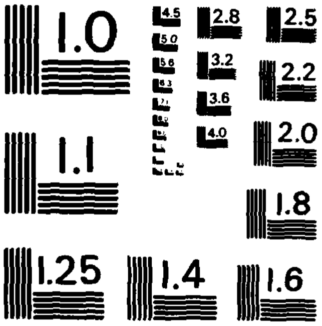
AD-A160 272 COST/BENEFIT ANALYSIS OF THE HEAT RECOVERY INCINERATOR 1/1
(HRI)(U) NAVAL CIVIL ENGINEERING LAB PORT HUENEME CA
R M ROBERTS ET AL. SEP 85 NCEL-TN-1735

UNCLASSIFIED F/G 13/2 NL

END
FILMED
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

(12)

N-1735

NCEL
Technical Note

September 1985
R. M. Roberts & K. T. C. Swanson
Sponsored By Naval Facilities
Engineering Command

AD-A160 272

COST/BENEFIT ANALYSIS OF THE HEAT RECOVERY INCINERATOR (HRI)

This report discusses the sensitivity of heat recovery incinerator (HRI) cost/benefits to various techno-economic parameters associated with the HRI computer model. These sensitivity data are presented in a form to aid in the conceptual design of the optimum HRI facility for a given Navy activity. The following techno-economic parameters are listed in order of their expected importance, considering both variance and sensitivity, to cost/benefit criteria of the HRI computer model: solid waste heating value, boiler thermal efficiency, energy inflation rate with respect to general inflation, cost of conventionally generated steam, solid waste disposal cost, differential landfill inflation of disposal cost, capital cost, and ratio of ash to waste input. Naval Facilities Engineering Command policy regarding HRI construction at Navy activities is to seek alternative waste management opportunities such as the use of nearby resource recovery facilities that have been financed and erected by private operators or civic entities.

DTIC FILE COPY

DTIC
ELECTE
OCT 1 6 1985
S D
E

NAVAL CIVIL ENGINEERING LABORATORY PORT HUENEME CALIFORNIA 93043

Approved for public release; distribution unlimited.

85 10 11 016

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

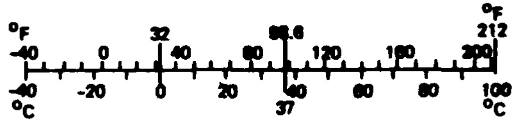
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2,000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

---

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1,000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1 REPORT NUMBER TN-1735	2 GOVT ACCESSION NO. DN787114	3 RECIPIENT'S CATALOG NUMBER AD-A160272
4 TITLE (and Subtitle) COST/BENEFIT ANALYSIS OF THE HEAT RECOVERY INCINERATOR (HRI)		5 TYPE OF REPORT & PERIOD COVERED Final; Jun 1984 - Feb 1985
		6 PERFORMING ORG REPORT NUMBER
7 AUTHOR(s) R. M. Roberts and K. T. C. Swanson		8 CONTRACT OR GRANT NUMBER(s)
9 PERFORMING ORGANIZATION NAME AND ADDRESS NAVAL CIVIL ENGINEERING LABORATORY Port Hueneme, CA 93043		10 PROGRAM ELEMENT PROJECT, TASK AREA & WORK UNIT NUMBERS 64710N; YO817-004-01-213 ZO371-01-421A/B
11 CONTROLLING OFFICE NAME AND ADDRESS NAVAL FACILITIES ENGINEERING COMMAND Alexandria, VA 22332		12 REPORT DATE September 1985
		13 NUMBER OF PAGES 75
14 MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15 SECURITY CLASS (of this report) Unclassified
		15a DECLASSIFICATION DOWNGRADING SCHEDULE

16 DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution is unlimited.

17 DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18 SUPPLEMENTARY NOTES

19 KEY WORDS (Continue on reverse side if necessary and identify by block number)

Energy conservation, heat recovery incinerator, solid waste, waste-to-energy, HRI economic factors, computer model.

20 ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report discusses the sensitivity of heat recovery incinerator (HRI) cost/benefits to various techno-economic parameters associated with the HRI computer model. These sensitivity data are presented in a form to aid in the conceptual design of the optimum HRI facility for a given Navy activity. The following techno-economic parameters are listed in order of their expected importance, considering both variance and sensitivity, to cost/benefit criteria of the HRI computer model: solid waste heating value, boiler thermal efficiency,

20. Continued

energy inflation rate with respect to general inflation, cost of conventionally generated steam, solid waste disposal cost, differential landfill inflation of disposal cost, capital cost, and ratio of ash to waste input. Naval Facilities Engineering Command policy regarding HRI construction at Navy activities is to seek alternative waste management opportunities such as the use of nearby resource recovery facilities that have been financed and erected by private operators or civic entities.

DTIC
COPY
INSPECTED

Library Card

Naval Civil Engineering Laboratory
COST/BENEFIT ANALYSIS OF THE HEAT RECOVERY INCINERATOR (HRI) (Final), by R. M. Roberts and K. T. C. Swanson
TN-1735 75 pp illus September 1985 Unclassified

1. Energy conservation 2. Heat recovery incinerator I. YO817-004-01-213

This report discusses the sensitivity of heat recovery incinerator (HRI) cost/benefits to various techno-economic parameters associated with the HRI computer model. These sensitivity data are presented in a form to aid in the conceptual design of the optimum HRI facility for a given Navy activity. The following techno-economic paratmeters are listed in order of their expected importance, considering both variance and sensitivity, to cost/benefit criteria of the HRI computer model: solid waste heating value, boiler thermal efficiency, energy inflation rate with respect to general inflation, cost of conventionally generated steam, solid waste disposal cost, differential landfill inflation of disposal cost, capital cost, and ratio of ash to waste input. Naval Facilities Engineering Command policy regarding HRI construction at Navy activities is to seek alternative waste management opportunities such as the use of nearby resource recovery facilities that have been financed and erected by private operators or civic entities.

CONTENTS

APPENDIXES

INTRODUCTION

The Naval Facilities Engineering Command (NAVFAC) has tasked the Naval Civil Engineering Laboratory (NCEL) to evaluate the heat recovery incinerator (HRI) technology for application to Navy shore activities. NCEL has developed criteria to be used as guidance in determining whether a Navy activity can benefit economically from the use of an HRI in disposing of solid wastes. These decision criteria have been incorporated into a publication titled "Heat Recovery Incinerator (HRI) Application Guide" (Ref 1).

The HRI model was one of the tools developed by NCEL to facilitate the use of the HRI Application Guide. The model determines the economic liability or profitability of conceptual candidate HRI plant designs for a given Navy activity. The model also dimensions the influence of the various techno-economic factors on the cost/benefit results for the conceptual HRI facility when it is operational. This analysis will be used in the decision-to-construct process.

This report presents data on the correlations (and their sensitivities) that exist between the major design techno-economic parameters and a conceptual plant's economic viability. These data result from systematic exercising of the model. These sensitivity data are presented so that, in conceptually designing the optimum candidate HRI facility sought for a given Navy activity, the responsible design engineer will fully appreciate and take advantage of the way individual techno-economic factors impact the ultimate cost/benefit pay-offs. In this way, the ultimate decision to construct or abandon an HRI project will be made only after faulty system designs have been identified and corrected. Some Navy HRI projects have been approved and others rejected on the basis of questionable system designs. The study reported here provides a more logical and consistent approach.

BACKGROUND

The HRI Application Guide was specifically developed to provide a logical approach whether to install an HRI plant. The HRI Application Guide tells the user how to proceed systematically through a diagrammed decision matrix wherein data requirements that must be input for the decision process are developed at three progressively refined levels of iteration. In this data development and analysis process, the HRI Model is a tool that serves to determine as to whether a conceptual HRI candidate project would be cost beneficial relative to the processes already in place for waste disposal and steam generation.

Use of the HRI Model on a microcomputer is explained in the NCEL terminal-handbook, "User's Manual for the Heat Recovery Incinerator (HRI) Model" (Ref 2). The model assumes that solid waste is disposed of in a landfill and that some kind of fossil fuel is being burned to generate steam for use at the Navy activity; either of these processes may be internal or contracted services. The model does not consider the HRI as being coupled to a turboelectric generator since, in order to be cost effective, the solid waste throughput would have to be considerably more than the typical large Navy activity generates. The model also assumes that the HRI has been selected for the primary function of disposing of sorted (possibly) but otherwise unprocessed solid waste (although cofiring of other waste and conventional fuels is permitted) and not as a system that has been designed primarily for fossil fuel firing with a secondary capability of firing specially prepared refuse derived fuels (RDF). Although not considered here, the latter scenario is now being studied at NCEL and should later lead to documentationt to: (1) identify any Navy-qualifiable RDF materials that are found to be reasonably marketable, and (2) define optimum usage of such materials in existing Navy boilers or in multiple-fuel-capable boiler designs now being considered by the Navy for future construction.

The various terms used in this report are defined in Appendix A. The techno-economic inputs called by the model will be discussed in some detail later but for immediate reference purposes are shown in Appendix B. The information format used in Appendix B actually comprises the input data screens presented to the user by the program. It can be seen in Appendix B that consideration is given to every aspect of facility design, construction, operation, reliability/availability/maintenance (RAM), and financing. As pointed out later, the values appearing on the screens are considered to be about what are average for an HRI plant installed at an average sized, typical Navy activity.

The outputs of the model are all tabulated on a single sheet, titled "The HRI Cost and Performance Report." This is presented as the last page of Appendix B. The program generates six categories of information, all of which are important to consider in deciding whether to install an HRI or to stay with the status quo. In the first category, the life cycle cost of the proposed system is computed by combining user inputs for the cost of capital, operation and maintenance, and system downtime due to failures. This cost is then compared to the sum of the costs of (1) using a conventional fossil fuel fired steam generator to produce the equivalent steam energy output for the HRI life cycle, and (2) disposal at a landfill of the solid waste that would be eliminated by operating the HRI.

The second category of model output information is the amount of limited-resource, prime (not reclaimed) fuel, such as petroleum fuels and natural gas, that is saved annually, as barrels of oil equivalent (BOE), by firing solid and possibly other wastes.

A third output category addressed by the model is the landfill capacity that is annually conserved by using the HRI. Because no practical disposal technique can completely eliminate the need for some landfill availability, conservation of landfills through maximum reduction of the waste volume is often economically important in the long term. However, if there are ample nearby landfill sites, an HRI project probably cannot be justified from the start.

This report also includes as a fourth category of information-output: the discounted life cycle costs and savings provided by the modelled HRI per ton of solid waste fired and per million Btus of steam generated. These data are very useful in making comparisons with other systems whether their function is basically one of waste disposal or of energy generation or both.

The two final output categories of the model are by far the most important. These are: Savings-to-Investment Ratio (SIR) and the HRI total payback period (including project lead-time). These, of course, are ultimate considerations in driving the decision process to the proper conclusion. Additionally, 13 other figures of merit are generated as outputs by the model that can be categorized together with one or the other of these two key parameters.

In the section following, the software of the HRI model is briefly described and introduced for optional study as an appendix. In the subsequent section of this report, the results of the sensitivity analyses performed are presented. The empirical functions describing the relationships of the techno-economic input variables with respect to selected parameters from each of the six output categories just discussed are tabulated and graphically presented. Comments on the significance of these operators in considering preliminary plant designs, operating cycles, and future changes in disposal practices are included in the discussion.

THE HRI MODEL SOFTWARE

The computer program of the HRI model is listed in Appendix C. The language is BASIC and is assembled for use in CP/M mode on a floppy disk microcomputer equipped with two disk drives. The software was developed on an Apple II computer and has been debugged and extensively exercised on the same type microcomputer.

The costing practices observed in the development of the HRI Model software are in conformity with NAVFAC P-442 (Ref 3). A possible exception is the specification of a 15-year life expectancy for the HRI plant, but this is only provided as a default value. The user is free to input any project lifespan he wishes, including the 25-year facility life specified in P-442 for conventionally fueled steam generators.

The mathematical subroutines effected by the HRI Model in achieving output results are explained in Reference 2. Appendix C may be consulted if a more detailed study of the techno-economic functions is desired.

THE HRI BASE CASE EXERCISED IN THE ANALYSIS

In order to evaluate the interrelationships of the input/output (I/O) model parameters, it was necessary to select some base case to represent the typical HRI plant that would fit the requirements of the average Navy activity. The accuracy of the definition of this base case is actually not critically important since small deviations from true average values do not significantly affect the comparative relationships (functions) of the I/O parameters with respect to each other but only offset to some varying degree the relative scaling of each. If these deviations from true averages assume larger proportions, then the parametric relationship can be affected, but only if the functions are nonlinear.

The values assigned for the model case are shown on the HRI Model input screens which, as mentioned earlier, are tabulated herein as Appendix B. A brief explanation of the use of the input data follows.

Screen 1--The inputs for current month and year represent the actual time the analysis is performed. Inflation rates are specified and reflect any differential rates that may operate between the factors considered in the analysis. Inflation rates are applied to the variously dated input costs until initial funding occurs when standard NAVFAC P-442 discounting is observed. Project lead time allows for distribution and discounting of the involved costs over the project lead time period. The economic life of the HRI is its expected term of beneficial occupancy. As noted earlier, this has been set at 15 years rather than the 25-year period specified for steam generators in NAVFAC P-442 because of the more deleterious stoking/combustion conditions that HRIs experience in comparison to fossil fuel fired boilers.

Screen 2--Capital costs shown on this screen are dated and broken down into discrete categories. This is an optional journal procedure since line item entrees are ignored by the model in favor of subtotals. Similarly, subtotals are ignored if an entry for Total Capital Costs is made at the top of Screen 3. Thus, in Appendix B the subtotals are entered while the line items are not journalized.

Screen 3--In addition to total capital costs, allowances are made for expected major modifications of the plant. These can be dated up through the entire economic life of the plant and will be accordingly discounted. The type of modifications can include both augmentative and restorative operations, for example, plant expansion through the addition of a new boiler or installation of new refractory in the HRIs, respectively.

Screen 4--Manpower requirements are broken down into operation and preventive/corrective maintenance. Wage rates are burdened to allow for fringe benefits and acceleration, which amounts to about 40% incrementation of pay scale. Full burdening as done at NIFI activities is not considered applicable since the inputs to the model itself consider the overhead charges normally going onto NIFI burdens. Assignment of operational personnel to maintenance procedures during outages is taken into account. The assumption is that the balance, if any, of their time will be reassigned to other duties and will not be assessed against HRI O&M.

Screen 5--Cost of consumables includes all requirements for the plant. Power consumption takes into account the plant mode of operation. Fuel usage, for auxiliary firing and operation of ancillary equipment such as front-end loaders, is broken down into "virgin" and other fuels. The former type fuels are those that the Navy seeks reduced usage of (fuel oils and natural gas), while the "other" category includes fuels that offset the virgin fuels and can include waste fuels (e.g., JP fuels rejected as being out of specification), other solid waste fuels (bagasse, wood chips, etc.) and fossil fuels that are domestically in potential long supply, such as coal, peat, shale oil, and the various coal derived fuels.

Screen 6--In addition to several more maintenance cost factors, costs are given for solid waste disposal. These costs are broken down into the three categories of waste that the HRI is involved with, which include nonburnable waste, ash, and as-received material. Disposal costs for the latter represent a saving when the HRI is operating but become a debit if the HRI is down and must divert waste.

Screen 7--Other costs are special entries that can include capital (C), energy (E), landfill (L), or other (O) costs. These may be input as fixed or conditional modifications after a model case has been developed. For the present exercise, Screen 7 was not used.

Screen 8--Many of the key design and operational factors are input to this screen and are largely self-explanatory. A possible exception is the specification of furnace type (refractory or water walled). This input implements a procedure for correcting for the differences in wall heat losses of the two furnace types when shut down during scheduled or unanticipated outages. Also the mathematical application of estimated maximum HRI downtime may not be obvious. The distribution of HRI downtimes is assumed to be log-normal and the user's estimate of the maximum duration of downtime is required to scale that function.

THE ANALYTICAL APPROACH

This section describes the approach used to determine how the various operating and cost factors (input parameters to the HRI model) affect the cost benefits of an HRI plant. The HRI cost benefit analysis program described above is essentially intended for the analysis of a specific HRI installation, which some user or user's consultant has developed as being appropriate to his particular activity. On the present undertaking, the specific conceptual HRI plant usually input to the model was replaced with the base case HRI. The program was then repetitively run with the selected parameters being varied over predetermined ranges at arbitrarily fixed intervals.

The summary report sheets obtained from these exercises were then plotted using the Tektronix 4052 ADP plotting system. Empirical equations were generated by polynomial regression by the same computer/plotter for each of the curves generated. These expressions were abbreviated to eliminate inconsequential terms and are tabulated here as Appendix D. These equations may be used to predict the behavior of the particular variable beyond the range examined in this study. The user should, however, be aware of the possibility of incurring significant error when empirical equations are exercised outside of the range in which they were developed.

The input data for the base HRI case were derived from existing HRI facilities costs and construction and operating conditions (e.g., Ref 4) and provide a reasonable reference point from which to execute variations in the input parameters. The independent variables were usually operated over rather broad ranges, ones that would not likely be exceeded in actual engineering practice. In most cases, the range of variation has been arbitrarily assigned and generally is not more then 50% above or below the base case value.

The independent variables that are discussed in this section have been divided into the following four groups: (1) costs, (2) inflation rates, (3) plant performance, and (4) other design criteria. Each group is individually discussed, with particular emphasis being given the comparative impact on cost benefits each of the group members was found to exhibit.

HRI COSTS

The first group of independent variables comprises cost parameters which include: capital costs, disposal costs, and cost of producing steam from an existing fossil fuel boiler.

HRI Capital Costs

Heat recovery incinerator capital costs refer to the total equipment and construction expenses for erecting an HRI plant. In addition to entering the capital cost figures, the year in which the money is anticipated to be spent must also be entered into the computer model, since inflation factors need to be applied to such costs.

Capital costs are a major fraction of the total investment cost of an HRI facility. As shown in Figures 1 and 2, the discounted life cycle cost (LCC), discounted life cycle savings (LCS), and payback period (the number of years required for the savings to equal the costs) all vary linearly with varying capital costs. The savings-to-investment ratio (SIR) decreases exponentially with increasing capital cost, approximated by a second order function. Because the rate of change for a second order curve is dependent on the specific location of the point on the plot, the accuracy of the capital cost value used is important in estimating its effect on SIR (unlike LCC, LCS, or payback period). While the data used are indeed of reasonable accuracy, the variations are essentially manipulations that would not likely occur within a population of properly designed HRI plants. The competitive bidding process would likely ensure that the average (stabilized) dollar cost for a given HRI purchase specification package would not vary greatly from one CONUS activity to another. The key lesson that is to be learned from Figures 1 and 2 is that designers should avoid frills, excessive redundancy, overdesigned components, and other liberalities that can drive capital costs up and render the resultant facility cost-ineffective.

Solid Waste Disposal Costs

In contrast to the somewhat artificial variation in capital costs practiced above, a variation in disposal costs is a very real and expectable thing. The scale range used ($0-50) is not heavily exaggerated, since costs of landfill disposal may soon approach the $50/ton level in certain parts of the country. Landfill disposal costs are, in fact, one of the principal factors incentivizing solid waste managers towards the construction of waste-to-energy plants.

Fortunately, however, the sensitivity of payback and SIR to variations in disposal costs is not as acute as it is to capital costs. This is apparent from Figures 1 and 2. This is, of course, due to the predominant role capital costs play in the initial (lead time) investment term, which is the denominator in both of the above expressions. In contrast, LCC and LCS are more profoundly influenced by disposal costs (see Figure 2), since these cost benefit terms deal only with the discounted costs and savings which are accrued over the entire economic life of the plant.

The fact that the difference between LCS and LCC does not appear to change over the range of disposal costs observed merely results from the fact that disposal costs for ash, oversized, and noncombustibles are also increasing, assumedly at the same rate as the regular disposal costs. Since the solid wastes emanating from the HRI are a fixed fraction of what is received, the slopes of the LCS and LCC curves should thus be the same, if all other factors remain the same. It will be noted that the difference in LCC and LCS is less than the capital cost of the base case; this does not mean, however, that the plant will be unprofitable. The capital cost is not a discounted value and cannot therefore be directly compared. The magnitude of the difference does, however, point up the justification for recovering energy in the process of reducing disposal volume.

Cost of Producing Steam From an Existing Fossil Fuel Boiler

Another cost that is an input parameter to the HRI model is that for operating a pre-existing fossil fuel boiler to provide the same amount of steam energy that would result from the operation (zero downtime) of the HRI design selected for input to the model. The input includes the cost of steam produced by the fossil fuel boiler in units of dollars per million British thermal units (MBtu), and the year for which this cost was derived. This implies that the user knows what he is paying for steam, a cost easily determined only if the steam is bought from the outside. If it is produced by the PWD utility division, the cost will not be so easily fixed, since typically only fuel costs, unburdened operating labor costs, and repair bills are recorded. Some activities do maintain comprehensive steam cost data that include life cycle costs of plant, maintenance labor, labor burden, and many other cost items. Based on such data, the standard case value entered in the model was $9/MBtu and was varied ±33% in the HRI study.

Given a competitively acquired and efficiently run fossil-fuel boiler plant that exhibits a RAM reasonably near the median, the principal operator that will impact steam cost is the cost of fuel. This, of course, is volatile enough that one could expect a range of variation in steam costs of the magnitude employed here. Thus, as one examines the strong reactions of the dependent cost/benefit parameters to fossil-fuel-based steam costs, one can essentially predict how the attractiveness of an HRI steam plant will be enhanced as fuel costs rise.

The behavior of the four dependent cost variables to fossil-fuel-based steam is shown in Figures 3 and 4. As could be expected, the HRI LC Savings (Figure 3) are dramatically influenced by changes in costs of conventionally generated steam. This is because HRI LC Savings are derived from energy, waste disposal, and other savings. The energy term, which contains the cost of steam conventionally generated and HRI total energy costs, is a dominant factor. Thus, the attractiveness of the HRI investment will hinge critically on what an activity is already paying to generate steam. A well-managed, coal-fired plant will likely prove hard competition, thus making the other HRI LC Savings factors (e.g., high solid waste disposal costs) prime movers in the decision-to-construct process.

Discounted Life Cycle Cost of the HRI proves much less sensitive (Figure 3) to cost of conventionally generated steam. This is because the steam term only enters the comprehensive cost-of-doing-business expression in the downtime cost. Thus, a 33% increase in cost of conventionally generated steam increases the HRI LC Cost by less than 7%. A similar situation is obtained when looking at SIR (Figure 4). Here, the HRI LC savings are essentially compared to inflation-normalized capital and engineering costs. Because the former term is dominated by the cost of conventionally generated steam and the HRI, in a right fit situation, is apparently an attractive investment otherwise, the SIR shows a strong response to steam cost variation. A 33% increase in the cost of generating steam from fossil fuel at a Navy activity will result in a 30% increase in the SIR for the modeled HRI plant displacing some of that production. The payback period is arithmetically more complicated than SIR even though the same economic expressions are involved. The discounting process exponentiates the function, giving the result shown in Figure 4. Here a 33% increase in conventional steam cost will decrease payback period by only about 10%, while a like steam cost decrease results in a 23% increase in payback time. Because of this peculiar sensitivity and the earlier mentioned dominance of fuel cost on the cost of generating steam with fossil fuels, investment in an HRI must involve a hard look at probable future trends in fuel costs.

COST OF MONEY

In the foregoing discussion, the sensitivity of HRI costs normalized for inflation was discussed. In this subsection, the influence of inflation rates themselves is considered. Because the impact of inflation on capital and engineering costs is well known, project lead times are typically held to a minimum. What is often not considered is the effect on costs that differences in inflation rates between commodities have. Such differences are particularly noteworthy in the case of fossil fuel and solid waste disposal costs and can influence the cost/benefits of a project over its entire economic life.

In the present model, inflation rates allow for both a differential energy inflation rate and differential landfill inflation rate. These differential inflation rates allow the user to inflate energy or landfill costs at a higher rate than general inflation that is applied to the balance of the HRI cost components. Based on trends that operated at the time (but which today may well no longer apply), the two differential inflation rates were set at twice that of the general rate of inflation, which was taken to be 5%. These energy and disposal cost inflation rates, each thus set at 10%, were actually considerably less than what prevailed a few years ago.

Energy Cost Inflation

The differential energy inflation rate affects both the cost of operating the fossil-fuel fired steam generator with which the HRI is compared and the various quantities (sometimes none) of auxiliary fuel burned during start-up and, perhaps, routine operation of the HRI. For the present analysis, variation of energy inflation rate about the default value of 10% was not attempted because a stabilization of fuel costs had occurred after the default value was set. The variation applied, therefore, was to start the range at the general inflation rate of 5% and then increase it 10 percentage points above that to 15%. Thus, the inflation rate of 10% for energy and landfill disposal costs used in the standard case locates midpoint in the differential range. The results are shown in Figures 5 and 6.

It can be seen that the HRI Life Cycle Savings (LCS) increase dramatically with energy inflation rate while the increases in HRI Life Cycle Cost (LCC), while much less, are nonetheless at about the same rate as the energy inflation rate. The results are entirely analogous with those obtained when steam costs are varied. HRI LCS derive from conventional energy, landfill disposal, and "other" costs savings. Energy dominates in this relationship and the cost of fuel dominates energy costs such that inflation of energy costs (through fuel price increases) results in a skyrocketing appeal developing for the waste-to-energy concept.

Landfill Disposal Cost Inflation

The economic impact of the landfill disposal cost inflation rate is similar in principal with that of energy costs but not as potent. For example, as energy cost inflation increases above general inflation from 0 to 10 percentage points, HRI LCS increases 197% while the same parameter is increased by "only" 30% when solid waste disposal costs are increased by the same amount. This is consistent with the analysis discussed earlier concerning Figures 1 and 2 where it was found that the relative (no inflation) cost of solid waste disposal did have a modest impact on cost/benefit parameters.

PLANT PERFORMANCE

Plant performance, which is the third group of independent variables to which cost/benefit parameters are sensitive, includes the following factors: (1) thermal efficiency, (2) ratio of wet ash to solid waste input, and (3) operating scenario.

Thermal Efficiency

As used in the model, thermal efficiency is simply expressed as the ratio of the design rates of steam energy output to thermal energy available from the combustion of the solid waste and any auxiliary fuel. The HRI thermal efficiency proved to be one of the more potent input parameters, with only capital cost and conventional steam costs exhibiting a greater influence on cost/benefit parameters. The potency of this parameter results from the direct relationship of efficiency to the savings of producing steam conventionally. Discounted LCC, LCS, payback period, and SIR are plotted against thermal efficiency (Figures 7 and 8) as it is varied from 40 to 70%. This range is somewhat improbable on the low end, in a Navy context at least, but achievable at the high end. Refractory furnace HRI's equipped with waste heat boilers typically furnish efficiencies between 55 and 65%. Water wall units, which are intrinsically less susceptible to wall heat losses, provide efficiencies in the range of 60 to 70%.

Because of the direct relationship with offset conventional steam production, the LCS for response to efficiency improvement is impressive. The LCS increases 65% as the efficiency is increased 30% relative from the selected minimum of 40%. Definite benefits, although not as arithmetically prominent, are also seen in the LCC, SIR, and payback period. The obvious lesson presented by these data is that boiler efficiency should not be merely regarded as a casual system characteristic, that a premium should be placed on high, sustainable boiler efficiency, and that guarantees for boiler efficiency must be secured.

