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LIFE-CYCLE COSTING FOR ENERGY CONSERVATION IN BUILDINGS: STUDENT'S MANUAL

Rosalie T. Ruegg
Stephen R. Petersen

United States Department of Commerce
National Institute of Standards and Technology
(Formerly National Bureauof Standards)

Prepared for
United States Department of Energy
Federal Energy Management Program

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U. S. Department of Energy
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Washington, D.C. 20585

LIFE-CYCLE COSTING

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LIFE-CYCLE COSTING

COURSE OVERVIEW

DAY ONE

The course begins with practical illustrations to demonstrate how life-cycle costing and related methods can improve energy-related decisions. Brief overviews are given of five methods of economic evaluation. Each method is described, examples of its use are given, and its limitations are discussed. Then, the major elements in performing a life-cycle cost evaluation are explained. Emphasis is placed on clarifying those issues which often confuse practitioners. Issues include why it is necessary to adjust cash flows for time and how to do it, how to estimate costs and benefits, and what to do about inflation. Sample exercises are provided. Students are shown, step-by-step, how to compute life-cycle costs, net savings, savings-to-investment ratio, adjusted internal rate of return, and time to payback. Federal criteria for performing economic evaluations of energy-related choices are presented. Students are asked to solve a sample problem. Then two computer programs, FBLCC for Federal applications and NBSLCC for non-Federal applications, are introduced. Students get acquainted with the software by performing a simple life-cycle cost evaluation using microcomputers.

DAY TWO

The second day broadens coverage to solution of more complex problems: designing and sizing independent and interdependent building systems, and allocating limited budgets among competing projects. The issue of uncertainty is discussed and guidance is provided on what to do about it. A computer laboratory in which students are given sample problems to solve concludes the two-day course on life-cycle costing.

LIFE-CYCLE COSTING

COURSE AGENDA

DAY 1

TOPIC		TIME ALLOTTED
A.	ECONOMICS CAN IMPROVE DECISIONS	50 minutes
B.	WHAT YOU NEED TO GET STARTED	50 minutes
C.	ADJUSTING CASH AMOUNTS FOR TIME OF OCCURRENCE	100 minutes
D.	CALCULATING LIFE-CYCLE COSTS, NET SAVINGS, SAVINGS-TO-INVESTMENT RATIO, OVERALL RATE OF RETURN, AND TIME TO PAYBACK	75 minutes
E.	LCC COMPUTER PROGRAMS	90 minutes

DAY 2

F.	DESIGNING AND SIZING INDEPENDENT AND INTERDEPENDENT PROJECTS	75 minutes
G.	DETERMINING PROJECT PRIORITY	60 minutes
H.	UNCERTAINTY	60 minutes
I.	REVIEW	75 minutes
J.	COMPUTER LAB: USING FBLCC & NBSLCC	150 minutes

LIFE-CYCLE COSTING

COURSE OBJECTIVES

AT THE CONCLUSION OF THE TWO-DAY COURSE, THE STUDENT WILL BE ABLE TO:

Perform life-cycle cost analyses of energy-related building systems in order to make economic decisions.

AT THE CONCLUSION OF THE TOPIC, THE STUDENT WILL BE ABLE TO:

TOPIC A -- ECONOMICS CAN IMPROVE DECISIONS (50 minutes)

Give examples of decisions affecting energy consumption which can be improved by economic evaluation, and explain the concepts of economic efficiency, cost-effectiveness, economic optimization, and incremental analysis.

TOPIC B -- WHAT YOU NEED TO GET STARTED (50 minutes)

Define alternatives to be evaluated, specify data requirements, and identify sources of data.

TOPIC C -- ADJUSTING CASH AMOUNTS FOR TIME OF OCCURRENCE (100 minutes)

Calculate the present value of (1) a single future amount (such as a replacement cost or residual value), (2) a uniform series of future amounts (such as routine maintenance and repair costs), and (3) a series of future amounts changing over time at specified rates (such as energy costs).

TOPIC D -- CALCULATING LIFE-CYCLE COSTS, NET SAVINGS, SAVINGS-TO-INVESTMENT RATIO, ADJUSTED INTERNAL RATE OF RETURN, AND TIME TO PAYBACK (75 minutes)

Calculate life-cycle costs, net savings, savings-to-investment ratio, adjusted internal rate of return, and time to payback for a Federal energy conservation project and, on the basis of those measures, decide whether to accept or reject the project.

COURSE OBJECTIVES (Continued)

TOPIC E -- LCC COMPUTER PROGRAMS (90 minutes)

Run the FBLCC or NBLCC computer program; enter data inputs for a sample problem; and read the results from a screen printout.

TOPIC F -- DESIGNING AND SIZING INDEPENDENT & INTERDEPENDENT SYSTEMS (75 minutes)

Find the cost-effective size of an energy-related building component, such as the level of attic insulation; and find the cost-effective combination of interdependent projects, such as the level of attic insulation and heating system efficiency.

TOPIC G -- DESIGNING PROJECT PRIORITY (60 minutes)

Use the SIR method to allocate a budget among independent projects.

TOPIC H -- UNCERTAINTY (60 minutes)

Perform sensitivity analysis, and make decisions under uncertainty.

TOPIC I -- REVIEW (60 minutes)

Summarize principal steps in performing economic evaluations, describe five methods of economic evaluation, and explain how each method is used to guide energy-related decisions.

TOPIC J -- COMPUTER LAB: USING FBLCC & NBSLCC (150 minutes)

Use FBLCC or NBSLCC to size a building system and establish funding priority among competing projects.

LIFE - CYCLE COSTING

INTRODUCTION

Why This Course?

The energy crises of the 1970's, the threat of new shortages, and environmental concerns have focused attention on a critical need for energy conservation and reduced reliance on fossil fuels. Energy has become a crucial element in the art of building. The Federal government as the owner and operator of nearly a half-million buildings, and the nation's largest user of energy, has a leadership role in improving the energy efficiency of buildings.

Principles of microeconomic theory and engineering economics can be applied to determine the economically efficient balance of energy and other resources used in buildings. Finding the balance enables us to lower the long-run costs of owning and operating buildings.

Congress and the President, through legislation and executive order, have recognized the importance of cost-effective energy conservation. They have directed Federal agencies to make their buildings life-cycle cost effective, taking into account life-cycle energy costs. They also have instructed the Federal government to make available to the private sector, methods, computational tools, and data developed in the Federal energy management effort.

This course has three main goals: (1) to instruct Federal engineers, architects, and managers in using life-cycle cost analysis for making decisions affecting energy consumption in Federal buildings; (2) to instruct contractors and consultants who work on Federal projects in evaluating projects according to Federal requirements; and (3) to provide members of the building community at large the methods, tools, and data for evaluating energy conservation and renewable energy projects in residential, commercial, and institutional buildings.

INTRODUCTION, continued

Scope

The principles of economic evaluation taught in the course are widely applicable to investment decisions in both the public and private sectors. They apply to the decisions of an individual, as well as to those of organizations, including state and Federal governments, non-profit institutions; companies and corporations. In the examples, principles are applied to energy conservation and renewable energy investments in Federal buildings.

About this Manual

This Manual is intended as both an in-class workbook and as a future source for reference and review. Like the course, the Manual is divided into 10 major modules which group material on each respective topic. Each module begins with the topic title, time, teaching techniques, and learning objectives. Next are paper copies of the set of instructional slides used for that topic. The copies are provided to assist you to concentrate on the presentation and with note taking. Following the slides is information to supplement your notes. It is provided for future reference and review.

ECONOMICS CAN IMPROVE DECISIONS

MODULE A

50 Minutes
Lecture and Discussion

OBJECTIVES

By the conclusion of this module, you are expected to be able to

- give examples of decisions affecting energy consumption which can be improved by economic evaluation; and
- explain the concepts of economic efficiency, cost effectiveness, economic optimization, and incremental analysis.

EXAMPLES OF DECISIONS

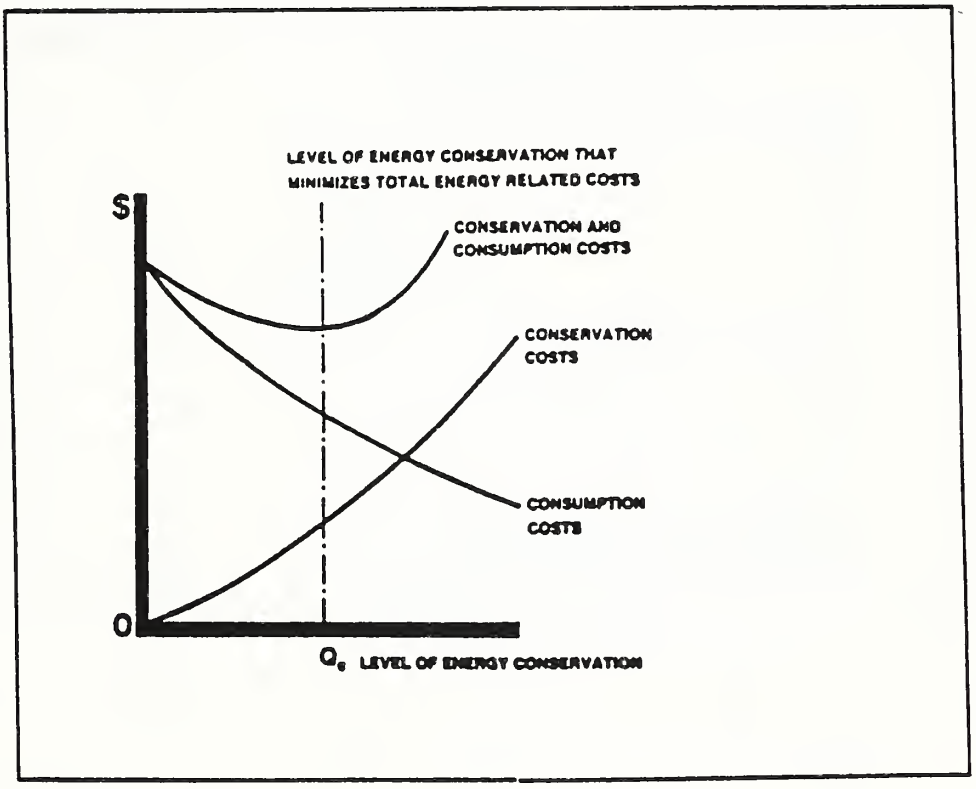
SLIDE A-1

ECONOMICS CAN IMPROVE DECISIONS

- to accept or reject?
- which design?
- what size?
- what combination?
- what priority?

NOTES:

SLIDE A-2



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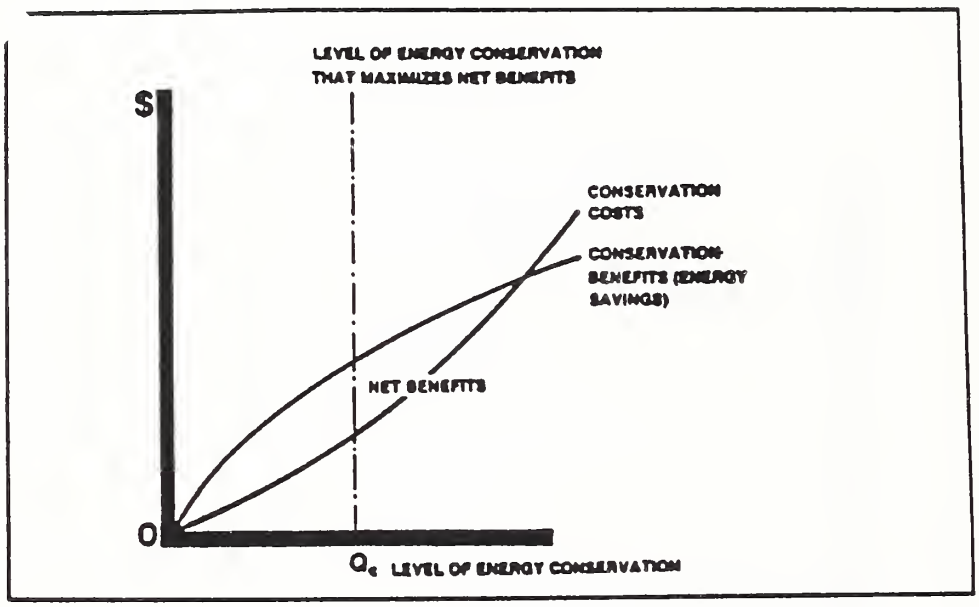
SLIDE A-3



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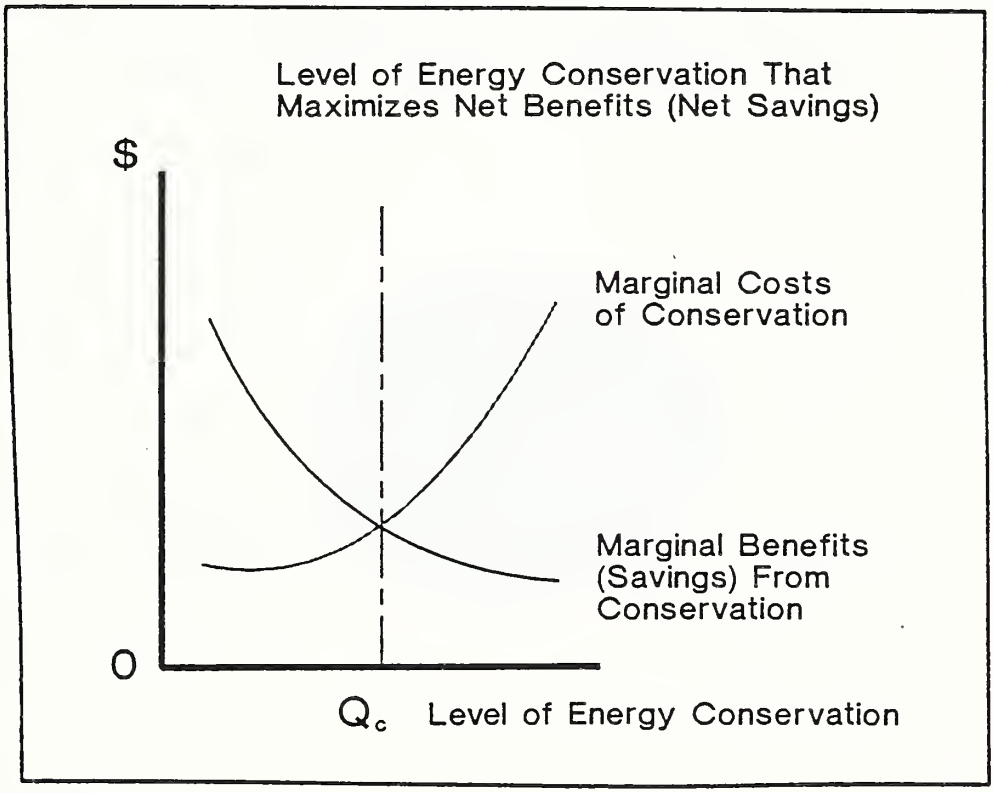

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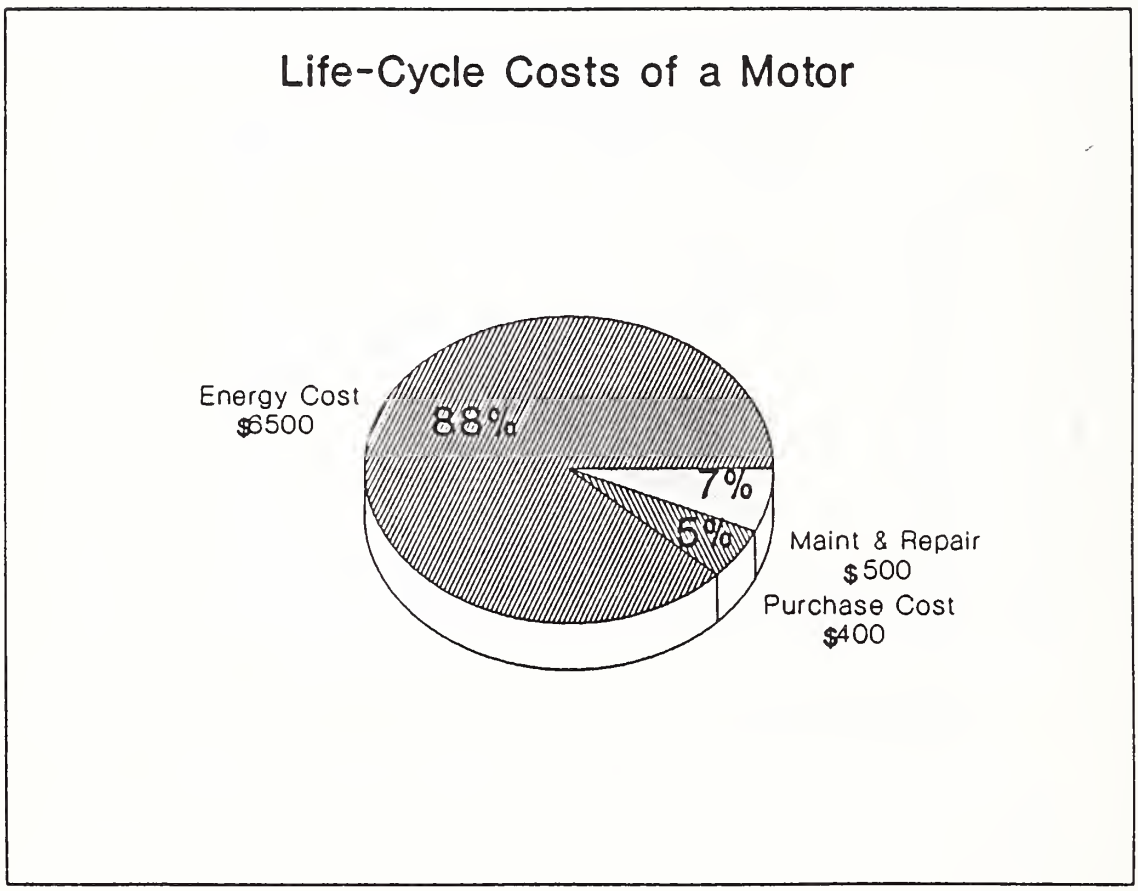
SLIDE A-5



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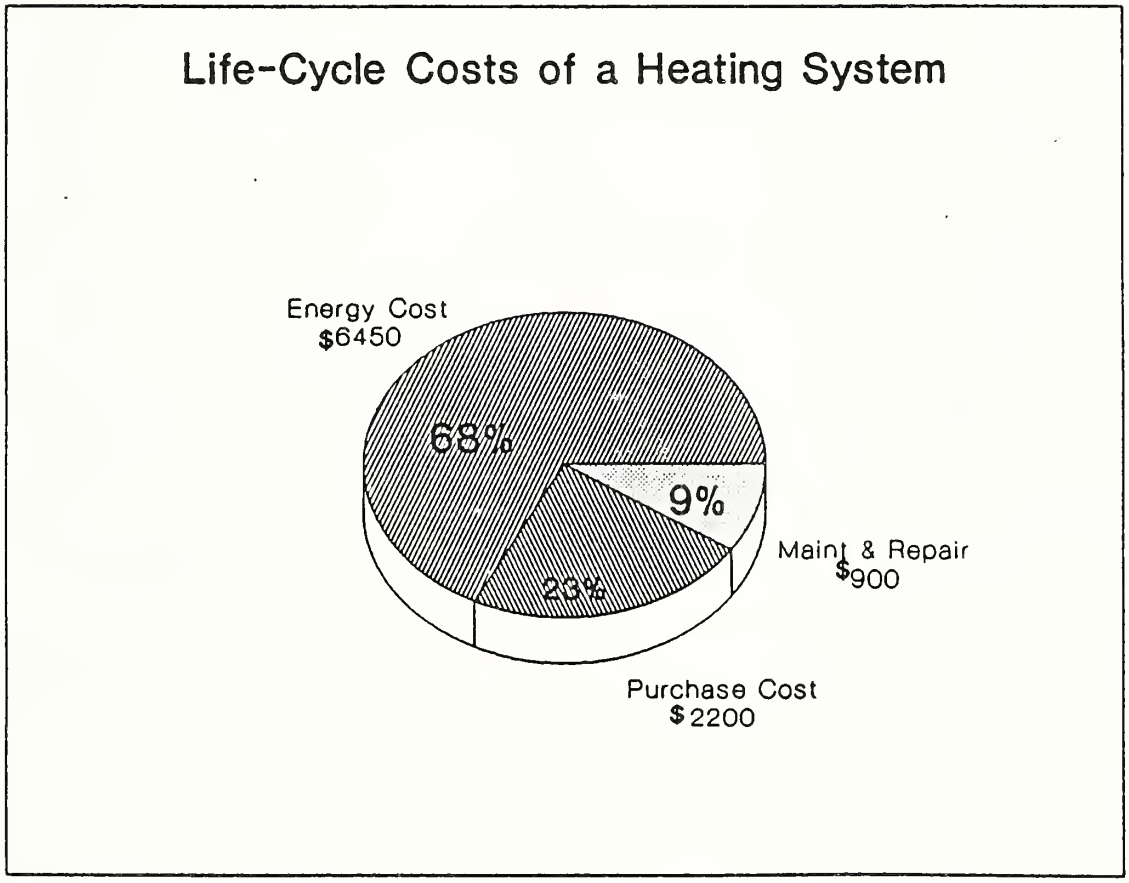
SLIDE A-6



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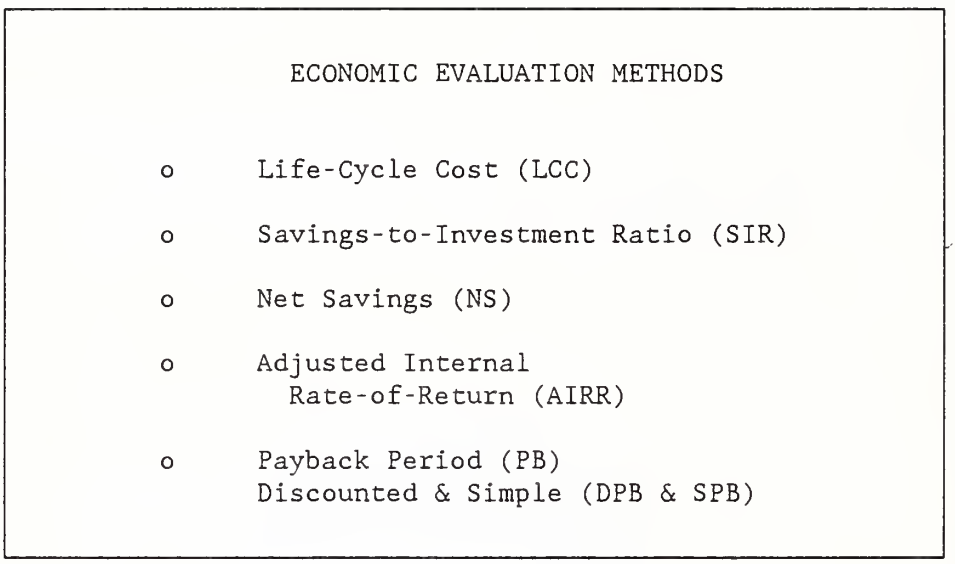
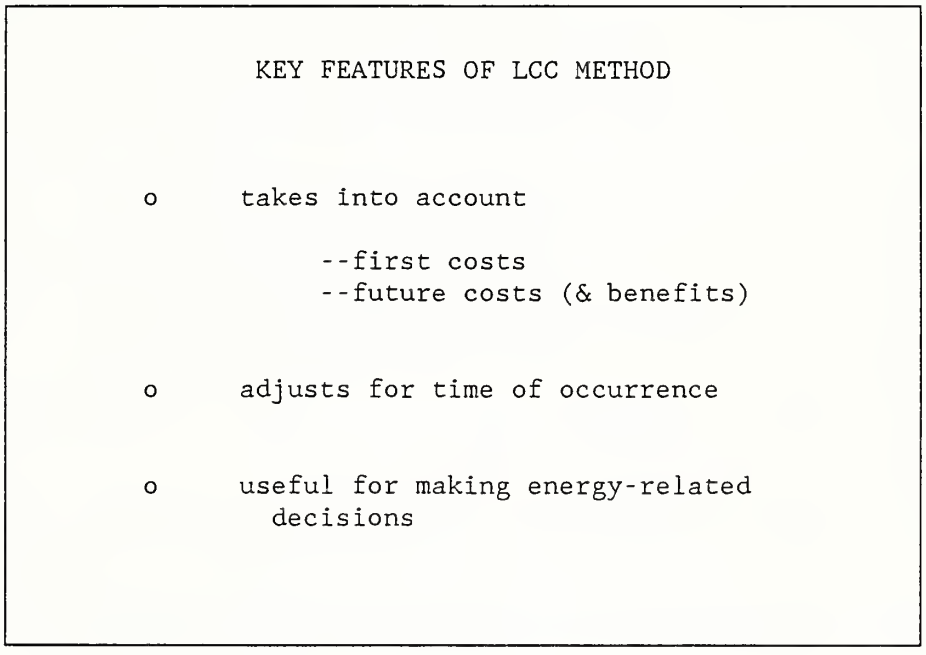
SLIDE A-7



NOTES:

SLIDE A-8



NOTES:

SLIDE A-9

HOW TO PERFORM LCC ANALYSIS

- compute LCC for each alternative
  - -- identify relevant effects
  - -- estimate in dollars
  - -- adjust $ amounts for time
  - -- sum time-equivalent amounts
- compare LCCs
- select alternative with lowest LCC

(alts must satisfy performance requirements)

NOTES:

EXAMPLES OF DECISIONS

Economic analysis is a powerful decision tool. It can be used to--

- Maximize net benefits (or profit) from a building investment.
- Find how much to spend on energy conservation to minimize lifetime building costs given a level of building performance.
- Achieve the largest possible savings for a given energy conservation budget.
- Meet a targeted reduction in energy costs for the lowest budget.

Slide A-1 lists types of decisions to which economic analysis can be usefully applied. Examples of these decisions are:

- Whether to add a computer control system to an HVAC system in an office building.
- Whether to add a solar energy hot water system to a launderette.
- Whether to select heating system of design A, B, or C for Building 1.
- Whether to install single-, double-, or triple-glazed windows in a new house in Bismarck, North Dakota; in Columbus, Ohio; in Atlanta, Georgia.
- What kind of insulation (e.g., cellulose or fiberglass), and how much, should be added to the walls, floors, and attic of houses in Madison, Wisconsin; in Washington, D.C.; and in Dallas, Texas.
- Whether to replace the furnace, add insulation, or do both in combination in existing housing?
- Which cost-effective projects to do first, given there are insufficient funds to do all of them.

ECONOMIC EFFICIENCY CONCEPTS

Improving the economic efficiency or cost effectiveness of buildings by taking into account the long-run costs of both energy consumption and conservation is at the heart of this course. Before going further, you should understand the concepts of economic efficiency, cost-effectiveness, and optimization. This will help you master the course material, diagnose economic problems, and select and apply economic methods correctly.

