in the boiler, where it is used to raise steam at as high temperature as possible. The steam drives the turbine, and then passes to the condensor, is condensed to water and returned to the boiler. The turbine drives an alternator (AC Generator) whose output is transformed to a high voltage and transmitted to the consumer, where the voltage is reduced to a more appropriate value for the consumer's purposes.

The burning of fuels creates environmental air pollution problems. The pollution is mainly due to the emission of sulfur oxides and particulates from burning fossil fuel. The pollution resulted from burning oil can be kept below allowable limits by using oil with a lower sulfur content. But when coal is used the pollution is more damaging and needs to be controlled by some technological means. A typical 1000 MW coal power plant releases 10^7 tons of sulfur dioxide and nitrous oxide and 10^5 tons of ash to the atmosphere each year [1]. Based on the environmental regulations, the pollution from burning coal should be limited. The 1976 new source performance standards (NSPS) specifies the allowable pollution caused by burning coal as 1.2 lb/10^6 BTU SO_x, 0.1 lb/10^6 BTU particulates and no standard for NO_x.

Pollution Control Technique

In this study it is assumed that flue gas desulfurization method is applied to control the coal plant pollution. For the

1000 MW plant size six desulfurization units are needed. Limestone is used and processed to absorb 80_x produced by the burning of the coal. Figure 2 shows the process diagram for the coal power plant with flue gas desulfurization. The contact of flue gas with a water slurry of limestone causes the SO_2 to react and form insoluble C_aSO_3.

Part of the recirculating slurry is purged to remove the sulfur compounds from the process. The flue gas is saturated, and flyash is removed in a venturi system. Then the flue gas passes through the scrubber, where SO_2 is absorbed into a re-circulating slurry of limestone and reaction by-products. The clean gas is reheated before passing up the stack. The slurry circulates from the bottom of the scrubber to a holding tank, where the reaction of the desolved sulfite with calcium irons occures. Also at the reaction tank, fresh limestone slurry is added. The main flow of circulating slurry is returned to the top of the scrubber; the purge is thickened; the overflow water is returned to the circulating slurry; and the under flow is pumped to the disposal pond.

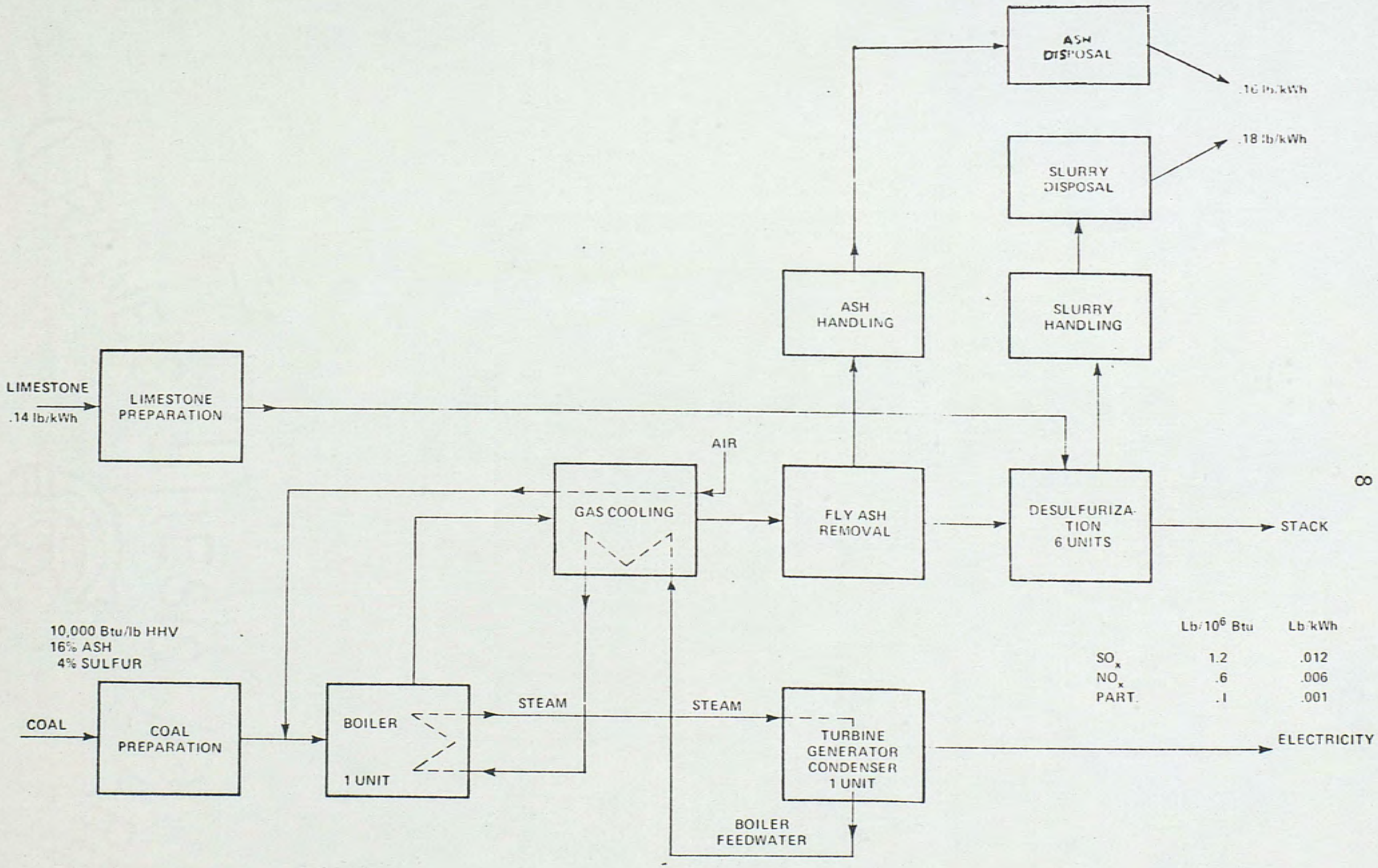


Figure 2. PROCESS DIAGRAM OF 1976 DESIGN COAL-FIRED PLANT WITH FLUE GAS DESULFURIZATION
Source: W. E. Balson, S. M. Barrager. "Case Study One: Comparison of Two Fossil Fuel Baseload Generation Technologies." Uncertainty Methods in Comparing Power Plants. California: EPRI, April 1979. 2-5.

CHAPTER 3

ECONOMICAL MODELING

In this Chapter a comprehensive mathematical model is presented for evaluation of power generation economics. In this model all the cost elements are identified and the total equivalent annual cost is calculated.

Structure of the Model

As shown in Figure 3, there are two phases in determining the total equivalent annual cost for each alternative. In Phase I the capital costs occurring during the construction period are calculated and in Phase II capital costs, depreciation charges and generation costs occurring throughout the entire plant service life are computed. The costs to be incurred during the construction period include debt finance cost, equity finance cost, insurance cost and Advalorem taxes. The costs related to the operational period are classified into three catagories, i.e., capital costs, production costs and depreciation costs. Capital costs include debt finance cost, equity finance cost, insurance cost and Advalorem taxes. Production costs include fuel costs as well as operating and maintenance costs. Depreciation costs include depreciation costs and salvage value. Investment tax credit is received at the end of the construction period. All the tax deductible expenses are added to find the tax savings and then the after-tax cash flow is calculated. Finally the equivalent annual cost of the total

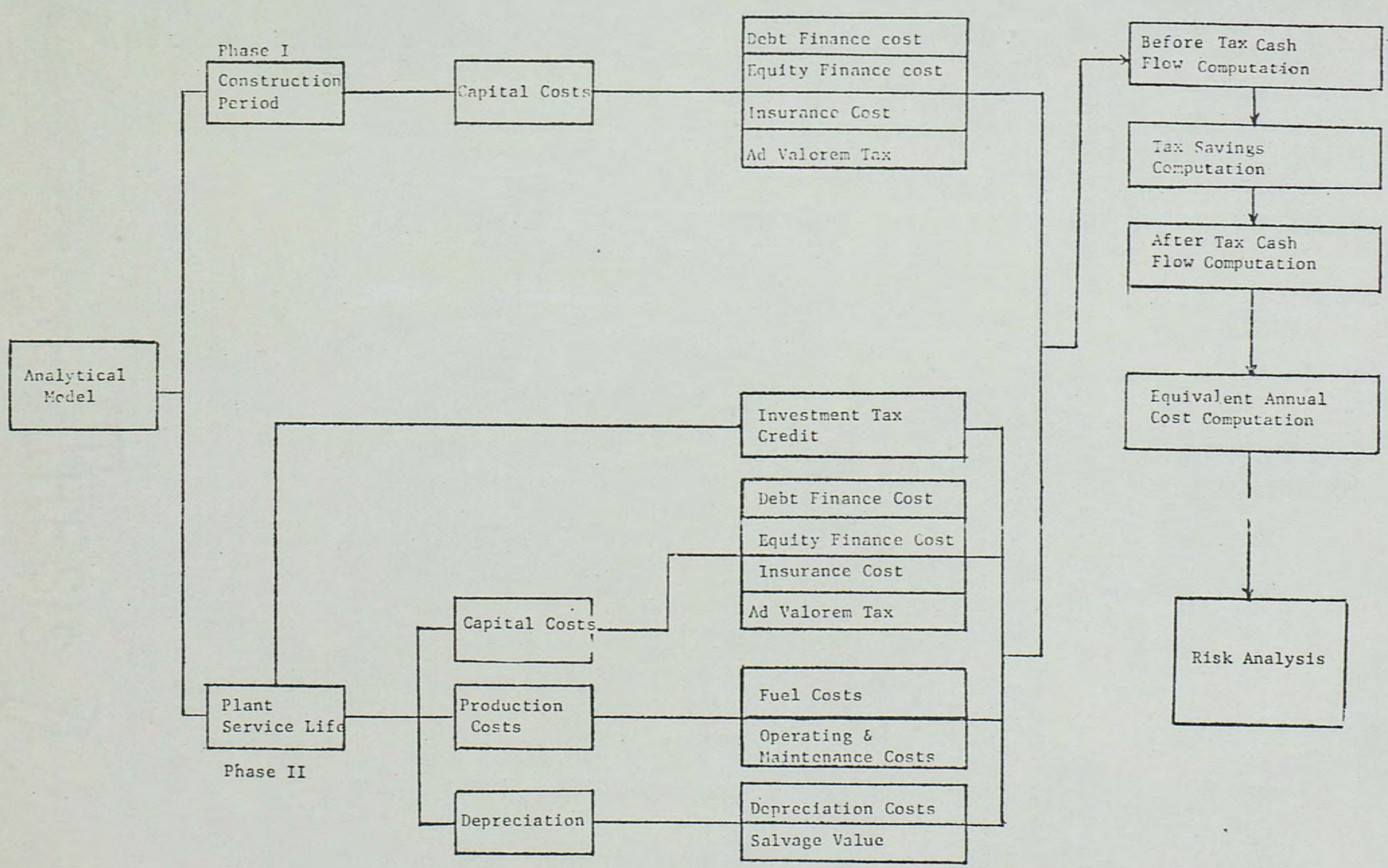


Figure 3. SYSTEMATIC MODEL BUILDING PROCESS

costs during the construction and operational period is determined.

All the costs are assumed to incur at the end of the year except the insurance cost which is paid at the beginning of each year.

Model Description

Phase I Model

How the investment project is to be financed affects the investment decision. In this study, a mixed financing policy is assumed and the real cost of financing the investment is incorporated into the mathematical model. Common stocks are sold to provide new equity if there is no sufficient retained earning to finance the project and the remaining funds are financed by selling bonds. During the operational period, equal annual payments are made for the equity part of the funds. Each payment includes return on investment and principal repayment.

The principal for the issued bonds are paid at the end of operational period. A yearly interest is paid for these bonds during both the construction and operational periods. Thus, the only financial costs incurred during the construction period are the interest paid for the issued bonds and return on investment for the equity portion of the funds.

Followings are the detail cash flow formulations included in the Phase I model:

i) Debt Interest

$$DI_n = (\sum_{j=1}^{n} C_j) d\, i_d \qquad (3\text{-}1)$$

$$n=1,2,\ldots N$$

where

DI_n: Debt interest to be paid at the end of year n during the construction period.

N: The total number of years of construction.

C_n: Plant construction cost in year n.

d: Debt ratio in financing mix.

i_d: Debt interest rate.

ii) Equity Return

$$ER_n = (\sum_{j=1}^{n} C_j)(1-d) i_e \qquad (3\text{-}2)$$

$$n = 1,2,\ldots N$$

where

ER_n: Equity return to be made at the end of year n during the construction period.

i_e: Equity return rate per year.

iii) Ad Valorem tax

The property tax is Ad valorem tax and it is based on the assumed value of property throughout the life of the project.

$$ADV_n = (\sum_{j=1}^{n} C_j)\, t_a \qquad (3\text{-}3)$$

$$n = 1, 2, \ldots. N$$

where

ADV_n: Ad valorem tax to be paid at the end of year n during the construction period.

t_a: Ad volorem tax rate.

iv) Insurance Cost

$$INS_n = (\sum_{j=1}^{n} C_j)\, \Theta \qquad (3\text{-}4)$$

$$n = 1, 2, \ldots N$$

where

INS_n: Insurance cost in year n.

Θ: Insurance rate per year (% of the total capital cost.)

v) Before-tax Cash Flow

The before tax cash flow during the construction period can be determined by adding i) through iv)

$$BTC_n = DI_n + ER_n + ADV_n + INS_n \qquad (3\text{-}5)$$

vi) Adjustment for Tax Purpose

Interest paid on indebtedness is deductible as a business expense. This means that a project which is financed with borrowed capital has its taxable income reduced by the amount of interest involved. Since the equity repayments and insurance payments are non-tax deductible expenses, the adjustment figure for tax purpose will be

$$TD_n = BTC_n - ER_n - INS_n \quad (3\text{-}6)$$

vii) Tax Savings

$$TS_n = TD_n \cdot t$$

$$= (DI_n + ADV_n) \cdot t \quad (3\text{-}7)$$

where

TS_n: Tax saving in year n during the construction.

t: Federal and State combined tax rate for income.

viii) After-tax Cash Flow

$$ATC_n = BTC_n - TS_n$$

$$= DI_n + ER_n + ADV_n + INS_n - (DI_n + ADV_n) \cdot t$$

$$= (1-t)\ DI_n + ER_n + (1-t)\ ADV_n + INS_n \quad (3\text{-}8)$$

where

ATC_n: After-tax cash flows in year n during the construction.

ix) Equivalent Construction Cost

From equation 3-9, the total future worth of the Phase I model at the time the plant begins commercial operation can be computed as

$$FW\ (i)_I = \sum_{n=1}^{N} (ATC_n)\ (1+i)^{N-n} \quad (3\text{-}9)$$

where

$F_W(i)_I$: Future worth of the project for Phase I.

i: Discount rate (or cost of capital).

Phase II Model

The Phase II model consists of the total generation cost, and the capital recovery cost associated with the initial plant investment throught the entire plant service life to calculate the future fuel cost as well as the operating and maintenance costs, it is necessary to determine the corresponding escalation rates. Following are the detail cash flow formulations involved in the Phase II model.

i) Fuel Cost

The fuel cost is a function of plant size, thermal conversion efficiency, and plant utilization factor. The fuel cost in each year would be calculated by the following:

$$F_n=(C)(H)(U_n)(8760/10^6)\ f_0(1+q)^{n-1} \qquad (3\text{-}10)$$

where

F_n: Annual fuel cost in year n (\$).

C: Plant size in KW.

H: Heat rate at operating conditions in BTU/KWH.

U_n: Plant utilization factor in year n.

f_0: Fuel cost at the starting year (\$/10^6BTU)

q: Average annual fuel escalation rate.

ii) Operating and Maintenance Cost (O&M)

Operating and maintenance costs consist of the fixed and variable portions. The fixed O&M cost can be expressed as function of the plant size, while the variable O&M cost is a function of the plant size, plant utilization factor, and efficiency of the plant.

The O&M cost can be written as:

$$(O\&M)_n = Of_n + OU_n \text{ and} \qquad (3\text{-}11)$$

Fixed Cost

$$Of_n = (C)\,Of_0(1+\Lambda)^{n-1} \qquad (3\text{-}11\text{-}1)$$

where

Of_n : Fixed O&M cost in year n ($).

Of_o : Fixed O&M cost at the starting year ($) $/KW)

Λ : Average annual escalation rate of fixed O&M cost.

Variable Cost

$$OU_n = (C)(H)(U_n)(8760/10^6)OV_o(1+\theta)^{n-1} \qquad (3\text{-}11\text{-}2)$$

where

OV_n : Variable O&M cost in year n ($) ($/10^6 BTU)

OV_o : Variable O&M cost at the starting year

Θ : Average annual escalation rate of variable O&M cost.

iii) Depreciation Cost

In computing depreciation deductions, a useful life and salvage value for the asset must be established. It is possible that the service life allowed for tax purpose may differ from the actual physical life of the asset as employed by the firm. Yearly depreciation deductions can be calculated by the following methods:

a. Straight line depreciation method.

$$SLD = \frac{K - s}{n_d} \qquad (3\text{-}12)$$

where

SLD: Straight line depreciation.

K: The total construction cost.

n_d: The depreciable life.

s: Salvage value.

b. Declining balance method

$$DB_n = R(1-R)^{n-1} \qquad (3\text{-}13)$$

where

DB_n: Declining balance depreciation.

R: Depreciation factor.

c. Sum of years digit method

$$SYD_n = (K-S)\left(\frac{nd-n+1}{n(n+1)/2}\right) \qquad (3\text{-}14)$$

where

SYD_n: Sum of $\left(\frac{nd-n+1}{nd(nd+1)/2}\right)$ years digit depreciation.

iv) Debt Finance Repayment

During the operational period the only payments for the debt portion of the funds are equal annual payments as the interest for the issued bonds and the principal of the debt portion is paid back at the end of the operational period.

$$DIn = \begin{cases} Kd.i_d & \text{, If } n=1,2,\ldots T-1 \\ Kd+Kd.i_d & \text{, If } n=T \end{cases} \qquad (3\text{-}15)$$

where

T: Plant service life in years.

DI_n: Debt finance payment to be made in year n during plant service life.

v) Equity Financc Payment

The payments for the equity are paid by equal annual payments. A portion of this payment is for interest and can be calculated as:

$$ER_n = Kd(A/P,\ i_e,T)$$

where

ER_n: Equity finance repayment to be made in year n during the plant service life.

and $EIP = (\ Kdi_e - ER_n)\ (1+i_e)^T + ER_n$ [2] (3-16)

where

EIP: The interest portion of the equity finance payment.

The debt portion of the funds also could be paid back by equal annual payment. In this case the interest portion of the payments should be calculated by using equation 3-16 and be considered as an expense for tax purposes.

vi) Ad Valorem Tax

$$ADV_n = (K - \sum_{j=1}^{n} D_j) t_a \qquad (3\text{-}17)$$

where

ADV_n: Ad valorem tax to be paid in year n during the plant service period

D_n : Depreciation deducted for year n.

vii) Insurance Cost

$$INS_n = (K)\,\Theta \qquad (3\text{-}18)$$

where

INS_n : Insurance cost to be paid in year n during the plant service life.

viii) Salvage Cost (Value)

If S_T is defined as the salvage value at the end of service life, then the end of year salvage as a function of n is given by:

$$S_n = \begin{cases} 0 & \text{If, } n \neq T \\ sK & \text{If, } n = T \end{cases} \qquad (3\text{-}19)$$

where

s: Salvage rate.

ix) Before Tax Cash Flow

The total cash flow before tax at the end of nth year will be calculated by:

$$BTC_n = F_n + Of_n + OU_n + DI_n + ER_n + ADV_n + INS_n - S_n \qquad (3\text{-}20)$$

x) Adjustments for Tax Purposes

Fuel cost, O&M cost, ad valorem tax, the interest paid for debt and the depreciation are tax deductible. For calculation of the tax deductible amount the following expression can be used.

$$TD_n = \begin{cases} BTC_n \, TD_n - ER_n - INS_n & \text{If } n=1,2,..,T-1 \\ BTC_n + D_n - ER_n - INS_n + S_n - Kd & \text{If } n=T \end{cases} \qquad (3\text{-}21)$$

where

TD_n : Tax deductions in year n

xi) Tax Savings

$$TS_n = TD_n \, .t$$

where

TS_n : Tax savings in year n (3-22)

xii) Investment Tax Credit

$$ITC_n = \begin{cases} mK & \text{If } n=1 \\ 0 & \text{Otherwise} \end{cases} \qquad (3\text{-}23)$$

where

ITC_n: Investment tax credit in year n.

m: Investment tax credit rate.

xiii) After-tax Cash Flow

$$ATC_n = BTC_n - TS_n - ITC_n \qquad (3\text{-}24)$$

where

ATC_n: After-tax cash flow in year n.

xiv) Present Worth Equivalent

The total present worth of the Phase II model can be computed by using equation 3-25. This is the present worth at the time the plant begins its commercial operation.

$$PW(i)_{II} = \sum_{t=1}^{T} (ATC_n)(1+i)^{-n} \qquad (3\text{-}25)$$

Annual Equivalent Cost Model

The cost of the two phase are combined together in order to find the annual equivalent cost.

$$AE(T,N,i) = \{FW(i)_I + PW(i)_{II}\}(A/P, T,i)$$

where $AE(T,N,i)$: The annual equivalent cost of the project.

The mathematical model developed in this Chapter includes all the cost elements which constitute the total cost of an investment. In order to incorporate explicitly the effect of inflation in the analysis, it becomes necessary to use a combined discount rate in computing the annual equivalent cost. The combined discount rate is simply found by the following relation:

$$(1 + i) = (1 + k)\ (1 + i')$$

where i = combined discount rate

k = the average inflation rate

i' = the rate representing the earning power of money with no inflation

Based on this model, the risk analysis model is developed in the next Chapter.

CHAPTER 4

RISK ANALYSIS MODEL

Risk analysis consists of estimating the probability distribution of each factor affecting an investment decision, and then simulating the possible combinations of the values for each factor to determine the range of possible outcomes and the probability associated with each possible outcome [3].

In order to accomplish risk analysis, all the factors subject to uncertainty were well identified and probability distributions for all these factors were developed. Based on the analytical model described in Chapter 3, a computer program was developed in order to find the equivalent annual costs by incorporating the probabilistic information through Monte Carlo sampling techniques.

Identification of Stochastic Parameters

It is important to determine what the critical factors are which affect the economic choice between the two alternatives. In this study the important factors were identified through intuitive observation and sensitivity analysis. These factors are:

- Construction Cost.
- Fuel Cost.
- Operation and Maintenance Cost (Fixed and Variable).
- Fuel Escalation Rate.
- O&M Escalation Rate.

Developing Probability Distributions

The probability distribution for all factors listed above need to be estimated. These distributions describe the likelihood of occurrence for the parameters. Three estimates, i.e., "optimistic", "pessimistic" and "most likely", for each factor are estimated by referring to various sources of information. If is assumed that these three estimates correspond to the "upper bound", "lower bound" and "mode", respectively, of the subjective probability distribution. The probability distribution is a beta distribution with a standard deviation equal to one-sixth (1/6) of the spread between the lower and upper bounds. Beta type distributions provide flexibility and consistency in assessing probabilities in the risk analysis [4].

