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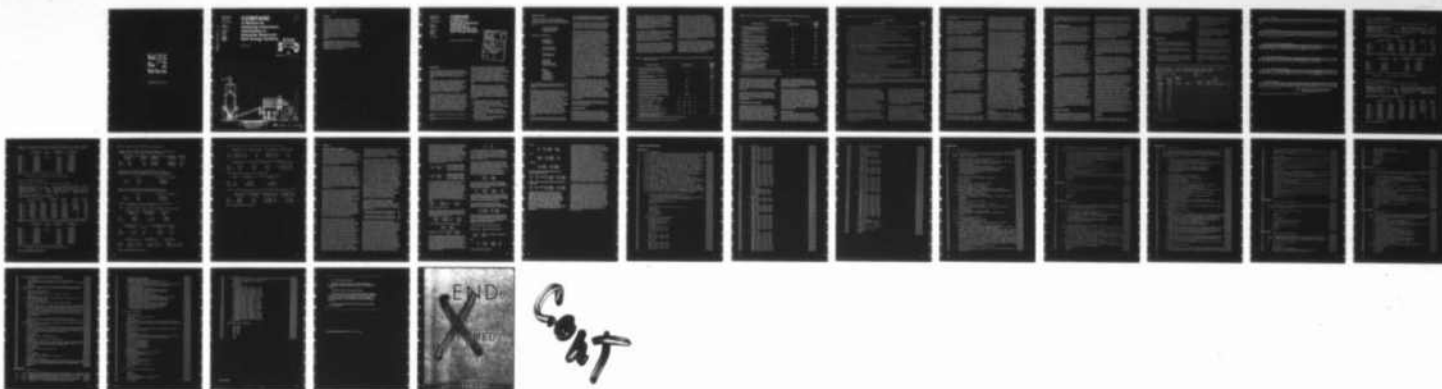
COMPARE: A METHOD FOR ANALYZING INVESTMENT ALTERNATIVES
IN INDUSTRIAL WOOD AND BARK ENERGY SYSTEMS(U) FOREST
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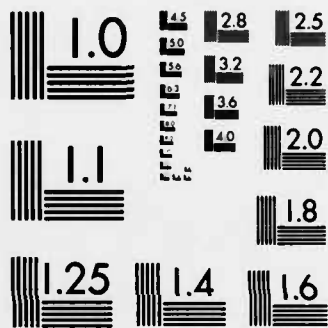
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United States
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Forest Service

Forest
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General
Technical
Report
FPL-36



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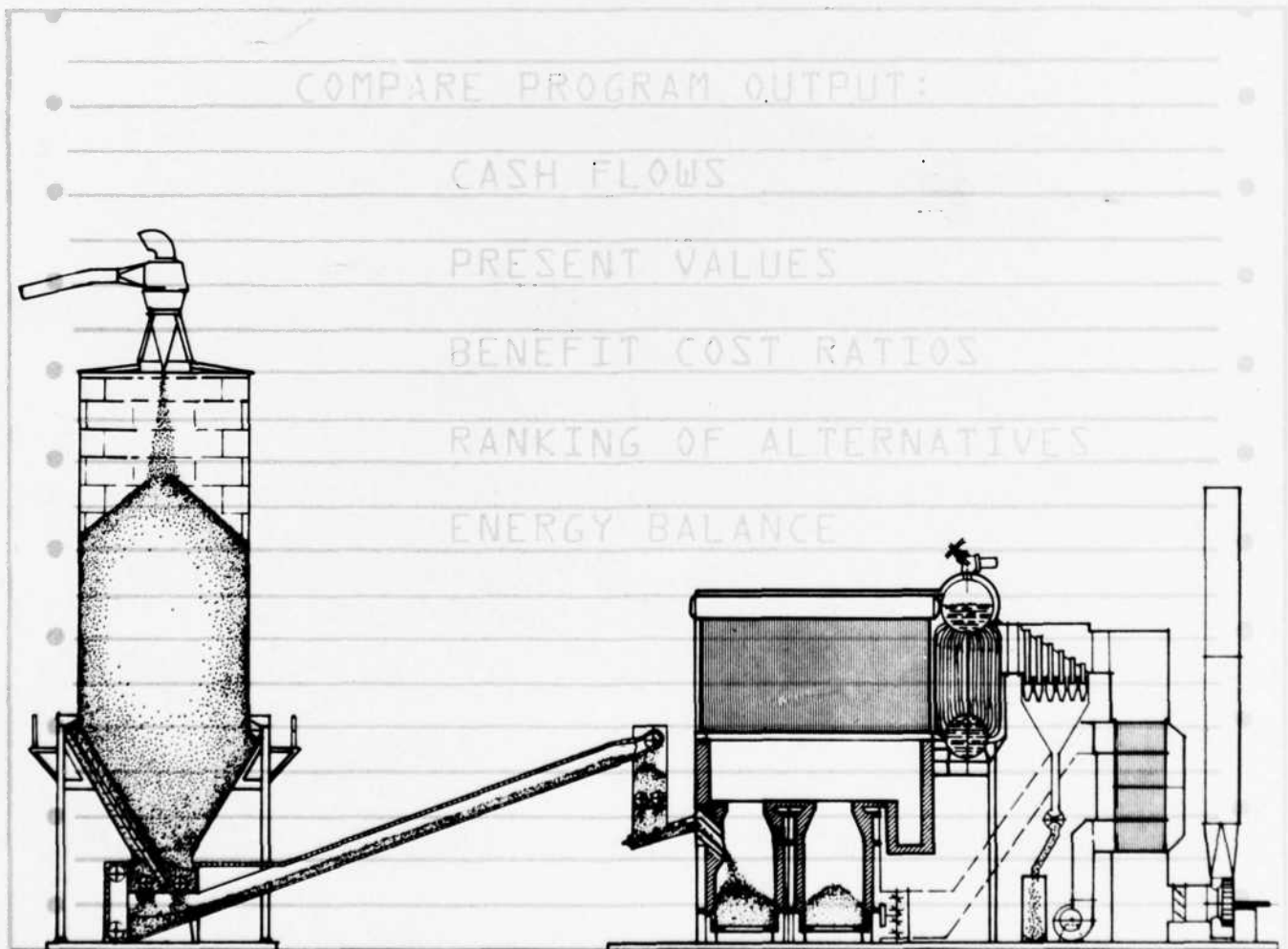
COMPARE

A Method for Analyzing Investment Alternatives in Industrial Wood and Bark Energy Systems

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Peter J. Ince

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Abstract

→ COMPARE is a FORTRAN computer program resulting from a study to develop methods for comparative economic analysis of alternatives in industrial wood and bark energy systems. COMPARE provides complete guidelines for economic analysis of wood and bark energy systems. As such, COMPARE can be useful to those who have only basic familiarity with investment analysis of wood and bark energy systems. This report provides instructions on how to prepare data for COMPARE, information on how to use the program, sample data, sample output, and a listing of the program.

COMPARE ranks investment alternatives according to the highest benefit cost ratio based on discounted energy values and cash flows. The use of a benefit cost ratio as a ranking criterion is analyzed and explained in an appendix to this report. ←

United States
Department of
Agriculture

Forest Service

Forest
Products
Laboratory¹

General
Technical
Report
FPL-36

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COMPARE

A Method for Analyzing Investment Alternatives in Industrial Wood and Bark Energy Systems

PETER J. INCE, Research Forester

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Introduction

This report presents a method that was developed to analyze investments in industrial wood and bark energy systems. The method is embedded in a computer program called COMPARE that is presented in this report.

COMPARE was written in FORTRAN language which is widely used among forest products researchers and professionals. COMPARE was developed using facilities of the University of Wisconsin UNIVAC 1110 computer under the EXEC 8 operating system, and is compatible with the Madison Academic Computer Center version of the FORTRAN V language.

This report contains instructions for others who would like to use COMPARE. A user must have access to a computer system capable of processing the COMPARE program listed in the appendix. Since all versions of FORTRAN and all computer systems are not precisely the same, some minor modifications may be required in the program to make COMPARE compatible with other systems. A user should have some experience or basic familiarity with FORTRAN computer programs, with cash flow investment analysis, and with the general

design or concepts of industrial energy systems that burn wood or bark as fuel. Several references are provided for general information on cash flow analysis (1, 2, 7, 8),² concepts of wood energy systems (3, 5), and computer programs for economic analysis (4, 6). Finally, the user will create the required data which are used as input for COMPARE and described in this report. COMPARE is therefore an analytical tool, the results of which depend mainly on data provided by the user.

COMPARE is a framework for economic investment analysis of alternatives in wood and bark energy systems. The user of COMPARE provides a set of data which describes two or more investment alternatives. With accurate data, COMPARE will calculate which alternative appears most economical. The following are some examples of applications where COMPARE may be useful:

1. An economic feasibility study of a new wood or bark energy system at a manufacturing plant.
2. A comparative economic analysis of using wood or bark fuel versus "fossil" fuel (e.g. coal, oil, or gas) at an industrial facility.
3. An economic feasibility study of adding new equipment to an existing wood or bark energy system (such as fuel pre-dryers or additional heat recovery devices).
4. Research and development economic analyses of new wood and bark energy systems or new equipment design concepts.

¹Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

²Italicized numbers in parentheses refer to literature cited at the end of this report.

Program Function

A complete listing of the COMPARE program is provided in the appendix. Overall, COMPARE performs the following series of data processing and analytical steps:

READ DATA SUPPLIED
BY USER AND ASSIGN
PROGRAMED DATA

FOR EACH ALTERNATIVE:

CALCULATE
DEPRECIATION
ALLOWANCES

CALCULATE HEAT
ENERGY RECOVERY

CALCULATE FUEL
REQUIREMENTS

CALCULATE
INVESTMENT
PARAMETERS AND
ECONOMIC CRITERIA

PRINT:
FINANCIAL
SUMMARIES
RANKING OF
ALTERNATIVES
ENERGY, FUEL
PARAMETERS

First, COMPARE reads the data input supplied by the user, and assigns programed data values for the analysis.

The program then calculates depreciation for each investment alternative being analyzed. In data input the user can specify the depreciation schedule that will be calculated from the four schedules that are mandated under the Federal Accelerated Cost Recovery System—ACRS (1981). The choice of schedule depends on when the investment is put in place. The first schedule applies in 1981 to 1984, the second schedule applies in 1985, and the third schedule applies in 1986 and thereafter. The fourth schedule is straight line depreciation which can be used at any time under ACRS guidelines. Alternatively, the user can simply enter a complete depreciation schedule as data input instead of having the schedule calculated by the program.

Next, the program calculates heat recovery in Btu per pound of wood or bark fuel for each alternative. Heat

recovery estimates are calculated on the basis of data input. The general algorithm for calculating heat recovery is described in a separate publication (5).

The program then calculates the quantity of wood or bark, as well as alternate or auxiliary fuels (nonwood or bark) required to satisfy user-specified annual heat requirements in each of the investment alternatives.

Next, the program calculates net cash flows and present value of net cash flows for each alternative. Net cash flow is conventionally defined as revenues minus operating expenses, taxes, and investments in a given time period. However, COMPARE only considers operating expenses (costs), taxes, and investment. COMPARE operates on the assumption that there are always sufficient revenues and tax liability, such that the full amount of depreciation allowances and expenses can be deducted from tax liability. Thus, in COMPARE the annual "net cash flows" are calculated as follows: The initial net cash flow occurs at the beginning of the first year (beginning of year 1, also known as "year 0"). The initial net cash flow is the old facility net salvage value, minus the total initial investment and working capital requirement. Subsequent cash flows are end of year flows. Net cash flow at the end of the first year is investment tax credit, plus first year depreciation allowance times the tax rate, minus additional investment (for working capital), and annual costs (including the nondepreciable expenses part of investment) times one minus the tax rate. Net cash flows for subsequent years are calculated as depreciation allowance times tax rate, minus additional investment, and annual costs times one minus the tax rate. Net cash flow for the last year is adjusted by adding back the accumulated working capital and ending salvage value.

The program then calculates a benefit cost ratio for each investment alternative. The benefit part of the ratio is the discounted present value of energy outputs which are assigned an arbitrary value by the user. The "cost" part is the discounted present value of net cash flows. In COMPARE, net cash flows represent essentially the net cost of energy, after taking into account investment, taxes, and depreciation. Energy output values are assigned in the data input in dollars per million Btu. The methodology and appropriateness of using a benefit cost ratio as a criterion is discussed in the appendix.

Finally, the program calculates the heat energy and fuel requirements balance for each alternative in terms of Btu and fuel sales units.

Data Requirements

COMPARE data input requirements are described in this section of the report. Data input is partly optional because COMPARE contains programed values for part of the data. The programed values are for data that can be assigned typical or common values. For example, the higher heating value of wood or bark is assigned a

value of 8,500 Btu per pound. The user may always refine an analysis by entering more accurate data to replace the programed values. The user may replace programed values by simply entering different values in the data. However, COMPARE does not contain programed values for some of the data (particularly economic data) so the user must always provide some of the data for program input.

The first step in using COMPARE is to create the data set for each of the investment alternatives. From 2 to 10 alternatives can be analyzed per run. It is an important and critical task for the user to create accurate data because the accuracy of results is likely to depend on the accuracy of the data.

The first items of data required for COMPARE are the number of alternatives to be analyzed and a name or title for each alternative. Next, data are required on the physical parameters of wood and bark, and alternate or auxiliary (nonwood or bark) fuels in each alternative. The data should represent average values, and are

intended to describe the average physical characteristics of fuels in each of the alternatives. Table 1 describes the specific data that are required for each alternative. As indicated in table 1, the COMPARE program is provided with programed values for most of the data. Thus, the user does not need to provide data if programed values are appropriate. Table 1 shows the specific values that are programed for all alternatives. As noted in table 1, the user must provide some data for which there are no programed values. A set of data corresponding to the data outlined in table 1 must be entered for each of the investment alternatives. Table 1 also gives the program name (four-letter variable code) for each of the items of data.

Data are required also on the physical parameters of the heat recovery system for each alternative. Those parameters are shown in table 2 as are the programed values that will be used for all alternatives unless the user provides substitute data. A separate set of data corresponding to that shown in table 2 must be developed for each investment alternative.

Table 1. — Description of data input parameters required by COMPARE for wood or bark fuel and auxiliary or alternate fuel for each investment alternative.

