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Stephen R. Petersen

United States Department of Commerce National Bureau of Standards Prepared for

States Department of Energy **Energy Management Program**

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A User's Guide to the Federal Building Life-Cycle Cost (FBLCC) Computer Program

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Prepared for Federal Programs Office Office of the Assistant Secretary for Conservation and Renewable Energy U.S. Department of Energy Washington, DC 20585 CENTER NBSC QC100 US753 NO.1222 1986 C.2

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ABSTRACT

The FBLCC Computer Program and this User's Guide provide computational tools and energy price data for performing life-cycle cost (LCC) analyses of Federal buildings and related subsystems. Two kinds of Federal building projects can be evaluated with FBLCC: (1) LCC analysis of projects directly related to energy conservation and renewable energy, and (2) LCC analysis of projects not directly concerned with energy conservation or renewable energy. The methods and procedures used in these LCC analyses are based on the rules set forth by the U.S. Department of Energy's Federal Energy Management Program and the U.S. Office of Management and Budget in Circular A-94, respectively. The FBLCC computer program and DoE energy price data are contained on a 5 1/4 inch diskette formatted for use on microcomputers with an MS-DOS operating system. A comparative LCC analysis of alternative building or subsystem designs can be performed by FBLCC in order to determine whether the additional costs of design improvements or retrofits to a Federal building are cost effective in terms of reductions in future operating-related costs when evaluated in present value dollars.

PREFACE

The FBLCC Computer Program and User's Guide have been prepared as an aid to implementing life-cycle cost (LCC) evaluations of energy conservation and renewable energy projects in new and existing Federal buildings. It is the third of a three-volume set of reports which together provide a comprehensive set of methods, data, and computational tools for Federal LCC analysis of energy projects.

Included in the three-volume set are the following:

(1) Life-Cycle Cost Manual for the Federal Energy Management Program (National Bureau of Standards, HB 135 (to be revised in 1986))

The manual is a guide to understanding the LCC method. It describes the required procedures and assumptions, defines and explains how to apply economic performance measures, gives examples of Federal decision problems and their solutions, and provides worksheets and other computational aids and instructions for calculating the required measures.

(2) Energy Prices and Discount Factors for Life-Cycle Cost Analysis (National Bureau of Standards, NBSIR 85-3273 (revised annually))

This report, which is updated annually, gives the energy price and discount factor multipliers needed to estimate the present value of energy and other future costs. The data are based on energy price projections developed by the Energy Information Administration of the U.S. Department of Energy.

(3) A User's Guide to the FBLCC Computer Program (National Bureau of Standards, NBS TN #### (revised annually))

FBLCC, designed to run on an IBM PC/XT/AT or compatible microcomputer, can be used to calculate the life-cyle costs, net benefits, and savings-to-investment ratios of Federal energy projects, consistent with the procedures and assumptions described in Handbook 135 (see #1 above) and incorporating the energy price data of NBSIR 85-3273 (see #2 above). FBLCC generates reports which summarize the assumptions and output in tabular form.

The above three-volume set of reports can be used to perform two kinds of Federal project evaluations:

(a) LCC evaluations of Federal building projects which are classified as energy conservation or renewable energy projects, and, hence, are subject to Subpart A of Part 436 of Title 10 of the Code of Federal Regulations (10 CFR Part 436) entitled "Federal Energy Management and Planning Programs;" and

(b) LCC evaluations of Federal building projects which have an energy cost component, but which are not primarily energy conservation or renewable energy projects, and, hence, are subject to U.S. Office of Management and Budget (OMB) Circular A-94, "Discount Rates to be used in Evaluating Time Distributed Costs and Benefits," dated March 27, 1972 (unless specifically exempted). Note to U.S. Department of Defense (DoD) users of FEMP methods: The U.S. Army Corps of Engineers is developing a computer program, Life-Cycle Cost in Design (LCCID), intended for use in evaluating DoD building projects. For more information on the LCCID program, contact the program developer, Ms. Linda Lawrie, U.S. Army Construction Engineering Laboratory (CERL), telephone (217) 352-6511.

IMPORTANT NOTICE

The FBLCC program and supporting files are provided to the user "AS IS". The United States Government makes no warranty, express or implied, concerning the accuracy, completeness, reliability, usability, or suitability for any particular purpose of the information and data contained in the FBLCC program and supporting files or as to any results generated through their use. Therefore, the user assumes the entire risk as to the results and performance of this software.

The FBLCC program was developed for the U.S. Department of Energy by the National Bureau of Standards and is the property of the United States Government. The programs and files on the FBLCC disk may be copied in unlimited numbers. Copies made for distribution to others should be carefully marked to identify the date and version of the program. The FBLCC program and the information on the FBLCC diskette is not subject to copyright.

The accuracy of this program is largely dependent on the user-supplied input data. It is the user's responsibility to understand how the input data affects the program output and to use the output data only as intended.

It is essential that the user return the FBLCC registration form on page vii. Only by completing and returning this form will the U.S. Department of Energy be able to inform the user of coding or data changes that may be announced from time to time as needed to ensure proper execution of the program. If the registration card has been removed from this document, please send your name, affiliation, and address, along with the words "FBLCC REGISTRATION", to:

> U.S. Department of Energy Office of the Assistant Secretary for Conservation and Renewable Energy Federal Energy Management Program CE 10.1 Washington, D.C. 20585

DISKETTE AVAILABILITY

The FBLCC program and related files are contained on a single 5-1/4 inch diskette in MS-DOS format. A limited number of diskettes have been distributed to agencies of the United States Government for distribution within those agencies. These diskettes can be duplicated for distribution by using the DISKCOPY utility on a MS-DOS-compatible microcomputer. If you require a copy of the FBLCC diskette, it can be ordered from:

> National Technical Information Service U.S. Department of Commerce 5285 Port Royal Road Springfield, VA 22161

Inquiries to NTIS about the availability and price of this disk should include the diskette name:

"Federal Building Life-Cycle Cost (FBLCC) Program Diskette"

For a list of alternative sources of the FBLCC diskette, see the loose insert in this document or write to:

U.S. Department of Energy Office of the Assistant Secretary for Conservation and Renewable Energy Federal Energy Management Program CE 10.1 Washington, D.C. 20585 All FBLCC users should complete and return this registration form to the address shown below. Only through this registration process will the U.S. Department of Energy be able to inform users of important coding, data, or procedural changes to the FBLCC program and supporting files.

	FBLCC REGISTRATION FORM	,
NAME		
AFFILIATION		
ADDRESS		
FBLCC VERSION		
Please send to:		
	U.S. Department of Energy Office of the Assistant Secretary Renewable Energy Federal Energy Management Program CE 10.1 Washington, D.C. 20585	for Conservation and



ACKNOWLEDGMENTS

The author wishes to thank Mr. William Bethea, Head of the Federal Programs Office of the U.S. Department of Energy, and Mr. K. Dean Devine, also of the Federal Programs Office, for their valuable support of the FBLCC program development project.

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Notice: Neither the Department of Energy nor the Department of Commerce/ National Bureau of Standards assumes any liability resulting from errors or omissions in this manual or in the FBLCC program itself, or from the use of the information obtained therein.

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1. INTRODUCTION TO FBLCC

1.1 Description of FBLCC Program Package

FBLCC is the Federal buildings version of BLCC, the Building Life-Cycle Cost computer program developed at the National Bureau of Standards.¹ FBLCC performs comprehensive life-cycle cost (LCC) analyses of Federal buildings and related subsystems and compares the present-value LCC of alternative building or subsystem designs to determine which is the most cost effective in a given application. FBLCC was developed to evaluate alternative building or subsystem designs which have higher initial costs but lower operating and maintenance costs (including energy-related costs) over their life than a corresponding base-case design. Federal guidelines for calculating the cost effectiveness of both energy-and non-energy-related projects are built into FBLCC. In addition, FBLCC directly accesses DoE long-term (i.e., 25-year) energy price projections included with the program.²

The FBLCC program is primarily intended to provide computational support for NBS Handbook 135, <u>Life-Cycle Cost Manual for the Federal Energy Management Program</u>.³ Handbook 135 provides specific guidelines for the LCC analysis of energy conservation and renewable energy projects in Federal buildings in accordance with rules set forth in the Code of Federal Regulations.⁴ Table 1 outlines those guidelines from Handbook 135 which are built into the FBLCC program. (Handbook 135 guidelines which refer to investments in leased buildings are not explicitly

¹Petersen, S. R., <u>A User's Guide to the Building Life-Cycle Cost (BLCC) Computer</u> Program, American Society of Testing and Materials, Philadephia, PA, 1985.

²The tax and financing-related algorithms contained in the BLCC program are not relevant to Federal buildings and have therefore been removed from the FBLCC version.

³Ruegg, R. T., <u>Life-Cycle Cost Manual for the Federal Energy Management Program</u>, NBS Handbook 135 (revised) (DE820717356), U.S. Department of Commerce, National Bureau of Standards, Gaithersburg, MD, 1986.

⁴¹⁰ Code of Federal Regulations, Revised, Sec. 436 (1985).

Table 1. LCC Guidelines for Federal Energy Conservation and Renewable Energy Projects^a Included in FBLCC Program

o Base Year = Current Year

- o Discount Rate = 7% Real (i.e., net of general price inflation)
- o Maximum Study Period = 25 years
- o Initial Project Costs, including the costs of design, engineering, purchase, and installation (but excluding sunk costs) occur as lump-sum present-value costs at the beginning of the base year.
- o Initial Conservation-Related Costs are adjusted to 90 percent of actual cost, i.e., reduced by 10%.
- o All Future Costs are estimated in Constant Base-Year Dollars.
- o Purchased Energy quantities are specified at the building boundary.
- o Actual Energy Prices to the agency are used in the analysis, or DOE baseyear Energy Prices are substituted if the former are not available.
- o DOE projected Energy Price Escalation Rates are used in the analysis unless specifically excepted.
- o Energy and Non-Fuel Operating, Maintenance, and Replacement Costs and Resale (Salvage) Values occur at the end of the year in which they are estimated to occur.

^aRuegg, R. T., <u>Life-Cycle Cost Manual for the Federal Energy Management Program</u>, NBS Handbook 135 (revised) (DE820717356), U.S. Department of Commerce, National Bureau of Standards, Gaithersburg, MD, 1986.

included in the FBLCC program. However; these investments can be evaluated with FBLCC provided that the user is familiar with these guidelines.)

The FBLCC program can also be used to calculate the LCC of Federal projects which are not directly related to energy conservation or renewable energy projects, but are instead subject to the provisions of the Office of Management and Budget (OMB) Circular A-94.¹ Table 2 summarizes the LCC analysis assumptions and options that are incorporated into the FBLCC program for use in evaluating such projects. These projects will be referred to as "non-energy-related" projects in this User's Guide, even though they may have some energy usage. All of the options in Table 2 are consistent with, although not necessarily required by, OMB Circular A-94.

The FBLCC program and related data files are contained on one 5-1/4 inch "floppy" disk in MS-DOS format.² Current (1985) Department of Energy (DOE) energy price forecasts for the 10 DOE regions and United States average are also stored on the disk and are automatically retrieved as appropriate by the LCCDATA subprogram. These price forecasts (in constant base-year dollars) extend to the year 2009, and vary both by end-use energy form and building type. (These forecasts are usually updated annually in the fall by DoE. It is currently anticipated that DoE will make available shortly thereafter an updated FBLCC disk.) Also

¹U.S. Office of Management and Budget, "Circular A-94: Discount Rate to be Used in Evalauting Time-Distributed Costs and Benefits," March 27, 1972.

²This product identification does not imply a recommendation nor endorsement by the National Bureau of Standards nor the U.S. Department of Energy, nor does it imply that the products identified are necessarily the most suitable for the purpose used.

o Base Year = Current Year

- o Discount Rate = 10% Real (i.e., net of general inflation)^a
- o The Study Period can be as long as 50 years.
- o A Planning/Construction Period of up to 10 years can be specified before the Occupancy Year and planning, design and construction costs can be phased in over any part of this period or on the Date of Occupancy.
- o All Future Costs are entered in Constant Base-Year Dollars but can be adjusted for changes in relative price levels where there is a reasonable basis for estimating such changes.^a
- o Base-Year Energy Prices to the agency can be used, or the DOE base-year Energy Prices can be used if the former are not available.
- o The use of DOE Energy Price Escalation Rates is optional; user can enter other escalation rates or modify DOE rates if there is a reasonable basis for estimating such changes.
- o Energy and Non-Fuel Operating, Maintenance, and Replacement Costs and Resale (Salvage) Values occur at the end of the year in which they are estimated to occur.

^aAssumptions specifically related to OMB Circular A-94.

contained on the FBLCC disk is a stand-alone discounting program called DISCOUNT, a worksheet-generating program called BCFFORM, and a number of files containing the data and assumptions used in the examples in this User's Guide.

The FBLCC program itself is user-oriented in that it prompts the user for all relevant data and assumptions, advises the user when these appear to be improper, permits the user to save and make changes to the input data file quickly and easily, and allows the user to move freely from subprogram to subprogram by menu selection. All entries are made from the microcomputer keyboard; the video monitor prompts the user and displays input data and summary output data. A printer is needed to print out the three types of reports generated by the FBLCC program and the worksheet. The DISCOUNT program uses the video monitor for both input and output data display.

1.2 Organization of this User's Guide

This User's Guide provides instructions for running FBLCC, explains the purpose of each of the subprograms, defines all of the input data to be entered by the user, assists the user in interpreting the three reports printed by the FBLCC subprograms, and documents the structure and underlying computational algorithms of the FBLCC program. In addition, it explains the use of the "DISCOUNT" program for stand-alone discounting operations.

This User's Guide is organized to help the user get started running the FBLCC program before the various subprograms and input requirements are discussed. The user who is anxious to get started may want to try running the FBLCC program

immediately after reading Chapter 2 (Microcomputer Requirements) and Chapter 3 (Installing and Starting the FBLCC Programs) and refer to the following chapters as needed. The interactive nature of the FBLCC subprograms will provide the user with much of the information needed to proceed through a LCC analysis. However, it is recommended that the user read Chapter 4 (Running the FBLCC Subprograms) to get a better understanding of the nature of each of the five subprograms and their logical sequence of use before actually trying to perform a LCC analysis. Chapter 5 (FBLCC Data Requirements) provides definitions of all of the variables to be entered by the user. These definitions give the user a better understanding of what is being asked for when using the LCCDATA subprogram. The three types of FBLCC reports are discussed in Chapter 6 (FBLCC Reports) along with a further example of a FBLCC analysis. Chapter 7 explains the use of the DISCOUNT program. For very simple LCC problems, the user may want to use the DISCOUNT program to perform discounting operations rather than set up a comprehensive FBLCC analysis.

The two appendices provide detailed information on the FBLCC subprograms. Appendix A lists the key variable names that are used in the subprograms. Appendix B documents the computational algorithms used in the LCCMAIN and COMPARE programs. The equations in Appendix B show how the results in the detailed LCC report and the comparative LCC report were calculated. Listings of the BASIC code for FBLCC and its subprograms can be made directly from the FBLCC disk at the "OK" prompt in BASIC.

2. MICROCOMPUTER REQUIREMENTS

The FBLCC program is intended for use on microcomputers with an MS-DOS operating system, such as the IBM-PC and compatibles.¹ Either a standard or wide carriage line printer can be used to print the three reports and data collection worksheets. Ordinarily, two disk drives are required. Once the FBLCC subprograms are copied onto a disk containing the disk operating system (DOS) and BASIC interpreter, only one disk drive is needed. However, this will greatly reduce storage space for the data files generated when using FBLCC. The program itself can be run on some other microcomputers in BASIC with only minor modifications. Some versions of BASIC may use different symbols for exponentiation and printfield declarations and may not recognize the clear screen command (CLS). Approximately 50K of free Random Access Memory (RAM) is needed to run the program after BASIC is loaded.

A limitation imposed by the use of BASIC with single precision variables is that only the first seven digits in a larger number are significant, and the last of these is rounded; e.g. 1,234,567,890 is printed as 1,234,568,000. Any dollar amount between \$1,000,000 and \$10,000,000 will be rounded to the nearest ten dollars; e.g., \$1,000,004 will be rounded to \$1,000,000 and \$1,000,005 will be rounded to \$1,000,010. Any number between \$10,000,000, and \$100,000,000 will be rounded to the nearest \$100, etc. Seven significant digits provide sufficient accuracy for LCC analysis purposes, which is limited more by assumptions regarding future costs than by significant digits.