Simulation

Once the probability distributions for all the important factors subject to risk are found, the equivalent annual cost that will result from a random combination of these factors needs to be determined. In Figure 4 the simulation process used in this study is illustrated. Monte Carlo methods are used to select values from probability distributions describing the likelihood of occurrence for the parameters having uncertainty. These selected values comprise a set of data utilized to compute the total equivalent annual cost for those parameters. This process is repeated with different sets of data being selected and an equivalent annual cost being computed for each set. By using these cost figures, a

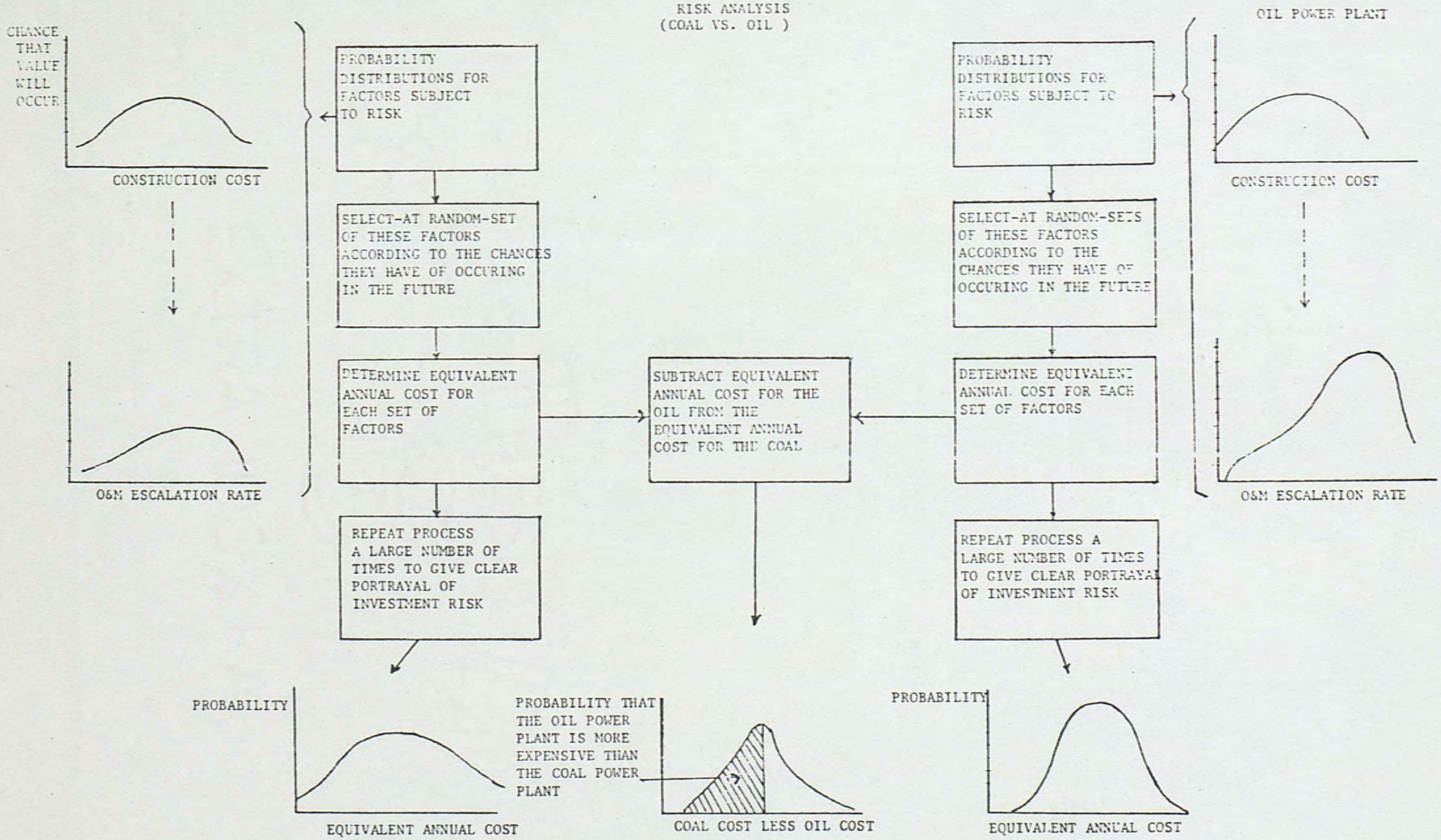


Figure 4. RISK ANALYSIS SIMULATION CHART

frequency distribution describing the likelihood that a particular equivalent annual cost might occur is generated. Then a probability distribution of the differences between the alternatives I (coal) and II (oil) is developed. From this probability distribution, the probability that alternative I will be less costly than alternative II can be determined.

Selected Simulation Language

For this study SLAM is used as the simulation language. Due to the flexibility inherent in SLAM, the complexities involved with programming models like the one used in this study are substantially reduced.

SLAM (Simulation Language for Alternative Modeling) is a FORTRAN based language which allows systems to be viewed from a process, event and state variable standpoint and all these can be combined in a unified systems modeling framework. In modeling this study's system, the process orientation of SLAM is most important and also unique. The process orientation of SLAM employs a network structure comprised of special symbols called nodes and branches in a manner similar to Q-GERT. These symbols model elements in a process such as queues, servers, and decision points. The modeling task consists of combining these symbols into a network model which pictorially represents the system of interest. Thus, a network is a pictorial representation of a process. The entities in the system (such as people and items) flow rhrough the network model. The pictorial representation of the system is transcribed by the modeler into a equivalent statement model for input to the SLAM processor. The use of SLAM as a simulation language faciliates the development of the necessary computer code to test and validate the risk analysis.

SLAM Modeling

A condensed network model for this is presented in Figure 5 and the statement listing is shown in Appendix 1. The explanation of the model will be given in terms of the statement listing. The model can be divided into four major segments. The first segment represents the initialization for all the data related to alternatives I (coal) and II (oil) and consists of statements 9 through 93. Statements 9 through 14 are initializations for values subject to uncertainty related to alternative I where three estimates, i.e., "optimistic", "most likely", and "pessimistic", are assigned to global variables.

The second segment shows the Monte Carlo sampling process for equivalent annual cost for alternative I and consists of statements 95 through 557. In this segment the costs during the construction and operational period are calculated and combined to give the result for the

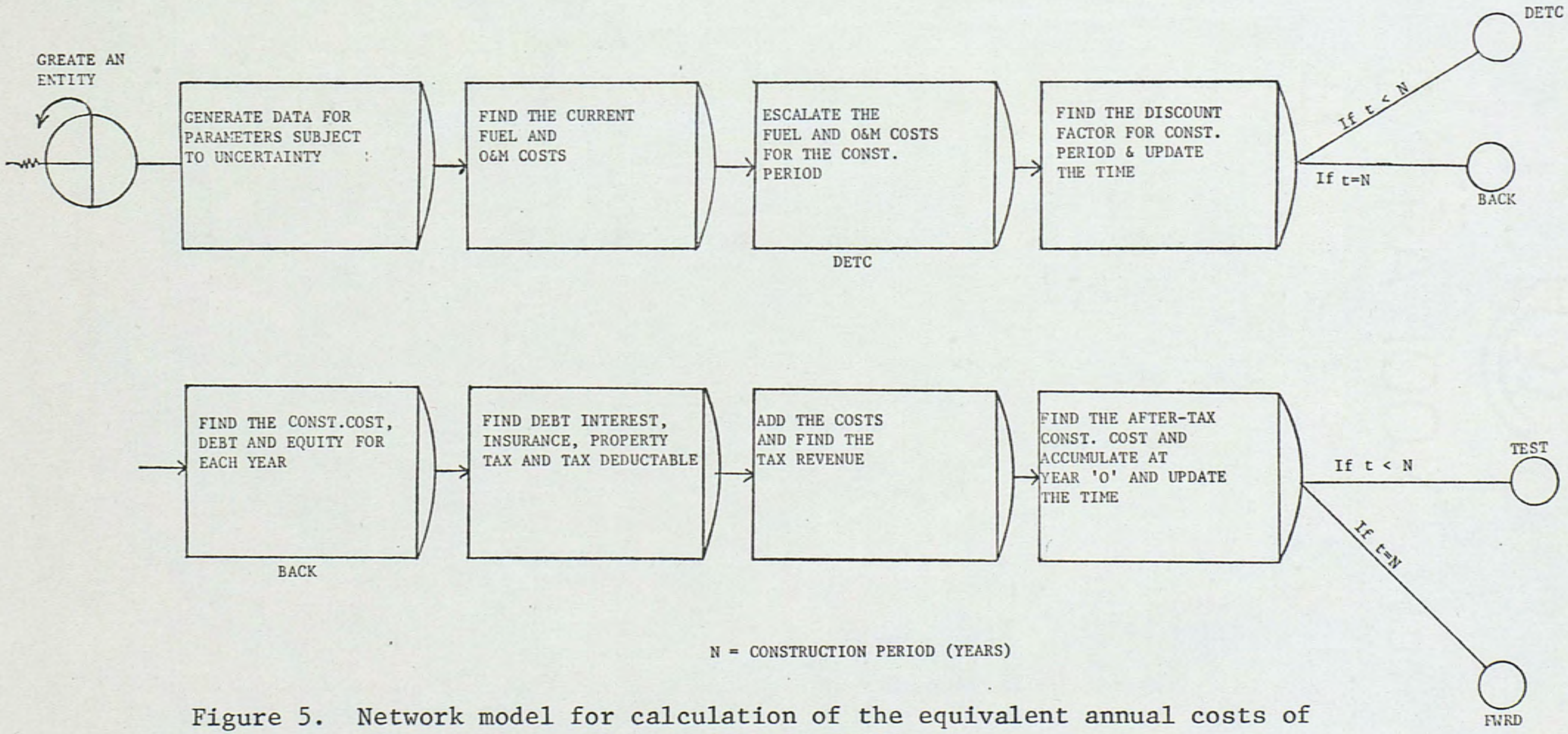


Figure 5. Network model for calculation of the equivalent annual costs of the two alternatives and their difference

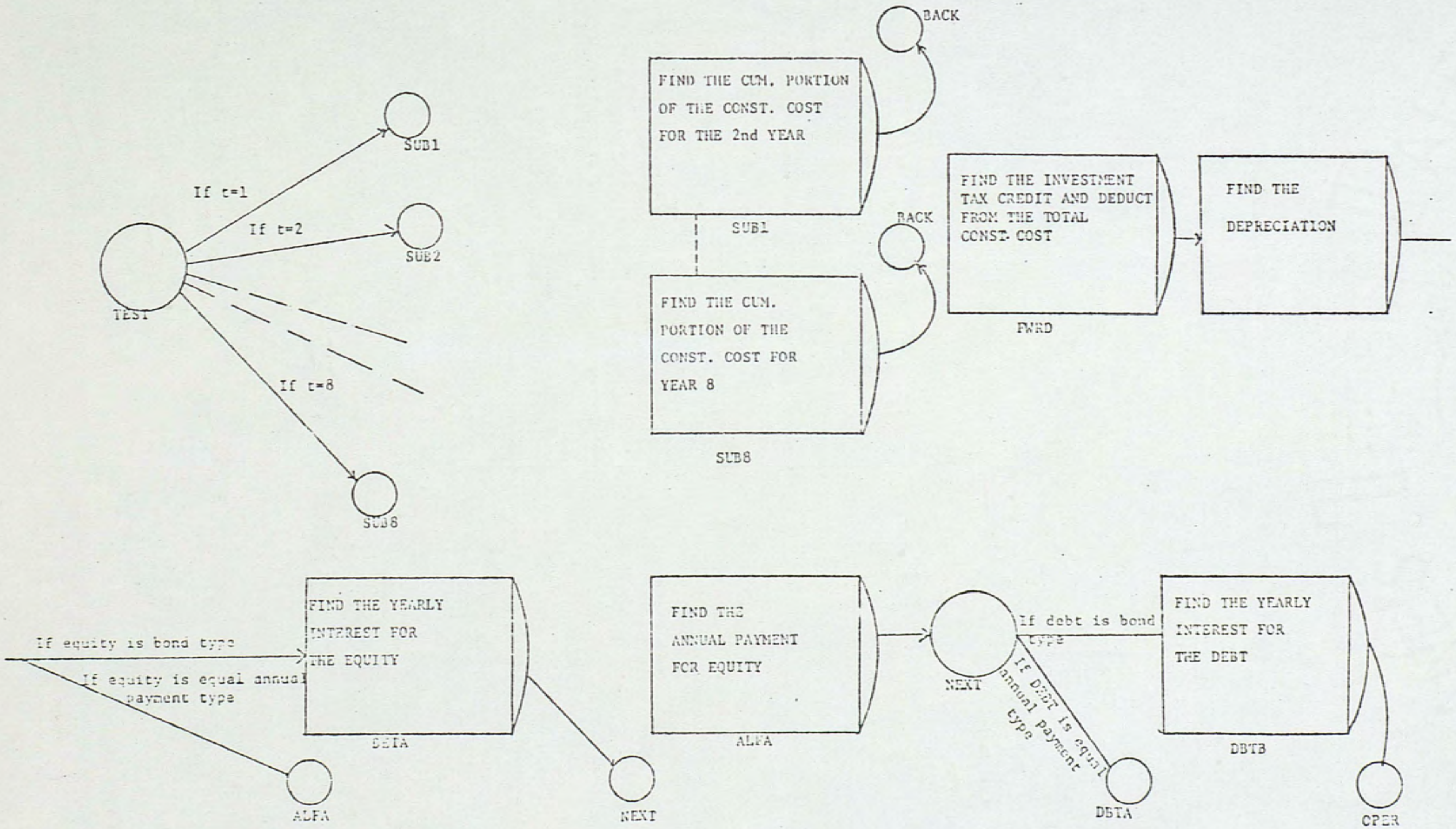
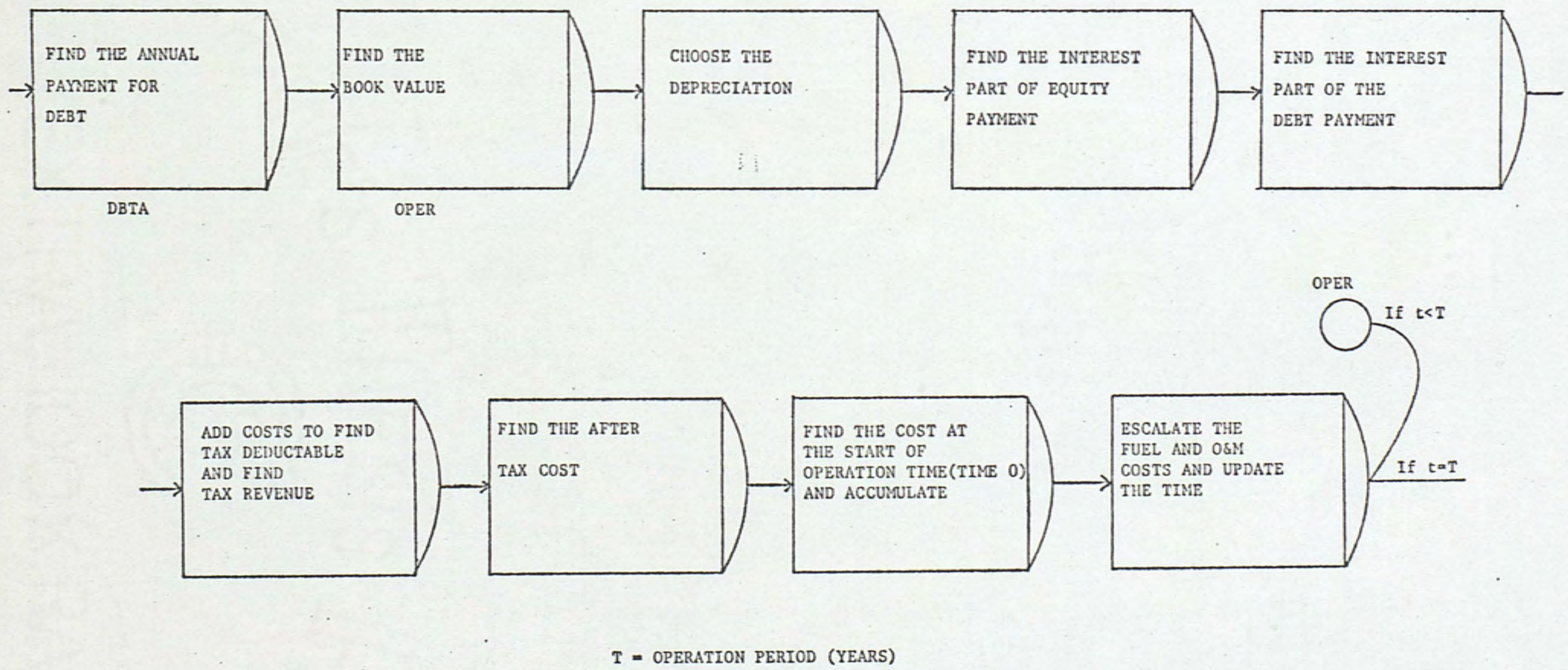


Figure 5. (Continued)



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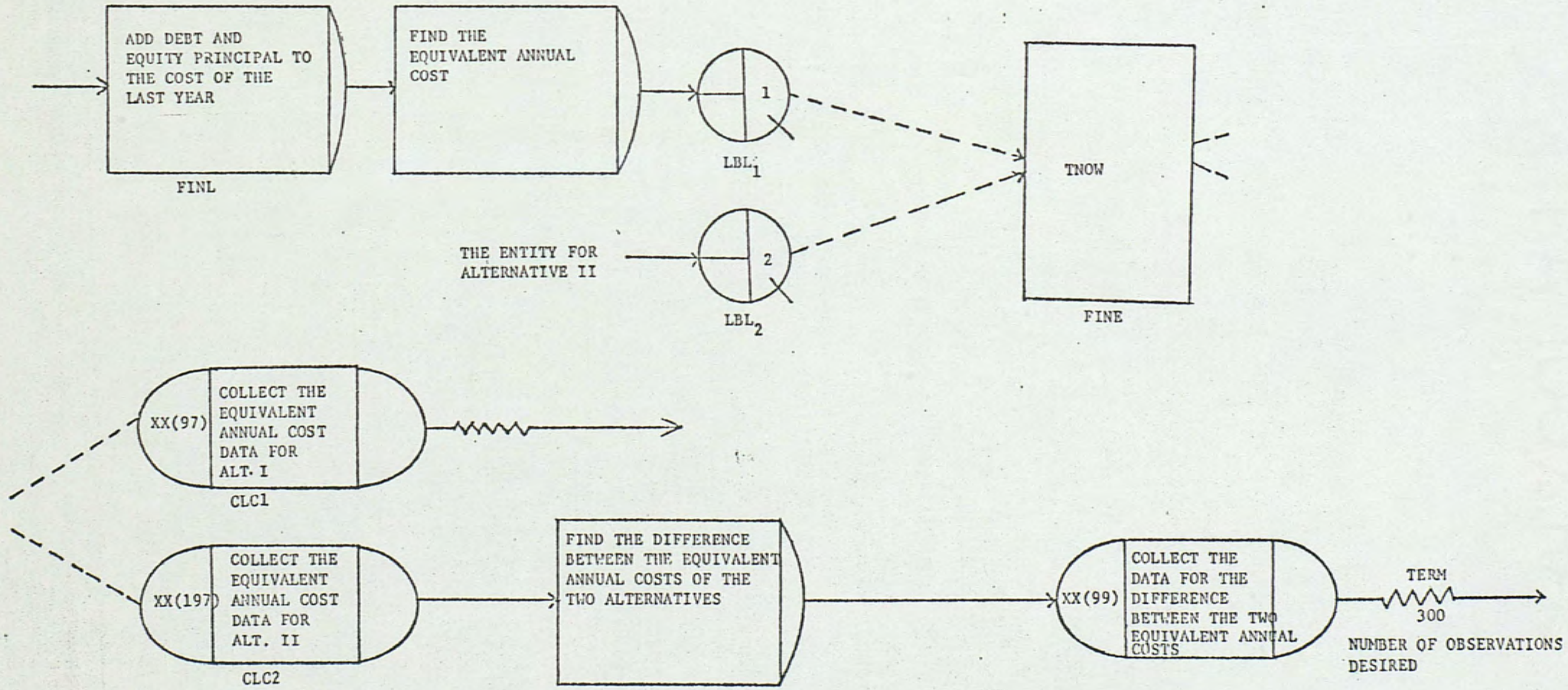


Figure 5. (Continued)

total cost for alternative I. This segment starts with the "network" statement which is the first statement of the network.

In the first part of this segment, the data subject to uncertainty are generated by the program. The following formulae show the relationship used for developing the distributions.

$$M = \frac{A\beta+B\alpha}{\alpha + \beta} \quad (4\text{-}1)$$

$$E = A + \frac{(B-A)(\alpha+1)}{\alpha+\beta+2} = \frac{1}{6}(A+B+4M) \qquad (4\text{-}2)$$

where M: The most likely value of the parameter.

A: The optimistic value of the parameter.

B: The pressimistic value of the parameter.

E: The expected value of the parameter.

α&β : Parameters used to generativ the beta distribution by solving equations (4-1) and (4-2).

The values of α and β were found to be

$$\alpha = \frac{4(A-M)(A+B-2M)}{A^2-B^2-2M(A-B)}, \quad \beta = \left(\frac{M-B}{A-M}\right)\alpha$$

These values were used in the SLAM statement, beta (α,β,2) where 2 is the random number stream.

The value generated by the computer is the $\frac{\alpha+1}{\alpha+\beta+2}$ portion of the equation (4-2), which is the mean of beta distribution and its value is between 0 and 1. Thus, the value of random variable would be:

$$E=A+(B-A).\ Beta(\alpha,\beta,2) \qquad (4-3)$$

The fuel cost is calculated by using equation (3-10). Also the O&M costs are found by applying expressions (3-11-1) and (3-11-2). These costs are for the year when the construction begins and are escalated throughout the construction period. In the mathematical modeling explained in Chapter 3 different escalation rates were assumed for the fixed and variable portions of the O&M cost. Howevever, based on the gathered data a single escalation rate can be applied to both portions of the O&M cost and in this study this rate is determined by ATRIB (85).

The present worth of the construction cost is calculated by statements 228 through 339.

The costs to be incurred during the construction period are equity return, debt interest, insurance cost, and Ad Valorem tax are tax deductible items and the tax savings for each year are calculated by equation (3-22). The present worth of the construction cost is calculated by multiplying the total construction cost of each year by a compound-amount factor to find the equivalent cost at the beginning of the operational period (time 0).

Calculation of the costs during the operational period starts from statement 348. The investment tax credit is received at the beginning of the operational period and this is shown in statement 349.

This program is designed to calculate three types of depreciation. Straight line (ATRIB(31)), sum of the years digits (ATRIB(58)) and declining balance (ATRIB(53)) depreciation are calculated. Global variable XX(32) is related to straight line depreciation, and XX(33) and XX(34) correspond to declining line balance and sum of the years digits, respectively. According to the depreciation policy adopted one (1) is assigned to the respective global variable and zero (0) is assigned to the other two global variables. Statements 451 through 453 are for selection of the desired depreciation policy.