Parameter description	Programed value ¹				Program variable name
(1) wood or bark fuel moisture content (as fired, average decimal fraction of wet weight)	(2)				AFMC
(2) weight of wood or bark fuel in oven-dry pounds per sales unit	(2)				AWRU
(3) the name of the wood or bark fuel sales unit (maximum of 8 letters)	(2)				RFS1 and RFS2
(4) the ultimate analysis hydrogen content of the wood or bark fuel (decimal fraction of dry weight)	0.06				AVHC
(5) the ultimate analysis oxygen content of the wood or bark fuel (decimal fraction of dry weight)	0.41				AVOC
(6) the ultimate analysis carbon content of the wood or bark fuel (decimal fraction of dry weight)	0.50				AVCC
(7) the ultimate analysis nitrogen content of the wood or bark fuel (decimal fraction of dry weight)	0.01				AVNC
(8) average higher heating value of the wood or bark fuel (Btu per pound, oven-dry)	8,500.0				AHHV
(9) type of alternate or auxiliary fuel (coded choice: 0-oil, 1-coal, 2-nat. gas, 3-other)	(0)	(1)	(2)	(3)	NCAF
(10) the name of the alternate or auxiliary fuel (max. of 4 letters)	OIL	COAL	GAS	(2)	AXFT
(11) the name of the sales unit for the alternate or auxiliary fuel (4 letters)	BBL.	TON	MCF	(2)	AFSU
(12) higher heating value of alternate or auxiliary fuel (millions of Btu per sales unit)	6.3	24.0	1.0	(2)	HHVU
(13) combustion heat recovery efficiency obtained from alternate or auxiliary fuel (decimal fraction of higher heating value)	0.8	0.67	0.76	(2)	CHRE

¹Programed values are used in the analysis unless the user enters substitute data.

²Indicates parameter must be supplied by user (no programed value).

Table 2. — Description of data input parameters required by COMPARE for the heat recovery system in each alternative

Heat recovery system parameters		
Parameter description	Programed value ¹	Program variable name
(14) essential annual heat energy requirements, or essential heat energy output of the system in millions of Btu per year	(²)	EBTU
(15) surplus heat energy output in millions of Btu per year	(²)	SBTU
(16) maximum quantity of wood or bark fuel available for use per year (sales units)	(²)	RAVL
(17) temperature of flue or stack gases just beyond heat recovery devices of the system when burning wood or bark fuel (°F)	500.0	ASGT
(18) temperature of the wood or bark fuel entering the furnace (°F)	60.0	ATRF
(19) temperature of the combustion air entering the furnace (°F) with wood or bark	60.0	ATCA
(20) excess air entering the furnace, as a decimal fraction of theoretical air needed for combustion, when burning wood or bark	0.40	AEOF
(21) "conventional" heat loss (decimal fraction of available heat of combustion that is lost via radiation, convection, conduction, etc.), when burning wood or bark	0.04	ACHL
(22) the decimal fraction of Btu output which is designed to be derived from wood or bark fuel when such fuel is available and used (remaining fraction is derived from auxiliary fuel)	0.0	AFBA

¹Programed values are used unless the user enters substitute data.

²Indicates parameter must be supplied by user (no programed values).

Finally, data are required on the economic parameters, for which there are no programed values, associated with each alternative. Table 3 outlines the required economic data, all of which must be entered by the user. A separate set of data corresponding to that shown in table 3 must be provided for each investment alternative.

The data outlined in tables 1 to 3 describe fully the pertinent physical and economic parameters of each alternative. There must be a title and a set of data corresponding to the data outlined in tables 1 to 3 for each alternative.

A Compare Analysis Example

The following is an example of analysis using the COMPARE program based on hypothetical sample data. Three investment alternatives in energy systems for a hypothetical forest products manufacturing facility are compared. The first is to continue operating a fully depreciated boiler system that uses natural gas fuel and requires no new investment. The second, requiring an investment of \$1,428,000, is to install a wood fuel and supplementary oil burning furnace and

boiler to burn available wood residues. The third alternative is to install a larger wood fuel and coal burning furnace and boiler requiring an investment of \$1,828,000. The second and third alternatives allow surplus heat energy output.

Under all three alternatives, the energy system will satisfy the essential process heat energy requirements of the wood products facility. Heat energy is required, for example, as process steam and for space heating. Essential heat energy requirements are 252,230 million Btu per year. The critical question is, which of the three investment alternatives is most economical? Sufficient data have been obtained to use the COMPARE program to analyze the three alternatives. The sample data and analysis results are provided here. Again, this is purely an illustrative example. Results are not applicable in general to other cases.

Data Input Format

The sample data illustrated in figure 1 describe each of the three investment alternatives. Data input is prepared for COMPARE using specific data format and instructions described in this section of the report. The data include the number of investment alternatives, the

Table 3. — Description of economic data parameters required by COMPARE

Economic parameters	
Parameter description	Program variable name
(23) the capital investment in new assets required to undertake the investment alternative or project (in dollars at the beginning of the first year of the planning period—year 0)	IVST
(24) the working capital requirements needed to undertake the project (dollars required at year 0)	WCRO
(25) the nondepreciable expenses required to undertake the project (dollars at year 0)	IEXP
(26) the salvage value, if any, from salvage of old assets (in dollars, after taxes, at year 0)	CSAL
(27) the after-tax salvage value of new assets at the end of the last year of the planning period (in dollars)	FATS
(28) the discount rate used for discounting future after-tax net cash flows to present value (decimal fraction)	DISR
(29) the effective tax rate on ordinary income (decimal fraction)	TXRT
(30) depreciation schedule for new assets (coded choice: 1—ACRS schedule for 1981 to 1984, 2—ACRS schedule for 1985, 3—ACRS schedule for 1986 and thereafter, 4—straight line depreciation, 0 or other—user enters depreciation, or no depreciation considered)	NDEP
(31) the number of years in the planning period (1 to 20)	NYRS
(32) the number of years in the depreciation period (usually 5 years for most manufacturing related combustion equipment)	NYRD
(33) the investment tax credit afforded by investment in new assets (dollars at end of year 1)	ITCR
(34) the annual rate of increase or inflation in total working capital requirements	INRT
(35) total annual variable costs, excluding depreciation, during each year of the planning period (in dollars)	VCST
(36) total annual fixed costs, excluding depreciation, during each year of the planning period (in dollars)	FCST
(37) value of essential heat energy outputs in dollars per million Btu	HVAL
(38) value of surplus heat energy outputs in dollars per million Btu	SVAL
(39) average value of auxiliary or alternate fuel during each year of the planning period (in dollars per fuel sales unit)	PAXF
(40) average value of wood or bark fuel during each year of the planning period (dollars per fuel sales unit)	RVAL
(41) (optional) annual depreciation allowances for new assets during each year of the planning period, in dollars (required only if parameter 30 is not specified as 1, 2, 3, or 4, or if the user does not intend to have depreciation calculated on the basis of parameter 30)	DEPR

Note: Each of parameters 35 to 40 may be specified optionally as the first-year value and an estimated annual rate of increase. The computer will calculate the appropriate values for all other years in the planning period. All dollar amounts should be in terms of actual dollars (not indexed, "real," or constant value dollars).

title of each alternative, and the 41 items listed in tables 1 to 3. In most data processing facilities such data can be entered either by using keypunched data cards, or by writing the data on a tape or disk file. Data format is the same whether the computer reads a card deck, or a file. (It is important to follow the instructions provided here because if the correct format is not used the program may not function properly.) The instructions are given on a card by card basis, assuming the user will prepare a data card deck. The same format would apply if the user prepared a data file on disk or tape except that the data would be entered line by line on the data file instead of on cards.

Six types of cards must be used to prepare data in order to use the COMPARE program. The program variables and the format used on the six types of data cards are shown in figure 2. The six types of data cards are prepared as follows:

Card type 1.—The first card in the data deck (or first line in a data file) is always the type 1 card and only one to a deck. The only data on the type 1 card is the number of investment alternatives to be considered in the analysis. The program name of this entry is NALT. The user may specify an integer number from 2 to 10, which will correspond to the number of alternatives. The number is entered in the first two columns justified to the right (using FORMAT (I2)).

Card type 2.—The titles of the investment alternatives are entered separately on type 2 data cards with one card for each alternative. There will be from 2 to 10 type 2 data cards, depending on the number of alternatives specified (NALT). For example, if three alternatives are specified, there will be a separate title for each and one type 2 data card for each title. Each title can be up to 80 columns wide (using FORMAT (20 A4)). Furthermore, the sequence in which the titles are

entered determines the sequence in which remaining data are entered.

Card type 3.—Type 3 cards contain data on physical parameters of wood and bark fuel for each alternative. All of the parameters (1-13) described in table 1 are entered on type 3 data cards. The number of type 3 cards must be the same as the number of alternatives (NALT). Type 3 cards are prepared in the same sequence of alternatives as type 2 cards. The format for data entry is illustrated in figure 2.

If programed values are appropriate then the user does not have to enter the data. Four of the data items, as noted in table 1, have no programed values (AFMC, AWRU, RFS1 and RFS2, and NCAF). The user must always enter data for those items. However, any of the other items on type 3 data cards may be left blank, in which case the programed values shown in table 1 will be used.

Card type 4.—Data on the physical parameters of the energy system as outlined in table 2 are entered next on type 4 data cards. The number of type 4 cards is the same as the number of alternatives (NALT), and are prepared in the same sequence of alternatives as the type 2 cards. All of the data outlined in table 2 (parameters 14-22) are entered on the type 4 cards. The format for data entry is illustrated in figure 2. Values for the parameters EBTU, SBTU, and RAVL must always be entered by the user. Values for the other items need not be entered if programed values are appropriate (programed values are given in table 2).

Card type 5.—Type 5 data cards are used to enter part of the economic parameters outlined in table 3 (parameters 23-34). One type 5 data card is prepared for each of the alternatives (NALT), again using the same sequence of alternatives as the type 2 cards. This format is also illustrated in figure 2. Values for all economic parameters must be entered by the user because COMPARE has no programed values for economic data (none of the entries on the type 5 data cards should be blank, unless an entry of zero is intended).

Card type 6.—The last type of data card, type 6, is used for entering the remaining economic data (parameters 35-41 from table 3). Type 6 data cards differ from previous cards in that only one parameter for each alternative is entered on each type 6 card. Values for the following parameters are entered separately on type 6 cards: VCST, FCST, HVAL, SVAL, PAXF, RVAL, and optionally, DEPR. For each parameter, a value is required for each year in the planning period for each alternative. The number of years in the planning period (or economic life) of each alternative is the number specified for NYRS on the type 5 data card.

There are two options for entering data on type 6 cards. One option is to enter data values for each year of the planning period for each alternative. The second option

is to enter only a first-year value followed by a decimal fraction which represents the annual rate of increase or decrease in the first-year value. Under the second option, the user does not have to provide estimates for each year of the planning period. Under that option, COMPARE will compute values for years following the first year by compounding the specified annual rate of increase or decrease over the entire planning period.

The sequence of data entry for type 6 data cards is as follows: First, the appropriate values are entered for the parameter VCST for the first alternative (using the sequence of alternatives established by type 2 cards). Only one card is required per alternative to enter values for VCST if the number of years in the planning period is 10 or less, or if a first-year value plus annual rate of increase is entered. Two cards are required if values for each year are entered and the number of years exceeds 10. After values for VCST are entered for the first alternative, values for VCST are entered for each of the remaining alternatives (again, following the sequence of alternatives established by type 2 cards), using the same instructions as for the first alternative. After VCST values have been entered for each of the alternatives, values for other parameters (FCST, HVAL, SVAL, PAXF, and RVAL in that sequence) are entered in the same way as VCST. Values for each alternative are entered before going to the next parameter. Again annual values for each year of the planning period may be entered; or optionally, just the first-year value (col. 1-8) plus the annual rate of increase as a decimal fraction (col. 9-16) may be entered.

COMPARE can calculate annual depreciation allowances based on user-specified investment in new assets, depreciation period, and selection of the appropriate schedule. The choice of depreciation schedule is made by the user in selecting the appropriate code for the variable NDEP for each alternative (1 for 1981 to 1984 ACRS schedule, 2 for 1985 ACRS schedule, 3 for 1986 and thereafter ACRS schedule, and 4 for straight line). Alternatively, the user can elect to enter annual depreciation allowances instead of having allowances calculated by the computer. That option is indicated by specifying some code value other than 1, 2, 3, or 4 for NDEP (e.g. by specifying 0 for example). If the user thus elects to enter annual depreciation data, the data are entered on type 6 cards, following the cards for RAVL, using the same sequence of alternatives. An allowance value must be entered for each year in the planning period. One card is required if the planning period is 10 years or less, two cards are required if the planning period is 11 to 20 years. No cards are required if codes 1, 2, 3, or 4 are specified for NDEP for a given alternative.

Sample Data

As illustrated with the sample data in figure 1, there is one type 1 data card (line 1), which specifies the number of alternatives ("3" in col. 1-2). There are three type 2 data cards which give the descriptive title of each alternative (lines 2-4); three type 3 data cards (lines

5-7); three type 4 data cards (lines 8-10 in fig. 1); and three type 5 data cards (lines 11-13 in fig. 1). Finally, there are 18 separate type 6 data cards (lines 14-31, in fig. 1).

Sample Program Output

When a COMPARE analysis is made with the sample data shown in figure 1, the results are the printed output shown in figure 3. The output consists of three parts. Part I of the printed output (the first two pages in fig. 3) has financial summaries for each of the three alternatives. The financial summaries show the investment parameters, fuel costs, and cash flows associated with each alternative. Annual net cash flows and present value of net cash flows are also provided.

A ranking of alternatives according to benefit cost ratios is found in part II of the printed output (one page). In the sample output (fig. 3), alternative 3 is ranked highest, with alternative 1 ranked lowest, according to benefit cost ratios. Generally, benefit cost ratios reveal the most economical of any two alternatives, provided that two sufficient assumptions can be made. The assumptions are that both alternatives will be replaced at the end of their economic lives by replacement projects which (1) have the same benefit cost ratio and carry the planning periods forward to an equal planning period for both alternatives, and (2) the replacement projects will have a benefit cost ratio that is between the ratios of the two alternatives evaluated over their current economic lives. The validity of benefit cost ratios as criteria and the two sufficient assumptions are discussed in the appendix.

Part III of the printed output (including tables 1-4 of the output) provides detailed information on the heat energy and fuel balance for each alternative. Table 1 of the output shows heat energy requirements and the proportions of energy requirements that are met by wood fuel and alternate or auxiliary fuel for each alternative. Table 1 also shows amounts of wood and alternate or auxiliary fuels that are needed annually to meet the energy requirements. Table 2 describes physical characteristics of the wood fuel and shows the amount of heat energy calculated as recoverable from the wood fuel (the recoverable heat energy estimate is used in COMPARE to determine the quantity of wood fuel required in each alternative based on heat output). Table 3 provides parameters related to the auxiliary or alternate (nonwood or bark) fuel. Table 4 shows selected parameters in terms of International System (SI) units.

Program Restrictions

COMPARE was developed as an analytical tool to aid in evaluating project feasibility, and as a research tool for economic evaluation of energy system alternatives. It is important for the user to recognize that parts I and III of the program output are not adequate to rank and

compare investment alternatives. For valid comparison of alternatives, the user must refer to part II of the program output, which contains the benefit cost ratios.

COMPARE is quite versatile, being able to simulate a variety of different types of investment alternatives. Yet, the structure of analysis is somewhat restricted by the structure of COMPARE data input and program output. Restrictions could be removed by making the COMPARE program more complicated, but in its current form COMPARE balances sophisticated analysis and simplicity of data input. Some of the restrictions are discussed here.

One restriction is that COMPARE can simulate the use of only one type of wood or bark fuel and only one type of auxiliary or alternate fuel under each alternative. In order to simulate the use of more than one type of wood or alternate fuel it is necessary to enter data that simulate average parameter values. COMPARE could be reprogrammed to handle data for more than one type of fuel in each alternative, but again that would add complexity.