¹This product identification does not imply a recommendation nor endorsement by the National Bureau of Standards nor the U.S. Department of Energy, nor does it imply that the products identified are necessarily the most suitable for the purpose used.

3. INSTALLING AND STARTING THE FBLCC PROGRAMS

All of the programs and files needed to run the FBLCC program are contained on the FBLCC diskette. Rather than use the original diskette, it is recommended that you copy these programs onto your own formatted diskette (along with the disk operating system files and BASIC interpreter) or hard disk. The following installation instructions are for an IBM-PC (or compatible microcomputer) with two disk drives. Consult your computer operating guide for copying these files on a single-drive or hard-disk systems.

INSTALLATION

- Step 1. Insert your own formatted diskette with operating system and BASIC in drive A. It is best if there are no other files on this disk. Insert the FBLCC disk in drive B. Always insert the diskette with the label side up. Close the doors to the disk drives.
- Step 2. If your computer is off, switch on the printer, video monitor, and then the computer.
- Step 3. If you do not see the DOS prompt (A>), press the System Reset keys (Ctrl> plus <Alt> plus).
- Step 4. If you are prompted for the date, enter the current date (e.g., MM/DD/YY). Otherwise type <u>DATE</u> at the A> and enter the date. It is important that you enter the correct year because the base year used in the FBLCC program is taken from the internal clock.
- Step 5. Copy all of the files from the FBLCC disk in drive B to the system disk in drive A as follows: At the A> type <u>COPY B:*.* A:</u>. The following files will be copied over to your disk in drive A:

BASIC Files	Building Charac- teristics Files	LCC Output Files	DoE Energy Price Files
FBLCC.BAS	FED1.BCF	FED1.LCC	ENCOSTXX.SEQ
LCCDATA BAS	FED2.BCF	FED2.LCC	ENCOSTFL.RAN
PRINTBCF.BAS	FED3.BCF	FED3.LCC	
LCCMAIN. BAS	FED4.BCF	FED4.LCC	
PRINTLCC.BAS	FED5.BCF	FED5.LCC	
COMPARE.BAS	FED6.BCF	FED6.LCC	
BCFFORM.BAS	FED7.BCF	FED7.LCC	

DISCOUNT.BAS

The building characteristics files and LCC output files listed here contain data and calculations used in the examples discussed in this User's Guide and are not integral to the FBLCC program package. You may delete them when you no longer need them.

Step 6. Remove the FBLCC disk and store it for safekeeping. Installation is complete.

STARTING FBLCC

The following instructions for running the FBLCC program are based on the installation instructions shown above.

Step 1. Insert your diskette containing BASIC and FBLCC files in drive A. If you want to save the files that you create on another disk, enter a formatted disk for this purpose in drive B.

- Step 2. Follow steps 2, 3, and 4 of the installation instructions above as necessary.
- Step 3. At the A>, type: <u>BASIC FBLCC /S:156</u>. (The /S:156 is needed to allocate space for the random access files used to retrieve the DoE energy price projections. Some microcomputers use other names for BASIC, e.g., GWBASIC, MBASIC.) The following messages will appear on the video monitor:

FBLCC computes the LIFE-CYCLE COST (LCC) of Federal buildings (or related subsystems) and COMPARES the LCC of alternative building (or subsystem) designs having the same purpose. An FBLCC analysis is most useful in the evaluation of first cost--future cost tradeoffs, i.e., increases in initial design or construction costs which reduce future operating-related costs (e.g., energy costs) but do not affect other requirements of the building design (e.g., the total rentable floor area).

The computational rules for a LCC analysis of a Federal project depend on the purpose of that project:

- For ENERGY CONSERVATION or RENEWABLE ENERGY PROJECTS, LCC computations are based on NBS Handbook 135, <u>Life-Cycle Cost Manual</u> for the Federal Energy Management Program, (revised 1982).
- (2) For other evaluations requiring an analysis of first cost--future cost tradeoffs, LCC computations are based on OMB Circular A-94, "Discount Rate to be Used in Evaluating Time-Distributed Costs and Benefits," March 27, 1972.

FBLCC consists of 5 subprograms, each with a distinct function:

- (1) LCCDATA A user-interactive program for creating or modifying a BUILDING CHARACTERISTICS FILE (BCF) for a particular building or subsystem design. The BCF is a complete list of all the data and assumptions for that design.
- (2) PRINTBCF Prints the BCF created or modified by (1).
- (3) LCCMAIN Computes the LCC for a building or subsystem, based on its BCF.
- (4) PRINTLCC Prints a detailed LCC REPORT based on the results of (3).
- (5) COMPARE Computes and prints a COMPARATIVE LCC ANALYSIS of two alternative building or subsystem designs.

You must create a BUILDING CHARACTERISTICS FILE for a project with LCCDATA before running PRINTBCF or LCCMAIN. You must compute the LCC of the project with LCCMAIN before running PRINTLCC. You must run LCCMAIN for a base case and at least one alternative design before running COMPARE. Enter subprogram code to proceed:

- Step 4. Type the number corresponding to the first subprogram to be used and proceed as directed by instructions on the video monitor. Each of these five subprograms and their input requirements are described in the following section. If you wish to stop the execution of the FBLCC program at this point, press the <ENTER> key. Execution of this program or any of the other subprograms can be stopped at any point by pressing <CTRL> <BREAK>.
- Step 5. Turn on <caps lock>. All alphabetic entries must be entered in upper case letters.

4. RUNNING THE FBLCC SUBPROGRAMS

The FBLCC program is divided into an introductory module (FBLCC) and five major subprograms, each with its own specific function. As indicated above, the FBLCC module provides a few brief instructions to the user and provides a menu which allows the user to proceed to any one of the subprograms. After the start-up sequence, the FBLCC module itself is no longer needed. This chapter describes the five major subprograms of FBLCC and the recommended sequence of subprogram operation. All of these subprograms use the video monitor to prompt the user for data entries.

4.1 <u>LCCDATA</u> - This first subprogram works in an interactive mode with the user to create or modify a building characteristics file for the project to be evaluated. A building characteristics file must be created and saved with LCCDATA before any of the other subprograms can be run. The building characteristics files contain a complete list of the data and assumptions used in the actual LCC calculations. A complete listing and description of these data and assumptions are provided in Chapter 5, "FBLCC Data Requirements."

The building characteristics file is divided into five sections:

- (1) project title,
- (2) basic LCC analysis assumptions,
- (3) capital component and replacement cost data,
- (4) operating and maintenance cost data, and
- (5) energy cost data.

Each time LCCDATA is initiated, it asks the user if a building characteristics file is to be created or modified:

ENTER C TO CREATE NEW FILE OR M TO MODIFY EXISTING FILE? Enter C for create or M for modify. Simply pressing <ENTER> in response to this question displays a menu which allows the user to move to the other subprograms or stop.

If a new file is to be created, the user will be prompted for the file name under which this file will be saved:

NAME OF NEW FILE?

A valid file name must be entered. A valid file name begins with a letter and has no more than eight alpha or numeric characters, e.g., HOUSEL. (No quotations or other punctuation should be used.) All building characteristic files are automatically provided with the suffix ".BCF"; this suffix will appear when listing the directory of files but is not needed when running the program.

The disk drive designator to store the new file must also be entered:

WHICH DISK TO STORE filename (A, B, C)?

If you designate the drive in which the FBLCC disk is located (usually A) the BCF file will be saved on that disk. If you designate the other drive (usually B) you must have a formatted disk in that drive on which to save the BCF files.

See "File Storage" below in this chapter for suggested procedures for storing files.

In the file creation mode, corrections cannot be made once the <ENTER> (i.e., carriage return) key is pressed for each entry. All corrections are made in the file modification mode. If you wish to make a correction before entering additional data, you can move to the file modification mode by pressing <ENTER> for each query, defaulting to the value shown at each point, until the modification menu appears. (At several points, you may need to specify a value within the limits displayed on the screen.) Once in the modification mode you can change entries in each section of the building characteristics file (see below). Alternatively, you can press the <Ctrl> <BREAK> and start over by typing RUN. In this latter case, however, you will lose all data entered up to that point. In general, if a new building characteristics file will be at all similar to an existing building characteristics file, it is much easier to modify the existing file than to create a new one. If a previously created file is to be modified, LCCDATA asks for the name of the existing file to be modified and a new file name for saving the modified file:

NAME OF EXISTING FILE TO BE MODIFIED?

WHICH DRIVE TO FIND filename (A, B, C)? .

NAME OF NEW FILE?

WHICH DISK TO STORE filename (A, B, C)?

If the modified file is to replace the existing file, save the new file under the old file name. Important: if the name designated for any new file is the same as that for any existing building characteristics file on the disk, the modified file will replace that existing file. The user would be wise to keep a log of all data files created and saved on the

disks. Data files which are no longer needed can be deleted from disk storage using the appropriate "erase" or "kill" command. (Remember to include the suffix when deleting a file.)

LCCDATA prompts the user for all data required to run the LCCMAIN program. Entries which are illegal or illogical are rejected. When an improper entry is made, the allowable range for that value is displayed and the user is asked to reenter the data requested.

Here are a few important "do's and don'ts" when setting up a building characteristics file:

- ° Do press the <ENTER> key after each complete response.
- Do enter all percentages as whole numbers, not decimals;
 e.g., 50% is entered as 50, not 0.50.
- ° If more than one entry is required on a line, do separate each entry with a comma (,); e.g.: 50,5,10.
- ° Do not enter \$ or % signs with any number.

In cases where more than one variable is requested at a time, separated by commas, but the user fails to make all of the required entries, a "redo from start" prompt appears, requiring that the entire line of data be reentered. (This does not mean that you have to start from the beginning of the file again.)

When creating a new building characteristics file, all relevant data must be entered sequentially as requested. Each of these data requirements

are described in Chapter 5, "FBLCC Data Requirements." In both the creation and modification modes, a default value will be shown for most data entries as they are requested. By pressing the <ENTER> key for any request, the default value is automatically entered into the new file. In the file creation mode, many of the default values are set at zero; some of these zeros must be changed to correspond to the range of values displayed in the prompt message (e.g., the expected life of a building component). If the response is invalid, the exact range of valid responses is displayed. In the file modification mode, the values in the existing file automatically become the default values for the new file.

After completing the file creation sequence, LCCDATA moves into the file modification mode. This allows the user to make corrections to this file before saving it. In the file modification mode, the user can move to any section of the building characteristics file in order to change one or more data entries in that section. The following menu is displayed in order to permit the user to move into the section where the change is to be made:

WHAT DO YOU WANT TO DO NOW?
(1) MODIFY PROJECT TITLE.
(2) MODIFY BASIC LCC ANALYSIS ASSUMPTIONS.
(3) MODIFY CAPITAL COMPONENT AND REPLACEMENT COST DATA.
(4) MODIFY OPERATING & MAINTENANCE COST DATA.
(5) MODIFY ENERGY COST DATA.
(6) SAVE NEW FILE.
(7) STOP.
ENTER CODE NUMBER...? .

When modifying an existing file, the user can move very quickly through any section of that file by pressing the <ENTER> key (i.e., defaulting to the value shown) for all but those entries to be changed. The user must move through the entire section selected for modification in order to return to the menu.

After the desired modifications (if any) are made, the file must be saved before creating/modifying another building characteristics file or before moving to the next subprogram. The file save command is executed by designating the appropriate menu selection (6). The file is saved on the diskette, under the name specified at the outset of the file creation/ modification sequence, with the ".BCF" suffix added.

Once the file has been saved, an expanded menu is displayed:

WHAT DO YOU WANT TO DO NOW?

- (1) MODIFY PROJECT TITLE.
- (2) MODIFY BASIC LCC ANALYSIS ASSUMPTIONS.
- (3) MODIFY CAPITAL COMPONENT AND REPLACEMENT COST DATA.
- (4) MODIFY OPERATING & MAINTENANCE COST DATA.
- (5) MODIFY ENERGY COST DATA.
- (6) SAVE NEW FILE.
- (7) STOP.
- (8) CREATE/MODIFY ANOTHER BLDG CHARACTERISTICS FILE.
- (9) PRINT BLDG CHAR'STICS FILE (GO TO 'PRINTBCF' PROGRAM).
- (10) CALCULATE LCC (GO TO 'LCCMAIN' PROGRAM).
- (11) PRINT LCC ANALYSIS (GO TO 'PRINTLCC' PROGRAM).
- (12) COMPARE LCC OF TWO BUILDINGS (GO TO 'COMPARE' PROGRAM).

ENTER CODE NUMBER...?

This expanded menu allows the user to make more changes to the building characteristics file just created or modified (1-5), to resave the file (6), to stop (7), to create or modify another building characteristics file (8), or to move to another subprogram operation (9-12). The proper sequence of subprogram operations is described below in section 4.6.

4.2 <u>PRINTBCF</u> - This subprogram prints out a summary of a building characteristics file that has been previously created (or modified) by LCCDATA and saved on the disk. The user must specify the name and location

of the file to be printed (Do not include the ".BCF" suffix.):

NAME OF BLDG CHARACTERISTICS FILE TO BE PRINTED?

WHICH DRIVE TO FIND filename (A, B, C)?

An example of the file summary printed by PRINTBCF is shown in Table 3. The file is divided into the five sections referenced in LCCDATA. This printed summary of the building characteristics file contains a complete listing of the input variable values used to run the LCCMAIN subprogram (described below) for the designated project.

Once the file has been printed out, a menu is displayed which allows the user to print out another building characteristics file or move to another subprogram operation.

4.3 <u>LCCMAIN</u> - This is the "core" subprogram of the overall FBLCC program. LCCMAIN computes the present value and annualized value of all costs incurred over the study period. When running the LCCMAIN subprogram, the name of the building characteristics file for the project to be evaluated must be entered (without the ".BCF" suffix):

ENTER BLDG CHARACTERISTICS FILE NAME?

WHICH DISK TO FIND filename (A, B, C)?

After the LCC analysis is completed, the LCC computations are saved in a LCC output file named by the user:

ENTER LCC OUTPUT FILE NAME TO STORE RESULTS OF THIS LCC ANALYSIS? WHICH DISK TO STORE filename (A, B, C)?

Table 3. Building Characteristics File for Building A (Example)

This example represents the base-case data file for the LCC analysis of a Federal office building for which an energy-conserving alternative is to be evaluated.