Economic Efficiency:

Economic efficiency means making decisions which result in maximum net benefits (excess of benefits over costs).

Cost Effectiveness:

Cost effectiveness is a term often used in place of "economic efficiency" when a choice is to be made among alternatives which differ in costs, but are considered equal in meeting performance requirements. It is a more restrictive term than economic efficiency, but the terms are frequently used interchangeably by practitioners.

Optimization:

Optimization is the process by which economic analysis is applied to determine the economically efficient or cost-effective choice among alternatives.

Graphical Illustration:

The concepts of economic efficiency, cost effectiveness, and optimization are illustrated in the three graphs shown in slides A-2, A-3, and A-4. The decision is what level of energy conservation (e.g., resistance level or "R-value" of insulation) to choose for a given building. In each graph, the physical quantity of inputs to conserve energy is measured on the horizontal axis. Dollars are measured on the vertical axis.

The graphs provide three ways of looking at the same problem, and they support the same decision: choose Qc as the economically-efficient (or cost-effective) level of energy conservation.

The optimal investment level of conservation is the level at which the difference between total costs and benefits (or savings) is greatest. The difference is greatest at level Qc. This method is called the "net benefits" or "net savings" method.

Slide A-2 shows the costs of conservation added to the costs of energy consumption and finds the level of energy conservation for which total long-run costs are minimum. Costs reach their minimum at level Qc. This method is appropriate if all the levels of energy conservation considered satisfy building performance requirements and compete primarily on the basis of their costs. The method is the "life-cycle cost" method.

Slide A-3 compares the costs of conservation as more is purchased, with the corresponding benefits (or savings). The total costs of conservation rise slowly at first but then more sharply as additional inputs of conservation

Graphical Illustration, continued:

are added and difficulties begin to be experienced in carrying out further conservation. The total conservation cost curve for a building investment typically bends upward at an increasing rate. The total savings curve also rises, but at a decreasing rate.

Slide A-4 shows how incremental or "marginal analysis" can be used to find the optimal level of conservation, i.e., the level which will yield the largest net benefits (net savings) or the lowest life-cycle costs. It shows changes in the total benefits or savings curve and in the total cost curve of slide A-2 as the inputs of energy conservation are increased, (i.e., slide A-4 shows the derivatives of slide A-2). The point of intersection of the two marginal curves indicates the most profitable level of energy conservation, level Qc. This is the level at which the costs of adding one more unit of conservation are just equal to the corresponding additional benefits in terms of energy savings; that is, the level for which "marginal costs" equal "marginal benefits" or "marginal savings."

For lower levels of conservation, the additional benefits or savings from increasing conservation by another unit are greater than the additional costs, and it pays to invest more. For higher levels of conservation, the costs of additional conservation exceed its benefits or savings causing the level of total net benefits to fall.

Note the correspondence between the optimal solution reached by (1) finding the minimum life-cycle costs, (2) finding the maximum net benefits or savings, and (3) using marginal analysis to find the point of equality between marginal costs and marginal benefits, i.e., where marginal net benefits equal zero.

LCC PROFILES OF ENERGY-RELATED SYSTEMS

Making choices on the basis of first costs among building systems and equipment that either consume energy directly or affect the consumption of energy, without regard to energy efficiency, can increase long-run costs. Only a small part of the long-run costs of most energy-consuming equipment is attributable to initial purchase price. The larger part is usually attributable to on-going support, energy, and maintenance costs.

The pie charts shown in slides A-5 and A-6 demonstrate the importance of taking into account energy efficiency in purchasing equipment.

The pie chart in slide A-5 shows the estimated costs over 20 years of owning and operating a 10-horsepower motor. Purchase costs comprise only 5% of the overall costs of the motor over its expected life of 20 years. Maintenance and repair are estimated to comprise another 7%. Energy costs comprise 88% of life-cycle costs. Increasing the efficiency of the motor from 0.75 to 0.90 is estimated to add about 25% to purchase price, or about $100, but to reduce life-cycle costs by about $1,000.

The pie chart in slide A-6 shows estimated costs over 15 years of owning and operating an oil-fired furnace to heat a 2,000 square foot house in the Washington, D.C., area. Purchase costs make up about one-fourth the long-run costs; maintenance and repair, about 10%; and fuel oil, about two-thirds of the total.

OVERVIEW OF ECONOMIC METHODS

Five closely related methods for evaluating the economic consequences of decisions are described here. The first treated, the life-cycle cost (LCC) method, is appropriate for addressing many energy conservation decisions and is the method emphasized in this course. But the other methods are needed for certain kinds of decisions and are therefore also treated. Since all of these methods are widely used, a working knowledge of all of them is important for communication.

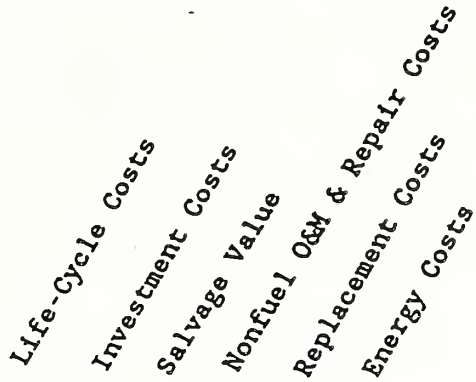
Life-Cycle Cost Method:

ABBREVIATION: LCC

DESCRIPTION: LCC is a method of evaluation which sums all significant time-equivalent dollar costs attributable to a given building design, system, or component. Positive cash flows, such as salvage values[1], are treated as negative costs which are time-adjusted and subtracted from the total.

[1]The term "salvage value" is used here to include resale value, reuse value, scrap value, or residual value remaining when the life of an asset exceeds the study period.

GENERAL FORMULA:



$$LCC = I - S + M + R + E, \qquad (1)$$

where all amounts are expressed as present-value[1] dollars.

USE: (1) Determine a project's cost effectiveness.
Use the LCC method to determine project cost effectiveness by computing LCC for the proposed project and LCC for the base case.[2] A building design, system, or component that results in a lower LCC than the base case while meeting the same or higher performance requirements is generally held to be cost effective. (Note that unquantified costs or benefits may be important to the decision.)

(2) Compare new building designs.
Use the LCC method to determine the cost-effective building design by computing LCCs for each of the alternative designs which meets requirements. The design alternative with minimum LCC is the cost-effective choice.

[1]The present value concept is treated in Module C.

[2]The base case should be a viable alternative with lowest first costs.

(3) Compare sizes or designs of a building system (e.g., alternative thickness of insulation for a given wall or alternative designs of a heating system).

Use the LCC method to determine the cost-effective design or size of a building system by computing LCCs for each of the alternatives and finding the design/size for which LCC is minimum.

Net Savings Method:

ABBREVIATION: NS

DESCRIPTION: NS is a method of evaluation which calculates the difference between the LCC of the base case and the LCC of the alternative building system. (See equation (2).)

NS may also be calculated as present value savings attributable to a project, less present value costs attributable to it. This second approach does not require the prior calculation of LCC for the base case and for the alternative, but rather, works directly from differences in individual cash flows. (See equation (3).)

The NS method is a variation of the Net Benefits (NB) method. It is used instead of the NB method when benefits occur primarily in the form of cost reductions.

GENERAL FORMULAS:

Net Savings = LCC for the Base Case − LCC for The Alternative Building System

$$NS = LCC_{BC} - LCC_{A}, \qquad (2)$$

where all amounts are expressed in present value dollars, the subscript "BC" designates the base case, and the subscript "A" designates the alternative building system.

Net Savings = Differential Energy Costs − [Differential Investment Costs − Differential Salvage Values + Differential Nonfuel O&M & Repair Costs + Differential Replacement Costs],

$$NS = \Delta E - [\Delta I - \Delta S + \Delta M + \Delta R], \quad (3)$$

where all amounts are expressed in present value dollars, and the values in equation (3) are as defined below in equations (3.1)-(3.5).

The delta symbol, Δ, used above in equation (3) and below in equations (3.1)-(3.5) signifies the taking of differences, where again the subscripts BC and A designate the base case and the alternative building system, respectively. The Δ terms are defined as follows:

Differential Present Value Energy Costs:	$\Delta E = (E_{BC} - E_A)$	(3.1)
Differential Present Value Investment Costs:	$\Delta I = (I_A - I_{BC})$	(3.2)
Differential Present Value Salvage Value Net of Disposal Costs:	$\Delta S = (S_A - S_{BC})$	(3.3)
Differential Present Value Nonfuel Operation and Maintenance (O&M) and Repair Costs:	$\Delta M = (M_A - M_{BC})$	(3.4)
Differential Present Value Replacement Costs:	$\Delta R = (R_A - R_{BC})$	(3.5)

Note that it is important to preserve the appropriate signs when entering the resulting values in the equations for NS, SIR, and PB:

USE: (1) Determine a project's cost effectiveness.

A positive NS generally means a project is cost effective. For example, an NS value of $50,000 for an alternative building system means the system is estimated to save over the study period an amount equivalent to a lump-sum amount today of $50,000, over and above the minimum acceptable rate of return.

(2) Compare designs or sizes of a building system (e.g., alternative thickness of insulation for a given wall, or alternative designs of a heating system).

Use the NS method to identify the design or size alternative of a building system which maximizes net savings.

Note that choosing project design or size with the highest NS is consistent with choosing the project design or size with the lowest LCC.

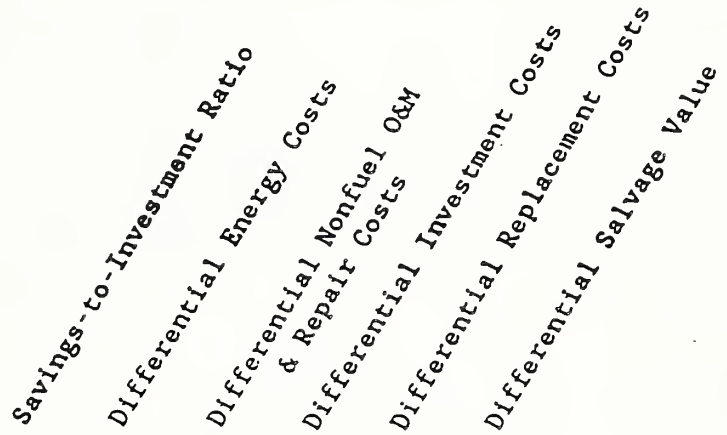
Savings-to-Investment Ratio Method:

ABBREVIATION: SIR

DESCRIPTION: The SIR is a method of evaluation which expresses the ratio of savings to costs. The numerator of the ratio is the reduction in energy costs, minus any increase (or plus any decrease) in nonfuel operation, maintenance, and repair costs. The denominator is the increase in investment cost, plus any increase (or minus any decrease) in replacement costs, and minus any increase (or plus any decrease) in salvage values.

The SIR method is a variation of the Benefit-to-Cost Ratio (BCR) method. It is used instead of the BCR method when benefits occur primarily as cost reductions.

GENERAL FORMULA:



$$SIR = [\Delta E - \Delta M] \div [\Delta I + \Delta R - \Delta S], \qquad (4)$$

where all amounts are expressed as present value dollars.

USE: (1) Determine a project's cost effectiveness.
An SIR greater than one generally means a project is cost effective. The higher the ratio, the greater the dollar savings per dollar spent. For example, an SIR of 4 computed for an alternative system relative to the base means that the alternative building system is estimated to save $4 on the average for every $1 invested, over and above the minimum acceptable rate of return.

(2) Rank nonmutually exclusive projects to determine their relative priorities.
The SIR is recommended for setting priority among nonmutually exclusive projects when the budget is insufficient to do all cost-effective projects. The approach is to rank projects in descending order of their SIRs. This ranking will provide a reliable guide to choosing the group of independent projects which will maximize overall net savings for the budget, provided

the budget can be used up exactly. Ranking of projects is treated further in Module G.

If project costs are "lumpy," so that the budget cannot be used up exactly by adhering strictly to SIR rankings, it may be necessary to depart from the SIR ranking in order to maximize overall NS from the budgeted expenditure. In this case, overall NS can be computed for trial combinations of projects to find the set that maximizes overall NS and stays within the confines of the budget.

Note that the SIR method is not reliable for designing and sizing alternative building systems unless the analysis is based on incremental SIRs. This is because SIRs computed on total savings and costs tend to fall before the most cost-effective design or size is reached. For example, the SIR on attic insulation of R11 versus R0 will tend to be higher than the SIR on R19 versus R0, but the incremental SIR on increasing insulation to R19 from R11 may nevertheless exceed one, indicating that the additional amount of insulation is cost effective. (Because of the tendency to misuse the SIR, the FEMP LCC Rule does not recommend its use for designing and sizing alternative building systems.)

Adjusted Internal Rate of Return Method:

ABBREVIATION: AIRR

DESCRIPTION: The AIRR method calculates the return on investment as a compound annual yield. The yield is calculated by subtracting 1 from the Nth root of the ratio of the terminal value of savings to the present value of costs. (See equation (5).) The compound yield is compared against the

investor's minimum acceptable rate of return (MARR) to measure economic performance. If it is lower than the MARR, the project is uneconomic; if higher, it is economic. The MARR is equal to the discount rate.

The AIRR is a replacement for the traditionally used internal rate of return (IRR). It makes an explicit assumption about the reinvestment of savings in each time period. The AIRR is preferred to the IRR because it avoids computational problems of the IRR and, unlike the IRR, provides a technically correct measure of the yield over the decision maker's study period.

GENERAL FORMULA:

$$AIRR = -1 + [TV/PVC]^{1/N} \qquad (5)$$

where:
- AIRR = Adjusted Internal Rate of Return
- TV = Terminal Value
- PVC = Investment-Related Costs at Beginning of Study Period
- N = Number of Years in Study Period

Adjusted Internal Rate of Return Method, continued:

where,

TV = value of all energy savings less increase in nonfuel operation, maintenance and repair costs as of the end of the study period (called "terminal value"), found by reinvesting net savings at rate r, i.e.,

$TV = \sum_{j=1}^{N} (\Delta\bar{E}_j - \Delta\bar{M}_j)\,(1+r)^{N-j}$, where $\Delta\bar{E}_j$ and $\Delta\bar{M}_j$ are differential energy costs and nonfuel operation, maintenance, and repair costs, respectively, as defined in equations (3.1) and (3.4), except that they are amounts in year j, <u>not</u> yet discounted to present values;

r = the reinvestment rate, i.e., the rate at which interim net savings earn a return until the end of the study period, which is set equal to the discount rate;

PVC = present value of investment-related costs (FEMP defines this as including future replacement costs and net of salvage values, i.e., PVC = $\Delta I + \Delta R - \Delta S$).

USE: (1) <u>Determine a project's cost effectiveness</u>.

An AIRR measure greater than the MARR generally means a project is cost effective.

Adjusted Internal Rate of Return Method, continued:

(2) Rank nonmutually exclusive projects to determine their relative priorities.

The AIRR is a substitute for the SIR for ranking. The approach is to rank projects in descending order of their AIRRs. When used for ranking, the AIRR is subject to the same limitations as the SIR. When the budget cannot be exhausted by taking projects in descending order of their AIRRs (i.e., project costs are "lumpy"), it may be necessary to depart from the AIRR ranking in order to maximize overall NS from the budgeted expenditure. Like the SIR, the AIRR is not reliable for designing and sizing unless the analysis is based on incremental AIRRs. [It is used optionally in the FEMP Program as a supplementary measure for managers who prefer the economic worth of a project expressed as a percentage rate of return.]

Payback Period Method:

ABBREVIATION: PB for payback; DPB for discounted payback, and SPB for simple payback.

DESCRIPTION: The PB method finds how long it takes a project to just break even, in the sense of recovering investment costs. The measure is calculated as the elapsed time between the initial investment and the time at which

cumulative savings, net of accrued costs, are just sufficient to offset investment costs.

If cash flows are expressed as time-equivalent values, the method is called "discounted payback" (DPB). If this is not done, that is, the opportunity cost is assumed to be zero--generally, a poor assumption--the method is called "simple payback" (SPB).

GENERAL FORMULA:
Find minimum value of y, years, for which

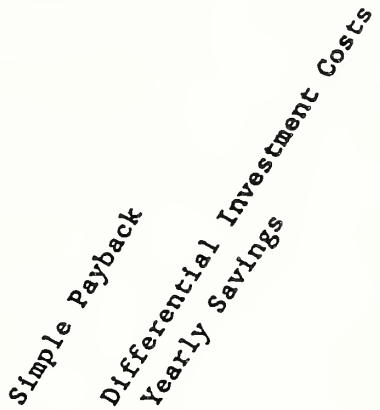
Summation of Years Until Payback is Reached
Differential Energy Costs (Undiscounted) in Year j
Differential Nonfuel O&M & Repair Costs (Undiscounted) in Year j
Differential Replacement Costs (Undiscounted) in Year j
Differential Salvage Value (Undiscounted) in Year j
Single Present Worth Discount Formula
Differential Investment Costs

$$\sum_{j=1}^{y} (\Delta\bar{E}_j - \Delta\bar{M}_j - \Delta\bar{R}_j + \Delta\bar{S}_j)/(1+d)^j = \Delta I \qquad (6)$$

where $\Delta\bar{E}_j$, $\Delta\bar{M}_j$, $\Delta\bar{R}_j$, and $\Delta\bar{S}_j$ are, respectively, differential energy costs, nonfuel operating, maintenance and repair costs, replacement costs, and salvage value as defined in equations (3.1) through (3.5), except that they are amounts in year j, not discounted to present values prior to being entered into equation (6); d = the discount rate. If $d \neq 0$, y = DPB, and if $d = 0$, y = SPB.

SIMPLIFIED SPB FORMULA: If future savings net of future costs are estimated to occur in an even amount from year to year, such that

$(\Delta\bar{E}_j - \Delta\bar{M}_j - \Delta\bar{R}_j + \Delta\bar{S}_j) = AS$ (a constant), and investment costs are assumed to occur as a lump-sum initial amount, the following simple formula can be used to determine SPB:



$$SPB = \Delta I/AS \qquad (7)$$

DPB can be approximated from SPB using graphs or discount factor tables, as explained in NBS Special Publication 709 and as illustrated in the example in Module D.

USE: (1) Supplementary measure.

Care is urged in using the PB method because it is subject to misuse and erroneous interpretation. A project design or size with a shorter payback period may be a poorer investment than a design or size with a longer payback period. For example, a level of R19 insulation may take longer to recover its investment cost than a level of R11, but that does not mean that the insulation level should be limited to R11. The simple version of payback has the added disadvantage of not indicating the correct time to payback because it ignores the cost of money. For these reasons, the PB method has limited application in project evaluation.

Primary advantages of the PB method are its simplicity, its usefulness in assessing the minimum required project life, and the insight it provides to protecting initial investment funds in the face of uncertainty over time.

Focus on LCC

The LCC method is particularly designed for evaluating cost-reducing investments, and for measuring costs over the long run. These characteristics make it well suited for energy-related decisions.

Slide A-8 lists key features of the LCC method. Slide A-9 outlines how LCC is performed. We will examine each of these subjects further in coming modules.

WHAT YOU NEED TO GET STARTED

MODULE B

50 Minutes
Lecture, Discussion, and Exercises

OBJECTIVES

At the conclusion of this module, you are expected to be able to

- define alternatives to be evaluated;
- specify data requirements; and
- identify sources of data.

DESIGN/RETROFIT ALTERNATIVES

SLIDE B-1

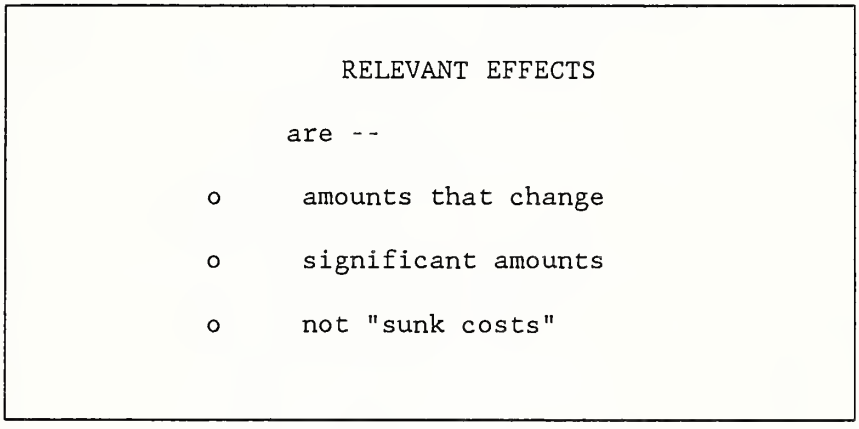
CHOOSE ALTERNATIVES

- good alternatives ESSENTIAL
- must meet performance requirements
- credit if benefits exceed requirements?

NOTES:

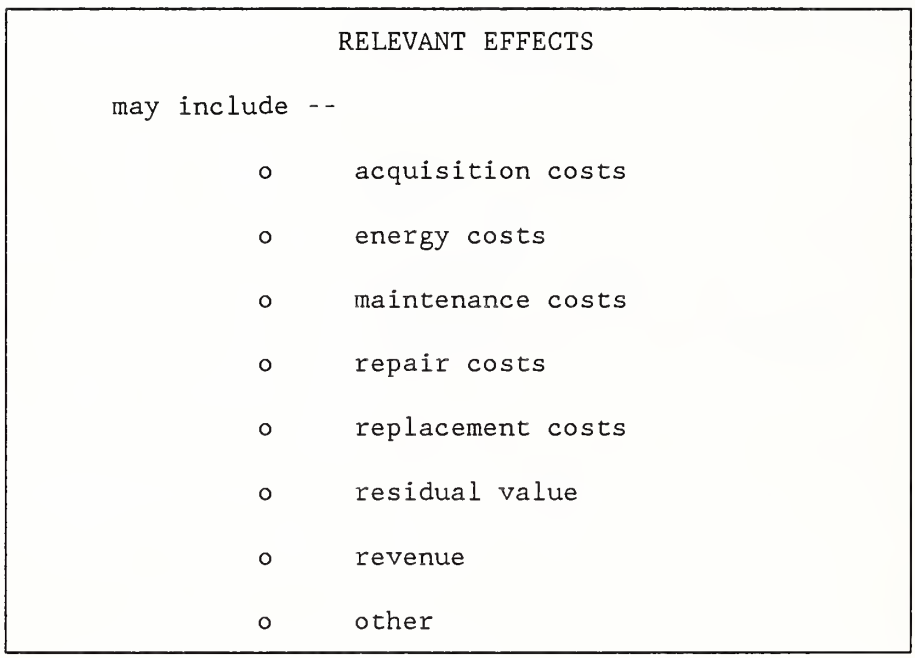
RELEVANT EFFECTS

SLIDE B-2



NOTES:

SLIDE B-3



NOTES:

ESTIMATING CASH FLOWS

SLIDE B-4

ESTIMATE IN DOLLARS

- o information from suppliers
- o energy analyses
- o data bases
- o previous experience
- o engineering judgment
- o today's costs and benefits

NOTES:

SETTING THE STUDY PERIOD

SLIDE B-5

STUDY PERIOD

should--

- be same length for alternatives if compared using LCC or NS
- correspond with time perspective of investor
- not exceed imposed limit

NOTES:

DESIGN/RETROFIT ALTERNATIVES

Slide B-1 lists three key points in choosing alternatives. The most important is to remember that your decision can be no better than the best alternative you consider, no matter how good your economic evaluation. The second point is to consider only alternatives which satisfy performance standards. Take into account constraints such as availability of energy sources, building code requirements, and local suppliers in identifying feasible alternatives. It is a waste of time evaluating alternatives which will not qualify on other grounds.

The third point concerns what to do if an alternative exceeds minimum performance standards. In this case, you need to determine if the additional benefits are important to your organization. Some organizations specify their performance standards tightly and give no credit to performance in excess of the standards. But others credit alternatives which exceed minimum performance standards with additional benefits.

RELEVANT EFFECTS

Slide B-2 gives characteristics of effects which are relevant to decisions and should be taken into account. Data requirements for making an economic decision are not identical to those for keeping an accounting system. To make a decision which is economically efficient, it is important to measure the economic consequences of alternatives. Only significant changes which are expected to result from a decision are relevant to making that decision. In making a decision, try to ignore "sunk costs," i.e., costs resulting from past decisions.

Relevant effects often include acquisition costs, energy costs, non-fuel operation, maintenance and repair costs, replacement costs, and salvage or residual value, and sometimes revenue and other benefits, as listed in slide B-3.

ESTIMATING CASH FLOWS

The economic evaluation methods--LCC, NS, SIR, AIRR, and PB--require inputs expressed in dollars. Effects not expressed in dollars are not included in the measure of economic performance. But effects not in dollars may be of critical importance, and should not be overlooked in making a decision.

Slide B-4 lists possible sources of data. Suppliers may provide cost quotes for off-the-shelf systems. Cost estimating guides may help in developing conceptual estimates of construction costs. Do not wait for a detailed take-off of quantities based on engineering specifications to do economic analysis. To wait means missing the best opportunities for using economic analysis to influence design decisions.

Estimating quantities of energy saved is the topic of the follow-on course (ASEAM). This course focuses on assigning present and future prices to energy. We use DOE forecasts of energy prices. Sample energy price data are in appendix B.

Three sets of data are provided to estimate energy prices: (1) yearly price indices, (2) average annual escalation rates for five-year intervals, and (3) uniform present worth discount factors modified to include yearly price escalation. We will use the data later in the course to do economic analysis.

The Army Corps of Engineer's Construction Engineering Research Laboratory (CERL) has developed an extensive data base for estimating maintenance and repair costs for a 25 year period. The database covers four major building systems: (1) architectural, (2) electrical, (3) plumbing, and (4) HVAC. Each is divided into components.

For example, architectural is divided into exterior and interior wall finishes, roofing, flooring, windows, and doors. Alternatives for flooring include ceramic tile, quarry tile, brick, wood parquet, linoleum, vinyl tile, concrete surfaces, terrazzo, and carpet. For each alternative, maintenance and repair cost indices are given in tables. By applying your labor and equipment rates, quantities, and location to the indices you can develop estimates of maintenance and repair costs.

Additional information on the database can be obtained by contacting:

Facility System Division
Construction Engineering Research Laboratory
Corps of Engineers
U.S. Department of the Army
P.O. Box 4005
Champaign, Illinois 61820-1305

Previous experience with similar systems can shed light on what values to use. One reason it is important to document LCC studies is that they may be useful in providing data for future studies. Engineering judgment is another source of data.

Today's costs and benefits can provide a useful starting point for estimating future costs and benefits. For example, suppose we know that a replacement would cost $100 if made today, and we need to know what the replacement will cost in five years. By estimating the rate of price change

during the interval, and applying that rate to the cost today we can estimate the future amount. More will be said about this topic in Module C.