Ash Outhaul/Disposal Rate

Another factor that is a measure of plant performance is the tons of wet ash produced per ton of solid waste input. This output-to-input ratio provides the basis for quantifying the amount of ash that must be "landfilled" - hauled to a landfill. Typical output-to-input ratios resulting from the reduction of waste weight range from 0.2 to 0.6, depending on the degree of fuel burnout and the moisture content of the ash, which is wetted by an appropriate means. Either end of this range is attainable by the various ash handling processes that are available. Because of the relationship of ash disposal to solid waste disposal, which has been shown earlier to have only a modest effect on the cost/benefit parameters, variation of the ratio also has minor impact, assuming that the cost of disposal for ash is the same as that for solid waste.

Figures 7 and 8 illustrate the performance of LCC, LCS, payback period, and SIR versus the ratio of wet ash output to solid waste input. These data were generated, however, with the assumption that ash can be landfilled at the same cost as ordinary refuse. Present environmental law on this is not clear and local regulations may differ considerably. If ash is not permitted to be disposed of in a Class 2 landfill and a hazardous dump must be used, the unit disposal cost could be two to five times higher, depending on location. The data shown, therefore, are for a best case situation. In this case, the data would suggest to the potential HRI plant operator that ash disposal costs are not important factors in the choice between wet or dry ash handling systems. This conclusion should be avoided until after specific ash disposal requirements have been established. The model, incidentally, segregates costs of disposing of oversized reject, ash, and unprocessed refuse so that the model user can study the economic impact of having to haul these various forms of waste to different types of dumps.

Operating Scenario

This phrase refers to the number of hours per day and days per week the HRI facility is scheduled to operate. The HRI model provides the user with five operating scenarios with which the user may match his own planned operating schedule. The purpose of inputting this information is to calculate the boiler reheat losses associated with scheduled downtime under the different shift arrangements. It is assumed that when the capital costs for the plant were arrived at, the sizing of the plant was already based on the operating scenario selected. Thus, the model cannot be used to determine the comparative attributes (other than heat loss) of the various scenarios.

In the standard case (Option 2 in the HRI model), the operation was based on working three 8-hour shifts a day (24 hours), 5 days per week. The other four options include burning two shifts, 5 or 7 days per week or three shifts, 7 or 4 days per week (following receipt of 1 day's refuse collection). Other operating scenarios are employed in the trade but are rather uncommon.

While the model cannot determine the comparative attributes of the various operating scenarios given a fixed set of operational requirements, it can be used to consider the cost benefits available if it is decided to expand the throughput of an existing HRI. If an operator is somehow confronted with an increased load of solid waste to dispose of and the activity can utilize the additional steam generated, the operator may opt to change the operating scenario rather than seek funding for the erection of new facilities. The model can then demonstrate the benefits available from these scenario changes. This can be done for any incremental increase in refuse input. In the present study, however, the standard case only was exercised, thus fixing the firing rate. That is, the standard case requires a refuse input rate of 250 tons/wk; therefore, a shift to 7-day continuous firing would require inputting 350 tons/wk.

Given the operating assumptions just stated, the SIR and payback period behave in relation to the five operating scenarios as seen in Figures 9 and 10. As expected, the results indicate that the total duty time is almost directly proportional to the cost benefits realized.

OTHER ECONOMIC FACTORS

The fourth and final group of economic factors includes: (1) solid waste heating value, (2) plant economic life, and (3) discount rate.

Solid Waste Heating Value

The calorific value of the fuel is expressed as the higher heating value (HHV) and will vary considerably depending on the composition of the solid waste. A probable HHV range for randomly sampled, unprocessed Navy solid waste would be between 3,500 and 6,500 Btu/lb. Besides geographic peculiarities, considerable fluctuation in the composition and, thus, the HHV of Navy activity solid waste can be expected from seasonal and even diurnal factors, as well as from the exercise of the activity's mission (e.g., variation in ship berthings). Nonetheless, the annual average HHV for a given Navy activity, if determined in accordance with Reference 1, should prove fairly reliable for HRI design purposes. What this value turns out to be, however, can be significantly influenced by the resource recovery policies in practice at the given activity. Source separation of refuse components, such as boxboard, aluminum cans, bottles, garbage, etc., can have a significant effect on heating value.

Changes in solid waste management practices or any other factors that affect the annual average HHV of solid waste will have a pronounced effect on the economics of an HRI facility. This sensitivity results simply from the HHV's direct relationship to the quantity of steam generated from a given amount of solid waste. Shown on Figures 11 and 12 are the LCC, LCS, payback period, and SIR versus Btu per pound of solid waste input. The HHV range plotted has been limited to between 4,000 and 6,000 Btu/lb, since the annual average range will be much narrower than the range for randomly sampled values mentioned above.

It can be seen that the LCS and SIR increase at almost the same rate as HHV. LCC is much less influenced since HHV enters the HRI cost base only when downtime costs are computed. The richer the waste fuel, the more energy that must be generated by a standby fossil-fuel-fired boiler per unit of downtime. The lesson available from these data is that some caution should be exercised in resource recovery if an HRI is to be operated. Source removal of valuable inerts (aluminum and glass containers, nonferrous junk, etc.) beneficiates the fuel and is certainly commendable if the separation process otherwise pays for itself. Removal of combustible fractions, such as IBM cards, boxboard, newspapers, etc., is another matter and should be given some thought. Boxboard now sells for about $80/ton if you can find a nearby salvor. For steam production, however, it will produce about $65/ton, assuming an HHV of 6000 Btu/lb, 60% boiler efficiency, and a steam value of $9/MBtu. Can you separate the boxboard and deliver it to the salvor for less than the differential of $15/ton? Also, you know that the value of steam will doubtless continue to increase, but what about the price of reclaimed boxboard, which has always been very volatile?

Economic Life of the HRI Plant

Useful economic life of the HRI plant was specified as 15 years for the standard case HRI model that was exercised on this study. This differs from the 25-year lifespan specified in P-442 for steam generators in fossil fuel fired systems, which inherently offer better longevity. The HRI life period was selected based on the experience operators have had in the field with a variety of HRI configurations. Some have been surveyed in a few years (e.g., Naval Air Station, Jacksonville) while others have been steaming well in excess of 15 years.

Because the HRI Application Guide (Ref 1) sets out design guidelines for an optimally configured HRI, it can be assumed that considerably extended plant life expectancies will result for those in the Navy availing themselves of this technology. For that reason it was felt justifiable to exercise the standard case assuming an economic life of 25 years. The results are shown in Figures 11 and 12. As expected, extending the economic life had essentially no effect on payback period but almost commensurately increased the SIR and the (SIR-related) LCS by the same fractional amount of the life extension. The effect on LCC was considerably lower (about half) because, while O&M costs were extended another 10 years, capital costs did not change.

Discount Rate

The discount rate is the minimum attractive rate of return that the Government expects on their money spent on a project. Per P-442, 10% has been used for several years, but recent trends are towards the use of 7%. In view of this possible change, the HRI model was executed at both 7 and 10% discount rates. The sensitivity of the discount rate was found to be rather small in the case of payback period but increased SIR by 24% when the lower discount rate was applied. These data are shown in Figure 13.

FINDINGS AND CONCLUSIONS

General Findings

The 11 parameters selected to determine their degree of influence on the cost/benefits of an HRI plant are presented in Table 1. The expectable range of variation these parameters may operate over (corrected for general inflation) is shown together with the degree of sensitivity SIR will experience when these variations occur.

Key Parameters

The three parameters expected to vary and thereby affect the economic characteristics of an HRI plant the most are: (1) heating value, (2) boiler thermal efficiency available from design, and (3) differential of energy inflation rate with respect to general inflation. These parameters can be expected to have both a moderate to high degree of variation and a high impact on SIR. Although other parameters may exhibit greater influence on SIR per unit of change, the overall effect of these parameters on the cost/benefits of the HRI plant is greater.

Capital Costs

Capital costs and the cost of conventionally generated steam both have the potential for significantly altering the cost/benefits of an HRI plant. Any trends that may result in the technological lowering of the former (corrected for inflation) or inflating the latter will markedly enhance the economic attractiveness of the HRI.

Disposal Costs

Both the cost of solid waste disposal and the differential inflation rate of that service with respect to general inflation proved to be less influential in the HRI cost/benefit picture than was expected.

Similarly, SIR exhibited relatively low sensitivity to HRI ash outhaul cost variations, but this is based on treating the ash as a nonhazardous material, a categorization that may prove faulty.

Uncertainties

Assignment of appropriate values for the money discount rate and the facility economic life was an uncertain process. Both can have very strong effects on the economic attractiveness of an HRI plant and should be better defined.

RECOMMENDATIONS

Capital Costs

Because of the powerful effect capital costs have on the economic viability of an HRI plant, they should not be allowed to vary upward through the inclusion of unnecessary features, redundancy, control sophistication, structural overdesign, etc. Protect your investment through the inclusion of component performance guarantees so that fix-money need not be applied. Be sure your bidders represent the competitive field of good technology purveyors and that your purchase specification package faithfully follows the guidelines in Reference 1.

Disposal Costs

There is no magic breakpoint in the costs for solid waste outhaul/disposal at which one should turn to the HRI Model Users' Manual. Rates can be expected to increase as they follow general inflation and rise sharply when new landfills come on line. Anticipate these relocations, preferably by several years, by running the HRI Model based on expected disposal costs.

Cost of Conventionally Generated Steam

This will go up as fossil fuel costs increase or if new plant (replacement or add-on) capacity is in MCON planning. If the latter is the case, determine if an HRI would satisfy the service required and, if so, at what comparative cost. Fossil fuel other than coal will certainly increase in cost enough to warrant the annual exercise of the HRI Model.

HRI Thermal Efficiency

Because of lack of development in small waterwall HRI's, the HRI Application Guide necessarily recommends a specific configuration of the refractory-furnace HRI, a device considerably lower in thermal efficiency than the waterwall system. With this design penalty considered, it becomes very important to specify a system that is very well insulated and that furnishes average residual carbon values not exceeding 3 wt-%. A minimum thermal efficiency of 60% must be guaranteed for a suitable operating term (at least 1 year) based on testing procedures that conform to ASTM Committee E38.10 standards.

Ash Production

Given efficient HRI combustion (low residual carbon), the quantity of ash output by an HRI will largely be determined by the composition of the fuel and the degree of wetting the ash experiences. The HRI Application Guide does not recommend the use of a dry ash handling system but instead promotes the use of quench tanks for handling bottom residues. Wet ash handling results in the leaching of metals from the ash and this can be a significant economic factor when considering landfill costs. Disposal of bottom/fly ash is variously regulated and, in some states, the material is treated as hazardous waste (high cost disposal) unless the leachable heavy metals are below certain limits. It will therefore be important to learn local disposal requirements and expected future requirements. If ash leaching becomes important, the ash handling system design should promote it.

Heating Value of the Fuel

Because the HRI Application Guide recommends mass firing of the received solid waste, beneficiation of the fuel should be done by source separation and a minimum amount of hand culling at the HRI plant. Source separation specifications should encourage removal of valuable inerts but leave combustibles that demonstrably will provide a better financial return when fired than when recycled. Upgrading the calorific value of the fuel will develop the economic viability of the HRI system significantly.

Operating Scenario

The HRI Application Guide recommends designing an HRI that will be operated continuously over a 5-day work week.

REFERENCES

1. Naval Civil Engineering Laboratory Technical Note N-___: Heat recovery incinerator application guide, by R.M. Roberts, K.T.C. Swanson, and J. Zimmerle. Port Hueneme, Calif. (in publication).

2. _______________. Contract Report CR 84.029: User's manual for the heat recovery incinerator (HRI) model, by J.M. Ertman. Port Hueneme, Calif., L.I. Dimmick Corp., Jun 1984.

3. Naval Facilities Engineering Command. NAVFAC P-442: Economic analysis handbook, Washington, D.C., Jun 1980.

4. Naval Civil Engineering Laboratory. Contract Report CR 84.013: Field examination of heat recovery incinerator (HRI) facilities of up to 50-tpd capacity; Comparison of ten HRI facilities, by R. Frounfelker, B.A. Hausfeld, and R.A. Haverland. Xenia, Ohio, Systech Corporation, Feb 1984.

Table 1. The Degree of Variation of and Sensitivity of SIR to 11 Techno-Economic Parameters

Parameter	Expected Degree of Variation	SIR Sensitivity
Capital Cost	Low	Very High
Solid Waste Disposal Cost	High	Moderate
Cost of Conventionally Generated Steam	Moderate	High
Differential Energy Inflation	High	Moderate
Differential Landfill Disposal Cost	High	Moderate
Boiler Thermal Efficiency	Moderate	High
Ratio of Ash to Waste Input	High	Low
Heating Value	High	High
Economic Plant Life	Fixed Value	High
Operating Scenario	As Required	N/A
Money Discount Rate	Fixed Value	Moderate

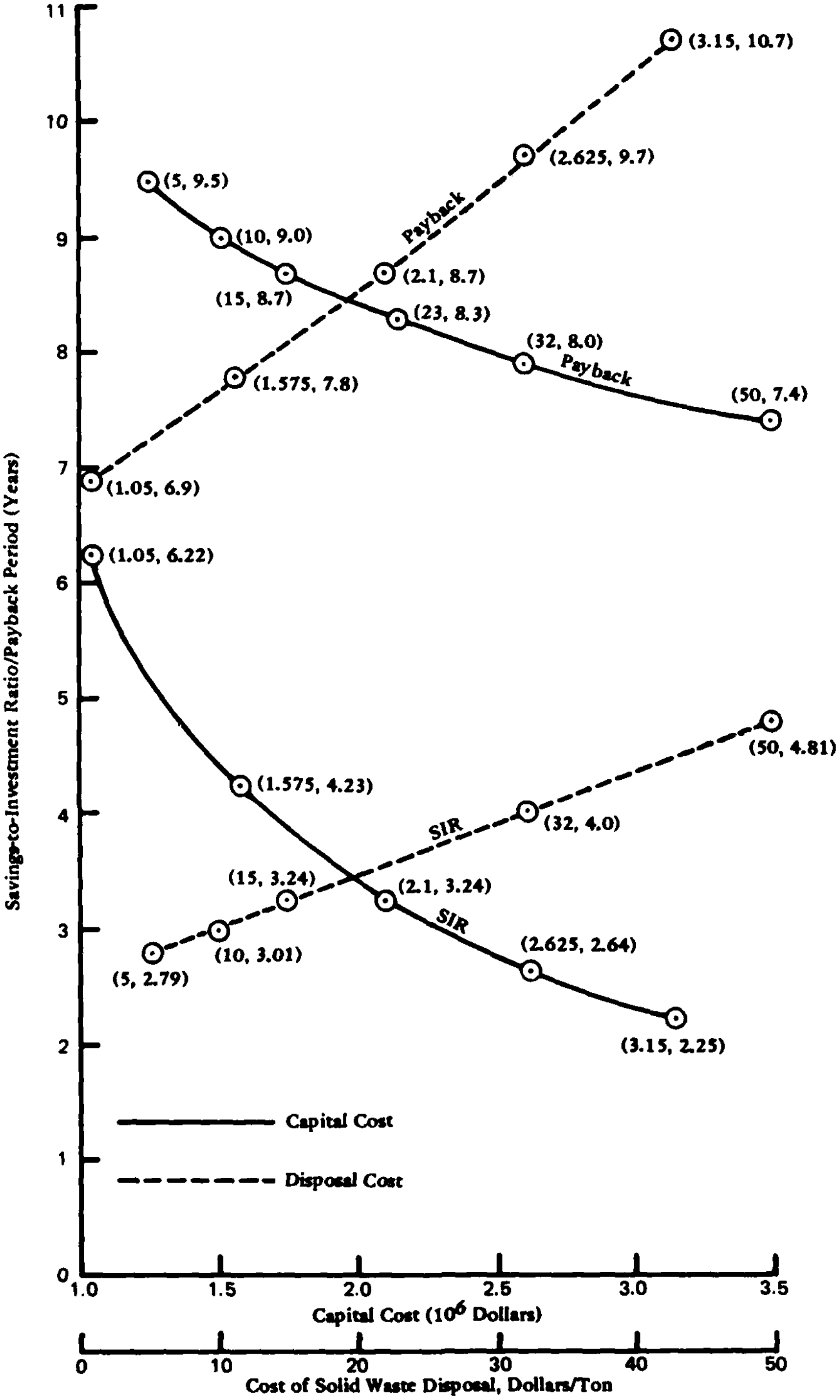


Figure 1. Savings to investment ratio (SIR) and payback period versus capital cost and solid waste disposal cost by landfilling.

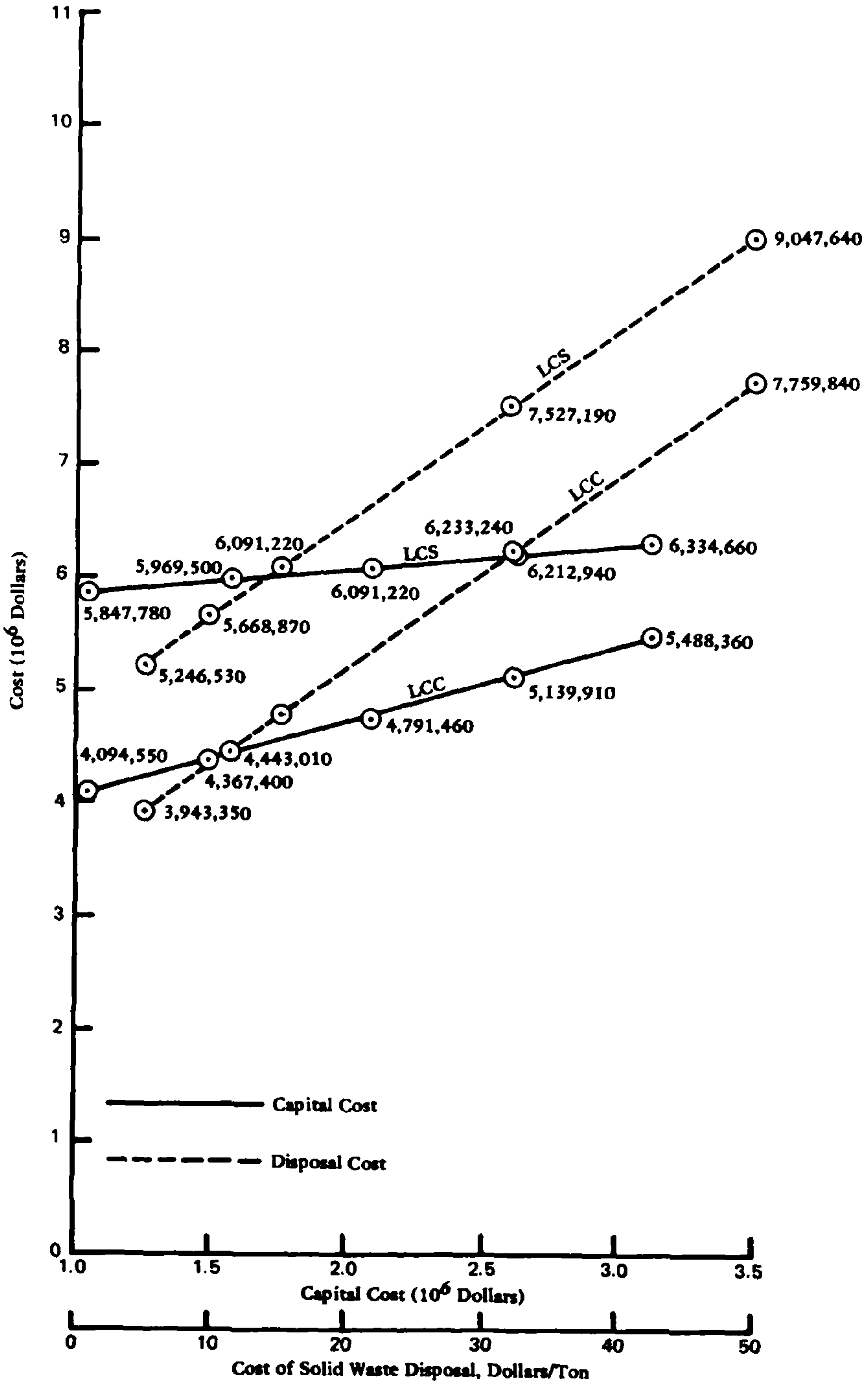


Figure 2. HRI discounted life cycle cost (LCC) and savings (LCS) versus HRI capital cost and solid waste disposal cost by landfilling.

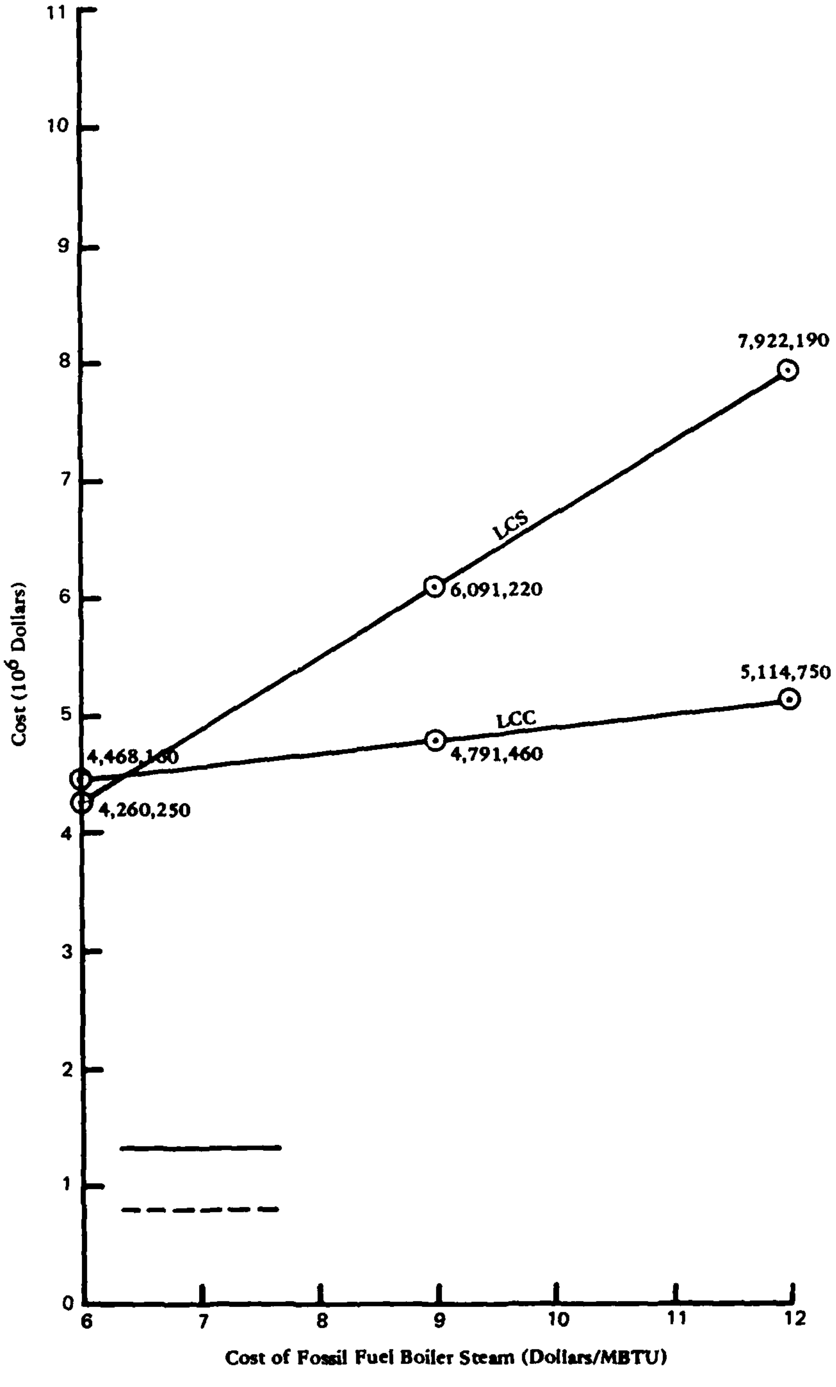


Figure 3. HRI life cycle cost (LCC) and savings (LCS) versus cost of fossil fuel boiler steam.

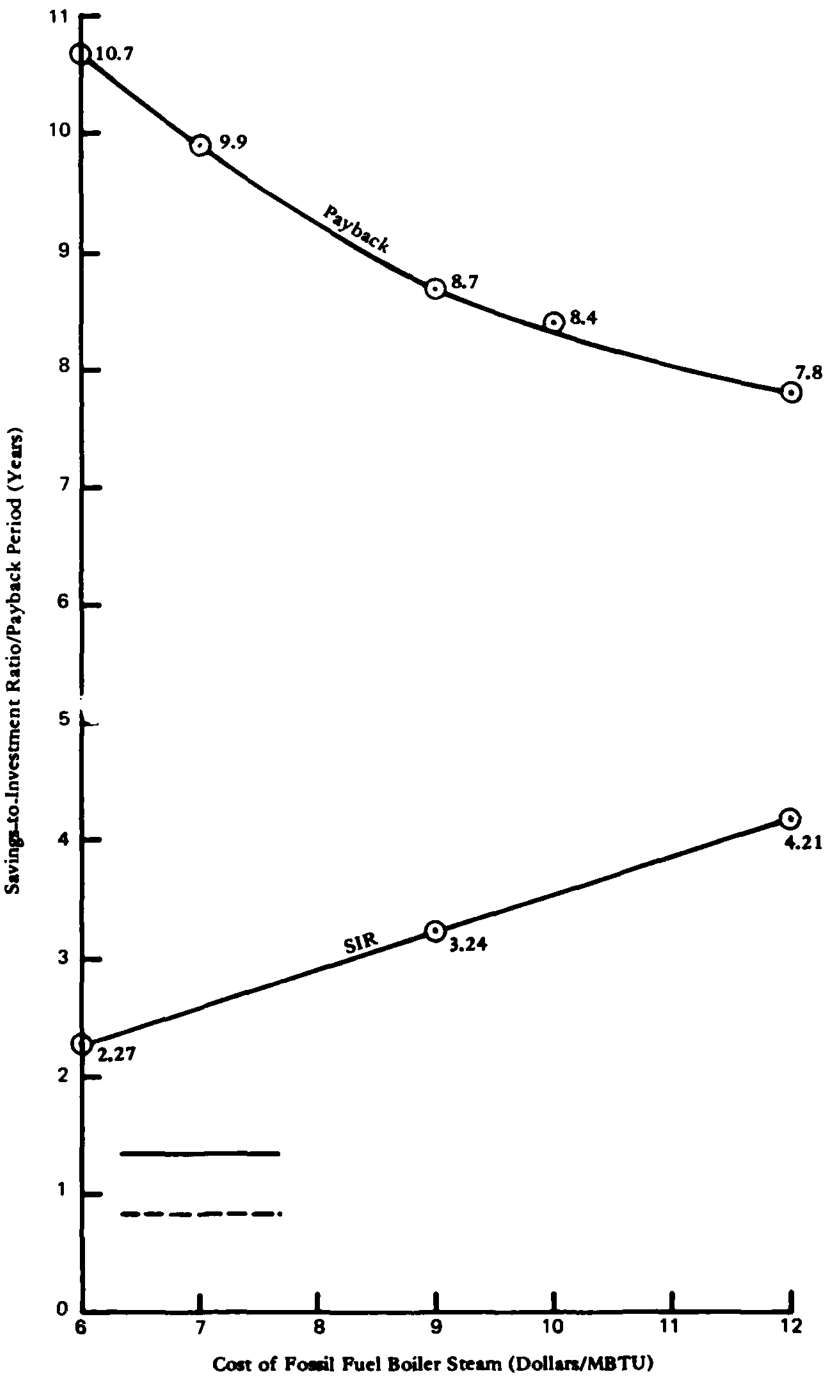


Figure 4. Savings to investment ratio (SIR) and payback period versus cost of fossil fuel boiler steam.