BUILDING CHARACTERISTICS FILE

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FILE NAME: FED1(.BCF) FILE LAST MODIFIED ON 02-01-1986 01:20:15

PROJECT TITLE: BUILDING A

BASIC LCC ANALYSIS ASSUMPTIONS:

ANALYSIS TYPE: NBS HANDBOOK 135 BASE DATE FOR LCC ANALYSIS: 1985 STUDY PERIDD: 20 YEARS DCCUPANCY DATE: 1985 DISCOUNT RATE (REAL) = 7.00% BUILDING TYPE = 2 COMMERCIAL DOE REGION = 1

CAPITAL COMPONENT AND REPLACEMENT COST DATA:

NUMBER OF CAPITAL COMPONENTS: 2		
CAPITAL COMPONENT DATA:		
COMPONENT NAME	STRUCTURE	EQUIPMENT
INITIAL COMPONENT COST	500000	100000
INIT. CONSERVATION-RELATED COST	0	0
EXPECTED COMPONENT LIFE(YRS)	50	20
AVG PRICE ESC RT DURING CONST.	0.00%	0.00%
AVG PRICE ESC RT DURING OCC.	0.00%	0.00%
RESALE VALUE FACTOR	50.00%	25.00%
NUMBER OF REPLACEMENTS	0	1

COST-PHASING SCHEDULE BY YEAR OF CONSTRUCTION AND AT OCCUPANCY: AT OCCUPANCY 100.00% 100.00%

REPLACEMENTS TO CAPITAL COMPONENTS:

REPLACEMENTS TO EQUIPMENT:	
REPLACEMENT NUMBER	1
YEAR OF REPLACEMENT	15
COST OF REPLACEMENT	25000
EXPECTED REPL. LIFE (YRS)	15
RESALE VALUE FACTOR	0.00%

OPERATING AND MAINTENANCE COST DATA:

ANNUAL RECURRING D AND M CDST = \$10000 ANNUAL RATE DF INCREASE FOR A.R.C. = 0.00% NUMBER DF NON-ANNUAL RECURRING D AND M CDSTS = 5 ANNUAL RATE DF INCREASE FOR N.A.R.C. CDSTS = 0.0% NDN-ANNUAL RECURRING D&M CDSTS: # YEAR AMOUNT

1	5	\$20000
2	8	\$10000
3	12	\$20000
4	16	\$10000
5	18	\$15000

```
ENERGY COST DATA:
NUMBER OF ENERGY TYPES = 2
ENERGY TYPE NO. 1 = ELECTRICITY
AVG ANNUAL CONSUMPTION = 1000.0 MILLION BTU
PRICE PER MILLION BTU =$26.03
ANNUAL DEMAND (AND/OR OTHER CHARGE) =
                                         $0
ESCALATION RATE METHOD = 2
 YEAR RATE
                 YEAR
                         RATE
                 1995
  1985
        0.96%
                         1.31%
       3.35%
4.35%
 1986
                 1996
                         1.33%
  1987
                 1997
                         1.31%
  1988 -2.09%
                 1998
                         1.33%
  1989
       -0.22%
                 1999
                         1.31%
  1990
       -0.37%
                  2000
                         0.84%
  1991
       -0.15%
                  2001
                         0.83%
  1992
        2.18%
                  2002
                         0.83%
  1993
       -1.29%
                  2003
                         0.85%
  1994
        0.00%
                 2004
                         0.81%
ENERGY TYPE NO. 2 = DISTILLATE OIL
AVG ANNUAL CONSUMPTION =
                           1000.0 MILLION BTU
FRICE PER MILLION BTU = $6.85
ANNUAL DEMAND (AND/OR OTHER CHARGE) =
                                          $0
ESCALATION RATE METHOD = 2
  YEAR
       RATE
                 YEAR
                         RATE
                 1995
  1985
       -2.27%
                         3.92%
  1986
        0.31%
                 1996
                         3.98%
 1987
                 1997
                         3.93%
        3.24%
  1988
        3.29%
                 1998
                         3.98%
        3.47%
  1989
                 1999
                         3.92%
  1990
        5.59%
                  2000
                         3.23%
  1991
         5.43%
                         3.22%
                  2001
  1992
        5.03%
                  2002
                         3.29%
  1993
        4.90%
                  2003
                         3.18%
  1994
        4.68%
                 2004
                         3.24%
```

This file name can be the same as the name used for the building characteristics file used in calculating the life-cycle cost, or it can be different. A ".LCC" suffix is automatically added to this LCC output file name. (If you make several runs for the same project with different discount rates, you might want to use different names for the LCC output file.) The LCC output file is the basis of the comprehensive LCC report printed out later using PRINTLCC and the comparative economic analysis made by COMPARE. As with building characteristics files, it is wise to keep a log of all the LCC output files created by LCCMAIN.

After the LCC computations have been completed and the LCC output file saved, a menu is displayed which allows the user to perform another LCC analysis using a different building characteristics file or to move to another subprogram operation.

4.4 <u>PRINTLCC</u> - This subprogram prints out a detailed life-cycle cost report for a designated building, using the LCC output file for that building created by LCCMAIN. Table 4 shows an example of this report. When running PRINTLCC, the user must enter the name of the LCC output file when asked (without the ".LCC" suffix):

ENTER NAME OF LCC OUTPUT FILE TO BE PRINTED?

WHICH DISK TO FIND filename (A, B, C)?

After the report is printed, a menu is displayed which allows the user to print a life-cycle cost report for another building or move to another subprogram operation.

Table 4. Detailed LCC Report for Building A (Example)

This example represents the base-case LCC analysis for a Federal office building for which an energy-conserving alternative is to be evaluated.

PART I - INITIAL ASSUMPTIONS AND COST DATA

PROJECT NAME: BUILDING A RUN DATE:03-05-1986 01:28:43 BLDG. CHAR. FILE NAME: FED1.BCF, LAST MODIFIED 02-01-1986 01:20:15 LCC DUTPUT FILE NAME: FED1.LCC, CREATED 02-03-1986 13:48:42 LCC ANALYSIS TYPE: NBS HANDBOOK 135 STUDY PERIOD: 20 YEARS (1985 TO 2005) DISCOUNT RATE: 7.0% BUILDING TYPE: COMMERCIAL DOE REGION: 1

INITIAL CAPITAL COMPONENT COSTS (NOT DISCOUNTED)

	INITIAL COST
TOTAL FOR STRUCTURE	\$500,000
TOTAL FOR EQUIPMENT	\$100,000
TOTAL PROJECT COST (ACTUAL)	\$600,000
LESS FEDERAL CONSERVATION CREDIT(a)	\$0
TOTAL ADJUSTED PROJECT COST	\$600,000

ENERGY-RELATED COSTS

ENERGY	MMBTU/	PRICE	DEMAND	UPW*	TOTAL
TYPE	YEAR	(\$/MMBTU)	COST	FACTOR	P.V. COST
ELECTRICITY	1000.0	\$26.03	\$0	11.48	\$29873 8
DISTILLATE	1000.0	\$6.85	\$0	13.82	\$94763

(a) TO REFLECT 10% FIRST COST ADJUSTMENT RULE IN NBS HANDBOOK 135.

PART II - LIFE-CYCLE COST ANALYSIS: DISCOUNT RATE = 7.0%

F	PROJECT NAME: BUILDING A	RUN DATE:	03-05-1986/01:28:43
		PRESENT VALUE (1985 DOLLARS)	ANNUAL VALUE (1985 DOLLARS)
	A. INITIAL INVESTMENT REQUIREMENTS	\$600,000	\$56,636
	B. OPERATING, MAINTENANCE & RELATED COSTS: ANNUALLY RECURRING COSTS (NON-ENERGY) NON-ANNUALLY RECURRING COSTS ENERGY COSTS	\$105,940 \$36,785 \$393,501	\$10,000 \$3,472 \$37,144
	SUBTOTAL	\$536,227	\$50,616
	C. REPLACEMENTS TO CAPITAL COMPONENTS	\$9,061	\$855
	D. LESS: REMAINING VALUE AT END OF STUDY PERIOD	-\$71,065	-\$6,708
	E. TOTAL LIFE-CYCLE PROJECT COST	\$1,074,223	\$101,399
ŀ	* * * * * * * * * * * * * * * * * * * *	* * * * * * * *	* * * * * * * * * *
4.5 <u>COMPARE</u> - This subprogram performs a comparative LCC analysis of two building or system designs (a "base case" and "alternative") once the LCC output files have been created by LCCMAIN for both. An example of such a comparative analysis is shown in Table 5 for a new building design problem. Two alternative building designs are compared in this example to determine which has the lower LCC.

Individual design modifications can also be evaluated at the component level (e.g., storm windows over existing single-pane windows), without performing a comprehensive analysis of the entire building. In this latter type of analysis, the base case can be set up as a "do-nothing" case with zero initial cost, while the alternative case may include the initial cost (and replacement costs, if any) of the modification. In addition, those future cost items related to the component modification (e.g., maintenance and energy costs) must be specified for both cases (i.e., before and after the modification is made). The COMPARE program will then determine whether the design modification is cost effective on a LCC basis. An example of the use of the FBLCC program for the analysis of an individual building component (attic insulation) is provided in Chapter 6.

A comparative analysis requires that the study period, discount rate, and other basic LCC analysis assumptions be the same for both designs. In addition, the alternative building design must have a higher initial cost and lower future costs (e.g., operating, maintenance, or energy costs) than the base case design. (If an alternative design has both a lower initial cost and lower future costs than the base case, no analysis is needed to

Table 5. Comparative LCC Analysis for Buildings A and B (Example)

This example shows the comparison of LCC costs for a base-case and alternative (energy-conserving) Federal office building.

FBLCC: COMPARATIVE LCC ANALYSIS BASE CASE = BUILDING A ALTERNATIVE = BUILDING B PRINCIPAL STUDY PARAMETERS: LCC ANALYSIS TYPE: NBS HANDBOOK 135 BASE YEAR: 1985 STUDY PERIOD: 20 YEARS DISCOUNT RATE: 7.0% FED. CONSERVATION CREDIT: 10% DOE REGION: - 1 BUILDING TYPE: 2 (COMMERCIAL) BASE CASE FILES: FED1.BCF FED1.LCC ALTERNATIVE CASE FILES: FED2.BCF FED2.LCC RUN DATE: 03-05-1986 01:55:50

	COMPARISON	OF PRESENT-VAL	LUE COSTS
	BASE CASE: ALTERNATIVE: BUILDING A BUILDING B		SAVINGS FROM ALT.
	(1)	(2)	(3) = (1) - (2)
INVESTMENT-RELATED COSTS: INITIAL INVEST. (AS OF OCCUPANCY) REPLACEMENTS TO CAPITAL COMPONENT LESS: RESALE VALUE	\$600,000 \$9,061 -\$71,065	\$454,000 \$10,873 -\$78,172	-\$54,000 -\$1,812 \$7,107
SUBTOTAL	\$537,996	\$586,702	-\$48,706
OPERATING AND MAINTENANCE-RELATED COST AN. AND NON-AN. O&M COSTS ENERGY EXPENDITURES	S: \$142,726 \$393,501	\$132,132 \$256,498	\$10,594 \$137,003
SUBTOTAL	\$536,227	\$388,630	\$147,597
TOTAL P.V. LIFE-CYCLE COST	\$1,074,223	\$975,331	\$98,892

COMPUTATION OF NET SAVINGS FOR ALTERNATIVE

NET SAVINGS	=	P.V. LESS	OF ADD	1&0 1 L	1-RELATED	SAVING	S COSTS	\$147,597 -\$48,706
								\$78,872

COMPUTATION OF SAVINGS-TO-INVESTMENT RATIO (SIR) FOR ALTERNATIVE

	P.V. OF O&M-ELATED SAVINGS		\$147597		
SIR =		=		=	3.03
	P.V. OF ADD'L INVESTRELATED COST		\$48706		

show that the alternative design has the lower life-cycle cost.) If the alternative building design has a lower initial cost and higher future costs than the base-case design, COMPARE allows the user to switch the base case and alternative case designators.

In general, a comparative analysis of two alternative building designs requires that they both have the same general purpose and provide approximately the same level of ammenities. The FBLCC program does not compute benefits from building projects which cannot be directly expressed in terms of changes in owning and operating costs (e.g., increased rental revenues). If the level of ammenities is expected to change significantly as the result of a design change (e.g., the use of a passive solar atrium), the non-energy related benefits can be incorporated into the LCC analysis by subtracting them from annually (or non-annually) recurring operating and maintenance costs.

The present-value net savings and savings-to-investment ratio (SIR) are both computed for the alternative building design in the comparative analysis. The SIR for the alternative design is based on its additional investment requirements relative to the base case. When a planning/ construction period is included in the LCC analysis (this is only allowed for a non-energy-related building project) all costs incurred during the planning/construction period and on the date of occupancy are considered to be initial investment costs.

When the comparative analysis is completed, a menu is displayed which allows the user to perform another comparative analysis or to move to any other subprogram operation.

A senstivity analysis of the comparative LCC measures (net savings and savings-to-investment ratio) is strongly encouraged when there is considerable uncertainty about the appropriate values to use in performing the evaluation of Federal building-related projects. For example, uncertainty about the life of the project, the quantity of energy it will save, and/or its future replacement costs may raise doubts about its cost effectiveness. To assess the likely range of possible outcomes, several evaluations of the project can be made, based on alternative values of the parameters in question. In no case, however, should the appropriate discount rate be changed in performing a sensitivity analysis of Federal building-related projects.

4.6 Sequence of FBLCC Subprogram Operations

Usually the FBLCC subprogram sequence is started with the creation of a building characteristics file, since the other subprograms cannot be run until such a file has been created. Thus a "1" is normally entered when the main FBLCC menu is displayed. This loads and starts the LCCDATA subprogram.

After completion of the LCCDATA file creation or modification session, or any other subprogram task, a menu will appear which allows the user to rerun that subprogram or execute another subprogram. If a new subprogram is specified, it is automatically loaded and initiated. If, for any reason, the execution of a subprogram is terminated by a menu command, an

error, or the <Ctrl> <BREAK> command, the same subprogram can be restarted by typing <u>RUN</u>. In some cases, after an error message or a <Ctrl> <BREAK> command, a subprogram can be continued rather than restarted by typing <u>CONT</u> <ENTER> (or pressing function key <F5>). Any subprogram can be started at the "OK" or "READY" prompt by typing <u>RUN "NAME"</u>, where where NAME is the name (not the number) of the subprogram to be executed. (Quotation marks must be entered as shown.)

The flow chart in Figure 1 gives the user an overview of the typical sequence of operations for the five major LCC subprograms. However, this sequence is not entirely mandatory. For example, printing the building characteristics file with PRINTBCF does not need to be done before computing the LCC with LCCMAIN. Similarly, once the LCC analyses have been completed for two design alternatives, the comparative analysis can be made using COMPARE without printing the detailed LCC report using PRINTLCC. If a comparison of two design alternatives is required, it is usually faster to run LCCDATA, PRINTBCF, LCCMAIN, and PRINTLCC for both the base and alternative cases before moving on to the next subprogram in the sequence, as shown in Figure 2. This saves subprogram loading time for the second set of calculations.

4.7 File Storage

The building characteristics files and LCC output files created and saved during a FBLCC session can be stored on either the FBLCC disk itself or on a second formatted disk in another disk drive. In general it is better to save these files on a second disk because the FBLCC disk has limited additional storage capacity and therefore may fill up. If the disk fills







up in the process of saving a file, this can cause an error which will terminate the run. The disk drive designator is always requested when reading from or writing to a disk file.

4.8 Backup Copies of Files

After completing the FBLCC analyses, you may want to make backup copies of any building characteristics files or LCC files that were created during that session. You can use your computer's "COPY" utility to copy these files to a formatted disk kept for this purpose, or the "DISKCOPY" utility to make a copy of the entire contents of the disk containing these files. Most microcomputers require that you return to the "SYSTEM" mode before you copy or backup the contents of a disk.

5. FBLCC DATA REQUIREMENTS

All of the data required to perform a LCC analysis for a particular project are contained in the building characteristics file assigned to that project. The LCCDATA subprogram is used to set up or modify a building characteristics file. LCCDATA uses the video display to prompt the user for data entries from the keyboard. Note that all costs are entered in base-year dollars (i.e., today's costs) and that all price escalation rates are entered in real terms (i.e., net of general inflation.)¹

A generalized worksheet that can be used to collect and organize the data necessary for the creation of a building characteristics file is shown in Table 6. This worksheet can be printed out by running the utility program called "BCFFORM". BCFFORM is not an integral FBLCC subprogram; it should be run separately from the FBLCC analysis session. To run BCFFORM in BASIC, type <u>RUN "BCFFORM"</u>. Each of the variables listed in this file format is defined below. The user should be familiar with these definitions, and be prepared with the data needed to set up a building characteristics file, before running the LCCDATA subprogram.

E = (1 + E)/(1 + GI) - 1

where E' is the escalation rate in real terms (decimal equivalent), E is the escalation rate in nominal terms (decimal equivalent), and GI is the rate of general inflation (decimal equivalent).

Thus, for example, if E = 10% and GI = 6%, E' = 1.1/1.06 - 1 = 0.0377, or 3.77%.