Another restriction is that for each alternative COMPARE permits only one estimate of annual heat energy requirement, which remains the same for each year in the planning period. In some cases, it might be useful to assume that heat energy requirement changes during the planning period, but that sort of assumption cannot be handled by COMPARE in its current form. Again, the restriction could be removed by reprogramming COMPARE to accept and analyze additional data input.

Another limitation is that COMPARE is designed for analysis of wood or bark energy systems that involve combustion and heat recovery from combustion gases, as opposed to energy systems that do not involve combustion. COMPARE contains an algorithm which calculates the recoverable heat energy from combustion of wood or bark fuels, and uses the recoverable heat estimate to determine heat output per unit of fuel and amount of fuel required. A user should understand that COMPARE is designed to calculate recoverable heat energy on the basis of physical parameters given in tables 1 and 2. The recoverable heat estimate is essentially the maximum amount of heat energy that will be recovered (e.g. in the form of steam) given the specified physical parameters. However, some circumstances could result in actual heat output being less than estimated recoverable heat energy. Those circumstances include situations where the furnace and boiler system are used very intermittently, or where heat energy is wasted after it is recovered. Such circumstances generally are assumed not to apply in any of the alternatives the user specifies.

Summary

COMPARE has considerable versatility and can simulate a variety of different types of investments in

PART I. FINANCIAL SUMMARIES

FINANCIAL SUMMARY--ALTERNATIVE 1

FIRST ALTERNATIVE - RETAIN OLD BOILER SYSTEM FOR FIVE YEARS (GAS FIRED)

INVESTMENT PARAMETERS (YEAR 0):	ENDING NET SALVAGE (YEAR 5)\$	30000.
DEPRECIABLE ASSETS - - - \$	0.	EFFECTIVE ANNUAL TAX RATE - - - - .350
NONDEPREC. EXPENSES- - - \$	0.	HEAT ENERGY REQUIREMENTS AND OUTPUT:
WORKING CAPITAL- - - - - \$	20000.	ESSENTIAL REQ. - - 252230. MMRTU/YR.
OLD FACILITY NET SALV. - \$	0.	TOTAL OUTPUT - - - 252230. MMRTU/YR.

ANNUAL COSTS, DEPRECIATION AND AVERAGE ANNUAL COST PER MMRTU OF TOTAL ENERGY OUTPUTS

	FUEL COSTS		OTHER VAR.	FIXED	DEPRE-	COST/
	WOOD-BARK	GAS	COSTS	COSTS	CIATION	MMRTU
	\$	\$	\$	\$	\$	\$
YEAR 1	0.	1742378.	35000.	70000.	0.	7.32
YEAR 2	0.	2177973.	40250.	80500.	0.	9.11
YEAR 3	0.	2722466.	46287.	92575.	0.	11.34
YEAR 4	0.	3403083.	53231.	106461.	0.	14.13
YEAR 5	0.	4253853.	61215.	122430.	0.	17.59

BEFORE TAX NET EXPENSES, INVESTMENT TAX CREDIT, ADDITIONAL INVESTMENT (WORKING CAPITAL) AND AFTER TAX NET CASH FLOW INCLUDING SALVAGE (END OF YEAR VALUES):

	BEFORE TAX	TAX	ADDITIONAL	AFTER TAX
	NET EXPENSES	CREDIT	INVESTMENT	NET CASH FLOW
	\$	\$	\$	\$
YEAR 0	0.			-20000.
YEAR 1	1847378.	0.	3600.	-1204396.
YEAR 2	2298723.		4248.	-1498418.
YEAR 3	2861329.		5013.	-1864876.
YEAR 4	3562774.		5915.	-2321718.
YEAR 5	4437499.		6980.	-2815599.

PRESENT VALUE (YEAR 0) OF AFTER TAX NET CASH FLOWS:

\$ -5394624. AT 20.0 PERCENT ANNUAL DISCOUNT RATE

FINANCIAL SUMMARY--ALTERNATIVE 2

SECOND ALTERNATIVE - INSTALL NEW WOOD AND OIL FIRED SYSTEM

INVESTMENT PARAMETERS (YEAR 0):	ENDING NET SALVAGE (YEAR 10)\$	160000.
DEPRECIABLE ASSETS - - - \$	1428000.	EFFECTIVE ANNUAL TAX RATE - - - - .350
NONDEPREC. EXPENSES- - - \$	50000.	HEAT ENERGY REQUIREMENTS AND OUTPUT:
WORKING CAPITAL- - - - - \$	70000.	ESSENTIAL REQ. - - 252230. MMRTU/YR.
OLD FACILITY NET SALV. - \$	80000.	TOTAL OUTPUT - - - 352230. MMRTU/YR.

ANNUAL COSTS, DEPRECIATION AND AVERAGE ANNUAL COST PER MMRTU OF TOTAL ENERGY OUTPUTS

	FUEL COSTS		OTHER VAR.	FIXED	DEPRE-	COST/
	WOOD-BARK	OIL	COSTS	COSTS	CIATION	MMRTU
	\$	\$	\$	\$	\$	\$
YEAR 1	222344.	293525.	75000.	90000.	214200.	2.54
YEAR 2	244578.	366906.	86250.	103500.	314160.	3.17
YEAR 3	269036.	458633.	99187.	119025.	299880.	3.54
YEAR 4	295940.	573291.	114066.	136879.	299880.	4.03
YEAR 5	325534.	716614.	131175.	157411.	299880.	4.63
YEAR 6	358087.	895767.	150852.	181022.	0.	4.50
YEAR 7	393896.	1119709.	173480.	208175.	0.	5.38
YEAR 8	433285.	1399636.	199501.	239402.	0.	6.45
YEAR 9	476614.	1749545.	229427.	275312.	0.	7.75
YEAR 10	524275.	2186932.	263841.	316609.	0.	9.35

Figure 3. — Sample program output.

BEFORE TAX NET EXPENSES, INVESTMENT TAX CREDIT, ADDITIONAL INVESTMENT (WORKING CAPITAL) AND AFTER TAX NET CASH FLOW INCLUDING SALVAGE (END OF YEAR VALUES):

	BEFORE TAX NET EXPENSES \$	TAX CREDIT \$	ADDITIONAL INVESTMENT \$	AFTER TAX NET CASH FLOW \$
YEAR 0	50000.			-1450500.
YEAR 1	895069.	500000.	12600.	119805.
YEAR 2	1115395.		14868.	-425714.
YEAR 3	1245761.		17544.	-527409.
YEAR 4	1420055.		20702.	-643858.
YEAR 5	1630613.		24429.	-784447.
YEAR 6	1585728.		28826.	-1059549.
YEAR 7	1495260.		34014.	-1265933.
YEAR 8	2271825.		40137.	-1516823.
YEAR 9	2730898.		47362.	-1822445.
YEAR 10	3291657.		55887.	-1669095.

PRESENT VALUE (YEAR 0) OF AFTER TAX NET CASH FLOWS:

\$ -4260940. AT 20.0 PERCENT ANNUAL DISCOUNT RATE

FINANCIAL SUMMARY--ALTERNATIVE 3

THIRD ALTERNATIVE - INSTALL NEW WOOD AND COAL FIRED SYSTEM

INVESTMENT PARAMETERS (YEAR 0):	ENDING NET SALVAGE (YEAR 10)\$	200000.
DEPRECIABLE ASSETS - - - \$	EFFECTIVE ANNUAL TAX RATE - - -	.350
NONDEPREC. EXPENSES - - - \$	HEAT ENERGY REQUIREMENTS AND OUTPUT:	
WORKING CAPITAL - - - - \$	ESSENTIAL REQ. - -	252230. MMBTU/YR.
OLD FACILITY NET SALV. - \$	TOTAL OUTPUT - - -	402230. MMBTU/YR.

ANNUAL COSTS, DEPRECIATION AND AVERAGE ANNUAL COST PER MMBTU OF TOTAL ENERGY OUTPUTS

	FUEL COSTS		OTHER VAR. COSTS	FIXED COSTS	DEPRE- CIATION	COST/ MMBTU
	WOOD-HARK \$	COAL \$	\$	\$	\$	\$
YEAR 1	225694.	325186.	90000.	100000.	274200.	2.52
YEAR 2	248264.	373964.	103500.	115000.	402160.	3.09
YEAR 3	273090.	430058.	119025.	132250.	383880.	3.33
YEAR 4	300399.	494567.	136879.	152087.	383880.	3.65
YEAR 5	330439.	568752.	157411.	174901.	383880.	4.02
YEAR 6	363483.	654065.	181922.	201136.	0.	3.48
YEAR 7	399831.	752175.	208175.	231306.	0.	3.96
YEAR 8	439814.	865001.	239402.	266002.	0.	4.50
YEAR 9	483796.	994751.	275312.	305902.	0.	5.12
YEAR 10	532176.	1143964.	316509.	351788.	0.	5.83

BEFORE TAX NET EXPENSES, INVESTMENT TAX CREDIT, ADDITIONAL INVESTMENT (WORKING CAPITAL) AND AFTER TAX NET CASH FLOW INCLUDING SALVAGE (END OF YEAR VALUES):

	BEFORE TAX NET EXPENSES \$	TAX CREDIT \$	ADDITIONAL INVESTMENT \$	AFTER TAX NET CASH FLOW \$
YEAR 0	70000.			-1883500.
YEAR 1	1015080.	650000.	16200.	248198.
YEAR 2	1242888.		19116.	-424833.
YEAR 3	1338304.		22557.	-508574.
YEAR 4	1467813.		26617.	-596815.
YEAR 5	1615383.		31408.	-697527.
YEAR 6	1399706.		37062.	-946871.
YEAR 7	1591488.		43733.	-1078200.
YEAR 8	1810219.		51805.	-1228247.
YEAR 9	2059761.		60894.	-1399738.
YEAR 10	2344536.		71854.	-924757.

PRESENT VALUE (YEAR 0) OF AFTER TAX NET CASH FLOWS:

\$ -4158436. AT 20.0 PERCENT ANNUAL DISCOUNT RATE

Figure 3.—Sample program output (continued).

PART II. BENEFIT COST RATIOS FOR ALL ALTERNATIVES

FIRST YEAR HEAT ENERGY VALUES (USER SPECIFIED) AND DISCOUNTED PRESENT VALUE OF HEAT ENERGY FOR EACH ALTERNATIVE:

	HEAT ENERGY VALUE (\$/MMBTU) ESSENTIAL ENERGY	SURPLUS ENERGY	PRESENT VALUE OF HEAT ENERGY (BASED ON ESSENTIAL)	DISCOUNT (INCLUDING SUPPLIUS) RATE (PCT.)
ALT 1	6.00	5.50	6305750.	20.0
ALT 2	6.00	5.50	12611499.	20.0
ALT 3	6.00	5.50	12611499.	20.0

RANKING OF ALTERNATIVES BY HIGHEST BENEFIT COST RATIO (RATIO OF P.V. OF HEAT ENERGY OUTPUT TO P.V. OF AFTER TAX NET CASH FLOW) BASED ON ESSENTIAL HEAT ENERGY REQUIREMENTS:

	B/C RATIO	REQUIRED NET INVESTMENT
ALT 3	3.03	1908000.0
ALT 2	2.96	1468000.0
ALT 1	1.17	20000.0

RANKING OF ALTERNATIVES BY HIGHEST BENEFIT COST RATIO BASED ON TOTAL HEAT ENERGY OUTPUT (INCLUDING SURPLUS):

	B/C RATIO	REQUIRED NET INVESTMENT
ALT 3	4.69	1908000.0
ALT 2	4.04	1468000.0
ALT 1	1.17	20000.0

PART III. DESCRIPTION OF ENERGY BALANCE AND FUEL PARAMETERS FOR EACH ALTERNATIVE (TABLES 1 TO 4)

TABLE 1.--HEAT ENERGY BALANCE AND FUEL REQUIREMENTS (ANNUAL BASIS)

	ESSENTIAL ENERGY REQUIREMENTS (MMBTU)	SURPLUS ENERGY REQUIREMENTS (MMBTU)	TOTAL ENERGY OUTPUT (MMBTU)
ALT 1	252230.	0.	252230.
ALT 2	252230.	100000.	352230.
ALT 3	252230.	150000.	402230.

	ENERGY SUPPLIED BY WOOD-BARK FUEL (MMBTU)	(PCT. OF TOTAL)	ENERGY SUPPLIED BY OTHER OR AUXILIARY FUEL (MMBTU)	(PCT. OF TOTAL)
ALT 1	0.	0	252230.	100.0
ALT 2	317007.	90.0	35223.	10.0
ALT 3	321784.	80.0	80446.	20.0

	QUANTITY OF WOOD-BARK AVAILABLE	WOOD-BARK FUEL REQUIREMENTS	OTHER FUEL REQUIREMENTS
ALT 1	30000. 0.0. TON	0. 0.0. TON	331882. MCF (GAS)
ALT 2	30000. 0.0. TON	27793. 0.0. TON	6989. BRL. (OIL)
ALT 3	30000. 0.0. TON	28212. 0.0. TON	5003. TON (COAL)

Figure 3.—Sample program output (continued).

TABLE 2.--WOOD-BARK FUEL PARAMETERS AND ESTIMATED HEAT RECOVERY

	OVENDRY WT (LBS) PER SALES UNIT	MOISTURE CONT. (DRY WT BASIS)	WET WT (LBS) PER SALES UNIT	MOISTURE CONT. (WET WT BASIS)
ALT 1	2000./0.0. TON	.82	3636./0.0. TON	.45
ALT 2	2000./0.0. TON	.82	3636./0.0. TON	.45
ALT 3	2000./0.0. TON	.82	3636./0.0. TON	.45

	HIGHER HEAT VALUE (BTU/DRY LB)	ESTIMATED HEAT ENERGY RECOVERY (BTU/DRY LB)	ESTIMATED HEAT ENERGY RECOVERY (BTU/WET LB)	ESTIMATED HEAT ENERGY RECOVERY (MMBTU/SALES UNIT)
ALT 1	8700.	5703.	3137.	11.406/0.0. TON
ALT 2	8700.	5703.	3137.	11.406/0.0. TON
ALT 3	8700.	5703.	3137.	11.406/0.0. TON

TABLE 3.--OTHER OR AUXILIARY FUEL PARAMETERS

	TYPE OF FUEL	HIGHER HEAT VALUE (MMBTU)	ESTIMATED HEAT RECOVERY (MMBTU)
ALT 1	GAS	1.00/ MCF	.76/ MCF
ALT 2	OIL	6.30/ BRL.	5.04/ BRL.
ALT 3	COAL	24.00/ TON	16.08/ TON

TABLE 4.--INTERNATIONAL SYSTEM (SI) UNIT RECOVERABLE HEAT ENERGY ESTIMATES

	ENERGY IN WOOD-BARK FUEL (KJOULE/KG DRY BASIS)	ENERGY IN WOOD-BARK FUEL (KJOULE/KG WET BASIS)	OTHER FUEL (BILLION JOULE PER SALES UNIT)	OTHER FUEL (BILLION JOULE PER SALES UNIT)
ALT 1	13275.	7301.	26.6/0.0. TON	1.8/ MCF
ALT 2	13275.	7301.	26.6/0.0. TON	11.7/ BRL.
ALT 3	13275.	7301.	26.6/0.0. TON	37.4/ TON

Figure 3.—Sample program output (continued).