As discussed in Chapter 3, the equity and debt portion of the investment could be financed by equal annual payment policy or by issuing bonds. This program is designed with the flexibility of handling all possible cases of financing the investment. The global variables XX(48) and XX(51) correspond to equity and debt portion of the investment, respectively. According to the financing policy, these global variables are initialized at the beginning of the program. If the equal annual payment policy is adopted one (1) and if bonds are issued (zero) 0 is assigned to the corresponding global variables. The interest paid for the debt portion of the investment is regarded as an expense and is a tax deductible expense. If the debt portion is financed by the equal annual payment policy, the interest portion of the payment should be calculated according to expression 3-16. This is accomplished in the program by statements 464 through 470.

In Chapter 3 the costs incurring during the operational period are discussed in detail. The fuel cost, O&M cost, Ad Valorem taxes and the interest paid for the debt are tax deductible expenses. These are all added to the depreciation to get the total tax deductible expenses and then tax savings for each year are determined (statements 477 through 484). The total after-tax cash flow during the operational period is multiplied by a discount factor to calculate the present worth at the time when the operation starts statement 502) Then all the values for the operation years are accumulated to find the total present worth of the investment.

The fuel and O&M costs are escalated by using the escalation rates which are generated at the earlier part of the program (statements 571 and 512). Thus, a single escalation rate is assumed for the whole period of plant operation.

The principal for the total construction cost is paid back at the end of operational period if the funds are financed by issuing bonds. Finally, the equivalent annual cost is found by multiplying the capital recovery factor by Atrib(50) which is the present worth for the total cost during the construction and operational periods.

The third segment of the program represents the Monte Carlo sampling process for the equivalent annual cost of alternative II which is to be compared with alternative I. This is identical to the above procedure and consists of statements 566 through 807.

The last segment of the program represents a collection of equivalent annual cost statistics for each alternative and comparison of the two alternatives. The statements 808 through 818 represent this operation. The specific explanations are as follows:

By representing one particular sequence of Monte Carlo sampling of cash flow realizations as an entity, these entities are generated by the "CREATE" node (statement 96) and are routed to the assign nodes. The entities with the equivalent annual cost statistics wait in file 1 at the LAB1 QUEUE node to be compared with an entity generated for alternative II. The identical simulation process is done for alternative II and the global variable XX(97) which carries the value of equivalent annual cost for alternative I can be interpreted as the counter part of XX(197) for alternative II. The entities with the equivalent annual cost statistics wait in file 2 at the LAB2 QUEUE node to be compared with those of alternative I.

In order to compare the two investment alternatives a MATCH node holds entities in files 1 and 2 at queue nodes LAB1 and LAB2 until there is an entity in each QUEUE node that has an ATRIBUTE 90 value that is the same. Atribute 90 represents the mark time of both entities of alternatives I and II at their creation. This implies that the equivalent annual costs sampled from each alternative be compared in terms of their respective common sampling time period. Once a match occurs, the entity associated with alternative I is routed to the COLCT node LAB2 while the entity associated with alternative II is routed to the node CLC_2 where statistics are collected on the equivalent annual cost. Following the node CLC_2, both entities arrive at the assign node (statement 817) where the difference equivalent annual costs is computed by XX(99)=XX(97)-XX(197). At the completion of computation of the difference in equivalent annual cost, the entity arrives at the COLT node where statistics are collected on the difference in annual equivalent costs. The 'TERM' statement then destroys the entity. The above process will repeat until the total number of entities to be processed on a simulation run reaches the number listed with TERM statement. The ENDNET statement denotes an end to the network description.

CHAPTER 5

INPUT DATA DESCRIPTION

In the previous Chapter the factors subject to risk were identified as construction cost, fuel cost, O&M cost and the escalation rate for the fuel and O&M costs. When Monte Carlo simulation is used, finding subjective probability distributions from which stochastic parameters are to be generated is a very important task. In this Chapter the data used to develop such probability distributions will be explained. Also the validity and source of the input data will be discussed.

Selection of Starting Base and Load Capacity

The year 1985 was selected as starting time for commercial operation of the plant so this would allow 5 years for construction of the coal power plant. Since most of the gathered cost estimates for construction, operating and maintenance is based on a plant size of 1000 megawatt (MW) capacity, this capacity was chosen for comparison purposes.

Plant Construction Cost

The construction cost data ($/KW) used in this study is based on the assumption that the plant size is 1000 MW. However, for other plant capacities the costs vary substantially. Figure 6 shows the sensitivity of unit capital cost ($/KW) to plant size.

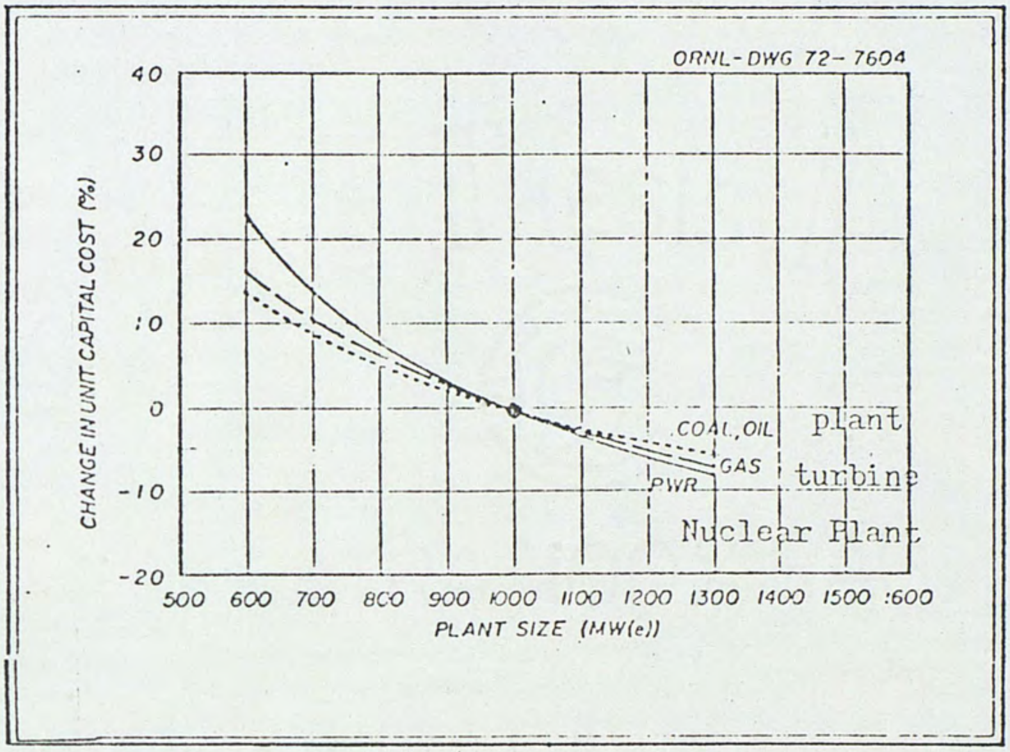


Figure 6. THE SENSITIVITY OF UNIT CAPITAL COST TO PLANT SIZE
Source: Power Engineering, January 1973

As shown in this Figure a higher unit capital cost would be incurred for a smaller plant. For coal and oil power plants the unit capital cost for a 600 MW plant is 20% more than the unit capital cost for a 1300 MW power plant.

i) Coal Power Plant

For controlling the pollution, limestone scrubbers are used. Depending on the quality of coal use, the cost of pollution control varies as required to meet EPA standards. In some cases it consists of 25-30% of the total capital cost [5]. The plants in this study were assumed to be constructed in Southeast part of the country where "EASTERN" coal with 4% sulfur content and 16% ash is used. Table 1 shows the range of construction costs involved for the 1000 MW coal power plant.

Table 1. COAL POWER PLANT CONSTRUCTION COST ESTIMATES

		Low	Most Likely	High
a.	Process plant investment ($/KW)	401	424	445
b.	General facilities ($/KW)	80	85	89
c.	Project contingencies ($/KW)	77	81	85
d.	Pollution control facilities ($/KW)	80	98	131
	TOTAL	638	688	750

Source: Balson, W. E. et al. 2-7.

The above estimates were made based on meeting the 1975 New Source Performance Standard (NSPS) for sulfur dioxide emission (1.2 lbs $SO_2/10^6$ BTU).

ii) Oil Power Plant

The cost of construction of an oil power plant is generally lower than a coal power plant due mainly to the cost of pollution control equipments which are substantially substantially lower for the oil power plant.

Palnt Construction Time and Financing

Construction lead time and the rate of construction are important factors for planning and financing the project. In order to avoid having extra interest costs only the amount needed for each year of construction is financed. A more detailed description of the financing policy was shown in Section 3.2.1.

The construction lead time and cumulative yearly construction for the coal power plant are listed in Table 2.

As it is shown in this table the construction cost for the beginning years of the construction period are less than of the later years.

Table 2. CONSTRUCTION PLANNING FOR COAL POWER PLANT

Construction Period: 5 years	
1st year cumulative constructed portion	10%
2nd year cumulative construction portion	25%
3rd year cummulative construction portion	45%
4th year cummulative construction portion	70%
5th year cummulative construction portion	100%

i) Oil Power Plant

The construction lead time for the oil power plant is generally shorter than of the coal power plant. In Table 3 the construction lead time and cummulative yearly construction for the oil power plant are shown.

Table 3. CONSTRUCTION PLANNING FOR OIL POWER PLANT

Construction period: 4 years	
1st year cummulative construction portion	15%
2nd year cummulative construction portion	35%
3rd year cummulative construction portion	65%
4th year cummulative construction portion	100%

Projection of Fuel Cost

Fuel cost is a very important factor in this study and affects the total cost of the project significantly. However, this portion of the cost is subject to general uncertainty and is a major factor when studying the oil power plant since the fuel cost constitutes a major portion of the total cost for the oil power plant. Because the period of operation for power plants in the study is 30years and the average escalation rates for fuel costs used in this study are assumed to be less than the current escalation rates.

Operation and Maintenance Costs

The pollution control expenses were considered as O&M costs. For coal power plant, the flue gas desulfurization method is used to control the pollution where limestone is used in the process as explained in Chapter 3. The O&M costs consist of the fixed and variable portions. The cost of maintaining scrubbers and other pollution control equipments are included in the fixed portion of O&M cost and the cost of limestone is regarded as a variable O&M

cost. Similar to the escalation rate of the fuel cost, the average O&M escalation rate used in this study is assumed to be less than the current escalation rates.

Plant Efficiency (Heat Rate)

The heat rate is a function of scale and technological parameters reflected in the plant specifications and design. The plant heat rate affects the fuel cost and the variable portion of the O&M cost. The oil power plant has a higher efficiency than the coal power plant. This is reflected as a lower value for the heat rate corresponding to the oil power plant. The values of heat rate used in this study were based on the average annual values.

Data Input for Assessment of Probabilities

As described in Chapter 4, the variables associated with uncertainty in this study were: Construction cost, fuel and O&M costs, and their respective escalation rates.

Beta distribution was chosen as the most appropriate to attain flexibility and consistency in assigning probabilities.

The three estimates used in developing BETA distributions for the parameters are listed in Table 4.

Other Input Data

The data listed in Table 5 are estimated with certainty and their values do not change in the program.

Table 4. ESTIMATES-BETA DISTRIBUTION PARAMETERS

Probabilistic Variables	Coal Power Plant			Oil Power Plant		
	Optimistic Value	Most likely Value	Pessimistic Value	Optimistic Value	Most likely Value	Pessimistic Value
Construction Cost ($/KW)	640	690	750	490	530	580
Fuel Cost ($/10^6 BTU) 1980	1.2	1.6	1.9	2.5	3.0	3.7
Fixed O&M Cost ($/KW) 1980	9.8	10.3	10.9	1.5	1.85	2.25
Viriable O&M Cost ($/KW.HR) 1980	.0017	.0025	.0030	.0024	.003	.0035
Fuel Escalation Rate (%/Year)	4	5	7	6	8	12
O&M Escalation Rate (%/Year)	12	15	17	5	7.5	9.5

Source: The Technical Assessment Group of EPRI Planning Staff. Technical Assessment Guide, PS-866-SR, (Palo Alto, California: Electric Power Research Institute, 1978).
Balson, W. E. et al.
Y. S. Dept. of Energy. Short Term Energy Outlook., October, 1979.

TABLE 5. INPUT DATA ESTIMATED WITH CERTAINTY

Input	Data Used	
	Coal Power Plant	Oil Power Plant
1. Plant Size (MW)	1000	1000
2. Heat Rate (BTU/KW)	10000	9500
3. Plant Capacity Factor (% over 30 years)	70	70
4. Economic Plant Life (years)	30	30
5. Depreciation (years)	20	20
6. Consruction Lead Time (years)	5	4
7. Discount Rate (%)	12	12
8. Effective Combined State and Federal Income Tax Rate	0.5	0.5
9. Debt Ratio	0.5	0.5
10. Equity Ratio	0.5	0.5
11. AD Valorem Tax Rate	0.005	0.005
12. Insurance Rate	0.001	0.001
13. Investment Tax Credit Rate	0.05	0.05
14. Debt Payment Rate (Bond Interest Rate)	0.10	0.10
15. Equity Return Rate	0.15	0.15
16. Plant Salvage Value (% of Initial Investment)	−0.005	−0.005

CHAPTER 6

ECONOMIC ANALYSIS

In this Chapter the expected cost of gnerating electricity by using coal is compared to the expected cost when using oil. The distributions resulting from risk analysis are compared for the two alternatives. Then, the interrelationships and sensitivity of these alternatives to changes in the input parameters are analyzed.

Simulation Experimental Design

It is important to have a sufficiently large number of Monte Carlo trials to reduce sampling variation to a level which is tolerable in view of the accuracy needed and economically justified. In Table 6 the results of simulations with different numbers of observations are listed.

Table 6. Simulation results with various numbers of observations

No. of Observations	Alter-native	Mean ($)	STD.DEV ($)	Prob.[EAC(Oil)> EAC(Coal)]
100	Coal Oil	$312X10^6$ $317X10^6$	$32X10^6$ $41X10^6$	54%
200	Coal Oil	$317X10^6$ $319X10^6$	$32X10^6$ $40X10^6$	60%
300	Coal Oil	$306X10^6$ $320X10^6$	$31.5X10^6$ $42.6X10^6$	60.3%
500	Coal Oil	$303X10^6$ $316X10^6$	$31X10^6$ $41X10^6$	59.5%

As it is expected the values of outcomes dampen or stabilize as the number of trials is increased. The number of trails at which the results become stable appears to be 300.

Simulation Results

The results of each simulation run include the probability distribution for the cost of each alternative and also the probability distribution of the cost difference between generating electricity by coal and by oil. Developing the distribution of the cost differences between these two alternatives allows us to quantify the probability that the first alternative (coal) will be less costly than the second alternative (oil). In Table 6 with 300 observations the expected cost of alternative I is $\$306X10^6$ which is less than $\$320X10^6$ of the expected cost of alternative II. Also the standard deviation of alternative I is less than that of alternative II indicating that the risk associated with alternative I is less than the risk involved with alternative II. The probability that alternative I will be less costly than alternative II is 60.3%. In Figure 7 graphs for the distributions of the costs for the two alternatives and their difference are shown.

Applying Current Escalation Rates

As explained in Chapter 5, the rates of escalation of the fuel cost for the alternatives have very significant effect on the results of the study. The escalation rates which are listed in Table 4 are assumed to be average value over a 30 year period, despite of the fact that these values are lower than the current

STATISTICS FOR VARIABLES BASED ON OBSERVATION

	MEAN VALUE	STANDARD DEVIATION	COEFF. OF VARIATION	MINIMUM VALUE	MAXIMUM VALUE	NUMBER OF OBSERVATIONS
ANN.EQ.COST1	0.3057E+09	0.3155E+08	0.1032E+00	0.2334E+09	0.3825E+09	300
ANN.EQ.COST2	0.3200E+09	0.4262E+08	0.1332E+00	0.2283E+09	0.4390E+09	300
DIFFERENCE	-0.1421E+08	0.5178E+08	-0.3645E+01	-0.1705E+09	0.1106E+09	300

FILE STATISTICS

FILE NUMBER	ASSOCIATED NODE TYPE	AVERAGE LENGTH	STANDARD DEVIATION	MAXIMUM LENGTH	CURRENT LENGTH
1	QUEUE	0.0	0.0	1	0
2	QUEUE	0.0	0.0	1	0
3		2.0000	0.0	4	2

HISTOGRAM NUMBER 1

ANN.EQ.COST1

OBSV FREQ	RELA FREQ	CUML FREQ	UPPER CELL LIMIT
0	0.0	0.0	0.2000E+09
0	0.0	0.0	0.2100E+09
0	0.0	0.0	0.2200E+09
0	0.0	0.0	0.2300E+09
2	0.007	0.007	0.2400E+09
5	0.017	0.023	0.2500E+09
20	0.067	0.090	0.2600E+09
20	0.067	0.157	0.2700E+09
23	0.077	0.233	0.2800E+09
25	0.083	0.317	0.2900E+09
39	0.130	0.447	0.3000E+09
29	0.097	0.543	0.3100E+09
34	0.113	0.657	0.3200E+09
26	0.087	0.743	0.3300E+09
34	0.113	0.857	0.3400E+09
22	0.073	0.930	0.3500E+09
8	0.027	0.957	0.3600E+09
7	0.023	0.980	0.3700E+09
5	0.017	0.997	0.3800E+09
1	0.003	1.000	0.3900E+09
0	0.0	1.000	0.4000E+09
0	0.0	1.000	0.4100E+09
0	0.0	1.000	0.4200E+09
0	0.0	1.000	0.4300E+09
0	0.0	1.000	0.4400E+09
0	0.0	1.000	0.4500E+09
0	0.0	1.000	INF

300			

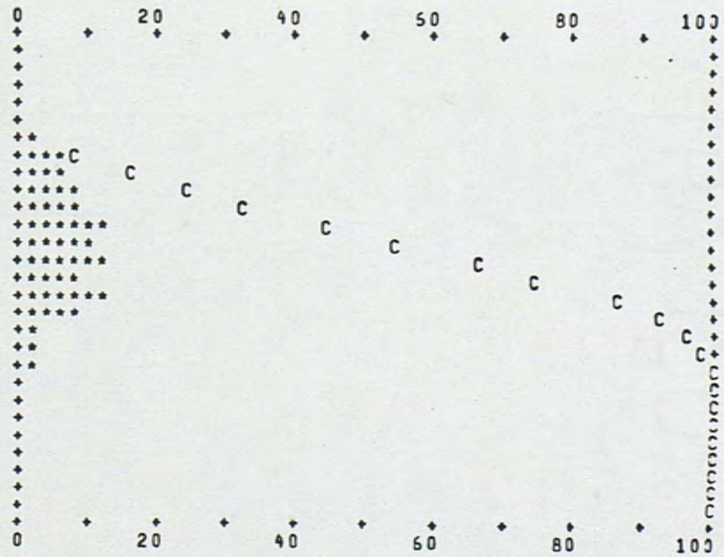


Figure 7. THE DISTRIBUTION OF ANNUAL EQUIVALENT COST OF THE TWO ALTERNATIVES AND THEIR DIFFERENCE

HISTOGRAM NUMBER 2

ANN.EQ.COST2

OBSV FREQ	RELA FREQ	CUML FREQ	UPPER CELL LIMIT
0	0.0	0.0	0.2000E+09
0	0.0	0.0	0.2100E+09
0	0.0	0.0	0.2200E+09
1	0.003	0.003	0.2300E+09
2	0.007	0.010	0.2400E+09
3	0.010	0.020	0.2500E+09
14	0.047	0.067	0.2600E+09
17	0.057	0.123	0.2700E+09
18	0.060	0.183	0.2800E+09
30	0.100	0.283	0.2900E+09
24	0.080	0.363	0.3000E+09
29	0.097	0.460	0.3100E+09
26	0.087	0.547	0.3200E+09
20	0.067	0.613	0.3300E+09
18	0.060	0.673	0.3400E+09
22	0.073	0.747	0.3500E+09
14	0.047	0.793	0.3600E+09
23	0.077	0.870	0.3700E+09
7	0.023	0.893	0.3800E+09
13	0.043	0.937	0.3900E+09
9	0.030	0.967	0.4000E+09
3	0.010	0.977	0.4100E+09
4	0.013	0.990	0.4200E+09
1	0.003	0.993	0.4300E+09
2	0.007	1.000	0.4400E+09
0	0.0	1.000	0.4500E+09
0	0.0	1.000	0.4600E+09
0	0.0	1.000	0.4700E+09
0	0.0	1.000	0.4800E+09
0	0.0	1.000	0.4900E+09
0	0.0	1.000	0.5000E+09
0	0.0	1.000	INF
300			

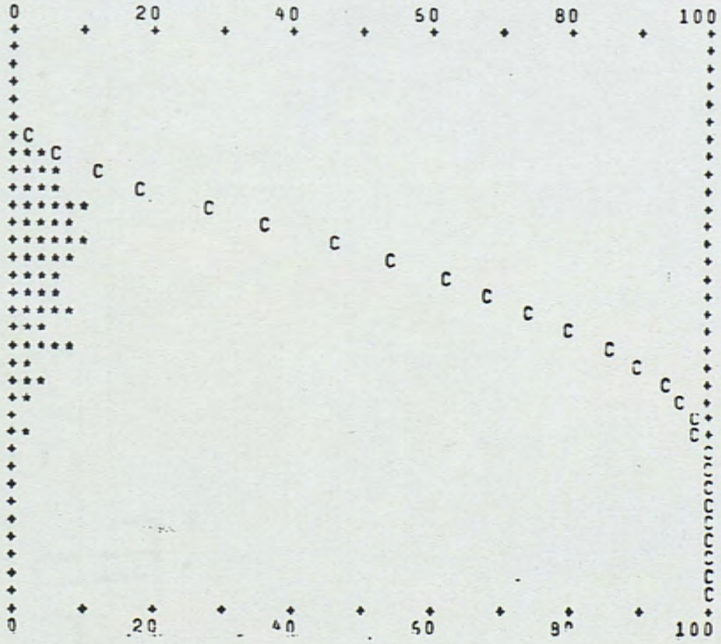


Figure 7. (Continued)