¹To adjust a price escalation rate in nominal terms (i.e., including general inflation) to real terms (i.e., net of general inflation), use the following formula:

Table 6. Generalized Format for Building Characteristics File

GENERALIZED FORMAT FOR BUILDING CHARACTERISTICS FILE

SECTION 1. PROJECT TITLE:

SECTION 2. BASIC LCC ANALYSIS ASSUMPTIONS:

STUDY PERIOD (YRS)												
OCCUPANCY YEAR												
LCC ANALYSIS TYPE												
DOE REGION						•				•		
BUILDING TYPE CODE	•	•	•	-	•	•	•	•		•	•	

SECTION 3. CAPITAL COMPONENT AND REPLACEMENT COST DATA:

NO. OF CAPITAL COMPONENTS:

COMPONENT NO.	1	2	3	
COMPONENT NAME				
*INITIAL CONCER -RELATED COCT				
FYDERTED COMP LIFE (VDC)	•••••	• • • • • • • • • • • •		
EXPELIED LUMP. LIFE (TRS)				
+AVG. PRILE ESL. DURING P/L		• • • • • • • • • • •	*******	
+AVG. PRICE ESC. DURING UCC.		• • • • • • • • • • •	• • • • • • • • • • •	
RESALE VALUE FACTUR (%)			•••••	
NUMBER OF REPLACEMENTS	• • • • • • • • • • •	• • • • • • • • • • •	• • • • • • • • • • •	
+COST-PHASING SCHEDULE BY YEA	R OF PLANNING	/CONSTRUCTION	PERIOD AND A	T OCCUPANCY
PLANNING/CONSTRUCTION YEAR 1	%	%	%	
PLANNING/CONSTRUCTION YEAR 2	%	%	%	
PLANNING/CONSTRUCTION YEAR 3	%	%	%	
PLANNING/CONSTRUCTION YEAR 4	7.		%	
PLANNING/CONSTRUCTION YEAR 5		%	%	
AT OCCUPANCY				
COMPONENT NO.	4	5	6	
COMPONENT NAME				
AINITIAL CONCEP -PELATED COST				
EXPECTED COMP LIFE (VPC)				
EXPECTED COMP. LIFE (TRS)				
+AVG. PRILE ESL. DURING F/L				
+AVG. PRILE ESL. DURING ULL.				
RESALE VALUE FALTUR (%)		• • • • • • • • • • •	• • • • • • • • • • •	
NUMBER OF REPLACEMENIS		• • • • • • • • • • •		
+COST-PHASING SCHEDULE BY YEA	R OF PLANNING	CONSTRUCTION	PERIOD AND A	T OCCUPANCY
PLANNING/CONSTRUCTION YEAR 1		%	%	
PLANNING/CONSTRUCTION YEAR 2	%	%	%	
PLANNING/CONSTRUCTION YEAR 3		%	%	
PLANNING/CONSTRUCTION YEAR 4		%		
PLANNING/CONSTRUCTION YEAR 5	%			
AT OCCUPANCY	%	%	%	
* USED UNLY FOR ENERGY RELATE.	D PROJECTS (L	CC ANALYSIS T	(PE 1)	

+ USED ONLY FOR NON-ENERGY RELATED PROJECTS (LCC ANALYSIS TYPE 2)

REPLACEMENTS TO CAPITAL COMPONENTS:

		COMPONENT NO.	. 1	
	1	2	3	4
YEAR OF REPLACEMENT				
INIT. COST OF REPLACEMENT (UNADJ))		********	
EXPECTED REPLACEMENT LIFE (YRS)				
RESALE VALUE (% OF INT COST)	• • • • • • • • • • •			

		COMPONENT NO.	. 2	
	1	2	3	4
YEAR OF REPLACEMENT				
INIT. COST OF REPLACEMENT (UNADJ)			
EXPECTED REPLACEMENT LIFE (YRS)				
RESALE VALUE (% OF INT COST)			• • • • • • • • • •	

	1	COMPONENT NU.		
	1	2	3	4
YEAR OF REPLACEMENT				
INIT. COST OF REPLACEMENT (UNADJ)				
EXPECTED REPLACEMENT LIFE (YRS)				
RESALE VALUE (% OF INT COST)				

		COMPONENT NO.	. 4	
	1	2	3	4
YEAR OF REPLACEMENT				
INIT. COST OF REPLACEMENT (UNADJ)				
EXPECTED REPLACEMENT LIFE (YRS)				
RESALE VALUE (% OF INT COST)				

	1	COMPONENT NO.	5	
	1	2	3	4
YEAR OF REPLACEMENT				
INIT. COST OF REPLACEMENT (UNADJ)				• • • • • • • • • • •
EXPECTED REPLACEMENT LIFE (YRS)				
RESALE VALUE (% OF INT COST)	• • • • • • • • • • •			

		COMPONENT NO	, 6	
	1	2	3	4
YEAR OF REPLACEMENT				
INIT. COST OF REPLACEMENT (UNADJ))			
EXPECTED REPLACEMENT LIFE (YRS)				
RESALE VALUE (% OF INT COST)				

Table 6. Generalized Format for Building Characteristics File (continued)

SECTION 4. OPERATING AND MAINTENANCE COST DATA:

ANNUAL RECURRING COST (BASE-YEAR \$'S)	
+AVG. AN. RATE OF INCREASE, ARC	
NO. OF NON-AN RECURRING COSTS (NARC'S)	
+AVG. AN. RATE OF INCREASE, NARC'S	

NON-ANNUALLY RECURRING COSTS (BASE-YEAR DOLLARS) (NOTE: YEARS BEGIN WITH DCCUPANCY; E.G.,1,2,...,50)

ND. Y	EAR	AMOUNT	ND. YEAR	AMOUNT	ND. YEAR	AMOUNT	NO. YEAR	AMOUNT
1			14		27		40	
2			15		28		41	
3			16		29		42	
4			17		30		43	
5			18		31		44	
6			19		32		45	
7			20		33		46	
8			21		34		47	
9			22		35		48	
10			23		36		49	
11			24		37		50	
12			25		38			
13	• • • •		26	• • • • • •	39			

SECTION 5. ENERGY COST DATA:

NUMBER OF ENERGY TYPES

	ÉNÉRGY TYPE			
	1	2	3	
ENERGY TYPE CODE				
ANNUAL CONSUMP. (MIL. BTU)				
**PRICE PER MILLION BTU	\$	\$	\$	
DEMAND (OR OTHER) CHARGE **AVG. AN. RATE OF INCREASE	\$	\$	\$	
DURING PLAN/CONSTRUCTION	%	%	7.	
+PRICE ESCALATION METHOD	••••			

+**PRICE INCREASES DURING OCCUPANCY (NET OF GENERAL INFLATION): NO. OF DISCRETE TIME INTERVALS

ND.	DUR. (YRS)	AN. RATE	NO.	DUR. (YRS)	AN. RATE	NO	DUR. (YRS)	AN. RATE
1		%	1			1		%
2		%	2		%	2		%
3		%	3		%	3		%
4		%	4		%	4		%
5		%	5		%	5		%
6		%	6		%	6		%
7		%	7		%	7		%
8		%	8		%	8		%
9		%	9		%	9		%
0		%	10		%	10		%
	1 2 3 4 5 6 7 8 9 0	ND. DUR. (YRS) 1 2 3 4 5 6 7 8 9 0	NO. DUR. AN. (YRS) RATE 1	ND. DUR. AN. ND. (YRS) RATE	ND. DUR. AN. ND. DUR. (YRS) RATE (YRS) 1	ND. DUR. AN. ND. DUR. AN. (YRS) RATE (YRS) RATE 1	NO. DUR. AN. NO. DUR. AN. NO. (YRS) RATE (YRS) RATE (YRS) RATE 1 1 % 1 % 2 % 2 3 % 3 % 3 3 3 4 % 4 % 4 5 5 6 % 5 % 5 6 6 6 7 % 8 % 8 8 7	ND. DUR. AN. ND. DUR. AN. (YRS) 1

+ USED ONLY FOR NON-ENERGY RELATED PROJECTS (LCC ANALYSIS TYPE 2) *NEEDED ONLY WHEN DEFAULTING TO DOE ENERGY PRICE PROJECTIONS ON DISK **NOT NEEDED WHEN DEFAULTING TO DOE ENERGY PRICE PROJECTIONS The following definitions of LCC-related variables are presented in the order in which they appear in the building characteristics file:

Section 1 - Project Title

o Project title - The user can supply any name desired to identify the project to be evaluated. Up to 12 characters can be used. A distinct project title should be assigned to each variation in building or subsystem design to be evaluated.

Section 2 - Basic LCC Analysis Assumptions

- Study Period The number of years over which project costs will be summed. For analyses based on Handbook 135, the study period is limited to 25 years, and begins with the current year. For other analyses, study periods of up to 50 years can be evaluated, including a planning/ construction period of up to 10 years. In both cases, all costs are discounted back to the current year.
- o Occupancy Year The calendar year in which occupancy is expected to begin. Operating and maintenance costs, including energy costs, are not assumed to be incurred until occupancy begins. For LCC analyses based on Handbook 135, occupancy is assumed to begin at the start of the study period. For non-energy-related projects, the occupancy year can be specified in a later year (up to 10 years after the base year). The years prior to occupancy are referred to as the planning/construction period.
- Analysis Type: Choose either of the following LCC evaluation methods for Federal buildings:

1 - LCC evaluation of energy conservation or renewable energy projects based on NBS Handbook 135 (see Table 1), or

2 - LCC evaluation of non-energy-related projects consistent with the provisions of OMB Circular A-94 (see Table 2).

- o DoE Region This is the Doe Region in which the project is located. The following codes are used to enter the region:
 - 1 DoE Region 1 (ME, NH, MA, VT, CT, RI)
 2 DoE Region 2 (NY, NJ, PR, VI)
 3 DoE Region 3 (PA, MD, WV, VA, DC, DE)
 4 DoE Region 4 (KY, TN, NC, SC, MS, AL, GA, FL, CZ)
 5 DoE Region 5 (MN, WI, MI, IL, IN, OH)
 6 DoE Region 6 (TX, NM, OK, AR, LA)
 7 DoE Region 7 (KS, MO, IA, NE)
 8 DoE Region 8 (MT, ND, SD, WY, UT, CO)
 9 DoE Region 9 (CA, NV, AZ, Trust Ter. of the Pacific Islands, Guam)
 10 DoE Region 10 (WA, OR, ID, AK)
- o Building Type Code The building type is used in the LCCDATA program when accessing the DoE energy price projections from the ENCOSTFL file on the FBLCC disk. This building type designation refers to the appropriate energy rate schedule for the building, rather than to the actual building purpose. Use one of the following codes to enter the building type:
 - 1 Residential
 - 2 Commercial
 - 3 Industrial

Section 3 - Capital Component and Replacement Cost Data

 Number of Capital Components - The project can be divided into as many as six major capital components (e.g., land, structure, and equipment). For each component, the variables described in this section must be specified separately. Major components with different expected lives are usually specified separately. If one component is of particular interest--for example, the roof construction--this component can be also specified separately. A capital component which has a shorter life than the study period and must therefore be replaced should be set up as a separate component. Replacements to capital components are discussed below.

The following variables are to be specified for each capital component where appropriate:

- o Component Name Use a descriptive term with maximum of 10 characters.
- Initial Component Cost The total installed cost of the component, in constant base-year dollars. For energy-related projects, this cost is assumed to be incurred as a lump sum at the beginning of the study period. For non-energy related projects, this cost can be phased in over the planning/construction period. If a planning/construction period of one year or more is assumed, the Average Price Escalation Rate During Planning/ Construction Period (below) can be used to adjust component costs incurred in each year of construction and at occupancy to reflect price changes net of general inflation, if any.
- Initial Conservation-Related Cost The dollar amount (part or all) of the initial cost of this component subject to the 10% adjustment factor for conservation-related projects. (LCC analyses of energy-conservation and renewable energy projects only.)
- o Cost Phasing Schedule (for each year of the planning/construction period and at occupancy, %) - Applies to non-energy-related projects only: If a planning/construction period prior to the occupancy year is assumed, a schedule to phase in component acquisition costs must be entered. For each year of the planning/construction period, specify the percent of the initial component cost (in constant base-year dollars) that is incurred in that year (the incremental amount only). All costs phased in during any planning/ construction year are assumed to be incurred at the beginning of that year. Any costs not phased in during the planning/construction period are automatically assigned to the first day of the occupancy period.

- Expected Component Life The useful life of the component (in years) anticipated by the Federal agency making the analysis. (This is intended to be a realistic assessment of the component life.) Use an integer between 2 and 100; use 999 for land. (Code 999 locks out the capital replacement algorithm.)
- o Average Price Escalation Rate During Planning/Construction Period (%) -Applies to non-energy-related projects only: This is the average annual rate at which the cost of this component is expected to change (net of general inflation) during the planning/construction period, if any. No adjustment is made to component costs phased in during the first year of construction since component costs are assumed to be incurred on the first day of the assigned year. All component costs phased in after the first year of the planning/construction period are adjusted using this rate. If component costs are expected to increase at the same rate as general inflation during the planning/construction period, this entry will be bypassed. If component costs are expected to increase approximately 2% faster than general inflation over this same period, enter a 2.
- o Average Price Escalation Rate During Occupancy (%) Applies to non-energyrelated projects only: This is the average annual rate at which the cost of similar building components is expected to change during the occupancy period (net of general inflation). 'his variable is used in calculating future replacement costs, and in establishing the resale value of the component after adjustments for wear, deterioration, or obsolescence. (See Resale Value Factor below.) If these costs are expected to increase at approximately the same rate as general price ir flation, this entry will be bypassed.

- o Resale Value Factor (percent of initial component cost) This is the percent of the initial component cost which remains at the end of the study period (or at the end of the component life, if this comes first), in constant base-year dollars. This factor is intended to reflect a decrease in real value due to wear, deterioration, or obsolescence. The resale value is treated as a negative cost element in the life-cycle cost equation. Even if the Federal government does not intend to dispose of the property at the end of the study period, the "resale value" may be used to reflect residual value from the project. For non-energy-related projects, FBLCC uses the Average Price Escalation Rate During Planning/Occupancy Period for a component to adjust the resale value of that component for any changes in price levels (net of general inflation) during the occupancy period.
- o Number of Replacements Replacements for a capital component should only be specified if the actual life of the component is shorter than the study period and the component is entirely replaced. It is best to include the cost of a partial replacement in the non-annually-recurring cost schedule (see below). A maximum of four capital replacements can be specified for each component.

For each replacement to a component the following variables must be specified:

- o Year of Replacement The year of occupancy in which the replacement is made, counting from the start of occupancy. Use an integer between 2 and last year of study period. Replacements are assumed to be made on the last day of the year of replacement.
- Initial Cost of Replacement The installed cost of the replacement, in constant base-year dollars. For non-energy-related projects, the

replacement cost will be calculated using the Average Price Escalation Rate during Planning/Construction Period and the Average Price Escalation Rate during Occupancy specified for the original component, if these are different than zero.

- o Expected Life of Replacement (years) The useful life of the replacement anticipated by the investor. Use integer between 2 and 100.
- o Resale Value Factor (percent of initial replacement cost) This is the percent of the initial replacement cost remaining at the end of the study period (or at the end of the replacement life if this comes first), in constant base-year dollars.

Section 4 - Operating and Maintenance Cost Data (other than Energy Costs)

- o There are two types of operating and maintenance costs (including repairs) treated in the FBLCC program: annually recurring costs (ARC's) and non-annually recurring costs (NARC's). The ARC and all NARC's are incurred during occupancy years only, and are assumed to be paid at the end of each year in which they occur. The values for the ARC and all NARC's are to be specified in constant base-year dollars.
- Annually Recurring Costs (ARC) The ARC includes all O&M-related costs (except energy costs) which recur in approximately the same amount every year. In the case of non-energy-related projects, the ARC may increase from year to year at a constant rate (see next definition).
- o Average Annual Rate of Increase, ARC (%) Applies to non-energy-related projects only. This is the average annual rate at which the ARC is assumed to increase over the enttre study period (net of general inflation).
- o Non-Annually Recurring Costs. The non-annually recurring costs (NARC's) do not follow a regular pattern. They must be specified individually for each

occurrence. (More than one occurrence per year is permitted.) The following variables must be specified:

- o Number of NARC's to be entered. (Integer between 0 and 50), and
- o Average Annual Rate of Increase, NARC's (%) Applies to non-energy-related projects only. See "Average Annual Rate of Increase, ARC". This one rate applies to all NARC's.

For each NARC, the following two variables must be entered together, separated by a comma:

- Year of Occurrence. Year designation begins with the occupany year, year 1. (Integer between 1 and 50.)
- o Non-Annually Recurring Costs. Amount, in constant base-year dollars.

Section 5 - Energy cost data

Annual energy costs are treated like non-energy annually recurring costs except that up to three different energy types may be specified in each analysis, and the rate of price change does not have to be constant over the entire study period. Annual consumption of each energy type is assumed to be the same in every year during occupancy. (Energy costs are not calculated during the planning/construction period, if any.) Annual energy costs consist of direct energy costs (i.e., those costs computed directly from annual energy consumption in million Btu) and indirect costs (e.g., demand-related or other energy costs that cannot be computed directly from the amount of annual energy consumption in Btu).