Appendix

Benefit Cost Ratios in COMPARE

A major purpose of COMPARE is to provide an objective comparison of different investment alternatives in wood or bark energy systems. However, in the case of investment alternatives in wood and bark energy systems it is likely that the economic lives, initial investment requirements, and the discount rates will all be different among different alternatives. It is necessary therefore to adopt an economic criterion which will be valid for comparison despite the varied nature of the alternatives.

Consider discounted benefit cost ratios which are generally valid criteria even if the discount rates and investment requirements are different among alternatives. Discounted benefit cost ratios are derived on the basis of discount rates and therefore take into account any difference in discount rates. If the investment requirements are different, the opportunity cost of higher capital requirements for one alternative can be taken into account by simply increasing the discount rate for the higher investment alternative. The difference in discount rate will again be reflected in the benefit cost ratio. Hence, the only problem in regard to use of benefit cost ratios as criteria is that of unequal economic lives.

As will be shown here, the discounted benefit cost ratio will serve as a valid criterion for comparison of any two investment alternatives provided that two sufficient assumptions can be made. The sufficient assumptions are that (1) both alternatives are replaced by replacement projects which both have the same benefit cost ratio and which carry the planning period forward to an equal overall planning period for both alternatives, and (2) the replacement project's benefit cost ratio is numerically in the same range as (e.g. between) the benefit cost ratios of the two investment alternatives over their current economic lives. Under these reasonable assumptions, the most economical of two current investment alternatives will always be the one with the highest benefit cost ratio, calculated over the economic life of each alternative, even if the alternatives have different economic lives.

Consider any two investment alternatives. The two alternatives may have different economic lives, different initial investment requirements, and different discount rates. Economic common sense implies that the two alternatives cannot be compared directly unless they represent the same interval in time, the same planning period. For example, suppose there are two mutually exclusive investment alternatives which involve installation of two different types of boiler systems. One system has an economic or service life which is 30 percent longer than the other. Just the benefits and costs of the two alternatives alone will not show which alternative is most economical because the cost of replacing the shorter lived alternative must be considered. Replacement projects have benefits and costs which must be considered, and may have different economic lives. In fact, it is necessary to choose a planning period which includes the economic lives of current investments plus the lives of selected

replacement project(s) for both alternatives, such that the overall planning periods are equal for both alternatives. (Note that if both current investment alternatives have the same economic life, replacement projects need not be considered.)

It should be noted at this point that the standard approach to the problem of unequal economic lives, which is recommended in many texts, is to try to estimate the cash flows of replacement projects such that cash flows will be obtained for both alternatives over an equal planning period. However, anyone who is familiar with cost estimation knows that estimation of costs and numerical benefits for a replacement project is a very imprecise task especially if the project is scheduled for many years from now. It is often difficult just to obtain reliable estimates for well understood current investment alternatives, let alone tentative future replacement projects. In developing COMPARE the obvious question was asked—"Is there some way to avoid the difficult task of having to estimate benefits and costs for future replacement projects, and still be able to use the simple benefit cost ratios of current alternatives as a valid criteria for comparison?" The answer was "yes" provided that two sufficient assumptions (introduced previously) can be made. The rationale for why those assumptions permit use of benefit cost ratios in directly comparing two investment alternatives is presented as follows.

Let the benefit cost ratios of two investment alternatives be denoted as B_1/C_1 and B_2/C_2 respectively. In both cases, the benefit cost ratios are the ratio of discounted benefit values to discounted costs (or after tax net cash flows based on costs as in COMPARE). Thus,

$$\frac{\text{(Present value of benefits for first alternative)}}{\text{(Present value of costs for first alternative)}} = \frac{B_1}{C_1}$$

$$\frac{\text{(Present value of benefits for second alternative)}}{\text{(Present value of costs for second alternative)}} = \frac{B_2}{C_2}$$

In considering future replacement projects it is necessary to establish a basic fact about benefit cost ratios. The fact is that if associated benefits and costs are further discounted to an earlier point in time, the numerical value of the benefit cost ratio will remain the same. That fact is true regardless of the discount rate or length of discount period. For example, consider some future replacement project. The replacement project has benefit values and costs which can be discounted to the beginning of the economic life of the project (some future point in time). The discounted benefits and costs can then be expressed as a benefit cost ratio for the replacement project. Now suppose that the same benefit values and costs are discounted to the present point in time, and are then expressed as a present benefit cost ratio. The fact is that the present benefit cost ratio will be exactly the same as the benefit cost ratio derived for the future point in time.

Denote the benefit cost ratio of the future replacement projects as $Br1/Cr1$ for the first alternative and $Br2/Cr2$ for the second alternative. A replacement project benefit cost ratio is the ratio of discounted benefit values (Br) to discounted costs (Cr) for the replacement project. Benefits and costs are discounted to the future point in time at which the replacement project begins and at which the economic life of the current investment ends. That point in time will be denoted as year n for the first alternative and year m for the second alternative. Thus,

$$\text{For 1st Alt.: } \frac{Br1(n)}{Cr1(n)} = \frac{\text{(Year } n \text{ value of benefits for the replacement project)}}{\text{(Year } n \text{ value of costs for the replacement project)}}$$

$$\text{For 2nd Alt.: } \frac{Br2(m)}{Cr2(m)} = \frac{\text{(Year } m \text{ value of benefits for the replacement project)}}{\text{(Year } m \text{ value of costs for the replacement project)}}$$

The first sufficient assumption is that future replacement projects for both alternatives will have the same benefit cost ratio. The assumption implies that $Br1(n)/Cr1(n) = Br2(m)/Cr2(m)$. It can now be observed that if a replacement project's benefits and costs are discounted to present values and are then expressed as a ratio, the ratio will equal the original benefit cost ratio for the replacement project. In other words, if $Br1(p)$ is the present value of benefits and $Cr1(p)$ is the present value of costs for the replacement project under the first alternative, then the following ratios are equal:

$$\frac{Br1(p)}{Cr1(p)} = \frac{Br1(n)/(1+i)^n}{Cr1(n)/(1+i)^n} = \frac{Br1(n)}{Cr1(n)}$$

(where i is the discount rate).

Likewise, if $Br2(p)$ equals the present value of benefits and $Cr2(p)$ equals the present value of costs for the replacement project under the second alternative, the following ratios are also equal:

$$\frac{Br2(p)}{Cr2(p)} = \frac{Br2(m)/(1+i)^m}{Cr2(m)/(1+i)^m} = \frac{Br2(m)}{Cr2(m)}$$

It is true then that the following equality holds:

$$\frac{Br1(p)}{Cr1(p)} = \frac{Br2(p)}{Cr2(p)}$$

Because, by assumption, $\frac{Br1(n)}{Cr1(n)} = \frac{Br2(m)}{Cr2(m)}$

It is finally necessary to recognize another basic fact concerning mathematical ratios and combinations of ratios. Suppose there are four numerical values, $B1$, $C1$, $B2$, and $C2$ (the values are analogous to the present values of benefits and costs of two current investment projects or alternatives, which may have different economic lives). Suppose arbitrarily that the ratios of the values are different so that one ratio is greater than the other as follows:

$$\frac{B1}{C1} > \frac{B2}{C2}$$

(If the ratios are benefit cost ratios, it would appear that the first alternative is more economical because it has a higher benefit cost ratio. However, as discussed earlier, replacement project benefits and costs must also be considered if the two current alternatives have different economic lives.)

Furthermore, suppose there are four other numerical values, $Br1(p)$, $Cr1(p)$, $Br2(p)$, and $Cr2(p)$. (Those values correspond to the present values of benefits and costs of replacement projects under the two alternatives. The replacement projects in both cases carry the alternatives forward to a planning period which is the same for both alternatives.) Now we can assume that those values satisfy the following relationship:

$$\frac{Br1(p)}{Cr1(p)} = \frac{Br2(p)}{Cr2(p)}$$

(This corresponds to the first sufficient assumption that benefit cost ratios are the same for replacement projects under both alternatives.) Also assume that the following relationship holds:

$$\frac{B1}{C1} > \frac{Br1(p)}{Cr1(p)} = \frac{Br2(p)}{Cr2(p)} > \frac{B2}{C2}$$

(This relationship corresponds to the second sufficient assumption that the benefit cost ratios of replacement projects are numerically between the benefit cost ratios of the two current investment alternatives.)

Then it is a fact that so long as the previous assumptions hold, the following result always holds regardless of the values represented by the eight terms:

$$\frac{B1 + Br1(p)}{C1 + Cr1(p)} > \frac{B2 + Br2(p)}{C2 + Cr2(p)}$$

(The last result says simply that the benefit cost ratio of the first alternative is higher than the benefit cost ratio of the second alternative, even when replacement projects and an equal planning period for both alternatives are taken into account.)

A proof of the last result is given as follows:

Suppose $\frac{B1}{C1} > \frac{B2}{C2}$ (arbitrary assumption),

$$\frac{Br1(p)}{Cr1(p)} = \frac{Br2(p)}{Cr2(p)} \text{ (first sufficient assumption),}$$

and,

$$\frac{B1}{C1} > \frac{Br1(p)}{Cr1(p)} = \frac{Br2(p)}{Cr2(p)} > \frac{B2}{C2}$$

(second sufficient assumption).

Then,

$$\frac{B_1}{C_1} > \frac{B_1 + Br_1(p)}{C_1 + Cr_1(p)} > \frac{Br_1(p)}{Cr_1(p)}$$

and,

$$\frac{Br_2(p)}{Cr_2(p)} > \frac{B_2 + Br_2(p)}{C_2 + Cr_2(p)} > \frac{B_2}{C_2}$$

therefore,

$$\frac{B_1 + Br_1(p)}{C_1 + Cr_1(p)} > \frac{B_2 + Br_2(p)}{C_2 + Cr_2(p)}$$

Thus, under the two sufficient assumptions, the following result will be true:

$$\frac{B_1}{C_1} > \frac{B_2}{C_2} \text{ implies } \frac{B_1 + Br_1(p)}{C_1 + Cr_1(p)} > \frac{B_2 + Br_2(p)}{C_2 + Cr_2(p)}$$

Likewise, under reverse assumptions, the opposite will also be true:

$$\frac{B_2}{C_2} > \frac{B_1}{C_1} \text{ implies } \frac{B_2 + Br_2(p)}{C_2 + Cr_2(p)} > \frac{B_1 + Br_1(p)}{C_1 + Cr_1(p)}$$

Therefore, under the two sufficient assumptions regardless of the economic lives of two current investment alternatives, the one with the highest benefit cost ratio will be the most economical even when replacement projects and equalized planning periods are considered. Under the two sufficient assumptions, it is not necessary to consider replacement projects or equalization of planning periods for either alternative, provided that discounted benefit cost ratios are used to compare the two alternatives.

Finally, the appropriateness of the two sufficient assumptions can be addressed. In regard to the first assumption of equal benefit cost ratios for replacement projects over equal planning periods, it may be helpful to think of the replacement projects for both alternatives as extending over an infinite planning period. As the planning period goes to infinity, it becomes relatively equal for both alternatives. Also, if the same sort of replacement project will be undertaken in both alternatives, it follows that both replacement projects have the same benefit cost ratio. The second sufficient assumption that the replacement project benefit cost ratio will be between the benefit cost ratios of the two current alternatives is equivalent to saying that the future replacement project will be neither less economical than the least economical current alternative, nor more economical than the most economical current alternative. Both assumptions must be recognized as merely sufficient, not necessary assumptions. In other words, benefit cost ratios may still be valid criteria for comparing two alternatives in certain cases where the assumptions are not met.

In summary, it is valid to compare any two current investment alternatives by comparing their benefit cost ratios even if the two alternatives have different economic lives (e.g. the most economical alternative is the one with the highest benefit cost ratio), provided the following two sufficient assumptions can be made: (1) the replacement projects which carry the planning periods forward to an equal planning period will have the same benefit cost ratio in both cases, and (2) the replacement project benefit cost ratio will be numerically in the range (e.g. between) the benefit cost ratios of the two current investment alternatives. Under those assumptions, the investment with the highest current benefit cost ratio is indeed the alternative which provides the greatest discounted return per unit of discounted cost.