SETTING THE STUDY PERIOD

The study period is the time over which the effects of a decision are of interest to the decision maker. For very long investments, the study period may be set for a selected period. For example, the Federal government uses a maximum study period of 25 years from the beneficial occupancy date.

Although there is some flexibility in choosing the study period, there are also rules. Slide B-5 gives three guidelines for setting the study period. Note especially the first: The same study period must be used when comparing alternatives in present value dollars with the LCC or NS method.

EXERCISE B-1

Relevant Effects

Suppose you want to evaluate whether it is cost effective to replace an existing HVAC system with a new system. Assume that the existing system can continue to meet heating and cooling requirements over the remaining 10 years that the owner plans to occupy the building. From the following list, check the data you need:

1.	Original land costs	$100,000
2.	Original site improvements	$50,000
3.	Initial construction costs	$5,000
4.	Purchase and installation costs of the existing HVAC system	$10,000
5.	Duct work for the existing HVAC system	$10,000
6.	Modification of the existing duct work to meet requirements of the new HVAC system	$2,000
7.	Purchase and installation costs of the new HVAC system	$50,000
8.	Maintenance cost of the existing HVAC	$2,000/year
9.	Maintenance cost of the new HVAC	$2,000/year
10.	Heating efficiency/cooling COP of existing system	0.65/2.0
11.	Heating efficiency/cooling COP of new system	0.80/3.0
12.	Current price of energy used by the existing system	$25.00/MBtu
13.	Current price of energy used by the new system	$22.00/MBtu
14.	Projected rate of change in price of energy used by existing system	7%/year
15.	Projected rate of change in price of energy used by new system	5%/year
16.	Building heating load (annual)	3,000 MBtu

Exercise B-1, continued

17.	Building cooling load (annual)	4,000 MBtu
18.	Existing HVAC system's current resale, less removal costs	$5,000
19.	New HVAC system's resale, less removal costs, at the end of its 30 year service life	$10,000
20.	Replacement costs of existing system at end of its 15 year remaining service life	$35,000
21.	Replacement of new system at the end of end of its 30 year service life	$45,000
22.	The amount the new system will add to resale value of the building in 10 years	$10,000
23.	The new system operates more quietly than the existing system	

EXERCISE B-2
Setting the Study Period

Choose a study period for each of the following situations:

1. A building owner wants to evaluate the cost effectiveness of an automatic thermostat control which will last 15 years. The building will be used indefinitely.

2. A designer wishes to perform an LCC comparison of two solar window films. Film A lasts five years; film B lasts 10 years. The building will be used indefinitely.

3. A state government sets a limit of 25 years on its LCC studies. An analyst is evaluating alternative roofing systems, one of which lasts 15 years and one of which lasts 30 years.

ADJUSTING CASH AMOUNTS FOR TIME OF OCCURRENCE

MODULE C

100 MINUTES

Lecture, Discussion, Slides, and Exercises

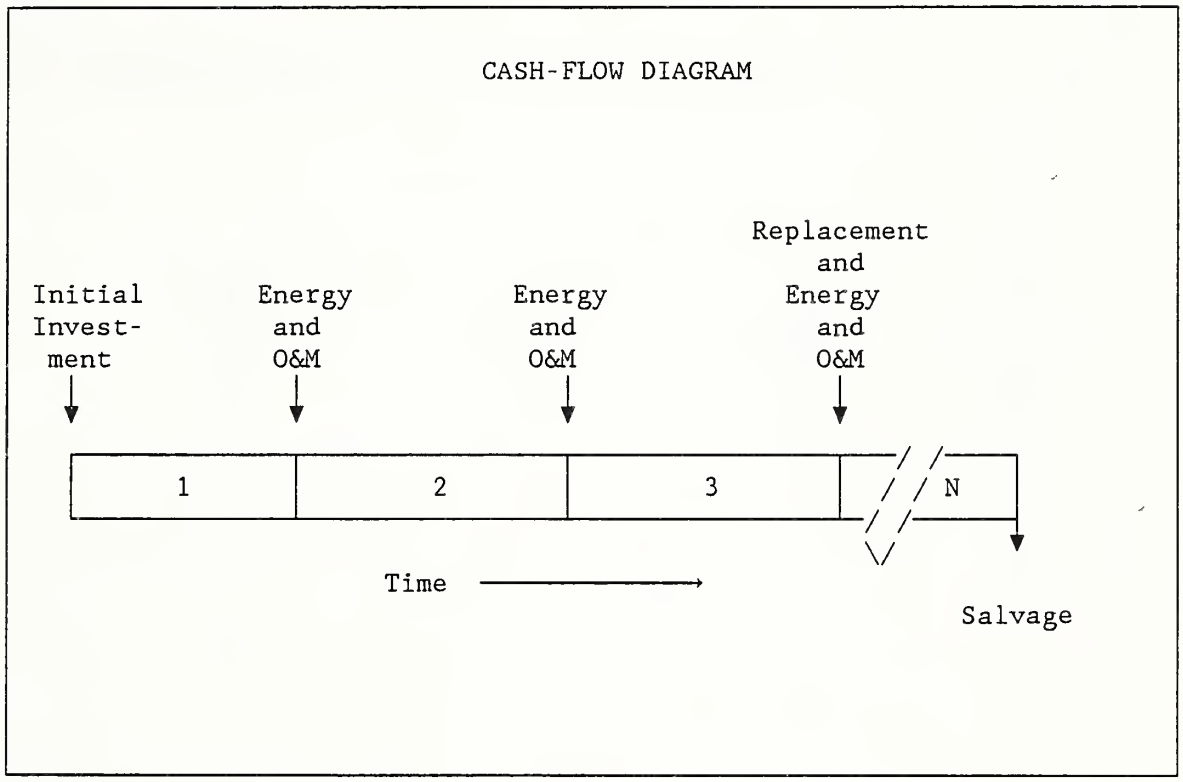
OBJECTIVES

At the conclusion of this module, you are expected to be able to

- calculate the present value of
  - -- a single future amount,
  - -- a uniform series of future amounts, and
  - -- a series of future amounts changing over time at specified rates.

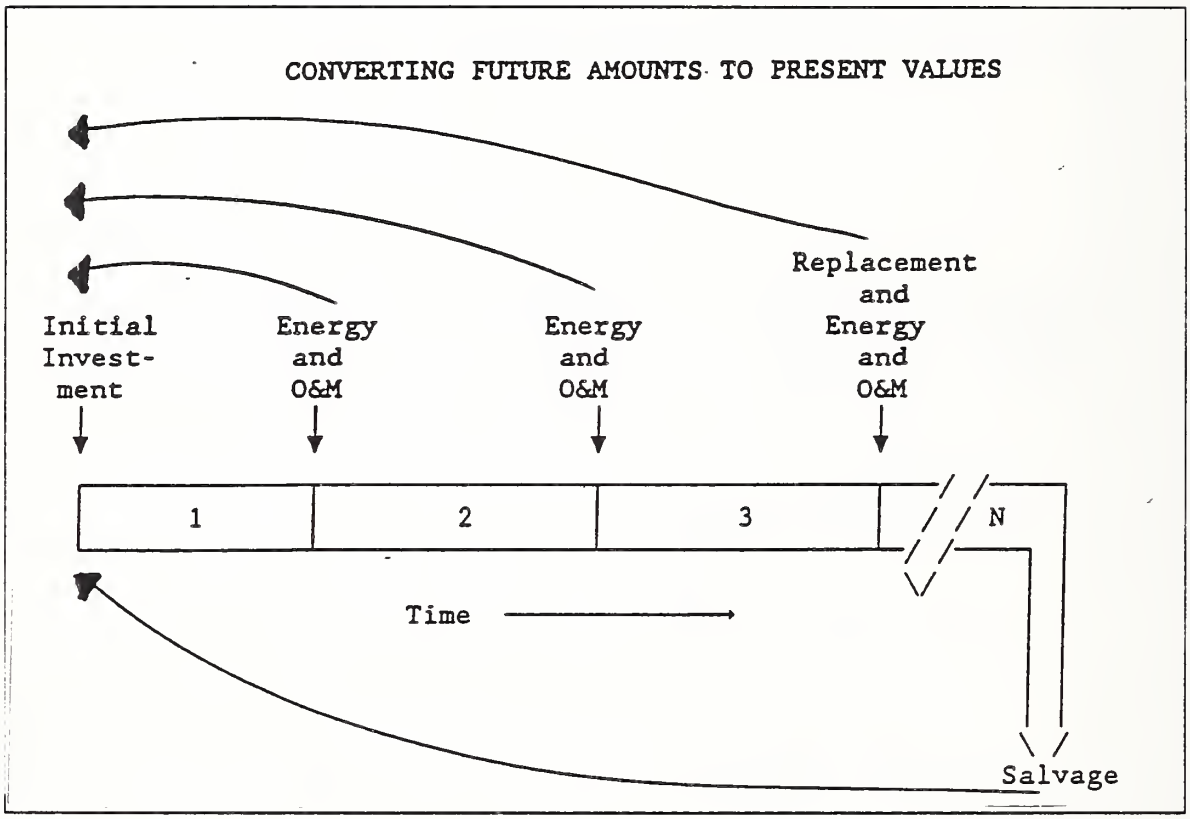
CASH-FLOW MODELING

SLIDE C-1



NOTES:

SLIDE C-2

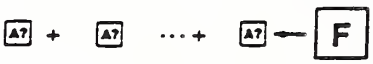
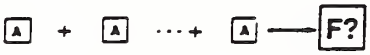


NOTES:

TIME VALUE OF MONEY

NOTES:

Table C-1 - Discount Formulas

Name	Schematic Illustration	Application	Algebraic Form[a,b]
Single Compound-Amount (SCA) Equation		To find F when P is known	$F = P \cdot [(1 + d)^N]$
Single Present-Value (SPW) Equation		To find P when F is known	$P = F \cdot \left[\frac{1}{(1 + d)^N}\right]$
Uniform Sinking-Fund (USF) Equation		To find A when F is known	$A = F \cdot \left[\frac{d}{(1 + d)^N - 1}\right]$
Uniform Capital-Recovery (UCR) Equation		To find A when P is known	$A = P \cdot \left[\frac{d(1 + d)^N}{(1 + d)^N - 1}\right]$
Uniform Compound-Amount (UCA) Equation		To find F when A is known	$F = A \cdot \left[\frac{(1 + d)^N - 1}{d}\right]$
Uniform Present-Value (UPW) Equation		To find P when A is known	$P = A \cdot \left[\frac{(1 + d)^N - 1}{d(1 + d)^N}\right]$
Modified Uniform Present-Value (UPW*) Equation		To find P when known A_0 is escalating at rate e	$P = A_0 \cdot \left(\frac{1 + e}{d - e}\right) \cdot \left[1 - \left(\frac{1 + e}{1 + d}\right)^N\right]$

where:

- P = present sum of money,
- F = future sum of money equivalent to P at the end of N periods of time at d interest or discount rate,
- A = end-of-period payment (or receipt) in a uniform series of payments (or receipts) over N periods at d interest or discount rate,
- A_0 = initial value of a periodic payment (receipt) evaluated at the beginning of the study period,
- A_t = $A_0 \cdot (1 + e)^t$, where t = 1, . . . , N,
- N = number of interest or discount periods,
- d = interest or discount rate, and
- e = price escalation rate per period

[a] Note that the USF, UCR, UCA, and UPW equations yield undefined answers when d = 0. The correct algebraic forms for this special case would be as follows: USF formula, A = F/N; UCR formula, A = P/N; UCA formula, F = A · N. The UPW* equation also yields an undefined answer when e = d. In this case, P = A_0 · N.

[b] The terms by which the known values are multiplied in these equations are the formulas for the factors found in discount factor tables. Using acronyms to represent the factor formulas, the discounting equations can also be written as F = P · SCA, P = F · SPW, A = F · USF, A = P · UCR, F = UCA, P = A · UPW, and P = A_0 · UPW*.

Table C-2 - 3% Discount Factors

	Single Compound Amount Factor SCA	Single Present Value Factor SPV	Uniform Capital Recovery Factor UCR	Uniform Present Value Factor UPV	Uniform Sinking Fund Factor USF	Uniform Compound Amount Factor UCA
For-mula	$(1+i)^n$	$\frac{1}{(1+i)^n}$	$\frac{i(1+i)^n-1}{(1+i)^n-1}$	$\frac{(1+i)^n-1}{i(1+i)^n}$	$\frac{i}{(1+i)^n-1}$	$\frac{(1+i)^n-1}{i}$
Given To Find	P F	F P	P A	A P	F A	A F
Period n	i = 3%					
1	1.030	.9709	1.030	.9709	1.000	1.000
2	1.061	.9426	.5226	1.913	.4926	2.030
3	1.093	.9151	.3535	2.829	.3235	3.091
4	1.126	.8885	.2690	3.717	.2390	4.184
5	1.159	.8626	.2184	4.580	.1884	5.309
6	1.194	.8375	.1846	5.417	.1546	6.468
7	1.230	.8131	.1605	6.230	.1305	7.662
8	1.267	.7894	.1425	7.020	.1125	8.892
9	1.305	.7664	.1284	7.786	.0984	10.16
10	1.344	.7441	.1172	8.530	.0872	11.46
11	1.384	.7224	.1081	9.253	.0781	12.81
12	1.426	.7014	.1005	9.954	.0705	14.19
13	1.469	.6809	.0940	10.64	.0640	15.62
14	1.513	.6611	.0885	11.30	.0585	17.08
15	1.558	.6419	.0838	11.94	.0538	18.60
16	1.605	.6232	.0796	12.56	.0496	20.16
17	1.653	.6050	.0760	13.17	.0460	21.76
18	1.702	.5874	.0727	13.75	.0427	23.41
19	1.754	.5703	.0698	14.32	.0398	25.12
20	1.806	.5537	.0672	14.88	.0372	26.87
21	1.860	.5375	.0649	15.42	.0349	28.68
22	1.916	.5219	.0627	15.94	.0327	30.54
23	1.974	.5067	.0608	16.44	.0308	32.45
24	2.033	.4919	.0590	16.94	.0290	34.43
25	2.094	.4776	.0574	17.41	.0274	36.46
26	2.157	.4637	.0559	17.88	.0259	38.55
27	2.221	.4502	.0546	18.33	.0245	40.71
28	2.288	.4371	.0533	18.76	.0233	42.93
29	2.357	.4243	.0521	19.19	.0221	45.22
30	2.427	.4120	.0510	19.60	.0210	47.58
31	2.500	.4000	.0500	20.00	.0200	50.00
32	2.575	.3883	.0490	20.39	.0190	52.50
33	2.652	.3770	.0482	20.77	.0182	55.08
34	2.732	.3660	.0473	21.13	.0173	57.73
35	2.814	.3554	.0465	21.49	.0165	60.46
36	2.898	.3450	.0458	21.83	.0158	63.28
37	2.985	.3350	.0451	22.17	.0151	66.17
38	3.075	.3252	.0445	22.49	.0145	69.16
39	3.167	.3158	.0438	22.81	.0138	72.23
40	3.262	.3066	.0433	23.11	.0133	75.40

* All formulas assume end-of-period payments.

P = a present sum of money; F = a future sum of money, equivalent to P at the end of n periods of time at discount rate of i; A = an end-of-period payment (or receipt) in a uniform series of payments (or receipts) over n periods at interest rate of i.

Note: table nomenclature uses i for interest rate or discount rate.

Table C-3 - 9% Discount Factors

	Single Compound Amount Factor SCA	Single Present Value Factor SPV	Uniform Capital Recovery Factor UCR	Uniform Present Value Factor UPV	Uniform Sinking Fund Factor USF	Uniform Compound Amount Factor UCA
For-mula	$(1+i)^n$	$\frac{1}{(1+i)^n}$	$\frac{i(1+i)^n}{(1+i)^n-1}$	$\frac{(1+i)^n-1}{i(1+i)^n}$	$\frac{i}{(1+i)^n-1}$	$\frac{(1+i)^n-1}{i}$
Given To Find	P F	F P	P A	A P	F A	A F
Period n	i = 9%					
1	1.090	.9174	1.090	.9174	1.000	1.000
2	1.188	.8417	.5685	1.759	.4785	2.090
3	1.295	.7721	.3951	2.531	.3051	3.278
4	1.412	.7084	.3087	3.240	.2187	4.573
5	1.539	.6499	.2571	3.890	.1671	5.985
6	1.677	.5963	.2229	4.486	.1329	7.523
7	1.828	.5470	.1987	5.033	.1087	9.200
8	1.993	.5019	.1807	5.535	.0907	11.03
9	2.172	.4604	.1668	5.995	.0768	13.02
10	2.367	.4224	.1558	6.418	.0658	15.19
11	2.580	.3875	.1469	6.805	.0569	17.56
12	2.813	.3555	.1397	7.161	.0497	20.14
13	3.066	.3262	.1336	7.487	.0436	22.95
14	3.342	.2992	.1284	7.786	.0384	26.02
15	3.642	.2745	.1241	8.061	.0341	29.36
16	3.970	.2519	.1203	8.313	.0303	33.00
17	4.328	.2311	.1170	8.544	.0270	36.97
18	4.717	.2120	.1142	8.756	.0242	41.30
19	5.142	.1945	.1117	8.950	.0217	46.02
20	5.604	.1784	.1095	9.129	.0195	51.16
21	6.109	.1637	.1076	9.292	.0176	56.76
22	6.659	.1502	.1059	9.442	.0159	62.87
23	7.258	.1378	.1044	9.580	.0144	69.53
24	7.911	.1264	.1030	9.706	.0130	76.79
25	8.623	.1160	.1018	9.823	.0118	84.70
26	9.399	.1064	.1007	9.929	.0107	93.32
27	10.25	.0976	.0997	10.03	.0097	102.7
28	11.17	.0895	.0989	10.12	.0089	113.0
29	12.17	.0822	.0981	10.20	.0081	124.1
30	13.27	.0754	.0973	10.27	.0033	136.3
31	14.46	.0691	.0967	10.34	.0067	149.6
32	15.76	.0634	.0961	10.41	.0061	164.0
33	17.18	.0582	.0956	10.46	.0056	197.8
34	18.73	.0534	.0951	10.52	.0051	197.0
35	20.41	.0490	.0946	10.57	.0046	215.7
36	22.25	.0449	.0942	10.61	.0042	236.0
37	24.25	.0412	.0939	10.65	.0039	258.4
38	26.44	.0378	.0935	10.69	.0035	282.6
39	28.82	.0347	.0932	20.73	.0032	309.1
40	31.41	.0318	.0930	10.76	.0030	337.9

* All formulae assume end-of-period payments.

P = a present sum of money; F = a future sum of money, equivalent to P at the end of n periods of time at discount rate of i; A = an end-of-period payment (or receipt) in a uniform series of payments (or receipts) over n periods at i interest rate.

Table C-4 - 6% UNIFORM PRESENT VALUE FACTORS MODIFIED FOR ESCALATION

Rate of Escalation

Year	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
1	.9528	.9623	.9717	.9811	.9906	1	1.009	1.019	1.028	1.038
2	1.861	1.888	1.916	1.944	1.972	2	2.028	2.057	2.086	2.115
3	2.726	2.779	2.883	2.888	2.944	3	3.057	3.115	3.173	3.232
4	3.550	3.637	3.725	3.815	3.907	4	4.095	4.192	4.291	4.392
5	4.335	4.462	4.591	4.724	4.860	5	5.143	5.290	5.441	5.595
6	5.084	5.256	5.433	5.616	5.805	6	6.201	6.409	6.623	6.844
7	5.727	6.019	6.251	6.491	6.741	7	7.269	7.549	7.839	8.140
8	6.476	6.755	7.046	7.350	7.668	8	8.347	8.710	9.089	9.485
9	7.124	7.462	7.818	8.192	8.586	9	9.435	9.893	10.37	10.88
10	7.740	8.143	8.568	9.019	9.496	10	10.53	11.10	11.70	12.33
11	8.328	8.798	9.298	9.830	10.40	11	11.64	12.33	13.06	13.83
12	8.888	9.428	10.01	10.63	11.29	12	12.76	13.58	14.45	15.39
13	9.422	10.03	10.69	11.41	12.17	13	13.89	14.89	15.89	17.01
14	9.930	10.62	11.36	12.17	13.05	14	15.03	16.15	17.37	18.69
15	10.41	11.18	12.01	12.92	13.92	15	16.18	17.48	18.89	20.43
16	10.88	11.72	12.65	13.66	14.78	16	17.35	18.82	20.45	22.24
17	11.32	12.24	13.26	14.38	15.63	17	18.52	20.20	22.06	24.12
18	11.73	12.74	13.86	15.09	16.47	18	19.70	21.60	23.71	26.07
19	12.13	13.22	14.44	15.79	17.31	19	20.90	23.03	25.41	28.09
20	12.51	13.69	15.00	16.47	18.13	20	20.10	24.48	27.16	30.19
21	12.88	14.13	15.55	17.14	18.95	21	23.32	25.96	28.96	32.36
22	13.22	14.56	16.08	17.80	19.76	22	24.55	27.47	30.80	34.62
23	13.55	14.97	16.59	18.45	20.57	23	25.79	29.01	32.70	36.97
24	13.87	15.37	17.10	19.08	21.36	24	27.05	30.57	34.66	39.40
25	14.16	15.75	17.58	19.70	22.15	25	28.31	32.17	36.67	41.92
26	14.45	16.12	18.06	20.31	22.93	26	29.59	33.79	38.43	44.54
27	14.72	16.47	18.52	20.91	23.71	27	30.88	35.45	40.86	47.26
28	14.98	16.81	18.97	21.49	24.48	28	32.18	37.14	43.04	50.08
29	15.22	17.14	19.40	22.07	25.24	29	33.49	38.86	45.29	53.01
30	15.46	17.46	19.82	22.64	25.99	30	34.81	40.61	47.60	56.05
31	15.68	17.76	20.23	23.19	26.73	31	36.15	42.39	49.97	59.20
32	15.90	18.05	20.53	23.73	27.47	32	37.50	44.45	53.83	62.47
33	16.10	18.33	21.02	24.27	28.20	33	38.87	46.07	54.93	65.87
34	16.29	18.60	21.40	24.79	28.93	34	40.24	47.95	57.51	69.39
35	16.48	18.87	21.76	25.30	29.65	35	41.63	49.88	60.17	73.05
36	16.65	19.12	22.12	25.81	30.36	36	43.03	51.84	62.90	76.84
37	16.82	19.36	22.47	26.30	31.06	37	44.45	53.83	65.71	80.78
38	16.98	19.59	22.80	26.79	31.76	38	45.88	55.87	68.59	84.87
39	17.13	19.81	23.13	27.26	32.45	39	47.32	57.94	71.56	89.11
40	17.28	20.03	23.44	27.73	33.13	40	48.78	60.05	74.62	93.51

SLIDE C-3

DISCOUNTING FORMULAS

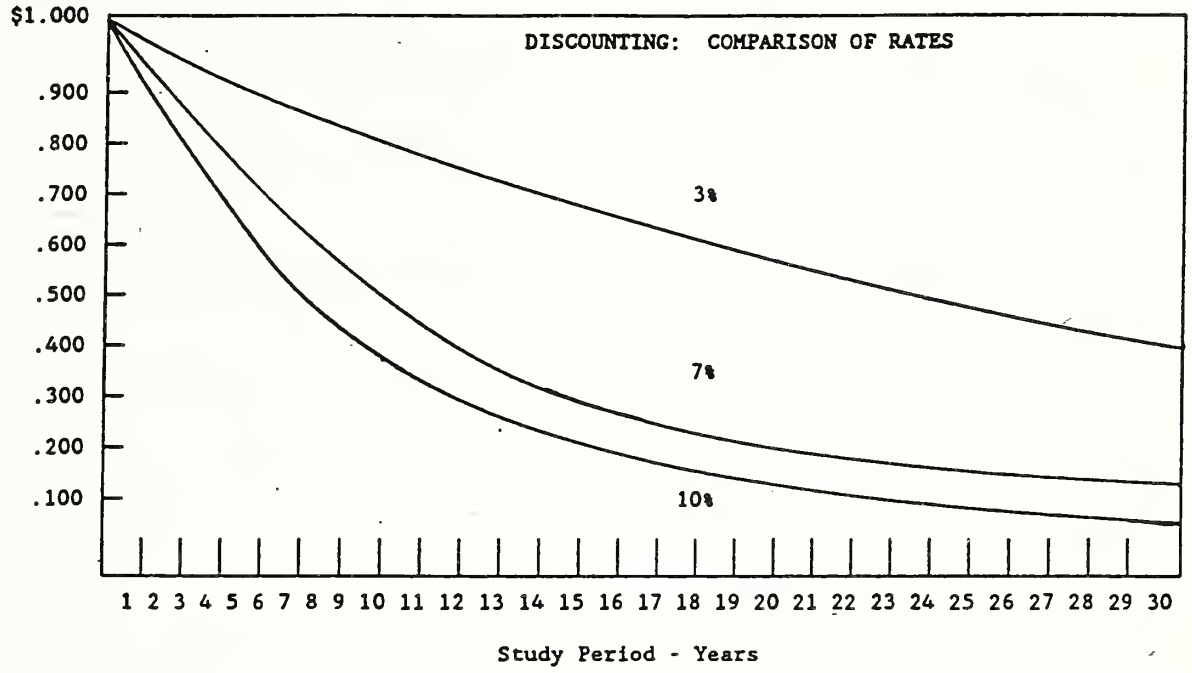
Amount to be discounted	Formula
single future amount	$P = F \times SPW$
recurring annual amount	$P = A \times UPW$
changing annual amount	$P = A_0 \times UPW^*$

where:

SPW = Single Present Worth factor
UPV = Uniform Present Worth factor
UPV*= Modified Uniform Present Worth factor

NOTES:

SLIDE C-4



NOTES:

SLIDE C-5

DISCOUNTING EXAMPLE

Find present value (P) of a future replacement cost (F)

- replacement cost: $10,000
- time of replacement: end of year 6
- discount rate: 3%

NOTES:

SLIDE C-6

Solution:

P = F x SPW

= ____ X ____

= $_____

NOTES:

SLIDE C-7

DISCOUNTING EXAMPLE

Find present value (P) of an annually recurring maintenance cost (A)

- annual maintenance cost: $200
- occurrence: end of each of 12 years
- discount rate: 9%

NOTES:

SLIDE C-8

Solution:

$$P = A \times UPW$$

$$= \$_____$$

NOTES:

SLIDE C-9

DISCOUNTING EXAMPLE

Find present value (P) of energy costs which are changing at a constant rate

- annual energy cost at today's price (A_0): $25,000
- occurrence: end of years 1-7
- discount rate: 6%
- projected annual rate of change: 2%

NOTES:

SLIDE C-10

Solution:

$P = A_0 \times UPW^*$

$= _____ \times _____$

$= \$_____$

NOTES:

SLIDE C-11

DISCOUNTING EXAMPLE

Find present value (P) of energy costs which are changing at annual rates projected by DOE

- annual energy cost at today's price (A_0): $50,000
- occurrence: beginning 1988 and continuing over 25 years
- building location: Federal office building in Atlanta
- energy type: natural gas
- DOE 1988 energy price projections

NOTES:

SLIDE C-12

Solution:

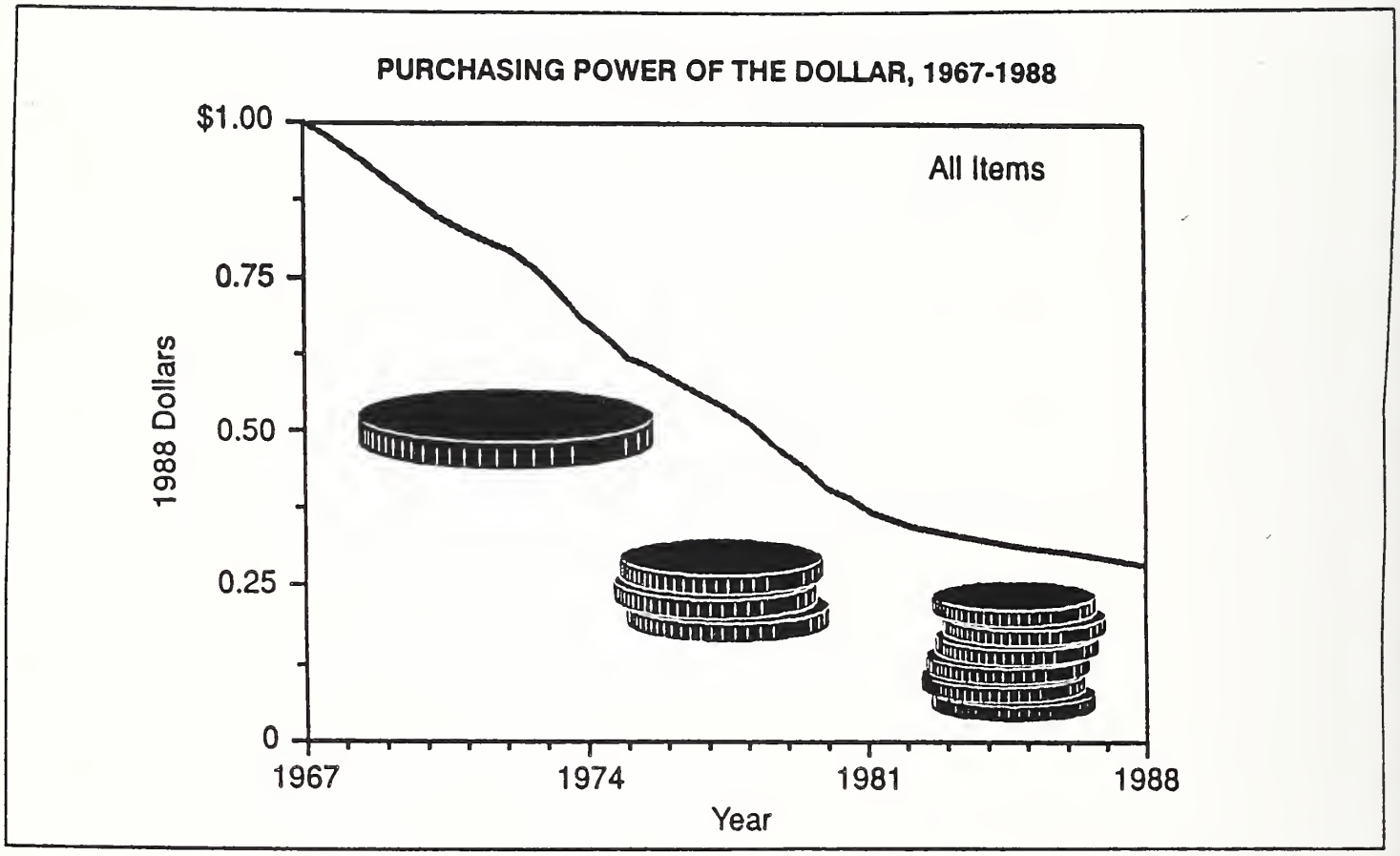
$P = A_0 \times UPW^*$

$= _____ \times _____$

$= \$_____$

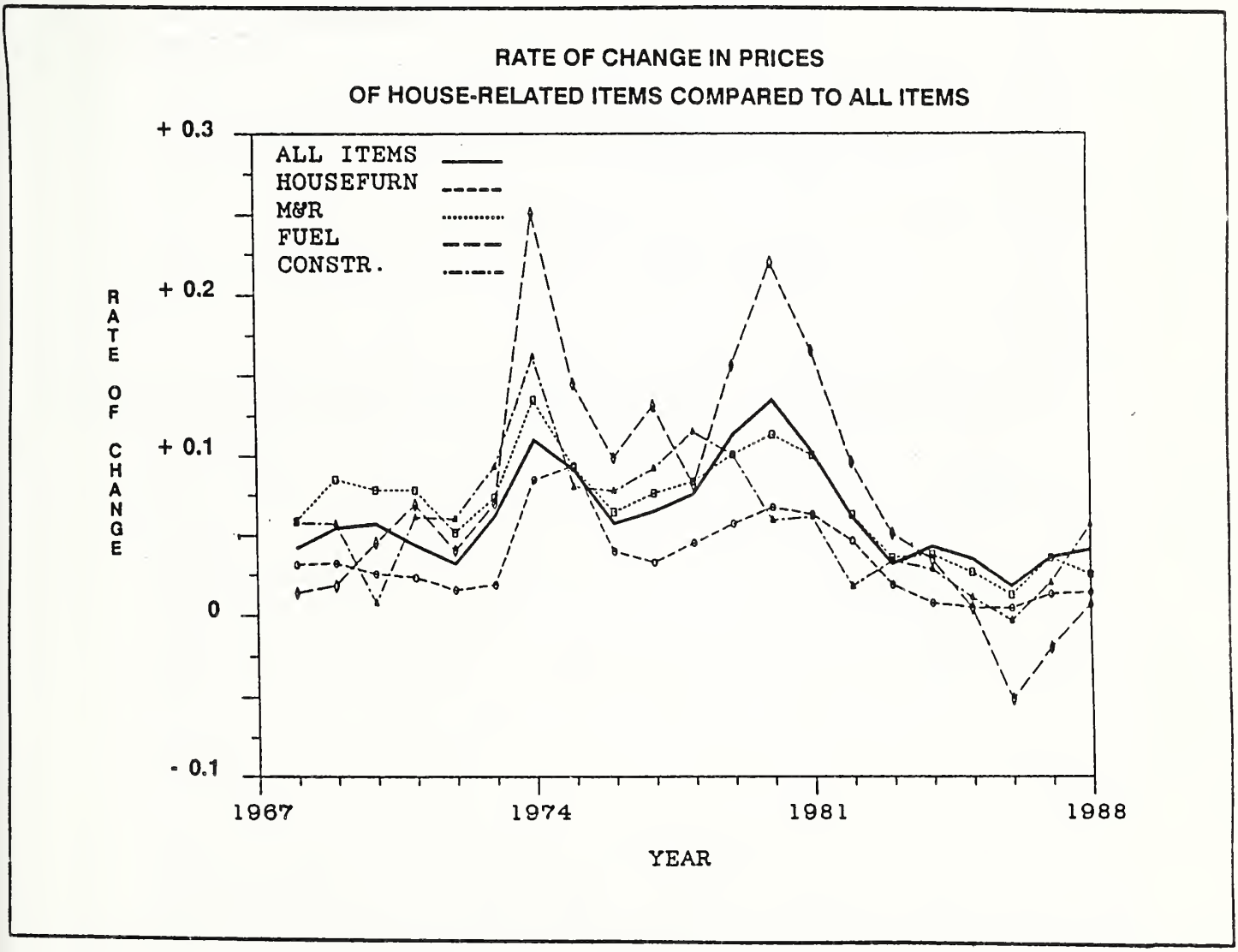
NOTES:

SLIDE C-13



NOTES:

SLIDE C-14
(series a to d)



NOTES:

SLIDE C-15

Two approaches for dealing with inflation

1. work in absolute terms (current $ & nominal discount rate)

2. work in relative terms (constant $ & real discount rate)

NOTES:

CASH-FLOW MODELING

Cash-Flow Diagram:

Slide C-1 shows a cash-flow diagram. Diagraming cash flows provides a visual checklist of relevant effects including their timing. It organizes data. It helps others grasp the problem quickly. It is easy to do, because it is usually more of a sketch than a formal drawing.

Cash-Flow Modeling:

It is common practice in economics to model cash amounts which occur at varying times within the year as though they occur either at the beginning of the year, middle of the year, end of the year, or continuously throughout the year, rather than exactly as each amount actually is paid. Additionally, cash amounts which are more or less repeating are typically modeled as a uniformly recurring series. The effort to describe exactly the timing of costs and benefits is generally not worthwhile. Complex flows of costs and benefits can be represented in simple form with little sacrifice in accuracy.

Common-time Convention:

Once the patterns of cash flows are established, the next step is to convert them all to a common time. In fact, the main reason we lay them out in the diagram is because it helps identify how they must be moved.

The common time can be

(1) the present, whereby all cash amounts are converted to an equivalent lump-sum value occurring now, i.e., a present value (this conversion is illustrated by slide C-2);

(2) annually, whereby all cash amounts are converted to an equivalent value occurring in a uniform amount each year over the study period, i.e., an annual value; and

(3) the future, whereby all cash amounts are converted to an equivalent lump-sum value occurring at some common time in the future, i.e., a future value.

[For uniformity, Federal agencies use present values.]

TIME VALUE OF MONEY CONCEPT

"Opportunity cost" is the return that could be realized if funds were used for the best alternative use instead of for the use at hand.

If an investor cannot realize a rate of return greater than the opportunity cost, there is no economic reason to undertake the investment at hand. That is, the opportunity cost is the investor's "minimum acceptable rate of return" or MARR.

The implication of opportunity cost for energy-related decisions is that the higher the investor's opportunity cost, the less willing the investor is to forego present investment dollars for future energy savings.

When the MARR is used to find the present-value equivalent of a future amount, such as the present value of a stream of energy savings, it is called a "discount rate." Hence, the discount rate equals the investor's MARR and reflects the investor's opportunity cost.

Time Relationships:

You can calculate a person's or organization's MARR if you know a future amount which the person or organization is willing to trade for a present amount. Likewise, if you know the MARR, you can calculate the future amount for which a person or organization is willing to trade a present amount; or the present amount for which a person or organization is willing to trade a future amount.

To solve for MARR, when F and P are given:

$$MARR = -1 + (F/P)^{1/n} \quad (8)$$

To solve for F, when P and MARR are given:

$$F = P\ (1 + MARR)^n \quad (9)$$

To solve for P, when F and D are given:

$$P = F/(1+D)^n \quad (10)$$

where,

P = present amount,

MARR = investor's minimum acceptable rate of return,

F = future amount which is equally acceptable to the investor as P,

n = number of periods, and

D = discount rate (equal to the investor's MARR).

Table C-1 lists common formulas for converting various cash flows to time-equivalent amounts.

Slide C-3 lists formulas frequently used in evaluating energy-related investments. Note that they are expressed in simplified form, using discount factors.

Tables C-2, C-3, and C-4 provide discount factors. Those in table C-2 are all based on a discount rate of 3%; those in table C-3 on a discount rate of 9%; and those in table C-4 on 6%. Note that table C-4 contains only one type of factor. These are uniform present worth factors modified for escalation.

Slide C-4 shows the impact of the discount rate over time. The higher the discount rate and the longer into the future a dollar is received or paid, the lower its equivalent value today.

Slides C-5 through C-12 show examples of discounting. For reference, a set of sample problems with solutions is provided at the end of this module, just before Exercise C-1.

WHAT TO DO ABOUT INFLATION

Just as a constant unit of measure is required to determine the physical dimensions of a building (foot or meter), so are dollars with a constant unit of measure required for measuring economic performance.

Inflation reduces the purchasing power of the dollar as illustrated by slide C-13. This changes the unit for measuring economic impact. Measuring economic effects in inflating or deflating dollars, without adjustment, is meaningless.

There are two correct (and equivalent) ways to deal with inflation:

(1) Include estimated general price inflation in cost and benefit estimates and in the discount rate, such that "current" dollar cash flows are discounted using a "nominal" discount rate which cancels out general price inflation.

With this approach, for example, projections of benefits and costs include the absolute (actual) change in prices of individual items (shown in Slide C-14), and the discount rate includes the absolute change in the average price of all items.

(2) Include in estimates of cost and benefits only those changes which are expected to be faster or slower than the general price inflation rate, and discount the "constant" dollar cash flows using a "real" discount rate which also excludes general price inflation.

With this approach, for example, projections of benefits and costs include only the "differential change" in prices of individual items relative to the change in the average price of all items, and the discount rate excludes the absolute change in the average price of all items.

Slide C-15 lists the two approaches to treating inflation.

Relationships of "Real" and "Nominal" Rates

$$e = (1 + E)/(1 + I) - 1 \qquad (11)$$

$$E = (1 + e)\ (1 + I) - 1 \qquad (12)$$

$$d = (1 + D)/(1 + I) - 1 \qquad (13)$$

$$D = (1 + d)\ (1 + I) - 1 \qquad (14)$$

where,

e = "real" rate of change, excluding inflation;
E = "nominal" rate of change, including inflation;
d = "real" discount rate, excluding inflation; and
D = "nominal" discount rate, including inflation.

Discounting Formulas and Sample Problems with Solutions:

Find F, given P

$F = P(1 + MARR)^n$

$F = P \times SCA\ factor$

Given P = \$10,000
MARR = 9%
n = 10 years

$F = \$10,000 \times (1+0.09)^{10}$
$F = \$10,000 \times 2.3674$
$= \$23,674$

Find P, given F

$P = F\ [1/(1+D)^n] = F/(1+D)^n$

$P = F \times SPW\ factor$

Given F = \$6,000
D = 8%
n = 4 years

$P = \$6,000 \times 0.7350$
$= \$4,410$

Find P, given A

$P = A\ [((1+D)^n-1)/D(1+D)^n]$

$P = A \times UPW\ factor$

Given A = \$2,000
D = 11%
n = 20 years

$P = 2,000 \times 7.9629$
$= \$15,926$

Find P, given A_0 and E

$$P = A_0 \sum_{j=1}^{n} [(1 + E)/(1 + D)]^j$$

$$= A_0\ [((1 + E)/(D - E))\ (1-((1 + E)/(1+D))^n)]$$

$P = A_0 \times UPW^* \ factor$

Given A_0 = \$100
D = 10%
n = 10 years
E = 8%

P = \$100 x 11.10
= \$1,110

Discounting Formulas and Sample Problems with Solutions, continued:

Find P, given A_0 and DOE energy price projections

$P = A_0 \times UPW^*_{DOE}$

Given A_0	= $10,000
Location	= New York City
Energy Pricing	= Office Building
Energy Type	= Distillate
Future Prices	= 1988 projections
n	= 15 years

$P = \$10,000 \times 12.16 = \$12,160$

EXERCISE C-1

Discounting Using Discount Factor Tables

1. Find the value at the end of seven years of a present amount of $100 which grows at a rate of 9% compounded annually. (Sketch a cash-flow diagram.)

2. Find the present value of $1,000 to be received at the end of 20 years when the discount rate is 10%. (Sketch a cash-flow diagram.)

EXERCISE C-1, CONTINUED

3. You are notified that you have won the million-dollar lottery, and that you will receive the $1,000,000 in $50,000 installments paid at the end of each of the next 20 years. Assuming you can invest funds on hand to earn 10% per annum, what is the present value of your prize? (Sketch a cash-flow diagram.)

4. What is the estimated present value of a $10,000 cost (in constant dollars) to be incurred five years from now, based on a 7% (real) discount rate?

EXERCISE C-1, CONTINUED

5. What is the estimated present value of a uniform annual cost of $1,000 (in constant dollars) that is expected to recur over the next 20 years, if the discount rate is 7% (real)?

6. What is the present value of the energy savings from a retrofit project in Seattle which reduces annual electricity bills in a Federal office building by $5,000 at today's prices, assuming that savings accrue over the next 25 years.

CALCULATING LIFE-CYCLE COSTS, NET SAVINGS, SAVINGS-TO-INVESTMENT RATIO, ADJUSTED INTERNAL RATE OF RETURN, AND TIME TO PAYBACK

MODULE D

75 MINUTES

Lecture, Discussion, and Problem Solving

OBJECTIVES

At the conclusion of this session, you are expected to be able to

- calculate LCC, NS, SIR, AIRR, and PB for a Federal project;
- describe the special features of a Federal economic evaluation of energy-related investments; and
- decide whether to accept or reject a project based on economic measurements.

FEDERAL CRITERIA

SLIDE D-1

FEDERAL CRITERIA
o DOE discount rate
o constant dollars
o present values
o quantity of energy at boundary
o actual agency energy prices
o DOE energy price projections
o instantaneous or delayed investment
o study period 25 years
o end-of-year or when-actually-incurred cash flows
o no evaluation required under certain conditions

NOTES:

WORKSHEETS

- Retrofit Worksheets for Calculating Life-Cycle Costs, Net Savings, and Savings-to-Investments Ratio
- New Building Design Worksheets for Calculating Life-Cycle Costs
- Solar Energy Worksheets

(See Handbook 135)

NOTES:

CALCULATIONS

SLIDE D-2

DATA

Location:	Washington, D.C.
Building:	House on a military base (commercial pricing)
Performance:	Both systems meet performance requirements
Discount Rate:	7%, real
Energy Prices:	Based on DOE 1988 projections

Costs stated in constant 1989 dollars.

NOTES:

SLIDE D-3

Base Case: Baseboard Heating System with Window Air Conditioners

- Purchase and installation costs: $1,500

  Baseboard heaters = $500
  Window air conditioners = $1,000

- Annual maintenance cost = $50

- Air conditioner repairs in year 8 = $400

- Salvage value: $150

  Baseboard = $50 (10% of initial cost)
  Window air conditioners = $100 (10% of initial cost)

- Annual electricity cost valued at the beginning of the study period = $1,200

- Useful life = 15 years

- Study period = 15 years

NOTES:

SLIDE D-4

Alternative System: Heat Pump

- Purchase and installation cost = $3,000
- Annual maintenance cost = $100
- Compressor repair at end of year 8 = $600
- Salvage value (net of disposal costs) at end of life = $250
- Annual electricity costs, valued at the beginning of the study period = $800
- Useful life = 15 years
- Study period: 15 years

NOTES:

SLIDE D-5

Calculate LCC of Base Case:

$$LCC = I - S + M + R + E$$

$I = \$1,500$

$S = \$150 \times SPW_{15}$

$M = [\$50 \times UPW_{15}] + [\$400 \times SPW_{8}]$

$R = 0$

$E = \$1,200 \times UPW^{*}_{Reg3,Com,Elec,15}$

$$LCC = \$1,500 - (\$150 \times 0.36) + (\$50 \times 9.11) + (\$400 \times 0.58) + (\$1,200 \times 8.88)$$

$$= \$1500 - \$54 + \$455.50 + \$232 + \$10,656$$

$$= \$12,790$$

NOTES:

SLIDE D-6

Calculate LCC of Alternative:

$I = \$3,000$

$S = \$250 \times SPW_{15}$

$M = [\$100 \times UPW_{15}] + [\$600 \times SPW_{8}]$

$R = 0$

$E = \$800 \times UPW^{*}_{Reg3,Com,Elec,15}$

$$LCC = \$3,000 - (\$250 \times 0.36) + (\$100 \times 9.11) + (\$600 \times 0.58) + (\$800 \times 8.88)$$

$$= \$3,000 - \$90 + \$911 + \$348 + \$7,104$$

$$= \$11,273$$

NOTES:

SLIDE D-7

Calculate NS of Heat Pump from LCCs:

$$NS = LCC_{BC} - LCC_{A}$$

$$= \$12,790 - \$11,273$$

$$= \$1,517$$

NOTES:

SLIDE D-8

Calculate NS of Heat Pump by Subtracting Differences in Costs from Savings:

$$NS = [\Delta E] - [\Delta I - \Delta S + \Delta M + \Delta R]$$

$$\Delta E = (\$1,200 - \$800) \times UPW^{*}_{Reg3,Com,Elec,15}$$
$$\Delta I = (\$3,000 - \$1,500)$$
$$\Delta S = (\$250 - \$150) \times SPW_{15}$$
$$\Delta M = [(\$100 - \$50) \times UPW_{15}] + [(\$600 - \$400) \times SPW_{8}]$$
$$\Delta R = 0$$

$$NS = [(\$1,200 - \$800) \times 8.88]$$
$$- \left[(\$3,000 - \$1,500)\right.$$
$$- (\$250 - \$150) \times 0.36$$
$$\left. + [(\$100 - \$50) \times 9.11] + [(\$600 - \$400) \times 0.58]\right]$$
$$= [\$3,552] - [\$1,500 - \$36 + \$571.50]$$
$$= \$1,517$$

NOTES:

SLIDE D-9

Calculate SIR of Heat Pump:

$$SIR = [\Delta E - \Delta M]/[\Delta I - \Delta S + \Delta R]$$

$$= [\$3,552 - \$571.50]/[\$1,500 - \$36 + 0]$$

$$= \$2,980.50/\$1,464$$

$$= 2.04$$

NOTES:

SLIDE D-10

Formula for Calculating AIRR:

$$AIRR = -1 + [TV/PVC]^{1/N}$$

TV = terminal value of savings
PVC = present value investment-related costs

NOTES:

SLIDE D-11

Calculate TV Savings of Heat Pump:

$$TV = \sum_{j=1}^{N} (\Delta\bar{E}_j - \Delta\bar{M}_j)(1 + r)^{N-j}$$

=	[($400 x 0.99) - $50] x $(1.07)^{14}$	= $892.17
+	[($400 x 0.98) - $50] x $(1.07)^{13}$	= $824.17
+	[($400 x 0.97) - $50] x $(1.07)^{12}$	= $761.24
+	[($400 x 0.96) - $50] x $(1.07)^{11}$	= $703.02
+	[($400 x 0.96) - $50] x $(1.07)^{10}$	= $657.03
+	[($400 x 0.95) - $50] x $(1.07)^{9}$	= $606.69
+	[($400 x 0.96) - $50] x $(1.07)^{8}$	= $573.87
+	[($400 x 0.96) - $50 - $200] x $(1.07)^{7}$	= $215.17
+	[($400 x 0.97) - $50] x $(1.07)^{6}$	= $507.25
+	[($400 x 0.98) - $50] x $(1.07)^{5}$	= $479.67
+	[($400 x 0.98) - $50] x $(1.07)^{4}$	= $448.29
+	[($400 x 1.00) - $50] x $(1.07)^{3}$	= $428.77
+	[($400 x 1.00) - $50] x $(1.07)^{2}$	= $400.72
+	[($400 x 1.00) - $50] x $(1.07)^{1}$	= $374.50
+	[($400 x 1.00) - $50] x $(1.07)^{0}$	= $350.00
=	$8,223	

[Note use of Energy Price Indices from appendix B, Table Ca-3, to estimate yearly cash flow.]

r = reinvestment rate = discount rate

NOTES:

SLIDE D-12

Calculate PVC of Heat Pump:

$$PVC = \Delta I + \Delta R - \Delta S$$

$$= (\$3,000 - \$1,500) + 0 - \$36$$

$$= \$1,464$$

NOTES:

SLIDE D-13

Calculate AIRR of Heat Pump:

$$AIRR = -1 + [TV/PVC]^{1/N}$$

$$= -1 + [\$8,223/\$1,464]^{1/15}$$

$$= 0.12 \text{ or } 12\%$$

NOTES:

SLIDE D-14

Estimate SPB of Heat Pump:

$$SPB = \Delta I/\Delta S$$

$$= (\$3,000 - \$1,500)/(\$400 - \$50)$$

$$= (\$3,000 - \$1,500)/\$350$$

$$= 4.3$$

NOTES:

SLIDE D-15

APPROXIMATE DPB FROM SPB:

- o find in UPW* table, ELEC column
- o find factor closest to SPB of 4.3
- o read off corresponding year in N column

(Appendix B) TABLE B-3a. UPW* DISCOUNT FACTORS
Census Region 3

N	ELEC	DIST	RESID	NATGAS	COAL
1	0.93	1.01	0.98	0.95	0.95
2	1.78	1.97	1.90	1.84	1.85
3	2.58	2.89	2.76	2.68	2.71
4	3.31	3.78	3.57	3.46	3.53
5	3.99	4.64	4.37	4.22	4.31
6	4.63	5.49	5.17	4.94	5.05
7	5.23	6.32	6.00	5.64	5.75
8	5.79	7.14	6.85	6.32	6.42
9	6.31	7.96	7.71	6.97	7.05

NOTES:

FEDERAL CRITERIA

Slide D-1 lists principal criteria for performing economic evaluations in support of Federal energy conservation decisions. Each criterion is discussed in the following sections.

DOE Discount Rate:
To evaluate energy conservation or renewable energy projects, discount future amounts to present value using the rate set each year by the Secretary of DOE. It is a "real" discount rate based on current market rates. Prior to FY 1990, the discount rate for evaluating energy conservation projects was 7% (real), set by Congress. (To evaluate most other Federal projects except those specifically exempted, discount future amounts to present value or annual value using a 10% (real) discount rate.)

Constant Dollars:
Estimate all future amounts in constant dollars, with the purchasing power of the dollar fixed as of the base year. For example, if an LCC evaluation were being made in 1990, a future cost expected to occur in 1995 should be stated in 1990 dollars without an estimate for the purely inflationary/ deflationary trends that may cause the general level of prices in the economy to change between 1990 and 1995.

This approach allows for the inclusion in data estimates of "differential price changes," i.e., changes that are projected to be faster or slower than the projected rate of general price inflation, when there is a reasonable basis for estimating such changes.

Present Values:
For consistency, Federal agencies use present values for evaluating energy-related projects.

FEDERAL CRITERIA, continued

Quantity of Energy at Boundary:

Estimate the quantity of energy at the building boundary. The life-cycle cost approach uses energy prices to evaluate the cost effectiveness of an investment. Because these prices already reflect the relationship of "boundary energy" to "source energy," the measure of the physical quantity of energy associated with a building or building system should be based on the quantity of energy delivered to the boundary of the Federal building for the purpose of making the LCC evaluation.

A possible exception is when fuel is used to generate electricity on site. If, in the case of on-site generation of electricity, the agency estimates the value of the electricity on the basis of the actual price of electricity to the agency, the quantity of electricity generated should be used in the LCC evaluations, not the boundary purchases of fuel to produce the electricity. If, however, the agency estimates the value of on-site electricity/steam/hot water on the basis of the input fuel plus generating and distributing costs, the quantity of the input energy should be based on the boundary purchases of the fuel.