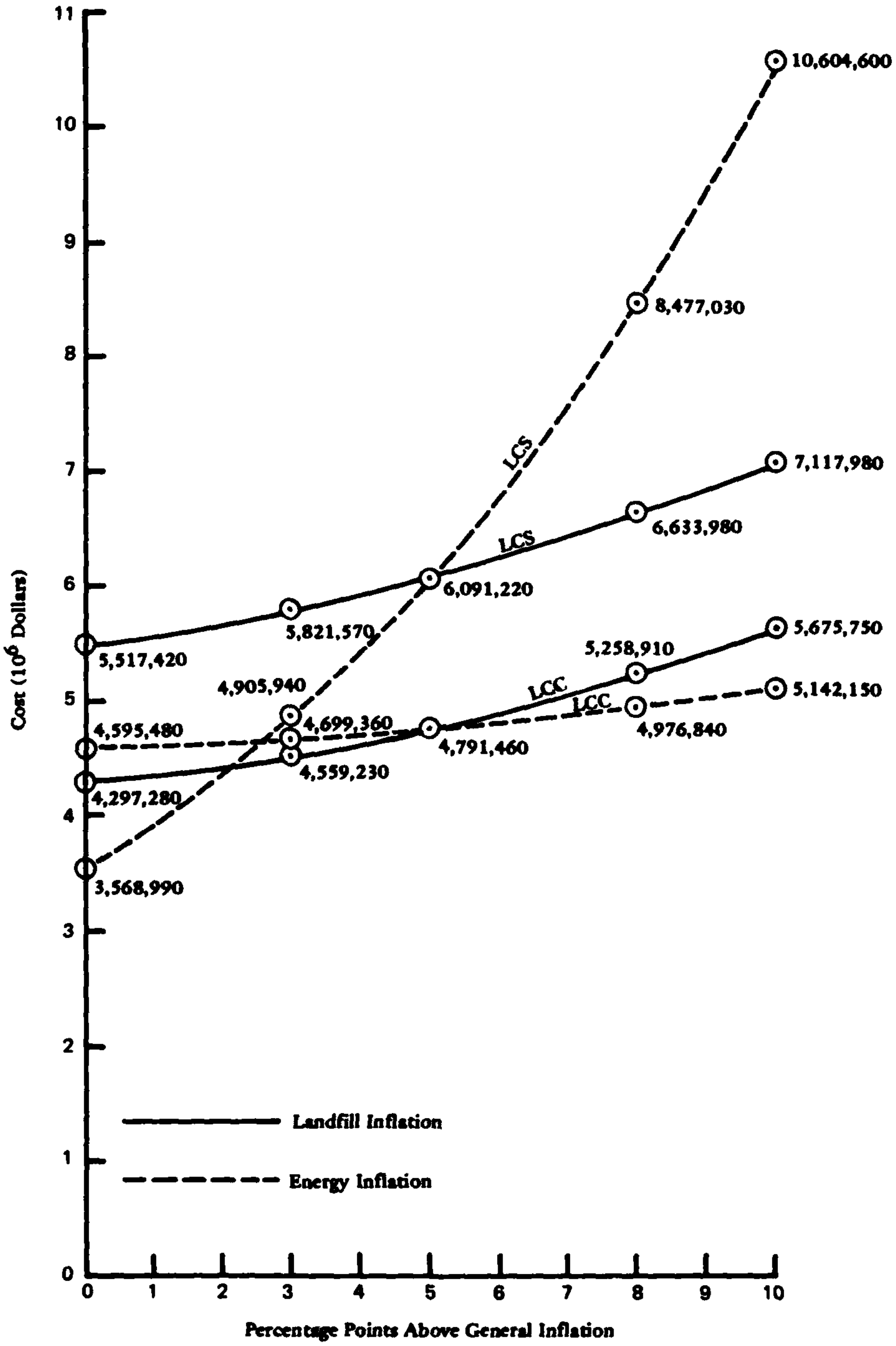


Figure 5. Discounted life cycle cost (LCC) and savings (LCS) versus differential energy and landfill inflation rates.

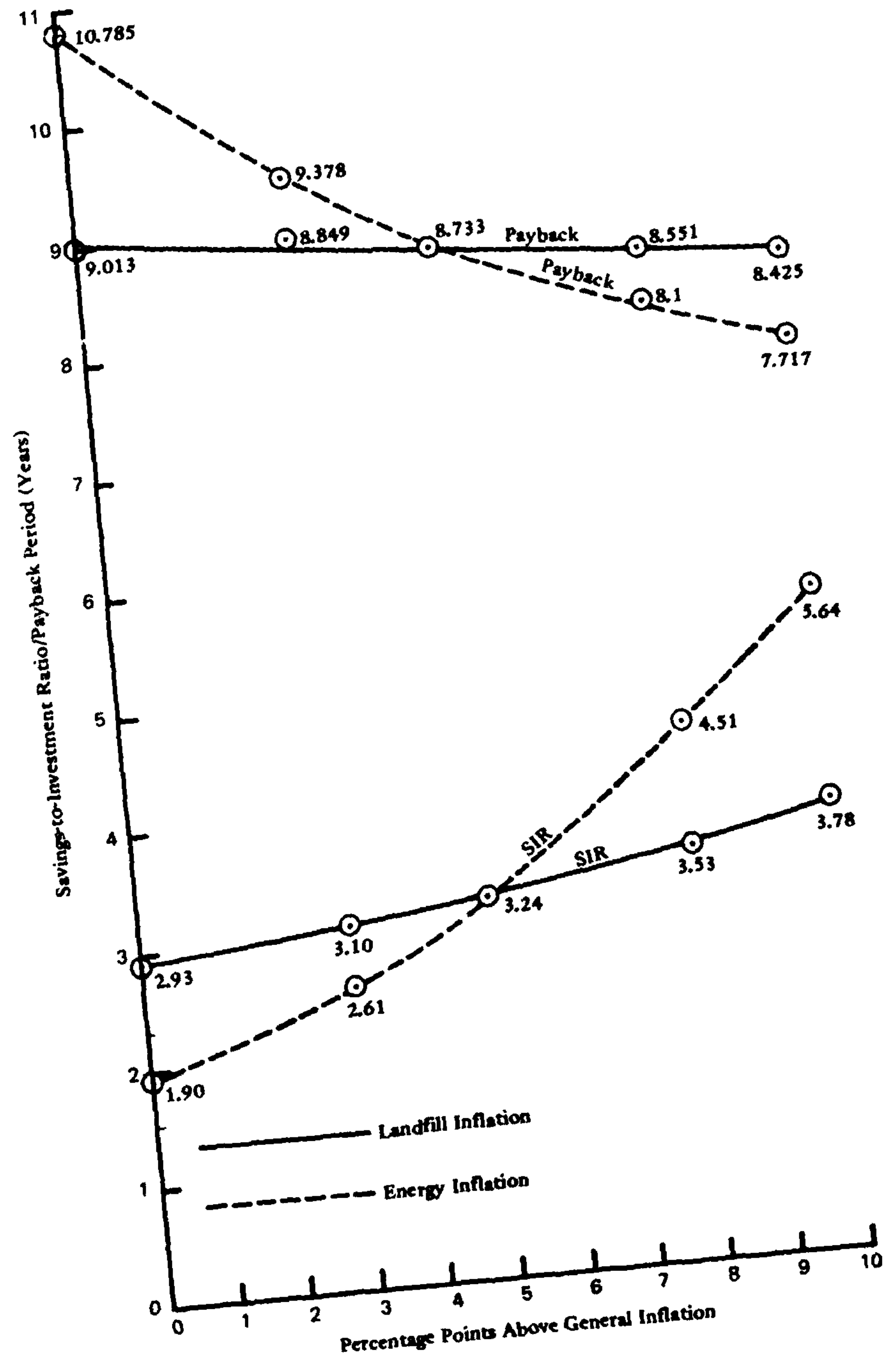


Figure 6. Savings to investment ratio (SIR) and payback period versus differential energy and landfill inflation rates.

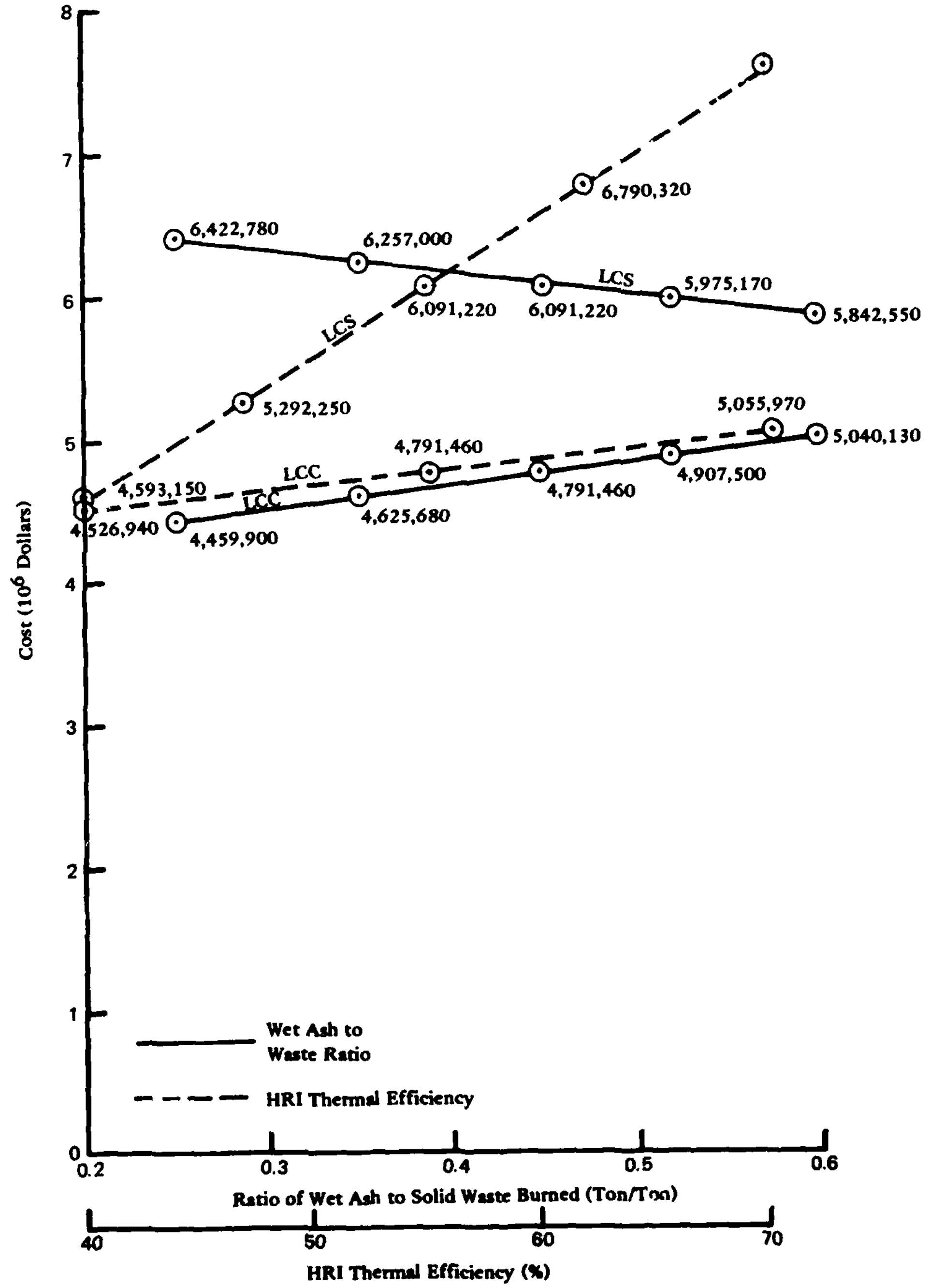


Figure 7. Discounted life cycle cost (LCC) and savings (LCS) versus ratio of wet ash to solid waste and HRI thermal efficiency.

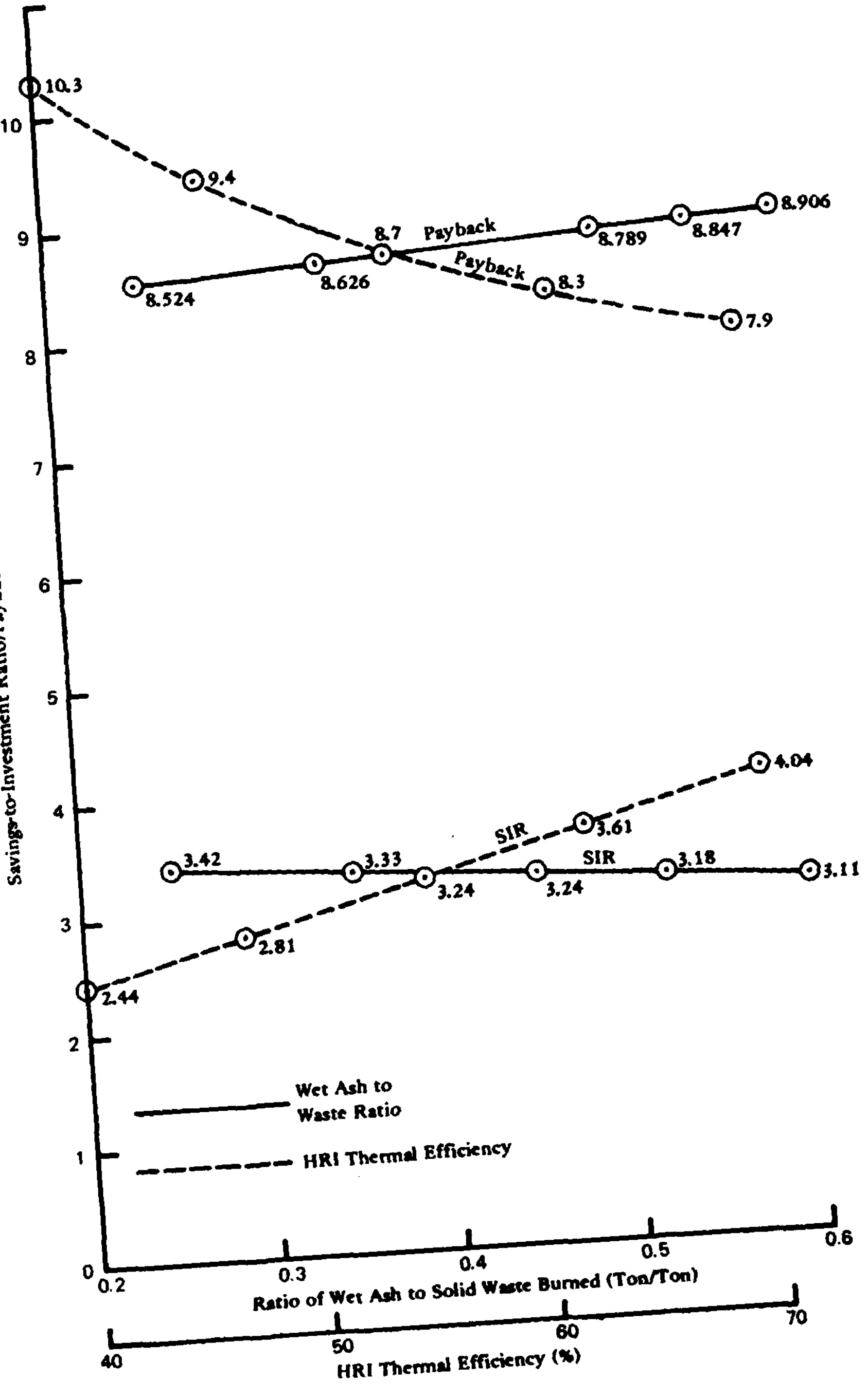


Figure 8. Savings to investment ratio (SIR) and payback period versus ratio of wet ash to solid waste and HRI thermal efficiency.

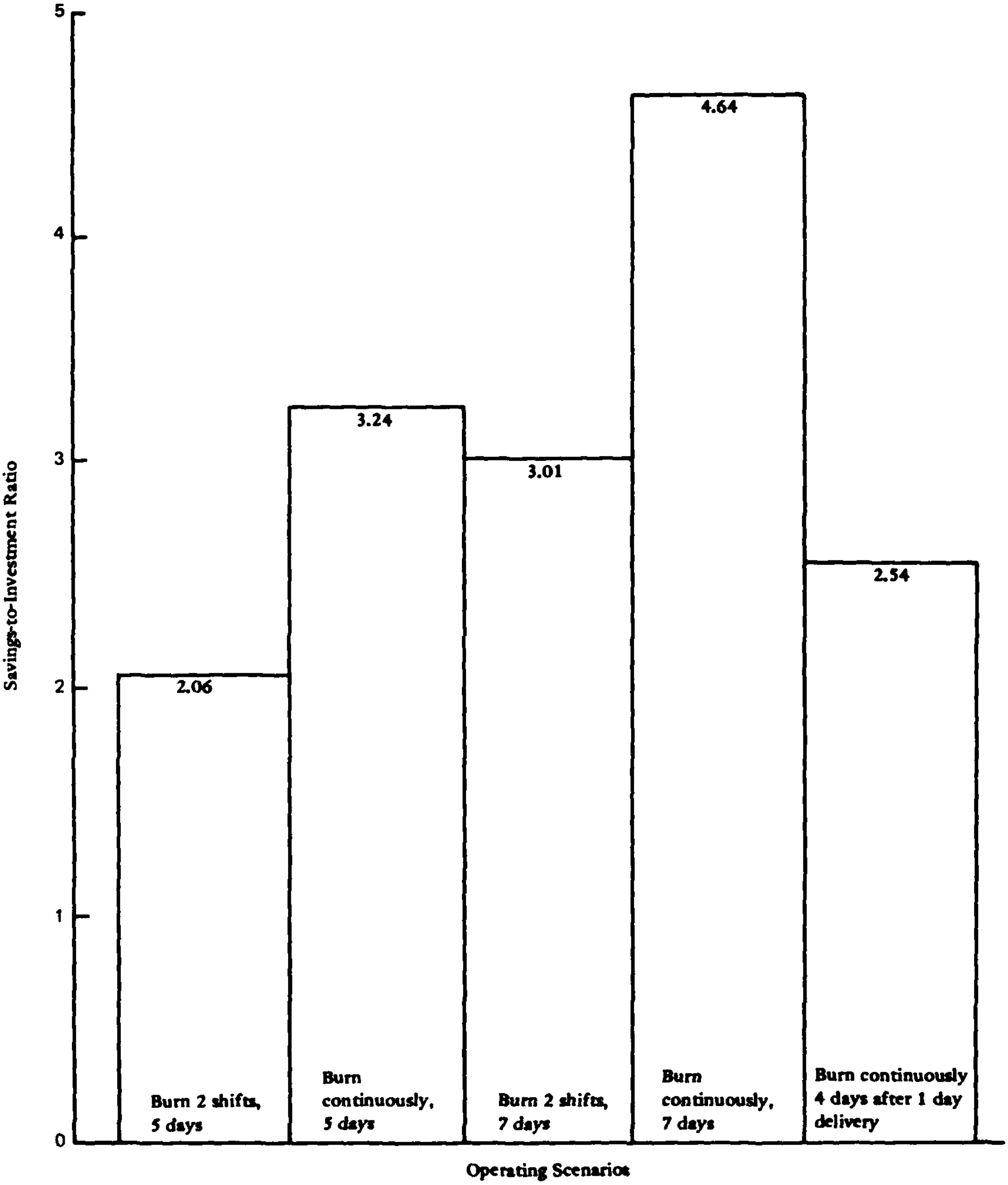


Figure 9. Savings to investment ratio versus operating scenario.

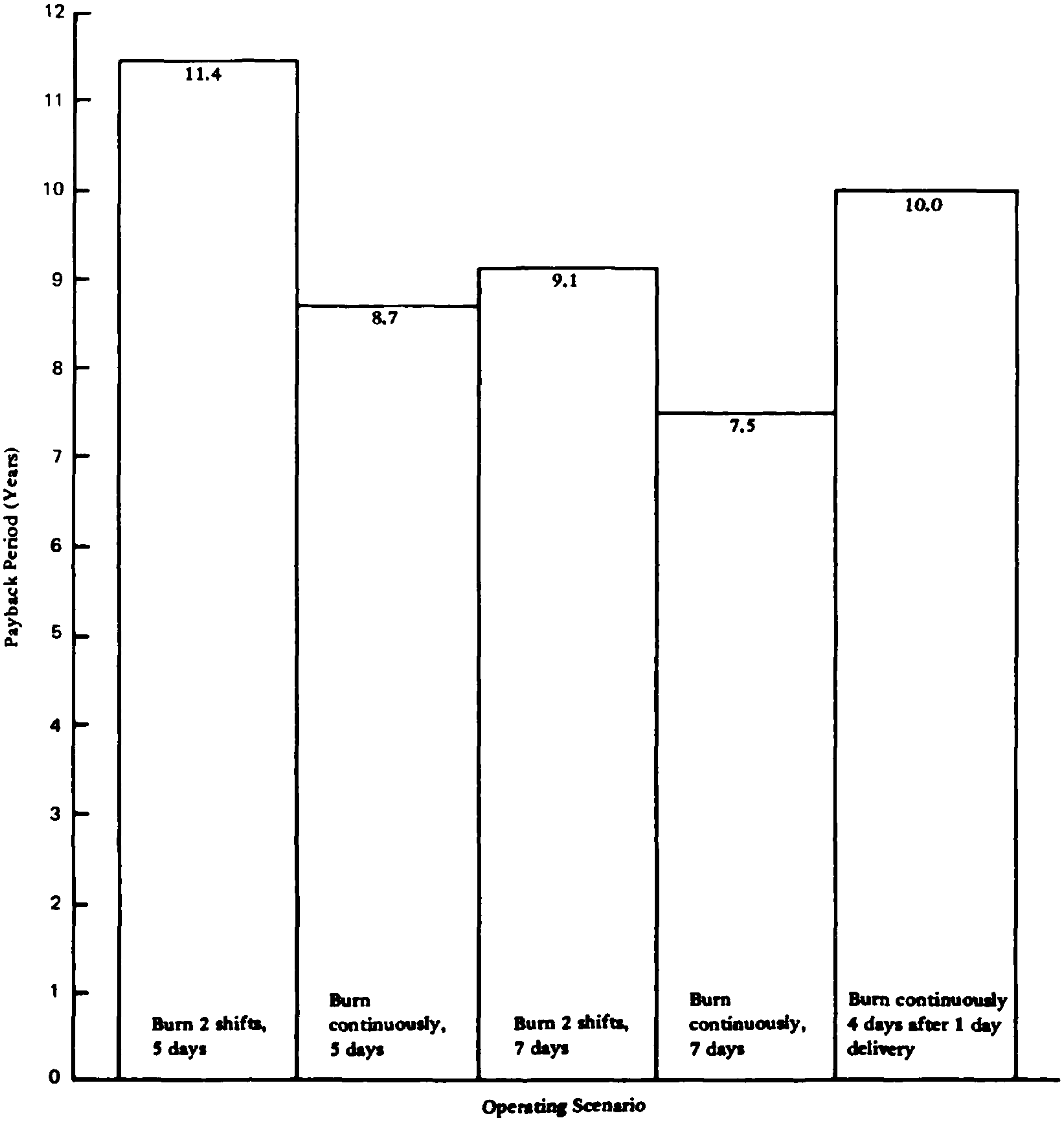


Figure 10. Payback period versus operating scenario.

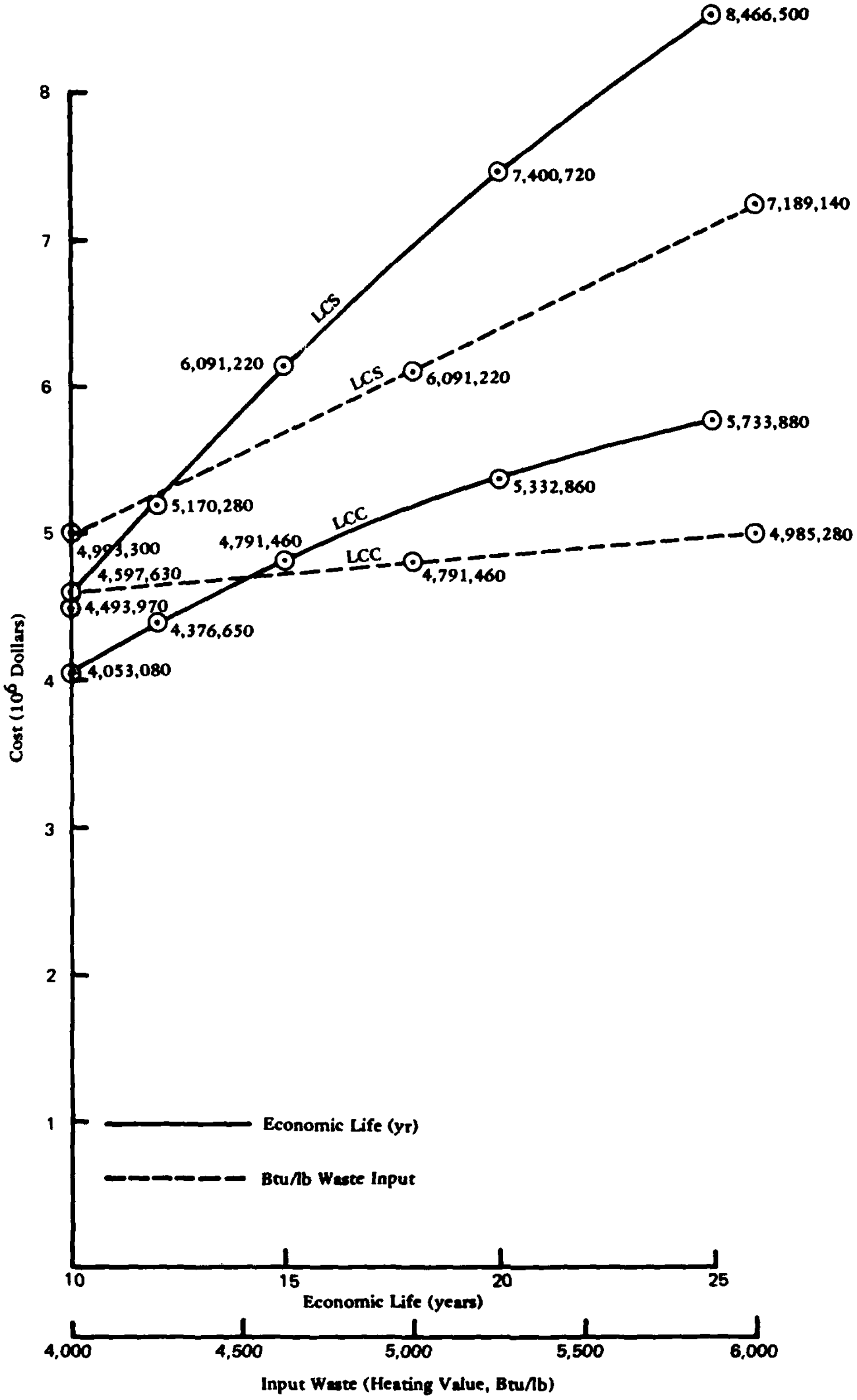


Figure 11. Discounted life cycle cost (LCC) and savings (LCS) versus economic life and input waste heating value.