Listing of the COMPARE Program

Subroutine DEP

```

1.      SUBROUTINE DEP                                DEP00010
2.      C *** THIS SUBROUTINE CALCULATES DEPRECIATION ALLOWANCES FOR ECONOMIC DEP00020
3.      C *** ALTERNATIVES (J), UNLESS THE USER HAS SPECIFIED ANNUAL ALLOWANCES. DEP00030
4.      C *** THE USER MAY ALWAYS ENTER DEPRECIATION ALLOWANCES AS DATA, DEP00040
5.      C *** INSTEAD OF HAVING THE SCHEDULE CALCULATED BY THIS SUBROUTINE. DEP00050
6.      C *** DATA REQUIREMENTS INCLUDE: USER CODE SPECIFICATION OF THE TYPE OF DEP00060
7.      C *** SCHEDULE (CODE VARIABLE, NDEP(J)), 1= U.S. INTERNAL REVENUE DEP00070
8.      C *** SERVICE (IPS) SCHEDULES FOR NEW PROPERTY PUT IN SERVICE FROM DEP00080
9.      C *** 1961 TO 1964, 2=IRS SCHEDULES FOR NEW PROPERTY PUT IN SERVICE DEP00090
10.     C *** IN 1965, 3=IPS SCHEDULES FOR NEW PROPERTY PUT IN SERVICE IN 1966 DEP00100
11.     C *** AND THEREAFTER, 4=STRAIGHT-LINE DEPRECIATION. ALL SCHEDULES DEP00110
12.     C *** CORRESPOND TO THE MANDATORY (1961) ACCELERATED COST RECOVERY DEP00120
13.     C *** SYSTEM GUIDELINES. ADDITIONAL DATA REQUIRED ARE THE NUMBER OF DEP00130
14.     C *** ALTERNATIVES (NALT), INITIAL ASSET VALUE (IVST(J)), AND DEP00140
15.     C *** DEPRECIATION PERIOD (NYRD(J)). DEPRECIATION PERIOD MUST EQUAL DEP00150
16.     C *** 3, 5, 10, OR 15 YEARS UNDER OPTIONS 1, 2, OR 3, OTHERWISE DEP00160
17.     C *** STRAIGHT-LINE DEPRECIATION WILL BE CALCULATED. DEP00170
18.     C *** ACCORDING TO STATUTORY GUIDELINES, SALVAGE VALUE IS DEP00180
19.     C *** DISREGARDED. THE USER WILL SELECT THE APPROPRIATE SCHEDULE DEP00190
20.     C *** DEPENDING ON WHEN THE INVESTMENT IS PUT IN PLACE, AND WILL ALSO DEP00200
21.     C *** SELECT THE APPROPRIATE DEPRECIATION PERIOD ACCORDING TO ACRS DEP00210
22.     C *** GUIDELINES; (GENERALLY 5 YEARS IS APPROPRIATE FOR NEW DEP00220
23.     C *** MANUFACTURING EQUIPMENT UNDER CURRENT GUIDELINES). INITIAL DEP00230
24.     C *** DEPRECIATION BASIS EQUALS INITIAL ASSET VALUE (IVST). IF THE DEP00240
25.     C *** USER DOES NOT ENTER OPTIONS 1, 2, 3, OR 4, (IF CODE VARIABLE DEP00250
26.     C *** NDEP IS SPECIFIED AS 0 OR SOME OTHER NUMBER), THEN IT IS ASSUMED DEP00260
27.     C *** AND REQUIRED THAT THE USER ENTER DEPRECIATION ALLOWANCES AS DATA DEP00270
28.     C *** (SEE DATA INPUT INSTRUCTIONS IN DOCUMENTATION REPORT). DEP00280
29.     C
30.     COMMON/ALL/AFMC(10),AMHV(10),AWRU(10),AXFT(10), DEP00290
31.     + RTUR(10),DISP(10),FBTU(10),FATS(10), DEP00300
32.     + MHVU(10),HRAF(10),HRAF(10),IVST(10),NYPS(10),PVAT(10),PCT(10), DEP00310
33.     + RAVL(10),RECY(10),TAUX(10),TRES(10),DEPR(10,20), DEP00320
34.     + NALT,NOR1,NYRD(10) DEP00330
35.     COMMON/DEP1/R(21),D(10),NDEP(10), DEP00340
36.     REAL IVST DEP00350
37.     C
38.     DO 10 J=1,NALT DEP00360
39.     IF(NDEP(J).LT.1.OR.NDEP(J).GT.4) GO TO 10 DEP00370
40.     NK=NYRD(J) DEP00380
41.     NYR=NYRS(J) DEP00390
42.     R(1) = IVST(J) DEP00400
43.     DO 100 N=1,NYR DEP00410
44.     DEPR(J,N)=0.0 DEP00420
45.     100 CONTINUE DEP00430
46.     C *** CALCULATE (ACRS) DEPRECIATION DEP00440
47.     IF(NDEP(J).EQ.1) GO TO 1 DEP00450
48.     IF(NDEP(J).EQ.2) GO TO 2 DEP00460
49.     IF(NDEP(J).EQ.3) GO TO 3 DEP00470
50.     IF(NDEP(J).EQ.4) GO TO 4 DEP00480
51.     1 CONTINUE DEP00490
52.     IF (NK.EQ.3) GO TO 11 DEP00500
53.     IF (NK.EQ.5) GO TO 12 DEP00510
54.     IF (NK.EQ.10) GO TO 13 DEP00520
55.     IF (NK.EQ.15) GO TO 14 DEP00530
56.     GO TO 4 DEP00540
57.     11 CONTINUE DEP00550
58.     DEPR (J,1) = 0.25 * R(1) DEP00560
59.     DEPR (J,2) = 0.38 * R(1) DEP00570
60.     DEPR (J,3) = 0.37 * R(1) DEP00580
61.     GO TO 10 DEP00590
62.     12 CONTINUE DEP00600
63.     DEPR (J,1) = 0.15 * R(1) DEP00610
64.     DEPR (J,2) = 0.22 * R(1) DEP00620
65.     DEPR (J,3) = 0.21 * R(1) DEP00630
66.     DEPR (J,4) = 0.21 * R(1) DEP00640
67.     DEPR (J,5) = 0.21 * R(1) DEP00650
68.     GO TO 10 DEP00660

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69. 13 CONTINUE
70. DEPR (J,1) = 0.08 * A(1)
71. DEPR (J,2) = 0.14 * A(1)
72. DEPR (J,3) = 0.12 * A(1)
73. DEPR (J,4) = 0.10 * A(1)
74. DEPR (J,5) = 0.10 * A(1)
75. DEPR (J,6) = 0.10 * A(1)
76. DEPR (J,7) = 0.09 * A(1)
77. DEPR (J,8) = 0.09 * A(1)
78. DEPR (J,9) = 0.09 * A(1)
79. DEPR (J,10) = 0.09 * B(1)
80. GO TO 10
81. 14 CONTINUE
82. DEPR (J,1) = 0.05 * A(1)
83. DEPR (J,2) = 0.10 * A(1)
84. DEPR (J,3) = 0.09 * B(1)
85. DEPR (J,4) = 0.08 * B(1)
86. DEPR (J,5) = 0.07 * A(1)
87. DEPR (J,6) = 0.07 * A(1)
88. DEPR (J,7) = 0.06 * A(1)
89. DEPR (J,8) = 0.06 * A(1)
90. DEPR (J,9) = 0.06 * A(1)
91. DEPR (J,10) = 0.06 * A(1)
92. DEPR (J,11) = 0.06 * A(1)
93. DEPR (J,12) = 0.06 * A(1)
94. DEPR (J,13) = 0.06 * A(1)
95. DEPR (J,14) = 0.06 * A(1)
96. DEPR (J,15) = 0.06 * A(1)
97. GO TO 10
98. 2 CONTINUE
99. IF (NK.EQ.3) GO TO 21
100. IF (NK.EQ.5) GO TO 22
101. IF (NK.EQ.10) GO TO 23
102. IF (NK.EQ.15) GO TO 24
103. GO TO 4
104. 21 CONTINUE
105. DEPR (J,1) = 0.29 * A(1)
106. DEPR (J,2) = 0.47 * A(1)
107. DEPR (J,3) = 0.24 * A(1)
108. GO TO 10
109. 22 CONTINUE
110. DEPR (J,1) = 0.18 * B(1)
111. DEPR (J,2) = 0.33 * B(1)
112. DEPR (J,3) = 0.25 * A(1)
113. DEPR (J,4) = 0.16 * A(1)
114. DEPR (J,5) = 0.08 * A(1)
115. GO TO 10
116. 23 CONTINUE
117. DEPR (J,1) = 0.09 * A(1)
118. DEPR (J,2) = 0.19 * A(1)
119. DEPR (J,3) = 0.16 * A(1)
120. DEPR (J,4) = 0.14 * A(1)
121. DEPR (J,5) = 0.12 * A(1)
122. DEPR (J,6) = 0.10 * A(1)
123. DEPR (J,7) = 0.08 * A(1)
124. DEPR (J,8) = 0.06 * A(1)
125. DEPR (J,9) = 0.04 * B(1)
126. DEPR (J,10) = 0.02 * A(1)
127. GO TO 10
128. 24 CONTINUE
129. DEPR (J,1) = 0.06 * A(1)
130. DEPR (J,2) = 0.12 * B(1)
131. DEPR (J,3) = 0.12 * A(1)
132. DEPR (J,4) = 0.11 * A(1)
133. DEPR (J,5) = 0.10 * A(1)
134. DEPR (J,6) = 0.09 * A(1)
135. DEPR (J,7) = 0.08 * A(1)
136. DEPR (J,8) = 0.07 * A(1)
137. DEPR (J,9) = 0.06 * A(1)
138. DEPR (J,10) = 0.05 * A(1)
139. DEPR (J,11) = 0.04 * A(1)
140. DEPR (J,12) = 0.04 * A(1)
141. DEPR (J,13) = 0.03 * A(1)

DEP00670
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DEP01270
DEP01280
DEP01290
DEP01300
DEP01310
DEP01320
DEP01330
DEP01340
DEP01350
DEP01360
DEP01370
DEP01380
DEP01390

142.	DEPR (J,14) = 0.02 * A(1)	DEP01400
143.	DEPR (J,15) = 0.01 * A(1)	DEP01410
144.	GO TO 10	DEP01420
145.	3 CONTINUE	DEP01430
146.	IF (NK.EQ.3) GO TO 31	DEP01440
147.	IF (NK.EQ.5) GO TO 32	DEP01450
148.	IF (NK.EQ.10) GO TO 33	DEP01460
149.	IF (NK.EQ.15) GO TO 34	DEP01470
150.	GO TO 4	DEP01480
151.	31 CONTINUE	DEP01490
152.	DEPR (J,1) = 0.33 * A(1)	DEP01500
153.	DEPR (J,2) = 0.45 * A(1)	DEP01510
154.	DEPR (J,3) = 0.22 * A(1)	DEP01520
155.	GO TO 10	DEP01530
156.	32 CONTINUE	DEP01540
157.	DEPR (J,1) = 0.20 * A(1)	DEP01550
158.	DEPR (J,2) = 0.32 * A(1)	DEP01560
159.	DEPR (J,3) = 0.24 * A(1)	DEP01570
160.	DEPR (J,4) = 0.16 * A(1)	DEP01580
161.	DEPR (J,5) = 0.08 * A(1)	DEP01590
162.	GO TO 10	DEP01600
163.	33 CONTINUE	DEP01610
164.	DEPR (J,1) = 0.10 * A(1)	DEP01620
165.	DEPR (J,2) = 0.18 * A(1)	DEP01630
166.	DEPR (J,3) = 0.16 * A(1)	DEP01640
167.	DEPR (J,4) = 0.14 * A(1)	DEP01650
168.	DEPR (J,5) = 0.12 * A(1)	DEP01660
169.	DEPR (J,6) = 0.10 * A(1)	DEP01670
170.	DEPR (J,7) = 0.08 * A(1)	DEP01680
171.	DEPR (J,8) = 0.06 * A(1)	DEP01690
172.	DEPR (J,9) = 0.04 * B(1)	DEP01700
173.	DEPR (J,10) = 0.02 * B(1)	DEP01710
174.	GO TO 10	DEP01720
175.	34 CONTINUE	DEP01730
176.	DEPR (J,1) = 0.07 * A(1)	DEP01740
177.	DEPR (J,2) = 0.12 * A(1)	DEP01750
178.	DEPR (J,3) = 0.12 * A(1)	DEP01760
179.	DEPR (J,4) = 0.11 * B(1)	DEP01770
180.	DEPR (J,5) = 0.10 * A(1)	DEP01780
181.	DEPR (J,6) = 0.09 * A(1)	DEP01790
182.	DEPR (J,7) = 0.08 * A(1)	DEP01800
183.	DEPR (J,8) = 0.07 * B(1)	DEP01810
184.	DEPR (J,9) = 0.06 * A(1)	DEP01820
185.	DEPR (J,10) = 0.05 * A(1)	DEP01830
186.	DEPR (J,11) = 0.04 * B(1)	DEP01840
187.	DEPR (J,12) = 0.03 * B(1)	DEP01850
188.	DEPR (J,13) = 0.03 * A(1)	DEP01860
189.	DEPR (J,14) = 0.02 * A(1)	DEP01870
190.	DEPR (J,15) = 0.01 * B(1)	DEP01880
191.	GO TO 10	DEP01890
192.	4 CONTINUE	DEP01900
193.	DO 41 N = 1,NK	DEP01910
194.	IF(NYRD(J).EQ.0) GO TO 10	DEP01911
195.	DEPR (J,N) = A(1)/NYRD(J)	DEP01920
196.	41 CONTINUE	DEP01930
197.	DEPR (J,1) = 0.5 * DEPR (J,1)	DEP01940
198.	N = NK + 1	DEP01950
199.	DEPR (J,N) = DEPR (J,1)	DEP01960
200.	10 CONTINUE	DEP01970
201.	RETURN	DEP01980
202.	END	DEP01990

Subroutine ECO

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1.
2.
3. SUBROUTINE ECO EC000010
4. C EC000020
5. C *** THIS SUBROUTINE SUMMARIZES AND PRINTS OUT ESTIMATED FUTURE ANNUAL EC000030
6. C *** CASH FLOWS AND PRESENT VALUE OF CASH FLOWS FOR EACH ALTERNATIVE, EC000040
7. C *** (PART 1 OF OUTPUT). EC000050
8. C EC000060
9. COMMON/ALL/AFMC(10),AMHV(10),AWRU(10),AXFT(10), EC000070
10. + BTUR(10),DISP(10),ERTH(10),FATS(10), EC000080
11. + MHVU(10),HRAF(10),HRRF(10),IVST(10),NYRS(10),PVAT(10),PCT(10), EC000090
12. + RAVL(10),RECY(10),TAUX(10),TRFS(10),DEPR(10,20), EC000100
13. + NALT,NOP1,NYRD(10) EC000110
14. COMMON/ECO1/CSAL(10),IEXP(10),ITCR(10), EC000120
15. + TXPT(10),WCRQ(10),ACST(10,20),ANCF(10,20),HNCF(10,20), EC000130
16. + VCST(10,20),FCST(10,20),CMMR(10,20),AZER(10), EC000140
17. + PAXF(10,20),RCST(10,20),RVAL(10,20),WCRA(10,21), EC000150
18. + WCRT(10,21),TITL(20,10), EC000160
19. REAL IVST,ITCR,IEXP EC000170
20. C EC000180
21. IF (NOP1.NF.1) WRITE (6,11) EC000190
22. 11 FORMAT ('1','PART 1. FINANCIAL SUMMARIES') EC000200
23. DO A J=1,NALT EC000210
24. MYRS = NYRS(J) EC000220
25. DO 1 N=1,MYRS EC000230
26. C *** CALCULATE ANNUAL WOOD-BARK FUEL COSTS EC000240
27. RCST(J,N) = RVAL(J,N) * TPES(J) EC000250
28. C *** CALCULATE ANNUAL ALT/AUX FUEL COSTS EC000260
29. ACST(J,N) = PAXF(J,N) * TAUX(J) EC000270
30. C *** CALCULATE BEFORE TAX NET EXPENSES AND AVG. COST/MMRTU EC000280
31. BNCF(J,N)=(VCST(J,N)+FCST(J,N)+RCST(J,N)+ACST(J,N)+DEPR(J,N)) EC000290
32. CMMR(J,N)=ANCF(J,N)/BTUR(J) EC000300
33. C *** CALCULATE AFTER TAX NET CASH FLOW EC000310
34. ANCF(J,N) = -(VCST(J,N) + FCST(J,N) + EC000320
35. + RCST(J,N) + ACST(J,N)) * (1.0 - TXPT(J)) + DEPR(J,N) * TXRT(J) - EC000330
36. + WCRA(J,N) EC000340
37. 1 CONTINUE EC000350
38. ANCF(J,1) = ANCF(J,1) + ITCR(J) EC000360
39. N = NYRS(J) EC000370
40. ANCF(J,N) = ANCF(J,N) + FATS(J) + WCRT(J,N) EC000390