Base year energy prices, in dollars per million Btu, can be entered by the user for each energy type, based on local energy prices at the building site. Alternatively, DoE average energy prices for the DoE region and

building type specified can be automatically accessed from the energy price data file (ENCOSTFL) stored on the FBLCC disk. However, the former method is preferred. The indirect annual energy cost, if any, for each energy type must be entered directly by the user. All energy prices and indirect energy costs must be in constant base-year dollars.

The DoE energy price projections on the FBLCC disk may be in a different year's dollars than that needed for the LCC analysis. In such case, the program will automatically ask the user for the appropriate conversion factor (e.g., the cumulative amount of general inflation from the middle of the year in which the DoE prices are denominated to the current date.)

For energy-related projects in Federal buildings, DoE energy price escalation rates (net of general inflation) for each year of the study period are automatically accessed from the disk for each energy type (based on the region and building type) and entered into the building characteristics file. For Federal projects not directly related to energy conservation or renewable energy resources, but containing an energy use component, the DoE energy price escalation rates can be used, or price escalation rates for each energy type from an alternative source can be entered directly by the user for discrete time intervals over the occupancy period. In this latter case, the average escalation rate for each energy type over the planning/construction period (if any) must also be entered.

Energy-related variables are entered as follows: Number of Energy Types - This is the number of specific energy types used in the building or affected by the project. (Integer between 0 and 3.)

For each energy type, specify the following variables:

- o Energy Type Code The type of energy is designated by the following codes:
 - 1 Electricity
 2 Distillate Fuel Oil
 3 Residual Fuel Oil
 4 Natural Gas
 5 Liquified Petroleum Gas (LPG)
 6 Coal (Steam Coal)
- o Annual Energy Consumption (million Btu/yr) This represents the average annual energy consumption related to this project in each of the occupancy years. The DoE price estimates are based on the following conversion factors:¹

1 kWh = 0.003412 million Btu or 1 million Btu = 293.1 kWh.

- 1 gallon of distillate = 0.13869 million Btu or 1 million Btu =
 7.21 gallons of distillate
- 1 gallon of residual = 0.14969 million Btu or 1 million Btu =
 6.68 gallons of residual
- 1 therm of natural gas = 0.10 million Btu or 1 million Btu =
 10 therms of natural gas
- 1 gallon LPG = 0.0955 million Btu or 1 million Btu = 10.471 gallons of LPG
- 1 ton steam coal = 0.0225 million Btu or 1 million Btu = 44.44 tons
 of steam coal
- o Energy price (\$/million Btu) The price per million Btu to be used in calculating direct energy costs for the project. This price should be entered in constant base-year dollars. The base-year DoE energy price for the appropriate energy type, building type, and DoE region will be automatically entered here if the user so specifies. (Pressing <ENTER> at this point defaults to the DoE energy price.)

¹Source: NBS Handbook 135, p. 134.

- o Annual Demand (or other) Energy Charge (\$/yr) Annual costs related to energy consumption not directly accounted for in the energy prices used to compute direct energy costs. Example: Charges for peak kilowatt-hour demand, summed over the entire year. This cost should be entered in constant base-year dollars. This cost is assumed to increase annually at the same escalation rate specified for the energy price.
- o Energy Price Escalation Methods For energy conservation and renewable energy projects, escalation rates are automatically entered from the DoE energy price data base, but the rate in any year during the study period can be changed by the user if the user has a documented basis for such a change (e.g., a short-term forecast from the local utility). For projects not directly related to energy conservation of renewable energy resources, the following two methods are available to input energy price escalation rates:
 - 1 Escalation rates are entered by the user.
 - 2 Escalation rates are automatically retrieved from the DoE energy price data base on the FBLCC disk.

Regardless of the method used to input energy price escalation rates, the same method and rates must be used for any given energy type in both the base case and alternative case in order to run a comparative analysis.

If escalation rates are to be entered by the user, the following variables must be specified:

o Number of Discrete Time Intervals - This is the number of discrete energy price escalation rates that are to be specified over the occupancy period. (Integer between 1 and 50.) See Duration and Annual Rate of Energy Price Increase below.

For each discrete time interval, specify the following two variables, separated by a comma:

- o Duration (years) The number of years over which a given energy price escalation rate remains constant (occupancy period only). Note: For each energy type, the sum of these intervals must equal or exceed the occupancy period.
- o Energy Price Escalation Rate (%) This is the average annual rate of price increase of this energy type during the corresponding time interval. These rates must be entered in real terms, i.e., net of general inflation.

In addition, if a planning/construction period is used in the analysis, the following variable must be specified by the user for each energy type: o Energy Price Escalation Rate During Planning/Construction Period (%) - The average rate at which the price of this energy type is expected to change over the planning/construction period, relative to general inflation. (Only needed when the user is entering escalation rates for the study period.)

For example, energy price escalation rates for an occupancy period of 25 years might be entered as follows: Number of Discrete Time Intervals: 3 Duration, Rate:

- 10,2
- 10,1
- 5,0

In this example, for the first 10 years the price of the designated energy type is expected to increase at 2 percent per year above general inflation, for the next 10 years at 1 percent above inflation, and for the last 5 years at the same rate as general inflation.

6.1 FBLCC Report Types

A report of a life-cycle cost analysis of a building or building system should specify both the major elements of the LCC computations and the key assumptions used in the analysis. A report of a comparative LCC analysis of alternative building designs or systems should provide key measures of their relative economic performance. Three different LCC-related reports can be printed at various stages of the FBLCC analysis to satisfy these requirements: (1) a building characteristics file, (2) a detailed LCC analysis report, and (3) a comparative LCC analysis for two design alternatives. Users should refer to NBS Handbook 135 for assistance in interpreting the measures of economic performance which are provided by FBLCC.

(1) The <u>building characteristics file</u> is printed by subprogram PRINTBCF. This file provides a comprehensive listing of all the data and assumptions used by the LCCMAIN subprogram in the analysis of a given building. It is divided into five sections:

- 1. Project title
- 2. Basic LCC assumptions
- 3. Capital component and replacement cost data
- 4. Operating and maintenance cost data

5. Energy cost data

An example of a building characteristics file for use as a base case in evaluating alternative energy-conserving designs for a Federal office building is shown in Table 3.

(2) The <u>detailed LCC analysis</u> report is printed by the PRINTLCC subprogram, based on the LCC output file created and saved on the disk by LCCMAIN. An example of this report for the base-case Federal office building design is shown in Table 4. This report is divided into two parts: Part I lists the key assumptions used in the LCC computations; the initial capital component costs (before discounting), their time phasing during the construction period, if any; and a detailed analysis of the energy costs. Part II shows the major elements of the LCC computations and the total LCC.

The LCC elements are presented both in present value terms as of the base date specified in the analysis, and in annual value terms. The annual value is a uniform annual amount which is equivalent to the corresponding present-value amount when taking into account the discount rate throughout the study period. This means that the present value of that uniform annual amount over the entire study period is equal to the corresponding present value amount.

The major elements of the LCC computations are divided into four sections.

- A. Initial Investment Requirements
- B. Operating, Maintenance, and Related Costs
- C. Replacements to Capital Components
- D. Remaining Value at End of Study Period (Salvage Value)

(3) The <u>comparative LCC analysis</u> report for two alternative building designs is computed and printed by the COMPARE subprogram, based on their LCC output files. An example of this comparative analysis for a hypothetical base case and energy conserving alternative office building design is shown in Table 5. The

comparative LCC analysis report lists the major elements of the LCC computations for two buildings or building systems: a base case design (Building A) with a lower initial cost and higher operating-related costs, and an alternative design (Building B) with a higher initial cost and lower operating-related costs. The difference between the cost of the alternative and base cases is reported for each major element of the LCC as the savings attributable to the alternative. Also included are the present-value LCC cost of each design, the present value net savings (or, if negative, the present-value net losses) attributable to the alternative design, and the savings-to-investment ratio (SIR) for the additional investment required by the alternative design.

6.2 Further Examples of FBLCC Reports

Tables 3, 4, and 5 in chapter 4 of this User's Guide provide examples of the three FBLCC reports needed for a comprehensive economic analysis of a Federal energy conservation project. Additional examples are provided here for (1) the LCC analysis of a non-energy-related Federal building project, and (2) for the LCC analysis of an energy conservation project at the subsystem level rather for the entire building. These examples are hypothetical and are only presented to demonstrate the use of the FBLCC program.

Example of Non-Energy-Related Federal Building Project

Table 7 shows the building characteristics file for the same hypothetical Federal office building described in table 3. This is the base-case design to be used in the evaluation of an alternative building design with higher initial costs but reduced operating and maintenance (O&M) costs over the occupancy period. In this example a two year planning/construction period is

added¹ and the study period has been extended by two years so that the occupancy period is the same in both cases (20 years). A cost-phasing schedule is shown in Table 7 for each of the three components; this costphasing schedule includes the two years of the planning/construction period plus the first day of occupancy. All of the land acquisition costs are incurred in the first year; half the structure costs are incurred in the first year and half in the second; and half the equipment costs are incurred in the second year and half at occupancy. This schedule is defined by the user when creating/modifying the building characteristics file with LCCDATA. Costs are phased in incrementally using this schedule, and are always assumed to be incurred at the beginning of each year. All costs entries in Table 7 are the same as in Table 3 since costs must be entered in constant dollars as of the beginning of the study period (1985 in both cases). However, for the purpose of illustration, the component and replacement costs and the the O&M-related costs in this new example are assumed to increase at an annual rate of one percent above general price inflation. Also for the purpose of illustration, energy price escalation rates in this example are entered by the user from a (hypothetical) non-DoE source, using the method based on discrete time intervals. (See Energy Price Escalation Methods on page 44.)

Table 8 shows the LCC analysis for the building described in Table 7. This analysis is similar to that in Table 4, except that the initial component costs are now phased in over the two year construction period, and the 10 percent

¹The use of a planning/construction period here is for demonstration purposes only. This is not required in the analysis of non-energy-related Federal projects, but allows for a more rigorous analysis of buildings that are still in the early planning or construction phase.

Table 7. Building Characteristics File for Base Case Federal Office Building to be Used in Economic Evaluation of Alternative Design with Reduced O&M Costs

BUILDING CHARACTERISTICS FILE

FILE NAME: FED3(.BCF) FILE LAST MODIFIED ON 02-03-1986 16:26:21

PROJECT TITLE: BUILDING A

BASIC LCC ANALYSIS ASSUMPTIONS:

ANALYSIS TYPE: OMB CIRCULAR A-94 BASE DATE FOR LCC ANALYSIS: 1985 STUDY PERIOD: 22 YEARS OCCUPANCY DATE: 1987 DISCOUNT RATE (REAL) = 10.00% BUILDING TYPE = 2 COMMERCIAL DOE REGION = 1

CAPITAL COMPONENT AND REPLACEMENT COST DATA:

NUMBER OF CAPITAL COMPONENTS: 2		
CAPITAL COMPONENT DATA:		
COMPONENT NAME	STRUCTURE	EQUIPMENT
INITIAL COMPONENT COST	500000	100000
EXPECTED COMPONENT LIFE(YRS)	50	20
AVG PRICE ESC RT DURING CONST.	1.00%	1.00%
AVG PRICE ESC RT DURING OCC.	1.00%	1.00%
RESALE VALUE FACTOR	50.00%	25.00%
NUMBER OF REPLACEMENTS	0	1

 COST-PHASING SCHEDULE BY YEAR OF CONSTRUCTION AND AT OCCUPANCY:

 1
 40.00%
 0.00%

 2
 40.00%
 50.00%

AT	OCCUPANCY	20.00%	50.00%

REPLACEMENTS TO CAPITAL COMPONENTS:

REPLACEMENTS TO EQUIPMENT:REPLACEMENT NUMBER1YEAR OF REPLACEMENT15COST OF REPLACEMENT25000EXPECTED REPL. LIFE (YRS)15RESALE VALUE FACTOR0.00%

OPERATING AND MAINTENANCE COST DATA:

ANNUAL RECURRING D AND M CDST = \$10000 ANNUAL RATE DF INCREASE FOR A.R.C. = 1.00% NUMBER DF NON-ANNUAL RECURRING D AND M CDSTS = 5 ANNUAL RATE DF INCREASE FOR N.A.R.C. CDSTS = 1.0% NDN-ANNUAL RECURRING D&M CDSTS: # VEAR AMOUNT

#	YEAR	AMUUNI
1	5	\$20000
2	8	\$10000
3	12	\$20000
-4	16	\$10000
5	18	\$15000

Table 7. Building Characteristics File for Base Case Federal Office Building to be Used in Economic Evaluation of Alternative Design with Reduced O&M Costs (Continued)

ENERGY COST DATA: NUMBER OF ENERGY TYPES = 2 ENERGY TYPE NO. 1 = ELECTRICITY AVG ANNUAL CONSUMPTION = 1000.0 MILLION BTU PRICE PER MILLION BTU =\$26.03 ANNUAL DEMAND (AND/OR OTHER CHARGE) = \$0 ESCALATION RATE METHOD = 1 ANNUAL RATE OF PRICE INCREASE DURING CONSTRUCTION = 1.0% PRICE INCREASES DURING OCCUPANCY: NUMBER OF DISCRETE TIME INTERVALS = 3 # DURATION ANNUAL (YEARS) RATE 10 1 2.0% 2 5 1.0% 3 5 0.0% ENERGY TYPE NO. 2 = DISTILLATE OIL AVG ANNUAL CONSUMPTION = 1000.0 MILLION BTU PRICE PER MILLION BTU = \$6.85 ANNUAL DEMAND (AND/OR OTHER CHARGE) = \$0 ESCALATION RATE METHOD = 1 ANNUAL RATE OF PRICE INCREASE DURING CONSTRUCTION = 2.0% PRICE INCREASES DURING OCCUPANCY: NUMBER OF DISCRETE TIME INTERVALS = 3 # DURATION ANNUAL (YEARS) RATE 1 10 4.0% 2 5 3.0% 3 5 2.0%

Table 8. Detailed LCC Analysis of Base Case Federal Office Building to be Used in Economic Evaluation of Alternative Design with Reduced O&M Costs