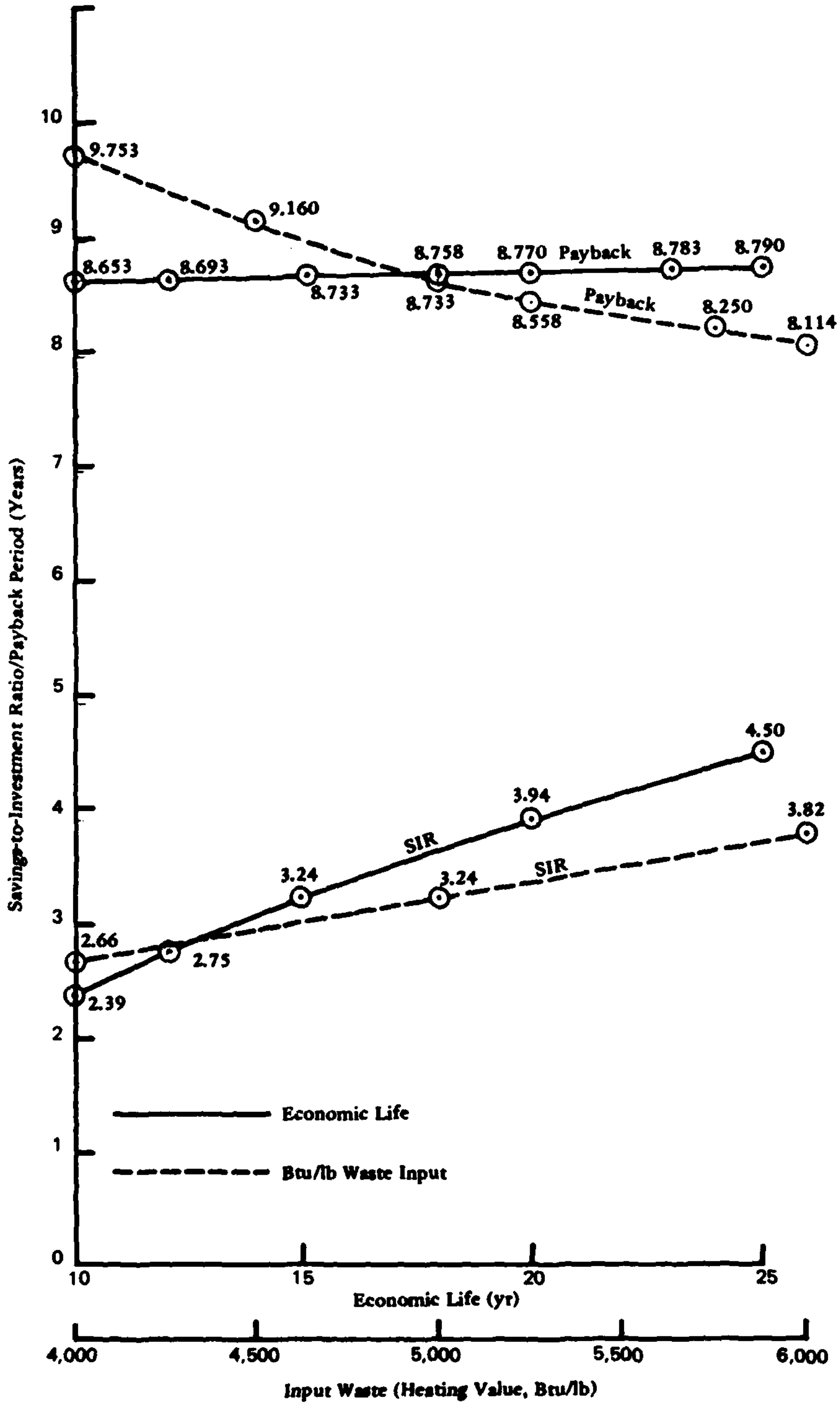


Figure 12. Savings to investment ratio (SIR) and payback period versus economic life and Btu/lb waste input.

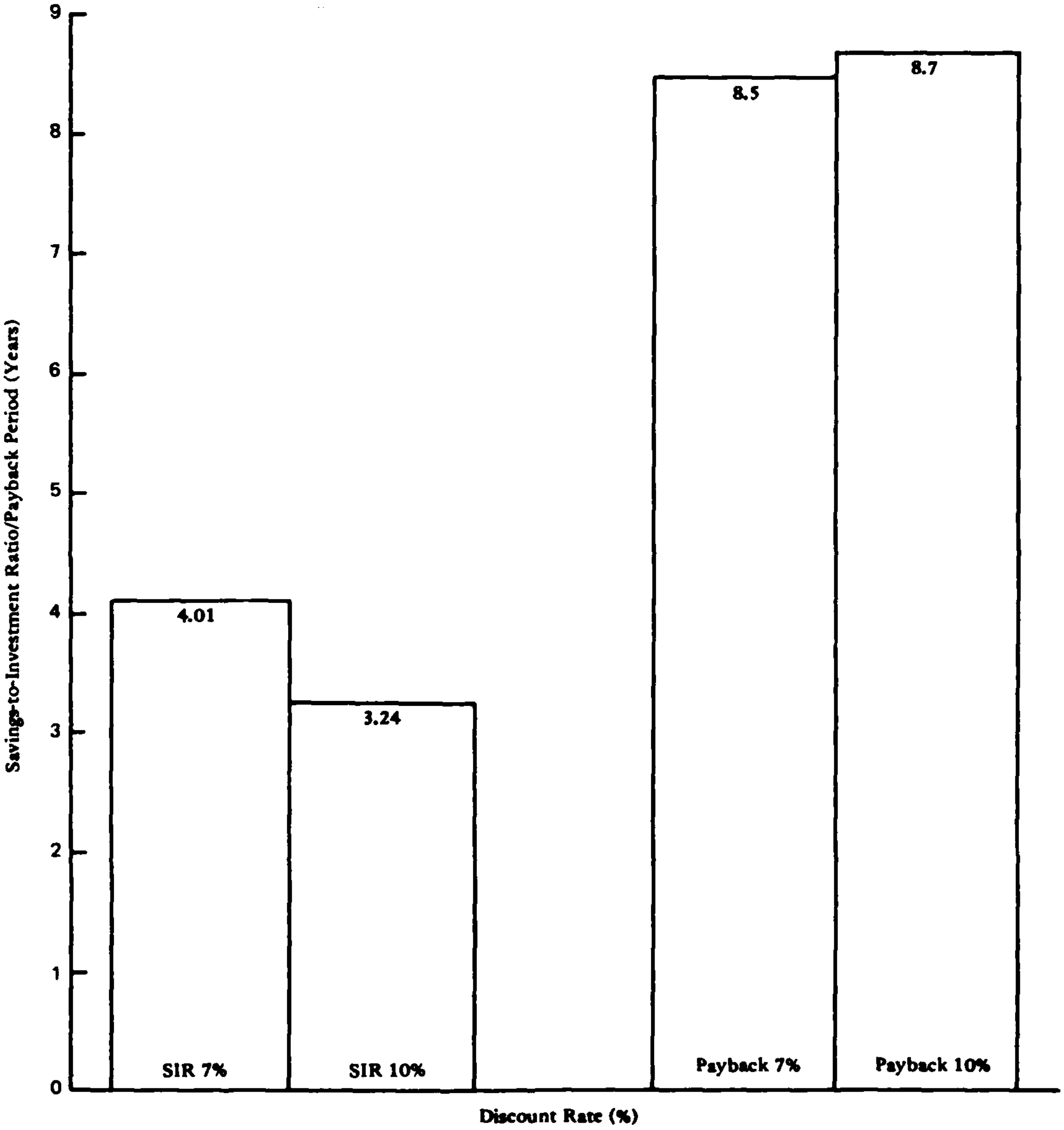


Figure 13. Savings to investment ratio (SIR) and payback versus discount rate.

Appendix A

DEFINITIONS FOR HRI COST AND PERFORMANCE REPORT

The cost and performance report presented by the HRI computer model prints out 22 parameters which may be useful in the design or economic evaluation of a Heat Recovery Incinerator. This appendix presents a discussion of how each output parameter is calculated and, where deemed necessary, what the output parameters represent as economic functions. The definitions are listed in the same order as they appear in the HRI Cost and Performance Report, which is shown at the end of Appendix B.

1. INFLATED PER TON COST OF DISPOSING WASTE OF THE TYPE GENERATED AT THE SITE TO THE LANDFILL--This is the cost of hauling (but not collecting) solid waste from the Navy activity to the landfill and disposing of it there. This cost is inflated at the specified landfill inflation rate called for on Screen 6.

2. INFLATED PER MBTU COST OF THE FOSSIL FUEL BOILER TO WHICH THE HRI IS BEING COMPARED--This is the cost of steam to the activity which an existing PWD boiler produces or which the activity may be paying for over-the-fence service from a commercial producer, whichever service is being partly or wholly displaced by the HRI plant. This value is inflated at the energy inflation rate input on Screen 8.

3. TONS OF TRASH BURNED ANNUALLY--This is the amount of solid waste collected annually and sent to the HRI plant less oversized trash and that trash that must be diverted to landfill during outages after the storage facility has filled.

4. MBTUS PRODUCED ANNUALLY BY THE HRI (CONSIDERING NO DOWNTIME)--This value is the sum of steady state steam production, calculated from the energy content of the trash and any other fuels burned and boiler thermal efficiency less heat losses incurred while cooling and reheating the furnace following scheduled maintenance.

5. VIRGIN FUEL OFFSET ANNUALLY BY THE HRI IN BARRELS-OF-OIL-EQUIVALENT--This is the amount of prime fossil fuel saved by generating the quantity of steam produced (Item 4 just preceding) in the HRI assuming no unscheduled downtime. The MBtus are then converted to the standard units of barrels-of-oil-equivalent (BOE).

6. LANDFILL SPACE CONSERVED ANNUALLY BY THE HRI IN TONS--This is (1) the amount of solid waste that would normally be hauled to landfill if there were no HRI less (2) that solid waste generated by the HRI (ash and oversized waste) or bypassing it due to outages.

7. COST OF USING A BOILER TO PRODUCE THE ANNUAL NO-DOWNTIME QUANTITY OF STEAM PRODUCED BY THE HRI AND LANDFILLING ALL WASTE--This is the sum of the inflated costs to the activity for generating the annual no-downtime quantity of steam produced by the HRI and the annual cost for disposing of all the activity's trash at a landfill without the benefits of an HRI.

8. INFLATED TOTAL CAPITAL COST OF THE HRI--This is the capital cost of the HRI plant (screen 2) inflated at the general inflation rate from the date these costs were estimated to the time the project is funded.

9. UNIFORM ANNUAL COST OF THE HRI--This is the sum of operating costs for the entire economic life of the facility divided by the years of economic life. These costs take into account the cost of consumables, repair parts, sewer, insurance, pest control, labor, project lead time costs, expected modifications, residue disposal, and downtime.

10. ANNUAL NO-DOWNTIME COST OF THE HRI--This cost is the same as the item just preceding except that downtime costs are excluded.

11. DISCOUNTED LIFE CYCLE COST OF USING A BOILER TO PRODUCE THE LIFE CYCLE NO-DOWNTIME QUANTITY OF STEAM PRODUCED BY THE HRI AND LANDFILLING ALL WASTE--This is the total cost of landfilling all waste and using a conventional boiler to produce the no-downtime steam generated by the HRI both over the entire economic life of the HRI facility. This combined cost is discounted per the rate input by the user on Screen 1.

12. DISCOUNTED LIFE CYCLE COST OF THE HRI--This is the Uniform Annual Cost of an HRI (Item 9 above) discounted over the economic life of the project at the rate specified on Screen 1.

13. DISCOUNTED LIFE CYCLE COST OF AUXILIARY FUELS USED BY THE HRI--This is the annual costs for auxiliary fuels that are burned in the HRI discounted over the economic life of the HRI.

14. DISCOUNTED LIFE CYCLE COST OF NONCOMBUSTIBLE WASTE, ASH, AND SCHEDULED DOWNTIME WASTE DISPOSAL--This is the annual cost of landfill disposal of oversized waste and ash from the HRI and ordinary waste diverted from the HRI during scheduled downtimes. This cost is discounted over the economic life of the project.

15. DISCOUNTED LIFE CYCLE COST OF HRI DOWNTIME--This is the discounted life cycle cost of the annual waste tonnage diverted to landfill because of unscheduled outages multiplied by the savings for no-downtime HRI operation realized per ton of waste fired. The latter is expressed as the annual no-downtime firing rate divided into the difference between Items 7 and 10.

16. DISCOUNTED LIFE CYCLE COST OF THE HRI PER TON OF WASTE FIRED--This is the life cycle cost of the HRI (Item 12) divided by the product of actual (all outages included) annual trash incinerated and the years of economic life of the HRI.

17. DISCOUNTED LIFE CYCLE SAVINGS OF THE HRI PER TON OF WASTE FIRED--This is the discounted LC HRI savings (see Item 20 below) divided by the product of actual (all outages included) annual trash incinerated and the economic life of the HRI.

18. DISCOUNTED LIFE CYCLE COST OF THE HRI PER MBTU PRODUCED--This is the HRI life cycle cost (Item 12) divided by the total energy produced over the economic life of the HRI, including that for steady state steaming, reheating the furnace and while turned up above nameplate rating.

19. DISCOUNTED LIFE CYCLE SAVINGS OF THE HRI PER MBTU PRODUCED--This is the Life Cycle Savings of the HRI (Item 20, next below) divided by the same energy term used in Item 18.

20. DISCOUNTED LIFE CYCLE SAVINGS OF THE HRI--This is the energy, landfill costs, and other savings (or losses) accrued by the HRI over its economic life and discounted to furnish an annual rate.

21. HRI SAVINGS-TO-INVESTMENT RATIO--This is the ratio of Item 20 to the Discounted Cost of Lead Time Expenditures, including inflated capital costs and A&E charges.

22. PAYBACK PERIOD IN YEARS--This is the time elapsed wherein the cumulative savings just exceed the Discounted Cost of Lead Time Expenditures.

Appendix B

HRI COST MODEL DATA SCREENS FOR THE STANDARD CASE

```
                    DATA INPUT SCREENS FOR B:KTC
                   ***  GENERAL INFORMATION  ***                SCREEN 01
              CURRENT MONTH:  6          CURRENT YEAR: 84

                       ***  NEAR-TERM FUTURE  ***
            NUMBER OF MONTHS BETWEEN ANALYSIS AND FUNDING: 12
             ANNUAL INFLATION RATES FOR THE FOLLOWING:
                        CAPITAL EXPENDITURES:  5.0
                                     ENERGY: 10.0
                             LANDFILL COSTS: 10.0
                      ALL OTHER EXPENDITURES:  5.0

                       ***  PROJECT LEAD TIME  ***
            ARCHITECT/ENGINEER(%)         CAPITAL COSTS(%)
     YEAR 1      33.3                      0.0
     YEAR 2      33.3                      0.0           (NOTE: PERCENTAGES
     YEAR 3      33.4                      0.0             MUST ADD TO 100)
     YEAR 4       0.0                     50.0
     YEAR 5       0.0                     50.0
                     ***  PROJECT ECONOMIC LIFE  ***
ECONOMIC LIFE OF HRI IN YEARS: 15                DISCOUNT RATE (%): 10
DIFFERENTIAL INFLATION RATES (%) FOR ENERGY:  5        AND LANDFILL:  5

                    IS EVERYTHING CORRECT (Y/N)?
```

```
                    ***  CAPITAL COST FOR EQUIPMENT  ***         SCREEN 02
                               YEAR $: 81
      ITEM                COST              ITEM                 COST
RECEIVING:               50679     QUENCH TANK WATER TREATMENT:         0
PROCESSING:                  0     BOILER WATER TREATMENT:              0
STORAGE:                     0     INSTRUMENTATION:                     0
RETRIEVAL:               36000     CONTROL SYSTEM:                      0
INCINERATION:           387200     FIRE AND EXPLOSION SUPPRESSION
BOILER:                 156500          EQUIPMENT:                      0
ASH REMOVAL:             29734     INITIAL SPARE PARTS INVENTORY:       0
AIR POLLUTION:               0     OTHER:                           28125
                                        TOTAL:                    1500000
                  ***  CAPITAL COST FOR SUPPORT FACILITIES  ***
                               YEAR $: 81
                       ITEM                                COST
                  BUILDING:                                   0
                  UTILITIES:                                  0
                  EARTHWORK AND ROAD CONSTRUCTION:            0
                  OTHER:                                      0
                         TOTAL:                          400000
                 ***  CAPITAL COST FOR CONSTRUCTION AND SETUP  ***
                             YEAR$:  81       TOTAL:  200000
                        IS EVERYTHING CORRECT (Y/N)?
```

```
                    ***  TOTAL CAPITAL COST  ***              SCREEN 03
                    YEAR $: 81    TOTAL:  2100000

              ***  CAPITAL COST FOR EXPECTED MODIFICATIONS  ***
                                YEAR $: 81
DESCRIPTION OF MODIFICATION         MODIFICATION COST      ECONOMIC LIFE YEAR
     STAK SCRUB                          100000                      5
     REFRAC ETC                          200000                     10
                                              0                      0
                                              0                      0
                                              0                      0
                                              0                      0
                                              0                      0
                                              0                      0
                                              0                      0
                                              0                      0

            ***  CAPITAL COST FOR ARCHITECT AND ENGINEER SERVICES  ***
              PERCENTAGE OF ALL CAPITAL COSTS IDENTIFIED ABOVE:  6.0


                    IS EVERYTHING CORRECT (Y/N)?
```

```
                         ***  LABOR COSTS  ***                    SCREEN 04
                            YEAR $:   81
                    NO DOWNTIME                                  ASSIGNED TO
OPERATION           ANNUAL MANHOURS(MHR)   RATE($/HR)       TOTAL  DOWNTIME(%)
    SUPERVISORY          2000                21.00          42000       50
    SKILLED              4000                18.00          72000       50
    UNSKILLED            4000                 9.00          36000       50
                              TOTAL OPERATION LABOR COST:  150000

PREVENTIVE MAINTENANCE       ANNUAL MANHOURS(MHR)   RATE($/HR)          TOTAL
            SUPERVISORY               75             21.00              1575
            SKILLED                  150             18.00              2700
            UNSKILLED                150              9.00              1350
                        TOTAL PREVENTIVE MAINTENANCE LABOR COST:        5625

CORRECTIVE MAINTENANCE       MHR/CORRECT MAINT HR    RATE($/HR)
            SUPERVISORY             0.1              21.00
            SKILLED                 0.2              18.00
            UNSKILLED               0.2               9.00
                        TOTAL CORRECTIVE MAINTENANCE LABOR COST:          0

                        IS EVERYTHING CORRECT (Y/N)?
```

```
                         ***  COST OF CONSUMABLES  ***              SCREEN 05
                                 YEAR $:   81
ELECTRICITY:         KWH/OPERATING HR:     50        $/KWH:  0.060
                          KWH/DOWNTIME HR (% OF KWH/OP HR):  20.0
                  KWH/SCHEDULED NON-OP HR (% OF KWH/OP HR):  10.0

WASTE AND OTHER FUELS THAT OFFSET                     VIRGIN GAS AND LIQUID FUELS
  USE OF VIRGIN FUELS
           GAL/TON    $/GAL      BTU/GAL          GAL/TON   $/GAL      BTU/GAL
LIQUID:      0.000     0.00            0            0.050    1.00       129600
       1000 CF/TON  $/1000 CF  BTU/1000 CF   1000 CF/TON  $/1000 CF  BTU/1000 CF
GAS:          0.00      0.00            0          0.00      0.00            0
           TON/TON    $/TON      BTU/TON
SOLID:     0.00         0.00            0
SOLID:     0.00         0.00            0

MAKEUP WATER:   GAL/TON:    0     $/1000 GAL:  0.00    OR ANNUAL TOTAL: 2100
CHEMICALS:
    CHEMICAL    UNITS/1000 GAL MAKEUP WATER   $/UNIT    OR     ANNUAL TOTAL
                       0.00                    0.00                    0
                       0.00                    0.00                    0
                                 TOTAL ANNUAL COST OF CHEMICALS:  3500
                              IS EVERYTHING CORRECT (Y/N)?
```

```
                         ***  OTHER COSTS  ***                    SCREEN 06
  ITEM                  ANNUAL COST          YEAR $
REPAIR PARTS               20000                81
SEWER                        300                81
INSURANCE                      0                 0
PEST/VERMIN CONTROL         3000                81
RESIDUE DISPOSAL                          YEAR $: 81
    (ENTRIES MUST BE MADE FOR EACH OF THE FOLLOWING THREE GROUPS)
       TRANSPORTATION COST OF NON-BURNABLE WASTE ($/TON-MILE):   0.00
       NUMBER OF MILES TO NON-BURNABLE WASTE LANDFILL:            0
       TIPPING FEE AT NON-BURNABLE WASTE LANDFILL ($/TON):       0.00
    OR COST OF LANDFILL DISPOSAL OF NON-BURNABLE WASTE ($/TON): 15.00

       TRANSPORTATION COST OF ASH ($/TON-MILE):                  0.00
       NUMBER OF MILES TO ASH DISPOSAL LANDFILL:                  0
       TIPPING FEE AT ASH DISPOSAL LANDFILL ($/TON):             0.00
    OR COST OF LANDFILL DISPOSAL OF ASH ($/TON):                15.00

       TRANSPORTATION COST OF ALL WASTE GENERATED ($/TON-MILE):  0.00
       NUMBER OF MILES TO LANDFILL:                               0
       TIPPING FEE AT LANDFILL ($/TON):                          0.00
    OR COST OF LANDFILL DISPOSAL OF ALL WASTE ($/TON):          15.00
                         IS EVERYTHING CORRECT (Y/N)?
```

```
                         ***  OTHER COSTS  ***                SCREEN 07

     ITEM            ANNUAL        ECONOMIC LIFE      TYPE COST
                      COST        YEAR AND  COST   (C,E,L, OR O)    YEAR $
                         0          0         0                        0
                         0          0         0                        0
                         0          0         0                        0
                         0          0         0                        0
                         0          0         0                        0
                         0          0         0                        0
                         0          0         0                        0
                         0          0         0                        0
                         0          0         0                        0
                         0          0         0                        0



                      IS EVERYTHING CORRECT (Y/N)?
```

```
                           ***   OPERATING DATA  ***                  SCREEN 08

TONS OF NON-BURNABLE WASTE/TON OF WASTE:                         0.030
ESTIMATE OF HRI COMBUSTION RATE (TONS/HOUR):                     2.10
HRI TURN-UP CAPABILITY (PERCENT ABOVE NORMAL FIRING RATE):        0.0
TONS OF ASH (BOTTOM OR FLY)/TON OF BURNED WASTE:                 0.45
$/MBTU OUTPUT OF FOSSIL FUEL BOILER AND YEAR $:                   9.00  83
THERMAL EFFICIENCY OF FOSSIL FUEL BOILER (%):                    80.0
HEATING VALUE OF BURNABLE WASTE (BTU/TON):                       10000000
HRI FURNACE TYPE (R=REFRACTORY, W=WATER WALL):                   R
THERMAL EFFICIENCY OF THE HRI (%):                               55.0
ESTIMATE OF HRI TOTAL ANNUAL DOWNTIME DUE TO FAILURE (%):        15
ESTIMATE OF HRI ANNUAL NUMBER OF FAILURES:                        20
ESTIMATE OF MAXIMUM HRI DOWNTIME (HOURS):                        120
TIME REQUIRED TO COMPLETE A DAYS DELIVERY (HOURS):                6
STORAGE SPACE AVAILABLE AT HRI (TONS):                           150
HRI OPERATING SCENARIO:
   1=BURN 2 SHIFTS, 5 DAYS   2=BURN CONTINUOUSLY, 5 DAYS         2
   3=BURN 2 SHIFTS, 7 DAYS   4=BURN CONTINUOUSLY, 7 DAYS
   5=BURN CONTINUOUSLY, 4 DAYS, FOLLOWING DAY 1 RECEIPT
HRI PLANNED ANNUAL OPERATING WEEKS:                              50

                           IS EVERYTHING CORRECT (Y/N)?
```

```
                                   HRI COST AND PERFORMANCE REPORT

INFLATED PER TON COST OF DISPOSING WASTE OF THE TYPE GENERATED AT THE SITE TO THE LANDFILL:                 $21.96
INFLATED PER MBTU COST OF THE FOSSIL FUEL BOILER TO WHICH THE HRI IS BEING COMPARED:                        $10.89


TONS OF TRASH BURNED ANNUALLY BY THE HRI:                                                                   10,710.
MBTUS PRODUCED ANNUALLY BY THE HRI (CONSIDERING NO DOWNTIME):                                               6.93E+04
VIRGIN FUEL OFFSET ANNUALLY BY THE HRI IN BARRELS-OF-OIL-EQUIVALENT:                                        12,135.
LANDFILL SPACE CONSERVED ANNUALLY BY THE HRI IN TONS:                                                        5,891.


COST OF USING A BOILER TO PRODUCE THE ANNUAL NO-DOWNTIME QUANTITY OF STEAM PRODUCED BY THE HRI AND LANDFIL-
   LING ALL WASTE:                                                                                         $1,051,810.
INFLATED TOTAL CAPITAL COST OF THE HRI (INCLUDES EQUIPMENT, SUPPORT FACILITIES, AND CONSTRUCTION AND SETUP): $2,552,560.
UNIFORM ANNUAL COST OF THE HRI (THE COST OF CAPITAL, MODIFICATIONS, LABOR, CONSUMABLES, RESIDUE DISPOSAL,
   DOWNTIME, AND OTHER COSTS SPREAD OVER THE ECONOMIC LIFE OF THE HRI):                                     $827,056.
ANNUAL NO-DOWNTIME COST OF THE HRI (THE TOTAL OF NO-DOWNTIME COSTS SPREAD OVER THE ECONOMIC LIFE OF THE HRI): $780,701.


DISCOUNTED LIFE CYCLE COST OF USING A BOILER TO PRODUCE THE LIFE CYCLE NO-DOWNTIME QUANTITY OF STEAM PRODUCED
   BY THE HRI AND LANDFILLING ALL WASTE (COSTS DISCOUNTED TO THE POINT OF INITIAL FUNDING):                 $9,001,990.
DISCOUNTED LIFE CYCLE COST OF THE HRI:                                                                     $4,791,460.
DISCOUNTED LIFE CYCLE COST OF AUXILIARY FUELS USED BY THE HRI:                                                 $6,710.
DISCOUNTED LIFE CYCLE COST OF NONCOMBUSTIBLE WASTE, ASH, AND SCHEDULED DOWNTIME WASTE DISPOSAL:            $1,076,780.
DISCOUNTED LIFE CYCLE COST OF HRI DOWNTIME:                                                                  $348,042.


DISCOUNTED LIFE CYCLE COST OF THE HRI PER TON OF WASTE FIRED:                                               $29.83
DISCOUNTED LIFE CYCLE SAVINGS OF THE HRI PER TON OF WASTE FIRED:                                            $37.92
DISCOUNTED LIFE CYCLE COST OF THE HRI PER MBTU PRODUCED:                                                     $5.42
DISCOUNTED LIFE CYCLE SAVINGS OF THE HRI PER MBTU PRODUCED:                                                  $6.89


DISCOUNTED LIFE CYCLE SAVINGS OF THE HRI:                                                                  $6,091,220.
HRI SAVINGS-TO-INVESTMENT RATIO:                                                                           +3.24
PAYBACK PERIOD IN YEARS (INCLUDES PROJECT LEAD TIME):                                                      8.7
```