41. PCT(J) = DISP(J) * 100.0 EC000400
42. PVAT(J)=(-IVST(J))-WCRQ(J)+CSAL(J)-(IEXP(J)*(1.0-TXPT(J))) EC000420
43. AZER(J)=PVAT(J) EC000430
44. DO 2 N=1,MYRS EC000440
45. C *** CALCULATE PRESENT VALUE AFTER TAXES EC000470
46. PVAT(J) = PVAT(J) + ANCF(J,N) / ((1.0 + DISR(J))**N) EC000480
47. 2 CONTINUE EC000490
48. C EC000500
49. C *** PRINTOUT FINANCIAL SUMMARY EC000510
50. IF (NOP1.EQ.1) GO TO 7 EC000520
51. C *** WRITE INVESTMENT COST PARAMETERS EC000530
52. IF (J.FQ.1) WRITE(6,333) J EC000540
53. 333 FORMAT('0',///'OFINANCIAL SUMMARY--ALTERNATIVE',1X,I2/) EC000550
54. IF (J.GT.1) WRITE(6,33) J EC000560
55. 33 FORMAT ('1FINANCIAL SUMMARY--ALTERNATIVE',1X,I2/) EC000570
56. WRITE(6,3) (TITL(I,J),I=1,20),NYRS(J),FATS(J),IVST(J),TXPT(J), EC000580
57. +IEXP(J),WCRQ(J),ERTH(J),CSAL(J),BTUR(J),AXFT(J) EC000590
58. 3 FORMAT(' ',20A4//1X,'INVESTMENT PARAMETERS (YEAR 0):',8X,'ENDING EC000600
59. +ET SALVAGE (YEAR ',I2,')$',F10.0/2X,'DEPRECIABLE ASSETS - - - $',EC000610
60. +F10.0,2X,'EFFECTIVE ANNUAL TAX RATE - - - ',F6.3/2X,'NONDEPREC. EC000620
61. +XPENSES- - - $',F10.0,2X,'HEAT ENERGY REQUIREMENTS AND OUTPUT:' EC000630
62. +2X,'WORKING CAPITAL- - - - $',F10.0,3X,'ESSENTIAL REQ. - - ',F10.0,EC000640
63. +.0,1X,'MMRTU/YR.'/2X,'OLD FACILITY NET SALV. - $',F10.0,3X,'TOTAL EC000650
64. +OUTPUT - - - ',F10.0,' MMRTU/YR.'//1X,'ANNUAL COSTS, DEPRECIATION EC000660
65. + AND AVERAGE ANNUAL'/2X,'COST PER MMRTU OF TOTAL ENERGY OUTPUTS'//EC000670
66. +17X,'FUEL COSTS',9X,'OTHER VAR.',4X,'FIXED',7X,'DEPRE-',5X,'COST'//EC000671
67. +/11X,'WOOD-BARK',6X,A4,8X,'COSTS',7X,'COSTS',7X,'CIATION',4X,'MMRTEC000672
68. +U'/15X,4('$',11X),('$',11X, '$') EC000673
69. C *** WRITE ANNUAL CASH FLOWS AND DEPRECIATION EC000730
70. DO 44 N=1,MYRS EC000740
71. WRITE(6,4) (N,RCST(J,N),ACST(J,N),VCST(J,N),FCST(J,N),DEPR(J,N), EC000750
72. +CMMR(J,N)) EC000760

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73.      44 CONTINUE                                EC000770
74.      4 FORMAT(' ',1X,'YEAR',1X,I2,5(2X,F10.0),2X,F8.2) EC000780
75.      C *** WRITE NET CASH FLOWS, INVESTMENT TAX CREDIT (END OF YEAR VALUES). EC000790
76.      C ***                                     EC000800
77.      WRITE(6,5) (IFXR(J),AZER(J),BNCF(J,1),TYCR(J),WCRA(J,1),ANCF(J,1)) EC000810
78.      5 FORMAT('0'/1X,'BEFORE TAX NET EXPENSES, INVESTMENT TAX CREDIT, ADDEC000820
79.      +ITIONAL INVESTMENT (WORKING'/2X,'CAPITAL) AND AFTER TAX NET CASH FLOW EC000821
80.      +LOW INCLUDING SALVAGE (END OF YEAR VALUES):// EC000822
81.      +16X,'BEFORE TAX',6X,'TAX',6X,'ADDITIONAL',6X,'AFTER TAX'/ EC000830
82.      +15X,'NET EXPENSES',4X,'CREDIT',4X,'INVESTMENT',4X,'NET CASH FLOW'/ EC000840
83.      +21X,'$',11X,'$',11X,'$',15X,'$'/ EC000850
84.      +1X,'YEAR 0',6X,F12.0,27X,F12.0/ EC000851
85.      +1X,'YEAR 1',6X,F12.0,F11.0,2X,F11.0,3X,F12.0) EC000860
86.      DO 55 N=2,NYRS EC000870
87.      WRITE(6,66) (N,BNCF(J,N),WCRA(J,N),ANCF(J,N)) EC000880
88.      55 CONTINUE EC000890
89.      66 FORMAT(1X,'YEAR',1X,I2,6X,F12.0,13X,F11.0,3X,F12.0) EC000900
90.      C *** WRITE PRESENT VALUE OF CASH FLOWS EC000910
91.      WRITE(6,6) PVAT(J),PCT(J) EC000920
92.      6 FORMAT('0'/1X,'PRESENT VALUE (YEAR 0) OF AFTER TAX NET CASH FLOWS: EC000930
93.      + '//6X,'$',F10.0,2X,'AT',1X,F4.1,' PERCENT ANNUAL DISCOUNT RATE') EC000940
94.      7 CONTINUE EC000940
95.      8 CONTINUE EC000990
96.      RETURN EC001000
97.      END EC001010

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Subroutine EQ1

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1.      SUBROUTINE EQ1(A,R)                        EQ100010
2.      C                                          EQ100020
3.      C *** THIS SUBROUTINE EQUATES TEN-ELEMENT ARRAYS - ARGUMENTS A AND R EQ100030
4.      C                                          EQ100040
5.      DIMENSION A(10),R(10)                    EQ100050
6.      C                                          EQ100060
7.      DO 1 J=1,10                                EQ100070
8.      A(J) = R(J)                                EQ100080
9.      1 CONTINUE                                EQ100090
10.     RETURN                                    EQ100100
11.     END                                        EQ100110

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Subroutine HTR

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1.      SUBROUTINE HTR                            HTR00010
2.      C                                          HTR00020
3.      C *** THIS SUBROUTINE CALCULATES APPROXIMATE AVG. HEAT RECOVERY FROM HTR00030
4.      C *** WOOD OR BARK FUELS, IN BTU PER POUND 'WET' (AS FIRED) BASED HTR00040
5.      C *** ON INPUT DATA AND ASSUMPTIONS. HTR00050
6.      C                                          HTR00060
7.      COMMON/ALL/AFMC(10),AHMV(10),AWRU(10),AXFT(10), HTR00070
8.      + HTUR(10),DISP(10),ERTU(10),FATS(10), HTR00080
9.      + HMVU(10),HRAF(10),HRRF(10),IVST(10),NYRS(10),PVAT(10),PCT(10), HTR00090
10.     + PAVL(10),RECY(10),TAUX(10),TRFS(10),CEPK(10,20), HTR00100
11.     + NALT,NOP1,NYRD(10) HTR00110
12.     COMMON/HTP1/ACHL(10),AEAF(10),ASGT(10),ATCA(10), HTR00120
13.     + ATRF(10),AVCC(10),AVHC(10),AVNC(10),AVOC(10), HTR00130
14.     + CONV(10),SGHD(10),SGHW(10), HTR00140
15.     C                                          HTR00150
16.     DO 1 J = 1, NALT HTR00160
17.     C *** CALCULATE HEAT ENERGY PER 'WET' POUND OF FUEL HTR00170
18.     C *** CALCULATE STACK GAS HEAT LOSS CAUSED BY FUEL MOISTURE AND WATER HTR00180
19.     C *** FROM HYDROGEN COMBUSTION HTR00190
20.     SGHW(J) = (970.0 + (212.0 - ATRF(J)) + (0.46 * (ASGT(J) - 212.0))) HTP00200
21.     + (AFMC(J) + 9.0 + AVHC(J) + (1.0 - AFMC(J))) HTR00210
22.     C *** CALCULATE STACK GAS HEAT LOSS CAUSED BY DRY GAS AND EXCESS AIR HTR00220
23.     SGHD(J) = (ASGT(J) - ATCA(J)) * (1.0 - AFMC(J)) * (0.24 + (((AVHC(HTR00230
24.     + J) + 8.0) + AVCC(J) + 2.667 - AVOC(J)) / 0.232) * AEAF(J) + (((AVHTR00240
25.     + HC(J) + 8.0) + AVCC(J) + 2.667 - AVCC(J)) / 0.232) * 0.768 + AVNC(HTR00250
26.     + J)) * 0.25 + AVCC(J) * 3.667 * 0.22) HTR00260
27.     C *** CALCULATE 'CONVENTIONAL' HEAT LOSSES (RADIATION, CONVECTION, ETC.) HTR00270
28.     CONV(J) = AHMV(J) * (1.0 - AFMC(J)) * ACHL(J) HTR00280
29.     C *** CALCULATE HEAT RECOVERY - BTU / POUND 'WET' WOOD OR BARK FUEL HTR00290
30.     RECY(J) = AHMV(J) * (1.0 - AFMC(J)) - (SGHW(J) + SGHD(J) + CONV(J)) HTR00300
31.     IF (RECY(J).LE.0.0001) RECY(J)=0.0001 HTR00310
32.     1 CONTINUE HTR00320
33.     RETURN HTR00330
34.     END HTR00340

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Subroutine PHY

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1.      SUBROUTINE PHY                                PHY000010
2.      C                                            PHY000020
3.      C *** THIS SUBROUTINE CONSOLIDATES AND PRINTS OUT DATA RELATED TO THE PHY000030
4.      C *** PHYSICAL PARAMETERS (FUEL VOLUME REQUIREMENTS, HEATING VALUE, PHY000040
5.      C *** WEIGHT, MOISTURE CONTENT) AND HEAT ENERGY REQUIREMENTS--FUEL PHY000050
6.      C *** SUPPLY BALANCE, IN BRITISH AND SI UNITS (SYSTEME INTERNATIONAL PHY000060
7.      C *** UNITS) PHY000070
8.      C                                            PHY000080
9.      COMMON/ALL/AFMC(10),AMHV(10),AMW(10),AXFT(10), PHY000090
10.     + RTUR(10),DISP(10),ERTU(10),FATS(10), PHY000100
11.     + MHV(10),HRAF(10),HREF(10),IVST(10),NYRS(10),PVAT(10),PCT(10), PHY000110
12.     + RAVL(10),RECY(10),TAUX(10),TPES(10),DEPR(10,20), PHY000120
13.     + NALT,NOP1,NYPD(10) PHY000130
14.     COMMON/PHY1/ARTU(10),AFSU(10),AFWR(10),ASSI(10), PHY000140
15.     + PCTA(10),PCTP(10),PRTU(10),PCOD(10),RDSI(10), PHY000150
16.     + RFS1(10),RFS2(10),PHSI(10),PSSI(10),SRTU(10), PHY000160
17.     DIMENSION DPMC(10) PHY000170
18.      C                                            PHY000180
19.      DO 1 J=1,NALT PHY000190
20.      C *** CALCULATE DRY WEIGHT MOISTURE CONTENT PHY000200
21.      DPMC(J) = AFMC(J)/(1.0 - AFMC(J)) PHY000210
22.      C *** CALCULATE MMRTU SUPPLIED BY WOOD OR BARK FUEL PHY000220
23.      RRTU(J)=TFES(J)*HRPF(J) PHY000230
24.      C *** CALCULATE MMRTU SUPPLIED BY AUX-ALT FUEL PHY000240
25.      ARTU(J)=TAUX(J)*HRAF(J) PHY000250
26.      C *** CALCULATE PCT. TOTAL HEAT SUPPLIED BY WOOD OR BARK FUEL PHY000260
27.      PCTR(J)=(RRTU(J)/(RRTU(J)+ARTU(J)))*100.0 PHY000270
28.      C *** CALCULATE PCT. TOTAL HEAT SUPPLIED BY AUX/ALT FUEL PHY000280
29.      PCTA(J)=(ARTU(J)/(PRTU(J)+ARTU(J)))*100.0 PHY000290
30.      C *** CALCULATE AVG. AS-FIRED WEIGHT OF WOOD OR BARK FUEL/SALES UNIT PHY000300
31.      AFWR(J)=AMW(J)/(1.0-AFMC(J)) PHY000310
32.      C *** CALCULATE RECOVERABLE HEAT IN RTU'S PER OVENDRY POUND PHY000320
33.      PCOD(J)=RECY(J)/(1.0-AFMC(J)) PHY000330
34.      C *** CALCULATE RECOVERABLE HEAT IN KJOULES/KG. AS-FIRED PHY000340
35.      PHSI(J)=RECY(J)*2.3278 PHY000350
36.      RDSI(J)=PCOD(J)*2.3278 PHY000360
37.      C *** CALCULATE RECOVERABLE HEAT IN KJOULES/KG. OVENDRY PHY000370
38.      C *** CALCULATE RECOVERABLE HEAT IN BILLION JOULES PER RESIDUE FUEL PHY000380
39.      C *** SALES UNIT PHY000390
40.      PSSI(J)=HREF(J)*2.3278 PHY000400
41.      C *** CALCULATE RECOVERABLE HEAT IN BILLION JOULES PER AUX-ALT FUEL PHY000410
42.      C *** SALES UNIT PHY000420
43.      ASSI(J)=HRAF(J)*2.3278 PHY000430
44.      1 CONTINUE PHY000440
45.      C *** TABLE 1 OUTPUT AND FORMAT PHY000450
46.      WRITE(6,11) PHY000460
47.      11 FORMAT('1','PART III. DESCRIPTION OF ENERGY BALANCE AND FUEL PARAMPHY000470
48.     +ETERS'/11X,'FOR EACH ALTERNATIVE (TABLES 1 TO 4)'/2X,'TABLE 1.--PHY000480
49.     +HEAT ENERGY BALANCE AND FUEL REQUIREMENTS (ANNUAL BASIS)', PHY000490
50.     + /9X,'ESSENTIAL ENERGY',3X,'SUPPLUS ENERGY',4X,'TOTAL ENERGY', PHY000500
51.     + /11X,'REQUIREMENTS',6X,'REQUIREMENTS',8X,'OUTPUT'/13X, PHY000510
52.     +'(MMRTU)',11X,'(MMRTU)',10X,'(MMBTU)'/) PHY000520
53.     WRITE(6,2) (J,ERTU(J),SRTU(J),RTUR(J),J=1,NALT) PHY000530
54.     2 FORMAT(' ALT',I2,1X,F16.0,2X,F16.0,1X,F16.0) PHY000540
55.     WRITE(6,22) PHY000550
56.     22 FORMAT('0'/7X,'ENERGY SUPPLIED BY',11X,'ENERGY SUPPLIED BY OTHER PHY000560