Actual Agency Energy Prices:

Federal agencies should use the actual prices of energy to them in the base year to establish base-year energy costs or savings. When fuel is purchased by a Federal agency to produce its own electricity, steam, or hot water on site, the base-year price of energy used to make LCC evaluations should be (a) the price of the input fuel to the agency plus the costs incurred by the agency in generating and distributing the electricity/steam/hot water, or (b) for electricity only, the agency price of electricity.

FEDERAL CRITERIA, continued

Actual Agency Energy Prices, continued:
If the energy conservation or renewable energy investment being evaluated affects the utility pricing structure, such as through time-of-day charges or demand changes, the demand and usage components should be broken out separately in establishing base-year energy costs.

DOE Energy Price Projections:
To account for anticipated change in future energy prices, use DOE energy price projections unless specifically exempted. DOE projects the future prices of coal, fuel oil, electricity, and natural gas to rise at rates different from the rate of change in the general level of prices. These "differential energy price escalation rates" are projected by Census Region, by sector, by fuel type, and over time. The sample UPW* factors of appendix B are based on DOE 1988 projections.

The DOE energy price projections can be incorporated into LCC evaluations in any of the four following ways:

(1) Multiply the appropriate UPW* factor of appendix B (tables B-1 through B-4) times the initially valued annual energy cost or savings to calculate present value; or

(2) Apply the appropriate energy price indices of appendix B (tables Ca-1 through Ca-4) to base-year prices, in the year-by-year approach described in appendix G of NBS Handbook 135; or

(3) Use the escalation rates of appendix B (tables Cb-1 through Cb-4) to calculate future energy prices, apply the prices to future quantities, and discount the result to present value; or

FEDERAL CRITERIA, continued

DOE Energy Price Projections, continued:

(4) Use an up-to-date version of the companion FBLCC or NBSLCC Computer Program, which contains the DOE-projected rates of change in energy prices in a file on the diskette.

There are two exceptions to using the DOE energy price projections:

(1) If base-year utility prices are broken into demand and usage components, and if component-specific escalation rates are available from the energy supplier, those rates can be used in lieu of the DOE rates. (If the component-specific projections are not available, but base-year utility prices are broken into demand and usage components, the DOE projections can be applied to each of the price components for the purpose of estimating life-cycle costs or savings.)

(2) A Federal agency conducting life-cycle analyses of energy projects for Federal buildings in a foreign country should use escalation rates which are "reasonable under the circumstances," and may refer to the U.S. average DOE-projections as shown in appendix B, tables B-5a, B-5b, Ca-5, and Cb-5.

Instantaneous or Delayed Investment:

At the discretion of the agency, investment costs, including costs of design, engineering, purchase, and installation (exclusive of sunk costs) may be treated as a lump-sum present value amount occurring at the beginning of the base year. Treating investment costs as occurring at the beginning of the base year is a simplification which allows these costs to be considered already in present value dollars without discounting. It avoids the need to adjust for the corresponding delay in the onset of other cash flows, such as energy costs.

FEDERAL CRITERIA, continued

Instantaneous or Delayed Investment, continued:

To assume that the initial investment costs for all projects to be evaluated in a given year occur at the beginning of that year is a simplification that gives somewhat less accurate results than a detailed analysis of actual estimated cash flows. Furthermore, it should be recognized that a detailed scheduling and accounting of costs is an important aspect of project management. However, for the purpose of making investment decisions, the difference in the results of a detailed cash-flow analysis and of the simplified approach is generally not great.

If the agency wishes, however, it can make a detailed analysis, taking into account project delays. This is, in fact, necessary when making choices among mutually exclusive project alternatives which have as a primary difference their time required for implementation. For example, if a natural gas heating system is being compared with an oil heating system for retrofit to a building which now has an electric resistance system, but access to the natural gas will not be available for three more years, the comparison relative to the existing system is between installing the oil heating system now and having it over the entire study period versus having the existing, or some other interim system, for three years and the gas system thereafter. In this example, the investment costs for the oil heating system would be treated as a lump-sum amount at the beginning of the base year, as would the costs for the interim system (either the residual value of the electric system if it is the interim system or the investment cost of some other system which might be the designated interim system). The investment costs for the gas heating system would be treated as a future amount occurring at the end of the third year.

FEDERAL CRITERIA, continued

Study Period 25 Years (Plus Planning/Scheduling Period):
For selecting among mutually exclusive designs and/or sizes for a given building or building system, use the same study period to evaluate all of the choices, not to exceed either 25 years or the period of intended use of the building.

When amounts are expressed in present values, it is essential that the same study period be used to evaluate mutually exclusive choices--such as alternative designs for a given building, alternative layers of glazing in windows, alternative solar collector designs and sizes, or alternative levels of thermal insulation. Choosing different study periods will automatically cause one choice to have a different life-cycle cost or net savings than another, because its cash flows will be examined over a longer or shorter time period.

The common study period for evaluating mutually exclusive choices, not to exceed 25 years from the beneficial occupancy date of the building, may be:

(a) The period of intended use of the building, with appropriate replacement and salvage values for each alternative.

(b) The lowest common multiple of the estimated lives of the mutually exclusive alternatives, with appropriate replacements for each alternative.

To evaluate or rank a given building system for a Federally owned building, choose a study period that is the lesser of (a) 25 years, (b) the estimated life of the building system, or (c) the period of intended use of the building.

FEDERAL CRITERIA, continued

Study Period 25 Years (Plus Planning/Scheduling Period), continued

For evaluating energy use and related investments in a leased Federal building, choose a study period that is the lesser of 25 years or the effective remaining term of the lease (including renewal options likely to be exercised). Since Federal agencies are required to consider only those costs that accrue to the Federal government in evaluating projects for leased buildings, the study period should be the effective remaining term of the lease, not in excess of the 25 year limit. Renewal options may be taken into account, if appropriate, in setting the study period.

End-of-Year or When-Actually-Incurred-Cash Flows:
Agencies have flexibility in modeling cash flows within years. They may use end-of-year, beginning-of-year, middle-of-year, continuous, or when-actually-incurred cash-flow modeling.

No Evaluation Required Under Certain Conditions:
Presume that an alternative building system is cost effective if its investment and other costs are insignificant.

Presume that an alternative building system is not cost effective if the building is (a) occupied under a short-term lease without renewal option or with a renewal option that is not likely to be exercised, (b) occupied under a lease that includes the cost of utilities in the rent, with no pass-through to the government of energy savings, or (c) scheduled for demolition or retirement within three years.

WORKSHEETS

A set of worksheets have been developed with step-by-step instructions to guide you through evaluating (a) new building design alternatives, (b) retrofit building systems, and (c) solar energy systems. The use of these worksheets is discretionary, but it is required that a structured format be used for documenting the evaluation. (See Handbook 135.)

CALCULATIONS

Slides D-2 through D-15 demonstrate for a sample problem how to calculate LCC, NS, SIR, AIRR, SPB, and DPB.

- Slide D-2 gives background data.
- Slide D-3 list data for the system with the lowest first cost.
- Slide D-4 lists data for the alternative system.
- Slide D-5 shows calculation of LCC for the lower first-cost system.
- Slide D-6 shows calculation of LCC for the alternative system.
- Slide D-7 shows calculation of NS from LCCs.
- Slide D-8 shows calculation of NS by subtracting individual items of increased costs from increased savings.
- Slide D-9 shows calculation of SIR.
- Slides D-10, D-11, D-12, and D-13 show calculation of AIRR.
- Slide D-14 shows calculation of SPB.
- Slide D-15 shows approximation of DPB from SPB.

PROBLEM D-1

Calculating LCC, NS, and SIR

Use LCC and NS to determine if adding a solar hot water system to a military launderette is estimated to be cost-effective, and, if so, what funding priority it should receive relative to other energy conservation projects. The alternatives are to

(1) continue using the existing hot water system as it is, or

(2) add the solar hot water system and use the existing system as a backup.

Data and Assumptions:

Location: Arizona

Hot Water Load: 1,750 MBtu/year

Fraction of Load to be Supplied by Solar: 60%

Existing Hot Water Heater: Electric Resistance

Today's Price of Electricity: $20/MBtu

DOE Price Projections: Industrial pricing

Cost of Purchasing and Installing Solar Energy System: $140,000

Annual Electricity to Operate the Solar Energy System: 2% of annual load supplied by solar energy

Annual Maintenance & Repair Costs for the Solar Energy System: 3% of purchase and installation costs

System Lives: Both the existing system and the solar energy system are expected to last the remaining 15 years the launderette is expected to remain in use.

Salvage Value: 0

LCC COMPUTER PROGRAMS

MODULE E

90 MINUTES
Lecture and Computer Lab

OBJECTIVES

At the end of this session, you will be able to

- run the FBLCC or NBSLCC Computer Program;
- enter data inputs; and
- read the results from a screen printout.

OVERVIEW OF FBLCC & NBSLCC

SLIDE E-1

INTRODUCTION TO FBLCC AND NBSLCC

FBLCC: THE FEDERAL BUILDINGS LIFE-CYCLE COST PROGRAM

NBSLCC: NATIONAL BUREAU OF STANDARDS LIFE-CYCLE COST PROGRAM

For detailed descriptions and user's guides, see --

- o A User's Guide to the FBLCC Computer Program, NBS Tech Note 1222.
- o NBSLCC User's Guide, Chapter 5 of Comprehensive Guide for Least-Cost Energy Decisions (NBS Special Publication 709).
- o "DOC" file on disk for updated information.
- o "Hard copy" of DOC file at the end of this module, "Supplement to User's Guide."

SLIDE E-2

FBLCC

- life-cycle cost computations for analysis of Federal energy conservation projects
- based on NBS Handbook 135, Life-Cycle Costing Manual for the Federal Energy Management Program
- also supports OMB Circular A-94 requirements for LCC analysis of non-energy-related Federal building projects

NOTES:

SLIDE E-3

FBLCC and NBSLCC

- evaluate life-cycle costs of buildings and building systems over a specified time horizon
- compare LCCs of projects with the same purpose but with different costs and savings
- determine most cost-effective building or system for a specific operating environment
  - MS-DOS applications
  - compiled BASIC

NOTES:

SLIDE E-4

FBLCC

- o constant dollar analysis only
- o maximum study period = 25 years from end of planning/ construction period (FEMP)
  50 years (OMB A-94)
- o no tax-related or mortgage computations
- o planning/construction period: optional
- o current year is base year

NOTES:

SLIDE E-5

NBSLCC

- o life-cycle cost computations conforming with ASTM E-917 (Measuring Life-Cycle Costs of Buildings and Building Systems)
- o taxable and non-taxable projects (depreciation allowed)
- o constant or current dollar analysis
- o maximum study period = 50 years
- o financing costs can be included
- o up to 10-year planning/construction period allowed
- o base year can be specified

NOTES:

SLIDE E-6

FBLCC and NBSLCC FILES

- building characteristics files: Extension = .BCF
- LCC output files: Extension = .LCC
- extensions are automatically assigned
- filenames have maximum of 8 characters (no spaces):

  examples: HOUSE1.BCF HOUSE1.LCC
  HEATPUMP.BCF HEATPUMP.LCC

- files are always stored on drive B

NOTES:

SLIDE E-7

START UP

program disk in drive B

at DOS prompt, type B <Enter>

at DOS prompt, type **FBLCC** <Enter>
or
NBSLCC <Enter>

NOTES:

If you are running FBLCC on your own computer, you may want to install and run it from a hard disk or run the program disk from drive A. In any case, you will need to have a formatted disk in drive B to save and read your data files. (Files are written to and read from drive B in order to maintain consistency with the ASEAM energy analysis program.)

SLIDE E-8

INITIAL MENU

(1) LCCDATA -	create or modify building characteristics files for a project
(2) PRINTBCF -	print out building characteristics files for a project
(3) LCCMAIN -	compute project LCC, display summary, save LCC computations
(4) PRINTLCC -	print out detailed LCC report for a project
(5) COMPARE -	compute and print comparative LCC analysis for two alternative projects

select option by number (1-5)

NOTES:

SLIDE E-9

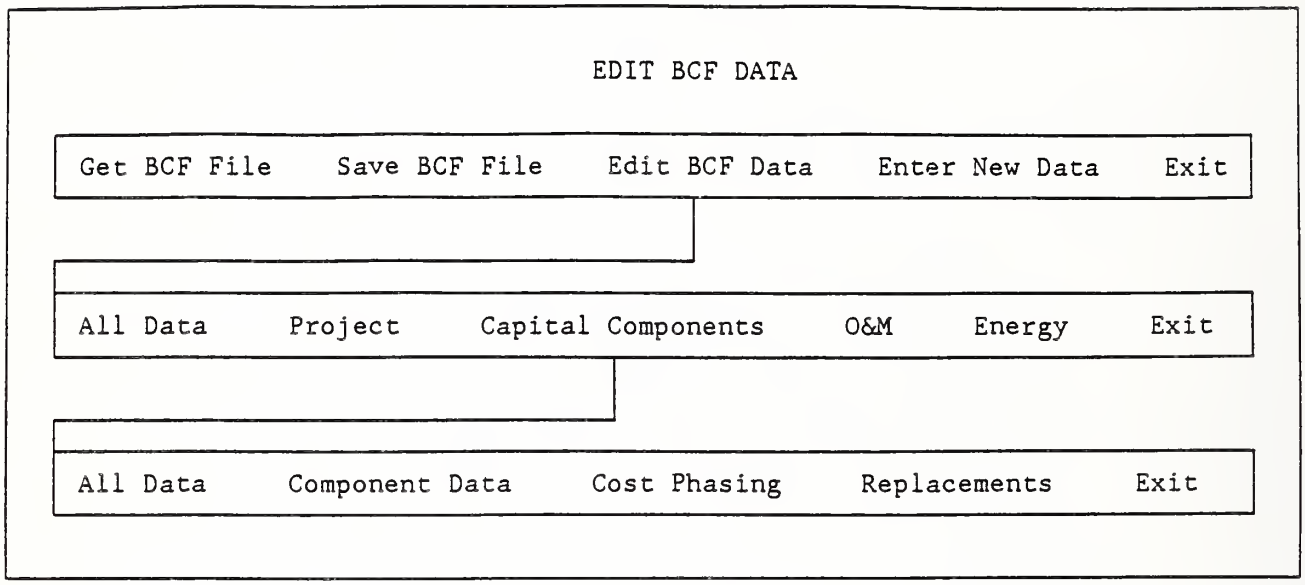
INITIAL LCCDATA SCREEN

Get BCF File	Save BCF File	Edit BCF Data	Enter New Data	Exit

- use right and left arrows to highlight choice, then press <Enter>
- get BCF File: need old file before editing
  BCF files on disk are displayed on screen;
  move highlight to desired file and press <Enter>
- save BCF file: enter new file name for saved file
- enter new data: start new BCF file
- ALWAYS SAVE YOUR FILE BEFORE EXITING OR GETTING NEW FILE

NOTES:

SLIDE E-10



NOTES:

SLIDE E-11

PROJECT DATA INPUT SCREEN

FBLCC input -

PROJECT INFORMATION (See NBS Technical Note 1222 for description of variables)

Section 1. Project Title: _____

Section 2. Basic LCC Analysis Assumptions:

LCC Analysis Type 1 = Energy Conservation or Renewable Energy Projects (NBS HB 135) 2 = Non-Energy Related Projects (OMB Circular A-94)	_____
Base Year for LCC Analysis (default)	1990
Study Period (Years)	_____
Occupancy Year (e.g. 1990)	_____
Discount Rate (%)	_____
2-Char. State Code (for DOE default energy prices)	_____
Building Type (1=Residential 2=Commercial 3=Industrial)	_____

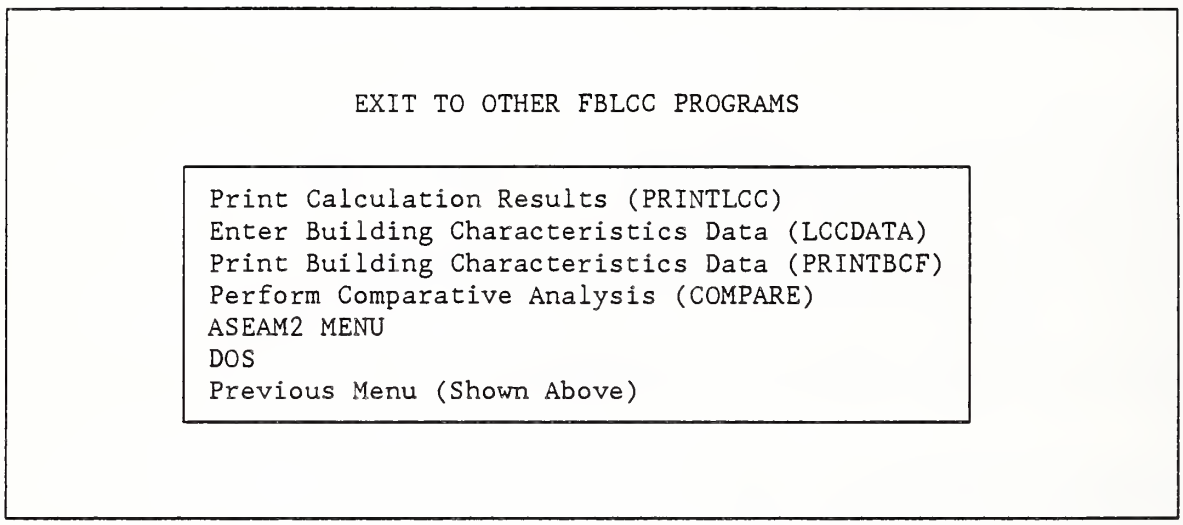
Comment:

F3 - Delete Entry F8 - Default F9 - Help F10 - Menu

NOTES:

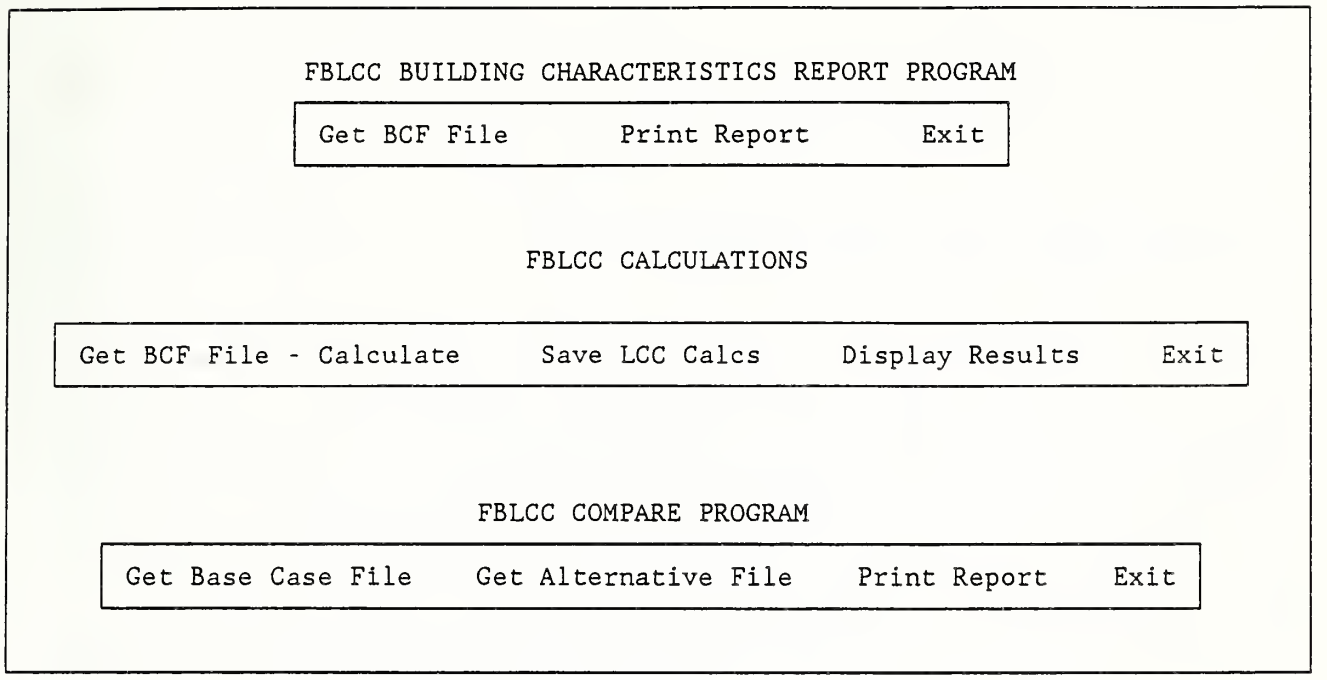
The F10 key will return to the main menu, but will not save current screen. Use <Pg Dn> first to save screen. See pages 145 and 146 for other function key descriptions.

SLIDE E-12



NOTES:

SLIDE E-13



NOTES:

GETTING ACQUAINTED WITH THE SOFTWARE

- FBLCC Data Entry Screens--pages 117-121
  - Project Information
  - Capital Components Data
  - Replacements to Capital Components
  - Operating and Maintenance Costs
  - Energy Cost Data
  - Energy Price Escalation Rates

- NBSLCC Data Entry Screens--pages 122-130
  - LCC Project Data
  - Capital Component Data
  - Cost Phasing Schedule
  - Replacements to Capital Components
  - Depreciation Factors
  - Mortgage Loan
  - Operating and Maintenance Costs
  - Energy Cost Data
  - Energy Price Escalation Rates

FBLCC Data Entry Screens

FBLCC INPUT -

PROJECT INFORMATION (See NBS Technical Note 1222 for description of variables)

Section 1. Project Title: _____

Section 2. Basic LCC Analysis Assumptions:

LCC Analysis Type 1 = Energy Conservation or Renewable Energy Projects (NBS 135) 2 = Non-Energy Related Projects (OMB Circular A-94)	_____
Base Year for LCC Analysis (default)	1990
Study Period (Years)	_____
Occupancy Year (e.g. 1990)	_____
Discount Rate (%)	_____
2-Char. State Code (for DOE default energy prices)	_____
Building Type (1=Residential 2=Commercial 3=Industrial)	_____

Comment: _____

F3 - Delete Entry F8 - Default F9 - Help F10 - Menu

FBLCC INPUT - TEST

CAPITAL COMPONENTS DATA LCC FILE:

Capital Component Data (Use F4 to Delete This Component) Item # 1

Component Name (or 'NA')	_____
Initial Cost of Component (base-year dollars)	_____
Expected Component Life (Years) - Use '999' for Land	_____
Average Escalation Rate During Planning/Construction Period	_____
Average Escalation Rate During Occupancy	_____
Resale Value Factor (% of Initial Cost in constant dollars)	_____

F3 - Delete Entry F8 - Default F9 - Help F10 - Menu

FBLCC INPUT - TEST

REPLACEMENTS TO CAPITAL COMPONENTS LCC FILE:

Capital Component #1 - COMP 1

	Replacements to Capital Component 1	2	3	4
Year of Replacement (from occupancy or 'NA')	__	__	__	__
Initial Cost of Replacement (unadjusted)	_____	_____	_____	_____
Expected Replacement Life (years)	__	__	__	__
Resale Value (% of replacement cost)	____	____	____	____

F3-Del Entry F4-Del Col F5-Ins Col F6-Copy Col F8-Deflt F9-Help F10-Menu

MODULE E, CONTINUED

FBLCC INPUT - TEST

OPERATING AND MAINTENANCE COSTS (Base-Year Dollars) LCC FILE: _____

Annually Recurring Costs
 Annual Recurring Cost (Amount)) _____
 Average Annual Rate of Price Change (% Real) _____
Non-Annually Recurring Costs
 Number of Non-Annually Recurring Costs __
 Average Annual Rate of Price Change (% Real) _____

Non-Annually Recurring Costs (Base Year Dollars)
(Note: Years begin with Occupancy; e.g., 1,2,...50)

No	Year	Amt	No	Year	Amt	No	Year	Amt	No	Year	Amt	No	Year	Amt
1	__	_____	11	__	_____	21	__	_____	31	__	_____	41	__	_____
2	__	_____	12	__	_____	22	__	_____	32	__	_____	42	__	_____
3	__	_____	13	__	_____	23	__	_____	33	__	_____	43	__	_____
4	__	_____	14	__	_____	24	__	_____	34	__	_____	44	__	_____
5	__	_____	15	__	_____	25	__	_____	35	__	_____	45	__	_____
6	__	_____	16	__	_____	26	__	_____	36	__	_____	46	__	_____
7	__	_____	17	__	_____	27	__	_____	37	__	_____	47	__	_____
8	__	_____	18	__	_____	28	__	_____	38	__	_____	48	__	_____
9	__	_____	19	__	_____	29	__	_____	39	__	_____	49	__	_____
10	__	_____	20	__	_____	30	__	_____	40	__	_____	50	__	_____

MODULE E, CONTINUED

FBLCC INPUT - TEST

ENERGY COST DATA LCC FILE:

Number of Energy Types _

	Energy Type 1	2	3
Energy Type Code 1=Electricity 2=Distillate Fuel Oil 3=Residual Fuel Oil 4=Natural Gas 5=Liquified Petroleum Gas (LPG) 6 = Coal	_	_	_
Annual Consumption (Million Btu)	_____	_____	_____
Price per MBTU (Use F8 for DOE default)	_____	_____	_____
Demand (or other fixed) Charge (Annual)	_____	_____	_____
Price Escalation Method 1 = User Entered 2 = Defaulted	_	_	_
Average Annual Rate of Price Change During Plan/Construction period (%)	_____	_____	_____

F3 - Delete Entry F8 - Default F9 - Help F10 - Menu

FBLCC PROJECT: TEST BCF FILE:

ENERGY ESCALATION RATES (REAL)

Fuel Type 1 - Electricity

Number of Discrete
Time Intervals: __

Note: Sum of time intervals must equal or exceed Occupancy Period (n).
First year in schedule is 19XX

#	Num Yrs	Annual Rate(%)	#	Num Yrs	Annual Rate(%)	#	Num Yrs	Annual Rate(%)	#	Num Yrs	Annual Rate(%)	#	Num Yrs	Annual Rate(%)
1	__	_____	11	__	_____	21	__	_____	31	__	_____	41	__	_____
2	__	_____	12	__	_____	22	__	_____	32	__	_____	42	__	_____
3	__	_____	13	__	_____	23	__	_____	33	__	_____	43	__	_____
4	__	_____	14	__	_____	24	__	_____	34	__	_____	44	__	_____
5	__	_____	15	__	_____	25	__	_____	35	__	_____	45	__	_____
6	__	_____	16	__	_____	26	__	_____	36	__	_____	46	__	_____
7	__	_____	17	__	_____	27	__	_____	37	__	_____	47	__	_____
8	__	_____	18	__	_____	28	__	_____	38	__	_____	48	__	_____
9	__	_____	19	__	_____	29	__	_____	39	__	_____	49	__	_____
10	__	_____	20	__	_____	30	__	_____	40	__	_____	50	__	_____