* * * * * * * * * * * * * * * * * * *	* * * * * * * * C C A N A L * * * * * * *	* * * * * * * * * * * *	* * * * * * * * * * *
PART I - INIT	IAL ASSUMPTIO	NS AND COST DATA	
PROJECT NAME: BUILDING RUN DATE:03-05-1986 01: BLDG. CHAR. FILE NAME: LCC OUTPUT FILE NAME: LCC ANALYSIS TYPE: OMB STUDY PERIOD: 22 CONSTRUCTION PERIOD: 20 DISCOUNT RATE: 10.0% BUILDING TYPE: COMMERCID DOE REGION: 1	6 A 5 A 5 FED3.BCF, LAS FED3.LCC, CRE CIRCULAR A-94 YEARS (1985 T(YEARS (1987 T) YEARS (1987 T) (AL	T MODIFIED 02-03-1 ATED 02-03-1986 16 D 2007) D 1987) D 2007)	986 16:26:21 ::31:43
INITIAL CAPITA	L COMPONENT CO	DSTS (NOT DISCOUNT	ED)
INVESTMENT CATEGORY YEAR	COST PHASING	ACTUAL COST	
STRUCTURE 1985	40.0%	\$200,000	
STRUCTURE 1986 STRUCTURE 1987	40.0% 20.0%	\$202,000 \$102,010	
TOTAL FOR STRUCTURE		,	\$504,010
EQUIPMENT 1986	50.0%	\$50,500	
	30.0%	\$31,005	
TOTHE FOR CONTINUES			\$101,505
			\$101,505
TOTAL PROJECT COST (AC	CTUAL)		\$101,505 \$605,515
TOTAL PROJECT COST (AC	STUAL)	DISCOUNT RATE = 10	\$101,505 \$405,515 9.0%
TOTAL PROJECT COST (AC PART II - LIFE-CYCLE CO ROJECT NAME: BUILDING A	CTUAL) DST ANALYSIS: I	DISCOUNT RATE = 10 RUN DATE: 0	\$101,505 \$405,515 0.0% 3-05-1986/01:31:27
TOTAL PROJECT COST (AL PART II - LIFE-CYCLE CO ROJECT NAME: BUILDING A	CTUAL) DST ANALYSIS: I	DISCOUNT RATE = 10 RUN DATE: 0 PRESENT VALUE (1985 DOLLARS)	\$101,505 \$605,515 0.0% 3-05-1986/01:31:27 ANNUAL VALUE (1985 DOLLARS)
TOTAL PROJECT COST (AC PART II - LIFE-CYCLE CO ROJECT NAME: BUILDING A A. INITIAL INVESTMENT REQUIR	CTUAL) DST ANALYSIS: 1	DISCOUNT RATE = 10 RUN DATE: 0 PRESENT VALUE (1985 DOLLARS)	\$101,505 \$605,515 0.0% 03-05-1986/01:31:27 ANNUAL VALUE (1985 DOLLARS)
TOTAL PROJECT COST (AC PART II - LIFE-CYCLE CO ROJECT NAME: BUILDING A A. INITIAL INVESTMENT REQUIR DURING CONSTRUCTION AT OCCUPANCY	CTUAL) DST ANALYSIS: 1	DISCOUNT RATE = 10 RUN DATE: 0 PRESENT VALUE (1985 DOLLARS) \$429,546 \$126 459	\$101,505 \$605,515 0.0% 03-05-1986/01:31:27 ANNUAL VALUE (1985 DOLLARS) 548,970 \$14,417
TOTAL PROJECT COST (AC PART II - LIFE-CYCLE CO ROJECT NAME: BUILDING A A. INITIAL INVESTMENT REQUIR DURING CONSTRUCTION AT OCCUPANCY	CTUAL) DST ANALYSIS: I REMENTS:	DISCOUNT RATE = 10 RUN DATE: 0 PRESENT VALUE (1985 DOLLARS) 	\$101,505 \$605,515 0.0% 3-05-1986/01:31:27 ANNUAL VALUE (1985 DOLLARS) \$48,970 \$14,417
TOTAL PROJECT COST (AC PART II - LIFE-CYCLE CC ROJECT NAME: BUILDING A A. INITIAL INVESTMENT REQUIR DURING CONSTRUCTION AT OCCUPANCY SUBTOTAL	CTUAL) DST ANALYSIS: I	DISCOUNT RATE = 10 RUN DATE: 0 PRESENT VALUE (1985 DOLLARS) 	\$101,505 \$605,515 0.0% 3-05-1986/01:31:27 ANNUAL VALUE (1985 DDLLARS) \$48,970 \$14,417 \$63,387
TOTAL PROJECT COST (AC PART II - LIFE-CYCLE CO ROJECT NAME: BUILDING A A. INITIAL INVESTMENT REQUIR DURING CONSTRUCTION AT OCCUPANCY SUBTOTAL 3. OPERATING, MAINTENANCE &	REMENTS:	DISCOUNT RATE = 10 RUN DATE: 0 PRESENT VALUE (1985 DOLLARS) 	\$101,505 \$605,515 0.0% 3-05-1986/01:31:27 ANNUAL VALUE (1985 DOLLARS) \$48,970 \$14,417 \$63,387
TOTAL PROJECT COST (AC PART II - LIFE-CYCLE CO ROJECT NAME: BUILDING A A. INITIAL INVESTMENT REQUIR DURING CONSTRUCTION AT OCCUPANCY SUBTOTAL 3. OPERATING, MAINTENANCE & ANNUALLY RECURRING COSTS	REMENTS:	DISCOUNT RATE = 10 RUN DATE: 0 PRESENT VALUE (1985 DOLLARS) 	\$101,505 \$605,515 0.0% 3-05-1986/01:31:27 ANNUAL VALUE (1985 DOLLARS) \$48,970 \$14,417 \$63,387 \$8,830
TOTAL PROJECT COST (AC PART II - LIFE-CYCLE CO ROJECT NAME: BUILDING A A. INITIAL INVESTMENT REQUIR DURING CONSTRUCTION AT OCCUPANCY SUBTOTAL B. OPERATING, MAINTENANCE & ANNUALLY RECURRING COSTS NON-ANNUALLY RECURRING CO	RELATED COSTS: (NON-ENERGY)	DISCOUNT RATE = 10 RUN DATE: 0 PRESENT VALUE (1985 DOLLARS) 	\$101,505 \$605,515 0.0% 03-05-1986/01:31:27 ANNUAL VALUE (1985 DOLLARS) \$48,970 \$14,417 \$63,387 \$8,830 \$2,986
TOTAL PROJECT COST (AC PART II - LIFE-CYCLE CO ROJECT NAME: BUILDING A A. INITIAL INVESTMENT REQUIR DURING CONSTRUCTION AT OCCUPANCY SUBTOTAL B. OPERATING, MAINTENANCE & ANNUALLY RECURRING COSTS NON-ANNUALLY RECURRING CO ENERGY COSTS	REMENTS: RELATED COSTS: (NON-ENERGY) DSTS	DISCOUNT RATE = 10 RUN DATE: 0 PRESENT VALUE (1985 DOLLARS) \$429,546 \$126,459 \$556,004 : \$77,450 \$26,188 \$281,442	\$101,505 \$605,515 0.0% 03-05-1986/01:31:27 ANNUAL VALUE (1985 DOLLARS) \$48,970 \$14,417 \$63,387 \$8,830 \$2,986 \$32,086
TOTAL PROJECT COST (AC PART II - LIFE-CYCLE CC ROJECT NAME: BUILDING A A. INITIAL INVESTMENT REQUIR DURING CONSTRUCTION AT OCCUPANCY SUBTOTAL DERATING, MAINTENANCE & ANNUALLY RECURRING COSTS NON-ANNUALLY RECURRING CO ENERGY COSTS SUBTOTAL	CTUAL) DST ANALYSIS: I REMENTS: RELATED COSTS: (NON-ENERGY) DSTS	DISCOUNT RATE = 10 RUN DATE: 0 PRESENT VALUE (1985 DOLLARS) 	\$101,505 \$605,515 0.0% 3-05-1986/01:31:27 ANNUAL VALUE (1985 DOLLARS) \$48,970 \$14,417 \$63,387 \$8,830 \$2,986 \$32,086 \$32,086 \$32,086
TOTAL PROJECT COST (AC PART II - LIFE-CYCLE CC ROJECT NAME: BUILDING A A. INITIAL INVESTMENT REQUIF DURING CONSTRUCTION AT OCCUPANCY SUBTOTAL B. OPERATING, MAINTENANCE & ANNUALLY RECURRING COSTS NON-ANNUALLY RECURRING CO ENERGY COSTS SUBTOTAL C. REPLACEMENTS TO CAPITAL C	CTUAL) DST ANALYSIS: I REMENTS: RELATED COSTS: (NON-ENERGY) DSTS	DISCOUNT RATE = 10 RUN DATE: 0 PRESENT VALUE (1985 DOLLARS) *429,546 \$126,459 *556,004 *556,004 *77,450 \$26,188 \$281,442 *385,081 \$5,858	\$101,505 \$605,515 .0% 3-05-1986/01:31:27 ANNUAL VALUE (1985 DDLLARS) \$48,970 \$14,417 \$63,387 \$8,830 \$2,986 \$32,086 \$32,086 \$43,901 \$668
TOTAL PROJECT COST (AC PART II - LIFE-CYCLE CC ROJECT NAME: BUILDING A A. INITIAL INVESTMENT REQUIF DURING CONSTRUCTION AT OCCUPANCY SUBTOTAL B. OPERATING, MAINTENANCE & ANNUALLY RECURRING COSTS NON-ANNUALLY RECURRING COSTS NON-ANNUALLY RECURRING CO ENERGY COSTS SUBTOTAL C. REPLACEMENTS TO CAPITAL CO D. LESS: REMAINING VALUE AT STUDY PERIOD	CTUAL) DST ANALYSIS: I REMENTS: RELATED COSTS: (NON-ENERGY) DSTS COMPONENTS END OF	DISCOUNT RATE = 10 RUN DATE: 0 PRESENT VALUE (1985 DOLLARS) 	\$101,505 \$605,515 .0% 3-05-1986/01:31:27 ANNUAL VALUE (1985 DDLLARS) \$48,970 \$14,417 \$63,387 \$8,830 \$2,986 \$32,086 \$32,086 \$43,901 \$668 \$4,740

first cost adjustment factor for energy conservation and renewable resource projects is not used. Table 9 shows the comparative analysis of the alternative building design with higher initial cost but reduced O&M costs. In this example, the present-value savings attributable to the design improvements are \$39,725; however the initial costs increase by \$52,614. Thus this alternative design, with negative net savings and an SIR less than 1.0, is not cost effective.

Example of Energy-Related Subsystem Analysis

For many problems, only the cost effectiveness of a single design modification or component retrofit may be required. In such cases, it is neither necessary nor desirable to perform a comprehensive LCC analysis of the overall building. Instead, the analysis should be directed at only those components and costs that are directly affected by the change. As an example, consider the installation of attic insulation in a residential building owned by the Federal government. The base case may be no insulation, and several alternatives may be set up in order to determine the "optimal" level of insulation, i.e., that level which minimizes the total LCC related to insulation and energy use. The base case will have no initial investment cost, but the annual energy use attributable to attic heat loss for this base case will be higher than for an insulated attic. As insulation is added to increasingly higher resistance (R) levels, the initial investment cost will increase but the annual energy use will decrease accordingly. LCCDATA can be used to create the building characteristics files for each case, and LCCMAIN can be used to determine the corresponding total LCC. The COMPARE program is not needed to determine which alternative has the lowest LCC; this can be done by simple inspection of the LCC reports printed by PRINTLCC. However, the COMPARE program can be used to provide measures of

Table 9.Comparative LCC Analysis of a Base Case and AlternativeFederal Office Building Design with Reduced O&M Costs

* * * * * * * * * * * * * * * * * * *	* * * * * * * * TIVE LCC ANAL * * * * * * *	* * * * * * * * * YSIS * * * * * * * * *	* * * * * * * *
BASE CASE = BUILDING ALTERNATIVE = BUILDIN	A G B		
PRINCIPAL STUDY PARAM			
LCC ANALYSIS TYPE: OM BASE YEAR: 1985 STUDY PERIOD: 22 YEA PLANNING/CONSTRUCTION OCCUPANCY YEAR: 1987 OCCUPANCY PERIOD: 20 DISCOUNT RATE: 10.0% DOE REGION: 1 BUILDING TYPE: 2 (CO BASE CASE FILES: ALTERNATIVE CASE FILE RUN DATE: 03-05-1986	B CIRCULAR A- RS PERIOD: 2 YI YEARS MMERCIAL) FED3.BCF S: FED4.BCF 01:58:11	94 EAR (S) FED3.LCC FED4.LCC	
	COMPARISO	N OF PRESENT-VAL	LUE COSTS
	BASE CASE: BUILDING A	ALTERNATIVE: BUILDING B	SAVINGS FROM ALT.
	(1)	(2)	(3)=(1)-(2)
INVESTMENT-RELATED COSTS: INITIAL INVEST. (AS OF OCCUPANCY) REPLACEMENTS TO CAPITAL COMPONENT LESS: RESALE VALUE	\$556,004 \$5,858 -\$41,578	\$611,605 \$7,029 -\$45,736	-\$55,601 -\$1,172 \$4,158
SUBTOTAL	\$520,284	\$572,898	-\$52,614
OPERATING AND MAINTENANCE-RELATED COST AN. AND NON-AN. O&M COSTS ENERGY EXPENDITURES	S: \$103,638 \$281,442	\$63,913 \$281,442	\$39,725 \$0
SUBTOTAL	\$385,081	\$345,356	\$39,725
	\$905.364	\$918,254	

COMPUTATION OF NET SAVINGS FOR ALTERNATIVE

NET SAVINGS	=	P.V. OF D&M-RELAT LESS ADD'L INVEST	ED SAVINGS -RELATED	\$39,725 COSTS -\$52,614
				-\$12,889

COMPUTATION OF SAVINGS-TO-INVESTMENT RATIO (SIR) FOR ALTERNATIVE

CID -	P.V. OF O&M-RELATED SAVINGS	\$39725	
51K =	P.V. OF ADD'L INVESTRELATED COST	\$52614	
	* * * * * * * * * * * * * * * * * * * *	* * * * * * * * * * * * * * *	÷

cost effectiveness for each level of insulation--the Net Benefits (NB) and the Savings to Investment Ratio (SIR)--either incrementally (i.e., relative to the next lower level) or in total (i.e., relative to the uninsulated case).¹

Table 10 shows the building characteristics file for the uninsulated case, with a 25-year study period, zero initial cost, and energy use (natural gas) attributable to attic heat loss of 20.0 million Btu/year. This insulation analysis is based on NBS Handbook 135 guidelines because it is a Federal project directly concerned with energy conservation. Table 11 shows the LCC analysis for the uninsulated case. Tables 12 and 13 show the LCC analysis for the same building with R-19 and R-30 attic insulation, with energy use reduced to 5.0 and 3.5 million Btu/year, respectively. In all three cases, the 10 percent firstcost-adjustment factor for Federal energy conservation projects is used, as required by the Federal LCC methodology. The alternative with the lowest LCC shown here is the R-30 insulation level (\$895). Table 14 shows the COMPARE analysis of the cost effectiveness of R-30 compared to R-19 insulation. In this example net benefits are \$75 and the SIR is 1.55. Further analysis with other levels of insulation in the same attic could be used to find the insulation level which has the lowest possible LCC.

¹ See NBS Handbook 135 for assistance in interpreting these measures of cost effectiveness.

Table 10. Building Characteristics File for R-O Attic Insulation in a Federal Building (Example)

BUILDING CHARACTERISTICS FILE

FILE NAME: FED5(.BCF) FILE LAST MODIFIED ON 02-01-1986 01:24:40

PROJECT TITLE: R-O INSULATION

BASIC LCC ANALYSIS ASSUMPTIONS:

ANALYSIS TYPE: NBS HANDBOOK 135 BASE DATE FOR LCC ANALYSIS: 1985 STUDY PERIOD: 25 YEARS OCCUPANCY DATE: 1985 DISCOUNT RATE (REAL) = 7.00% BUILDING TYPE = 1 RESIDENTIAL DOE REGION = 1

CAPITAL COMPONENT AND REPLACEMENT COST DATA:

NUMBER OF CAPITAL COMPONENTS: 1 CAPITAL COMPONENT DATA: COMPONENT NAME INSULATION INITIAL COMPONENT COST 0 INIT. CONSERVATION-RELATED COST 0 EXPECTED COMPONENT LIFE (YRS) 25 AVG PRICE ESC RT DURING CONST. 0.00% AVG PRICE ESC RT DURING OCC. 0.00% RESALE VALUE FACTOR 0.00% NUMBER OF REPLACEMENTS 0

COST-PHASING SCHEDULE BY YEAR OF CONSTRUCTION AND AT OCCUPANCY: AT OCCUPANCY 100.00%

NO REPLACEMENTS TO ANY CAPITAL COMPONENTS

OPERATING AND MAINTENANCE COST DATA:

ANNUAL RECURRING D AND M COST = \$0 ANNUAL RATE OF INCREASE FOR A.R.C. = 0.00% NUMBER OF NON-ANNUAL RECURRING O AND M COSTS = 0 ANNUAL RATE OF INCREASE FOR N.A.R.C. COSTS = 0.0%

ENERGY COST DATA:

NUMBER OF ENERGY TYPES = 1

0.04%

ENERGY TYPE NO. 1 = NATURAL GAS AVG ANNUAL CONSUMPTION = 20.0 MILLION BTU PRICE PER MILLION BTU = \$7.90 ANNUAL DEMAND (AND/OR OTHER CHARGE) = \$0 ESCALATION RATE METHOD = 2 YEAR RATE YEAR RATE 1985 -0.26% 1998 3.83% 1986 4.34% 1999 3.91% 1987 4.54% 2000 3.41% 1988 5.67% 2001 3.44% 1989 5.48% 2002 3.39% 1990 4.98% 2003 3.47% 1991 5.77% 2004 3.42% 1992 4.58% 2005 3.60% 1993 4.57% 2006 3.65% 1994 3.65% 2007 3.64% 1995 3.87% 2008 3.67% 1996 3.89% 2009 3.64% 1997

Table 11. Detailed LCC Analysis for R-O Attic Insulation in a Federal Building (Example)