HISTOGRAM NUMBER 3

DIFFERENCE

OBSV FREQ	RELA FREQ	CUML FREQ	UPPER CELL LIMIT
1	0.003	0.003	-0.1500E+09
2	0.007	0.010	-0.1440E+09
0	0.0	0.010	-0.1380E+09
0	0.0	0.010	-0.1320E+09
1	0.003	0.013	-0.1260E+09
3	0.010	0.023	-0.1200E+09
3	0.010	0.033	-0.1140E+09
3	0.010	0.043	-0.1080E+09
3	0.010	0.053	-0.1020E+09
4	0.013	0.067	-0.9600E+08
3	0.010	0.077	-0.9000E+08
7	0.023	0.100	-0.8400E+08
6	0.020	0.120	-0.7800E+08
5	0.017	0.137	-0.7200E+08
8	0.027	0.163	-0.6600E+08
11	0.037	0.200	-0.6000E+08
11	0.037	0.237	-0.5400E+08
8	0.027	0.263	-0.4800E+08
11	0.037	0.300	-0.4200E+08
12	0.040	0.340	-0.3600E+08
9	0.030	0.370	-0.3000E+08
8	0.027	0.397	-0.2400E+08
20	0.067	0.463	-0.1800E+08
10	0.033	0.497	-0.1200E+08
16	0.053	0.550	-0.6000E+07
16	0.053	0.603	0.9300E+02
9	0.030	0.633	0.6000E+07
12	0.040	0.673	0.1200E+08
9	0.030	0.703	0.1800E+08
9	0.030	0.733	0.2400E+08
14	0.047	0.780	0.3000E+08
11	0.037	0.817	0.3600E+08
10	0.033	0.850	0.4200E+08
11	0.037	0.887	0.4800E+08
8	0.027	0.913	0.5400E+08
7	0.023	0.937	0.6000E+08
4	0.013	0.950	0.6600E+08
2	0.007	0.957	0.7200E+08
7	0.023	0.980	0.7800E+08
2	0.007	0.987	0.8400E+08
1	0.003	0.990	0.9000E+08
0	0.0	0.990	0.9600E+08
2	0.007	0.997	0.1020E+09
0	0.0	0.997	0.1080E+09
1	0.003	1.000	0.1140E+09
0	0.0	1.000	0.1200E+09
0	0.0	1.000	0.1260E+09
0	0.0	1.000	0.1320E+09
0	0.0	1.000	0.1380E+09
0	0.0	1.000	0.1440E+09
0	0.0	1.000	0.1500E+09
0	0.0	1.000	INF

300			

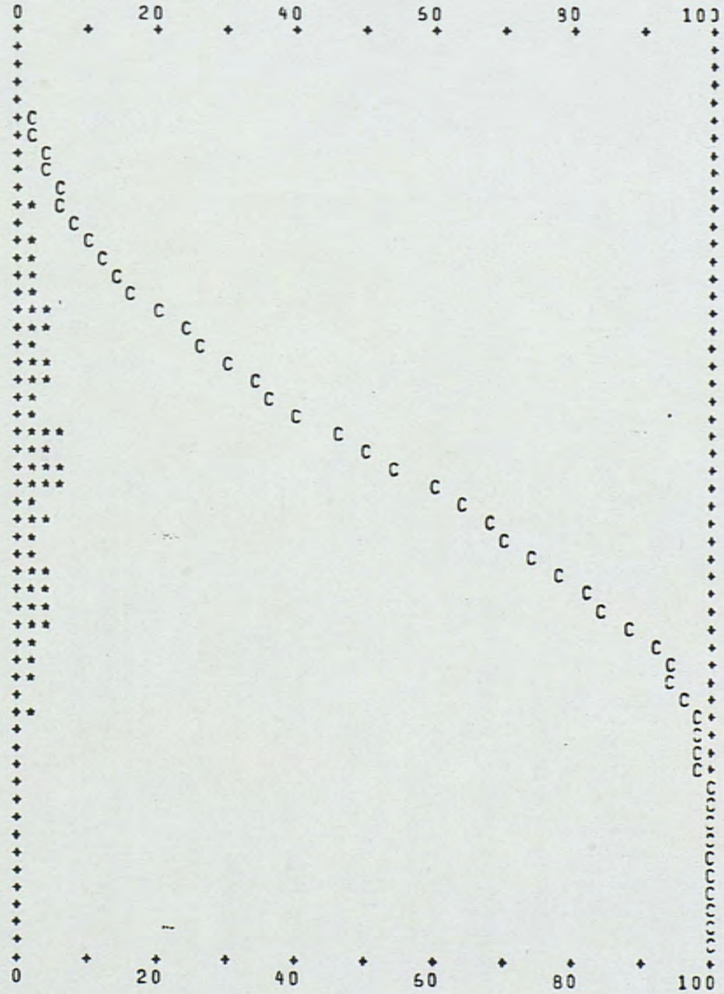


Figure 7. (Continued)

escalation rates. Some estimations of the current escalation rates are listed in Table 7. These values were used in a simulation and the results are summarized in Table 8.

Table 7. ESTIMATED CURRENT ESCALATION RATES FOR THE FUEL COST

Probabilistic Variables	Coal Power Plant			Oil Power Plant		
	Optimistic value	Most likely Value	Pessimistic value	Optimistic value	Most likely value	Pessimistic value
Fuel Escalation Rate (%/year)	7	10	12	8	12	15

As shown in Table 8 a higher escalation rate for the fuel cost increases the cost of alternative II (Oil) very significantly and this increase is substantially higher than the cost increase of alternative I (Coal). The probability that alternative II will be more costly than alternative I increases to 87%. Another important observation is the change in value of the standard deviation of alternative II which is the result of assuming a wide range for the escalation rate of the fuel cost. The distribution for the cost is spread such that the risk involved with this alternative is in general much greater than of the previous case.

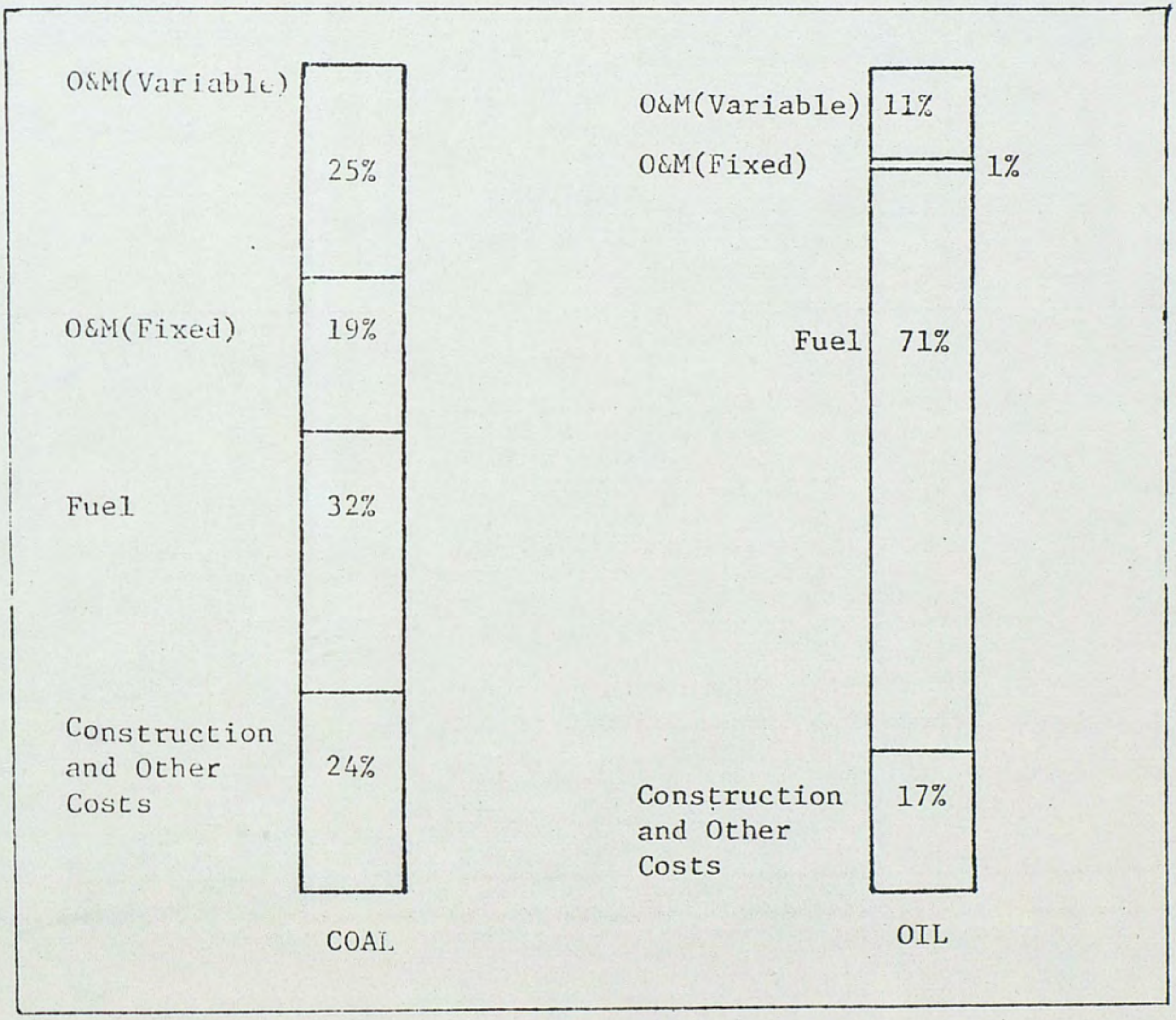
Evaluation of Cost Elements

It is of interest to examine the percent contribution of each cost element to the total annual equivalent cost for the results shown in Figure 7.

Table 8. SIMULATION RESULTS USING CURRENT ESCALATION RATES

Alternative	Mean	STD.DEV.	Prob. P[EAC(Oil) > EAC (Coal)]
I(Coal)	$413X10^6$	$49X10^6$	87%
II(Oil)	$560X10^6$	$128X10^6$	

Table 9. COST ELEMENTS FOR THE TWO ALTERNATIVES



According to the results shown in Table 9, seventy one percent of the total cost of the oil power plant is used for fuel whereas only 32% of the coal power plant is for fuel.

The cost of pollution control is included in the variable portion of the O&M cost which constitutes 25% of the total cost of the coal power plant. A major portion of these costs are for supplying and processing the limestone which is used for controlling the pollution. For the oil power plant 11% of the total cost is for the variable O&M costs. The fixed O&M costs constitute 19% of the total cost of the coal power plant and only 1% of the cost of the oil power plant. For the coal power plant the cost of maintaining the scrubbers and other pollution control devices is included in the fixed portion of the O&M costs. The remaining costs are mainly the construction cost as well as insurance costs, debt interest, and taxes. These costs constitute 24% of the total cost of the coal power plant and 17% of the total cost of the oil power plant.

The Effect of System Load Factor

Since operating and fuel costs are linear functions of system load factor, the system capacity factor is an important operating characteristic for a power plant. The results of simulations for some selected values of load factor are summarized in Figure 8. As it is shown in this Figure for values of the load factor of 55% or less the oil power plant would become the less costly alternative.

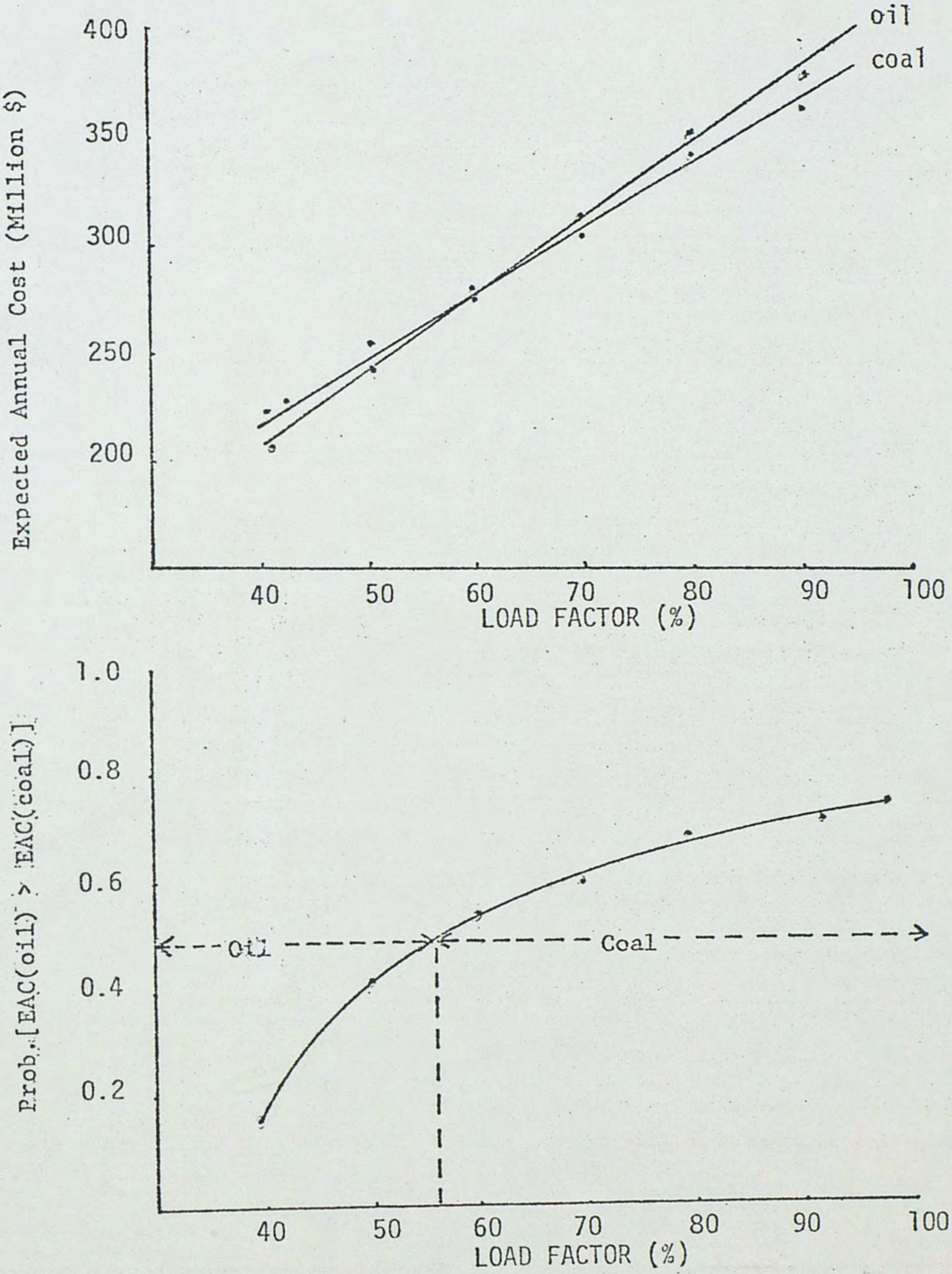


Figure 8. THE EFFECT OF LOAD FACTOR ON THE TOTAL COST AND ECONOMIC ATTRACTIVENESS

The effect of Discount Rate

As described in Chapter 3 the present worth of the net after-tax cash flow for each year is calculated and the equivalent annual cost for each alternative is found as a function of the discount rate. Thus, the selection of an appropriate discount rate in evaluation of capital investment is important.

Figure 9 shows the sensitivity of the equivalent annual cost of the two alternatives to the discount rate. As shown in this Figure, higher discount rates result in lower equivalent annual costs for both alternatives under study. For discount rates higher than 7%, alternative I (Coal) would be less costly than alternative II (Oil).

The Effective of Construction Cost

To examine the sensitivity of the total cost of alternatives to the construction cost, the original values for construction costs were inflated by increments of 5%. The results of the respective simulations are shown in Figure 10. Based on these results the total equivalent annual cost of coal power plant is more sensitive to construction cost than of the oil power plant and an increase of 28% or more in the construction costs would make the coal power plant a more costly alternative.

The Effect of Fuel Cost

As discussed in Chapter 4 the cost of fuel is a critical factor in economical analysis of power plants. The importance of this

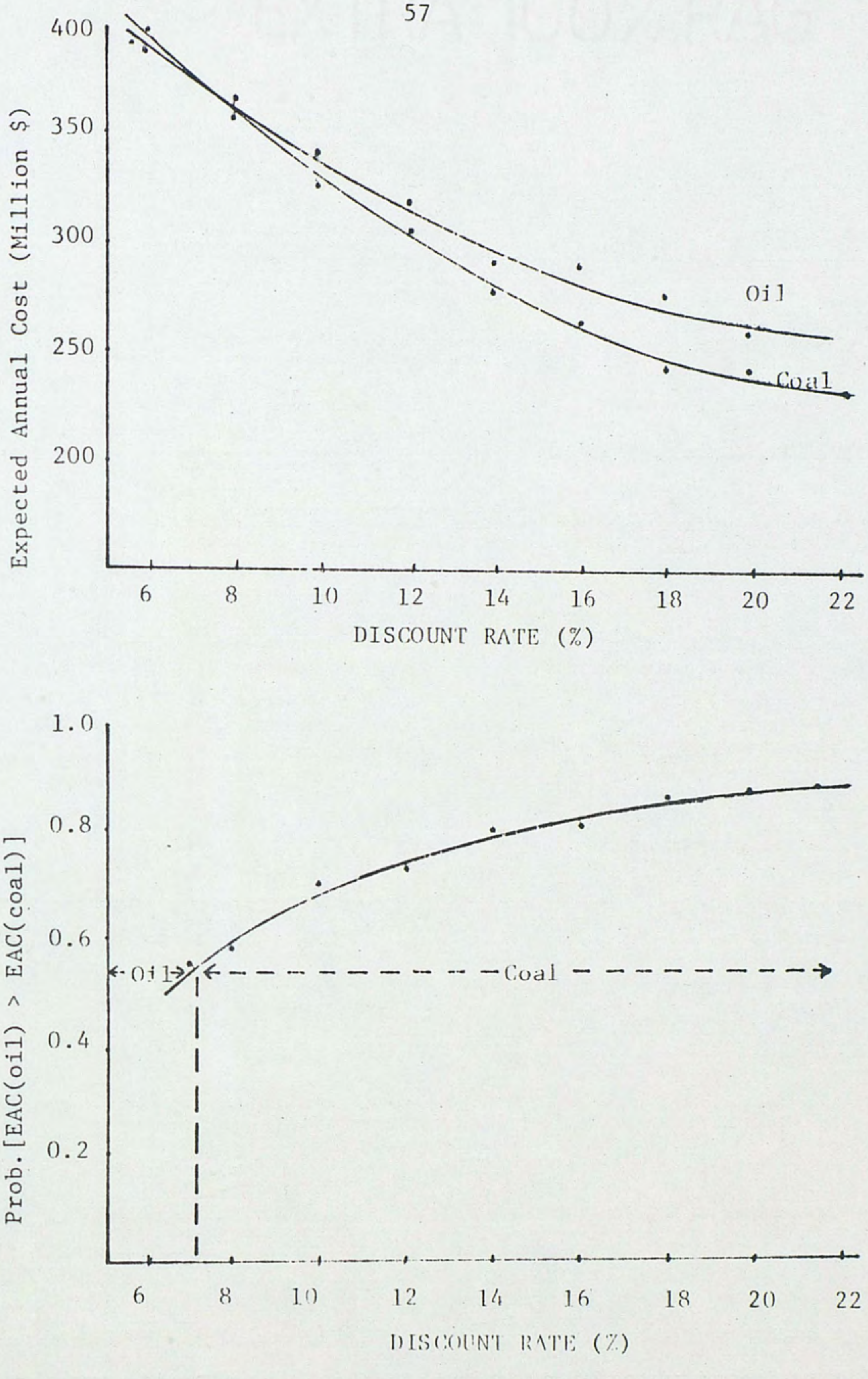
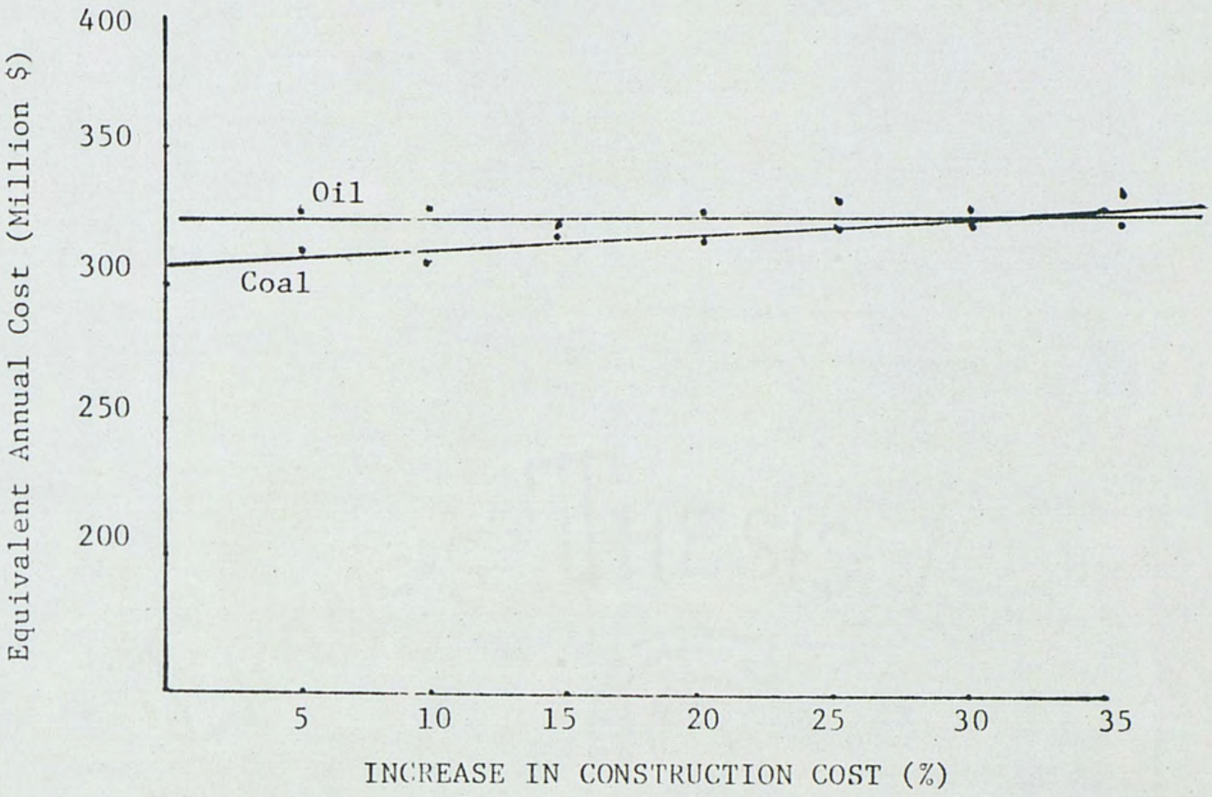