F3 - Delete Entry F8 - Default F9 - Help F10 - Menu

NBSLCC Data Entry Screens

NBSLCC INPUT -

LCC PROJECT DATA (See NBS Special Publication 709 for description of data)

Project Title	_____	
Study Period	__	years
Planning/Construction Period	__	years
Base Year (e.g., 1990)	____	
Tax Status Code (1=for profit 2=owner-occupied 3=non-profit)	_____	
Discount Rate Type (1=Real (non-profit only), 2=Nominal)	_____	
General Inflation Rate (%/Year Average over Study Period)	_____	%
Discount Rate	_____	%
Marginal Federal Income Tax Rate	_____	%
Marginal State Income Tax Rate	_____	%
Property Tax Rate	_____	%
Capital Gains Adjustment Factor	_____	%
Depreciation Recapture Code (see NBS SP 709 page 91) (0=none 1=capital gain 2=ordinary income 3=combination)	_	
Depreciation Basis Adjustment Factor	_____	%
Sales Tax Rate	_____	%
2-Char. State Code (for DOE Default Energy Prices only)	__	
Building Type (1=Residential 2=Commercial 3=Industrial)	_	

Comment: _____

F3 - Delete Entry F8 - Default F9 - Help F10 - Menu

MODULE E, CONTINUED

NBSLCC INPUT - TEST

CAPITAL COMPONENT DATA — LCC FILE:

Capital Component Data (Use F4 to Delete this Component) — Item # 1
Component Name (or 'NA') _____
Initial Cost of Component (in Base Year dollars) _____
Percent of Initial Cost Subject to Sales Tax _____
Expected Component Life (Years - Use '999' for Land) ___
Depreciation Method Code (for income tax calculations) _
  0 = no depreciation calculated
  1 = straight line
  2 = declining balance (accelerated)
  3 = sum of years digits
  4 = depreciation table (user entered)
Depreciation Life (in years) __
Depreciation Acceleration Rate (%) (Code 2 only) ___
Depreciation Salvage Value (Percent of Initial Cost) ___
Additional First Year Depreciation Factor ___
Average Escalation Rate During Planning/Construction Period ___
Average Escalation Rate During Occupancy ___
Property Tax Assessment Factor (%) ___
Investment (or Energy) Tax Credit Rate (% of Initial Cost) ___
Resale Value Factor (% of Initial Cost in constant dollars) ___

F3 - Delete Entry	F8 - Default	F9 - Help	F10 - Menu

MODULE E, CONTINUED

NBSLCC Input

COST PHASING SCHEDULE BY YEAR OF PLANNING/CONSTRUCTION PERIOD AND AT OCCUPANCY

Capital Component #1 - TEST

Enter Percentage of Cost for Each Year

Planning/Construction Year 1	(1988)	_____
Planning/Construction Year 2	(1989)	_____
At Occupancy	(1990)	_____

MODULE E, CONTINUED

NBSLCC INPUT - TEST

REPLACEMENTS TO CAPITAL COMPONENTS LCC FILE:TEST

Capital Component #1 - TEST

	Replacements to Capital Component 1	2	3	4
Year of Replacement (or 'NA') (from occupancy year e.g., 1,2,..,50)	____	____	____	____
Initial Cost of Repl (Base-year $)	_____	_____	_____	_____
Percent Subject to Sales Tax	____	____	____	____
Expected Replacement Life (years)	__	__	__	__
Depr Salv Val Factor (% of repl cost)	____	____	____	____
Depreciation Life (years)	__	__	__	__
Resale Value Factor (% of repl cost)	____	____	____	____
Property Tax Assessment Factor (%)	____	____	____	____

F3-Del Entry F4-Del Col F5-Ins Col F6-Copy Col F8-Deflt F9-Help F10-Menu

---

NBSLCC INPUT - TEST

DEPRECIATION FACTORS (Enter % of initial cost to be depreciated in each year.)
Capital Component 1 - TEST (Enter factors for 15 years)

Year		Year		Year		Year		Year	
1	_____	11	_____	21	_____	31	_____	41	_____
2	_____	12	_____	22	_____	32	_____	42	_____
3	_____	13	_____	23	_____	33	_____	43	_____
4	_____	14	_____	24	_____	34	_____	44	_____
5	_____	15	_____	25	_____	35	_____	45	_____
6	_____	16	_____	26	_____	36	_____	46	_____
7	_____	17	_____	27	_____	37	_____	47	_____
8	_____	18	_____	28	_____	38	_____	48	_____
9	_____	19	_____	29	_____	39	_____	49	_____
10	_____	20	_____	30	_____	40	_____	50	_____

MODULE E, CONTINUED

NBSLCC INPUT - TEST

MORTGAGE LOAN LCC FILE:

	Constrt Loan	Permanent Loans 1	2	3	4
Percent of Initial Cost Borrowed (or 'NA')	____	____	____	____	____
Loan Type Code 1=fully amortized (equal payments) 2=interest only (principal at end) 3=interest and principal at end	_	_	_	_	_
Annual Interest Rate (%)	____	____	____	____	____
Life of Loan (years)	__	__	__	__	__
Number of Payments per Year	__	__	__	__	__
Points Paid (% of loan amount)	____	____	____	____	____

F3-Del Entry	F4-Del Col	F5-Ins Col	F6-Copy Col	F8-Deflt	F9-Help	F10-Menu

NBSLCC INPUT - TEST

OPERATING AND MAINTENANCE COSTS (Base-Year Dollars) LCC FILE:TEST

Annually Recurring Costs
 Annual Recurring Cost (Amount)) _____
 Average Annual Rate of Price Change (% Real) _____
Non-Annually Recurring Costs
 Number of Non-Annually Recurring Costs __
 Average Annual Rate of Price Change (% Real) _____

Non-Annually Recurring Costs (Base Year Dollars)
(Note: Years begin with Occupancy; e.g., 1,2,...50)

No	Year	Amt	No	Year	Amt	No	Year	Amt	No	Year	Amt	No	Year	Amt
1	__	_____	11	__	_____	21	__	_____	31	__	_____	41	__	_____
2	__	_____	12	__	_____	22	__	_____	32	__	_____	42	__	_____
3	__	_____	13	__	_____	23	__	_____	33	__	_____	43	__	_____
4	__	_____	14	__	_____	24	__	_____	34	__	_____	44	__	_____
5	__	_____	15	__	_____	25	__	_____	35	__	_____	45	__	_____
6	__	_____	16	__	_____	26	__	_____	36	__	_____	46	__	_____
7	__	_____	17	__	_____	27	__	_____	37	__	_____	47	__	_____
8	__	_____	18	__	_____	28	__	_____	38	__	_____	48	__	_____
9	__	_____	19	__	_____	29	__	_____	39	__	_____	49	__	_____
10	__	_____	20	__	_____	30	__	_____	40	__	_____	50	__	_____

NBSLCC INPUT - TEST

ENERGY COST DATA LCC FILE:TEST

Number of Energy Types for this Project _

	Energy Type 1	2	3
Energy Type Code 1=Electricity 2=Distillate Fuel Oil 3=Residual Fuel Oil 4=Natural Gas 5=Liquified Petroleum Gas (LPG) 6 = Coal	_	_	_
Annual Consumption (Million Btu)	_____	_____	_____
Price per MBTU (Use F8 for DOE default)	_____	_____	_____
Demand (or other fixed) Charge (Annual)	_____	_____	_____
Price Escalation Method 1 = User Entered 2 = Defaulted	_	_	_
Average Annual Rate of Price Change During Plan/Construction period (%)	_____	_____	_____

F3 - Delete Entry F8 - Default F9 - Help F10 - Menu

NBSLCC INPUT - TEST

ENERGY PRICE ESCALATION RATES (REAL) LCC FILE:TEST

Fuel Type 1 - Electricity

Number of Discrete Time Intervals to be entered: __

Note: Sum of time intervals must equal or exceed Occupancy Period ( ).
First year in schedule is 1990

#	Dur Yrs	Annual Rate(%)	#	Dur Yrs	Annual Rate(%)	#	Dur Yrs	Annual Rate(%)	#	Dur Yrs	Annual Rate(%)	#	Dur Yrs	Annual Rate(%)
1	__	_____	11	__	_____	21	__	_____	31	__	_____	41	__	_____
2	__	_____	12	__	_____	22	__	_____	32	__	_____	42	__	_____
3	__	_____	13	__	_____	23	__	_____	33	__	_____	43	__	_____
4	__	_____	14	__	_____	24	__	_____	34	__	_____	44	__	_____
5	__	_____	15	__	_____	25	__	_____	35	__	_____	45	__	_____
6	__	_____	16	__	_____	26	__	_____	36	__	_____	46	__	_____
7	__	_____	17	__	_____	27	__	_____	37	__	_____	47	__	_____
8	__	_____	18	__	_____	28	__	_____	38	__	_____	48	__	_____
9	__	_____	19	__	_____	29	__	_____	39	__	_____	49	__	_____
10	__	_____	20	__	_____	30	__	_____	40	__	_____	50	__	_____

F3 - Delete Entry F8 - Default F9 - Help F10 - Menu

Supplements to Computer Program

User's Guides

- Supplement to FBLCC User's Guide
- Supplement to NBSLCC User's Guide

FBLCC - THE FEDERAL BUILDING LIFE CYCLE COST PROGRAM

Note: The National Bureau of Standards has changed its name (as of August 1988) to the National Institute of Standards and Technology.

FBLCC Update: August 1, 1989

The FBLCC program on this disk is designated as version se2.3. Several new changes have been made since the release of version se2.1, which is described on the following pages. (Version se2.2 was a classroom version similar to se2.3.) These new changes include:

(1) The base date is now shown with the project input data as you enter project data. This date is taken directly from the clock in your computer (i.e., it is the current year). It cannot be changed except by changing your clock. It is important that your clock be set properly when you start up your computer.

(2) You can no longer use the default energy prices on the disk. You must enter your local energy prices. The energy price data on the disk are still used to provide default energy price escalation rates.

(3) The Federal energy conservation credit (10%) is no longer used. Therefore the "initial conservation-related cost" data entry has been omitted from the program.

(4) The discount rate defaults to 7% for energy conservation studies and 10% for other Federal projects, as before. However, these discount rates can now be changed like any other variable (except the base date). Remember that the discount rate must be entered in real terms, i.e., net of general inflation.

(5) The main bar menu in LCCDATA (data entry subprogram) now highlights the most logical next step after completion of a previous step. (E.g., after "getting" an existing file, the "EDIT FILE" choice will be highlighted.)

(6) Several small bugs have been cleaned up. For example, all lower case entries will now be converted to upper case to facilitate data entry.

Note: These changes are primarily related to data entry, and do not affect the computational results, with the exception of omitting the Federal conservation credit.

Be sure to read the section entitled "Additional Help" on page 5 of this DOC file.

Additional Note (January, 1990): The latest Department of Energy's energy price forecast, released January 1990, is included on this disk in files ENCOST90.SEQ and ENCOST90.RAN.

IMPORTANT NOTES FOR SCREEN-EDITOR VERSION se2.1 OF FBLCC

The FBLCC program is described in NBS Technical Note 1222 A User's Guide to the Federal Building Life Cycle Cost Program, May 1986. For information on how to obtain this publication, write to:

Applied Economics Group
Center for Computing and Applied Mathematics
National Engineering Laboratory
National Institute of Standards and Technology
Building 101, Room A415
Gaithersburg, MD 20899

This disk contains a new version of that program, Version se-2.1. While input data and output results are (nearly) identical to the original version, the program has been enhanced with full-screen data entry capabilities to facilitate data entry and editing. The Department of Energy's (DOE) energy price projections included on the disk for direct access by the FBLCC program were released in January 1990.

This new version is also compatible with the DOE's ASEAM energy analysis program for buildings. If you are already using ASEAM with the FBLCC program, you should discard the version of FBLCC supplied with ASEAM and use the new version on these disks.

Files on FBLCC disk:

FBLCC .EXE	FLCCDATA.EXE	FLCCMAIN.EXE	FCOMPARE.EXE
FPRNTBCF.EXE	FPRNTLCC.EXE	DISCOUNT.EXE	BASRUN .EXE
ENCOST90.RAN	ENCOST90.SEQ	STATES	
FIENECDT.FIS	FIENEEDT.FIS	FIOMCSDT.FIS	FLCCCAPC.FIS
FLCCPROJ.FIS	FLCCREPL.FIS		
HDYESNO .DAT			
FED1.BCF	FED2.BCF	FED3.BCF	FED4.BCF
FED5.BCF	FED6.BCF	FED7.BCF	
FED1.LCC	FED2.LCC	FED3.LCC	FED4.LCC
FED5.LCC	FED6.LCC	FED7.LCC	
FBLCC.DOC			

The first six files with the extension .EXE are FBLCC executable program files. BASRUN.EXE (copyright by IBM) is the runtime module needed to run these six programs. If you copy these programs to another disk you must copy the runtime module as well or the FBLCC programs will not run. The DISCOUNT program is a stand-alone program discussed in the FBLCC User's Guide. It is now run simply by typing 'DISCOUNT' at the ready prompt. (The previous version required that you load the BASIC interpreter first.) It does not need the runtime module to be executed.

The FBLCC User's Guide and the FBLCC program reference the subprograms slightly differently than they are referenced above. All of the FBLCC subprograms on the disk are saved with the initial letter 'F' (to distinguish them from similarly named NBSLCC programs). The following list shows the correspondence between the actual program name and its reference in the program:

Actual Program Name	Reference Name
FBLCC.EXE	FBLCC
FLCCDATA.EXE	LCCDATA
FPRNTBCF.EXE	PRINTBCF
FLCCMAIN.EXE	LCCMAIN
FPRNTLCC.EXE	PRINTLCC
FCOMPARE.EXE	COMPARE

It is not essential that the user be familiar with this correspondence, since the various subprograms are executed from a menu with functional choices. This list is included here primarily for sake of completeness.

The ENCOST.RAN file contains the 1990 DOE energy price forecast for the years 1990 through 2030, used to provide default energy prices and rates of energy price escalation over those years. It is in binary (random access) form to conserve space on the disk and speed up disk access. There are now only four regions (northeast, southeast, midwest, and west) rather than ten regions as in the earlier DOE projections. The appropriate region for any

location is automatically selected by entering the two-character state code for the actual location of the project rather than the DOE region itself.

The ENCOSTXX.SEQ file is a shorter file which tells FBLCC how the larger energy price file is arranged so that it can be read properly. The STATES file is used to show the appropriate code for all 50 states (plus the District of Columbia) in the help mode.

All files with the extension .FIS provide the formatting needed to display the data input screens.

HDYESNO.DAT is a small file used when calling ASEAM from FBLCC to determine whether or not FBLCC and ASEAM are saved in the same subdirectory in a hard disk. The single upper case letter 'Y' or 'N' is contained in this file.

All files ending in .BCF are the building characteristics files used in the examples in the FBLCC user's guide.

All files ending in .LCC are the life-cycle cost output files used in the examples in the FBLCC user's guide.

STARTING FBLCC

To run the FBLCC program from the default drive, type 'FBLCC' at the ready prompt. IMPORTANT NOTE: YOU MUST HAVE A FORMATTED DISK IN YOUR B DRIVE FOR SAVING AND RETRIEVING DATA FILES. If you are running the program from a hard disk and do not have a B drive, try putting the data disk in the A drive. It will usually act as though it were the B drive as well. If you want to access the building characteristics files (extension = .BCF) and life-cycle cost output files (extension = .LCC) that have been included on the master disk, these must be copied to another disk that can be inserted into the B drive. (Alternatively, the FBLCC program can be run from the B

drive; then these files can be accessed directly from the master disk. However, this is not a recommended general procedure for running the program, since there is only limited space available on the master disk.)

Refer to the FBLCC user's guide for general information about the FBLCC program. Information needed to run the screen-editor version of this program is included below in this file. Chapter 10 of the ASEAM user's manual provides more complete documentation about the data input screens in this new version of FBLCC.

Change in DoE Energy Price Projections

The DOE energy price projections contained in the ENCOST.RAN file on this disk are current as of January 1990. The energy cost analyses reported in the examples in the FBLCC User's Guide are based on older (1985) projections. The building characteristics files on this disk which correspond to those examples are based on the older DOE energy price projections and thus will match the results reported if they are not edited. However, if you load a building characteristics file into the LCCDATA data entry module, the DOE projections of energy price increases (if specified) will automatically be updated. Thus the resulting LCC analysis will no longer match the published examples exactly. Note that only the rates of energy price increase (i.e., the energy price escalation rates) over the study period are automatically updated. The unit energy price for each energy type is updated by pressing <F8> when the cursor is at the energy price input line in order to retrieve the appropriate price from the DOE energy price file.

New Variables

Two new variables have been added to the FBLCC program: (1) a comment line (70 character maximum, no commas allowed) which can be used to include general reference information about a project in its building

characteristics file for future reference, and (2) a two-character state code for use in accessing the DOE energy price projections. The two-character state code must correspond to the official Postal Service code (e.g., CA for California). Use 'US' to access DOE average U.S. energy price projections. Use 'H' for help; then all of the Postal Service codes can be scanned at the bottom of the screen using the up and down cursor arrows. (Once the appropriate code has been determined, it must still be entered in the appropriate space.)

Additional Help

Do not confuse "Project Title" with "File Name". The project title is used to identify the project when printing out the LCC reports (LCC analysis and comparative analysis). It can have up to twelve characters. The file name is used to save and retrieve the data files to and from the disk, and must conform to the Disk Operating System (DOS) file-name conventions, i.e., no more than eight alpha-numeric characters. Never include a file name extension with the file name; this is automatically added by the program to distinguish between file types. Never insert a space in a file name; it will be saved but can't be retrieved.

Note that a separate building characteristic file must be set up for each alternative project to be evaluated. You cannot evaluate several projects simultaneously by specifying each as a separate component of a single project. Separate components are specified to a single project to make it easier to compute replacements, depreciation, property taxes, and resale value at the end of the study period. (Operating, maintenance, and energy costs are not specific to individual components but only to the entire building or building system being evaluated. Once you set up a building characteristics file for a project and save it, it is often easier to edit that file with data from the alternative project and then save it under a new name than to start from scratch on a new file.

Using LCC Menus

Menu choices are displayed in horizontal bars across the screen. One of the selections is highlighted by a reverse video box (the first selection when entering a program). Select the option you want by moving this box using the right and left cursor control keys (the arrows on the 4 and 6 keys of the numeric keypad) until it is over the option you desire and then pressing <ENTER>. This command will be executed or another menu will appear. Pressing any key other than the left or right arrow or <ENTER> will cause a beep.

Secondary menus may either appear as additional horizontal selections, or a vertical "pull down" menu under the item first selected. These vertical pull-down menus work exactly like the horizontal menus, except that the up and down arrows (instead of left and right) must be used to move the highlighted selection. Once again, pressing <ENTER> is required to "select" an option, and pressing any key other than these three will cause the computer to beep.

Many times you will see "Exit" as a valid choice in a menu. If you are in a program's top level horizontal menu, "Exit" means to leave this program and to go into another program. On a secondary menu (either horizontal or vertical), "Exit" means to return to a higher level menu--not to leave the LCC program.

When you begin running the LCC input program, the first menu appears on the screen. The fully expanded input menu is shown below. Note that the second bar menu appears if you select "Edit BCF Data" from the first menu bar. The third menu bar and vertical menu appears if you select "Capital Components" from the second menu bar.

FBLCC BUILDING CHARACTERISTICS INPUT PROGRAM

Get BCF File	Save BCF File	Edit BCF Data	Enter New Data	Exit

All Data	Project	Capital Components	O&M	Energy	Exit

All Data	Component Data	Cost Phasing	Replacements	Exit

All Components
Component 1
Component 2
Component 3
Component 4
Component 5
Component 6
Exit

Get BCF File

The Get command retrieves an existing BCF data file from the data disk in drive 'B' and loads it into memory. You must use this command before you can edit a file, since the editing program works within memory and not directly from the disk.

When you choose "Get BCF File" the program will respond with a list of all BCF input files stored on your data disk. Move the highlighted bar with the cursor control keys (up, down, right, left) until it is over the file you want to get and press <ENTER>. If the file which you want to edit is not on the list, first mark "Exit" and press <ENTER> (to get out of "Get BCF File"), then insert the correct data disk with the file to edit in drive 'B', and try "Get BCF file" again. Once you see the file you want, mark it with the reverse video box and press <ENTER>. A message will appear on the screen for a few moments while the computer reads the file into memory. When the Main Menu reappears, you are ready to "Edit BCF File."

If you use the "Get BCF File" command when data is currently in memory, a warning will be issued. Retrieving a file overwrites all data in memory with the data from the file.

Save BCF File

The Save command saves a data file so that you can use the file again at a later time. This command copies the complete input data file from memory (temporary storage) where you have been editing it, to disk (permanent storage). If you do not save a file, it will be gone forever once you exit from the BCF Input program or get a different data file. The Save command should be used each time you are done editing a file. The only exceptions are if you have made no changes at all to the file, or if you have made erroneous changes and would prefer to have the previous (last saved) version of the file. When you use the Save command, a message asking you for the file name to save will be displayed. Pressing <ENTER> causes the file to be saved under the same name (what you retrieved the file as); typing a new name causes the file to be saved under that name; typing 'X' aborts the Save command and returns you to the BCF Input Menu.

WARNING: If you enter an <ENTER> for the filename, the file in memory will overwrite the file on disk. You may want to use a new filename and have the old file as a backup.

File names may be up to eight alphanumeric characters. (Refer to your DOS manual for valid filename characters.) Do not specify an extension.

Edit BCF Data

The Edit command allows you to review and change the contents of the data file in memory. You must first "Get" a file before you can "Edit" it. When

you use the Edit command, another menu will be displayed which lists particular screens to edit. You may edit the entire data file or only one particular screen.

Each time you complete an input screen, the information on it is transferred into memory. After you have finished the screens which you indicated for editing, the Main Menu will reappear. Choose either additional sections to edit, save the file and proceed to edit another file, or exit to the other subprograms.

Enter New Data

The Enter New Data command clears the memory and lets you begin entering a new set of data for the BCF file. All of the input screens will appear sequentially, with blank lines where you should fill in values. REMEMBER to store the file in memory before you Enter New Data. A warning message appears if data is presently in memory.

Exit

The Exit command should be used when you want to leave the BCF Input routine. The question "Did You Remember to Save Your Files?" will be printed on the screen. If you answer 'N' followed by a <ENTER>, you will be returned to the BCF Input Menu for another chance to save the file.

Cautions about Memory

Memory is only temporary. The data stored in memory is destroyed when you exit any of the BCF input programs, turn off the computer or otherwise lose power, or reboot. Also, only one file can be held in memory at a time. Thus, if you replace the file in memory with a different file (either an existing file with "Get BCF File" or an blank file with "Enter New Data") the file which was previously in memory will be lost. (The program issues a

warning message whenever you use the "Get" or "Enter New Data" commands and there is existing data in memory.) To save the contents of the file in memory, you must "Save BCF File" before editing other files or leaving any BCF Input program.

The "Save BCF File" command copies the file in memory to the data diskette in drive 'B', where it is stored permanently. Since the disk file is not changed until you save, if you make many mistakes or accidentally erase a lot of information while editing, you can always go back to the last saved version of the file by getting the file again.

The BCF Input Screens

This section will tell you how to move around within and between input screens.

The body of the screen is a series of input questions with lines for the data input. There may be more than one column for data entry. The cursor will move to only those lines where you should input data. Cursor control is discussed below. At the bottom of each input screen is a function key menu, describing the action resulting from pressing each function key. This information is explained in more detail below. The cursor control and function key conventions are the same for all LCC and ASEAM2 input data screens. They apply both for editing existing and editing new data.

Cursor Control

There are two different types of cursors in the program. A "smiley face" cursor is what originally shows on the screen, at the first entry. With this cursor you can move between entries. Once you begin to type an entry the cursor changes to a blinking underline. The cursor control keys have different functions for the two types of cursors.

Smiley-Face Cursor

When you first enter an input screen (through either the "Edit" or the "Enter New Data" command) the screen will display a list of input questions followed by either the current values (in the case of edit) or blank lines (in the case of new data). A smiley face cursor is in front of the first question. This cursor is used to move around the screen, from one input question to another.

The following keys are used to move the smiley face cursor:

Up - moves up to next entry without error checking

Down - moves down to next entry without error checking

Right - moves right to next entry (down if no multiple columns) without error checking

Left - moves left to next entry (down if no multiple columns) without error checking

PgUp - completes error checking for entire screen. If no errors are found, moves to previous screen. If an error is found, prints an explanatory message at the bottom of the screen, beeps, and positions cursor at the incorrect entry. If current screen is the first in the editing sequence, returns to BCF Input Menu.

PgDn - completes error checking for entire screen. If no errors are found, moves to next screen. If an error is found, prints an explanatory message at the bottom of the screen, beeps, and positions cursor at the incorrect entry. If current screen is the last in the editing sequence, returns to BCF Input Menu. NOTE: after the last entry is made on a screen, a message at the bottom of the screen will advise you to press PgDn for the next page. This message will be visible for about 4 seconds. You cannot execute this command until the message disappears.

Return - completes entry, performs error checking, moves to next entry if data is valid. If the entry is incorrect, an explanatory message is printed at the bottom of the screen and the cursor remains at this entry.

Esc - refreshes the screen. The data will appear as it was when you first entered the screen. Any data which was changed will be replaced with the original data.

The function keys may also be used. These are discussed below. Any other keystroke will be interpreted as data entry and written on the entry line.

Underline Cursor

When you begin to type an entry, the cursor changes to a blinking underline. What you type is entered on the data entry line. With this cursor, you move WITHIN an entry, NOT between entries. The cursor control keys have different actions from those for the smiley face cursor.

The following keys are used to move the underline cursor:

Up - completes entry, performs error checking, moves up to previous entry if answer is valid.

Down - completes entry, performs error checking, moves down to next entry is answer is valid.

Return - same as Down

Right - moves cursor right to next character

Left - moves cursor left to previous character

Home - moves to first character of entry

End - moves to last character of entry

Delete - deletes the character at the cursor, characters to the right of the cursor are moved one space to the left

Insert - inserts characters at the cursor

Backspace - deletes the character to the left of the cursor

Ctrl-End - deletes all characters to the right of the cursor

Escape - clears entry

Any alphanumeric character will be entered as data. The function keys F9 (help) and F10 (exit) may be used with the underline cursor. Any other keystroke will only cause a beep.