* * * * * * * * * * * * * FBLCC ANALYSIS PART I - INITIAL ASSUMPTIONS AND COST DATA PROJECT NAME: R-O INSULATION RUN DATE: 03-05-1986 01:39:39 BLDG. CHAR. FILE NAME: FED5. BCF, LAST MODIFIED 02-01-1986 01:24:40 LCC OUTPUT FILE NAME: FED5.LCC, CREATED 02-03-1986 16:32:58 LCC ANALYSIS TYPE: NBS HANDBOOK 135 STUDY PERIOD: 25 YEARS (1985 TO 2010) DISCOUNT RATE: 7.0% BUILDING TYPE: RESIDENTIAL DOE REGION: 1 INITIAL CAPITAL COMPONENT COSTS (NOT DISCOUNTED) INITIAL COST TOTAL FOR INSULATION \$0 TOTAL PROJECT COST (ACTUAL) \$0 LESS FEDERAL CONSERVATION CREDIT(a) \$0 TOTAL ADJUSTED PROJECT COST \$0 ENERGY-RELATED COSTS ENERGY MMBTU/ PRICE DEMAND UPW# TOTAL TYPE YEAR (\$/MMBTU) COST FACTOR P.V. COST _____ 17.70 NATURAL GAS 20.0 \$7.90 \$0 \$2797 (a) TO REFLECT 10% FIRST COST ADJUSTMENT RULE IN NBS HANDBOOK 135. PART II - LIFE-CYCLE COST ANALYSIS: DISCOUNT RATE = 7.0% PROJECT NAME: R-O INSULATION RUN DATE: 03-05-1986/01:39:39 PRESENT VALUE ANNUAL VALUE (1985 DOLLARS) (1985 DOLLARS) _____ A. INITIAL INVESTMENT REQUIREMENTS \$0 \$0 B. OPERATING, MAINTENANCE & RELATED COSTS: ANNUALLY RECURRING COSTS (NON-ENERGY) \$0 \$0 NON-ANNUALLY RECURRING COSTS \$0 \$0 ENERGY COSTS \$2,797 \$240 SUBTOTAL \$2,797 \$240 D. LESS: REMAINING VALUE AT END OF STUDY PERIOD \$0 \$0 \$2,797 E. TOTAL LIFE-CYCLE PROJECT COST \$240
Table 12. Detailed LCC Analysis for R-19 Attic Insulation in a Federal Building (Example)

PART I - INITIAL ASSUMPTIONS AND COST DATA PROJECT NAME: R-19 INSULATION RUN DATE:03-05-1986 01:41:59 BLDG. CHAR. FILE NAME: FED6.BCF, LAST MODIFIED 02-01-1986 01:44:34 LCC DUTPUT FILE NAME: FED6.LCC, CREATED 02-03-1986 16:33:36 LCC ANALYSIS TYPE: NBS HANDBOOK 135 STUDY PERIOD: 25 YEARS (1985 TO 2010) DISCOUNT RATE: 7.0% BUILDING TYPE: RESIDENTIAL DOE REGION: 1 INITIAL CAPITAL COMPONENT COSTS (NOT DISCOUNTED) INITIAL COST TOTAL FOR INSULATION \$300 TOTAL PROJECT COST (ACTUAL) \$300 LESS FEDERAL CONSERVATION CREDIT(a) \$30 TOTAL ADJUSTED PROJECT COST \$270 ENERGY-RELATED COSTS ENERGY MMBTU/ PRICE DEMAND UPW* TOTAL TYPE YEAR (\$/MMBTU) COST FACTOR P.V.COS FACTOR P.V. COST \$7.90 \$0 17.70 NATURAL GAS 5.0 \$699 (a) TO REFLECT 10% FIRST COST ADJUSTMENT RULE IN NBS HANDBOOK 135. PART II - LIFE-CYCLE COST ANALYSIS: DISCOUNT RATE = 7.0% PROJECT NAME: R-19 INSULATION RUN DATE: 03-05-1986/01:41:59 PRESENT VALUE ANNUAL VALUE (1985 DOLLARS) (1985 DOLLARS) -----_____ A. INITIAL INVESTMENT REQUIREMENTS \$270 \$23 B. OPERATING, MAINTENANCE & RELATED COSTS: ANNUALLY RECURRING COSTS (NON-ENERGY) \$0 \$0 NON-ANNUALLY RECURRING COSTS \$0 \$0 ENERGY COSTS \$699 \$60 \$699 SUBTOTAL \$60 D. LESS: REMAINING VALUE AT END OF STUDY FERIOD \$0 \$0 \$83 E. TOTAL LIFE-CYCLE PROJECT COST \$969 * * * * * * * *

Table 13. Detailed LCC Analysis for R-30 Attic Insulation in a Federal Building (Example)

* * * * * * * * * * * * * FBLCC ANALYSIS * PART I - INITIAL ASSUMPTIONS AND COST DATA PROJECT NAME: R-30 INSULATION RUN DATE:03-05-1986 01:52:54 BLDG. CHAR. FILE NAME: FED7.BCF, LAST MDDIFIED 02-01-1986 01:45:27 LCC OUTPUT FILE NAME: FED7.LCC, CREATED 02-03-1986 16:51:11 LCC ANALYSIS TYPE: NBS HANDBOOK 135 STUDY PERIOD: 25 V DISCOUNT RATE: 7.0% 25 YEARS (1985 TD 2010) BUILDING TYPE: RESIDENTIAL DOE REGION: 1 INITIAL CAPITAL COMPONENT COSTS (NOT DISCOUNTED) INITIAL COST TOTAL FOR INSULATION \$450 TOTAL PROJECT COST (ACTUAL) \$450 LESS FEDERAL CONSERVATION CREDIT(a) \$45 TOTAL ADJUSTED PROJECT COST \$405 ENERGY-RELATED COSTS ENERGY MMBTU/ PRICE DEMAND UPW* TOTAL TYPE YEAR (\$/MMBTU) COST FACTOR P.V. COST NATURAL GAS 3.5 \$7.90 \$0 17.70 \$490 (a) TO REFLECT 10% FIRST COST ADJUSTMENT RULE IN NBS HANDBOOK 135. PART II - LIFE-CYCLE COST ANALYSIS: DISCOUNT RATE = 7.0% PROJECT NAME: R-30 INSULATION RUN DATE: 03-05-1986/01:52:54

| | | PRESENT VALUE
(1985 DOLLARS) | ANNUAL VALUE
(1985 DOLLARS) |
|---|---|---------------------------------|--------------------------------|
| | A. INITIAL INVESTMENT REQUIREMENTS | \$405 | \$35 |
| | B. OPERATING, MAINTENANCE & RELATED COSTS:
ANNUALLY RECURRING COSTS (NON-ENERGY)
NON-ANNUALLY RECURRING COSTS
ENERGY COSTS | \$0
\$0
\$490 | \$0
\$0
\$42 |
| | SUBTOTAL | \$490 | \$42 |
| | D. LESS: REMAINING VALUE AT END OF
STUDY PERIOD | \$0 | \$0 |
| | E. TOTAL LIFE-CYCLE PROJECT COST | \$895 | \$77 |
| F | * | * * * * * * * * * | * * * * * * * * * |

Table 14. Comparative LCC Analysis: R-30 Over R-19 Attic Insulation in a Federal Building (Example)

FBLCC: COMPARATIVE LCC ANALYSIS BASE CASE = R-19 INSULATION ALTERNATIVE = R-30 INSULATION PRINCIPAL STUDY PARAMETERS: LCC ANALYSIS TYPE: NBS HANDBOOK 135 BASE YEAR: 1985 STUDY PERIOD: 25 YEARS DISCOUNT RATE: 7.0% FED. CONSERVATION CREDIT: 10% DOE REGION: 1 BUILDING TYPE: 1 (RESIDENTIAL) BASE CASE FILES: FED6. BCF ALTERNATIVE CASE FILES: FED7. BCF FED6.LCC FED7.LCC RUN DATE: 03-05-1986 02:00:51 COMPARISON OF PRESENT-VALUE COSTS BASE CASE: ALTERNATIVE: SAVINGS R-19 INSULATI R-30 INSULATI FROM ALT. ---------____ (1) (2) (3)=(1)-(2)INVESTMENT-RELATED COSTS: INITIAL INVEST. (AS OF OCCUPANCY) \$270 \$405 -\$135 \$270 \$405 SUBTOTAL -\$135 OPERATING AND MAINTENANCE-RELATED COSTS: \$699 ENERGY EXPENDITURES \$490 \$210 ____ _____ SUBTOTAL \$490 \$699 \$210 TOTAL P.V. LIFE-CYCLE COST \$969 \$895 \$75 COMPUTATION OF NET SAVINGS FOR ALTERNATIVE NET SAVINGS = P.V. OF D&M-RELATED SAVINGS \$210 LESS ADD'L INVEST.-RELATED COSTS -\$135 ______ \$75 COMPUTATION OF SAVINGS-TO-INVESTMENT RATIO (SIR) FOR ALTERNATIVE P.V. OF O&M-RELATED SAVINGS \$210 SIR = -----_____ 1.55 P.V. OF ADD'L INVEST. -RELATED COST \$135

7. THE DISCOUNT PROGRAM

DISCOUNT is a program written in BASIC for microcomputer applications which can perform all of the discounting operations described in Table 2.1 of NBS Handbook 135, Life-Cycle Cost Manual for the Federal Energy Management Program. The DISCOUNT program is stored on the solid diskette as the FBLCC programs, but it is executed independently of those $p_{1,0,0}$ fames. The main menu displayed on the video screen when running DISCOUNT is shown in Figure 3. The program will determine present, future, and equivalent annual values related to cash flows in different time periods. It also displays the corresponding discount factor for the selected operation. The number of time periods (usually years), discount rate, and, where appropriate, rate of price change, can be entered or changed by the user while running the program.

You must be in the BASIC mode to run DISCOUNT. At the system level, type BASIC DISCOUNT to run this program. In BASIC, simply type RUN "DISCOUNT".

Once running, the DISCOUNT program can be used repeatedly for any of the discounting operations shown in the menu. In order to save time, the discount rate can be temporarily locked in by pressing <L> and specifying the discount rate. If you wish to change the discount rate, use <U> to unlock the rate, or press <L> again to lock in a new rate.

Most of the terms used in the menu can be defined by pressing $\langle D \rangle$. This command displays a second menu, as shown in Figure 6-4. The definition of

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| | DISCOUNTING APPLICATIONS MENU |
|------------------|--|
| CODE | TO FIND: |
| 1 2 | FUTURE VALUE WHEN PRESENT VALUE IS KNOWN
PRESENT VALUE WHEN FUTURE VALUE IS KNOWN |
| 3
4
5
6 | UNIFORM SERIES OF PAYMENTS
PERIODIC PAYMENT AMOUNT WHEN FUTURE AMOUNT IS KNOWN
PERIODIC PAYMENT AMOUNT WHEN PRESENT AMOUNT IS KNOWN
FUTURE VALUE WHEN PERIODIC PAYMENT AMOUNT IS KNOWN
PRESENT VALUE WHEN PERIODIC PAYMENT AMOUNT IS KNOWN |
| 7 | NON-UNIFORM SERIES OF PAYMENTS
PRESENT VALUE WHEN PERIODIC PAYMENT AMOUNT INCREASES
AT CONSTANT RATE |
| 8 | PRESENT VALUE WHEN PERIODIC PAYMENT AMOUNT INCREASES
AT CHANGING RATE |
| L
D | =LOCK IN DISCOUNT RATE U=UNLOCK DISCOUNT RATE
=DEFINE TERMS S=STOP |

ENTER APPLICATIONS CODE:

Figure 4. Definitions Menu from the DISCOUNT Program

| DEFI | NITI | ONS | OF | TERMS |
|------|------|-----|----|-------|
|------|------|-----|----|-------|

| CODE | E TERM TO BE DEFINED |
|------|------------------------------|
| | |
| 1 | DISCOUNT RATE |
| 2 | ESCALATION RATE |
| 3 | FUTURE VALUE |
| 4 | INTEREST RATE |
| 5 | NON-UNIFORM SERIES |
| 6 | PERIODIC PAYMENT AMOUNT |
| 7 | PRESENT VALUE |
| 8 | STUDY PERIOD |
| 9 | TIME PERIOD |
| 10 | UNIFORM SERIES |
| | |
| | R=RETURN TO MAIN MENU S=STOP |

ENTER CODE FOR DEFINITION:

each of these terms will be displayed by entering the corresponding code and pressing the carriage return.

If a discounting operation is desired that is not included in the menu shown, it is possible that it can be accomplished through a combination of steps using the DISCOUNT program. For example, to find the present value of a future amount that is unknown but has been defined in constant base-year dollars and is expected to increase in value at a constant rate, use the following procedure: (1) Find the future value of the present amount (code 1), substituting the rate of price increase for the discount rate. Then (2) determine the present value of that future amount (code 2) using the appropriate discount rate.

REFERENCES

- Lippiatt, B. C., Weber, S. F., and Ruegg, R. T., <u>Energy Prices and Discount</u> <u>Factors for Life Cycle Cost Analysis</u>, NBSIR 85-3273, U.S. Department of Commerce, National Bureau of Standards, Gaithersburg, MD 20899, 1985.
- Petersen, S. R., <u>A User's Guide to the Building Life-Cycle Cost (BLCC) Computer</u> <u>Program</u>, <u>American Society of Testing and Materials</u>, <u>Philadelphia</u>, PA, <u>1985</u>.
- Ruegg, R. T., Life-Cycle Cost Manual for the Federal Energy Management Program, National Bureau of Standards Handbook 135 (revised), U.S. Department of Commerce, National Bureau of Standards, Gaithersburg, MD 20899, 1982.

Title 10 Code of Federal Regulations, Revised, See 436, 1985.

U.S. Office of Management and Budget, Circular A-94 "Discount Ratee to be Used in Evaluating Time-Distributed Costs and Benefits," March 27, 1972.

APPENDIX A

KEY VARIABLES USED IN THE FBLCC PROGRAM

AS = PROJECT TITLE*AF = INITIAL COST ADJUSTMENT FACTOR FOR CONSERVATION INVESTMENTS (10%) *P1 = PLANNING/CONSTRUCTION PERIOD (years) (Y2-Y1) *P2 = OCCUPANCY PERIOD (years) (P3-P1)P3 = STUDY PERIOD (years) Y1 = BASE DATE FOR LCC ANALYSIS AND DISCOUNTING (year) Y2 = OCCUPANCY DATE (year)*Y4 = FIRST YEAR IN DOE ENERGY PRICE FILE *Y5 = CONSTANT DOLLAR BASE IN DOE ENERGY PRICE FILE *Y6 = NUMBER OF YEARS IN DOE ENERGY PRICE FILE Il = DISCOUNT RATE (real, i.e., net of inflation) *I2 = 1 + I1RG = DOE REGIONT7 = BUILDING TYPE FOR DOE ENERGY PRICE FILE:1 = RESIDENTIAL2 = COMMERCIAL3 = INDUSTRIALTYPE = 1 FOR NBS HANDBOOK 135 ANALYSIS, 2 FOR OMB CIRCULAR A-94 ANALYSIS

CAPITAL COMPONENT VARIABLES

C1 = NUMBER OF CAPITAL COMPONENTS TO BE TREATED SEPARATELY (e.g, land, building, equipment)

FOR EACH CAPITAL COMPONENT, I = 1 to C1:

- $C_{(I)} = NAME OF THE Ith COMPONENT$
- C(I,1) = INITIAL COST OF THE Ith COMPONENT (base-year dollars)
- C(1,2) = AMOUNT OF C(1,1) SUBJECT TO FEDERAL CONSERVATION ADJUSTMENT
- C(I,10) = EXPECTED USEFUL LIFE OF Ith COMPONENT, IN YEARS (use 999 for land)
- C(I,11) = PERCENT OF C(I,1) ESTIMATED TO REMAIN AS RESALE VALUE, UNADJUSTED FOR INFLATION, AT THE END OF ITS USEFUL LIFE OR END OF THE STUDY PERIOD (whichever comes first)
- C(I,12) = NUMBER OF REPLACEMENTS TO THE Ith COMPONENT DURING THE STUDY PERIOD
- *C(I,13) = MINIMUM OF [occupancy period; useful life] FOR Ith COMPONENT
- *C(I,14) = ACTUAL COST OF Ith COMPONENT (i.e., adjusted for real price increases during construction, if any)
- C(I,15) = ANNUAL PRICE ESCALATION RATE DURING PLANNING/CONSTRUCTION PERIOD FOR THE Ith COMPONENT (% change in real terms, i.e., net of general inflation)

^{*} Asterisked variables are calculated internally.