57.     +R'/8X,'WOOD-BARK FUEL',3X,'(PCT. OF',6X,'AUXILIARY FUEL',3X, PHY000570
58.     +'(PCT. OF'/14X,'(MMRTU)',5X,'TOTAL)',12X,'(MMRTU)',6X,'TOTAL)'/) PHY000580
59.     WRITE(6,23) (J,PRTU(J),PCTP(J),ARTU(J),PCTA(J),J=1,NALT) PHY000590
60.     23 FORMAT(' ALT',I2,F16.0,4X,F5.1,4X,F16.0,6X,F5.1) PHY000600
61.     WRITE(6,33) PHY000610
62.     33 FORMAT('0'/10X,'QUANTITY OF',9X,'WOOD-BARK FUEL',9X,'OTHER FUEL'/ PHY000620
63.     +7X,'WOOD-BARK AVAILABLE',5X,'REQUIREMENTS',9X,'REQUIREMENTS)'/) PHY000630
64.     WRITE(6,3) (J,RAVL(J),RFS1(J),RFS2(J),TPES(J),RFS1(J),RFS2(J), PHY000640
65.     +TAUX(J),AFSU(J),AXFT(J),J=1,NALT) PHY000650
66.     3 FORMAT(' ALT',I2,2X,F10.0,1X,2A4,F12.0,1X,2A4,1X,'(', PHY000660
67.     +A4,')') PHY000670
68.      C *** TABLE 2 OUTPUT AND FORMAT PHY000680
69.      WRITE(6,44) PHY000690
70.      44 FORMAT('0'//2X,'TABLE 2.--WOOD-BARK FUEL PARAMETERS AND ESTIMATED PHY000700
71.     +HEAT RECOVERY'//6X,'OVENDRY WT (LBS)',3X,'MOISTURE CONT.',5X,'WET PHY000710
72.     +WT (LBS)',4X,'MOISTURE CONT.'/7X,'PER SALES UNIT',4X,'(DRY WT BASIPHY000720

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73.      +S)' ,4X,'PER SALES UNIT',3X,'(WET WT BASIS)')//                PHY00730
74.      WRITE (6,4) (J,AHV(J),RFS1(J),RFS2(J),DWMC(J),AFAR(J),RFS1(J),  PHY00740
75.      +RFS2(J),AFMC(J),J=1,NALT)                                     PHY00750
76.      4 FORMAT(' ALT',I2,2X,F6.0,'/',2A4,8X,F4.2,8X,F6.0,'/',2A4,8X,F4.2) PHY00760
77.
78.      WRITE (6,55)                                                  PHY00780
79.      55 FORMAT('0'//6X,'HIGHER HEAT VALUE', ' - - - - ESTIMATED HEAT ENERGY PHY00790
80.      +Y RECOVERY',5(' - ')//                                        PHY00800
81.      +8X,'(BTU/DRY LB)',4X,'(BTU/DRY (R))',2X,'(BTU/WET (R))',6X,'(MMBTU/SPHY00810
82.      +ALES UNIT)')//                                              PHY00820
83.      WRITE(6,5) (J,AHV(J),RFS1(J),RFS2(J),RPF(J),RFS1(J),RFS2(J),  PHY00830
84.      +J=1,NALT)                                                  PHY00840
85.      5 FORMAT(' ALT',I2,6X,F6.0,10X,F6.0,8X,F6.0,4X,F12.3,'/',2A4)  PHY00850
86.      C *** TABLES 3 AND 4 OUTPUT AND FORMAT                       PHY00860
87.      WRITE (6,66)                                                  PHY00870
88.      66 FORMAT ('1'//7X//2X,'TABLE 3.--OTHER OF AUXILIARY FUEL PARAMETER PHY00880
89.      +TERS'//7X,'TYPE OF',3X,'HIGHER HEAT VALUE',3X,              PHY00890
90.      +ESTIMATED HEAT RECOVERY'/8X,'FUEL',10X,'(MMBTU)',17X,'(MMBTU)'// PHY00900
91.      WRITE (6,6) (1,AXFT(1),AHV(J),AFSU(J),HRAF(J),AFSU(J),J=1,NALT) PHY00910
92.      6 FORMAT (' ALT',I2,2X,A4,6X,FR.2,'/',A4,12X,FR.2,'/',A4)  PHY00920
93.      WRITE (6,77)                                                  PHY00930
94.      77 FORMAT ('0'//2X,'TABLE 4.--INTERNATIONAL SYSTEM (SI) UNIT RECOVERY PHY00940
95.      +ABLE HEAT ENERGY ESTIMATES'//                               PHY00950
96.      +9X,6(' - '), 'ENERGY IN WOOD-BARK FUEL',9(' - '), 'OTHER FUEL - -/' PHY00960
97.      +10X,'(KJ/OLE/KG)',6X,'(KJ/OLE/KG)',6X,'(BILLION JOULE',6X,'(BILLION PHY00970
98.      +JOULE'//                                                    PHY00980
99.      +10X,'DRY BASIS)',6X,'WET BASIS)',6X,'PER SALES UNIT)',5X,'PER SALE PHY00990
100.     +S UNIT)')//                                                PHY01000
101.     WRITE (6,7) (J,RDSI(1),RHSI(J),RSSI(J),RFS1(J),RFS2(J),ASST(J),  PHY01010
102.     +AFSU(J),J=1,NALT)                                           PHY01020
103.     7 FORMAT(' ALT',I2,4X,FR.0,8X,FR.0,4X,FR.1,'/',2A4,5X,FR.1,'/',A4) PHY01030
104.     WRITE(6,8)                                                    PHY01040
105.     8 FORMAT('1','END OF OUTPUT')                                  PHY01050
106.     RETURN                                                         PHY01060
107.     END                                                             PHY01070

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Subroutine RAN

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1.      SUBROUTINE RAN(DAT,NRK,NALT)                                  RAN00010
2.      C                                                            RAN00020
3.      C *** THIS SUBROUTINE RANKS ELEMENTS IN THE ARRAY (DAT) BY NUMERICAL RAN00030
4.      C *** MAGNITUDE, AND CREATES THE INTEGER ARRAY (NRK) WHICH IS THE ORDER RAN00040
5.      C *** OF MAGNITUDE OF ELEMENTS                               RAN00050
6.      C                                                            RAN00060
7.      DIMENSION DAT(10),NRK(10),DATA(10)                          RAN00070
8.      C                                                            RAN00080
9.      CALL EQ1(DAT,DAT)                                            RAN00090
10.     NRK(1)=1                                                    RAN00100
11.     KK=1                                                         RAN00110
12.     DO 2 J=1,NALT                                               RAN00120
13.     DO 1 K=1,NALT                                               RAN00130
14.     IF (DATA(K).GT.DATA(KK)) NRK(1)=K                           RAN00140
15.     IF (DATA(K).GT.DATA(KK)) KK=K                                RAN00150
16.     1 CONTINUE                                                  RAN00160
17.     DATA(K)=(-10.0)*(10.0**20.0)                               RAN00170
18.     2 CONTINUE                                                  RAN00180
19.     RETURN                                                       RAN00190
20.     END                                                           RAN00200

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Subroutine RD1

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1.      SUBROUTINE RD1 (V,NYRS,NALT)                                RD100010
2.      C                                                            RD100020
3.      C *** THIS SUBROUTINE READS ANNUAL CASH FLOW AND PRICE INPUT DATA. RD100030
4.      C *** ANNUAL ESTIMATES MAY BE READ IN, OR ALTERNATIVELY THE FIRST RD100040
5.      C *** YEAR ESTIMATE PLUS ANNUAL RATE OF INCREASE WILL BE READ IN. RD100050
6.      C                                                            RD100060
7.      DIMENSION V(10,20),NYRS(10)                                RD100070
8.      C                                                            RD100080
9.      DO 3 J=1,NALT                                              RD100090
10.     RI = 0.0                                                    RD100100
11.     READ (5,4) (V(J,N),N=1,10)                                  RD100110
12.     IF (V(J,2).LT.1.0.AND.V(J,2).GT.0.00001) RI = V(J,2)     RD100120
13.     IF (V(J,2).LT.1.0.AND.V(J,2).GT.0.00001) GO TO 1          RD100130

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14.	IF(NYRS(J).LE.10) GO TO 3	RD100140
15.	READ(5,4)(V(J,N),N=11,20)	RD100150
16.	IF(V(J,2).GE.1.0.OR.V(J,2).LE.0.0) GO TO 3	RD100160
17.	1 CONTINUE	RD100170
18.	NY = NYRS(J)	RD100180
19.	DO 2 N=2,NY	RD100190
20.	K = N - 1	RD100200
21.	V(J,N) = V(J,K) * (1.0 + RI)	RD100210
22.	2 CONTINUE	RD100220
23.	3 CONTINUE	RD100230
24.	4 FORMAT(10F8)	RD100240
25.	RETURN	RD100250
26.	END	RD100260

Subroutine REQ

1.	SUBROUTINE REQ	REQ00010
2.	C	REQ00020
3.	C *** THIS SUBROUTINE CALCULATES HEAT RECOVERY AND VOLUME REQUIREMENTS	REQ00030
4.	C *** FOR WOOD OR BARK AND AUXILIARY OR ALTERNATE FUELS PER SALES UNIT	REQ00040
5.	C	REQ00050
6.	COMMON/ALL/AFMC(10),AHHV(10),AWRU(10),AXFT(10),	REQ00060
7.	+ BTUR(10),DISR(10),ERTU(10),FATS(10),	REQ00070
8.	+ HHVU(10),HRAF(10),HRRF(10),IVST(10),NYRS(10),PVAT(10),PCT(10),	REQ00080
9.	+ RAVL(10),RECY(10),TAUX(10),TRES(10),DEPR(10,20),	REQ00090
10.	+ NALT,NOR1,NYRD(10)	REQ00100
11.	COMMON/REQ1/AFBA(10),CHRE(10),	REQ00110
12.	DO 1 J=1,NALT	REQ00120
13.	C *** CALCULATE HEAT RECOVERY IN MILLION BTU PER SALES UNIT	REQ00130
14.	C *** WOOD OR BARK FUEL	REQ00140
15.	HRRF(J) = (AWRU(J) / (1.0 - AFMC(J)) * RECY(J) / (10.0**6))	REQ00150
16.	C *** CALCULATE HEAT RECOVERY IN MILLION BTU PER SALES / VALUE UNIT	REQ00160
17.	C *** AUXILIARY OR ALTERNATE FUEL	REQ00170
18.	HRAF(J) = HHVU(J) * CHRE(J)	REQ00180
19.	C *** CALCULATE TOTAL SALES UNITS OF WOOD OR BARK FUEL REQUIRED	REQ00190
20.	TRES(J) = BTUR(J) + AFBA(J) / HRRF(J)	REQ00200
21.	C *** CALCULATE TOTAL SALES UNITS OF AUXILIARY OR ALT. FUEL REQUIRED	REQ00210
22.	TAUX(J) = BTUR(J) * (1.0 - AFBA(J)) / HRAF(J)	REQ00220
23.	IF(TRES(J).GT.RAVL(J)) TAUX(J) = TAUX(J) + (TRES(J) - RAVL(J)) * HRRF(J) / HRAF(J)	REQ00230
24.	+RPF(J) / HRAF(J)	REQ00240
25.	IF(TRES(J).GT.RAVL(J)) TRES(J) = RAVL(J)	REQ00250
26.	1 CONTINUE	REQ00260
27.	RETURN	REQ00270
28.	END	REQ00280

Subroutine RNK

1.	SUBROUTINE RNK	RNK00010
2.	C	RNK00020
3.	C *** THIS SUBROUTINE RANKS ECONOMIC ALTERNATIVES ACCORDING TO HIGHEST	RNK00030
4.	C *** BENEFIT COST RATIO OF ESSENTIAL (PROCESS) HEAT REQUIREMENTS	RNK00040
5.	C *** AND HIGHEST BENEFIT COST RATIO OF TOTAL HEAT REQUIREMENTS.	RNK00050
6.	REAL IVST, IEXP	RNK00060
7.	COMMON/ALL/AFMC(10),AHHV(10),AWRU(10),AXFT(10),	RNK00070
8.	+ BTUR(10),DISR(10),ERTU(10),FATS(10),	RNK00080
9.	+ HHVU(10),HRAF(10),HRRF(10),IVST(10),NYRS(10),PVAT(10),PCT(10),	RNK00090
10.	+ RAVL(10),RECY(10),TAUX(10),TRES(10),DEPR(10,20),	RNK00100
11.	+ NALT,NOR1,NYRD(10)	RNK00110
12.	COMMON/RNK1/DAT1(10),DAT2(10),HVAL(10,20),	RNK00120
13.	+ NRK1(10),NRK2(10),SVAL(10,20),	RNK00130
14.	COMMON/ECG1/CSAL(10),IEXP(10),ITCR(10),TXRT(10),	RNK00131
15.	+ WCRQ(10),ACST(10,20),ANCF(10,20),RNCF(10,20),	RNK00132
16.	+ VCST(10,20),FCST(10,20),CMMR(10,20),AZER(10),	RNK00133
17.	+ PAXF(10,20),RCST(10,20),RVAL(10,20),WCRA(10,21),	RNK00134
18.	+ WCRT(10,21),TITL(20,10),	RNK00135
19.	COMMON/PHY1/ARTU(10),AFSU(10),AFWR(10),ASSI(10),	RNK00136
20.	+ PCTA(10),PCTR(10),RRTU(10),RCOC(10),RDSI(10),	RNK00137
21.	+ RFS1(10),RFS2(10),RHSI(10),RSSI(10),SRTH(10)	RNK00138
22.	DIMENSION BCAT(10),RCAE(10)	RNK00150
23.	C *** CALCULATE, FOR EACH ALTERNATIVE, THE BENEFIT COST RATIO	RNK00170
24.	C *** (RATIO OF PRESENT VALUE OF OUTPUT TO PRESENT VALUE OF COST)	RNK00180
25.	DIMENSION RVST(10)	RNK00190
26.	DO 2 J=1,NALT	RNK00200
27.	DAT1(J)=0.0	RNK00210
28.	DAT2(J)=0.0	RNK00220
29.	NY=NYRS(J)	RNK00250