Function Keys

The function keys may also be used during the input sessions. When you have the blinking underline cursor, only F9 and F10 may be used. All function keys are available with the smiley face cursor. The function keys have the following actions:

F3 - delete entry at cursor

F4 - delete column at cursor (only for screens with multiple columns) all other columns move to left

F5 - insert column at cursor (only for screens with multiple columns) all other columns move to the right

WARNING: data in rightmost column is lost (moves off-screen)

F6 - copy column at cursor (only for screens with columns) copies to column at right; if pressed again, copies further right

WARNING: data in rightmost column is lost (moves off-screen)

F8 - use default value (if there is one; if not, message appears)

F9 - help, supplies context-specific message (if there is one)

F10 - exit to BCF INPUT MENU

WARNING: F10 is like a break--editing changes made during this screen are not stored. Every time you PgUp or PgDn out of a screen or are moved to the next screen or the menu automatically, the information you input has been stored in memory. But whenever you use F10 to return to the menu, the information from that particular screen will not be stored. If you want to keep the changes you have made in an input screen, press PgDn before using the F10 key.

In addition, two other commands may be useful; these can be executed at any time:

<Alt> H - toggles off and on automatic help messages at the bottom of the screen. When the automatic help messages are toggled off, individual help messages can still be displayed by pressing F9 at the point where help is needed. (Default setting is 'on'.)

<Alt> P - toggles on and off the automatic screen advance command. When off (the default setting), you must press <PgDn> to advance to the next screen. When on, the screen is automatically advanced after the last entry on a page is complete. (The default setting is 'off' so that you can continue to examine the screen after completing the last entry.)

Error Checking

Many questions have upper and/or lower numeric limits or other restrictions (such as number of digits, alphanumeric strings, etc.) imposed on them. When you enter an unacceptable value (such as a letter when a number is required), the computer will beep and an error message will appear briefly at the bottom of the screen; the smiley face cursor will remain at that line for you to enter a new value. You cannot exit from a screen with incorrect or missing data with the cursor control keys. If you try to do so, the cursor will be returned to the erroneous data field. You can exit from a screen using the F10 key at any time, but the data you just entered will not be saved and the previously existing data for that screen will be kept.

Default Values

Default values have been assigned for many of the input questions. To enter a default value, press the F8 key. If there is no default value, the computer will beep and a message will appear briefly at the bottom of the screen. The cursor will remain at the same entry.

National Bureau of Standards* Life-Cycle Cost Program
NBSLCC Update: February 1990
Version se2.33

Important Note: This version of NBSLCC is executed directly without need for a BASIC compiler. The NBSLCC user's guide referenced below is still useful for defining terms and demonstrating examples of LCC analyses, but is no longer current with regard to the menu choices and full-screen editing capability of NBSLCC. Be sure to read over the notes in this NBSLCC.DOC before running the program, especially the section entitled "Additional Help".

Several enhancements were made to improve the look and performance of the NBSLCC program during 1989 and early 1990. These changes include:

(1) Physical energy quantities purchased are now entered in their common units, e.g., kWh for electricity, gallons for oil, therms for natural gas. The appropriate units are shown on the energy data input screen. Energy prices are entered for the same units (e.g., dollars per kWh, gallon, etc.; use 0.06 if electricity costs 6 cents per kWh). In earlier versions of NBSLCC, annual energy usage and prices were entered in terms of million Btu for all energy types. (The product of the physical energy quantity (in any units) and the price per corresponding unit will always produce the same annual energy expenditure regardless of which units are used. However, the units are now identified in their common form in the LCC report.)

(2) You can no longer use the default regional energy prices on the disk. You must enter your local energy prices. The Department of Energy's energy

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* The National Bureau of Standards changed its name to the National Institute of Standards and Technology in August, 1988. We will continue to use the name NBSLCC for this computer program.

price data on the disk are still used to provide default energy price escalation rates (i.e., the rate at which energy prices are expected to increase over time). Estimates of life-cycle costs will generally be better if you use local prices rather than regional prices. If you are estimating

changes in energy use due to improvements in building design, it is best to use rates that reflect the level of energy usage in that building and the seasonal nature of that usage. For example, many electric utilities have declining block rates and winter and summer rate schedules, so that an average cost per kWh will not reflect the actual cost of the kWh's saved from improvements in building or system design.

(3) The main bar menu in each NBSLCC subprogram now highlights the most logical next step after completion of a previous step. (E.g., after "getting" an existing file, the "EDIT FILE" choice will be highlighted in LCCDATA.)

(4) Several small bugs have been cleaned up. For example, all lower case entries will now be converted to upper case to facilitate data entry.

(5) Color has now been added for use with color monitors.

(6) DOE's energy price projections in ENCOST90.RAN were released in January 1990.

Note: None of the above changes affects the computational procedures in NBSLCC. The following change does affect the computation of tax savings:

(7) Several changes have been made to LCCMAIN to reflect changes in the Federal tax laws (a), (b), or to improve the calculation of resale value (c):

(a) construction points and interest are now capitalized and depreciated over the life of the depreciable building components (for-profit cases only); previously these were amortized over 10 years (see appendix I in the user's guide).

(b) sales tax on any capital asset is now capitalized and depreciated over the life of that asset (for-profit cases only); previously this was deducted in the year it was incurred (see appendix I).

(c) The resale value of each component is now shown without the capital gains tax adjustment. The capital gains tax adjustment is now included with the other tax adjustments for the overall building.

NBSLCC version 3.0 will be ready in spring 1990. This new version will have a cashflow module and revenue calculations, and will compare two or more projects at the same time. It will also contain the latest DOE energy cost projections.

IMPORTANT NOTES FOR SCREEN-EDITOR VERSION OF NBSLCC

This file contains information on the NBSLCC program to supplement the user's guide. The NBSLCC user's guide is contained in NBS Special Publication 709, Comprehensive Guide for Least-Cost Energy Decisions, by R. Ruegg and S. Petersen, 1987. For information on how to obtain this publication, write to:

Applied Economics Group
Center for Computing and Applied Mathematics
National Engineering Laboratory
National Institute of Standards and Technology
Building 101, Room 415
Gaithersburg, MD 20899

Please note that NBSLCC should not be confused with FBLCC, a similar program used for LCC analysis of Federal buildings. The two programs cannot be used interchangeably because their data file structures are different. Information on the FBLCC program and its user's guide can be obtained from the organization named above.

Tax law changes in 1987

The NBSLCC program was written before the tax law changes of 1987 were finalized. The algorithms for computing tax savings related to capital investments are flexible and can accommodate most of these changes. However, since the Federal and State tax rates used in the program are fixed over the study period, the phasing in of new tax rates over a number of years cannot be evaluated in an NBSLCC analysis. The user should specify tax rates that are expected to prevail over the greater part of the study period.

Appendix I of NBS Special Publication 709 explains the types of income tax adjustments that are computed in the NBSLCC program. For owner-occupied houses, interest and 'points' are calculated as tax deductions in the year in which they are paid, but sales taxes are not calculated as tax deductions. If capital gains are to be treated as ordinary income, the capital gains tax factor (i.e., the percent of capital gains subject to income tax) should be set to 100% (the current default value). (This factor was typically 40% for individuals under the old tax law.) (Appendix I provides simple coding changes that can change the deductibility of certain expenses. However, these changes cannot be made to the executable version. Please contact the office shown above for further information about such changes if needed.)

Notes on Screen-editor version

This disk contains an executable screen-editor version of the NBSLCC program. While input data and output results are nearly identical to the original version, the program has been enhanced with full-screen data entry capabilities to facilitate data entry and editing. NBSLCC is now executed without loading the BASIC compiler.

This new version is also compatible with the latest version (September 1988) of the ASEAM energy analysis program for buildings. If you are using an earlier version of ASEAM, you will need to transfer the energy calculations into the new version of the NBSLCC program manually. The later version of ASEAM can automatically access the NBSLCC data files to transfer the energy calculations. For information on the latest version of ASEAM, contact the American Consulting Engineers Council, (202) 347-7474.

Files on the NBSLCC disk:

NBSLCC .EXE	PLCCDATA.EXE	PLCCMAIN.EXE	PCOMPARE.EXE
PPRNTBCF.EXE	PPRNTLCC.EXE	DISCOUNT.EXE	BASRUN .EXE
ENCOST90.RAN	ENCOST90.SEQ	STATES	
FICAPCDT.FIS	FIENECDT.FIS	FIMORTDT.FIS	FIPROJDT.FIS
FIDEPRDT.FIS	DIENEEDT.FIS	FIOMCSDT.FIS	FIREPLDT.FIS
ALTA .BCF	ALTB .BCF	ALTCR .BCF	ALTDR .BCF
LCCFILE1.BCF	LCCFILE2.BCF		
ALTA .LCC	ALTB .LCC	ALTCR .LCC	ALTDR .LCC
LCCFILE1.LCC	LCCFILE2.LCC		
NBSLCC.DOC	HDYESNO.DAT		

The first six files with the extension .EXE are NBSLCC executable program files. BASRUN.EXE (copyright by IBM) is the runtime module needed to run these six programs. If you copy these programs to another disk you must copy the runtime module as well or the NBSLCC programs will not run. The DISCOUNT program is a stand-alone program discussed in the NBSLCC User's Guide. It is now run simply by typing 'DISCOUNT' at the ready prompt. (The

previous version required that you load the BASIC interpreter first.) It does not need the runtime module to be executed.

The NBSLCC User's Guide and the NBSLCC program reference the subprograms slightly differently than they are referenced above. All of the NBSLCC executable programs on the disk are saved with the initial letter 'P' (to distinguish them from similarly named FBLCC programs). The following list shows the correspondence between the actual program name and its reference in the program:

Actual Program Name	Reference Name
NBSLCC.EXE	NBSLCC
PLCCDATA.EXE	LCCDATA
PPRNTBCF.EXE	PRINTBCF
PLCCMAIN.EXE	LCCMAIN
PPRNTLCC.EXE	PRINTLCC
PCOMPARE.EXE	COMPARE

It is not essential that the user be familiar with this correspondence, since the various subprograms are executed from a menu with functional choices. This list is included here primarily for sake of completeness.

The ENCOST90.RAN file contains the 1990 DOE energy price forecast for the years 1990 through 2030, used to provide default energy prices and rates of energy price escalation over those years. It is in binary (random access) form to conserve space on the disk and speed up disk access. There are now only four regions (northeast, southeast, midwest, and west) rather than ten regions as in the earlier DOE projections. The appropriate region for any location is automatically selected by entering the two-character state code for the actual location of the project rather than the DOE region itself. The ENCOST90.SEQ file is a shorter file which tells NBSLCC how the larger energy price file is arranged so that it can be read properly. The STATES file is used to show the appropriate code for all 50 states (plus the District of Columbia) in the help mode.

All files with the extension .FIS provide the formatting needed to display the data input screens.

All files ending in .BCF are the building characteristics files used in the examples in the NBSLCC user's guide.

All files ending in .LCC are the life-cycle cost output files used in the examples in the NBSLCC user's guide.

HDYESNO.DAT is a small file used when calling ASEAM from NBSLCC to determine whether or not NBSLCC and ASEAM are saved in the same subdirectory in a hard disk. The single upper case letter 'Y' or 'N' is contained in this file.

STARTING NBSLCC

To run the NBSLCC program from the default drive, type 'NBSLCC' at the ready prompt. IMPORTANT NOTE: YOU MUST HAVE A FORMATTED DISK IN YOUR B DRIVE FOR SAVING AND RETRIEVING DATA FILES. If you are running the program from a hard disk and do not have a B drive, try putting the data disk in the A drive. It will usually act as though it were the B drive as well. If you want to access the building characteristics files (extension = .BCF) and life-cycle cost output files (extension = .LCC) that have been included on the master disk, these must be copied to another disk that can be inserted into the B drive.

Alternatively, the NBSLCC program can be run from the B drive; then these files can be accessed directly from the master disk. However, since there is only limited space available on the master disk, this is not a recommended general procedure for running the program.

Refer to the NBSLCC user's guide for general information about the NBSLCC program. Information needed to run the screen-editor version of this program is included below in this file.

Change in DOE Energy Price Projections

The DOE energy price projections contained in the ENCOST.RAN file on this disk are current as of January 1990. The energy cost analyses reported in the examples in the NBSLCC user's guide are based on older (1985) projections. The building characteristics files on this disk which correspond to those examples are based on the older DOE energy price projections and thus will match the results reported if they are not edited. However, if you load a building characteristics file into the LCCDATA data entry module, the DOE projections of energy price increases (if specified) will automatically be updated. Thus the resulting LCC analysis will no longer match the published examples exactly. Note that only the rates of energy price increase (i.e., the energy price escalation rates) over the study period are automatically updated. The unit energy price for each energy type is updated by pressing <F8> when the cursor is at the energy price input line in order to retrieve the appropriate price from the DOE energy price file.

New Variables

Two new variables have been added to the NBSLCC program since the user's guide was published: (1) a comment line (70 character maximum, no commas allowed) which can be used to include general reference information about a project in its building characteristics file for future reference, and (2) a two- character state code for use in accessing the DOE energy price projections. The two-character state code must correspond to the official Postal Service code (e.g., CA for California). Use 'US' to access DOE average U.S. energy price projections. Use 'H' for help; then all of the Postal Service codes can be scanned at the bottom of the screen using the up and down cursor arrows. (Once the appropriate code has been determined, it must still be entered in the appropriate space.)

Additional Help

Do not confuse "Project Title" with "File Name". The project title is used to identify the project when printing out the LCC reports (LCC analysis and comparative analysis). It can have up to 12 characters. The file name is used to save and retrieve the data files to and from the disk, and must conform to the Disk Operating System (DOS) file-name conventions, i.e., no more than eight alpha-numeric characters. Never include a file name extension with the file name; this is automatically added by the program to distinguish between file types. Never insert a space in a file name; it will be saved but can't be retrieved.

Note that a separate building characteristic file must be set up for each alternative project to be evaluated. You cannot evaluate several projects simultaneously by specifying each as a separate component of a single project. Separate components are specified to a single project to make it easier to compute replacements, depreciation, property taxes, and resale value at the end of the study period. (Operating, maintenance, and energy costs are not specific to individual components but only to the entire building or building system being evaluated. Once you set up a building characteristics file for a project and save it, it is often easier to edit that file with data from the alternative project and then save it under a new name than to start from scratch on a new file.

Using LCC Menus

Menu choices are displayed in horizontal bars across the screen. One of the selections is highlighted by a reverse video box (the first selection when entering a program). Select the option you want by moving this box using the right and left cursor control keys (the arrows on the 4 and 6 keys of the numeric keypad) until it is over the option you desire and then pressing <Enter>. This command will be executed or another menu will appear.

Pressing any key other than the left or right arrow or <Enter> will cause a beep.

Secondary menus may either appear as additional horizontal selections, or a vertical "pull down" menu under the item first selected. These vertical pull-down menus work exactly like the horizontal menus, except that the up and down arrows (instead of left and right) must be used to move the highlighted selection. Once again, pressing <Enter> is required to "select" an option, and pressing any key other than these three will cause the computer to beep.

Many times you will see "Exit" as a valid choice in a menu. If you are in a program's top level horizontal menu, "Exit" means to leave this program and to go into another program. On a secondary menu (either horizontal or vertical), "Exit" means to return to a higher level menu--not to leave the LCC program.

When you begin running the LCC input program, the first menu appears on the screen. The fully expanded input menu is shown below. Note that the second bar menu appears if you select "Edit BCF Data" from the first menu bar. The third menu bar and vertical menu appears if you select "Capital Components" from the second menu bar.

NBSLCC BUILDING CHARACTERISTICS INPUT PROGRAM

Get BCF File	Save BCF File	Edit BCF Data	Enter New Data	Exit

All Data	Project	Capital Components	O&M	Energy	Exit

All Data	Component Data	Cost Phasing	Replacements	Exit

All Components
Component 1
Component 2
Component 3
Component 4
Component 5
Component 6
Exit

Get BCF File

The Get command retrieves an existing BCF data file from the data disk in drive 'B' and loads it into memory. You must use this command before you can edit a file, since the editing program works within memory and not directly from the disk.

When you choose "Get BCF File" the program will respond with a list of all BCF input files stored on your data disk. Move the highlighted bar with the cursor control keys (up, down, right, left) until it is over the file you want to get and press <Enter>. If the file which you want to edit is not on the list, first mark "Exit" and press <Enter> (to get out of "Get BCF File"), then insert the correct data disk with the file to edit in drive 'B', and try "Get BCF file" again. Once you see the file you want, mark it with the reverse video box and press <Enter>. A message will appear on the screen for a few moments while the computer reads the file into memory. When the Main Menu reappears, you are ready to "Edit BCF File."

If you use the "Get BCF File" command when data is currently in memory, a warning will be issued. Retrieving a file overwrites all data in memory with the data from the file.

Save BCF File

The Save command saves a data file so that you can use the file again at a later time. This command copies the complete input data file from memory (temporary storage) where you have been editing it, to disk (permanent storage). If you do not save a file, it will be gone forever once you exit from the BCF Input program or get a different data file. The Save command should be used each time you are done editing a file. The only exceptions are if you have made no changes at all to the file, or if you have made erroneous changes and would prefer to have the previous (last saved) version of the file. When you use the Save command, a message asking you for the

file name to save will be displayed. Pressing <Enter> causes the file to be saved under the same name (what you retrieved the file as); typing a new name causes the file to be saved under that name; typing 'X' aborts the Save command and returns you to the BCF Input Menu.

WARNING: If you press <Enter> for the filename, the file in memory will overwrite the file on disk. You may want to use a new filename and have the old file as a backup.

File names may be up to eight alphanumeric characters. (Refer to your DOS manual for valid filename characters.) Do not specify an extension.

Edit BCF Data

The Edit command allows you to review and change the contents of the data file in memory. You must first "Get" a file before you can "Edit" it. When you use the Edit command, another menu will be displayed which lists particular screens to edit. You may edit the entire data file or only one particular screen.

Each time you complete an input screen, the information on it is transferred into memory. After you have finished the screens which you indicated for editing, the Main Menu will reappear. Choose either additional sections to edit, save the file and proceed to edit another file, or exit to the other subprograms.

Enter New Data

The Enter New Data command clears the memory and lets you begin entering a new set of data for the BCF file. All of the input screens will appear sequentially, with blank lines where you should fill in values. REMEMBER to

store the file in memory before you Enter New Data. A warning message appears if data is presently in memory.

Exit

The Exit command should be used when you want to leave the BCF Input routine. The question "Did You Remember to Save Your Files?" will be printed on the screen. If you answer 'N' followed by an <Enter>, you will be returned to the BCF Input Menu for another chance to save the file.

Cautions about Memory

Memory is only temporary. The data stored in memory is destroyed when you exit any of the BCF input programs, turn off the computer or otherwise lose power, or reboot. Also, only one file can be held in memory at a time. Thus, if you replace the file in memory with a different file (either an existing file with "Get BCF File" or a blank file with "Enter New Data") the file which was previously in memory will be lost. (The program issues a warning message whenever you use the "Get" or "Enter New Data" commands and there is existing data in memory.) To save the contents of the file in memory, you must "Save BCF File" before editing other files or leaving the BCF input program.

The "Save BCF File" command copies the file in memory to the data diskette in drive 'B', where it is stored permanently. Since the disk file is not changed until you save, if you make many mistakes or accidentally erase a lot of information while editing, you can always go back to the last saved version of the file by getting the file again.

The BCF Input Screens

This section will tell you how to move around within and between input screens. The body of the screen is a series of input questions with lines for the data input. There may be more than one column for data entry. The cursor will move to only those lines where you should input data. Cursor control is discussed below. At the bottom of each input screen is a function key menu, describing the action resulting from pressing each function key. This information is explained in more detail below. The cursor control and function key conventions are the same for all LCC and ASEAM2 input data screens. They apply both for editing existing and editing new data.

Cursor Control

There are two different types of cursors in the program. A "smiley face" cursor is what originally shows on the screen, at the first entry. With this cursor you can move between entries. Once you begin to type an entry the cursor changes to a blinking underline. The cursor control keys have different functions for the two types of cursors.

Smiley Face Cursor

When you first enter an input screen (through either the "Edit" or the "Enter New Data" command) the screen will display a list of input questions followed by either the current values (in the case of edit) or blank lines (in the case of new data). A smiley face cursor is in front of the first question. This cursor is used to move around the screen, from one input question to another.

The following keys are used to move the smiley face cursor:

<Up> - moves up to next entry without error checking

<Down> - moves down to next entry without error checking

<Right> - moves right to next entry (down if no multiple columns) without error checking

<Left> - moves left to next entry (down if no multiple columns) without error checking

<PgUp> - completes error checking for entire screen. If no errors are found, moves to previous screen. If an error is found, prints an explanatory message at the bottom of the screen, beeps, and positions cursor at the incorrect entry. If current screen is the first in the editing sequence, returns to BCF Input Menu.

<PgDn> - completes error checking for entire screen. If no errors are found, moves to next screen. If an error is found, prints an explanatory message at the bottom of the screen, beeps, and positions cursor at the incorrect entry. If current screen is the last in the editing sequence, returns to BCF Input Menu. NOTE: after the last entry is made on a screen, a message at the bottom of the screen will advise you to press <PgDn> for the next page. This message will be visible for about four seconds. You cannot execute this command until the message disappears.

<Enter> - completes entry, performs error checking, moves to next entry if data is valid. If the entry is incorrect, an explanatory message is printed at the bottom of the screen and the cursor remains at this entry.

<Esc> - refreshes the screen. The data will appear as it was when you first entered the screen. Any data which was changed will be replaced with the original data.

The function keys may also be used. These are discussed below. Any other keystroke will be interpreted as data entry and written on the entry line.

Underline Cursor

When you begin to type an entry, the cursor changes to a blinking underline. What you type is entered on the data entry line. With this cursor, you move WITHIN an entry, NOT between entries. The cursor control keys have different actions from those for the smiley face cursor.

The following keys are used to move the underline cursor:

<Up> - completes entry, performs error checking, moves up to previous entry if answer is valid.

<Down> - completes entry, performs error checking, moves down to next entry if answer is valid.

<Enter> - same as Down.

<Right> - moves cursor right to next character.

<Left> - moves cursor left to previous character.

<Home> - moves to first character of entry.

<End> - moves to last character of entry.

<Del> - deletes the character at the cursor, characters to the right of the cursor are moved one space to the left.

<Ins> - inserts characters at the cursor.

<Backspace>- deletes the character to the left of the cursor.

<Ctrl><End>- deletes all characters to the right of the cursor.

<Esc> - clears entry.

Any alphanumeric character will be entered as data. The function keys <F9> (help) and <F10> (exit) may be used with the underline cursor. Any other keystroke will only cause a beep.

Function Keys

The function keys may also be used during the input sessions. When you have the blinking underline cursor, only <F9> and <F10> may be used. All function keys are available with the smiley face cursor. The function keys have the following actions:

<F3> - delete entry at cursor.

<F4> - delete column at cursor (only for screens with multiple columns) all other columns move to left.

<F5> - insert column at cursor (only for screens with multiple columns) all other columns move to the right.

WARNING: data in rightmost column is lost (moves off-screen).

<F6> - copy column at cursor (only for screens with columns) copies to column at right; if pressed again, copies further right.

WARNING: data in rightmost column is lost (moves off-screen).

<F8> - use default value (if there is one; if not, message appears).

<F9> - help, supplies context-specific message (if there is one).

<F10> - exit to BCF INPUT MENU.

WARNING: <F10> is like a break--editing changes made during this screen are not stored. Every time you <PgUp> or <PgDn> out of a screen or are moved to the next screen or the menu automatically, the information you input has been stored in memory. But whenever you use <F10> to return to the menu, the information from that particular screen will not be stored. If you want to keep the changes you have made in an input screen, press <PgDn> before using the <F10> key.

In addition, two other commands may be useful; these can be executed at any time:

<Alt> H - toggles off and on automatic help messages at the bottom of the screen. When the automatic help messages are toggled off, individual help messages can still be displayed by pressing <F9> at the point where help is needed. (Default setting is on.)

<Alt> P - toggles on and off the automatic screen advance command. When off (the default setting), you must press <PgDn> to advance to the next screen. When on, the screen is automatically advanced after the last entry on a page is complete. (The default setting is 'off' so that you can continue to examine the screen after completing the last entry.)

Error Checking

Many questions have upper and/or lower numeric limits or other restrictions (such as number of digits, alphanumeric strings, etc.) imposed on them. When you enter an unacceptable value (such as a letter when a number is required), the computer will beep and an error message will appear briefly at the bottom of the screen; the smiley face cursor will remain at that line for you to enter a new value. You cannot exit from a screen with incorrect or missing data with the cursor control keys. If you try to do so, the cursor will be returned to the erroneous data field. You can exit from a screen using the <F10> key at any time, but the data you just entered will not be saved and the previously existing data for that screen will be kept.

Default Values

Default values have been assigned for many of the input questions. To enter a default value, press the <F8> key. If there is no default value, the computer will beep and a message will appear briefly at the bottom of the screen. The cursor will remain at the same entry.

PROBLEM-SOLVING USING FBLCC AND NBSLCC

Solve Problem E-1 using FBLCC. (Note that this problem was presented as an illustration of manual calculations in Module D.)

When completed, have an instructor review your screen printouts and check you off as having successfully completed the exercise.

If you have sufficient time, try solving Problem D-1 using FBLCC. Or if you prefer experience with the tax and loan analysis features of NBSLCC, modify the assumptions of Problem D-1 as follows and use NBSLCC:

Launderette is a commercial operation.
Marginal income tax rate is 34%.
Depreciation method is straight line.
Depreciation period is 15 years.
After-tax discount rate is 12% nominal.
Annual inflation rate is 5%.
All (energy and non-energy) operating, maintenance, and repair costs are deductible from taxable income.

PROBLEM E-1

Selecting a Heating and Cooling System

Compare the LCCs of the following two systems for heating and cooling a house on a military base in Washington, D.C., based on their comparative cost effectiveness:

Baseboard Heating System with Window Air Conditioners (Lowest First-Cost System)

- Purchase and installation costs:

  Baseboard heaters = $500
  Window air conditioners = $1,000

- Annual maintenance cost = $50
- Air conditioner repairs in year 8 = $400
- Salvage values:

  Baseboard = $50 (10% of initial cost)
  Window air conditioners = $100 (10% of initial cost)

- Useful life = 15 years
- Annual electricity consumption = 60 MBtu (17,580 kWh)
- Price of electricity = $20/MBtu (0.068/kWh) (Commercial Pricing)

Heat Pump

- Purchase and installation cost = $3,000
- Annual maintenance cost = $100
- Compressor repair at end of year 8 = $600
- Salvage value (net of disposal costs) at end of life = $250 (8.33% of initial cost)
- Useful life = 15 years
- Annual electricity consumption = 40 MBtu (11,720 kWh)
- Price of electricity = $20/MBtu (0.068/kWh) (Commercial Pricing)

Problem E-1, continued

Additional Assumptions Common to Both Systems

- All costs are stated in constant dollars
- Discount rate = 7% (real)
- All variables not specified, such as comfort level, are the same for both systems.