Figure 9. THE EFFECT OF DISCOUNT RATE ON THE TOTAL COST AND ECONOMIC ATTRACTIVENESS



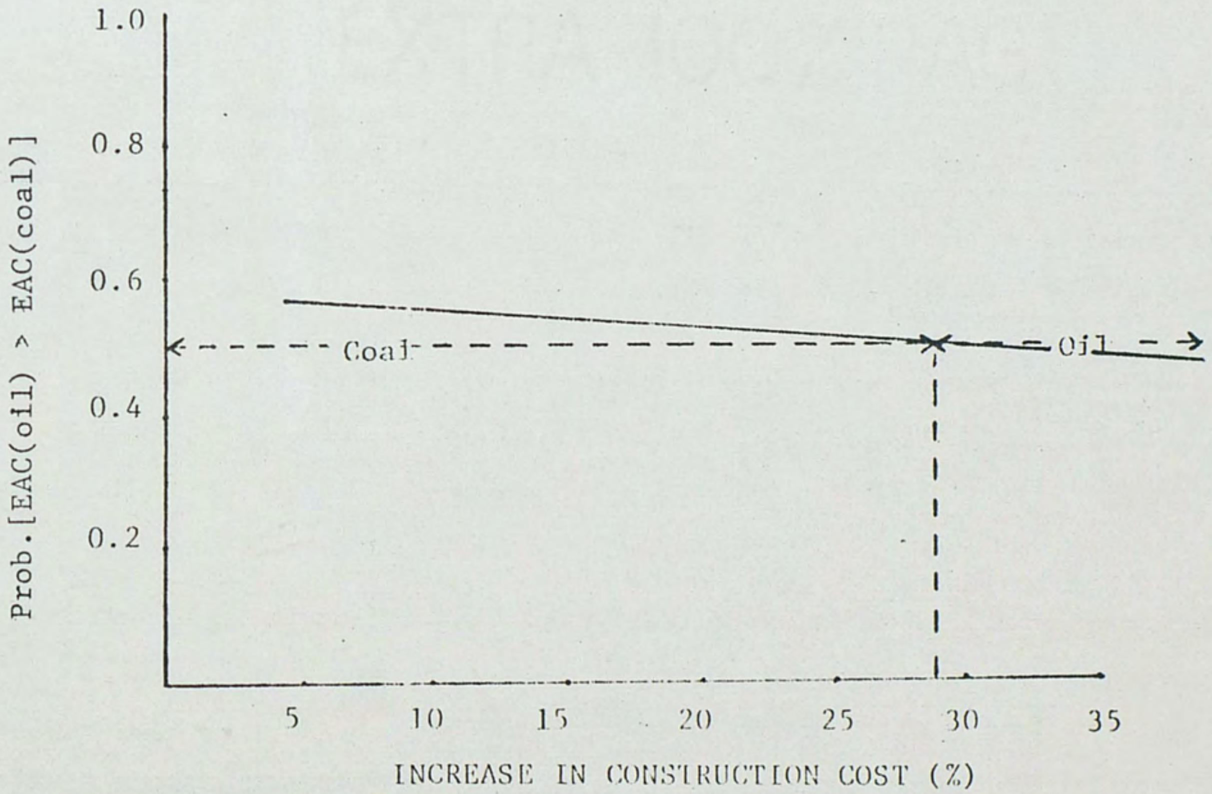


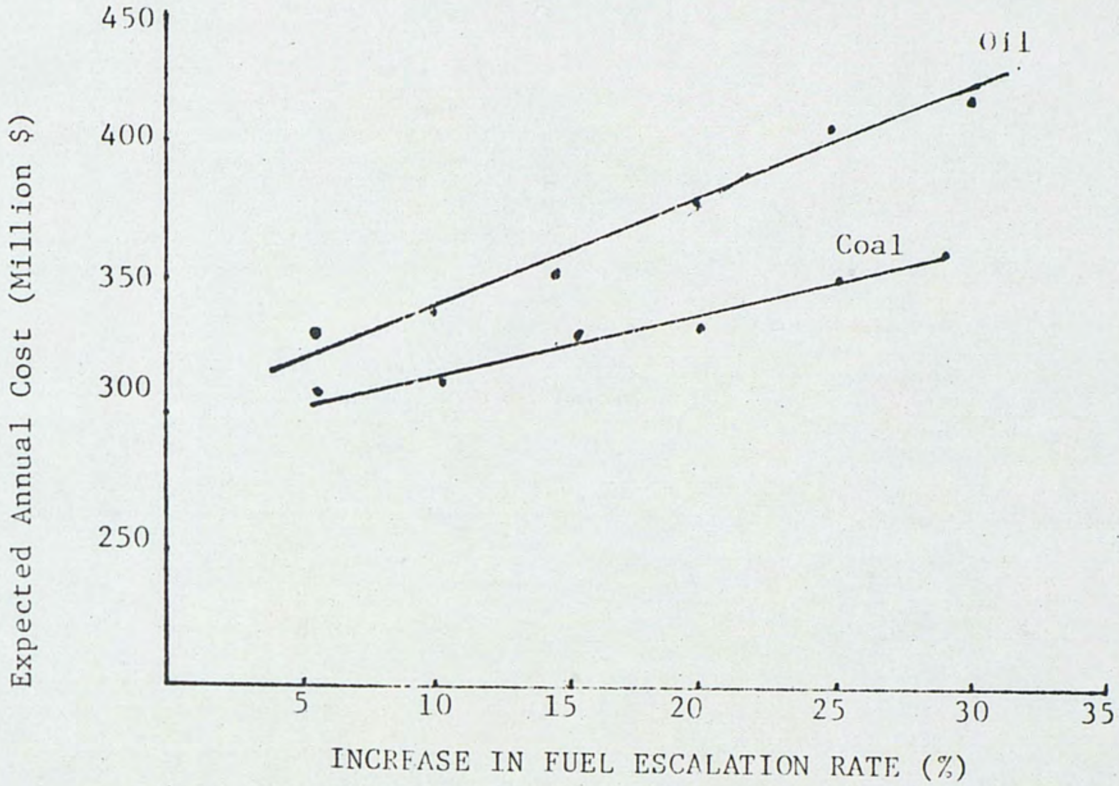
Figure 10. THE EFFECT OF CONSTRUCTION COST ON THE TOTAL COST AND ECONOMIC ATTRACTIVENESS

factor is greater for the oil power plant since the fuel cost constitutes a major portion of the total cost of this alternative.

In this study the values for the average escalation rate of fuel cost are 5.16% for coal and 7.4% for oil. These values were inflated by increments of 5% to examine the sensitivity of the total cost of the alternatives to the fuel cost. In Figure 11 the values of the total cost are plotted vs. the inflated values of fuel escalation rate. In this Figure the high sensitivity of the total cost of the oil power plant to the fuel cost is shown.

The Effect of O&M Cost

To examine the sensitivity of the total cost of both alternatives to the O&M cost, simulation runs were made by assuming a set of values for the O&M escalation rates. The simulation results are presented in Figure 12. According to the results shown in this Figure, the total cost of the coal power plant is substantially more sensitive to the O&M cost than the oil power plant. For O&M escalation rates 3% higher than the rates assumed in this study the coal power plant would be the more costly alternative.



Esc. Rate(Coal)	5.16	5.4	5.7	5.9	6.2	6.4	6.7	7
Esc. Rate(Oil)	7.4	7.8	8.1	8.5	8.9	9.2	9.6	10

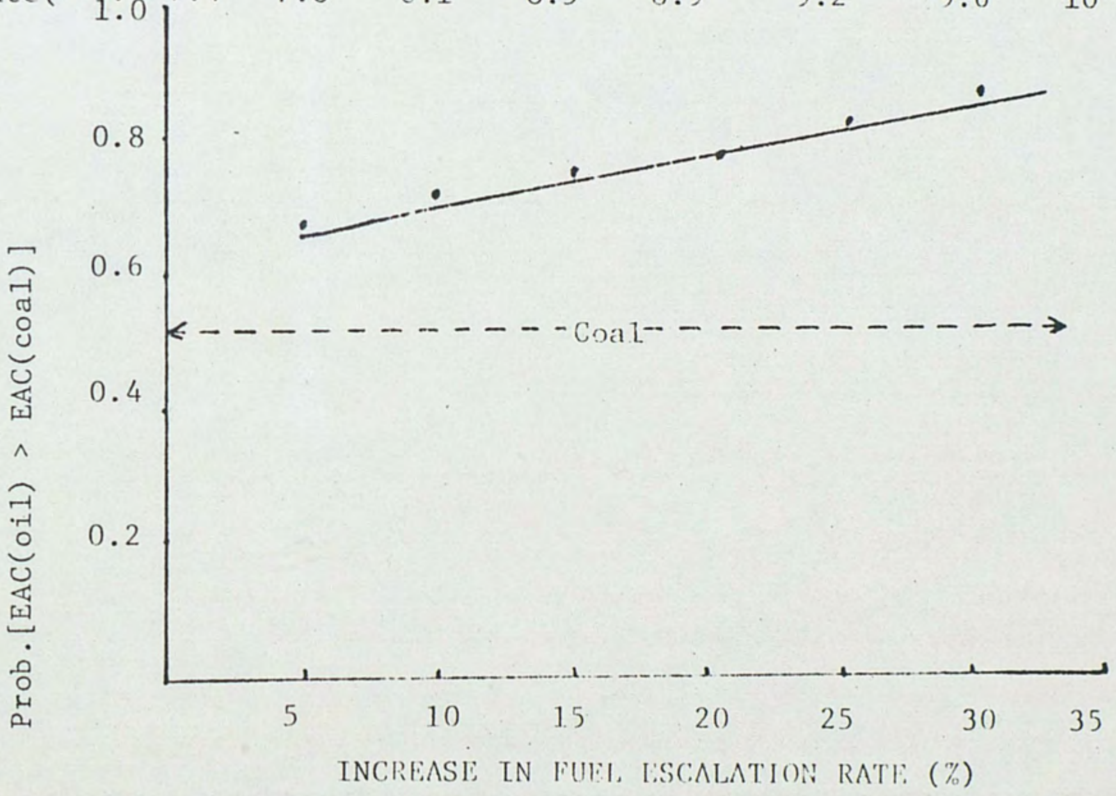
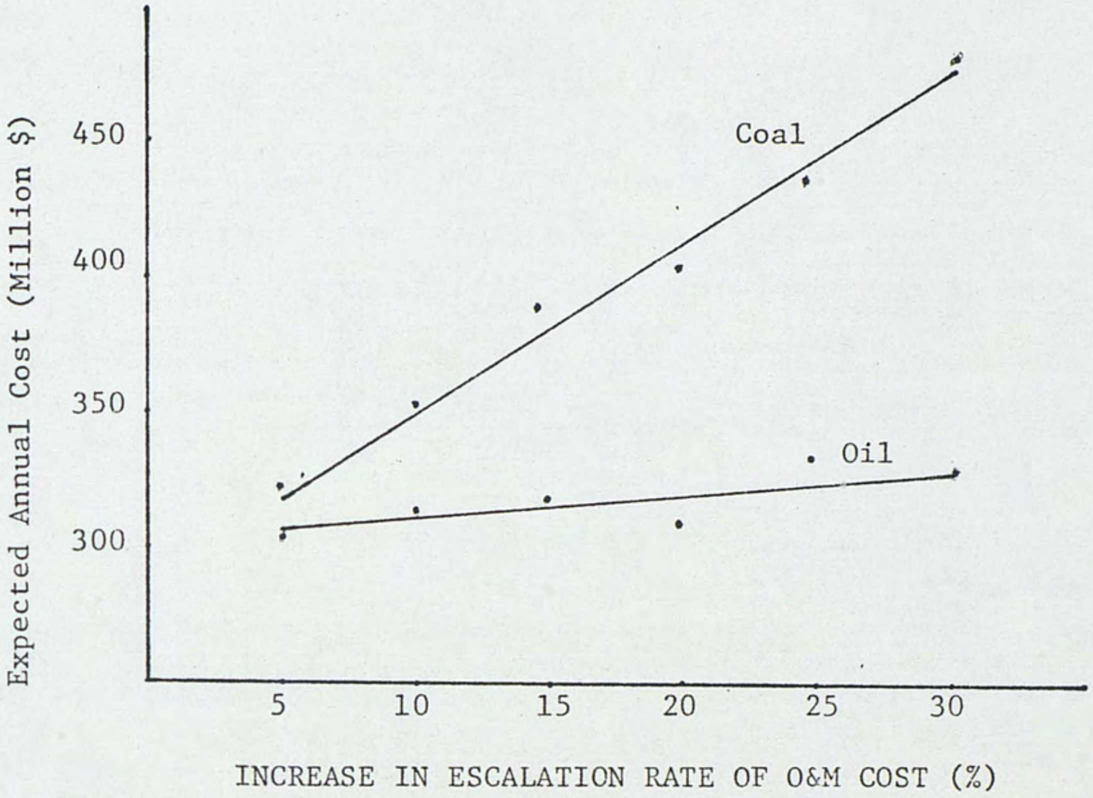


Figure 11. THE EFFECT OF FUEL COST ON THE TOTAL COST AND ECONOMICAL ATTRACTIVENESS



Esc.Rate (Coal)	14.8	15.5	16.3	17	17.8	18.5	19.2
Esc.Rate (Oil)	8.3	8.7	9.1	9.5	10	10.4	10.8

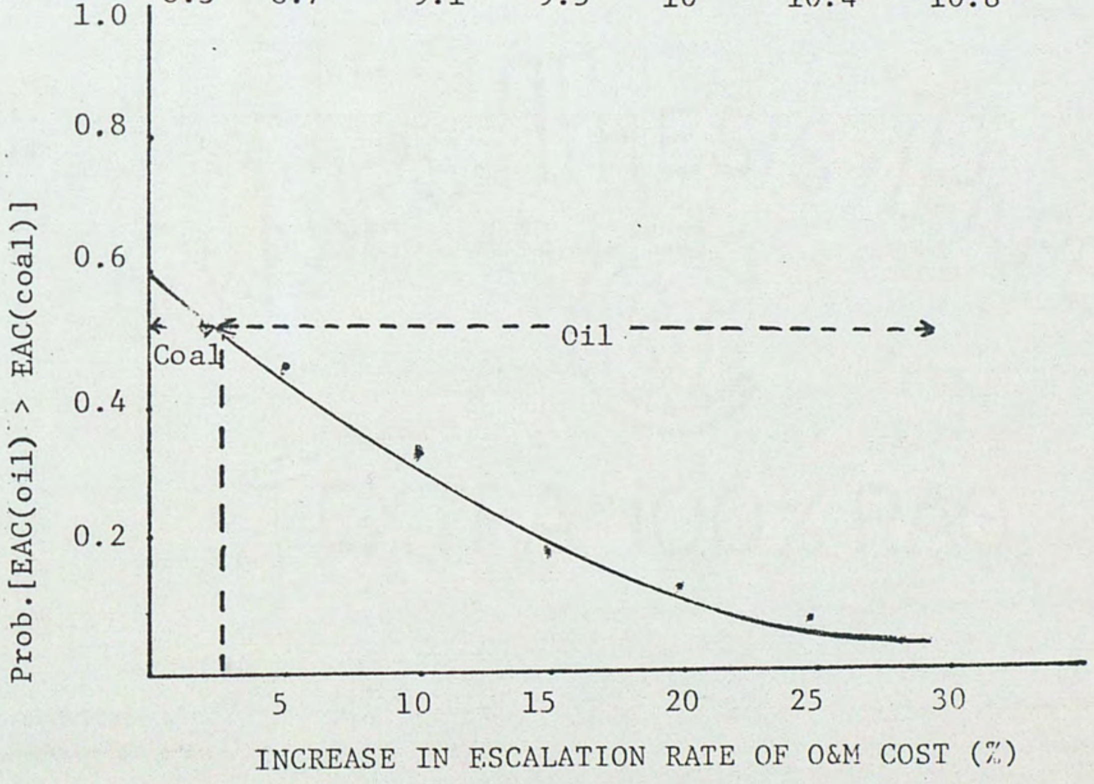


Figure 12. THE EFFECT OF O&M COST ON THE TOTAL COST AND ECONOMIC ATTRACTIVENESS

CHAPTER 7

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary and Conclusions

This report describes the application of risk analysis approach to the problem of assessing the cost of two competing technologies for electric power production. Oil and coal power plants were compared assuming equal plant size, operating life and a similar financing policy. It has been shown that the comparison of two technologies is complicated by various factors. The difficulty stems from the fact that these technologies differ along many dimensions; capital cost, fuel cost, operating and maintenance cost, and environmental effects. Furthermore, the combustion of coal produces airborne emissions of particulates, nitrogen and sulfur oxides. These emissions should be reduced to some acceptable levels specified by Environmental Protection Agency (EPA).

A comprehensive mathematical model for evaluation of power plants was developed. The cost elements were identified and the total equivalent annual cost was derived in order to accomplish risk analysis, all the factors subject to uncertainty were identified and corresponding probability distributions for all these factors were defined. A computer program was developed to find the equivalent annual costs by incorporating the probabilistic information through Monte Carlo sampling techniques. SLAM was the computer language used in this study and the inherent flexibility of this language reduced the complexity involved in programming the economical model of this study.

By referring to various sources of information, the necessary data was collected for this study. For factors subject to uncertainty three estimates i.e., "optimistic", "most likely", and "pessimistic" were made. These estimates were used to develop the probability distributions for the respective parameters.

The expected cost of generating electricity by using coal was compared to the expected cost when oil is used. The distributions resulting from risk analysis were compared for the two alternatives and the interrelationships and sensitivity of these alternatives to changes in the input parameters were analyzed.

According to the results achieved with 300 observations in a simulation run the expected equivalent annual cost of the oil power plant was higher than of the coal power plant. The same observation was made with the standard deviations of costs of the two alternatives. This indicates that the risk involved with the oil power plant is higher than the associated risk with the coal power plant. The probability that the coal power plant would be less costly than the oil power plant was 60%.

By applying fuel escalation rates closer to the current rates a significant increase was observed in the values of the expected equivalent annual costs and the respective standard deviations. In this case the probability that the coal power plant would be less costly than the coal power plant incresed to 87%.

Seventy one per cent of the total cost of the oil power plant was found to be due to the fuel costs, whereas, for the coal power plant only 32% of the total cost was observed to be for the fuel cost. However, the construction and O&M costs of the coal power plant were found to constitute a higher percentage of the total cost of this alternative than the respective cost elements for the oil power plant.

By assuming higher values for the load factor the economic attractiveness of the coal power plant was further enhanced. For all values of load factor less than 55% the oil power plant appeared to be the less costly alternative.

For an increase in the value of discount rate the expected value of equivalent annual cost was decreased. Discount rates lower than 7% would make the oil power plant the less costly alternative.

The coal power plant was found to be more sensitive to an increase in the construction cost. For any increase in construction costs greater than 28% over the initially estimated value the coal power plant would become the more costly alternative.

For the coal power plant the O&M cost was found to have significant effect on the total equivalent annual cost. For O&M escalation rates 3% higher than the rates assumed in this study the coal power plant would be the more costly option to undertake.

Recommendation for Future Research

The selection of SLAM as the simulation language simplified the programming effort to a minimum. A significant advantage of the program developed for this study is its flexibility and capability of handling various conditions when studying power generation economics. Development of an interactive version of SLAM could put the package at the reach of a wider range of users. The role of the user would be reduced to selecting options offered by the program and entering the data pertaining to his specific case, without mastering SLAM simulation language.

Another feature of the possible extension of the study is to develop a comprehensive program to evaluate a variety of power plants such as nuclear, solar, and synthetic fuel.

APPENDIX I

SLAM SIMULATION PROGRAM LISTINGS

```
                    J E S 2   J O B   L O G  --  S Y S T E M   I P 0 1  --  N O D E   C F R

22.57.57 JOB 2940   $HASP373 SLAM     STARTED - INIT  3 - CLASS 5 - SYS IP01
23.09.12 JOB 2940   $HASP395 SLAM     ENDED

------ JES2 JOB STATISTICS ------

 10 JUL 80 JOB EXECUTION DATE

       830 CARDS READ

     1,228 SYSOUT PRINT RECORDS

         0 SYSOUT PUNCH RECORDS

         0 SYSOUT PLOT RECORDS

     11.24 MINUTES EXECUTION TIME

     1      //SLAM JOB (XF1954,01,300),MEDI
            ***PASSWORD  $ACF1770 PASSWORD(S) SUCCESSFULLY SCANNED                     JOB 2940
            ***JOBPARM   ROOM=UCF
     2      // EXEC IRF4X,PROG=SLAM500
     3      XXDEFAULTS PROC     PROG=                                                  00050000
            *** DATE LAST MODIFIED - 09/26/79 BY J. W. RADFORD                         00100000
     4      XXIRF4X       EXEC     PGM=&PROG                                           00150000
     5      XXSTEPLIB  DD   DSN=FTU.SS.IRLINK,DISP=SHR                                 00200000
     6      XXFT05F001 DD DDNAME=SYSIN                                                 00250000
     7      XXFT06F001 DD SYSOUT=*                                                     00300000
     8      //FT07F001 DD UNIT=SYSDA,SPACE=(CYL,(1,1)),SYSOUT=
            X/FT07F001 DD SYSOUT=B                                                     00350000
     9      //SYSIN DD *
    10      XXSTEP2       EXEC     PGM=IRLOG,PARM='&PROG',COND=EVEN                    00400000
    11      XXSTEPLIB     DD       DSN=FTU.SS.IRLINK,DISP=SHR                          00450000
    12      XXSYSPRINT    DD       SYSOUT=*                                            00500000
    13      XXLOGFILE     DD       DSN=FTU.OU.P1003.@LOGFILE,DISP=SHR                  00550000
            *** PROJ 1003                 FTU SYSTEMS PROGRAMMING                      00600000
            //

 STMT NO. MESSAGE

     4      IEF653I SUBSTITUTION JCL - PGM=SLAM500
    10      IEF653I SUBSTITUTION JCL - PGM=IRLOG,PARM='SLAM500',COND=EVEN
IEF236I ALLOC. FOR SLAM IRF4X
IEF237I 151  ALLOCATED TO STEPLIB
IEF237I 151  ALLOCATED TO SYS00030
IEF237I JES2 ALLOCATED TO FT05F001
IEF237I JES2 ALLOCATED TO FT06F001
IEF237I 153  ALLOCATED TO FT07F001
IEF142I SLAM IRF4X - STEP WAS EXECUTED - COND CODE 0000
IEF285I   FTU.SS.IRLINK                                   KEPT
IEF285I   VOL SER NOS= FTUPK2.
IEF285I   SYSCTLG.VFTUPK2                                 KEPT
IEF285I   VOL SER NOS= FTUPK2.
IEF285I   JES2.JOB02940.SI0101                            SYSIN
IEF285I   JES2.JOB02940.SO0102                            SYSOUT
IEF285I   SYS80192.T225757.RA000.SLAM.R0000001            DELETED
IEF285I   VOL SER NOS= SYSWK1.
IEF373I STEP /IRF4X    / START 80192.2257
IEF374I STEP /IRF4X    / STOP  80192.2309 CPU    4MIN 02.64SEC SRB    0MIN 13.27SEC VIRT   380K SYS   216K
IEF236I ALLOC. FOR SLAM STEP2
```

```
JOB PERFORMANCE ANALYSIS AND CHARGES FOR USE OF  C.F.R.D.C.                    SYSID-IP VS/2 RELEASE-03.8   MODEL-165

 JOBNAME -  SLAM           ACCOUNT NO. - XF1954            DATE - 10 JUL 80   JOB CLASS - 5              36.3 OPACITY
 22:57:58 STARTED          23:09:12 ENDED           00:11:14 ELAPSED           00:11:09 NET TIME               JOB PRTY
                                                                                                    CAS-ACTRT REL 3.6M

 BASIC CHARGES- CPU TIME            -        242.95 SECONDS     AT    .07500 $/SEC     =        18.22
                VOLUNTARY WAIT      -        425.70 SECONDS     AT    .00000 $/SEC     =          .00
                VIRT CORE           -        92,213 KCPU SEC    AT    .00037 $/KCS     =        34.12
                PAGE-INS                       93               AT    .00000 $EACH     =          .00
                PAGE-OUTS                     128               AT    .00000 $EACH     =          .00
                                                               BASIC SUB- TOTAL        =        52.34*

 DEVICE CHARGES-DEVICE    ------MOUNTING-------          ---EXCP---          --OCCUP---
                CLASS     NUM      $EA     CHARGE          CHARGE              CHARGE

                DASD      00       .00      .00             3.35                .00    =         3.35
                TAPE      00       .00      .00              .00                .00    =          .00
                U/R                                          .00                .00    =          .00
                OTHER                                        .00                .00    =          .00
                                                              DEVICE SUB- TOTAL        =         3.35*

 PRIORITY AND SHIFT TOTAL =            .00      JOB TOTAL =        55.69 JOB CHARGE    =       $55.69*
```

```
SLAM

VERSION 1.0
RELEASE 1.0
```


PRITSKER AND ASSOCIATES, INC.