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30. C *** CALCULATE PRESENT VALUE OF ENERGY OUTPUT RNK00260
31. C *** FOR ESSENTIAL AND TOTAL HEAT REQUIREMENTS. RNK00270
32. DO 1 N=1,NY RNK00280
33. DAT1(J)=DAT1(J)+(HVAL(J,N)*ERTU(J))/((1.0+DISR(J))*N) RNK00290
34. DAT2(J)=DAT2(J)+(HVAL(J,N)*FRTU(J)+SVAL(J,N)*SRTU(J))/((1.0+DISR(J) RNK00300
35. +))*N) RNK00301
36. 1 CONTINUE RNK00310
37. C *** CALCULATE BENEFIT COST RATIO (RATIO OF PRESENT VALUE OF ENERGY RNK00380
38. C *** OUTPUTS TO PRESENT VALUE OR COSTS OF HEAT ENERGY REQUIREMENTS) RNK00390
39. C *** RNK00400
40. HCAE(J)=-DAT1(J)/PVAT(J) RNK00410
41. HCAT(J)=-DAT2(J)/PVAT(J) RNK00420
42. RVST(J) = (IVST(J) + IFXP(J) + WCRQ(J)) - CSAL(J) RNK00421
43. 2 CONTINUE RNK00450
44. IF(NOP1.EQ.1) GO TO 13 RNK00460
45. C *** RANKING OF ALTERNATIVES BY HIGHEST BENEFIT COST RATIO OF HEAT RNK00470
46. CALL RAN(HCAE,NPK1,NALT) RNK00500
47. CALL RAN(HCAT,NRK2,NALT) RNK00520
48. C *** PRINT OUT USER SPECIFIED HEAT ENERGY VALUE($/MMBTU) RNK00530
49. WRITE(6,3) RNK00540
50. 3 FORMAT('1',2X,'PART II. BENEFIT COST RATIOS FOR ALL ALTERNATIVES' RNK00550
51. + '//4X,'FIRST YEAR HEAT ENERGY VALUES (USER SPECIFIED) AND DISCOUNT' RNK00551
52. +ED'/4X,'PRESENT VALUE OF HEAT ENERGY FOR EACH ALTERNATIVE:'// RNK00552
53. +9X,'HEAT ENERGY VALUE ($/MMBTU)',3X,'PRESENT VALUE OF HEAT ENRGY' RNK00553
54. +,3X,'DISCOUNT'/10X,'ESSENTIAL',9X,'SURPLUS',4X,'BASED ON',10X, RNK00554
55. +'(INCLUDING',5X,'RATE'/11X,'ENERGY',11X,'ENERGY',5X,'ESSENTIAL)', RNK00555
56. +10X,'SURPLUS)',4X,'(PCT.)'// RNK00556
57. DO 20 J=1,NALT RNK00553
58. M=1 RNK00554
59. WRITE(6,4) J,HVAL(J,M),SVAL(J,M),DAT1(J),DAT2(J),PCT(J) RNK00555
60. 4 FORMAT(4X,'ALT',1X,I2,2X,F6.2,10X,F6.2,4X,F10.0,9X,F10.0,4X,F5.1) RNK00556
61. 20 CONTINUE RNK00557
62. C *** PRINT OUT BENEFIT COST RATIO IN RANKED ORDER OF HIGHEST TO LOWEST RNK00560
63. C *** VALUE FOR EACH ALTERNATIVE. RNK00565
64. WRITE(6,14) RNK00570
65. 14 FORMAT(///4X,'RANKING OF ALTERNATIVES BY HIGHEST BENEFIT COST RATIO' RNK00580
66. +0'/4X,'(RATIO OF P.V. OF HEAT ENERGY OUTPUT TO P.V. OF AFTER TAX'// RNK00590
67. +4X,'NET CASH FLOW) BASED ON ESSENTIAL HEAT ENERGY REQUIREMENTS:'// RNK00600
68. +21X,'R/C RATIO',15X,'REQUIRED NET INVESTMENT'// RNK00601
69. DO 5 J=1,NALT RNK00620
70. K = NRK1(J) RNK00620
71. WRITE(6,6) NRK1(J),HCAE(K),RVST(K) RNK00640
72. 5 CONTINUE RNK00650
73. 6 FORMAT(10X,'ALT',1X,I2,2X,F10.2,20X,F10.1) RNK00660
74. WRITE(6,7) RNK00670
75. 7 FORMAT('0'///4X,'RANKING OF ALTERNATIVES BY HIGHEST BENEFIT COST RATIO' RNK00680
76. +TIO'/4X,'BASED ON TOTAL HEAT ENERGY OUTPUT (INCLUDING SURPLUS):'// RNK00690
77. +21X,'R/C RATIO',15X,'REQUIRED NET INVESTMENT'// RNK00691
78. DO 8 J=1,NALT RNK00720
79. K = NRK2(J) RNK00730
80. WRITE(6,6) NRK2(J),HCAT(K),RVST(K) RNK00750
81. 8 CONTINUE RNK00760
82. NH = 0 RNK00780
83. DO 9 J=1,NALT RNK00800
84. DIF2 = EBTU(1) - ERTU(J) RNK00830
85. IF(DIF2.GT.0.0001.OR.DIF2.LT.-0.0001) NH = 1 RNK00840
86. 9 CONTINUE RNK00870
87. IF(NH.EQ.1) WRITE(6,11) RNK00890
88. 11 FORMAT('0'///4X,'THE RANKINGS BY BENEFIT COST RATIO ARE NOT VALID CRNK00940
89. +ITERIA FOR'/4X,'COMPARISON BECAUSE THE USER HAS SPECIFIED DIFFEREN RNK00950
90. +T ESSENTIAL'/4X,'HEAT REQUIREMENTS AMONG THE ALTERNATIVES'//) RNK00960
91. 13 CONTINUE RNK01000
92. END RNK01010

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Subroutine RUP

===== RIIR =====

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1. C *** THIS IS THE MAIN SUBROUTINE FOR THE COMPRE PROGRAM. THE COMPRE RUP00010
2. C *** PROGRAM PROVIDES COMPARISON OF ECONOMIC ALTERNATIVES IN SYSTEMS RUP00020
3. C *** FOR PROVIDING PROCESS HEAT ENERGY, IN THE CONTEXT OF A FOREST RUP00030
4. C *** PRODUCTS MANUFACTURING FACILITY WITH AVAILABLE WOOD OR PAPER RUP00040
5. C *** RESIDUE FUEL. THE PROGRAM PROVIDES A RANKING OF ALTERNATIVES RUP00050
6. C *** ACCORDING TO THE LOWEST DISCOUNTED BENEFIT COST RATIO. RUP00060

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7.	C	REAL IVST,ITCP,ITXP,INRT	RUR00070
8.		DIMENSION NCAF(10),INPT(10)	RUP00090
9.		COMMON/ALL/AFMC(10),AMHV(10),AWRU(10),AXFT(10),	PUP00100
10.		+ BTUR(10),DISR(10),ERTU(10),FATS(10),	RUP00110
11.		+ HHVU(10),HPAF(10),HRPF(10),IVST(10),NYPS(10),RVAT(10),PCT(10),	RUP00120
12.		+ RAVL(10),PECV(10),TAUX(10),TPES(10),DEPP(10,20),	RUP00130
13.		+ NALT,NOP1,NYRD(10)	RUP00140
14.		COMMON/REQ1/AFBA(10),CHPE(10),	RUP00150
15.		COMMON/HTR1/ACHL(10),AEAF(10),ASGT(10),ATCA(10),	RUP00160
16.		+ ATPF(10),AVCC(10),AVHC(10),AVNC(10),AVOC(10),	RUP00170
17.		+ CONV(10),SGHD(10),SGHW(10),	RUR00180
18.		COMMON/DEP1/B(21),D(10),NDEP(10),	RUP00190
19.		COMMON/FC01/CSAL(10),ITXP(10),ITCR(10),	RUP00200
20.		+ TXRT(10),WCRQ(10),ACST(10,20),ANCF(10,20),RNCF(10,20),	RUP00210
21.		+ VCST(10,20),FCST(10,20),CMMR(10,20),AZEP(10),	RUP00220
22.		+ PAXF(10,20),RCST(10,20),RVAL(10,20),WCPA(10,21),	RUP00230
23.		+ TXRT(10,21),TITL(20,10),	RUP00240
24.		COMMON/PHY1/AHTU(10),AFSU(10),AFWR(10),ASSI(10),	RUP00250
25.		+ PCTA(10),RCTR(10),RRTU(10),RCOD(10),PDSI(10),	PUP00260
26.		+ RFS1(10),RFS2(10),RHST(10),RSSI(10),SRTU(10),	RUP00270
27.		COMMON/PNK1/DAT1(10),DAT2(10),HVAL(10,20),	RUP00280
28.		+ NRK1(10),NRK2(10),SVAL(10,20)	RUP00290
29.			RUP00300
30.	C		PUR00310
31.	C ***	READ STATEMENTS	RUR00320
32.	C		PUP00330
33.		READ (5,1) NALT	RUP00340
34.		DO 11 J=1,NALT	PUP00350
35.		READ (5,2) (TITL(I,J),I=1,20)	RUP00360
36.		11 CONTINUE	RUP00370
37.		DO 22 J=1,NALT	RUP00380
38.		READ (5,3) AFMC(J),AWRU(J),RFS1(J),RFS2(J),AVHC(J),AVOC(J),	RUP00390
39.		+AVCC(J),AVNC(J),AMHV(J),NCAF(J),AXFT(J),AFSU(J),HHVU(J),CHPE(J),	RUP00400
40.		22 CONTINUE	RUP00410
41.		DO 33 J=1,NALT	PUP00420
42.		AFBA(J) = 1.0	RUR00430
43.		READ (5,4) ERTU(J),SRTU(J),RAVL(J),ASGT(J),ATRF(J),ATCA(J),	PUP00440
44.		+AEAF(J),ACHL(1),AFBA(J)	PUR00450
45.		33 CONTINUE	PUR00460
46.		DO 44 J=1,NALT	RUP00470
47.		HTUR(J)=ERTU(J) + SRTU(J)	RUP00480
48.		READ (5,5) IVST(J),WCRQ(J),ITXP(J),CSAL(J),FATS(J),DISP(J),	RUP00490
49.		+TXRT(J),NDEP(J),NYRS(J),NYRD(J),ITCR(J),INRT(J)	RUP00500
50.		44 CONTINUE	RUP00510
51.		CALL RD1 (VCST,NYRS,NALT)	RUP00520
52.		CALL PD1 (FCST,NYRS,NALT)	RUR00530
53.		CALL RD1 (HVAL,NYRS,NALT)	RUP00540
54.		CALL RD1 (SVAL,NYRS,NALT)	RUR00550
55.		CALL RD1 (PAXF,NYRS,NALT)	RUP00560
56.		CALL PD1 (RVAL,NYRS,NALT)	RUR00570
57.		1 FORMAT(I2)	RUR00580
58.		2 FORMAT(20A4)	RUP00590
59.		3 FORMAT(F5,F6,2A4,4(F5),F6,I1,2A4,F5,F4)	RUR00600
60.		4 FORMAT(4F10,3F5,2F4)	RUP00610
61.		5 FORMAT(5F10,2F4,I1,2I2,F9,F6)	RUP00620
62.		6 FORMAT(10F8)	RUP00630
63.		DO 7 J=1,NALT	RUP00640
64.		IF(NDEP(J).NE.9) GO TO 7	RUP00650
65.		READ (5,6) (DEPP(J,N),N=1,10)	RUP00660
66.		IF(NYRS(J).LE.10) GO TO 7	RUP00670
67.		NY = NYRS(J)	RUP00680
68.		READ (5,6) (DEPP(J,N),N=11,NY)	RUR00690
69.		7 CONTINUE	RUR00700
70.	C		RUR00710
71.	C ***	INITIALIZATION OF STORAGE ARRAYS	RUP00720
72.	C		PUR00730
73.		NOP1 = 0	PUP00740
74.		NOP2 = 0	PUP00750
75.		DO 9 J=1,NALT	RUP00760
76.		WCPT(J,1) = WCRQ(J) * (1.0 + INRT(J))	RUP00770
77.		WCRA(J,1) = WCRT(J,1) - WCRQ(J)	RUP00780
78.		NY = NYPS(J)	RUP00790
79.		DO 8 N=1,NY	RUP00800

80.	NN = N + 1	RUP00810
81.	C *** CALCULATE YEARLY ADDITIONAL WORKING CAPITAL REQUIREMENTS PER YEAR	RUP00820
82.	WCRT(J,NN) = WCRT(J,N) * (1.0 + INPT(J))	RUP00830
83.	WCRA(J,NN) = WCRT(J,NN) - WCRT(J,N)	RUP00840
84.	ANCF(J,N) = 0.0	RUP00850
85.	R CONTINUE	RUP00860
86.	9 CONTINUE	RUP00870
87.	DO 10 J=1,NALT	RUP00880
88.	IF(AVHC(J).LE.0.0) AVHC(J) = 0.06	RUP00890
89.	IF(AVOC(J).LE.0.0) AVOC(J) = 0.41	RUP00900
90.	IF(AVCC(J).LE.0.0) AVCC(J) = 0.50	RUP00910
91.	IF(AVNC(J).LE.0.0) AVNC(J) = 0.01	RUP00920
92.	IF(AHVV(J).LE.0.0) AHVV(J) = 8500.0	RUP00930
93.	IF(NCAF(J).EQ.0) AXFT(J) = ' OIL '	RUP00940
94.	IF(NCAF(J).EQ.0) AFSU(J) = 'RRL'	RUP00950
95.	IF(NCAF(J).EQ.0) HHVII(J) = 6.3	RUP00960
96.	IF(NCAF(J).EQ.0) CHRE(J) = 0.8	RUP00970
97.	IF(NCAF(J).EQ.1) AXFT(J) = 'COAL'	RUP00980
98.	IF(NCAF(J).EQ.1) AFSU(J) = 'TON'	RUP00990
99.	IF(NCAF(J).EQ.1) HHVII(J) = 24.0	RUP01000
100.	IF(NCAF(J).EQ.1) CHPE(J) = 0.67	RUP01010
101.	IF(NCAF(J).EQ.2) AXFT(J) = ' GAS '	RUP01020
102.	IF(NCAF(J).EQ.2) AFSU(J) = ' MCF '	RUP01030
103.	IF(NCAF(J).EQ.2) HHVII(J) = 1.0	RUP01040
104.	IF(NCAF(J).EQ.2) CHRE(J) = 0.76	RUP01050
105.	IF(ASGT(J).LF.0.0) ASGT(J) = 500.0	RUP01060
106.	IF(ATRF(J).LE.0.0) ATRF(J) = 60.0	RUP01070
107.	IF(ATCA(J).LE.0.0) ATCA(J) = 60.0	RUP01080
108.	IF(AFAF(J).LE.0.0) AFAF(J) = 0.40	RUP01090
109.	IF(ACHL(J).LE.0.0) ACHL(J) = 0.04	RUP01100
110.	10 CONTINUE	RUP01110
111.	C	RUP01120
112.	C *** CALL RUP SUBROUTINES	RUP01130
113.	C	RUP01140
114.	CALL DEP	RUP01150
115.	CALL HTR	RUP01160
116.	CALL REQ	RUP01170
117.	CALL ECO	RUP01180
118.	CALL RNK	RUP01190
119.	CALL PHY	RUP01200
120.		RUP01210
121.	STOP	RUP01220
122.	END	RUP01230

U.S. Forest Products Laboratory

COMPARE—A Method for Analyzing Investment Alternatives in Industrial Wood and Bark Energy Systems, by Peter J. Ince, Madison, Wis., FPL 1982.

28 p. (USDA For. Serv. Gen. Tech. Rep. FPL-36)

A method is presented that was developed to analyze investments in industrial wood and bark energy systems. The method is embedded in a computer program called COMPARE. This program provides complete guidelines for economic analysis of wood and bark energy systems.

Keywords: Investment alternatives, Industrial wood, bark energy systems, COMPARE

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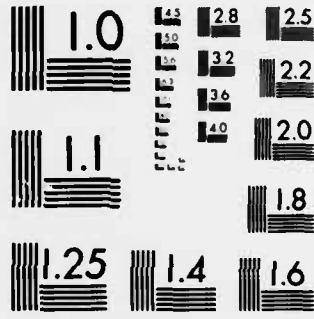
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Errata

COMPARE:

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Industrial Wood and
Bark Energy Systems

In figure 1, page 8, of this publication, the entry written in columns 2 through 9 of lines 8, 9, and 10 of the data input should be

252230.

and not

25230.

as written.

The corrected entries will produce the output as shown in figure 3 of this publication. The uncorrected entries will produce output with different output values than those shown in figure 3.

Ince, Peter J. COMPARE--A Method for Analyzing Investment Alternatives in Industrial Wood and Bark Energy Systems. Gen. Tech. Rep. FPL-36. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory; 1982. 28 p.

**DAT
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