Appendix C

SYSTEM MANUAL FOR THE HEAT RECOVERY INCINERATOR (HRI) MODEL

```
5 PRINT "THE FOUR MAIN PROGRAMS COMPRISING THE HRI MODEL WILL NOW SUCCESSIVELY BE"
6 PRINT "LOADED INTO THE COMPUTER AND RUN.  PLEASE DO NOT TOUCH THE KEYBOARD."
10 DIM LEAD AE PCT(5),  LEAD CAP PCT(5)
20 DIM COST MOD(10),  COST MOD INF(10),  YEAR MOD(10), COST MOD AE INF(10), COST MOD TOT INF(10)
30 DIM CHEM$(6),  CHEM UNITS PER GAL(6),  CHEM COST PER UNIT(6), CHEM COST PER UNIT INF(6),  CHEM COST TOT(6),  CHEM COST TOT INF(6)
40 DIM  OTHER$(12),  COST OTHER ANNUAL(12),  COST OTHER ANNUAL INF(12),  OTHER COST PROJ YR(12),  COST OTHER ONETIME(12),  COST OTHE
R ONETIME INF(12),  OTHER TYPE COST$(12),  OTHER YR DOLL%(12)
41 DIM SINGLE(30),  CUM(30)
42 DIM SINGLE ENERGY DIFF(30),  CUM ENERGY DIFF(30)
43 DIM SINGLE LANDFILL DIFF(30), CUM LANDFILL DIFF(30)
44 DIM COST OTHER INF(12), DIS LC COST OTHER(12)
45 DIM SIR COST HRI ENERGY(30), SIR COST HRI LANDFILL(30), SIR COST HRI OTHER(30)
46 DIM DIS ENERGY SAVINGS(30), DIS LANDFILL SAVINGS(30), DIS OTHER SAVINGS(30), DIS TOT SAVINGS(30)
47 DIM EQ(15), SUPP(4), OP HR(3), OP RATE(3), OP TOT(3), PMAINT HR(3), PMAINT RATE(3), PMAINT TOT(3), TRASH IN STORAGE NORMAL(7)
50 OPEN "I",#1,"B WORKFILE.TXT"
55 INPUT#1,X,ANALYSIS MONTH%,X$,X,ANALYSIS YEAR%,X$,X,NEAR TERM MONTHS%,X$,X,CAP INF RATE,X$,X,ENERGY INF RATE,X$,X,LANDFILL INF RAT
E,X$,X,OTHER INF RATE,X$
60 FOR I=1 TO 5
65 INPUT#1,X,LEAD AE PCT(I),X$
70 NEXT I
72 FOR I=1 TO 5
73 INPUT#1,X,LEAD CAP PCT(I),X$
74 NEXT I
75 INPUT#1,X,ECON LIFE,X$,X,ENERGY DIFF INF PCT,X$,X,LANDFILL DIFF INF PCT,X$,X,EQP YR DOLL%,X$
80 FOR I=1 TO 15
85 INPUT#1,X,EQ(I),X$
90 NEXT I
95 INPUT#1,X,COST EQP TOT,X$
100 IF COST EQP TOT <> 0 THEN GOTO 120
105 FOR I=1 TO 15
110 COST EQP TOT=COST EQP TOT + EQ(I)
115 NEXT I
120 INPUT#1,X,SUPP YR DOLL%,X$
125 FOR I=1 TO 4
130 INPUT#1,X,SUPP(I),X$
135 NEXT I
140 INPUT#1,X,COST SUPP TOT,X$
145 IF COST SUPP TOT <> 0 THEN GOTO 165
150 FOR I=1 TO 4
155 COST SUPP TOT=COST SUPP TOT + SUPP(I)
160 NEXT I
165 INPUT#1,X,CONST YR DOLL%,X$,X,COST CONST TOT,X$,X,MOD YR DOLL%,X$
168 FOR I=1 TO 10
170 INPUT#1,X,X,X$,X,COST MOD(I),X$,X,YEAR MOD(I),X$
172 NEXT I
174 INPUT#1,X,AE SERVICES PCT,X$,X,LABOR YR DOLL%,X$
176 FOR I=1 TO 3
178 INPUT#1,X,OP HR(I),X$,X,OP RATE(I),X$,X,OP TOT(I),X$
180 NEXT I
182 INPUT#1,X,COST OP LABOR TOT,X$
184 IF COST OP LABOR TOT <> 0 THEN GOTO 196
186 FOR I=1 TO 3
188 IF OP TOT(I) <> 0 THEN GOTO 192
190 OP TOT(I) = OP HR(I) * OP RATE(I)
192 COST OP LABOR TOT = COST OP LABOR TOT + OP TOT(I)
194 NEXT I
195 GOTO 200
196 COST DOWN OP LABOR TOT = COST OP LABOR TOT
200 FOR I=1 TO 3
210 INPUT#1,X,PMAINT HR(I),X$,X,PMAINT RATE(I),X$,X,PMAINT TOT(I),X$
```

```
220 NEXT I
230 INPUT#1,X,COST PMAINT LABOR TOT,X$
240 IF COST PMAINT LABOR TOT <> 0 THEN GOTO 300
250 FOR I=1 TO 3
260 IF PMAINT TOT(I) <> 0 THEN GOTO 280
270 PMAINT TOT(I) = PMAINT HR(I) * PMAINT RATE(I)
280 COST PMAINT LABOR TOT = COST PMAINT LABOR TOT + PMAINT TOT(I)
290 NEXT I
300 INPUT#1,X,SUPER CMAINT MHR,X$,X,SUPER CMAINT LABOR RATE,X$,X,SKILL CMAINT MHR,X$,X,SKILL CMAINT LABOR RATE,X$,X,UNSKIL CMAINT MH
R,X$,X,UNSKIL CMAINT LABOR RATE,X$
310 INPUT#1,X,CONSUM YR DOLL%,X$,X,KWH PER OP HR,X$,X,COST PER KWH,X$,X,KWH PER DOWN HR PCT,X$,X,KWH PER SCHED NONOP HR PCT,X$
320 INPUT#1,X,OFFSET LIQ GAL TON,X$,X,OFFSET LIQ COST GAL,X$,X,OFFSET LIQ BTU GAL,X$,X,LIQ GAL TON,X$,X,LIQ COST GAL,X$,X,LIQ BTU GA
L,X$,X,OFFSET GAS CF TON,X$,X,OFFSET GAS COST CF,X$,X,OFFSET GAS BTU CF,X$,X,GAS CF TON,X$,X,GAS COST CF,X$
330 INPUT#1,X,GAS BTU CF,X$,X,WATER GAL PER TON,X$,X,WATER COST PER GAL,X$,X,COST WATER TOT,X$
340 INPUT#1,X,OFFSET SOL1 TON TON,X$,X,OFFSET SOL1 COST TON,X$,X,OFFSET SOL1 BTU TON,X$,X,SOL1 TON TON,X$,X,SOL1 COST TON,X$,X,SOL1
BTU TON,X$,X,OFFSET SOL2 TON TON,X$,X,OFFSET SOL2 COST TON,X$,X,OFFSET SOL2 BTU TON,X$,X,SOL2 TON TON,X$
350 INPUT#1,X,SOL2 COST TON,X$,X,SOL2 BTU TON,X$
360 FOR I=1 TO 2
370 INPUT#1,X,X,X$,X,CHEM UNITS PER GAL(I),X$,X,CHEM COST PER UNIT(I),X$,X,CHEM COST TOT(I),X$
380 NEXT I
390 INPUT#1,X,COST CHEMICALS TOT,X$,X,COST REPAIRPARTS TOT,X$,X,REPAIRPARTS YR DOLL%,X$,X,COST SEWER TOT,X$,X,SEWER YR DOLL%,X$,X,CO
ST INSUR TOT,X$,X,INSUR YR DOLL%,X$,X,COST PEST TOT,X$,X,PEST YR DOLL%,X$
400 INPUT#1,X,RESIDUEDISP YR DOLL%,X$,X,COST TRANS NONBURN PER TONMILE,X$,X,MILES NONBURN FILL,X$,X,TIPFEE NONBURN PER TON,X$,X,COST
 NONBURNFILL PER TON,X$
410 INPUT#1,X,COST TRANS ASH PER TONMILE,X$,X,MILES ASH FILL,X$,X,TIPFEE ASH PER TON,X$,X,COST ASHFILL PER TON,X$
420 INPUT#1,X,COST TRANS ALLWASTE PER TONMILE,X$,X,MILES ALLWASTE FILL,X$,X,TIPFEE ALLWASTE PER TON,X$,X,COST ALLWASTE PER TON,X$
430 FOR I=1 TO 10
440 INPUT#1,X,X,X$,X,COST OTHER ANNUAL(I),X$,X,OTHER COST PROJ YR(I),X$,X,COST OTHER ONETIME(I),X$,X,X,OTHER TYPE COST$(I),X,OTHER Y
R DOLL%(I),X$
450 NEXT I
460 INPUT#1,X,TONS NONBURN PER TON,X$,X,TURN UP PCT,X$,X,WASTE BURN PER HR,X$,X,ASH PER TON BURN,X$,X,COST PER BOILER MBTU,X$,X,BOIL
ER MBTU YR DOLL%,X$
470 INPUT#1,X,EFFICIENCY BOILER,X$,X,HEAT VAL BURN WASTE,X$,X,NUM BURN WEEKS,  ,X,EFFICIENCY HRI,X$,X,ANN DOWNTIME PCT,X$,X,NUMBER O
F FAILURES,X$,X,MAX REPAIR TIME,X$
480 INPUT#1,X,X,FURNACE TYPE$,X,TIME FOR DAYS DELIVERY,X$,X,STORAGE SPACE,X$,X,OP DOWN PCT(1),X$,X,OP DOWN PCT(2),X$,X,OP DOWN PCT(3
),X$
490 INPUT#1,X,DISCOUNT PCT,X$,X,CAP TOT YR DOLL%,X$,X,COST CAP TOT,X$,X,COST CMAINT LABOR TOT,X$,X,OP SCENARIO,X$
500 CLOSE #1
510 GOSUB 570    REM   IDENTIFY INITIAL FUNDING DATE
520 GOSUB 630      REM  IDENTIFY ANNUAL HOUR TOTALS
530 GOSUB 740    REM   INFLATE ALL COSTS TO POINT OF INITIAL FUNDING
540 GOSUB 2650   REM  CALCULATE DISCOUNT TABLES
550 CHAIN "HRIMOD3 BAS",,ALL
560 REM
570 REM  IDENTIFY INITIAL FUNDING DATE
580 INIT FUND YEAR%=INT((ANALYSIS MONTH% + NEAR TERM MONTHS%)/12) + ANALYSIS YEAR%
590 INIT FUND MONTH% = ANALYSIS MONTH% + NEAR TERM MONTHS% - INT((ANALYSIS MONTH% + NEAR TERM MONTHS%)/12) * 12
600 RETURN
610 REM
620 REM  IDENTIFY ANNUAL HOUR TOTALS
630 IF OP SCENARIO > 4 OR OP SCENARIO < 1 THEN GOTO 660
640 IF OP SCENARIO=1 THEN DAILY BURN TIME=16   NUM BURN DAYS=5 ELSE IF OP SCENARIO=2 THEN DAILY BURN TIME=24   NUM BURN DAYS=5 ELSE
IF OP SCENARIO=3 THEN DAILY BURN TIME=16   NUM BURN DAYS=7 ELSE IF OP SCENARIO=4 THEN DAILY BURN TIME=24   NUM BURN DAYS=7
650 GOTO 670
660 IF OP SCENARIO=5 THEN DAILY BURN TIME=24   NUM BURN DAYS=4 ELSE DAILY BURN TIME=24   NUM BURN DAYS=5
670 PLANNED OP HRS = DAILY BURN TIME * NUM BURN DAYS * NUM BURN WEEKS
680 DOWN HOURS = PLANNED OP HRS * ANN DOWNTIME PCT/100
690 UP HOURS = PLANNED OP HRS - DOWN HOURS
700 SCHED NONOP HOURS = 8760 - PLANNED OP HRS
720 RETURN
```

```
730 REM
740 REM  INFLATE ALL COSTS TO POINT OF INITIAL FUNDING
750 REM
760 REM  INFLATE CAPITAL COSTS
770 DEF FNINFLATE(COST,RATE,YEARS DIFF)=COST*(1+RATE/100)^YEARS DIFF
780 IF COST CAP TOT=0 THEN GOTO 850
790 YR DOLL%=CAP TOT YR DOLL%
800 GOSUB 2600
810 COST=COST CAP TOT
820 RATE=CAP INF RATE
830 COST CAP TOT INF=FNINFLATE(COST,RATE,YEARS DIFF)
840 GOTO 1020
850 YR DOLL%=EQP YR DOLL%
860 YEARS DIFF=0
870 GOSUB 2600
880 COST=COST EQP TOT
890 RATE=CAP INF RATE
900 COST EQP TOT INF=FNINFLATE(COST,RATE,YEARS DIFF)
910 YEARS DIFF=0
920 YR DOLL%=SUPP YR DOLL%
930 GOSUB 2600
940 COST=COST SUPP TOT
950 COST SUPP TOT INF=FNINFLATE(COST,RATE,YEARS DIFF)
960 YEARS DIFF=0
970 YR DOLL%=CONST YR DOLL%
980 GOSUB 2600
990 COST=COST CONST TOT
1000 COST CONST TOT INF=FNINFLATE(COST,RATE,YEARS DIFF)
1010 COST CAP TOT INF = COST EQP TOT INF + COST SUPP TOT INF + COST CONST TOT INF
1020 YEARS DIFF=0
1030 YR DOLL%=MOD YR DOLL%
1040 GOSUB 2600
1050 FOR I=1 TO 10
1060 IF COST MOD(I)=0 THEN  GOTO 1140
1070 COST=COST MOD(I)
1080 RATE=CAP INF RATE
1090 COST MOD INF(I)=FNINFLATE(COST,RATE,YEARS DIFF)
1100 COST=COST MOD(I) * AE SERVICES PCT/100
1110 RATE=OTHER INF RATE
1120 COST MOD AE INF(I)=FNINFLATE(COST,RATE,YEARS DIFF)
1130 COST MOD TOT INF(I)=COST MOD INF(I) + COST MOD AE INF(I)
1140 NEXT I
1150 YEARS DIFF=0
1160 COST AE SERVICES INF=COST CAP TOT INF*(AE SERVICES PCT/100)
1170 REM
1180 REM  INFLATE LABOR COSTS
1190 YR DOLL%=LABOR YR DOLL%
1200 GOSUB 2600
1210 COST=COST OP LABOR TOT
1220 RATE=OTHER INF RATE
1230 COST OP LABOR TOT INF=FNINFLATE(COST,RATE,YEARS DIFF)
1250 IF COST DOWN OP LABOR TOT <> 0 THEN GOTO 1320
1260 FOR I=1 TO 3
1270 DOWN OP TOT(I) = OP TOT(I) / PLANNED OP HRS * UP HOURS
1280 COST DOWN OP LABOR TOT = COST DOWN OP LABOR TOT + DOWN OP TOT(I)
1290 OP CMAINT(I) = (OP TOT(I) - DOWN OP TOT(I)) * (OP DOWN PCT(I)/100)
1300 OP CMAINT TOT = OP CMAINT TOT + OP CMAINT(I)
1310 NEXT I
1320 COST = COST DOWN OP LABOR TOT
1330 COST DOWN OP LABOR TOT INF = FNINFLATE(COST,RATE,YEARS DIFF)
```

```
1350 COST=COST PMAINT LABOR TOT
1360 COST PMAINT LABOR TOT INF=FNINFLATE(COST,RATE,YEARS DIFF)
1370 IF COST CMAINT LABOR TOT <> 0 THEN GOTO 1390
1380 COST CMAINT LABOR TOT = (SUPER CMAINT MHR * SUPER CMAINT LABOR RATE + SKILL CMAINT MHR * SKILL CMAINT LABOR RATE + UNSKIL CMAIN
T MHR * UNSKIL CMAINT LABOR RATE) * DOWN HOURS
1390 COST CMAINT LABOR TOT = COST CMAINT LABOR TOT + OP CMAINT TOT
1400 COST=COST CMAINT LABOR TOT
1410 COST CMAINT LABOR TOT INF=FNINFLATE(COST,RATE,YEARS DIFF)
1430 YEARS DIFF=0
1440 REM
1450 REM  INFLATE COSTS OF ELECTRICITY AND FOSSIL FUELS
1460 YR DOLL%=CONSUM YR DOLL%
1470 GOSUB 2600
1480 COST=COST PER KWH
1490 RATE=ENERGY INF RATE
1500 COST PER KWH INF=FNINFLATE(COST,RATE,YEARS DIFF)
1510 COST=LIQ COST GAL    LIQ COST GAL INF=FNINFLATE(COST,RATE,YEARS DIFF)
1520 COST=GAS COST CF    GAS COST CF INF=FNINFLATE(COST,RATE,YEARS DIFF)
1530 COST=SOL1 COST TON    SOL1 COST TON INF=FNINFLATE(COST,RATE,YEARS DIFF)
1540 COST=SOL2 COST TON    SOL2 COST TON INF=FNINFLATE(COST,RATE,YEARS DIFF)
1550 RATE=OTHER INF RATE
1560 COST=OFFSET LIQ COST GAL    OFFSET LIQ COST GAL INF=FNINFLATE(COST,RATE,YEARS DIFF)
1570 COST=OFFSET GAS COST CF    OFFSET GAS COST CF INF=FNINFLATE(COST,RATE,YEARS DIFF)
1580 COST=OFFSET SOL1 COST TON    OFFSET SOL1 COST TON INF=FNINFLATE(COST,RATE,YEARS DIFF)
1590 COST=OFFSET SOL2 COST TON    OFFSET SOL2 COST TON INF=FNINFLATE(COST,RATE,YEARS DIFF)
1600 REM
1610 REM INFLATE COST OF WATER
1620 IF COST WATER TOT <> 0 THEN GOTO 1660
1630 COST=WATER COST PER GAL
1640 WATER COST PER GAL INF=FNINFLATE(COST,RATE,YEARS DIFF)
1650 GOTO 1700
1660 COST=COST WATER TOT
1670 COST WATER TOT INF=FNINFLATE(COST,RATE,YEARS DIFF)
1680 REM
1690 REM  INFLATE COST OF CHEMICALS
1700 IF COST CHEMICALS TOT<>0 THEN GOTO 1800
1710 FOR I=1 TO 2
1720 IF CHEM COST TOT(I)<>0 THEN GOTO 1760
1730 COST=CHEM COST PER UNIT(I)
1740 CHEM COST PER UNIT INF(I)=FNINFLATE(COST,RATE,YEARS DIFF)
1750 GOTO 1780
1760 COST=CHEM COST TOT(I)
1770 CHEM COST TOT INF(I)=FNINFLATE(COST,RATE,YEARS DIFF)
1780 NEXT I
1790 GOTO 1820
1800 COST=COST CHEMICALS TOT
1810 COST CHEMICALS TOT INF=FNINFLATE(COST,RATE,YEARS DIFF)
1820 YEARS DIFF=0
1830 REM
1840 REM INFLATE COSTS OF REPAIR PARTS AND SEWER
1850 YR DOLL%=REPAIRPARTS YR DOLL%
1860 GOSUB 2600
1870 COST=COST REPAIRPARTS TOT
1880 COST REPAIRPARTS TOT INF=FNINFLATE(COST,RATE,YEARS DIFF)
1890 YEARS DIFF=0
1900 YR DOLL%=SEWER YR DOLL%
1910 GOSUB 2600
1920 COST=COST SEWER TOT
1930 COST SEWER TOT INF=FNINFLATE(COST,RATE,YEARS DIFF)
1940 YEARS DIFF=0
```

```
1950 REM
1960 REM  INFLATE COST OF RESIDUE DISPOSAL
1970 YR DOLL%=RESIDUEDISP YR DOLL%
1980 GOSUB 2600
1990 RATE=LANDFILL INF RATE
2000 IF COST NONBURNFILL PER TON <> 0 THEN GOTO 2060
2010 COST=COST TRANS NONBURN PER TONMILE
2020 COST TRANS NONBURN PER TONMILE INF=FNINFLATE(COST,RATE,YEARS DIFF)
2030 COST=TIPFEE NONBURN PER TON
2040 TIPFEE NONBURN PER TON INF=FNINFLATE(COST,RATE,YEARS DIFF)
2050 GOTO 2080
2060 COST=COST NONBURNFILL PER TON
2070 COST NONBURNFILL PER TON INF=FNINFLATE(COST,RATE,YEARS DIFF)
2080 IF COST ASHFILL PER TON <> 0 THEN GOTO 2140
2090 COST=COST TRANS ASH PER TONMILE
2100 COST TRANS ASH PER TONMILE INF=FNINFLATE(COST,RATE,YEARS DIFF)
2110 COST=TIPFEE ASH PER TON
2120 TIPFEE ASH PER TON INF=FNINFLATE(COST,RATE,YEARS DIFF)
2130 GOTO 2160
2140 COST=COST ASHFILL PER TON
2150 COST ASHFILL PER TON INF=FNINFLATE(COST,RATE,YEARS DIFF)
2160 IF COST ALLWASTE PER TON <> 0 THEN GOTO 2220
2170 COST=COST TRANS ALLWASTE PER TONMILE
2180 COST TRANS ALLWASTE PER TONMILE INF=FNINFLATE(COST,RATE,YEARS DIFF)
2190 COST=TIPFEE ALLWASTE PER TON
2200 TIPFEE ALLWASTE PER TON INF=FNINFLATE(COST,RATE,YEARS DIFF)
2210 GOTO 2240
2220 COST=COST ALLWASTE PER TON
2230 COST ALLWASTE PER TON INF=FNINFLATE(COST,RATE,YEARS DIFF)
2240 YEARS DIFF=0
2250 REM
2260 REM  INFLATE COSTS OF INSURANCE AND PEST CONTROL
2270 YR DOLL%=INSUR YR DOLL%
2280 GOSUB 2600
2290 RATE=OTHER INF RATE
2300 COST=COST INSUR TOT
2310 COST INSUR TOT INF=FNINFLATE(COST,RATE,YEARS DIFF)
2320 YEARS DIFF=0
2330 YR DOLL%=PEST YR DOLL%
2340 GOSUB 2600
2350 COST=COST PEST TOT
2360 COST PEST TOT INF=FNINFLATE(COST,RATE,YEARS DIFF)
2370 YEARS DIFF=0
2380 REM
2390 REM  INFLATE COSTS OF OTHER EXPENDITURES
2400 FOR I=1 TO 10
2410 IF COST OTHER ANNUAL(I)=0 AND COST OTHER ONETIME(I)=0 THEN GOTO 2470
2420 YR DOLL%=OTHER YR DOLL%(I)
2430 GOSUB 2600
2440 IF COST OTHER ANNUAL(I)<>0 THEN COST=COST OTHER ANNUAL(I) ELSE COST=COST OTHER ONETIME(I)
2450 IF OTHER TYPE COST$(I)="C" THEN RATE=CAP INF RATE ELSE IF OTHER TYPE COST$(I)="E" THEN RATE=ENERGY INF RATE ELSE IF OTHER TYPE
COST$(I)="L" THEN RATE=LANDFILL INF RATE ELSE RATE=OTHER INF RATE
2460 COST OTHER INF(I)=FNINFLATE(COST,RATE,YEARS DIFF)
2470 NEXT I
2480 YEARS DIFF=0
2490 REM
2500 REM  INFLATE COST OF MBTUS FOR BOILER
2510 YR DOLL%=BOILER MBTU YR DOLL%
2520 GOSUB 2600
2530 RATE=ENERGY INF RATE
```

```
2540 COST=COST PER BOILER MBTU
2550 COST PER BOILER MBTU INF=FNINFLATE(COST,RATE,YEARS DIFF)
2560 YEARS DIFF=0
2570 RETURN
2580 REM
2590 REM  IDENTIFY NUMBER OF YEARS BETWEEN YEAR-DOLLAR ENTERED AND POINT OF INITIAL FUNDING
2600 MONTHS DIFF%=INIT FUND MONTH% - 6
2605 IF YR DOLL% <= 0 OR YR DOLL% > ANALYSIS YEAR% THEN YR DOLL% = ANALYSIS YEAR%
2610 YEARS DIFF = ((INIT FUND YEAR% - YR DOLL%) * 12 + MONTHS DIFF%) / 12
2620 RETURN
2630 REM
2640 REM  CALCULATE DISCOUNT TABLES
2650 GOSUB 2710
2660 DEF FNPOS SINGLE DIFF(DISCOUNT RATE,RATE,I)=(((1+RATE)/(1+DISCOUNT RATE))^I + ((1+RATE)/(1+DISCOUNT RATE))^(I-1))/2
2670 DEF FNNEG SINGLE DIFF(DISCOUNT RATE,RATE,I)=((1/((1+DISCOUNT RATE)+RATE))^I + (1/((1+DISCOUNT RATE)+RATE))^(I-1))/2
2680 IF ENERGY DIFF INF PCT=0 THEN GOSUB 2780 ELSE IF ENERGY DIFF INF PCT>0 THEN GOSUB 2830 ELSE IF ENERGY DIFF INF PCT<0 THEN GOSUB
 2890
2690 IF LANDFILL DIFF INF PCT=0 THEN GOSUB 2950 ELSE IF LANDFILL DIFF INF PCT>0 THEN GOSUB 3000 ELSE IF LANDFILL DIFF INF PCT<0 THEN
 GOSUB 3060
2700 RETURN
2710 FOR I=1 TO 30
2720 IF DISCOUNT PCT=0 THEN DISCOUNT PCT=10
2730 DISCOUNT RATE = DISCOUNT PCT/100
2740 SINGLE(I)=((1/(1+DISCOUNT RATE))^I + (1/(1+DISCOUNT RATE))^(I-1))/2
2750 CUM(I)=SINGLE(I) + CUM(I-1)
2760 NEXT I
2770 RETURN
2780 FOR I=1 TO 30
2790 SINGLE ENERGY DIFF(I)=SINGLE(I)
2800 CUM ENERGY DIFF(I)=SINGLE ENERGY DIFF(I) + CUM ENERGY DIFF(I-1)
2810 NEXT I
2820 RETURN
2830 RATE=ENERGY DIFF INF PCT/100
2840 FOR I=1 TO 30
2850 SINGLE ENERGY DIFF(I)=FNPOS SINGLE DIFF(DISCOUNT RATE,RATE,I)
2860 CUM ENERGY DIFF(I)=SINGLE ENERGY DIFF(I) + CUM ENERGY DIFF(I-1)
2870 NEXT I
2880 RETURN
2890 RATE=ABS(ENERGY DIFF INF PCT/100)
2900 FOR I=1 TO 30
2910 SINGLE ENERGY DIFF(I)=FNNEG SINGLE DIFF(DISCOUNT RATE,RATE,I)
2920 CUM ENERGY DIFF(I)=SINGLE ENERGY DIFF(I) + CUM ENERGY DIFF(I-1)
2930 NEXT I
2940 RETURN
2950 FOR I=1 TO 30
2960 SINGLE LANDFILL DIFF(I)=SINGLE(I)
2970 CUM LANDFILL DIFF(I)=SINGLE LANDFILL DIFF(I) + CUM LANDFILL DIFF(I-1)
2980 NEXT I
2990 RETURN
3000 RATE=LANDFILL DIFF INF PCT/100
3010 FOR I=1 TO 30
3020 SINGLE LANDFILL DIFF(I)=FNPOS SINGLE DIFF(DISCOUNT RATE,RATE,I)
3030 CUM LANDFILL DIFF(I)=SINGLE LANDFILL DIFF(I) + CUM LANDFILL DIFF(I-1)
3040 NEXT I
3050 RETURN
3060 RATE=ABS(LANDFILL DIFF INF PCT/100)
3070 FOR I=1 TO 30
3080 SINGLE LANDFILL DIFF(I)=FNNEG SINGLE DIFF(DISCOUNT RATE,RATE,I)
3090 CUM LANDFILL DIFF(I)=SINGLE LANDFILL DIFF(I) + CUM LANDFILL DIFF(I-1)
3100 NEXT I
3110 RETURN
```

```
20 REM  THIS IS HRIMOD3 BAS
25 GOSUB 52   REM  IDENTIFY LEAD TIME
30 GOSUB 60   REM  IDENTIFY REHEATING COSTS
40 GOSUB 720   REM  IDENTIFY ANNUAL TONS OF TRASH BURNED
50 CHAIN "HRIMOD1 BAS",,ALL
52 REM
53 REM  IDENTIFY LEAD TIME
54 FOR I=1 TO 5
55 IF LEAD AE PCT(I)<>0 OR LEAD CAP PCT(I)<>0 THEN LEAD=I
56 NEXT I
57 RETURN
60 REM
70 REM  IDENTIFY REHEATING COSTS
100 IF FURNACE TYPE$ = "R" THEN TC=20 ELSE TC=12
110 REHEAT OFFSET FUEL BTU TON LOST = (OFFSET LIQ GAL TON * OFFSET LIQ BTU GAL) ^  667 + (OFFSET GAS CF TON * OFFSET GAS BTU CF) ^
667 + (OFFSET SOL1 TON TON * OFFSET SOL1 BTU TON) ^  667 + (OFFSET SOL2 TON TON * OFFSET SOL2 BTU TON) ^  667
120 REHEAT FUEL BTU TON LOST = (LIQ GAL TON * LIQ BTU GAL) ^  667 + (GAS CF TON * GAS BTU CF) ^  667 + (SOL1 TON TON * SOL1 BTU TON)
 ^  667 + (SOL2 TON TON * SOL2 BTU TON) ^  667
150 FUEL FOR ONE LONG DOWN = (1 5 * WASTE BURN PER HR) * (HEAT VAL BURN WASTE ^  667 + REHEAT OFFSET FUEL BTU TON LOST + REHEAT FUEL
 BTU TON LOST)
165 AVE REPAIR TIME = DOWN HOURS / NUMBER OF FAILURES
170 IF DAILY BURN TIME = 16 THEN GOSUB 680 ELSE GOSUB 200
172 COST ALL REHEATS = FUEL ALL REHEATS * (EFFICIENCY HRI/100) * COST PER BOILER MBTU INF *  000001
176 DIS LC COST ALL REHEATS = COST ALL REHEATS * (CUM ENERGY DIFF(LEAD+ECON LIFE) - CUM ENERGY DIFF(LEAD))
180 RETURN
200 MEAN1 = (-5 41205 + 2*LOG(MAX REPAIR TIME) + SQR((5 41205 - 2*LOG(MAX REPAIR TIME))^2 - 4*(LOG(MAX REPAIR TIME)^2) + 21 6482*LOG
(AVE REPAIR TIME))) / 2
220 MEAN2 = (-5 41205 + 2*LOG(MAX REPAIR TIME) - SQR((5 41205 - 2*LOG(MAX REPAIR TIME))^2 - 4*(LOG(MAX REPAIR TIME)^2) + 21 6482*LOG
(AVE REPAIR TIME))) / 2
240 IF MEAN1 >= MEAN2 THEN MEAN=MEAN1 ELSE MEAN=MEAN2
250 STD DEV = (LOG(MAX REPAIR TIME) - MEAN) / 1 645
260 Z SCORE = (LOG(TC) - MEAN) / STD DEV
280 IF Z SCORE <= 3 99 AND Z SCORE >= -3 99 THEN GOTO 360
290 IF Z SCORE < -3 99 THEN GOTO 330
295 TIME SHORT DOWNS = NUMBER OF FAILURES * 1 5 * EXP(MEAN)/TC
300 FUEL SHORT DOWNS = NUMBER OF FAILURES * FUEL FOR ONE LONG DOWN * EXP(MEAN) / TC
310 IF NUM BURN DAYS=4 OR NUM BURN DAYS=5 THEN TIME LONG DOWNS = 1 5 * NUM BURN WEEKS   FUEL LONG DOWNS = NUM BURN WEEKS * FUEL FOR
ONE LONG DOWN ELSE TIME LONG DOWNS = 0   FUEL LONG DOWNS = 0
320 GOTO 645
330 IF NUM BURN DAYS=4 OR NUM BURN DAYS=5 THEN FUEL LONG DOWNS = (NUM BURN WEEKS + NUMBER OF FAILURES) * FUEL FOR ONE LONG DOWN ELSE
 FUEL LONG DOWNS = NUMBER OF FAILURES * FUEL FOR ONE LONG DOWN
335 IF NUM BURN DAYS=4 OR NUM BURN DAYS=5 THEN TIME LONG DOWNS = (NUM BURN WEEKS + NUMBER OF FAILURES) * 1 5 ELSE TIME LONG DOWNS =
NUMBER OF FAILURES * 1 5
338 TIME SHORT DOWNS = 0
340 FUEL SHORT DOWNS = 0
350 GOTO 645
360 Z = INT(ABS(Z SCORE) * 100 +  5) + 1
380 OPEN "R",#2,"NORMAL2",6
390 FIELD #2, 6 AS ZPCT2$
400 GET #2, Z