P.O. BOX 2413

WEST LAFAYETTE, INDIANA 47906

```
GEN,MEDI,EXERCISE,01/22/80,1;
LIMITS,2,90,200;
;
;
;       ***********************************************************************
;                 INITIALIZATION FOR ALTERNATIVE  I
;
;*******************VARIABLES SUBJECT TO UNCERTAINTY **************************
INTLC,XX(74)=640.,XX(73)=690.,XX(83)=750.; CONSTRUCTION COST ($/KW)
INTLC,XX(18)=1.2,XX(19)=1.6 ,XX(20)=1.9  ;    FUEL COST
INTLC,XX(80)=9.8 ,XX(86)=10.3 ,XX(88)=10.9  ;     O&M COST(FIXED)
INTLC,XX(28)=0.0017 ,XX(29)=0.0025 ,XX(30)=0.003  ; O&M COST (VARBL.)
INTLC,XX(37)=0.12 ,XX(39)=0.15 ,XX(24)=0.17  ;    O&M ESC.RATE
INTLC,XX(93)=0.04 ,XX(94)=0.05 ,XX(95)=0.07  ;FUEL ESCALATION RATE
;       ***********************************************************************
;;      ******************VARIABLES ESTIMATED WITH CERTAINTY ******************
;
INTLC,XX(26)=30 ; OP.LIFE
;
INTLC,XX(66)=20 ; DEP.LIFE
;
INTLC,XX(27)=0.05 ; INV.TAX CREDIT RATE
;
INTLC,XX(2)=0.5 ; TAX RATE
;
INTLC,XX(16)=5 . ;          CONSTRUCTION PERIOD
;
INTLC,XX(5)=0.005 ; PROP.TAX
;
INTLC,XX(6)=0.001 ; INS.RATE
;
INTLC,XX(32)=1,XX(33)=0,XX(34)=0; STRAIGHT LINE DEPRECIATION
;
INTLC,XX(77)=-0.005 ; SALVAGE VALUE(% OF INIT.INVST.)
;
INTLC,XX(78)=10000  ; HEAT RATE
;
INTLC,XX(82)=0.7  ; CAPACITY FACTOR
;
INTLC,XX(90)=1000000,XX(300)=0,; PLANT SIZE(KW)
;
INTLC,XX(51)=0; DEBT:BOND TYPE
;
INTLC,XX(48)=1; EQUITY:EQUAL ANNUAL PAYMENT TYPE
;
INTLC,XX(1)=1.12   ; 1+ INTEREST RATE
;
INTLC,XX(3)=0.15;EQUITY INTEREST RATE
;
INTLC,XX(4)=0.10;DEBT INTEREST RATE
;
INTLC,XX(11)=0.5 ; DEBT PORTION OF THE INVESTMENT
;
INTLC,XX(12)=0.1 , ;     PORTION TO BE CONSTRUCTED BY THE END OF YEAR 1
;
INTLC,XX(13)=0.25  ;     PORTION TO BE CONSTRUCTED BY THE END OF YEAR 2
;
INTLC,XX(14)=0.45 ;      PORTION TO BE CONSTRUCTED BY THE END OF YEAR 3
;
INTLC,XX(15)=0.7  ;      PORTION TO BE CONSTRUCTED BY THE END OF YEAR 4
;
INTLC,XX(58)=1    ;      PORTION TO BE CONSTRUCTED BY THE END OF YEAR 5
;
INTLC,        XX(59)=0,XX(60)=0,XX(61)=0,XX(62)=0; REMAINING YEARLY PORTIONS OF
                                                   THE PROJECT CONSTRUCTION
;
INTLC,XX(35)=0.1  ; DECLINING BALANCE DEPRECIATION FACTOR
;
INTLC,XX(7)=0 ,XX(8)=0 ,XX(36)=1 ;              INITIALIZATIONS
;
```

```
;         ****************************************************************************
;                      INITIALIZATION FOR ALTERNATIVE II
;         ***************************************************************************
INTLC,XX(174)=490.,XX(173)=530.,XX(183)=580. ;   CONSTRUCTION COST($/KW)
INTLC,XX(118)=2.5 ,XX(119)=3.0 ,XX(120)=3.7 ;    FUEL COST
INTLC,XX(180)=1.50,XX(185)=1.85,XX(188)=2.25 ;   O&M COST(FIXED)
INTLC,XX(128)=0.0024,XX(129)=0.003,XX(130)=0.0035 ;   O&M COST (VRBL.)
INTLC,XX(137)=0.06 ,XX(139)=0.08 ,XX(124)=0.12 ;  ESC. RATE (O&M)
INTLC,XX(193)=0.05  ,XX(194)=0.075 ,XX(195)=0.095  ;
;         ****************************************************************************
INTLC,XX(126)=30 ,XX(166)=20,XX(127)=0.05  ,XX(102)=0.5  ,XX(116)=4  ;
INTLC,XX(105)=0.005  ,XX(106)=0.001  ,XX(177)=-0.005,XX(178)=9500        ;
INTLC,XX(132)=1,XX(133)=0,XX(134)=0;
INTLC,XX(182)=0.7,XX(190)=1000000,XX(400)=0,XX(103)=0.15,XX(104)=0.1;
INTLC,XX(111)=0.5,XX(112)=0.15,XX(113)=0.35,XX(114)=0.65,XX(115)=1,XX(158)=0;
INTLC,XX(159)=0  ,XX(160)=0  ,XX(161)=0  ,XX(162)=0      ;
INTLC,XX(101)=1.12 ,XX(103)=0.15,XX(104)=0.10,XX(135)=0.30       ;
INTLC,XX(151)=0,XX(148)=1                                ;
INTLC,XX(107)=0 ,XX(108)=0, XX(136)=1;
;         ***************************************************************************
;         CONSTANTS USED FOR ADJUSTING ESCALATION RATES
INTLC,XX(279)=1,XX(273)=1 ,XX(285)=1 ,XX(284)=1 ,XX(281)=1 ,  XX(282)=1     ;
INTLC,XX(379)=1,XX(373)=1 ,XX(385)=1 ,XX(384)=1 ,XX(381)=1 ,  XX(382)=1     ;
;         ***************************************************************************
NETWORK;
     CREATE,1;
     ASSIGN,ATRIB(90)=TNOW;
;
;
;                      THIS PART GENERATES DATA BY BETA DISTRIBUTION
;    *********************   CONSTRUCTION COST    ********************************
     ASSIGN,ATRIB(1)=XX(74)-XX(73),ATRIB(2)=XX(74)+XX(83),
     ATRIB(3)=XX(73)*2,ATRIB(4)=ATRIB(2)-ATRIB(3);
     ASSIGN,ATRIB(4)=ATRIB(4)*ATRIB(1),ATRIB(4)=ATRIB(4)*4;
     ASSIGN,ATRIB(5)=XX(74)*XX(74),ATRIB(6)=XX(83)*XX(83);
     ASSIGN,ATRIB(6)=ATRIB(5)-ATRIB(6),ATRIB(7)=XX(74)-XX(83);
     ASSIGN,ATRIB(7)=ATRIB(7)*ATRIB(3),ATRIB(7)=ATRIB(6)-ATRIB(7),
     ATRIB(8)=ATRIB(4)/ATRIB(7),ATRIB(9)=XX(73)-XX(83);
     ASSIGN,ATRIB(9)=ATRIB(9)/ATRIB(1),ATRIB(10)=ATRIB(8)*ATRIB(9);
     ASSIGN,XX(92)=ATRIB(8),XX(87)=ATRIB(10),
     XX(89)=BETA(XX(92),XX(87),2),XX(81)=XX(83)-XX(74);
     ASSIGN,XX(81)=XX(81)*XX(89),XX(21)=XX(81)+XX(74);
     ASSIGN,ATRIB(73)=XX(21)*XX(90);
     ASSIGN,ATRIB(73)=ATRIB(73)*XX(273) ;
;    *********************       FUEL COST        ********************************
     ASSIGN,ATRIB(1)=XX(18)-XX(19),ATRIB(2)=XX(18)+XX(20),
     ATRIB(3)=XX(19)*2;
     ASSIGN,ATRIB(4)=ATRIB(2)-ATRIB(3),ATRIB(4)=ATRIB(4)*ATRIB(1),
     ATRIB(4)=ATRIB(4)*4;
     ASSIGN,ATRIB(5)=XX(18)*XX(18),ATRIB(6)=XX(20)*XX(20),
     ATRIB(6)=ATRIB(5)-ATRIB(6),ATRIB(7)=XX(18)-XX(20);
     ASSIGN,ATRIB(7)=ATRIB(7)*ATRIB(3),ATRIB(7)=ATRIB(6)-ATRIB(7),
     ATRIB(8)=ATRIB(4)/ATRIB(7);
     ASSIGN,ATRIB(9)=XX(19)-XX(20),
     ATRIB(9)=ATRIB(9)/ATRIB(1),ATRIB(10)=ATRIB(8)*ATRIB(9);
     ASSIGN,XX(92)=ATRIB(8),XX(87)=ATRIB(10),
     XX(89)=BETA(XX(92),XX(87),2);
     ASSIGN,XX(81)=XX(20)-XX(18),XX(81)=XX(81)*XX(89),
     ATRIB(79)=XX(81)+XX(18);
     ASSIGN,ATRIB(79)=ATRIB(79)*XX(279);
;    *********************     O&M COST(FIXED)    ********************************
     ASSIGN,ATRIB(1)=XX(80)-XX(86),ATRIB(2)=XX(80)+XX(88),
     ATRIB(3)=XX(86)*2;
     ASSIGN,ATRIB(4)=ATRIB(2)-ATRIB(3),ATRIB(4)=ATRIB(4)*ATRIB(1),
     ATRIB(4)=ATRIB(4)*4;
     ASSIGN,ATRIB(5)=XX(80)*XX(80),ATRIB(6)=XX(88)*XX(88),
     ATRIB(6)=ATRIB(5)-ATRIB(5),ATRIB(7)=XX(80)-XX(88);
     ASSIGN,ATRIB(7)=ATRIB(7)*ATRIB(3),ATRIB(7)=ATRIB(6)-ATRIB(7),
     ATRIB(8)=ATRIB(4)/ATRIB(7);
     ASSIGN,ATRIB(9)=XX(86)-XX(88),
```

```
        ATRIB(9)=ATRIB(9)/ATRIB(1),ATRIB(10)=ATRIB(8)*ATRIB(9);
        ASSIGN,XX(92)=ATRIB(8),XX(87)=ATRIB(10),
        XX(89)=BETA(XX(92),XX(87),2);
        ASSIGN,XX(81)=XX(88)-XX(80),XX(81)=XX(81)*XX(89),
        ATRIB(81)=XX(81)+XX(80);
        ASSIGN,ATRIB(81)=ATRIB(81)*XX(281) ;
;     ********************     O&M COST(=VRBL.)      ********************************
        ASSIGN,ATRIB(1)=XX(28)-XX(29),ATRIB(2)=XX(28)+XX(30),
        ATRIB(3)=XX(29)*2;
        ASSIGN,ATRIB(4)=ATRIB(2)-ATRIB(3),ATRIB(4)=ATRIB(4)*ATRIB(1),
        ATRIB(4)=ATRIB(4)*4;
        ASSIGN,ATRIB(5)=XX(28)*XX(28),ATRIB(6)=XX(30)*XX(30),
        ATRIB(6)=ATRIB(5)-ATRIB(6),ATRIB(7)=XX(28)-XX(30);
        ASSIGN,ATRIB(7)=ATRIB(7)*ATRIB(3),ATRIB(7)=ATRIB(6)-ATRIB(7),
        ATRIB(8)=ATRIB(4)/ATRIB(7);
        ASSIGN,ATRIB(9)=XX(29)-XX(30),
        ATRIB(9)=ATRIB(9)/ATRIB(1),ATRIB(10)=ATRIB(8)*ATRIB(9);
        ASSIGN,XX(92)=ATRIB(8),XX(87)=ATRIB(10),
        XX(89)=BETA(XX(92),XX(87),2);
        ASSIGN,XX(81)=XX(30)-XX(28),XX(81)=XX(81)*XX(89),
        ATRIB(82)=XX(81)+XX(28);
        ASSIGN,ATRIB(82)=ATRIB(82)*XX(282) ;
;     ********************     O&M ESC.RATE          ********************************
        ASSIGN,ATRIB(1)=XX(37)-XX(39),ATRIB(2)=XX(37)+XX(24),
        ATRIB(3)=XX(39)*2.;
        ASSIGN,ATRIB(4)=ATRIB(2)-ATRIB(3),ATRIB(4)=ATRIB(4)*ATRIB(1),
        ATRIB(4)=ATRIB(4)*4;
        ASSIGN,ATRIB(5)=XX(37)*XX(37),ATRIB(6)=XX(24)*XX(24),
        ATRIB(6)=ATRIB(5)-ATRIB(6),ATRIB(7)=XX(37)-XX(24);
        ASSIGN,ATRIB(7)=ATRIB(7)*ATRIB(3),ATRIB(7)=ATRIB(6)-ATRIB(7),
        ATRIB(8)=ATRIB(4)/ATRIB(7);
        ASSIGN,ATRIB(9)=XX(39)-XX(24),
        ATRIB(9)=ATRIB(9)/ATRIB(1),ATRIB(10)=ATRIB(8)*ATRIB(9);
        ASSIGN,XX(92)=ATRIB(8),XX(87)=ATRIB(10),
        XX(89)=BETA(XX(92),XX(87),2);
        ASSIGN,XX(81)=XX(24)-XX(37),XX(81)=XX(81)*XX(89),
        ATRIB(85)=XX(81)+XX(37);
        ASSIGN,ATRIB(85)=ATRIB(85)*XX(285) ;
;     ********************     FUEL ESC. RATE        ********************************
        ASSIGN,ATRIB(1)=XX(93)-XX(94),ATRIB(2)=XX(93)+XX(95),
        ATRIB(3)=XX(94)*2;
        ASSIGN,ATRIB(4)=ATRIB(2)-ATRIB(3),ATRIB(4)=ATRIB(4)*ATRIB(1),
        ATRIB(4)=ATRIB(4)*4;
        ASSIGN,ATRIB(5)=XX(93)*XX(93),ATRIB(6)=XX(95)*XX(95),
        ATRIB(6)=ATRIB(5)-ATRIB(6),ATRIB(7)=XX(93)-XX(95);
        ASSIGN,ATRIB(7)=ATRIB(7)*ATRIB(3),ATRIB(7)=ATRIB(6)-ATRIB(7),
        ATRIB(8)=ATRIB(4)/ATRIB(7);
        ASSIGN,ATRIB(9)=XX(94)-XX(95),
        ATRIB(9)=ATRIB(9)/ATRIB(1),ATRIB(10)=ATRIB(8)*ATRIB(9);
        ASSIGN,XX(92)=ATRIB(8),XX(87)=ATRIB(10),
        XX(89)=BETA(XX(92),XX(87),2);
        ASSIGN,XX(81)=XX(95)-XX(93),XX(81)=XX(81)*XX(89),
        ATRIB(84)=XX(81)+XX(93);
        ASSIGN,ATRIB(84)=ATRIB(84)*XX(284) ;
;
;
;
;         ************************************************************************
;                                         FIND THE FUEL COST
;
        ASSIGN,ATRIB(77)=XX(78),
        ATRIB(78)=XX(82),
              XX(22)=ATRIB(77)*ATRIB(78),
              XX(22)=XX(22)*ATRIB(79) ,
              XX(22)=XX(22)*8760 ;
;
;         XX(22) IS THE FUEL COST (1980)
;
```

```
;       *************************************************************************
;                                                    FIND THE O&M COST
        ASSIGN,XX(23)=ATRIB(81)*XX(90),
               ATRIB(83)=ATRIB(82)*ATRIB(78),
               ATRIB(83)=ATRIB(83)*8760,
               ATRIB(83)=ATRIB(83)*XX(90),
               XX(23)=ATRIB(83)+XX(23);
;
;          XX(23) IS THE TOTAL O&M COST (1980)
;
;       *************************************************************************
;
;          *************************************************************************
;          *************************************************************************
;                      ***THIS PART OF THE PROGRAM  CALCULATES THE TOTAL COST
;                        DURING THE CONSTRUCTION PERIOD
;
;          *************************************************************************
;          *************************************************************************
        ASSIGN,XX(9)=ATRIB(84)+1,
               XX(10)=ATRIB(85)+1;
;
;          *************************************************************************
;                                                    THE PERCENTAGE OF CONSTRUCTION PER YEAR
        ASSIGN,ATRIB(20)=XX(12),
        ATRIB(1)=XX(1),
        ATRIB(61)=1,
               ATRIB(65)=1,
               ATRIB(71)=1,
               ATRIB(2)=2;
        ASSIGN,ATRIB(24)=XX(22),
               ATRIB(24)=ATRIB(24)*XX(9),
               ATRIB(24)=ATRIB(24)*XX(9),
        ATRIB(25)=XX(23),
               ATRIB(25)=ATRIB(25)*XX(10),
               ATRIB(25)=ATRIB(25)*XX(10);
        ASSIGN,XX(21)=XX(300)*ATRIB(73),XX(21)=XX(21)+ATRIB(73),
               XX(25)=XX(21)*XX(77);
;          XX(300) IS THE ADJUSTING FACTOR FOR CONSTRUCTION COST
;          XX(25) IS THE SALVAGE VALUE
;          *************************************************************************
;                                                    THE FACTOR TO BRING THE COST TO TIME '0'
DETC    ASSIGN,ATRIB(2)=ATRIB(2)+1,
        ATRIB(3)=XX(1),
               ATRIB(24)=ATRIB(24)*XX(9),
               ATRIB(25)=ATRIB(25)*XX(10),
        ATRIB(1)=XX(1)*ATRIB(1);
;
;          AT(24) IS THE ESCALATED FUEL COST AT THE START OF ORERATION YEAR
;          AT(25) IS THE ESCALATED O&M COST AT THE START OF OPERATION YEAR
;
        ACT,,ATRIB(2).LT.XX(16),DETC;
        ACT,,ATRIB(2).GE.XX(16),BACK;
;
;
;          *************************************************************************
;                                                    THE CONSTRUCTION COST PER YEAR
BACK    ASSIGN,ATRIB(4)=XX(21)*ATRIB(20);
        ASSIGN,ATRIB(5)=XX(11)*ATRIB(4),
        ATRIB(6)=ATRIB(4)-ATRIB(5),
        ATRIB(7)=ATRIB(5)*XX(4),
        ATRIB(8)=ATRIB(6)*XX(3);
;
;
;          AT(5) IS THE DEBT PORTION AND AT(6) IS THE EQUITY PORTION
;
```

```
;          ******************************************************************
;                                               FIND THE INSURANCE COST AND ADD DEBT
;                                               INTEREST TO PROPERTY TAX TO GET TAXABLE
;
        ASSIGN,ATRIB(9)=ATRIB(4)*XX(6),
        ATRIB(10)=ATRIB(9)*XX(1),
        ATRIB(11)=ATRIB(4)*XX(5),
        ATRIB(12)=ATRIB(7)+ATRIB(11);
;
;          AT(10) IS THE YEARLY INSURANCE PAID
;          AT(12) IS THE TAX DEDUCTIBLE AMOUNT
;
;          ******************************************************************
;                                               ADD THE COSTS
        ASSIGN,ATRIB(13)=ATRIB(12)*XX(2),
        ATRIB(14)=ATRIB(8),
        ATRIB(14)=ATRIB(14)+ATRIB(10),
        ATRIB(14)=ATRIB(14)+ATRIB(12);
;
;          AT(13) IS THE TAX REVENUE
;
;          ******************************************************************
;                                               FIND THE COST AFTER TAXES AT YEAR '0'
        ASSIGN,ATRIB(14)=ATRIB(14)-ATRIB(13),
        ATRIB(15)=ATRIB(14)*ATRIB(1),
        ATRIB(15)=ATRIB(16)+ATRIB(15),
        ATRIB(1)=ATRIB(1)/XX(1);
;
;          AT(16) IS THE CUM.CONST.COST AT YEAR '0'
;
;          ******************************************************************
;                                               THE YEARS OF CONSTRUCTION
        ASSIGN,ATRIB(17)=ATRIB(17)+1;
;
        ACT,,ATRIB(17).LT.XX(16),TEST;
        ACT,,ATRIB(17).GE.XX(16),FWRD;
;
TEST    GOON,8;
        ACT,,ATRIB(17).EQ.1,SUB1;
        ACT,,ATRIB(17).EQ.2,SUB2;
        ACT,,ATRIB(17).EQ.3,SUB3;
        ACT,,ATRIB(17).EQ.4,SUB4;
        ACT,,ATRIB(17).EQ.5,SUB5;
        ACT,,ATRIB(17).EQ.6,SUB6;
        ACT,,ATRIB(17).EQ.7,SUB7;
        ACT,,ATRIB(17).EQ.8,SUB8;
;
;          ******************************************************************
;                                               FIND THE TOTAL CONSTRUCTION AT YEAR END
SUB1    ASSIGN,ATRIB(20)=XX(13);
        ACT,,,BACK;
SUB2    ASSIGN,ATRIB(20)=XX(14);
        ACT,,,BACK;
SUB3    ASSIGN,ATRIB(20)=XX(15);
        ACT,,,BACK;
SUB4    ASSIGN,ATRIB(20)=XX(58);
        ACT,,,BACK;

SUB5    ASSIGN,ATRIB(20)=XX(59);
        ACT,,,BACK;
SUB6    ASSIGN,ATRIB(20)=XX(60);
        ACT,,,BACK;
SUB7    ASSIGN,ATRIB(20)=XX(61);
          ACT,,,BACK;
SUB8    ASSIGN,ATRIB(20)=XX(62);
        ACT,,,BACK;
;
;          AT(20) IS THE CUM.PORTION OF THE PROJECT CONSTRUCTED AT THE END OF YEAR
```

```
     ;        ******************************************************************
     ;                   ***THIS PART OF THE PROGRAM CALCULATES THE TOTAL COST
     ;                      DURING THE OPERATION PERIOD
     ;        ******************************************************************
     ;
FWRD  ASSIGN,ATRIB(27)=XX(27)*XX(21),
      ATRIB(16)=ATRIB(16)-ATRIB(27),
      ATRIB(26)=ATRIB(6),
      ATRIB(34)=XX(21);
     ;
     ;        AT(27) IS THE INVESTMENT TAX CREDIT BIS DEDUCTED FROM TOTAL COST
     ;
     ;        ******************************************************************
     ;                                      FIND THE DEPRECIATION
      ASSIGN,ATRIB(30)=XX(21)-XX(25),
             ATRIB(76)=ATRIB(30),
             XX(76)=XX(65),
             ATRIB(31)=ATRIB(30)/XX(66),
             ATRIB(51)=XX(35),
      ATRIB(52)=XX(36)-ATRIB(51);
      ASSIGN,ATRIB(56)=XX(65),
                   ATRIB(54)=XX(66)+XX(36),
                   ATRIB(55)=ATRIB(54)*XX(66),
             ATRIB(55)=ATRIB(55)/2;
     ;
     ;        AT(30) IS(P-L) FOR SLDBAT(55) IS N(N+1)/2 FOR SYD DEPRECIATION
     ;        ******************************************************************
     ;                                      CHECK FOR TYPE OF EQUITY
      ACT,,XX(48).EQ.0,BETA;
      ACT,,XX(48).EQ.1,ALFA;
     ;        **********************************************************  ******
     ;                                      WHEN EQUITY IS BOND TYPE FIND YRLY INTRST
BETA  ASSIGN,ATRIB(64)=ATRIB(6)*XX(3),
      ATRIB(63)=ATRIB(6);
      ACT,,,NEXT;
     ;
     ;        AT(64) IS THE YEARLY INTEREST FOR THE EQUITY
     ;        ******************************************************************
     ;                                      WHEN EQUITY IS EQUAL ANNUAL PYMNT TYPE
     ;                                      FIND THE ANNUAL PAYMENT
ALFA  ASSIGN,XX(40)=XX(3)+1,
             XX(41)=XX(3)+1;
EQIT  ASSIGN,ATRIB(61)=ATRIB(61)+1,
      XX(41)=XX(41)*XX(40);
      ACT,,ATRIB(61).LT.XX(26),EQIT;
      ACT,,ATRIB(61).GE.XX(26),EQCT;
EQCT  ASSIGN,XX(42)=XX(41)-1,
      XX(43)=XX(41)*XX(3),
      XX(44)=XX(43)/XX(42),
      ATRIB(36)=ATRIB(6)*XX(44);
      ASSIGN,XX(45)=ATRIB(6)*XX(3),
      XX(46)=XX(45)-ATRIB(36),
      ATRIB(62)=XX(40)/XX(40);
     ;
     ;        AT(36) IS ANNUAL PAYMENT (A=INTRST+PRINCP.)BXX(46) IS(P*I-A)
     ;
     ;        ******************************************************************
     ;                                      CHECK FOR TYPE OF DEBT
NEXT  GOON,2;
      ACT,,XX(51).EQ.0,DBTB;
      ACT,,XX(51).EQ.1,DBTA;
     ;
     ;        ******************************************************************