- *DA(I) = RESALE VALUE OF COMPONENT I IF REMAINING AT END OF STUDY PERIOD
- *DB(I) = RESALE VALUE OF COMPONENT I IF DISPOSED OF BEFORE END OF STUDY PERIOD
- Q(I,J) = PERCENT OF THE TOTAL ACQUISITION COST (unadjusted for inflation) OF THE Ith COMPONENT ALLOCATED TO THE Jth YEAR OF THE PLANNING/ CONSTRUCTION PERIOD (J = 1 to P1) OR BEGINNING OF OCCUPANCY (J = P1 + 1)
- *T1(I,J) = CONSTRUCTION/ACQUISITION EXPENDITURE FOR Ith COMPONENT IN PLANNING/ CONSTRUCTION YEAR J

REPLACEMENT VARIABLES

FOR EACH REPLACEMENT (K = 1 TO C(I, 12)) TO THE Ith CAPITAL COST COMPONENT:

- R2(I,K) = INITIAL COST OF REPLACEMENT (in base-year dollars)
- R6(I,K) = EXPECTED USEFUL LIFE OF REPLACEMENT K TO COMPONENT I
- R7(I,K) = PERCENT OF R2(I,K) ESTIMATED TO REMAIN AS RESALE VALUE, UNADJUSTED FOR INFLATION, AT END OF ITS USEFUL LIFE OR END OF THE STUDY PERIOD (whichever comes first)
- *R9(I,K) = ACTUAL COST OF REPLACEMENT (i.e., adjusted for real price increases, if any)
- *RA(I,K) = RESALE VALUE OF REPLACEMENT K TO COMPONENT I IF REMAINING AT END OF STUDY PERIOD
- *RB(I,K) = RESALE VALUE OF REPLACEMENT K TO COMPONENT I IF DISPOSED OF BEFORE END OF STUDY PERIOD

O&M COST VARIABLES

- M1 = ANNUALLY RECURRING O&M COSTS (in base-year dollars)
- M2 = AVERAGE ANNUAL RATE OF INCREASE FOR ANNUALLY RECURRING 0&M COSTS OVER STUDY PERIOD (% change in real terms, i.e., net of general inflation)
- *M3 = UPW* FACTOR FOR ANNUALLY RECURRING O&M COSTS (including price increases during construction)
- M4 = NUMBER OF NON-ANNUALLY RECURRING COSTS
- M5 = AVERAGE ANNUAL RATE OF INCREASE FOR NON-ANNUALLY RECURRING O&M COSTS DURING STUDY PERIOD (% change in real terms; i.e., net of general inflation)
- M(1,J) = YEAR OF OCCURANCE OF Jth NON-ANNUALLY RECURRING O&M COST (1 = first year of occupancy)
- M(2,J) = AMOUNT OF Jth NON-ANNUALLY RECURRING 0&M COST (in base-year dollars)

| E1 = | = NUMBER OF ENERGY TYPES USED |
|------------|---|
| FOR EACH | ENERGY TYPE: |
| E(I) : | = ENERGY NAME CODES: |
| | 1 - ELECTRICITY |
| | 2 - DISTILLATE FUEL OIL |
| | 3 - RESIDUAL FUEL OIL |
| | 4 - NATURAL GAS |
| | 5 - LIQUIFIED PETROLEUM GAS (LPG) |
| | 6 - COAL (OR STEAM COAL) |
| EM(I) | = ENERGY PRICE ESCALATION CODES: |
| | 1 - KALES ENIEKED DI USEK
2 - DATES ACCESSED EDOM ENCOSTEL |
| E1(1 T) | - ENERCY DELCE FOR Ith ENERCY TYPE (in becomyour dollars per |
| LI(1,1) | million Btu) |
| E1(2,T) | = NUMBER OF DISCRETE ENERGY PRICE ESCALATION RATES TO BE USED |
| ~-(-)-/ | (starting at occupancy date) FOR Ith ENERGY TYPE |
| *E1(3,I) * | = UPW* FACTOR FOR Ith ENERGY TYPE (as of the date of occupancy) |
| *E1(4,I) = | = PRESENT VALUE COST OF ALL USE OF ENERGY TYPE I OVER STUDY PERIOD |
| E1(5,I) | = ANNUAL RATE OF INCREASE IN PRICE OF Ith ENERGY TYPE DURING PLANNING/ |
| | CONSTRUCTION PERIOD (% change in real terms, i.e., net of |
| | general inflation) |
| *E1(6,I) | = ANNUAL ENERGY COST FOR ENERGY TYPE I AT THE BEGINNING OF OCCUPANCY |
| | (including real energy price increases during planning/construction |
| | period, if any) |
| E2(1,J) | LENGTH OF JEN TIME INTERVAL FOR IEN ENERGY TIPE (years) |
| F3(T T) | (J = 1 IO GI(2,1)) = ENERGY DEFORE ESCALATION PATE IN It'S TIME PERIOD (I = 1 TO F1(2 I)) |
| $F_4(T)$ | = ANNIAL ENERGY CONSIMPTION (Million Btu/yr) for Ith ENERGY TYPE |
| E5(T) | = ANNUAL INDIRECT ENERGY COST (s/vr) for the Ith ENERGY TYPE (in |
| 20(2) | base-vear dollars) |
| | |
| *SUMMATIO | N VARIABLES (ALL INTERNAL COMPUTATIONS) |
| | |
| | |

- NOTE: All T(1,I) variables are in actual dollars, i.e., including price increases during planning/construction period, if any and not discounted
 - T(1,1) = TOTAL PROJECT COST
 - T(1,2) = TOTAL PROJECT COST INCURRED DURING PLANNING/CONSTRUCTION PERIOD
 - T(1,3) = REDUCTION IN INITIAL PROJECT COST DUE TO CONSERVATION ADJUSTMENT
 - T(1,6) = TOTAL PROJECT COST INCURRED AT OCCUPANCY

^{*} Asterisked variables are calculated internally.

NOTE: All T(2,I) and T(3,I) variables are discounted to base date (Y1) T(2,2) = TOTAL PROJECT COST DURING PLANNING/CONSTRUCTION PERIOD T(2,6) = ADDITIONAL PROJECT COST AT OCCUPANCY (reduced by <math>T(1,3)) T(2,17) = RESALE VALUE OF CAPITAL COMPONENTS AND REPLACEMENTS REMAINING AT END OF STUDY PERIOD T(2,18) = RESALE VALUE OF COMPONENTS AND REPLACEMENTS DISPOSED OF BEFORE THE END OF STUDY PERIOD^a T(2,21) = TOTAL ANNUALLY RECURRING O&M COSTS T(2,22) = TOTAL NON-ANNUALLY RECURRING O&M COSTST(2,25) = TOTAL ENERGY COSTST(2,27) = TOTAL COST OF REPLACEMENTST(3,1) = TOTAL RESALE VALUE OF PROJECT T(3,5) = TOTAL RECURRING & NON-RECURRING O&M COSTST(3,7) = TOTAL PROJECT COST AS OF OCCUPANCYT(3,12) = TOTAL, PRESENT VALUE, LIFE-CYCLE PROJECT COST T(3,18) = T(2,27) TOTAL COST OF REPLACEMENTS T(3,19) = T(2,25) TOTAL ENERGY COSTS

NOTE: All T(4,I) and T(5,I) variables are annual value equivalents of present-value costs incurred over the entire study period (P3):

T(4,I) = ANNUAL VALUE OF T(2,I), where T(2,I) is present value T(5,I) = ANNUAL VALUE OF T(3,I), where T(3,I) is present value

^{*} Asterisked variables are calculated internally.

APPENDIX B KEY EOUATIONS USED IN THE LCCMAIN AND COMPARE SUBPROGRAM

Note: All variables are listed in Appendix A except for variables DO-D9 and DA-DD. These latter variables are used for intermediate calculations and have no unique purpose. Convert all factors defined in percent form to decimal form (e.g., 75%=0.75) before using these equations. The mathematical symbol "**" means "raised to the power."

I. Initial cost calculations.

A. Without planning/construction period (P1=0)

- Actual component cost = initial cost for each component: C(I,14)=C(I,1)
- 2. Compute total project cost, T(1,1), T(1,6): Cl

$$T(1,1) = \sum_{I=1}^{\infty} C(I,14)$$

$$T(1,6)=T(1,1)$$

3. If Analysis Type = 1 (NBS Handbook 135 analysis), compute conservation adjustment to initial project cost, T(1,3): Cl T(1,3) = $\sum_{i=1}^{n} C(I,2)*AF$

- 4. Compute (adjusted) project cost at occupancy, T(2,6)T(2,6) = T(1,6)-T(1,3)
- B. With planning/construction period (Type 2 Analysis Only)
 - Compute actual component cost incurred in Jth year of planning/ construction period and at occupancy (Pl+1) for Ith component, Tl(I,J):

$$T1(I,J) = C(I,1)*Q(I,J)*(1+C(I,15))**(J-1)$$

- 2. Compute total cost of Ith component, C(I,14): P1+1 C(I,14) = $\sum_{J=1}^{J}$ T1(I,J)
- 3. Compute total project cost, T(1,1): C1 T(1,1) = $\sum_{i=1}^{n} C(I,14)$
- 4. Compute total project cost incurred during planning/construction period, undiscounted (T(1,2)) and discounted (T(2,2)):

$$T(1,2) = \sum_{i=1}^{CI} \sum_{j=1}^{PI} T1(I,j)$$

I=1

$$T(2,2) = \sum_{I=1}^{C1} \sum_{J=1}^{P1} T1(I,J)/(I2**(J-1))$$

5. Compute total project cost incurred at occupancy, undiscounted (T(1,6)) and discounted (T(2,6)): T(1,6)=T(1,1)-T(1,2) T(2,6)=T(1,6)/(I2**P1)

- II. Replacement cost calculations.
 - Note: Replacements are considered to be capital expenditures incurred at the end of the designated occupancy years.

Calculate cost for each replacement K = 1 to C(I, 12) of each component I = 1 to CI.

A. Actual cost of the replacement at time of installation, R9(I,K):

R9(I,K) = [R2(I,K)*(1+C(I,15))**P1]*[(1+C(I,7))**R1(I,K)].

B. PV of all replacement expenditures discounted from end of year of replacement, T(2,27):

 $T(2,27) = \sum_{I=1}^{C1} \sum_{K=1}^{C(I,12)} \frac{R9(I,K)}{(1+I1)**R1(I,K)}$

III. Resale value of components and replacements.

- A. Compute resale value of all components and replacements.
 - - to C where C(I,10)<P2.
 - 2. Compute resale value of replacements remaining at end of study
 period, RA(I,K), and disposed of before end of study period,
 RB(I,K):
 a. RA(I,K) = R9(I,K)*R7(I,K)*(1+C(I,7))**(P2-R1(I,K+1))

for all I,K (I = 1 to C1, K = 1 to C(I,12))
where
$$Rl(I,K) + R6(I,K) \ge P2$$
.

- b. RB(I,K) = R9(I,K)*R7(I,K)*(1+C(I,7))**R6(I,K)
 for all I,K (I = 1 to Cl, K = 1 to C(I,12))
 where R1(I,K) + R6(I,K) < P2.</pre>
- B. Compute PV of total resale value of all components and replacements:
 - PV of resale value of components and replacements remaining at end of study period, T(2,17):

$$T(2,17) = \frac{\begin{array}{ccc} C1 & C1 & C(I,12) \\ \sum & DA(I) + \sum & \sum & RA(I,K) \\ \underline{I=1} & I=1 & K=1 \\ \hline & (1+I1)**P2 \end{array}$$

 PV of resale value of components and replacements disposed of before end of a study period, T(2,18):

$$T(2,18) = \sum_{I=1}^{C1} \frac{DB(I)}{(1+I1)**C(I,10)} + \sum_{I=1}^{C1} \frac{C(I,12)}{K=1} \frac{RB(I,K)}{(1+I1)**(RI(I,K)+R6(I,K))}$$

- IV. Present Value of Recurring and Non-Recurring O&M Expenditures
 - A. Present value (PV) of all annually recurring O&M costs (ARC), discounted from end of year incurred, T(2,21):
 - 1. Compute PV factor for ARC, M3:
 - a. If M2 $\langle \rangle$ I1 then

 $M3 = \left(\frac{1+M2}{11-M2}\right) * \left[1 - \left(\frac{1+M2}{1+11}\right) **P2\right] * (1+M2) **P1.$

2. T(2,21) =M1*M3.

B. Present value of all non-annually recurring O&M costs (NARC), discounted from end of year incurred, T(2,22):

 $T(2,22) = \sum_{J=1}^{M4} \frac{M(2,J)*(1+M5)**(P1+M(1,J))}{(1+I1)**M(1,J)}$

- V. Present value PV of all energy costs, discounted from end of year incurred, T(2,25):
 - A. Compute PV of total cost for each energy type (I=1 to E1), E1(4,I):
 - Compute modified uniform present worth factor for each energy type in time interval K, D8:

a. If $I1 \iff E3(I,K)$ then

 $D8 = \frac{1+E3(I,K)}{I1-E3(I,K)} * \left[\frac{1+E3(I,K)}{1+I1} \right] * * E2(I,K)] .$

b. If II = E3(I,K) then

D8 = E2(I,K).

 Compute modified uniform present worth factor for each energy type I over the entire study period, El(3,I):

$$E1(3,I) = \sum_{K=1}^{E1(2,I)} \frac{K-1}{J=0} \frac{1+E3(I,J)}{(1+I1)**E2(I,J)}$$

3. Compute PV cost for energy type I over the study period, El(4,I):

A. E1(4,I)=[E1(1,I)*E4(I)+E5(I)]*[(1+E1(5,I))**P1]*E1(3,I).

B.
$$T(2,25) = \sum_{I=1}^{E1} E1(4,I)$$
.

VI. If P1>0, then discount T(2,1), I=5 to 27, from beginning of occupancy to beginning of study period:

T(2,I) is replaced by
$$\frac{T(2,I)}{(1*I1)**P1}$$
 for I = 5 to 27.

VII. Aggregate all costs in present value terms at beginning of study period.

Aggregate cost variables: 1. T(3,1) = T(2,17) + T(2,18). 2. T(3,5) = T(2,21) + T(2,22). 3. T(3,7) = T(2,2) + T(2,6). 4. T(3,12) = T(3,5)+T(3,7)+T(3,18)+T(3,19)-T(3,1). 5. T(3,18) = T(2,27). 6. T(3,19) = T(2,25).

VIII. Find annualized value of all T(2,I) and T(3,I) costs.

A. Compute capital recovery factor, D9:

1. If Il<0 then

 $D9 = \frac{11*(1+11)**P3}{(1+11)**P3 - 1}$

2. If I1 = 0 then D9 = 1/P3

- B. T(4,I) = T(2,I)*D9 for I = 1,5,7,12,18, and 19.
- C. T(5,I) = T(3,I)*D9 for I = 1,5,7,12,18, and 19.

Note: The following variables are used in the COMPARE program:

- IX. Calculation of cost differentials (base case costs alternative case costs), NB(I):
 - A. Define new variables CC(1,I) = T(3,I) for base case, I = 1,5,7,12,18 and 19. CC(2,I) = T(3,I) for alternative case, I = 1,5,7,12,18 and 19.
 - B. Adjust credit items: CC(K,1) = CC(K,1)*-1 for K = 1 to 2.
 - C. Calculate differential costs between base case and alternative for each element of the LCC, NB(I):

NB(I) = CC(1,I) - CC(2,I) for I = 1,5,7,12,18 and 19.

where NB(1) = net increase in resale value, NB(5) = net increase in 0&M costs, NB(7) = net increase in initial project cost, NB(12) = net increase in total LCC project cost, NB(18) = net increase in replacement costs, NB(19) = net increase in energy costs, all in present-value terms.

X. Calculation of Savings-to-Investment Ratio

Savings-to-Investment Ratio (SIR):

 $SIR = \frac{NB(5)+NB(19)}{(NB(7)+NB(18)-NB(1))*-1}$

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