410 ZPCT TABLE = CVS(ZPCT2$)
420 IF Z SCORE > 0 THEN PROB DOWN GT TC = ZPCT TABLE ELSE PROB DOWN GT TC = 1 - ZPCT TABLE
440 IF NUM BURN DAYS=4 OR NUM BURN DAYS=5 THEN LONG DOWNS = NUM BURN WEEKS + (PROB DOWN GT TC * NUMBER OF FAILURES) ELSE LONG DOWNS
= PROB DOWN GT TC * NUMBER OF FAILURES
445 TIME LONG DOWNS = 1 5 * LONG DOWNS
450 FUEL LONG DOWNS = LONG DOWNS * FUEL FOR ONE LONG DOWN
460 PROB DOWN LT TC = 1 - PROB DOWN GT TC
470 SHORT DOWNS = PROB DOWN LT TC * NUMBER OF FAILURES
480 I=1
490 GET #2, I
```

```
500 ZPCT TABLE LOW = CVS(ZPCT2$)
510 IF PROB DOWN LT TC/2 )= ZPCT TABLE LOW THEN GOTO 540
520 I=I+1
530 GOTO 490
540 GET #2, I-1
550 ZPCT TABLE HIGH = CVS(ZPCT2$)
560 IF ZPCT TABLE HIGH - PROB DOWN LT TC/2 (= PROB DOWN LT TC/2 - ZPCT TABLE LOW THEN MED TIME SHORT DOWN ZSCORE = -((I-1)/100 -  01
) ELSE MED TIME SHORT DOWN ZSCORE = -(I/100 -  01)
570 CLOSE #2
590 MED TIME SHORT DOWN LN = MED TIME SHORT DOWN ZSCORE * STD DEV + MEAN
600 MED TIME SHORT DOWN = EXP(MED TIME SHORT DOWN LN)
620 FUEL FOR ONE SHORT DOWN = FUEL FOR ONE LONG DOWN * MED TIME SHORT DOWN / TC
625 TIME SHORT DOWNS = SHORT DOWNS * 1 5 * MED TIME SHORT DOWN/TC
630 FUEL SHORT DOWNS = SHORT DOWNS * FUEL FOR ONE SHORT DOWN
645 TIME ALL REHEATS = TIME LONG DOWNS + TIME SHORT DOWNS
650 FUEL ALL REHEATS = FUEL LONG DOWNS + FUEL SHORT DOWNS
670 RETURN
680 FUEL FOR ONE SHORT DOWN = FUEL FOR ONE LONG DOWN * 8 / TC
690 IF NUM BURN DAYS=5 THEN FUEL ALL REHEATS=NUM BURN WEEKS * (4 * FUEL FOR ONE SHORT DOWN + FUEL FOR ONE LONG DOWN) ELSE FUEL ALL R
EHEATS = NUM BURN WEEKS * 7 * FUEL FOR ONE SHORT DOWN
695 IF NUM BURN DAYS = 5 THEN TIME ALL REHEATS = NUM BURN WEEKS * (4 * 1 5 * 8/TC + 1 5) ELSE TIME ALL REHEATS = NUM BURN WEEKS * 7
* 1 5 * 8/TC
710 RETURN
720 REM
730 REM  ANNUAL TONS OF TRASH BURNED
750 TURN UP RATE = (1 + TURN UP PCT/100) * WASTE BURN PER HR
760 IF TURN UP RATE > WASTE BURN PER HR + .001 THEN GOTO 800
770 TOTAL TONS LOST = DOWN HOURS * WASTE BURN PER HR
780 TOTAL TURN UP TIME = 0
790 GOTO 830
800 WASTE PER WEEK = NUM BURN DAYS * DAILY BURN TIME * WASTE BURN PER HR
810 BURNABLE INPUT RATE = WASTE PER WEEK / 5 / TIME FOR DAYS DELIVERY
820 IF NUM BURN DAYS = 4 THEN GOSUB 1720 ELSE GOSUB 850
830 ANN TRASH BURNED = PLANNED OP HRS * WASTE BURN PER HR - TOTAL TONS LOST
840 RETURN
850 IF NUM BURN DAYS = 5 THEN DAILY ADDITIONAL = 0 ELSE DAILY ADDITIONAL = WASTE PER WEEK * 2 / 35
860 FOR I=0 TO 7 : TRASH IN STORAGE NORMAL(I)=0 : NEXT I
870 IF NUM BURN DAYS=5 THEN GOTO 940
880 FOR I=1 TO 5
890 TRASH IN STORAGE NORMAL(I) = TRASH IN STORAGE NORMAL(I-1) + DAILY ADDITIONAL
900 NEXT I
910 FOR I=6 TO 7
920 TRASH IN STORAGE NORMAL(I) = TRASH IN STORAGE NORMAL(I-1) - DAILY BURN TIME * WASTE BURN PER HR
930 NEXT I
940 PROB OF FAIL DURING RECEIPT = TIME FOR DAYS DELIVERY / (NUM BURN DAYS * DAILY BURN TIME)
950 PROB OF FAIL DURING BURN = (DAILY BURN TIME - TIME FOR DAYS DELIVERY) / (NUM BURN DAYS * DAILY BURN TIME)
960 IF NUM BURN DAYS=5 THEN PROB OF FAIL DURING BURN ONLY = 0 ELSE PROB OF FAIL DURING BURN ONLY = 1/7
970 BURN FLAG$="NO"   BURN ONLY FLAG$="NO"
980 RCPT ONE FAILURE TONS LOST=0   RCPT ONE FAILURE TURN UP TIME=0 : BURN ONE FAILURE TONS LOST=0   BURN ONE FAILURE TURN UP TIME=0
: BURN ONLY ONE FAILURE TONS LOST=0   BURN ONLY ONE FAILURE TURN UP TIME=0
990 FOR J=1 TO 5
1000 GOSUB 1240
1020 RCPT ONE FAILURE TONS LOST = RCPT ONE FAILURE TONS LOST + (TONS LOST * PROB OF FAIL DURING RECEIPT)
1030 RCPT ONE FAILURE TURN UP TIME = RCPT ONE FAILURE TURN UP TIME + (TIME AT TURN UP RATE * PROB OF FAIL DURING RECEIPT)
1040 NEXT J
1050 FOR J=1 TO 5
1060 BURN FLAG$="YES"
1070 GOSUB 1240
1090 BURN ONE FAILURE TONS LOST = BURN ONE FAILURE TONS LOST + (TONS LOST * PROB OF FAIL DURING BURN)
1100 BURN ONE FAILURE TURN UP TIME = BURN ONE FAILURE TURN UP TIME + (TIME AT TURN UP RATE * PROB OF FAIL DURING BURN)
```

```
1110 NEXT J
1120 IF NUM BURN DAYS = 5 THEN GOTO 1200
1130 FOR J=6 TO 7
1140 BURN ONLY FLAG$="YES"
1150 GOSUB 1240
1170 BURN ONLY ONE FAILURE TONS LOST = BURN ONLY ONE FAILURE TONS LOST + (TONS LOST * PROB OF FAIL DURING BURN ONLY)
1180 BURN ONLY ONE FAILURE TURN UP TIME = BURN ONLY ONE FAILURE TURN UP TIME + (TIME AT TURN UP RATE * PROB OF FAIL DURING BURN ONLY
)
1190 NEXT J
1200 TOTAL TONS LOST = (RCPT ONE FAILURE TONS LOST + BURN ONE FAILURE TONS LOST + BURN ONLY ONE FAILURE TONS LOST) * NUMBER OF FAILU
RES
1210 TOTAL TURN UP TIME = (RCPT ONE FAILURE TURN UP TIME + BURN ONE FAILURE TURN UP TIME + BURN ONLY ONE FAILURE TURN UP TIME) * NUM
BER OF FAILURES
1230 RETURN
1240 TONS LOST=0   TIME SINCE FAILURE=0   LOSING TONS=1   TIME AT TURN UP RATE=0
1250 IF NUM BURN DAYS = 5 THEN GOTO 1280 ELSE IF J<>1 THEN GOTO 1280
1260 IF BURN FLAG$="NO" THEN STORAGE REQUIREMENT = TRASH IN STORAGE NORMAL(7) ELSE STORAGE REQUIREMENT = TRASH IN STORAGE NORMAL(7)
+ TIME FOR DAYS DELIVERY * (BURNAPLE INPUT RATE - WASTE BURN PER HR)
1270 GOTO 1290
1280 IF BURN FLAG$="NO" THEN STORAGE REQUIREMENT = TRASH IN STORAGE NORMAL(J-1) ELSE STORAGE REQUIREMENT = TRASH IN STORAGE NORMAL(J
-1) + TIME FOR DAYS DELIVERY * (BURNABLE INPUT RATE - WASTE BURN PER HR)
1290 I=J
1300 WHILE LOSING TONS
1310 IF BURN FLAG$="YES" THEN GOTO 1520
1320 IF BURN ONLY FLAG$ = "YES" THEN GOTO 1600
1330 IF I=6 OR I=7 THEN GOTO 1600
1340 TIME SINCE FAILURE = TIME SINCE FAILURE + TIME FOR DAYS DELIVERY
1350 IF TIME SINCE FAILURE <= AVE REPAIR TIME THEN GOTO 1450
1360 TIME AT TURN UP RATE = TIME AT TURN UP RATE + TIME FOR DAYS DELIVERY
1370 NEW STORAGE REQUIREMENT = STORAGE REQUIREMENT + TIME FOR DAYS DELIVERY * (BURNABLE INPUT RATE - TURN UP RATE)
1380 IF NEW STORAGE REQUIREMENT <= STORAGE SPACE THEN GOTO 1430
1390 TIME TILL PIT FULL = (STORAGE SPACE - STORAGE REQUIREMENT) / (BURNABLE INPUT RATE - TURN UP RATE)
1400 TONS LOST = TONS LOST + (TIME FOR DAYS DELIVERY - TIME TILL PIT FULL) * BURNABLE INPUT RATE
1410 STORAGE REQUIREMENT = STORAGE SPACE - (TIME FOR DAYS DELIVERY - TIME TILL PIT FULL) * TURN UP RATE
1420 GOTO 1520
1430 STORAGE REQUIREMENT = NEW STORAGE REQUIREMENT
1440 GOTO 1520
1450 NEW STORAGE REQUIREMENT = STORAGE REQUIREMENT + TIME FOR DAYS DELIVERY * BURNABLE INPUT RATE
1460 IF NEW STORAGE REQUIREMENT <= STORAGE SPACE THEN GOTO 1510
1470 TIME TILL PIT FULL = (STORAGE SPACE - STORAGE REQUIREMENT) / BURNABLE INPUT RATE
1480 TONS LOST = TONS LOST + (TIME FOR DAYS DELIVERY - TIME TILL PIT FULL) * BURNABLE INPUT RATE
1490 STORAGE REQUIREMENT = STORAGE SPACE
1500 GOTO 1520
1510 STORAGE REQUIREMENT = NEW STORAGE REQUIREMENT
1520 BURN FLAG$="NO"
1530 TIME SINCE FAILURE = TIME SINCE FAILURE + DAILY BURN TIME - TIME FOR DAYS DELIVERY
1540 IF TIME SINCE FAILURE <= AVE REPAIR TIME THEN GOTO 1680
1550 TIME AT TURN UP RATE = TIME AT TURN UP RATE + DAILY BURN TIME - TIME FOR DAYS DELIVERY
1560 STORAGE REQUIREMENT = STORAGE REQUIREMENT - TURN UP RATE * (DAILY BURN TIME - TIME FOR DAYS DELIVERY)
1570 IF STORAGE REQUIREMENT > TRASH IN STORAGE NORMAL(I) THEN GOTO 1680
1580 LOSING TONS = 0
1590 GOTO 1690
1600 BURN ONLY FLAG$="NO"
1610 TIME SINCE FAILURE = TIME SINCE FAILURE + DAILY BURN TIME
1620 IF TIME SINCE FAILURE <= AVE REPAIR TIME THEN GOTO 1680
1630 TIME AT TURN UP RATE = TIME AT TURN UP RATE + DAILY BURN TIME
1640 STORAGE REQUIREMENT = STORAGE REQUIREMENT - TURN UP RATE * DAILY BURN TIME
1650 IF STORAGE REQUIREMENT > TRASH IN STORAGE NORMAL(I) THEN GOTO 1680
1660 LOSING TONS = 0
1670 GOTO 1690
```

```
1680 IF (NUM BURN DAYS=5 AND I=5) OR (NUM BURN DAYS=7 AND I=7) THEN I=1 ELSE I=I+1
1690 WEND
1700 RETURN
1710 REM
1720 DAILY ADDITIONAL = (96/5 - 24) * WASTE BURN PER HR
1730 TRASH IN STORAGE NORMAL(1) = WASTE PER WEEK / 5
1740 FOR I=2 TO 5
1750 TRASH IN STORAGE NORMAL(I) = TRASH IN STORAGE NORMAL(I-1) + DAILY ADDITIONAL
1760 NEXT I
1770 TIME FOR LAST BURN = 96/5 - TIME FOR DAYS DELIVERY
1780 TIME FOR FIRST BURN = 24 - TIME FOR DAYS DELIVERY - TIME FOR LAST BURN
1790 PROB OF FAIL DURING FIRST BURN = TIME FOR FIRST BURN / 96
1800 PROB OF FAIL DURING RECEIPT = TIME FOR DAYS DELIVERY / 96
1810 PROB OF FAIL DURING LAST BURN = TIME FOR LAST BURN / 96
1820 RCPT FLAG$="NO" : LAST BURN FLAG$="NO"
1830 FIRST BURN TONS LOST=0 : FIRST BURN TURN UP TIME=0 : RCPT TONS LOST=0   RCPT TURN UP TIME=0 : LAST BURN TONS LOST=0   LAST BURN
 TURN UP TIME=0
1840 FOR J=2 TO 5
1850 GOSUB 2080
1870 FIRST BURN TONS LOST = FIRST BURN TONS LOST + (TONS LOST * PROB OF FAIL DURING FIRST BURN)
1880 FIRST BURN TURN UP TIME = FIRST BURN TURN UP TIME + (TIME AT TURN UP RATE * PROB OF FAIL DURING FIRST BURN)
1890 NEXT J
1900 FOR J=2 TO 5
1910 RCPT FLAG$ = "YES"
1920 GOSUB 2080
1940 RCPT TONS LOST = RCPT TONS LOST + (TONS LOST * PROB OF FAIL DURING RECEIPT)
1950 RCPT TURN UP TIME = RCPT TURN UP TIME + (TIME AT TURN UP RATE * PROB OF FAIL DURING RECEIPT)
1960 NEXT J
1970 FOR J=2 TO 5
1980 LAST BURN FLAG$ = "YES"
1990 GOSUB 2080
2010 LAST BURN TONS LOST = LAST BURN TONS LOST + (TONS LOST * PROB OF FAIL DURING LAST BURN)
2020 LAST BURN TURN UP TIME = LAST BURN TURN UP TIME + (TIME AT TURN UP RATE * PROB OF FAIL DURING LAST BURN)
2030 NEXT J
2040 TOTAL TONS LOST = (FIRST BURN TONS LOST + RCPT TONS LOST + LAST BURN TONS LOST) * NUMBER OF FAILURES
2050 TOTAL TURN UP TIME = (FIRST BURN TURN UP TIME + RCPT TURN UP TIME + LAST BURN TURN UP TIME) * NUMBER OF FAILURES
2070 RETURN
2080 TONS LOST=0   TIME SINCE FAILURE=0   LOSING TONS=1   TIME AT TURN UP RATE=0
2090 IF RCPT FLAG$ = "YES" OR LAST BURN FLAG$ = "YES" THEN GOTO 2110 ELSE STORAGE REQUIREMENT = TRASH IN STORAGE NORMAL(J-1)
2100 GOTO 2130
2110 IF RCPT FLAG$ = "YES" THEN  STORAGE REQUIREMENT = TRASH IN STORAGE NORMAL(J-1) - TIME FOR FIRST BURN * WASTE BURN PER HR
2120 IF LAST BURN FLAG$ = "YES" THEN STORAGE REQUIREMENT = TRASH IN STORAGE NORMAL(J-1) - TIME FOR FIRST BURN * WASTE BURN PER HR +
TIME FOR DAYS DELIVERY * (BURNABLE INPUT RATE - WASTE BURN PER HR)
2130 I=J
2140 WHILE LOSING TONS
2150 IF RCPT FLAG$ = "YES" THEN GOTO 2210
2160 IF LAST BURN FLAG$ = "YES" THEN GOTO 2400
2170 TIME SINCE FAILURE = TIME SINCE FAILURE + TIME FOR FIRST BURN
2180 IF TIME SINCE FAILURE <= AVE REPAIR TIME THEN GOTO 2210
2190 TIME AT TURN UP RATE = TIME AT TURN UP RATE + TIME FOR FIRST BURN
2200 STORAGE REQUIREMENT = STORAGE REQUIREMENT - TURN UP RATE * TIME FOR FIRST BURN
2210 RCPT FLAG$ = "NO"
2220 TIME SINCE FAILURE = TIME SINCE FAILURE + TIME FOR DAYS DELIVERY
2230 IF TIME SINCE FAILURE <= AVE REPAIR TIME THEN GOTO 2330
2240 TIME AT TURN UP RATE = TIME AT TURN UP RATE + TIME FOR DAYS DELIVERY
2250 NEW STORAGE REQUIREMENT = STORAGE REQUIREMENT + TIME FOR DAYS DELIVERY * (BURNABLE INPUT RATE - TURN UP RATE)
2260 IF NEW STORAGE REQUIREMENT <= STORAGE SPACE THEN GOTO 2310
2270 TIME TILL PIT FULL = (STORAGE SPACE - STORAGE REQUIREMENT) / (BURNABLE INPUT RATE - TURN UP RATE)
2280 TONS LOST = TONS LOST + (TIME FOR DAYS DELIVERY - TIME TILL PIT FULL) * BURNABLE INPUT RATE
2290 STORAGE REQUIREMENT = STORAGE SPACE - (TIME FOR DAYS DELIVERY - TIME TILL PIT FULL) * TURN UP RATE
```

```
2300 GOTO 2400
2310 STORAGE REQUIREMENT = NEW STORAGE REQUIREMENT
2320 GOTO 2400
2330 NEW STORAGE REQUIREMENT = STORAGE REQUIREMENT + TIME FOR DAYS DELIVERY * BURNABLE INPUT RATE
2340 IF NEW STORAGE REQUIREMENT <= STORAGE SPACE THEN GOTO 2390
2350 TIME TILL PIT FULL = (STORAGE SPACE - STORAGE REQUIREMENT) / BURNABLE INPUT RATE
2360 TONS LOST = TONS LOST + (TIME FOR DAYS DELIVERY - TIME TILL PIT FULL) * BURNABLE INPUT RATE
2370 STORAGE REQUIREMENT = STORAGE SPACE
2380 GOTO 2400
2390 STORAGE REQUIREMENT = NEW STORAGE REQUIREMENT
2400 LAST BURN FLAG$ = "NO"
2410 TIME SINCE FAILURE = TIME SINCE FAILURE + TIME FOR LAST BURN
2420 IF TIME SINCE FAILURE <= AVE REPAIR TIME THEN GOTO 2480
2430 TIME AT TURN UP RATE = TIME AT TURN UP RATE + TIME FOR LAST BURN
2440 STORAGE REQUIREMENT = STORAGE REQUIREMENT - TURN UP RATE * TIME FOR LAST BURN
2450 IF STORAGE REQUIREMENT > TRASH IN STORAGE NORMAL(I) THEN GOTO 2480
2460 LOSING TONS = 0
2470 GOTO 2590
2480 IF I <> 5 THEN GOTO 2580
2490 I=2
2500 NEW STORAGE REQUIREMENT = STORAGE REQUIREMENT + TIME FOR DAYS DELIVERY * BURNABLE INPUT RATE
2510 IF NEW STORAGE REQUIREMENT <= STORAGE SPACE THEN GOTO 2560
2520 TIME TILL PIT FULL = (STORAGE SPACE - STORAGE REQUIREMENT) / BURNABLE INPUT RATE
2530 TONS LOST = TONS LOST + (TIME FOR DAYS DELIVERY - TIME TILL PIT FULL) * BURNABLE INPUT RATE
2540 STORAGE REQUIREMENT = STORAGE SPACE
2550 GOTO 2590
2560 STORAGE REQUIREMENT = NEW STORAGE REQUIREMENT
2570 GOTO 2590
2580 I=I+1
2590 WEND
2600 RETURN
```

```
650 GOSUB 2990    REM  IDENTIFY LEAD TIME COSTS
660 GOSUB 3100    REM  IDENTIFY COST OF EXPECTED MODIFICATIONS
670 GOSUB 3180    REM  IDENTIFY LABOR COSTS
680 GOSUB 3270    REM  IDENTIFY COST OF CONSUMABLES
690 GOSUB 4800    REM  IDENTIFY COSTS OF RESIDUE DISPOSAL AND OTHER
691 GOSUB 5180    REM  IDENTIFY COST OF CORRECTIVE MAINTENANCE DOWNTIME
693 CHAIN "HRIMOD2 BAS",,ALL
2980 REM
2990 REM IDENTIFY LEAD TIME COSTS
3030 FOR I=1 TO LEAD
3040 UNDIS COST LEAD(I)=COST AE SERVICES INF * LEAD AE PCT(I)/100 + COST CAP TOT INF * LEAD CAP PCT(I)/100
3050 DIS COST LEAD(I) = UNDIS COST LEAD(I) * SINGLE(I)
3060 DIS COST LEAD TOT = DIS COST LEAD TOT + DIS COST LEAD(I)
3070 NEXT I
3080 RETURN
3090 REM
3100 REM  IDENTIFY COST OF EXPECTED MODIFICATIONS
3110 FOR I=1 TO 10
3120 IF YEAR MOD(I) = 0 THEN GOTO 3150
3130 MOD CASH FLOW YR = LEAD + YEAR MOD(I)
3140 DIS COST MODS TOT = DIS COST MODS TOT + COST MOD TOT INF(I) * SINGLE(MOD CASH FLOW YR)
3150 NEXT I
3160 RETURN
3170 REM
3180 REM  IDENTIFY LABOR COSTS
3190 ANN COST LABOR=COST DOWN OP LABOR TOT INF + COST PMAINT LABOR TOT INF + COST CMAINT LABOR TOT INF
3200 DIS LC COST LABOR=ANN COST LABOR * (CUM(LEAD+ECON LIFE) - CUM(LEAD))
3250 RETURN
3260 REM
3270 REM  IDENTIFY COST OF CONSUMABLES
3300 GOSUB 4300    REM  IDENTIFY ANNUAL AND LIFE CYCLE COSTS OF ELECTRICITY
3310 GOSUB 4380    REM  IDENTIFY ANNUAL AND LIFE CYCLE COSTS OF FOSSIL FUELS
3320 GOSUB 4520    REM  IDENTIFY ANNUAL AND LIFE CYCLE COSTS OF WATER
3330 GOSUB 4610    REM  IDENTIFY ANNUAL AND LIFE CYCLE COSTS OF CHEMICALS
3340 RETURN
4300 REM  IDENTIFY ANNUAL AND LIFE CYCLE COSTS OF ELECTRICITY
4310 KWH PER DOWN HR = KWH PER OP HR * KWH PER DOWN HR PCT/100
4320 KWH PER SCHED NONOP HR = KWH PER OP HR * KWH PER SCHED NONOP HR PCT/100
4330 ANN USE ELEC = KWH PER OP HR * (UP HOURS - TOTAL TURN UP TIME) + KWH PER OP HR * (1 + .33 * TURN UP PCT/100) * TOTAL TURN UP TI
ME + KWH PER DOWN HR * DOWN HOURS + KWH PER SCHED NONOP HR * SCHED NONOP HOURS
4340 ANN COST ELEC = ANN USE ELEC * COST PER KWH INF
4350 DIS LC COST ELEC = ANN COST ELEC * (CUM ENERGY DIFF(LEAD+ECON LIFE) - CUM ENERGY DIFF(LEAD))
4360 RETURN
4370 REM
4380 REM  IDENTIFY ANNUAL AND LIFE CYCLE COSTS OF FOSSIL FUELS
4390 NOMINAL TONS BURNED = (UP HOURS - TOTAL TURN UP TIME) * WASTE BURN PER HR
4400 TURNUP TONS BURNED = TOTAL TURN UP TIME * TURN UP RATE
4410 NOMINAL OFFSET COST TON = OFFSET LIQ GAL TON * OFFSET LIQ COST GAL INF + OFFSET GAS CF TON * OFFSET GAS COST CF INF + OFFSET SO
L1 TON TON * OFFSET SOL1 COST TON INF + OFFSET SOL2 TON TON * OFFSET SOL2 COST TON INF
4420 NOMINAL COST TON = LIQ GAL TON * LIQ COST GAL INF + GAS CF TON * GAS COST CF INF + SOL1 TON TON * SOL1 COST TON INF + SOL2 TON
TON * SOL2 COST TON INF
4422 ANN COST OFFSET FUELS = NOMINAL OFFSET COST TON * NOMINAL TONS BURNED + (1 + TURN UP PCT/100) * NOMINAL OFFSET COST TON * TURNU
P TONS BURNED
4424 ANN COST NONOFF FUELS = NOMINAL COST TON * NOMINAL TONS BURNED + (1 + TURN UP PCT/100) * NOMINAL COST TON * TURNUP TONS BURNED
4430 ANN COST FUELS = ANN COST OFFSET FUELS + ANN COST NONOFF FUELS
4490 DIS LC COST OFFSET FUELS = ANN COST OFFSET FUELS * (CUM(LEAD+ECON LIFE) - CUM(LEAD))
4492 DIS LC COST NONOFF FUELS = ANN COST NONOFF FUELS * (CUM ENERGY DIFF(LEAD+ECON LIFE) - CUM ENERGY DIFF(LEAD))
4494 DIS LC COST FUELS = DIS LC COST OFFSET FUELS + DIS LC COST NONOFF FUELS
4500 RETURN
4510 REM
```

```
4520 REM  IDENTIFY ANNUAL AND LIFE CYCLE COSTS OF WATER
4530 IF COST WATER TOT INF <> 0 THEN GOTO 4570
4540 NODOWNTIME COST WATER = WATER GAL PER TON * WATER COST PER GAL INF/1000 * PLANNED OP HRS * WASTE BURN PER HR
4550 COST WATER TOT INF = (WATER GAL PER TON * (NOMINAL TONS BURNED + (1 + TURN UP PCT/100) * TURNUP TONS BURNED)) * WATER COST PER
GAL INF/1000
4560 GOTO 4580
4570 NODOWNTIME COST WATER = COST WATER TOT INF
4580 DIS LC COST WATER = COST WATER TOT INF * (CUM(LEAD+ECON LIFE) - CUM(LEAD))
4590 RETURN
4600 REM
4610 REM  IDENTIFY ANNUAL AND LIFE CYCLE COSTS OF CHEMICALS
4620 IF COST CHEMICALS TOT INF <> 0 THEN GOSUB 4650 ELSE GOSUB 4690
4630 DIS LC COST CHEMICALS = COST CHEMICALS TOT INF * (CUM(LEAD+ECON LIFE) - CUM(LEAD))
4640 RETURN
4650 NODOWNTIME COST CHEM = COST CHEMICALS TOT INF
4660 RETURN
4680 FOR I=1 TO 2
4690 IF CHEM COST TOT INF(I) <> 0 THEN GOTO 4750
4700 CHEM COST TOT INF(I) = ((CHEM UNITS PER GAL(I)/1000 * WATER GAL PER TON) * (NOMINAL TONS BURNED + (1 + TURN UP PCT/100) ^ 2 * T
URNUP TONS BURNED)) * CHEM COST PER UNIT INF(I)
4710 NODOWNTIME COST CHEM(I) = CHEM UNITS PER GAL(I)/1000 * CHEM COST PER UNIT INF(I) * WATER GAL PER TON * PLANNED OP HRS * WASTE B
URN PER HR
4720 NODOWNTIME COST CHEM = NODOWNTIME COST CHEM + NODOWNTIME COST CHEM(I)
4740 GOTO 4760
4750 NODOWNTIME COST CHEM = NODOWNTIME COST CHEM + CHEM COST TOT INF(I)
4760 COST CHEMICALS TOT INF = COST CHEMICALS TOT INF + CHEM COST TOT INF(I)
4770 NEXT I
4780 RETURN
4790 REM
4800 REM  IDENTIFY COSTS OF RESIDUE DISPOSAL AND OTHER
4810 GOSUB 4860   REM  IDENTIFY ANNUAL AND LIFE CYCLE COSTS OF RESIDUE DISPOSAL
4820 GOSUB 4950   REM  IDENTIFY LIFE CYCLE COSTS OF REPAIR PARTS, SEWER, INSURANCE, AND PEST AND VERMIN CONTROL
4830 GOSUB 5020   REM  IDENTIFY LIFE CYCLE COSTS OF OTHER EXPENDITURES
4840 RETURN
4850 REM
4860 REM  IDENTIFY ANNUAL AND LIFE CYCLE COSTS OF RESIDUE DISPOSAL
4870 IF COST NONBURNFILL PER TON=0 THEN COST NONBURNFILL PER TON INF = COST TRANS NONBURN PER TONMILE INF * MILES NONBURN FILL + TIP
FEE NONBURN PER TON INF
4880 ANN COST NONBURN DISP = WASTE BURN PER HR * NUM BURN DAYS * DAILY BURN TIME * 52 * (1/(1 - TONS NONBURN PER TON) - 1) * COST NO
NBURNFILL PER TON INF
4890 IF COST ASHFILL PER TON INF=0 THEN COST ASHFILL PER TON INF = COST TRANS ASH PER TONMILE INF * MILES ASH FILL + TIPFEE ASH PER
TON INF
4900 ANN COST ASH DISP = ASH PER TON BURN * ANN TRASH BURNED * COST ASHFILL PER TON INF
4901 IF COST ALLWASTE PER TON INF = 0 THEN COST ALLWASTE PER TON INF = COST TRANS ALLWASTE PER TONMILE INF * MILES ALLWASTE FILL + T
IPFEE ALLWASTE PER TON INF
4902 ANN COST SCHED DOWN DISP = (52 - NUM BURN WEEKS) * NUM BURN DAYS * DAILY BURN TIME * WASTE BURN PER HR  * COST ALLWASTE PER TON
 INF
4910 ANN COST RES DISP = ANN COST NONBURN DISP + ANN COST ASH DISP + ANN COST SCHED DOWN DISP
4920 DIS LC COST RES DISP = ANN COST RES DISP * (CUM LANDFILL DIFF(LEAD+ECON LIFE) - CUM LANDFILL DIFF(LEAD))