     ;                                      WHEN DEBT IS BOND TYPE FIND YRLY INTRST
DBTB  ASSIGN,ATRIB(66)=ATRIB(5)*XX(4),
             ATRIB(67)=ATRIB(5);
      ACT,,,OPER;
     ;
     ;        AT(66) IS THE YEARLY INTEREST FOR THE DEBT
     ;
     ;        ******************************************************************
     ;                                      WHENDEBT IS EQUAL ANNUAL PAYMENT TYPE
     ;                                      FIND THE ANNUAL PAYMENT
DBTA  ASSIGN,XX(49)=XX(4)+1,
```

```
                  ATRIB(7)=0,
                  XX(50)=XX(4)+1;
REDO     ASSIGN,ATRIB(65)=ATRIB(65)+1,
                  XX(50)=XX(50)*XX(49);
         ACT,,ATRIB(65).LT.XX(26),REDO;
         ACT,,ATRIB(65).GE.XX(26),CALC;
CALC     ASSIGN,XX(52)=XX(50)-1,
                  XX(53)=XX(50)*XX(4),
                  XX(54)=XX(53)/XX(52),
                  ATRIB(68)=ATRIB(5)*XX(54);
         ASSIGN,XX(55)=ATRIB(5)*XX(4),
                  XX(56)=XX(55)-ATRIB(68),
                  ATRIB(69)=XX(49)/XX(49);
;
;           AT(68) IS ANNUAL PAYMNT FOR DEBT @INCLUDES INTRST  AND XX(56)=P*I-A
;
;           ***********************************************************************
OPER     ASSIGN,ATRIB(56)=XX(55)-ATRIB(46),
                  ATRIB(57)=ATRIB(56)/ATRIB(55),
                  ATRIB(58)=ATRIB(57)*ATRIB(30);
;
;           AT(58) IS SYD DEPRETIATION
;
         ASSIGN,ATRIB(31)=ATRIB(76)/XX(76),
                  ATRIB(76)=ATRIB(75)-ATRIB(31),
                  XX(76)=XX(75)-1;
         ACT,,XX(76).LE.0.,CRCT;
         ACT,,XX(76).GT.0.,OKEY;
CRCT     ASSIGN,XX(76)=1,
                  XX(33)=0;
;           AT(31) IS THE SLD @AT(76) IS THE BOOK VALUE
;           *****************************************************************
;                                             CHOOSE THE DEPRECIATION  @ ELIMINATE REST
OKEY     ASSIGN,ATRIB(53)=XX(21)*ATRIB(51),
                  ATRIB(53)=ATRIB(53)*XX(33),
                  ATRIB(58)=ATRIB(58)*XX(34),
                  ATRIB(31)=ATRIB(31)*XX(32);
;
;           ***********************************************************************
;                                             FINT INTRST PART OF EQUITY PAYMNT,AT(37)
         ASSIGN,ATRIB(37)=XX(46)*ATRIB(62),
         ATRIB(37)=ATRIB(37)+ATRIB(36),
         XX(47)=ATRIB(36)-ATRIB(37);
;
;           AT(37) IS THE INTERST(I) AND XX(47) IS THE PRINCIPAL (P-I)
;           ***********************************************************************
;                                             FIND INTRST PART OF DEBT PAYMNT,AT(70)
         ASSIGN,ATRIB(70)=XX(56)*ATRIB(69),
                  ATRIB(70)=ATRIB(70)+ATRIB(68),
                  XX(57)=ATRIB(68)-ATRIB(70);
         ASSIGN,ATRIB(34)=ATRIB(34)-ATRIB(31),
                  ATRIB(34)=ATRIB(34)-ATRIB(53),
                  ATRIB(34)=ATRIB(34)-ATRIB(58),
         ATRIB(35)=ATRIB(34)*XX(5);
;
;           XX(57) IS (A-I),THE PTINCP. PAID  FOR DEBT
;
;           ***********************************************************************
;                                             ADD FUEL COST,O@M,PROPERTY TAX AND
;                                             DEPRECITTION  TO FIND TAX DEDUCTABLE
         ASSIGN,ATRIB(40)=ATRIB(24)+ATRIB(25),
         ATRIB(40)=ATRIB(40)+ATRIB(7),
                  ATRIB(40)=ATRIB(40)+ATRIB(70),
         ATRIB(40)=ATRIB(40)+ATRIB(35),
         ATRIB(41)=ATRIB(40)+ATRIB(31),
                  ATRIB(41)=ATRIB(41)+ATRIB(58),
                  ATRIB(41)=ATRIB(41)+ATRIB(53),
         ATRIB(42)=ATRIB(41)*XX(2);
;
;           AT(41) IS TAX DEDUCTABLE @ AT(42) IS THE TAX REVENUE
;
```

```
;          ******************************************************************
;                                         ADD FUEL COST,O&M,PROP.TAX,DEBT INTRST &
;                                         EQUITY RETURN TO FIND THE TOTAL COST AND
;                                         FIND THE AFTER TAX COST
        ASSIGN,ATRIB(40)=ATRIB(40)+ATRIB(10),
        ATRIB(40)=ATRIB(40)+ATRIB(36),
        ATRIB(40)=ATRIB(40)+ATRIB(64),
               ATRIB(40)=ATRIB(40)+XX(57),
        ATRIB(40)=ATRIB(40)-ATRIB(42);
;
;          AT(40) IS THE AFTER TAX COST AT THE END OF EACH YEAR
;
;          ******************************************************************
;                                         BRING THE COST TO TIME '0' AND ACCUMILATE
        ASSIGN,ATRIB(43)=ATRIB(40)/ATRIB(3),
        ATRIB(62)=ATRIB(62)*XX(40),
        ATRIB(69)=ATRIB(69)*XX(49),
        ATRIB(45)=ATRIB(45)+ATRIB(43);
;
;          AT(43) IS THE COST AT YEAR '0' AND AT(45) IS THE CUM.TOTAL COST
;
;          ******************************************************************
;                                         ESCALATE THE FUEL AND O&M COSTS
        ASSIGN,ATRIB(24)=ATRIB(24)*XX(9),
        ATRIB(25)=ATRIB(25)*XX(10),
        ATRIB(26)=ATRIB(26)-ATRIB(36),
               ATRIB(51)=ATRIB(51)*ATRIB(52),
        ATRIB(3)=ATRIB(3)*XX(1);
;
;          AT(3)=(1+I)**N FOR DISCOUNT FACTOR
;
;
;          ******************************************************************
;
;                                         CHECK FOR END OF OPERATION YEARS
        ASSIGN,ATRIB(46)=ATRIB(46)+1 ;
        ACT,,ATRIB(46).LT.XX(26),OPER;
        ACT,,ATRIB(46).GE.XX(26),FINL;
;          ******************************************************************
;
;                                         DEBT MONEY PAID BACK
FINL    ASSIGN,ATRIB(47)=ATRIB(3)/XX(1),
               ATRIB(67)=ATRIB(67)+ATRIB(63),
               ATRIB(67)=ATRIB(67)-XX(25),
               ATRIB(48)=ATRIB(67)/ATRIB(47),
        ATRIB(49)=ATRIB(45)+ATRIB(48),
        ATRIB(50)=ATRIB(49)+ATRIB(16);
;
;          AT(67) IS THE DEBT PRINCP.&AT(63) IS THE EQUITY PRINCP.
;
;          AT(50) IS THE TOTAL COST:OPERATION+CONSTRUCTION
;
;          ******************************************************************
;                                         THIS PART OF THE PROGRAM FINDS THE ANNUAL
;                                         EQUIVALENT COST OF THE PLANT
;
;          ******************************************************************
        ASSIGN,XX(67)=XX(1)-1,
               XX(69)=XX(1);
LAST    ASSIGN,ATRIB(71)=ATRIB(71)+1,
               XX(69)=XX(69)*XX(1);
        ACT,,ATRIB(71).LT.XX(26),LAST;
        ACT,,ATRIB(71).GE.XX(26),EDAM;
EDAM    ASSIGN,XX(70)=XX(67)*XX(69),
        XX(71)=XX(69)-1,
        XX(72)=XX(70)/XX(71),
               ATRIB(75)=XX(72),
               ATRIB(72)=ATRIB(50)*XX(72),
               XX(97)=ATRIB(72);
;
;          AT(72) IS THE ANNUAL EQUIVALENT COST
;
LBL1    QUEUE(1),,,,FINE;
;          ******************************************************************
```

```
;          *********************************************************************
;                            THIS PART OF THE PROGRAM IS FOR THE ALTERNATIVE II
;
       CREATE,1;
       ASSIGN,ATRIB(90)=TVOW;
;
;                            THIS PART GENERATES DATA BY BETA DISTRIBUTION
;    *******************     CONSTRUCTION COST      *****************************
       ASSIGN,ATRIB(1)=XX(174)-XX(173),ATRIB(2)=XX(174)+XX(183),
       ATRIB(3)=XX(173)*2;
       ASSIGN,ATRIB(4)=ATRIB(2)-ATRIB(3),ATRIB(4)=ATRIB(4)*ATRIB(1),
       ATRIB(4)=ATRIB(4)*4 ;
       ASSIGN,ATRIB(5)=XX(174)*XX(174),ATRIB(6)=XX(183)*XX(183),
       ATRIB(6)=ATRIB(5)-ATRIB(6),ATRIB(7)=XX(174)-XX(183);
       ASSIGN,ATRIB(7)=ATRIB(7)*ATRIB(3),ATRIB(7)=ATRIB(6)-ATRIB(7),
       ATRIB(8)=ATRIB(4)/ATRIB(7);
       ASSIGN,ATRIB(9)=XX(173)-XX(183),
       ATRIB(9)=ATRIB(9)/ATRIB(1),ATRIB(10)=ATRIB(8)*ATRIB(9);
       ASSIGN,XX(92)=ATRIB(8),XX(87)=ATRIB(10),
       XX(89)=BETA(XX(92),XX(87),2);
       ASSIGN,XX(81)=XX(183)-XX(174),XX(81)=XX(81)*XX(89),
       XX(121)=XX(81)+XX(174),ATRIB(73)=XX(121)*XX(190);
       ASSIGN,ATRIB(73)=ATRIB(73)*XX(373)  ;
;
;    *******************     FJEL COST              *****************************
       ASSIGN,ATRIB(1)=XX(118)-XX(119),ATRIB(2)=XX(118)+XX(120),
       ATRIB(3)=XX(119)*2;
       ASSIGN,ATRIB(4)=ATRIB(2)-ATRIB(3),ATRIB(4)=ATRIB(4)*ATRIB(1),
       ATRIB(4)=ATRIB(4)*4 ;
       ASSIGN,ATRIB(5)=XX(118)*XX(118),ATRIB(6)=XX(120)*XX(120),
       ATRIB(6)=ATRIB(5)-ATRIB(6),ATRIB(7)=XX(118)-XX(120);
       ASSIGN,ATRIB(7)=ATRIB(7)*ATRIB(3),ATRIB(7)=ATRIB(6)-ATRIB(7),
       ATRIB(8)=ATRIB(4)/ATRIB(7);
       ASSIGN,ATRIB(9)=XX(119)-XX(120),
       ATRIB(9)=ATRIB(9)/ATRIB(1),ATRIB(10)=ATRIB(8)*ATRIB(9);
       ASSIGN,XX(92)=ATRIB(8),XX(87)=ATRIB(10),
       XX(89)=BETA(XX(92),XX(87),2);
       ASSIGN,XX(81)=XX(120)-XX(118),XX(81)=XX(81)*XX(89),
       ATRIB(79)=XX(81)+XX(118);
       ASSIGN,ATRIB(79)=ATRIB(79)*XX(379) ;B
;
;    *******************     O&M COST(FIXED)        *****************************
       ASSIGN,ATRIB(1)=XX(180)-XX(186),ATRIB(2)=XX(180)+XX(188),
       ATRIB(3)=XX(186)*2;
       ASSIGN,ATRIB(4)=ATRIB(2)-ATRIB(3),ATRIB(4)=ATRIB(4)*ATRIB(1),
       ATRIB(4)=ATRIB(4)*4 ;
       ASSIGN,ATRIB(5)=XX(180)*XX(180),ATRIB(6)=XX(188)*XX(188),
       ATRIB(6)=ATRIB(5)-ATRIB(6),ATRIB(7)=XX(180)-XX(188);
       ASSIGN,ATRIB(7)=ATRIB(7)*ATRIB(3),ATRIB(7)=ATRIB(6)-ATRIB(7),
       ATRIB(8)=ATRIB(4)/ATRIB(7);
       ASSIGN,ATRIB(9)=XX(186)-XX(188),
       ATRIB(9)=ATRIB(9)/ATRIB(1),ATRIB(10)=ATRIB(8)*ATRIB(9);
       ASSIGN,XX(92)=ATRIB(8),XX(87)=ATRIB(10),
       XX(89)=BETA(XX(92),XX(87),2);
       ASSIGN,XX(81)=XX(188)-XX(180),XX(81)=XX(81)*XX(89),
       ATRIB(81)=XX(81)+XX(180);
;
       ASSIGN,ATRIB(81)=ATRIB(81)*XX(381) ;
;    *******************     O&M COST(VARBL.)       *****************************
       ASSIGN,ATRIB(1)=XX(128)-XX(129),ATRIB(2)=XX(128)+XX(130),
       ATRIB(3)=XX(129)*2;
       ASSIGN,ATRIB(4)=ATRIB(2)-ATRIB(3),ATRIB(4)=ATRIB(4)*ATRIB(1),
       ATRIB(4)=ATRIB(4)*4 ;
       ASSIGN,ATRIB(5)=XX(128)*XX(128),ATRIB(6)=XX(130)*XX(130),
       ATRIB(6)=ATRIB(5)-ATRIB(6),ATRIB(7)=XX(128)-XX(130);
       ASSIGN,ATRIB(7)=ATRIB(7)*ATRIB(3),ATRIB(7)=ATRIB(6)-ATRIB(7),
       ATRIB(8)=ATRIB(4)/ATRIB(7);
       ASSIGN,ATRIB(9)=XX(129)-XX(130),
       ATRIB(9)=ATRIB(9)/ATRIB(1),ATRIB(10)=ATRIB(8)*ATRIB(9);
       ASSIGN,XX(92)=ATRIB(8),XX(87)=ATRIB(10),
       XX(89)=BETA(XX(92),XX(87),2);
       ASSIGN,XX(81)=XX(130)-XX(128),XX(81)=XX(81)*XX(89),
       ATRIB(82)=XX(81)+XX(128);
       ASSIGN,ATRIB(82)=ATRIB(82)*XX(382) ;
```

```
;
;   ********************     D9M ESC.RATE          ******************************
         ASSIGN,ATRIB(1)=XX(137)-XX(139),ATRIB(2)=XX(137)+XX(124),
         ATRIB(3)=XX(139)*2;
         ASSIGN,ATRIB(4)=ATRIB(2)-ATRIB(3),ATRIB(4)=ATRIB(4)*ATRIB(1),
         ATRIB(4)=ATRIB(4)*4 ;
         ASSIGN,ATRIB(5)=XX(137)*XX(137),ATRIB(6)=XX(124)*XX(124),
         ATRIB(6)=ATRIB(5)-ATRIB(6),ATRIB(7)=XX(137)-XX(124);
         ASSIGN,ATRIB(7)=ATRIB(7)*ATRIB(3),ATRIB(7)=ATRIB(6)-ATRIB(7),
         ATRIB(8)=ATRIB(4)/ATRIB(7);
         ASSIGN,ATRIB(9)=XX(139)-XX(124),
         ATRIB(9)=ATRIB(9)/ATRIB(1),ATRIB(10)=ATRIB(8)*ATRIB(9);
         ASSIGN,XX(92)=ATRIB(8),XX(87)=ATRIB(10),
         XX(89)=BETA(XX(92),XX(87),2);
         ASSIGN,XX(81)=XX(124)-XX(137),XX(81)=XX(81)*XX(89),
         ATRIB(85)=XX(81)+XX(137);
         ASSIGN,ATRIB(85)=ATRIB(85)*XX(385) ;
;
;   ********************     FUEL ESC.RATE         ******************************
         ASSIGN,ATRIB(1)=XX(193)-XX(194),ATRIB(2)=XX(193)+XX(195),
         ATRIB(3)=XX(194)*2;
         ASSIGN,ATRIB(4)=ATRIB(2)-ATRIB(3),ATRIB(4)=ATRIB(4)*ATRIB(1),
         ATRIB(4)=ATRIB(4)*4 ;
         ASSIGN,ATRIB(5)=XX(193)*XX(193),ATRIB(6)=XX(195)*XX(195),
         ATRIB(6)=ATRIB(5)-ATRIB(6),ATRIB(7)=XX(193)-XX(195);
         ASSIGN,ATRIB(7)=ATRIB(7)*ATRIB(3),ATRIB(7)=ATRIB(6)-ATRIB(7),
         ATRIB(8)=ATRIB(4)/ATRIB(7);
         ASSIGN,ATRIB(9)=XX(194)-XX(195),
         ATRIB(9)=ATRIB(9)/ATRIB(1),ATRIB(10)=ATRIB(8)*ATRIB(9);
         ASSIGN,XX(92)=ATRIB(8),XX(87)=ATRIB(10),
         XX(89)=BETA(XX(92),XX(87),2);
         ASSIGN,XX(81)=XX(195)-XX(193),XX(81)=XX(81)*XX(89),
         ATRIB(84)=XX(81)+XX(193) ;
         ASSIGN,ATRIB(84)=ATRIB(84)*XX(384) ;
;
;
         ASSIGN,ATRIB(77)=XX(178),ATRIB(78)=XX(182),XX(122)=ATRIB(77)*ATRIB(78),
         XX(122)=XX(122)*ATRIB(79),XX(122)=XX(122)*8760 ;
         ASSIGN,XX(123)=ATRIB(81)*XX(190),ATRIB(83)=ATRIB(82)*ATRIB(78),
         ATRIB(83)=ATRIB(83)*8760,ATRIB(83)=ATRIB(83)*XX(190),
         XX(123)=ATRIB(83)+XX(123);
         ASSIGN,XX(109)=ATRIB(84)+1,XX(110)=ATRIB(85)+1 ;
         ASSIGN,ATRIB(20)=XX(112),ATRIB(1)=XX(101),ATRIB(61)=1,ATRIB(65)=1,
         ATRIB(71)=1,ATRIB(2)=2;
         ASSIGN,ATRIB(24)=XX(122),ATRIB(24)=ATRIB(24)*XX(109),
         ATRIB(24)=ATRIB(24)*XX(109),ATRIB(25)=XX(123),
         ATRIB(25)=ATRIB(25)*XX(110),ATRIB(25)=ATRIB(25)*XX(110);
         ASSIGN,XX(121)=XX(400)*ATRIB(73),XX(121)=XX(121)+ATRIB(73),
         XX(125)=XX(121)*XX(177);
DET2     ASSIGN,ATRIB(2)=ATRIB(2)+1,ATRIB(3)=XX(101),ATRIB(24)=ATRIB(24)*XX(109),
         ATRIB(25)=ATRIB(25)*XX(110),ATRIB(1)=XX(101)*ATRIB(1);
         ACT,,ATRIB(2).LT.XX(116),DET2;
         ACT,,ATRIB(2).GE.XX(116),BAC2;
BAC2     ASSIGN,ATRIB(4)=XX(121)*ATRIB(20);
         ASSIGN,ATRIB(5)=XX(111)*ATRIB(4),ATRIB(6)=ATRIB(4)-ATRIB(5),
         ATRIB(7)=ATRIB(5)*XX(104),ATRIB(8)=ATRIB(6)*XX(103);
         ASSIGN,ATRIB(9)=ATRIB(4)*XX(106),ATRIB(10)=ATRIB(9)*XX(101),
         ATRIB(11)=ATRIB(4)*XX(105),ATRIB(12)=ATRIB(7)+ATRIB(11);
         ASSIGN,ATRIB(13)=ATRIB(12)*XX(102),ATRIB(14)=ATRIB(8),
         ATRIB(14)=ATRIB(14)+ATRIB(10),ATRIB(14)=ATRIB(14)+ATRIB(12);
         ASSIGN,ATRIB(14)=ATRIB(14)-ATRIB(13),ATRIB(15)=ATRIB(14)*ATRIB(1),
         ATRIB(16)=ATRIB(16)+ATRIB(15),ATRIB(1)=ATRIB(1)/XX(101);
         ASSIGN,ATRIB(17)=ATRIB(17)+1;
         ACT,,ATRIB(17).LT.XX(116),TES2;
         ACT,,ATRIB(17).GE.XX(116),FWR2;
TES2     GOON,8;
         ACT,,ATRIB(17).EQ.1,SUC1;
         ACT,,ATRIB(17).EQ.2,SUC2;
         ACT,,ATRIB(17).EQ.3,SUC3;
         ACT,,ATRIB(17).EQ.4,SJC4;
         ACT,,ATRIB(17).EQ.5,SJC5;
         ACT,,ATRIB(17).EQ.6,SUC6;
         ACT,,ATRIB(17).EQ.7,SUC7;
         ACT,,ATRIB(17).EQ.8,SUC8;
```

```
SUC1   ASSIGN,ATRIB(20)=XX(113);
       ACT,,,BAC2;
SUC2   ASSIGN,ATRIB(20)=XX(114);
       ACT,,,BAC2;
SUC3   ASSIGN,ATRIB(20)=XX(115);
       ACT,,,BAC2;
SUC4   ASSIGN,ATRIB(20)=XX(158);
       ACT,,,BAC2;
SUC5   ASSIGN,ATRIB(20)=XX(159);
       ACT,,,BAC2;
SUC6   ASSIGN,ATRIB(20)=XX(160);
       ACT,,,BAC2;
SUC7   ASSIGN,ATRIB(20)=XX(161);
       ACT,,,BAC2;
SUC8   ASSIGN,ATRIB(20)=XX(162);
       ACT,,,BAC2;
FWR2   ASSIGN,ATRIB(27)=XX(127)*XX(121), ATRIB(16)=ATRIB(16)-ATRIB(27),
       ATRIB(26)=ATRIB(6),ATRIB(34)=XX(121);
       ASSIGN,ATRIB(30)=XX(121)-XX(125),ATRIB(76)=ATRIB(30),XX(176)=XX(166),
       ATRIB(31)=ATRIB(30)/XX(166),ATRIB(51)=XX(135),ATRIB(52)=XX(136)-ATRIB(51);
       ASSIGN,ATRIB(56)=XX(166),ATRIB(54)=XX(166)+XX(136),
       ATRIB(55)=ATRIB(54)*XX(166),ATRIB(55)=ATRIB(55)/2;
       ACT,,XX(148).EQ.0,BET2;
       ACT,,XX(148).EQ.1,ALF2;
BET2   ASSIGN,ATRIB(64)=ATRIB(6)*XX(103),ATRIB(63)=ATRIB(6);
       ACT,,,NEX2;
ALF2   ASSIGN,XX(140)=XX(103)+1,XX(141)=XX(103)+1;
EQI2   ASSIGN,ATRIB(61)=ATRIB(61)+1,XX(141)=XX(141)*XX(140);
       ACT,,ATRIB(61).LT.XX(126),EQI2;
       ACT,,ATRIB(61).GE.XX(126),EQC2;
EQC2   ASSIGN,XX(142)=XX(141)-1,XX(143)=XX(141)*XX(103),
       XX(144)=XX(143)/XX(142),ATRIB(36)=ATRIB(6)*XX(144);
       ASSIGN,XX(145)=ATRIB(6)*XX(103),XX(146)=XX(145)-ATRIB(36),
       ATRIB(62)=XX(140)/XX(140);
NEX2   GOON,2;
       ACT,,XX(151).EQ.0,DBT2;
       ACT,,XX(151).EQ.1,DBT3;
DBT2   ASSIGN,ATRIB(66)=ATRIB(5)*XX(104),ATRIB(67)=ATRIB(5);
       ACT,,,OPE2;
DBT3   ASSIGN,XX(149)=XX(104)+1,ATRIB(7)=0,XX(150)=XX(104)+1;
RED2   ASSIGN,ATRIB(65)=ATRIB(65)+1,XX(150)=XX(150)*XX(149);
       ACT,,ATRIB(65).LT.XX(126),RED2;
       ACT,,ATRIB(65).GE.XX(126),CAL2;
CAL2   ASSIGN,XX(152)=XX(150)-1,XX(153)=XX(150)*XX(104),
       XX(154)=XX(153)/XX(152),ATRIB(68)=ATRIB(5)*XX(154);
       ASSIGN,XX(155)=ATRIB(5)*XX(104),XX(156)=XX(155)-ATRIB(68),
       ATRIB(69)=XX(149)/XX(149);
OPE2   ASSIGN,ATRIB(56)=XX(166)-ATRIB(46),
              ATRIB(57)=ATRIB(56)/ATRIB(55),
              ATRIB(58)=ATRIB(57)*ATRIB(30);
       ASSIGN,ATRIB(31)=ATRIB(76)/XX(176),ATRIB(76)=ATRIB(76)-ATRIB(31),
       XX(176)=XX(176)-1;
       ACT,,XX(176).LE.0.,CRC2;
       ACT,,XX(176).GT.0.,OKE2;
CRC2   ASSIGN,XX(176)=1,XX(133)=0;
OKE2   ASSIGN,ATRIB(53)=XX(121)*ATRIB(51),ATRIB(53)=ATRIB(53)*XX(133),
       ATRIB(58)=ATRIB(58)*XX(134),ATRIB(31)=ATRIB(31)*XX(132);
       ASSIGN,ATRIB(37)=XX(146)*ATRIB(62),ATRIB(37)=ATRIB(37)+ATRIB(36),
       XX(147)=ATRIB(36)-ATRIB(37);
       ASSIGN,ATRIB(70)=XX(156)*ATRIB(69),ATRIB(70)=ATRIB(70)+ATRIB(68),
       XX(157)=ATRIB(68)-ATRIB(70);
       ASSIGN,ATRIB(34)=ATRIB(34)-ATRIB(31),
              ATRIB(34)=ATRIB(34)-ATRIB(53),
              ATRIB(34)=ATRIB(34)-ATRIB(58),
       ATRIB(35)=ATRIB(34)*XX(105);
       ASSIGN,ATRIB(40)=ATRIB(24)+ATRIB(25),
       ATRIB(40)=ATRIB(40)+ATRIB(7),
              ATRIB(40)=ATRIB(40)+ATRIB(70),
       ATRIB(40)=ATRIB(40)+ATRIB(35),
       ATRIB(41)=ATRIB(40)+ATRIB(31),
              ATRIB(41)=ATRIB(41)+ATRIB(58),
              ATRIB(41)=ATRIB(41)+ATRIB(53),
       ATRIB(42)=ATRIB(41)*XX(102);
       ASSIGN,ATRIB(40)=ATRIB(40)+ATRIB(10),
```