4930 RETURN
4940 REM
4950 REM  IDENTIFY LIFE CYCLE COSTS OF REPAIR PARTS, SEWER, INSURANCE, AND PEST AND VERMIN CONTROL
4960 DIS LC COST REPAIRPARTS = COST REPAIRPARTS TOT INF * (CUM(LEAD+ECON LIFE) - CUM(LEAD))
4970 DIS LC COST SEWER = COST SEWER TOT INF * (CUM(LEAD+ECON LIFE) - CUM(LEAD))
4980 DIS LC COST INSUR = COST INSUR TOT INF * (CUM(LEAD+ECON LIFE) - CUM(LEAD))
4990 DIS LC COST PEST = COST PEST TOT INF * (CUM(LEAD+ECON LIFE)- CUM(LEAD))
5000 RETURN
5010 REM
5020 REM  IDENTIFY LIFE CYCLE COSTS OF OTHER EXPENDITURES
5030 FOR I=1 TO 10
```

```
5040 IF COST OTHER INF(I)=0 THEN GOTO 5140
5050 IF OTHER TYPE COST$(I) = "E" THEN GOTO 5060 ELSE IF OTHER TYPE COST$(I) = "L" THEN GOTO 5090 ELSE GOTO 5120
5060 IF OTHER COST PROJ YR(I) = 0 THEN DIS LC COST OTHER(I) = COST OTHER INF(I) * (CUM ENERGY DIFF(LEAD+ECON LIFE) - CUM ENERGY DIFF
(LEAD)) ELSE DIS LC COST OTHER(I) = COST OTHER INF(I) * SINGLE ENERGY DIFF(LEAD + OTHER COST PROJ YR(I))
5070 DIS LC COST OTHER ENERGY = DIS LC COST OTHER ENERGY + DIS LC COST OTHER(I)
5080 GOTO 5140
5090 IF OTHER COST PROJ YR(I) = 0 THEN DIS LC COST OTHER(I) = COST OTHER INF(I) * (CUM LANDFILL DIFF(LEAD+ECON LIFE) - CUM LANDFILL
DIFF(LEAD)) ELSE DIS LC COST OTHER(I) =COST OTHER INF(I) * SINGLE LANDFILL DIFF(LEAD + OTHER COST PROJ YR(I))
5100 DIS LC COST OTHER LANDFILL = DIS LC COST OTHER LANDFILL + DIS LC COST OTHER(I)
5110 GOTO 5140
5120 IF OTHER COST PROJ YR(I) = 0 THEN DIS LC COST OTHER(I) = COST OTHER INF(I) * (CUM(LEAD+ECON LIFE) - CUM(LEAD)) ELSE DIS LC COST
 OTHER(I) = COST OTHER INF(I) * SINGLE(LEAD + OTHER COST PROJ YR(I))
5130 DIS LC COST OTHER OTHER = DIS LC COST OTHER OTHER + DIS LC COST OTHER(I)
5140 NEXT I
5150 DIS LC COST OTHER TOT = DIS LC COST OTHER ENERGY + DIS LC COST OTHER LANDFILL + DIS LC COST OTHER OTHER
5160 RETURN
5170 REM
5180 REM  IDENTIFY COST OF CORRECTIVE MAINTENANCE DOWNTIME
5190 GOSUB 5280    REM  COMPUTE HRI BTUS OF STEAM OUTPUT PER TON OF WASTE INPUT
5200 GOSUB 5370    REM  COMPUTE HRI ANNUAL STEAM PRODUCTION (IF NEVER DOWN) AND THE COST OF USING A BOILER TO PRODUCE AN EQUIVALENT Q
UANTITY OF STEAM
5220 GOSUB 5490    REM  COMPUTE ANNUAL COST OF LANDFILLING THE NO-DOWNTIME HRI SOLID WASTE CAPACITY
5230 GOSUB 5550    REM  COMPUTE ANNUAL COST OF NO HRI
5240 GOSUB 5600    REM  COMPUTE ANNUAL NO-DOWNTIME COST OF HRI
5250 GOSUB 5790    REM  COMPUTE ANNUAL AND LIFE CYCLE COSTS OF DOWNTIME
5260 RETURN
5270 REM
5280 REM  COMPUTE HRI BTUS OF STEAM OUTPUT PER TON OF WASTE INPUT
5290 STEADY OFFSET FUEL BTU TON = OFFSET LIQ GAL TON * OFFSET LIQ BTU GAL + OFFSET GAS CF TON * OFFSET GAS BTU CF + OFFSET SOL1 TON
TON * OFFSET SOL1 BTU TON + OFFSET SOL2 TON TON * OFFSET SOL2 BTU TON
5300 STEADY FUEL BTU TON = LIQ GAL TON * LIQ BTU GAL + GAS CF TON * GAS BTU CF + SOL1 TON TON * SOL1 BTU TON + SOL2 TON TON * SOL2 B
TU TON
5305 IF DAILY BURN TIME=16 THEN IF NUM BURN DAYS=5 THEN NODOWN TIME ALL REHEATS = NUM BURN WEEKS * (4 * 1.5 * 8/TC + 1.5) ELSE  NODO
WN TIME ALL REHEATS = NUM BURN WEEKS * 7 * 1.5 * 8/TC
5308 IF DAILY BURN TIME=24 THEN IF NUM BURN DAYS=4 OR NUM BURN DAYS=5 THEN NODOWN TIME ALL REHEATS = NUM BURN WEEKS * 1.5 ELSE NODOW
N TIME ALL REHEATS = 0
5310 NODOWN STEADY STATE TRASH BURNED = (PLANNED OP HRS - NODOWN TIME ALL REHEATS) * WASTE BURN PER HR
5320 NODOWN STEADY STATE ELEC BTU PER TON = (KWH PER OP HR * (PLANNED OP HRS - NODOWN TIME ALL REHEATS) + KWH PER SCHED NONOP HR*SCH
ED NONOP HOURS) / NODOWN STEADY STATE TRASH BURNED * 11600
5330 NODOWN FUEL EQ BTUS TO HRI = STEADY OFFSET FUEL BTU TON + STEADY FUEL BTU TON
5340 NODOWN HRI BTUOUT PER TON = (NODOWN FUEL EQ BTUS TO HRI + HEAT VAL BURN WASTE) * EFFICIENCY HRI/100
5350 RETURN
5360 REM
5370 REM  COMPUTE HRI ANNUAL STEAM PRODUCTION (IF NEVER DOWN) AND THE COST OF USING A BOILER TO PRODUCE AN EQUIVALENT QUANTITY OF ST
EAM
5380 NODOWN STEADY STATE STEAM PROD = NODOWN HRI BTUOUT PER TON * NODOWN STEADY STATE TRASH BURNED
5381 REHEAT ELEC BTU TON = KWH PER OP HR / WASTE BURN PER HR * 11600
5382 REHEAT BTUOUT PER TON = ((STEADY OFFSET FUEL BTU TON + STEADY FUEL BTU TON + HEAT VAL BURN WASTE) - (REHEAT OFFSET FUEL BTU TON
 LOST + REHEAT FUEL BTU TON LOST + HEAT VAL BURN WASTE ^ .667)) * EFFICIENCY HRI/100
5384 NODOWN REHEAT STEAM PROD = REHEAT BTUOUT PER TON * NODOWN TIME ALL REHEATS * WASTE BURN PER HR
5385 NODOWN STEAM PROD = NODOWN STEADY STATE STEAM PROD + NODOWN REHEAT STEAM PROD
5390 ANN COST EQUIV BOILER = COST PER BOILER MBTU INF * NODOWN STEAM PROD/1E+06
5400 DIS LC COST EQUIV BOILER = ANN COST EQUIV BOILER * (CUM ENERGY DIFF(LEAD+ECON LIFE) - CUM ENERGY DIFF(LEAD))
5410 RETURN
5480 REM
5490 REM  COMPUTE ANNUAL COST OF LANDFILLING THE NO-DOWNTIME HRI SOLID WASTE CAPACITY
5510 ANN COST LANDFILL ALLWASTE = (1/(1 - TONS NONBURN PER TON)) * WASTE BURN PER HR * NUM BURN DAYS * DAILY BURN TIME * 52 * COST A
LLWASTE PER TON INF
5520 DIS LC COST LANDFILL ALLWASTE = ANN COST LANDFILL ALLWASTE * (CUM LANDFILL DIFF(LEAD+ECON LIFE) - CUM LANDFILL DIFF(LEAD))
5530 RETURN
```

```
5540 REM
5550 REM  COMPUTE ANNUAL COST OF NO HRI
5560 ANN COST NO HRI = ANN COST EQUIV BOILER + ANN COST LANDFILL ALLWASTE
5570 DIS LC COST NO HRI = DIS LC COST EQUIV BOILER + DIS LC COST LANDFILL ALLWASTE
5580 RETURN
5590 REM
5600 REM  COMPUTE ANNUAL NO-DOWNTIME COST OF HRI
5610 ANN COST LEAD AND MODS = (DIS COST LEAD TOT + DIS COST MODS TOT) / (CUM(LEAD+ECON LIFE) - CUM(LEAD))
5630 ANN COST NODOWNTIME LABOR = COST OP LABOR TOT INF + COST FMAINT LABOR TOT INF
5640 NODOWNTIME COST ELEC = (KWH PER OP HR * PLANNED OP HRS + KWH PER SCHED NONOP HR * SCHED NONOP HOURS) * COST PER KWH INF
5650 NODOWNTIME COST FUELS = (NOMINAL OFFSET COST TON + NOMINAL COST TON) * PLANNED OP HRS * WASTE BURN PER HR
5680 NODOWNTIME COST CONSUM = NODOWNTIME COST ELEC + NODOWNTIME COST FUELS + NODOWNTIME COST WATER + NODOWNTIME COST CHEM
5690 NODOWNTIME COST REST =  2*COST REPAIRPARTS TOT INF + COST SEWER TOT INF + COST INSUR TOT INF + COST PEST TOT INF
5700 ANN COST OTHER ENERGY = DIS LC COST OTHER ENERGY / (CUM ENERGY DIFF(LEAD+ECON LIFE) - CUM ENERGY DIFF(LEAD))
5710 ANN COST OTHER LANDFILL = DIS LC COST OTHER LANDFILL / (CUM LANDFILL DIFF(LEAD+ECON LIFE) - CUM LANDFILL DIFF(LEAD))
5720 ANN COST OTHER OTHER = DIS LC COST OTHER OTHER / (CUM(LEAD+ECON LIFE) - CUM(LEAD))
5730 ANN COST OTHER TOT = ANN COST OTHER ENERGY + ANN COST OTHER LANDFILL + ANN COST OTHER OTHER
5740 NODOWNTIME COST ASH DISP = ASH PER TON BURN * PLANNED OP HRS * WASTE BURN PER HR * COST ASHFILL PER TON INF
5750 NODOWNTIME COST DISP = ANN COST NONBURN DISP + NODOWNTIME COST ASH DISP + ANN COST SCHED DOWN DISP
5755 IF DAILY BURN TIME=16 THEN NODOWN COST REHEATS=COST ALL REHEATS ELSE IF NUM BURN DAYS=4 OR NUM BURN DAYS=5 THEN NODOWN COST REH
EATS=NUM BURN WEEKS*FUEL FOR ONE LONG DOWN*(EFFICIENCY HRI/100)*COST PER BOILER MBTU INF* 000001 ELSE NODOWN COST REHEATS=0
5760 ANN NODOWNTIME COST HRI = ANN COST LEAD AND MODS + ANN COST NODOWNTIME LABOR + NODOWNTIME COST CONSUM + NODOWNTIME COST REST +
ANN COST OTHER TOT + NODOWNTIME COST DISP + NODOWN COST REHEATS
5770 RETURN
5780 REM
5790 REM  COMPUTE ANNUAL AND LIFE CYCLE COSTS OF DOWNTIME
5800 IF ANN COST NO HRI > ANN NODOWNTIME COST HRI THEN ANN COST DOWNTIME = (ANN COST NO HRI - ANN NODOWNTIME COST HRI) / (PLANNED OP
 HRS * WASTE BURN PER HR) * TOTAL TONS LOST ELSE ANN COST DOWNTIME = 0
5810 DIS LC COST DOWNTIME ENERGY = (ANN COST EQUIV BOILER/ANN COST NO HRI) * ANN COST DOWNTIME * (CUM ENERGY DIFF(LEAD+ECON LIFE) -
CUM ENERGY DIFF(LEAD))
5820 DIS LC COST DOWNTIME LANDFILL = (ANN COST LANDFILL ALLWASTE/ANN COST NO HRI) * ANN COST DOWNTIME * (CUM LANDFILL DIFF(LEAD+ECON
 LIFE) - CUM LANDFILL DIFF(LEAD))
5830 DIS LC COST DOWNTIME = DIS LC COST DOWNTIME ENERGY + DIS LC COST DOWNTIME LANDFILL
5840 RETURN
```

```
30 GOSUB 110   REM  IDENTIFY ANNUAL AND DISCOUNTED LIFE CYCLE COSTS OF HRI
40 GOSUB 240   REM  IDENTIFY HRI SAVINGS-TO-INVESTMENT RATIO
50 GOSUB 890   REM  IDENTIFY HRI PAYBACK PERIOD
60 GOSUB 1000   REM  IDENTIFY HRI FOSSIL FUEL OFFSET
70 GOSUB 1350   REM  IDENTIFY HRI LANDFILL SPACE CONSERVED
80 GOSUB 1450   REM  PRINT REPORT
90 SYSTEM
100 REM
110 REM  IDENTIFY ANNUAL AND DISCOUNTED LIFE CYCLE COSTS OF HRI
120 ANN COST CONSUM = ANN COST ELEC + ANN COST FUELS + COST WATER TOT INF + COST CHEMICALS TOT INF
140 ANN COST REST = COST REPAIRPARTS.TOT INF + COST SEWER TOT INF + COST INSUR TOT.INF + COST PEST TOT INF
160 ANN COST HRI = ANN COST LEAD AND MODS + ANN COST LABOR + ANN COST CONSUM + ANN COST REST + ANN COST OTHER TOT + ANN COST RES DIS
P + ANN COST DOWNTIME + COST.ALL REHEATS
180 DIS LC.COST.O AND M = DIS LC.COST.LABOR + DIS.LC COST WATER + DIS LC COST CHEMICALS + DIS LC COST REPAIRPARTS + DIS LC COST SEWE
R + DIS LC COST INSUR + DIS.LC COST PEST + DIS LC COST ELEC + DIS LC COST FUELS + DIS LC COST RES DISP
200 DIS LC COST.HRI = DIS COST LEAD TOT + DIS.COST.MODS TOT + DIS LC COST O AND M + DIS LC COST OTHER TOT + DIS LC COST DOWNTIME + D
IS LC.COST ALL REHEATS
210 DIS LC COST HRI PER TON = DIS.LC COST HRI / (ANN TRASH BURNED * ECON LIFE)
220 RETURN
230 REM
240 REM  IDENTIFY HRI SAVINGS TO INVESTMENT RATIO
250 SIR.ANN COST HRI ENERGY = ANN COST ELEC + ANN.COST NONOFF FUELS + (ANN COST EQUIV BOILER/ANN COST NO HRI) * ANN COST DOWNTIME +
COST ALL.REHEATS
270 SIR ANN COST HRI LANDFILL = ANN COST RES DISP + (ANN COST LANDFILL ALLWASTE/ANN COST NO HRI) * ANN COST DOWNTIME
290 SIR.ANN COST.HRI OTHER = ANN.COST OFFSET FUELS + ANN COST LABOR + COST WATER TOT INF + COST CHEMICALS TOT INF + COST REPAIRPARTS
.TOT.INF + COST SEWER.TOT INF + COST.INSUR TOT INF + COST PEST.TOT INF
310 FOR I=1 TO 10
320 IF COST.OTHER ANNUAL(I) = 0 THEN GOTO 400
330 IF OTHER TYPE.COST$(I) <> "E" THEN GOTO 360
340 SIR.ANN.COST HRI ENERGY = SIR.ANN COST HRI ENERGY + COST OTHER.INF(I)
350 GOTO 400
360 IF OTHER TYPE COST$(I) <> "L" THEN GOTO 390
370 SIR.ANN COST HRI LANDFILL = SIR ANN COST HRI LANDFILL + COST OTHER.INF(I)
380 GOTO 400
390 SIR.ANN COST HRI OTHER = SIR.ANNUAL COST HRI.OTHER + COST OTHER INF(I)
400 NEXT I
440 FOR I=LEAD+1 TO LEAD+ECON LIFE
450 SIR.COST HRI ENERGY(I) = SIR ANN COST HRI ENERGY
460 SIR COST HRI LANDFILL(I) = SIR ANN COST HRI LANDFILL
470 SIR COST HRI.OTHER(I) = SIR ANN COST HRI OTHER
480 NEXT I
490 FOR I=LEAD+1 TO LEAD+ECON LIFE
500 FOR J=1 TO 10
510 IF COST OTHER ONETIME(J) = 0 THEN GOTO 630
520 IF OTHER COST PROJ YR(J) + LEAD <> I THEN GOTO 630
530 IF OTHER TYPE COST$(J) <> "E" THEN GOTO 570
540 SIR COST HRI ENERGY(I) = SIR COST HRI ENERGY(I) + COST OTHER INF(J)
560 GOTO 630
570 IF OTHER TYPE COST$(J) <> "L" THEN GOTO 610
580 SIR COST HRI LANDFILL(I) = SIR COST HRI LANDFILL(I) + COST OTHER INF(J)
600 GOTO 630
610 SIR COST HRI OTHER(I) = SIR COST HRI OTHER(I) + COST OTHER INF(J)
630 NEXT J
640 NEXT I
650 FOR I=LEAD+1 TO LEAD+ECON LIFE
660 FOR J=1 TO 10
670 IF COST MOD TOT INF(J) = 0 THEN GOTO 710
680 IF YEAR MOD(J) + LEAD <> I THEN GOTO 710
690 SIR COST HRI OTHER(I) = SIR COST.HRI OTHER(I) + COST MOD.TOT INF(J)
710 NEXT J
```

```
720 NEXT I
730 FOR I=LEAD+1 TO LEAD+ECON LIFE
740 DIS ENERGY SAVINGS(I) = (ANN COST EQUIV BOILER - SIR COST HRI ENERGY(I)) * SINGLE ENERGY DIFF(I)
760 DIS LANDFILL SAVINGS(I) = (ANN COST LANDFILL ALLWASTE - SIR COST HRI LANDFILL(I)) * SINGLE LANDFILL DIFF(I)
780 DIS OTHER SAVINGS(I) = (0 - SIR COST HRI OTHER(I)) * SINGLE(I)
800 DIS TOT SAVINGS(I) = DIS ENERGY SAVINGS(I) + DIS LANDFILL SAVINGS(I) + DIS OTHER SAVINGS(I)
820 DIS TOT SAVINGS = DIS TOT SAVINGS + DIS TOT SAVINGS(I)
830 NEXT I
840 DIS TOT SAVINGS PER TON = DIS TOT SAVINGS / (ANN TRASH BURNED * ECON LIFE)
850 SIR = DIS TOT SAVINGS / DIS COST LEAD TOT
870 RETURN
880 REM
890 REM  IDENTIFY HRI PAYBACK PERIOD
900 M=LEAD+1
910 IF DIS TOT SAVINGS(M) + CUM DIS TOT SAVINGS )= DIS COST LEAD TOT THEN GOTO 950
920 CUM DIS TOT SAVINGS = CUM DIS TOT SAVINGS + DIS TOT SAVINGS(M)
930 M=M+1
940 IF M ( LEAD+ECON LIFE THEN GOTO 910 ELSE GOTO 980
950 PAYBACK YEAR = M-1 + (DIS COST LEAD TOT - CUM DIS TOT SAVINGS) / DIS TOT SAVINGS(M)
970 GOTO 990
980 REM  PRINT "PAYBACK PERIOD IS LONGER THAN PROJECT ECONOMIC LIFE"
990 RETURN
1000 REM
1010 REM  IDENTIFY HRI FOSSIL FUEL OFFSET
1020 STEADY STATE TRASH BURNED = (UP HOURS - TOTAL TURN UP TIME - TIME ALL REHEATS) * WASTE BURN PER HR
1030 STEADY STATE ELEC USED = ANN USE ELEC - KWH PER OP HR * TIME ALL REHEATS - KWH PER OP HR * (1 +  33 * TURN UP PCT/100) * TOTAL
TURN UP TIME
1040 HRI ELEC BTU PER TON = STEADY STATE ELEC USED / STEADY STATE TRASH BURNED * 11600
1050 FUEL EQ BTUS TO HRI = STEADY OFFSET FUEL BTU TON + STEADY FUEL BTU TON
1060 HRI BTUOUT PER TON = (FUEL EQ BTUS TO HRI + HEAT VAL BURN WASTE) * EFFICIENCY HRI/100
1075 STEADY STATE STEAM PROD = HRI BTUOUT PER TON * STEADY STATE TRASH BURNED
1080 FOSSIL FUEL EQUIV HRI BTUOUT = HRI BTUOUT PER TON  / (EFFICIENCY BOILER/100)
1100 HRI FOSSIL FUEL BTU OFFSET PER TON = FOSSIL FUEL EQUIV HRI BTUOUT - STEADY FUEL BTU TON - HRI ELEC BTU PER TON
1120 HRI STEADY STATE BTU OFFSET = HRI FOSSIL FUEL BTU OFFSET PER TON * STEADY STATE TRASH BURNED
1150 REHEAT STEAM PROD = REHEAT BTUOUT PER TON * TIME ALL REHEATS * WASTE BURN PER HR
1160 REHEAT FOSSIL FUEL EQUIV BTUOUT = REHEAT BTUOUT PER TON / (EFFICIENCY BOILER/100)
1170 REHEAT FOSSIL FUEL BTU OFFSET PER TON = REHEAT FOSSIL FUEL EQUIV BTUOUT - (STEADY FUEL BTU TON - REHEAT FUEL BTU TON LOST) - RE
HEAT ELEC BTU TON
1180 REHEAT BTU OFFSET = REHEAT FOSSIL FUEL BTU OFFSET PER TON * TIME ALL REHEATS * WASTE BURN PER HR
1190 TURNUP ELEC BTU TON = KWH PER OP HR * (1 +  33 * TURN UP PCT/100) / TURN UP RATE * 11600
1200 TURNUP BTUOUT PER TON = ((1 + TURN UP PCT/100) * (STEADY OFFSET FUEL BTU TON + STEADY FUEL BTU TON) + HEAT VAL BURN WASTE) * EF
FICIENCY HRI/100
1210 TURNUP STEAM PROD = TURNUP BTUOUT PER TON * TURN UP RATE * TOTAL TURN UP TIME
1220 TURNUP FOSSIL FUEL EQUIV BTUOUT = TURNUP BTUOUT PER TON / (EFFICIENCY BOILER/100)
1230 TURNUP FOSSIL FUEL BTU OFFSET PER TON = TURNUP FOSSIL FUEL EQUIV BTUOUT - (1 + TURN UP PCT/100) * STEADY FUEL BTU TON - TURNUP
ELEC BTU TON
1240 TURNUP BTU OFFSET = TURNUP FOSSIL FUEL BTU OFFSET PER TON * TOTAL TURN UP TIME * TURN UP RATE
1300 HRI ANN BTU OFFSET = HRI STEADY STATE BTU OFFSET + REHEAT BTU OFFSET + TURNUP BTU OFFSET
1310 HRI ANN BOE OFFSET = HRI ANN BTU OFFSET / 5 8E+06
1322 LC STEAM PROD = ECON LIFE * (STEADY STATE STEAM PROD + REHEAT STEAM PROD + TURNUP STEAM PROD) *  000001
1324 DIS LC COST HRI PER MBTU = DIS LC COST HRI / LC STEAM PROD
1326 DIS TOT SAVINGS PER MBTU = DIS TOT SAVINGS / LC STEAM PROD
1330 RETURN
1340 REM
1350 REM  IDENTIFY HRI LANDFILL SPACE CONSERVED
1355 ANN TOTAL WASTE = WASTE BURN PER HR * NUM BURN DAYS * DAILY BURN TIME * 52 / (1 - TONS NONBURN PER TON)
1360 ANN NONBURNABLE TO LANDFILL = ANN TOTAL WASTE * TONS NONBURN PER TON
1380 ANN ASH TO LANDFILL = ANN TRASH BURNED * ASH PER TON BURN
1390 SCHED DOWN BURNABLE = (52 - NUM BURN WEEKS) * NUM BURN DAYS * DAILY BURN TIME * WASTE BURN PER HR
1420 ANN LANDFILL SPACE CONSERVED = ANN TOTAL WASTE - (ANN NONBURNABLE TO LANDFILL + ANN ASH TO LANDFILL + TOTAL TONS LOST + SCHED D
```

```
OWN BURNABLE)
1440 RETURN
1450 LPRINT CHR$(12)
1460 LPRINT
1470 LPRINT
1480 LPRINT TAB(40) "HRI COST AND PERFORMANCE REPORT"
1490 LPRINT
1500 LPRINT
1510 REM  PRINT REPORT
1520 LPRINT "INFLATED PER TON COST OF DISPOSING WASTE OF THE TYPE GENERATED AT THE SITE TO THE LANDFILL "..
1530 LPRINT USING "$$###.##", COST.ALLWASTE PER.TON INF
1540 LPRINT "INFLATED PER MBTU COST OF THE FOSSIL FUEL BOILER TO WHICH THE HRI IS BEING COMPARED "..
1550 LPRINT USING "$$### ##"; COST.PER BOILER MBTU INF
1560 LPRINT
1570 LPRINT
1580 LPRINT "TONS OF TRASH BURNED ANNUALLY BY THE HRI  ".....
1590 LPRINT USING "######, "; ANN.TRASH BURNED
1620 LPRINT "MBTUS PRODUCED ANNUALLY BY THE HRI (CONSIDERING NO DOWNTIME)  "....
1630 LPRINT USING "##.##^^^^"; NODOWN STEAM PROD *  000001
1660 LPRINT "VIRGIN FUEL OFFSET ANNUALLY BY THE HRI IN BARRELS-OF-OIL-EQUIVALENT  " ...
1670 LPRINT USING "######,."; HRI ANN.BOE OFFSET
1680 LPRINT "LANDFILL SPACE CONSERVED ANNUALLY BY THE HRI IN TONS  ".....
1690 LPRINT USING "######, "; ANN.LANDFILL.SPACE CONSERVED
1700 LPRINT
1710 LPRINT
1720 LPRINT "COST OF USING A BOILER TO PRODUCE THE ANNUAL NO-DOWNTIME QUANTITY OF STEAM PRODUCED BY THE HRI AND LANDFIL-"
1730 LPRINT "   LING ALL WASTE ".......
1740 LPRINT USING "$$########,."; ANN COST.NO HRI
1750 LPRINT "INFLATED TOTAL CAPITAL COST OF THE HRI (INCLUDES EQUIPMENT, SUPPORT FACILITIES, AND CONSTRUCTION AND SETUP)  ".
1760 LPRINT USING "$$#########,.", COST CAP.TOT INF
1770 LPRINT "UNIFORM ANNUAL COST OF THE HRI (THE COST OF CAPITAL, MODIFICATIONS, LABOR, CONSUMABLES, RESIDUE DISPOSAL,"
1780 LPRINT "   DOWNTIME, AND OTHER COSTS SPREAD OVER THE ECONOMIC LIFE OF THE HRI).  "...
1790 LPRINT USING "$$########, ", ANN.COST HRI
1800 LPRINT "ANNUAL NO-DOWNTIME COST OF THE HRI (THE TOTAL OF NO-DOWNTIME COSTS SPREAD OVER THE ECONOMIC LIFE OF THE HRI)  ".
1810 LPRINT USING "$$########, ", ANN NODOWNTIME COST HRI
1820 LPRINT
1830 LPRINT
1840 LPRINT "DISCOUNTED LIFE CYCLE COST OF USING A BOILER TO PRODUCE THE LIFE CYCLE NO-DOWNTIME QUANTITY OF STEAM PRODUCED"
1850 LPRINT "   BY THE HRI AND LANDFILLING ALL WASTE (COSTS DISCOUNTED TO THE POINT OF INITIAL FUNDING)  "..
1860 LPRINT USING "$$#########, "; DIS.LC COST NO.HRI
1870 LPRINT "DISCOUNTED LIFE CYCLE COST OF THE HRI  "......
1880 LPRINT USING "$$#########,.", DIS LC.COST HRI
1890 LPRINT "DISCOUNTED LIFE CYCLE COST OF AUXILIARY FUELS USED BY THE HRI  "....
1900 LPRINT USING "$$########,.", DIS LC COST.FUELS
1910 LPRINT "DISCOUNTED LIFE CYCLE COST OF NONCOMBUSTIBLE WASTE, ASH, AND SCHEDULED DOWNTIME WASTE DISPOSAL  "..
1920 LPRINT USING "$$#########,."; DIS.LC COST.RES DISP
1930 LPRINT "DISCOUNTED LIFE CYCLE COST OF HRI DOWNTIME  ".....
1940 LPRINT USING "$$########, -", DIS LC COST DOWNTIME
1950 LPRINT
1960 LPRINT
1970 LPRINT "DISCOUNTED LIFE CYCLE COST OF THE HRI PER TON OF WASTE FIRED  "....
1980 LPRINT USING "$$###.##"; DIS.LC.COST.HRI PER.TON
1990 LPRINT "DISCOUNTED LIFE CYCLE SAVINGS OF THE HRI PER TON OF WASTE FIRED  "....
1991 LPRINT USING "$$###.##-"; DIS TOT.SAVINGS PER TON
1992 LPRINT "DISCOUNTED LIFE CYCLE COST OF THE HRI PER MBTU PRODUCED  "....
1993 LPRINT USING "$$### ##"; DIS LC COST HRI PER MBTU
1994 LPRINT "DISCOUNTED LIFE CYCLE SAVINGS OF THE HRI PER MBTU PRODUCED  "....
1995 LPRINT USING "$$### ##-"; DIS.TOT SAVINGS PER.MBTU
1996 LPRINT
1997 LPRINT
```

```
2000 LPRINT "DISCOUNTED LIFE CYCLE SAVINGS OF THE HRI  " ...
2010 LPRINT USING "$$#########.-", DIS TOT SAVINGS
2020 LPRINT "HRI SAVINGS-TO-INVESTMENT RATIO  ".......
2030 LPRINT USING "+## ##", SIR
2040 LPRINT "PAYBACK PERIOD IN YEARS (INCLUDES PROJECT LEAD TIME  " ....
2050 IF PAYBACK YEAR <> 0 THEN LPRINT USING "## #", PAYBACK YEAR ELSE LPRINT "> PROJECT LIFE"
2060 RETURN
```