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      ATRIB(40)=ATRIB(40)+ATRIB(36),
      ATRIB(40)=ATRIB(40)+ATRIB(64),
      ATRIB(40)=ATRIB(40)+XX(157),ATRIB(40)=ATRIB(40)-ATRIB(42);
      ASSIGN,ATRIB(43)=ATRIB(40)/ATRIB(3),
      ATRIB(62)=ATRIB(62)*XX(140),ATRIB(69)=ATRIB(69)*XX(149),
      ATRIB(45)=ATRIB(45)+ATRIB(43);
      ASSIGN,ATRIB(24)=ATRIB(24)*XX(109),ATRIB(25)=ATRIB(25)*XX(110),
      ATRIB(26)=ATRIB(26)-ATRIB(36),
             ATRIB(51)=ATRIB(51)*ATRIB(52),ATRIB(3)=ATRIB(3)*XX(101);
      ASSIGN,ATRIB(46)=ATRIB(46)+1 ;
      ACT,,ATRIB(46).LT.XX(126),OPE2;
      ACT,,ATRIB(46).GE.XX(126).FIN2;
FIN2  ASSIGN,ATRIB(47)=ATRIB(3)/XX(101),
             ATRIB(67)=ATRIB(67)+ATRIB(63),
      ATRIB(67)=ATRIB(67)-XX(125),ATRIB(48)=ATRIB(67)/ATRIB(47),
      ATRIB(49)=ATRIB(45)+ATRIB(48),
      ATRIB(50)=ATRIB(49)+ATRIB(16);
      ASSIGN,XX(167)=XX(101)-1,XX(169)=XX(101);
LAS2  ASSIGN,ATRIB(71)=ATRIB(71)+1,XX(169)=XX(169)*XX(101);
      ACT,,ATRIB(71).LT.XX(126),LAS2;
      ACT,,ATRIB(71).GE.XX(126),EDA2;
EDA2  ASSIGN,XX(170)=XX(167)*XX(169),XX(171)=XX(169)-1, XX(172)=XX(170)/XX(171),
      ATRIB(75)=XX(172),ATRIB(72)=ATRIB(50)*XX(172),XX(197)=ATRIB(72);
LBL2  QUEUE(2),,,,FINE;
FINE  MATCH,90,LBL1/CLC1,LBL2/CLC2;
;
;        *******************************************************************
;                                     COLLECTION OF DESIRED DATA
;
CLC1  COLCT,XX(97),ANN.EQ.COST1,25,0.20E+09,0.10E+08 ;
      TERM;
CLC2  COLCT,XX(197),ANN.EQ.COST2,30,0.20E+09,0.10E+08;
      ASSIGN,XX(99)=XX(97)-XX(197);
      COLCT,XX(99),DIFFERENCE,50,-0.15E+09,0.6E+7;
;        *******************************************************************
;                                     NUMBER OF OBSERVATIONS DESIRED
      TERM,300;
      ENDNET;
FIN;
```

S L A M   E C H O   R E P O R T

SIMULATION PROJECT EXERCISE   BY MEDI

DATE 1/22/1980   RUN NUMBER 1 OF 1

SLAM VERSION JAN 79

GENERAL OPTIONS

PRINT INPUT STATEMENTS (ILIST):	YES
PRINT ECHO REPORT (IECHO):	YES
EXECUTE SIMULATIONS (IXQT):	YES
PRINT INTERMEDIATE RESULTS HEADING (IPIRH):	YES
PRINT SUMMARY REPORT (ISMRY):	YES

LIMITS ON FILES

MAXIMUM NUMBER OF USER FILES (MFILS):	2
MAXIMUM NUMBER OF USER ATTRIBUTES (MATR):	90
MAXIMUM NUMBER OF CONCURRENT ENTRIES (MNTRY):	200

FILE SUMMARY

FILE NUMBER	INITIAL ENTRIES	RANKING CRITERION
1	0	FIFO
2	0	FIFO

```
STATISTICS BASED ON OBSERVATIONS

     COLCT      COLLECTION     IDENTIFIER          HISTOGRAM SPECIFICATIONS
     NUMBER     MODE                               NCEL      HLOW        HWID

        1       NETWORK        ANN.EQ.COST1          25    0.200E+09   0.100E+09
        2       NETWORK        ANN.EQ.COST2          30    0.200E+09   0.100E+08
        3       NETWORK        DIFFERENCE            50   -0.150E+09   0.600E+07

RANDOM NUMBER STREAMS

     STREAM          SEED      REINITIALIZATION
     NUMBER          VALUE     OF STREAM

        1       1274321477     NO
        2       2135124613     NO
        3       1743251541     NO
        4       1624217675     NO
        5       2014632579     NO
        6       2036774231     NO
        7       1452313571     NO
        8       1254240657     NO
        9       1410143363     NO
       10       2135621895     NO

INITIALIZATION OPTIONS

     BEGINNING TIME OF SIMULATION (TTBEG):   0.0
     ENDING TIME OF SIMULATION (TTFIN):      0.1000E+21
     STATISTICAL ARRAYS CLEARED (JJCLR):       YES
     VARIABLES INITIALIZED (JJVAR):            YES
     FILES INITIALIZED (JJFIL):                YES

NSET/QSET STORAGE ALLOCATION

     DIMENSION OF NSET/QSET (NNSET):           25000
     WORDS ALLOCATED TO FILING SYSTEM:         18800
     WORDS ALLOCATED TO NETWORK:                6010
     WORDS AVAILABLE FOR PLOTS/TABLES:           190

INPUT ERRORS DETECTED:     0

EXECUTION WILL BE ATTEMPTED
                                  **INTERMEDIATE RESULTS**


                                  S L A M   S U M M A R Y   R E P O R T

                        SIMULATION PROJECT EXERCISE               BY MEDI

                        DATE  1/22/1980                           RUN NUMBER     1 OF     1

                        CURRENT TIME   0.2990E+03
                        STATISTICAL ARRAYS CLEARED AT TIME  0.0
```

STATISTICS FOR VARIABLES BASED ON OBSERVATION

	MEAN VALUE	STANDARD DEVIATION	COEFF. OF VARIATION	MINIMUM VALUE	MAXIMUM VALUE	NUMBER OF OBSERVATIONS
ANN.EQ.COST1	0.3057E+09	0.3155E+08	0.1032E+00	0.2334E+09	0.3825E+09	300
ANN.EQ.COST2	0.3200E+09	0.4262E+08	0.1332E+00	0.2283E+09	0.4390E+09	300
DIFFERENCE	-0.1421E+08	0.5178E+08	-0.3645E+01	-0.1705E+09	0.1106E+09	300

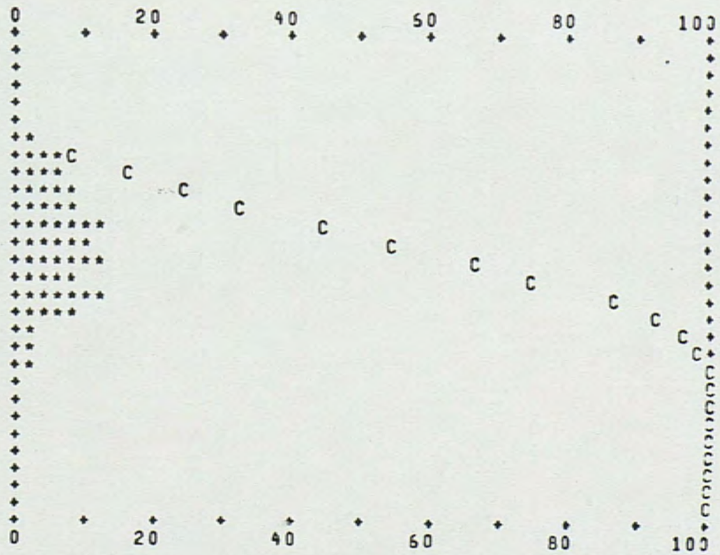
FILE STATISTICS

FILE NUMBER	ASSOCIATED NODE TYPE	AVERAGE LENGTH	STANDARD DEVIATION	MAXIMUM LENGTH	CURRENT LENGTH
1	QUEUE	0.0	0.0	1	0
2	QUEUE	0.0	0.0	1	0
3		2.0000	0.0	4	2

HISTOGRAM NUMBER 1

ANN.EQ.COST1

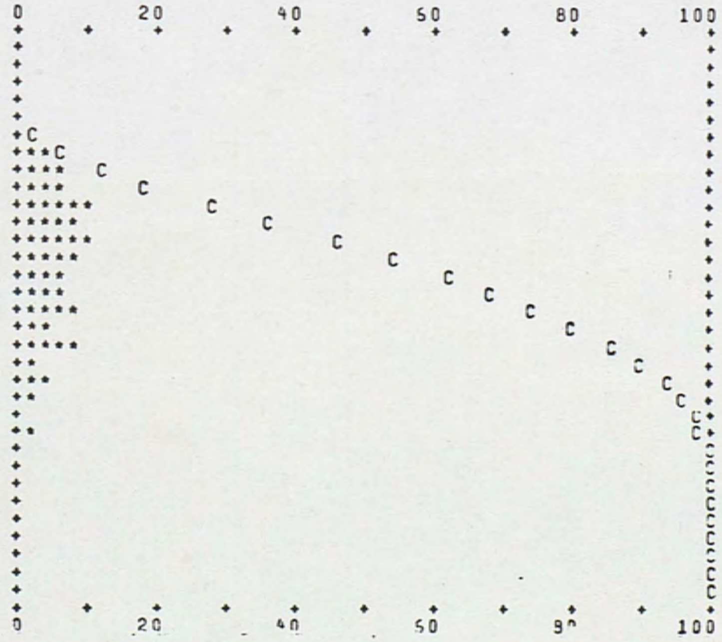
OBSV FREQ	RELA FREQ	CUML FREQ	UPPER CELL LIMIT
0	0.0	0.0	0.2000E+09
0	0.0	0.0	0.2100E+09
0	0.0	0.0	0.2200E+09
0	0.0	0.0	0.2300E+09
2	0.007	0.007	0.2400E+09
5	0.017	0.023	0.2500E+09
20	0.067	0.090	0.2600E+09
20	0.067	0.157	0.2700E+09
23	0.077	0.233	0.2800E+09
25	0.083	0.317	0.2900E+09
39	0.130	0.447	0.3000E+09
29	0.097	0.543	0.3100E+09
34	0.113	0.557	0.3200E+09
26	0.087	0.743	0.3300E+09
34	0.113	0.857	0.3400E+09
22	0.073	0.930	0.3500E+09
8	0.027	0.957	0.3600E+09
7	0.023	0.980	0.3700E+09
5	0.017	0.997	0.3800E+09
1	0.003	1.000	0.3900E+09
0	0.0	1.000	0.4000E+09
0	0.0	1.000	0.4100E+09
0	0.0	1.000	0.4200E+09
0	0.0	1.000	0.4300E+09
0	0.0	1.000	0.4400E+09
0	0.0	1.000	0.4500E+09
0	0.0	1.000	INF
300			



HISTOGRAM NUMBER 2

ANN.EQ.COST2

OBSV FREQ	RELA FREQ	CUML FREQ	UPPER CELL LIMIT
0	0.0	0.0	0.2000E+09
0	0.0	0.0	0.2100E+09
0	0.0	0.0	0.2200E+09
1	0.003	0.003	0.2300E+09
2	0.007	0.010	0.2400E+09
3	0.010	0.020	0.2500E+09
14	0.047	0.067	0.2600E+09
17	0.057	0.123	0.2700E+09
18	0.060	0.183	0.2800E+09
30	0.100	0.283	0.2900E+09
24	0.080	0.363	0.3000E+09
29	0.097	0.460	0.3100E+09
26	0.087	0.547	0.3200E+09
20	0.067	0.613	0.3300E+09
18	0.060	0.673	0.3400E+09
22	0.073	0.747	0.3500E+09
14	0.047	0.793	0.3600E+09
23	0.077	0.870	0.3700E+09
7	0.023	0.893	0.3800E+09
13	0.043	0.937	0.3900E+09
9	0.030	0.967	0.4000E+09
3	0.010	0.977	0.4100E+09
4	0.013	0.990	0.4200E+09
1	0.003	0.993	0.4300E+09
2	0.007	1.000	0.4400E+09
0	0.0	1.000	0.4500E+09
0	0.0	1.000	0.4600E+09
0	0.0	1.000	0.4700E+09
0	0.0	1.000	0.4800E+09
0	0.0	1.000	0.4900E+09
0	0.0	1.000	0.5000E+09
0	0.0	1.000	INF
300			

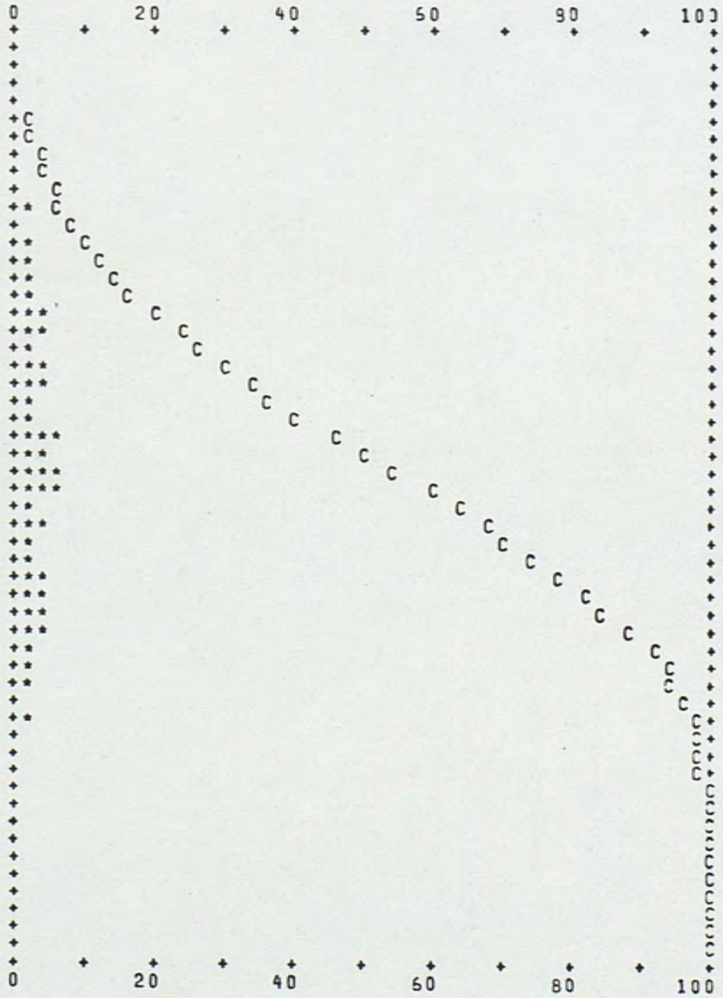


HISTOGRAM NUMBER 3

DIFFERENCE

OBSV FREQ	RELA FREQ	CUML FREQ	UPPER CELL LIMIT
1	0.003	0.003	-0.1500E+09
2	0.007	0.010	-0.1440E+09
0	0.0	0.010	-0.1380E+09
0	0.0	0.010	-0.1320E+09
1	0.003	0.013	-0.1260E+09
3	0.010	0.023	-0.1200E+09
3	0.010	0.033	-0.1140E+09
3	0.010	0.043	-0.1080E+09
3	0.010	0.053	-0.1020E+09
4	0.013	0.067	-0.9600E+08
3	0.010	0.077	-0.9000E+08
7	0.023	0.100	-0.8400E+08
6	0.020	0.120	-0.7800E+08
5	0.017	0.137	-0.7200E+08
8	0.027	0.163	-0.6600E+08
11	0.037	0.200	-0.6000E+08
11	0.037	0.237	-0.5400E+08
8	0.027	0.263	-0.4800E+08
11	0.037	0.300	-0.4200E+08
12	0.040	0.340	-0.3600E+08
9	0.030	0.370	-0.3000E+08
8	0.027	0.397	-0.2400E+08
20	0.067	0.463	-0.1800E+08
10	0.033	0.497	-0.1200E+08
16	0.053	0.550	-0.6000E+07
16	0.053	0.603	0.9300E+02
9	0.030	0.633	0.6000E+07
12	0.040	0.673	0.1200E+08
9	0.030	0.703	0.1800E+08
9	0.030	0.733	0.2400E+08
14	0.047	0.780	0.3000E+08
11	0.037	0.817	0.3600E+08
10	0.033	0.850	0.4200E+08
11	0.037	0.887	0.4800E+08
8	0.027	0.913	0.5400E+08
7	0.023	0.937	0.6000E+08
4	0.013	0.950	0.6600E+08
2	0.007	0.957	0.7200E+08
7	0.023	0.980	0.7800E+08
2	0.007	0.987	0.8400E+08
1	0.003	0.990	0.9000E+08
0	0.0	0.990	0.9600E+08
2	0.007	0.997	0.1020E+09
0	0.0	0.997	0.1080E+09
1	0.003	1.000	0.1140E+09
0	0.0	1.000	0.1200E+09
0	0.0	1.000	0.1260E+09
0	0.0	1.000	0.1320E+09
0	0.0	1.000	0.1380E+09
0	0.0	1.000	0.1440E+09
0	0.0	1.000	0.1500E+09
0	0.0	1.000	INF

300			



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