Appendix D

EQUATIONS FOR TECHNO-ECONOMIC FUNCTIONS SHOWN IN TEXT

Title	Equation
Discounted Life Cycle Cost vs Capital Cost	$F(x) = 0.6637x + 3{,}397{,}650$
Discounted Life Cycle Savings vs Capital Cost	$F(x) = 0.2319x + 5{,}604{,}340$
HRI Savings-to-Investment Ratio vs Capital Cost	$F(x) = 0.64246x^2 - 4.0872x + 8.99$
Payback Period in Years vs Capital Cost	$F(x) = 1.8095\text{ E-}6x + 4.9$
Discounted Life Cycle Cost vs Cost of Solid Waste Disposal	$F(x) = 84{,}811x + 3{,}519{,}339$
Discounted Life Cycle Savings vs Cost of Solid Waste Disposal	$F(x) = 84{,}469x + 4{,}824{,}225$
HRI Savings-to-Investment Ratio vs Cost of Solid Waste Disposal	$F(x) = 0.04488x + 2.5672$
Payback Period in Years vs Cost of Solid Waste Disposal	$F(x) = 0.0002904x^2 - 0.051311x + 9.3353$
Discounted Life Cycle Cost vs Btu/lb Waste Input	$F(x) = 194x + 3{,}822{,}335$
Discounted Life Cycle Savings vs Btu/lb Waste Input	$F(x) = 1{,}098x + 601{,}620$
HRI Savings-to-Investment Ratio vs Btu/lb Waste Input	$F(x) = 0.00058x + 0.34$
Payback Period in Years vs But/lb Waste Input	$F(x) = 1.7929\text{ E-}7x^2 - 2.5324\text{ E-}3x + 16.9126$
Discounted Life Cycle Cost vs HRI % Thermal Efficiency	$F(x) = 17{,}635x + 3{,}821{,}550$
Discounted Life Cycle Savings vs HRI % Thermal Efficiency	$F(x) = 99{,}871x + 598{,}318$

Title	Equation
HRI Savings-to-Investment Ratio vs HRI % Thermal Efficiency	$F(x) = 0.053333x + 0.30668$
Payback Period in Years vs HRI % Thermal Efficiency	$F(x) = 0.0020388x^2 - 0.29279x + 18.636$
Discounted Life Cycle Cost vs Economic Life (yr)	$F(x) = -3{,}277.7x^2 + 1{,}254{,}993x + 2{,}192{,}255$
Discounted Life Cycle Savings vs Economic Life (yr)	$F(x) = -5{,}308.6x^2 + 2{,}119{,}500x + 576{,}563$
Savings-to-Investment Ratio vs Economic Life (yr)	$F(x) = -0.0027639x^2 + 1.10726x + 0.312376$
Payback Period in Years vs Economic Life (yr)	$F(x) = 0.002484x^2 - 0.84773x + 9.1176$
Discounted Life Cycle Cost vs Wet Ash/Waste Burned (tons)	$F(x) = 1{,}657{,}804x + 4{,}045{,}456$
Discounted Life Cycle Savings vs Wet Ash/Waste Burned (tons)	$F(x) = -1{,}657{,}804x + 6{,}837{,}224$
Savings-to-Investment Ratio vs Wet Ash/Waste Burned (tons)	$F(x) = -0.88572x + 3.6385$
Payback Period in Years vs Wet Ash/Waste Burned (tons)	$F(x) = 37.682x^2 - 109.94x + 8.2985$
Discounted Life Cycle Cost vs Differential Energy Inflation Rate	$F(x) = 2{,}998.6x^2 + 21{,}599x + 4{,}608{,}500$
Discounted Life Cycle Savings vs Differential Energy Inflation Rate	$F(x) = 38{,}594x^2 + 277{,}932x + 4{,}701{,}580$
Savings-to-Investment Ratio vs Differential Energy Inflation Rate	$F(x) = 0.020694x^2 + 0.14628x + 1.9912$

Title	Equation
Payback Period in Years vs Differential Energy Inflation Rate	$F(x) = 0.022243x^2 - 0.49262x + 10.640$
Discounted Life Cycle Cost vs Differential Landfill Inflation Rate	$F(x) = 7{,}562.1x^2 + 54{,}451x + 4{,}330{,}150$
Discounted Life Cycle Savings vs Differential Landfill Inflation Rate	$F(x) = 8{,}779.7x^2 + 63{,}233x + 5{,}555{,}564$
Savings-to-Investment Ratio vs Differential Landfill Inflation Rate	$F(x) = 0.0053142x^2 + 0.026382x + 2.9752$
Payback Period in Years vs Differential Landfill Inflation Rate	$F(x) = -0.0006433x^2 - 0.052187x + 9.01002$
Savings-to-Investment Ratio vs Discount Rate	$F(x) = -0.25666x + 5.8066$
Payback Period in Years vs Discount Rate	$F(x) = 0.066665x + 8.03335$

DISTRIBUTION LIST

AFESC AFESC/TST, Tyndall AFB, FL
ARMY ARRADCOM, Dover, NJ; DAEN-CWE-M, Washington DC; DAEN-MPE-D Washington DC; DAEN-MPU, Washington DC; ERADCOM Tech Supp Dir. (DELSD-L) Ft. Monmouth, NJ; HQDA (DAEN-FEE-A)
ARMY - CERL Energy Systems, Champaign, IL; Library, Champaign IL
ARMY CORPS OF ENGINEERS Seattle Dist. Library, Seattle WA
ARMY ENGR DIST. Library, Portland OR
ARMY-MERADCOM DRDME-WC Ft Belvoir VA
CNO Code NOP-964, Washington DC; Code OP-413 Wash, DC; OP-098, Washington, DC; OP987J, Washington, DC
DTIC Alexandria, VA
DTNSRDC Code 4120, Annapolis, MD; Code 522 (Library), Annapolis MD
KWAJALEIN MISRAN BMDSC-RKL-C
LIBRARY OF CONGRESS Washington, DC (Sciences & Tech Div)
MARINE CORPS HQS Code LFF-2, Washington DC
NAS Weapons Offr, Alameda, CA
NATL RESEARCH COUNCIL Naval Studies Board, Washington DC
NAVEDTRAPRODEVCEN Technical Library, Pensacola, FL
NAVFACENGCOM Alexandria, VA; Code 03 Alexandria, VA; Code 032E, Alexandria, VA; Code 03T (Essoglou) Alexandria, VA; Code 04A1 Alexandria, VA; Code 04M, Alexandria, VA; Code 04T1B (Bloom), Alexandria, VA; Code 04T4 (D. Potter) Alexandria, VA; Code 051A Alexandria, VA; Code 082, Alexandria, VA; Code 09M54, Tech Lib, Alexandria, VA; Code 100, Alexandria, VA; Code 1113, Alexandria, VA; Code 112, Alexandria, VA
NAVFACENGCOM - CHES DIV. Code 405 Wash, DC; Library, Washington, D.C.
NAVFACENGCOM - LANT DIV. Code 1112, Norfolk, VA; Code 403, Norfolk, VA; Code 405 Civil Engr BR Norfolk VA; Library, Norfolk, VA
NAVFACENGCOM - NORTH DIV. (Boretsky) Philadelphia, PA; CO; Code 04 Philadelphia, PA; Code 04AL, Philadelphia PA; Code 111 Philadelphia, PA; Code 114 (A. Rhoads); Code 405 Philadelphia, PA
NAVFACENGCOM - PAC DIV. CODE 09P PEARL HARBOR HI; Code 402, RDT&E, Pearl Harbor HI; Library, Pearl Harbor, HI
NAVFACENGCOM - SOUTH DIV. Code 1112, Charleston, SC; Code 405 Charleston, SC; Code 406 Charleston, SC; Library, Charleston, SC
NAVFACENGCOM - WEST DIV. Code 04B San Bruno, CA; Code 102 San Bruno, CA; Code 114C, San Diego CA; Code 405 San Bruno, CA; Library, San Bruno, CA; O9P/20 San Bruno, CA; RDT&ELO San Bruno, CA; Security Offr, San Diego CA
NAVFACENGCOM CONTRACTS ROICC, Code 61, Silverdale, WA
NAVMAG SCE, Guam, Mariana Islands
NAVORDMISTESTFAC PWD - Engr Dir, White Sands, NM
NAVPHIBASE SCE Coronado, SD,CA
NAVSCOLCECOFF C35 Port Hueneme, CA
NAVSECGRUCOM Code G43, Washington DC
NAVSHIPYD Code 202.5 (Library), Bremerton, EA
NAVSTA SCE, Guam, Marianas
NAVSURFWPNCEN Code E211 (C. Rouse) Dahlgren, VA; Code W42 (R. Ponzetto), Dahlgren, VA
NAVWARCOL Fac Dir, Newport, RI
NAVWPNCEN Code 24 (Dir Safe & Sec) China Lake, CA
NETC Code 42, Newport, RI; Utilities Dir (Code 46), Newport, RI
NOAA Library Rockville, MD
OFFICE SECRETARY OF DEFENSE OASD (MRA&L) Dir. of Energy, Pentagon, Washington, DC
ONR Code 700F Arlington VA
PWC Code 101 (Library), Oakland, CA; Code 123-C, San Diego, CA; Code 438 (Aresto), San Diego, CA; Library, Guam, Mariana Islands; Library, Norfolk, VA; Library, Pearl Harbor, HI; Library, Pensacola, FL; Library, Yokosuka JA; Tech Lib (Code 154), Great Lakes, IL; Tech Library, Subic Bay, RP
USCG Library Hqs Washington, DC
USCG R&D CENTER Library New London, CT
USNA ENGRNG Div, PWD, Annapolis MD; Energy-Environ Study Grp, Annapolis, MD
USS JASON Repair Officer, San Francisco, CA
L.I. DIMMICK CORP J. Ertmann, Oxnard, CA

DISTRIBUTION QUESTIONNAIRE

The Naval Civil Engineering Laboratory is revising its primary distribution lists.

SUBJECT CATEGORIES

1 **SHORE FACILITIES**
2 Construction methods and materials (including corrosion control, coatings)
3 Waterfront structures (maintenance/deterioration control)
4 Utilities (including power conditioning)
5 Explosives safety
6 Construction equipment and machinery
7 Fire prevention and control
8 Antenna technology
9 Structural analysis and design (including numerical and computer techniques)
10 Protective construction (including hardened shelters, shock and vibration studies)
11 Soil/rock mechanics
13 BEQ
14 Airfields and pavements
15 **ADVANCED BASE AND AMPHIBIOUS FACILITIES**
16 Base facilities (including shelters, power generation, water supplies)
17 Expedient roads/airfields/bridges
18 Amphibious operations (including breakwaters, wave forces)
19 Over-the-Beach operations (including containerization, materiel transfer, lighterage and cranes)
20 POL storage, transfer and distribution
24 **POLAR ENGINEERING**
24 Same as Advanced Base and Amphibious Facilities, except limited to cold-region environments
28 **ENERGY/POWER GENERATION**
29 Thermal conservation (thermal engineering of buildings, HVAC systems, energy loss measurement, power generation)
30 Controls and electrical conservation (electrical systems, energy monitoring and control systems)
31 Fuel flexibility (liquid fuels, coal utilization, energy from solid waste)
32 Alternate energy source (geothermal power, photovoltaic power systems, solar systems, wind systems, energy storage systems)
33 Site data and systems integration (energy resource data, energy consumption data, integrating energy systems)
34 **ENVIRONMENTAL PROTECTION**
35 Solid waste management
36 Hazardous/toxic materials management
37 Wastewater management and sanitary engineering
38 Oil pollution removal and recovery
39 Air pollution
40 Noise abatement
44 **OCEAN ENGINEERING**
45 Seafloor soils and foundations
46 Seafloor construction systems and operations (including diver and manipulator tools)
47 Undersea structures and materials
48 Anchors and moorings
49 Undersea power systems, electromechanical cables, and connectors
50 Pressure vessel facilities
51 Physical environment (including site surveying)
52 Ocean-based concrete structures
53 Hyperbaric chambers
54 Undersea cable dynamics

TYPES OF DOCUMENTS

85 **Techdata Sheets**
83 **Table of Contents & Index to TDS**
86 **Technical Reports and Technical Notes**
82 **NCEL Guide & Updates**
91 **Physical Security**
☐ **None— remove my name**

INSTRUCTIONS

The Naval Civil Engineering Laboratory has revised its primary distribution lists. The bottom of the mailing label has several numbers listed. These numbers correspond to numbers assigned to the list of Subject Categories. Numbers on the label corresponding to those on the list indicate the subject category and type of documents you are presently receiving. If you are satisfied, throw this card away (or file it for later reference).

If you want to change what you are presently receiving:

- Delete – mark off number on bottom of label.
- Add – circle number on list.
- Remove my name from all your lists – check box on list.
- Change my address – line out incorrect line and write in correction (**ATTACH MAILING LABEL**).
- Number of copies should be entered after the title of the subject categories you select.

Fold on line below and drop in the mail.

Note: Numbers on label but not listed on questionnaire are for NCEL use only, please ignore them.

Fold on line and staple.

DEPARTMENT OF THE NAVY

NAVAL CIVIL ENGINEERING LABORATORY
PORT HUENEME, CALIFORNIA 93043

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300
1 IND-NCEL-2700/4 (REV. 12-73)
0930-LL-L70-0044

POSTAGE AND FEES PAID
DEPARTMENT OF THE NAVY
DOD-316

Commanding Officer
Code L14
Naval Civil Engineering Laboratory
Port Hueneme, California 93043

PLEASE HELP US PUT THE ZIP IN YOUR MAIL! ADD YOUR FOUR NEW ZIP DIGITS TO YOUR LABEL (OR FACSIMILE), STAPLE INSIDE THIS SELF-MAILER, AND RETURN TO US.

(fold here)

DEPARTMENT OF THE NAVY

NAVAL CIVIL ENGINEERING LABORATORY
PORT HUENEME, CALIFORNIA 93043-5003

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300
1 IND-NCEL-2700/4 (REV. 12-73)
0930-LL-L70-0044

POSTAGE AND FEES PAID
DEPARTMENT OF THE NAVY
DOD-316

U.S.MAIL®

Commanding Officer
Code L14
Naval Civil Engineering Laboratory
Port Hueneme, California 93043-5003

END

FILMED

12-85

DTIC