DESIGNING & SIZING INDEPENDENT AND INTERDEPENDENT SYSTEMS

MODULE F

75 Minutes
Lecture, Discussion, and Problem Solving

OBJECTIVES

At the conclusion of this module, you are expected to be able to

- find the cost-effective size of an energy-related building system; and
- find the cost-effective combination of interdependent building systems.

REVIEW

Notes:

SLIDE F-1

DECISIONS

Focus of Day 2:

- what design or size of a given system
- how to combine interdependent systems
- which projects--in what design and size--to fund with a limited budget

NOTES:

INDEPENDENT SYSTEMS

SLIDE F-2

Assumptions

- 1200 ft^2 Single-Family House
- Ohio (Region 2)
- Annual Space Heating Load (AHL) = 50 MBtu
- Electric Resistance System, Efficiency (EFF) = 100%
- ΔAHL (MBtu) as Attic Insulation is Added:

	0 - R11	R11 - R19	R19 - R30	R30 - R38
	-13.0	-2.1	-1.3	-0.5

- ΔInsulation Cost: $300 $150 $200 $150
- Price of Electricity = $21.75/MBtu
- Commercial Electricity Rates
- 1988 DOE Price Projections
- Heating Only
- Study Period: 25 years

NOTES:

SLIDE F-3

ANNUAL HEATING ENERGY REQUIREMENT
DEPENDS ON
LOAD & SYSTEM EFFICIENCY:

$$AER = \frac{AHL}{EFF} = \frac{50\ MBtu}{1} = 50\ MBtu$$

AER = Annual Energy Requirement
AHL = Annual Heating Load
EFF = Heating System Efficiency
or Seasonal Coefficient of Performance

NOTES:

SLIDE F-4

NET SAVINGS FROM ADDING R11 INSULATION

$$NS = \left[\Delta \text{ AHL/EFF} \times \text{Price/MBtu} \times \text{UPW*} \right] - I$$

$$= [(13.0 \text{ MBtu/1}) \times \$21.75/\text{MBtu} \times 11.34] - \$300$$

$$= \$3,206 - \$300$$

$$= \$2,906$$

NOTES:

SLIDE F-5

NET SAVINGS FROM INCREASING INSULATION FROM R11 TO R19

NS = [(2.1 MBtu/1) x $21.75/MBtu x 11.34] - $150

= $518 - $150

= $368

NOTES:

SLIDE F-6

NET SAVINGS FROM INCREASING INSULATION FROM R19 TO R30

NS = [(1.3 MBtu/1) x $21.75/MBtu x 11.34] - $200

= $321 - $200

= $121

NOTES:

SLIDE F-7

NET SAVINGS FROM INCREASING INSULATION FROM R30 TO R38

NS = [(0.5 MBtu/1) x $21.75/MBtu x 11.34] - $150

= $123 - $150

= -$27

NOTES:

SLIDE F-8

SIZING ATTIC INSULATION

Level of Insulation	Δ Cost $	Total Cost $	Δ Savings $	Total Savings $	Δ Net Savings $	Total Net Savings $
0 - R11	300	300	3,206	3,206	2,906	2,906
R11 - R19	150	450	518	3,724	368	3,274
R19 - R30	200	650	321	4,045	121*	3,395*
R30 - R38	150	800	123	4,168	-27	3,368

NOTES:

SLIDE F-9

INCREMENTAL SIR -- NOT TOTAL SIR -- MUST BE USED TO SIZE!

Level of Insulation	Δ Cost $	Total Cost $	Δ Savings $	Total Savings $	Incremental SIR	Total SIR
0 - R11	300	300	3,206	3,206	10.7	10.7
R11 - R19	150	450	518	3,724	3.5	8.3
R19 - R30	200	650	321	4,045	1.6*	6.2
R30 - R38	150	800	123	4,168	0.8	5.2

No Indication of Optimal Size

NOTES:

INTERDEPENDENT SYSTEMS

SLIDE F-10

REPLACE ELECTRIC RESISTANCE SYSTEM
WITH HEAT PUMP?

Assumptions

no attic insulation	
purchase and installation cost:	$3,000
seasonal coefficient of performance (EFF):	1.8
maintenance and repair cost:	same as existing system
service life:	25 years

NOTES:

SLIDE F-11

NET SAVINGS FROM REPLACING EXISTING HEATING SYSTEM

(No Attic Insulation)

$$NS = \left[(AHL/EFF_E - AHL/EFF_{HP}) \times Price/MBtu \times UPW^* \right] - I$$

$$= \left[(50\ MBtu/1.0) - (50\ MBtu/1.8) \times \$21.75/MBtu \times 11.34 \right] - \$3,000$$

$$= \$5,481 - \$3,000$$

$$= \$2,481$$

NOTES:

SLIDE F-12

NET SAVINGS FROM REPLACING EXISTING HEATING SYSTEM

(R11 Attic Insulation)

$$NS = \left[(37\ MBtu/1.0) - (37\ MBtu/1.8) \times \$21.75/MBtu \times 11.34\right] - \$3,000$$

$$= \$4,056 - \$3,000$$

$$= \$1,056$$

NOTES:

SLIDE F-13

NET SAVINGS FROM REPLACING EXISTING HEATING SYSTEM

(R19 Attic Insulation)

$$NS = \left[(34.9\ \text{MBtu}/1.0) - (34.9\ \text{MBtu}/1.8) \times \$21.75/\text{MBtu} \times 11.34\right] - \$3{,}000$$

$$= \$3{,}826 - \$3{,}000$$

$$= \$826$$

NOTES:

SLIDE F-14

NET SAVINGS FROM REPLACING EXISTING HEATING SYSTEM

(R30 Attic Insulation)

$$NS = \left[(33.6\ MBtu/1.0) - (33.6\ MBtu/1.8) \times \$21.75/MBtu \times 11.34\right] - \$3,000$$

$$= \$3,683 - \$3,000$$

$$= \$683$$

NOTES:

SLIDE F-15

NET SAVINGS FROM REPLACING EXISTING HEATING SYSTEM

(R38 Attic Insulation)

$$NS = \left[(33.1\ \text{MBtu}/1.0) - (33.1\ \text{MBtu}/1.8) \times \$21.75/\text{MBtu} \times 11.34\right] - \$3,000$$

$$= \$3,628 - \$3,000$$

$$= \$628$$

NOTES:

SLIDE F-16

NET SAVINGS FROM HEAT PUMP
WITH DIFFERENT LEVELS OF INSULATION

Level of Insulation	Heat Pump Net Savings
None	$2,481
R11	1,056
R19	826
R30	683
R38	628

Conclusion: Heat Pump is cost-effective with all levels of insulation considered

NOTES:

SLIDE F-17

NET SAVINGS FROM ADDING R11 INSULATION

(with heat pump)

$$NS = \left[\Delta \text{ AHL}/\text{EFF}_{HP} \times \text{Price/MBtu} \times \text{UPW*}\right] - \text{I}$$

$$= \left[(13.0 \text{ MBtu}/1.8) \times \$21.75/\text{MBtu} \times 11.34\right] - \$300$$

$$= \$1,781 - \$300$$

$$= \$1,481$$

NOTES:

SLIDE F-18

NET SAVINGS FROM INCREASING INSULATION R11 TO R19

(with heat pump)

$$NS = \left[(2.1 \text{ MBtu}/1.8) \times \$21.75/\text{MBtu} \times 11.34 \right] - \$150$$

$$= \$288 - \$150$$

$$= \$138$$

NOTES:

SLIDE F-19

NET SAVINGS FROM INCREASING INSULATION FROM R19 TO R30

(with heat pump)

$$NS = \left[((1.3\ MBtu)/1.8) \times \$21.75/MBtu \times 11.34\right] - \$200$$

$$= \$178 - \$200$$

$$= -\$22$$

NOTES:

SLIDE F-20

NET SAVINGS FROM INCREASING INSULATION FROM R30 TO R38

(with heat pump)

$$NS = \left[((0.5 \times MBtu)/1.8) \times \$21.75/MBtu \times 11.34\right] - \$150$$

$$= \$69 - \$150$$

$$= -\$81$$

NOTES:

SLIDE F-21

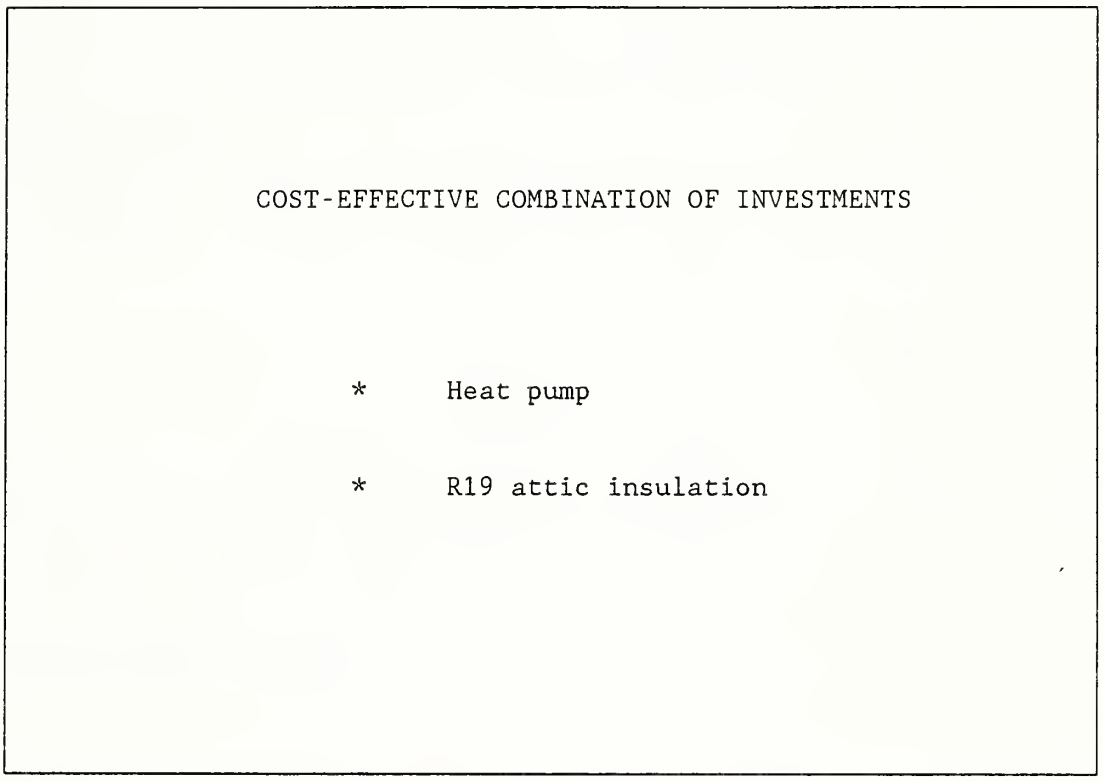
NS FROM ATTIC INSULATION ALONE
(Does not include Heat Pump Savings)

		Insulation Level			
		R11	R19	R30	R38
Replacement of Heating System	No	$2,906	$3,274	$3,395*	$3,368
	Yes	$1,481	$1,619*	$1,597	$1,516

Conclusion: With the heat pump, R19 insulation--not R30--is cost effective.

NOTES:

SLIDE F-22



NOTES:

INDEPENDENT SYSTEMS

Slides F-2 through F-8 show how to find the cost-effective level of insulation in a house on a military base in Ohio using the NS method. The NS method is convenient to use because the energy data are expressed as load reductions or savings. But the LCC method could also easily be used by starting with the base AHL and subtracting from it the reduction for each increment in insulation to derive AHLs for each level of insulation.

- Slide F-2 gives data.

- Slide F-3 shows that the annual energy requirement is calculated as the annual heating load divided by the efficiency of the heating system. This means there will be interdependence between actions taken on the envelope to reduce the load and actions taken to raise the heating system's efficiency.

- Slides F-4 through F-7 show how to calculate net savings (NS) from each additional increment of insulation.

- Slide F-8 summarizes the results of slides F-4 through F-7 and shows the level of insulation which maximizes net savings. It is R30. Past that point, additional increments result in net losses. Note that the level of energy conservation which provides the greatest Btu energy savings may not be the level which provides the

INDEPENDENT SYSTEMS

greatest dollar net savings. Also note the correspondence between results of the incremental NS approach and the total NS approach.

If there is no budget constraint, R30 is the cost-effective sizing choice. A budget less than $650 would make it necessary to cut back to an affordable level.

- Slide F-9 demonstrates that the SIR based on total costs and savings is not for sizing. However, used incrementally, the SIR gives results consistent with the LCC and NS methods. Size increments having SIRs greater than 1.0 are cost-effective.

INTERDEPENDENT SYSTEMS

Replacing the electric resistance heating system with a heat pump with a seasonal coefficient of performance of, say, 1.8, would reduce the annual heating energy requirement. Slide F-10 states assumptions. Slide F-11 shows the cost, savings, and net savings of replacing the heating system, assuming the insulation has not yet been added.

- Slides F-12 through F-22 show how to determine the cost-effective combination of the two retrofit investments.

- Slides F-12 through F-15 show calculation of net savings from replacing the heating system with increasing levels of attic insulation.

- Slides F-16 summarizes the results of slides F-12 through F-15. It may be seen that replacing the existing system with the heat pump continues to be cost-effective for all the levels of insulation considered.

- Slides F-17 through F-20 show calculation of net savings from insulation based on the condition that the existing heating system is first replaced by the heat pump.

- Slide F-21 summarizes the results of slides F-17 through F-20 and F-4 through F-7 and compares them. It may be seen that the cost-effective level of insulation is lower (R19) with the heat pump than with the existing system (R30).

- Slide F-22 identifies the cost-effective combination: add the heat pump and R19 attic insulation.

PROBLEM F-1

Use LCC or NS to Choose Among Single-, Double-, and Triple-Glazed Windows

Assumptions:

	Purchase & Installation Cost ($)	Δ Cost ($)	Annual Heating Load (MBtu)	Δ Annual Heating Load (MBtu)
Single-Glazed Windows	2,000	2,000	60	
Double-Glazed Windows	2,800	800	50	-10
Triple-Glazed Windows	3,400	600	48	-2

Furnace efficiency: 0.75

Fuel: Distillate Oil

Initial Price of Oil: $8.00/MBtu

Location: Vermont

Type of Building: Park Service, Ranger's House (Commercial Pricing)

All costs other than purchase and installation and energy are identical.

Estimated life: Indefinite

DETERMINING PROJECT PRIORITY

MODULE G

60 Minutes
Lecture, Illustration, and Exercise

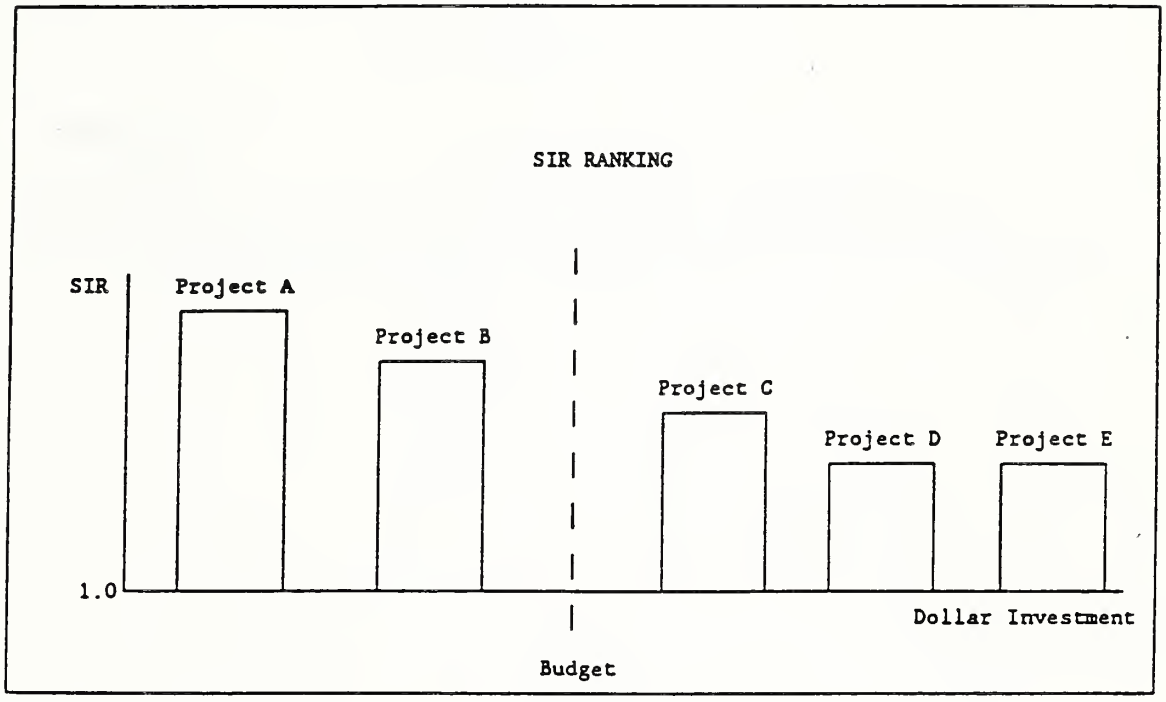
OBJECTIVES

At the conclusion of this module, you are expected to be able to

- use the SIR method to allocate a budget among independent projects.

SIR USEFUL FOR ASSIGNING PRIORITY

SLIDE G-1



NOTES:

SLIDE G-2

ASSUMPTIONS

Project	I ($1,000)	MBtu Saved	PV Energy Savings ($1,000)
A	10	100	20.0
B	10	1,000	17.0
C	5	200	11.0
D	5	220	11.5

Budget = $20,000

NOTES:

SLIDE G-3

RANKING BY BTU/I

Project	I ($1,000)	MBtu Saved	MBtu/ 1,000	Rank
A	10	100	10	4
B	10	1,000	100	1
C	5	200	40	3
D	5	220	44	2

NOTES:

SLIDE G-4

RANKING BY NET SAVINGS

Project	I ($1,000)	PV Energy Savings ($1,000)	NS ($1,000)	Rank
A	10	20.0	10.0	1
B	10	17.0	7.0	2
C	5	11.0	6.0	4
D	5	11.5	6.5	3

NOTES:

SLIDE G-5

RANKING BY SIR

Project	I ($1,000)	PV Energy Savings ($1,000)	SIR	Rank
A	10	20.0	2.0	3
B	10	17.0	1.7	4
C	5	11.0	2.2	2
D	5	11.5	2.3	1

NOTES:

SLIDE G-6

COMPARISON OF NET SAVINGS
FROM RANKING BY Btu/I, NS, and SIR

Projects Selected & Net Savings ($1,000)

	Btu/I	NS	SIR
		A (10.0)	A (10.0)
	B (7.0)	B (7.0)	
	C (6.0)		C (6.0)
	D (6.5)		D (6.5)
Total NS:	19.5	17.0	22.5

NOTES:

SLIDE G-7

SETTING PROJECT PRIORITIES -- LIMITED BUDGET ($10,000)

PROJECTS	FIRST COST ($1,000)	PV SAVINGS ($1,000)	NET SAVINGS ($1,000)	SIR	SIR RANKING
A	0.2	0.9	0.7	4.5	7
B	2.0	10.0	8.0	5.0	6
C	1.6	12.0	10.4	7.5	5
D	10.0	80.0	70.0	8.0	4
E	2.0	25.0	23.0	12.5	1
F	3.0	36.0	33.0	12.0	2
G	1.0	9.0	8.0	9.0	3
	$19.8	$172.9	$153.1		

NOTES:

SLIDE G-8

Projects	First-Cost ($1,000)	Net Savings ($1,000)
Option 1 -- accept all projects except D:		
E	2.0	23.0
F	3.0	33.0
G	1.0	8.0
C	1.6	10.4
B	2.0	8.0
A	0.2	0.7
Total	$9.8	$83.1
Option 2 -- accept only project D:		
D	$10.0	$70.00

NOTES:

SLIDE G-9

Allocating a Budget Among Projects of Variable Size: Data

Project Alternatives	First Cost ($)	PV Savings ($)	NS ($)
A	12,000	60,000	48,000
B(1)	5,000	15,000	10,000
B(2)	6,000	17,000	11,000
C	6,000	5,000	-1,000
D	3,000	12,000	9,000
E	8,000	12,000	4,000
F	5,000	14,500	9,500

NOTES:

SLIDE G-10

ALLOCATING A BUDGET AMONG PROJECTS OF VARIABLE SIZE: SIR RANKING

Projects	I ($)	Savings ($)	NS ($)	Δ SIR	Priority
A	12,000	60,000	48,000	5.00	1
B(1)	5,000	15,000	10,000	3.00	3
B(1) ---→ B(2)	1,000	2,000	1,000	2.00	5
D	3,000	12,000	9,000	4.00	2
E	8,000	12,000	4,000	1.50	6
F	5,000	14,500	9,500	2.90	4

NOTES:

SLIDE G-11

Selection for budget of $20K:

Select	I ($)	NS ($)
A	12,000	48,000
D	3,000	9,000
B(1)	5,000	10,000
	$20,000	$67,000

NOTES:

SLIDE G-12

ALLOCATING A BUDGET AMONG PRESIZED PROJECTS: SIR RANKING

Projects	I ($)	Savings ($)	NS ($)	SIR	Priority
A	12,000	60,000	48,000	5.00	1
B(2)	6,000	17,000	11,000	2.83	4
D	3,000	12,000	9,000	4.00	2
E	8,000	12,000	4,000	1.50	5
F	5,000	14,500	9,500	2.90	3

for budget of $20,000:

Select	I ($)	NS ($)
A	12,000	48,000
D	3,000	9,000
F	5,000	9,500
	$20,000	$66,500

NOTES:

SIR USEFUL FOR ASSIGNING PRIORITY

The Savings-to-Investment Ratio (SIR) is useful for assigning priority to cost-effective projects when the budget is limited.[1] Selecting projects in descending order of their SIRs can be relied on to maximize total net savings for the budget, provided the budget can be fully expended without departing from the SIR ranking.

- Slide G-1 depicts how projects are ranked in descending order of their SIRs and selected until the budget is exhausted.

The LCC and NS methods are not appropriate for assigning funding priority to individual projects. It may seem a paradox that assigning highest priority to projects with the greatest individual net savings will usually not maximize total net savings for the budget.

Furthermore, assigning highest priority to projects with the greatest Btu savings per investment dollar (Btu/I) will usually not maximize total net savings for the budget. The Btu/I measure treats all Btus as equal, ignoring that it is more economic to save expensive electricity Btus in New York City than inexpensive coal Btus in Ohio.

[1]The Adjusted Internal Rate of Return (AIRR) is also appropriate for assigning priority to cost-effective projects when the budget is limited. It may be used as an alternative ranking method.

SIR USEFUL FOR ASSIGNING PRIORITY, continued:

- Slide G-2 gives investment cost, annual quantity of energy savings, and present value energy savings for four independent projects, A, B, C, and D. Project A saves electricity in New York City. Project B saves coal in West Virginia. Project C saves natural gas in Iowa. Project D saves distillate oil in Alaska.

- Slide G-3 shows project ranking by Btu/I. Note that B is ranked first; D, second; C, third; and A, fourth.

- Slide G-4 shows project ranking by NS. Note that A is now first ranked; B is second; D, third; and C, fourth.

- Slide G-5 shows project ranking by SIR. Note that D is now first ranked; C is second; A, third; and B, fourth.

- Slide G-6 compares total net savings resulting from each of the three rankings, assuming a total budget of $20K. Note that ranking by SIR gives a higher total NS ($22.5K) than ranking by Btu/I ($19.5K) or NS ($17.0K).

LIMITATIONS OF SIR FOR ASSIGNING PRIORITY

"Lumpiness" in project costs may cause it not to be possible to fully exhaust the budget by taking projects exactly in descending order of their SIRs (or AIRRs). In this case, ranking by SIR may

LIMITATIONS OF SIR FOR ASSIGNING PRIORITY, continued

fail to identify the group of projects which will maximize overall net savings for the budget. Slides G-7 and G-8 illustrate this problem.

- Slide G-7 lists for seven independent projects, A through G, first cost, present value savings, net savings, SIR, and SIR ranking. Project costs total nearly $20,000. Assume the available budget is only $10,000. According to the SIR ranking, project E (SIR = 12.5) is first chosen for an expenditure of $2,000.

  Next, project F (SIR = 12.0) is chosen for a total expenditure of $5,000. Project G (SIR = 9.0) is chosen for a total expenditure of $1,600. The next ranked project is project D (SIR = 8.0), but its cost, $10,000, drives total cost over the budget.

  The options are to (1) drop projects E, F, and G, and take only project D; or (2) take projects E, F, and G, skip over project D, and take the remaining projects, C, B, and A.

- Slide G-8 compares total net savings of option 1 ($83.1) and option 2 ($70.0), and finds the former to be higher and, hence, preferable.

  (Note that any funds left uninvested, such as the $200 left uninvested by choosing alternative 1, are assumed

LIMITATIONS OF SIR FOR ASSIGNING PRIORITY, continued

to earn a rate of return equal to the discount rate, and, hence, add nothing to net savings.)

When it is necessary to depart from the SIR ranking to fully allocate the budget, a comparison of total NS of the various possible combinations of projects must be made to ensure that the combination which maximizes net savings is selected.

ALLOCATING A BUDGET AMONG PROJECTS OF VARIABLE DESIGN/SIZE

To maximize total net savings from investing in a group of projects of variable design and size, design/size decisions must be made jointly with budget allocation decisions. Slides G-9 through G-11 show how this can be done.

- Slide G-9 lists for six independent projects, A through F, first cost, present value savings, and net savings. One of the projects, B, can be done in a small size, designated B(1), or in a larger size, designated B(2). Size B(2) costs $1,000 more than B(1) and saves $2,000 more, which means that its net savings are $1,000 higher than B(1). If there is no budget limitation, clearly it pays to choose the larger size B(2) over the smaller size B(1). But if there is a budget constraint, the increment to project B may be less worthwhile than a competing use of funds.

ALLOCATING A BUDGET AMONG PROJECTS OF VARIABLE DESIGN/SIZE, continued:

- Slide G-10 ranks the increment to project B (designated B(1) ⟶ B(2)) relative to the competing projects. It ranks fifth. For a budget of $15,000, projects A and D are chosen. For a budget of $20,000, projects A, D, and B in its smaller size are chosen. For a budget of $25,000, project F is added. Only if the budget reaches $26,000, is project B selected in its larger size.

- Slide G-11 shows the budget allocation/sizing for a budget of $20,000. Net savings are $67,000.

- Slide G-12, for comparison, shows how net savings are less if project B is sized first, without regard to the budget limitation. Project B in its larger size is ranked fourth. For a budget of $20,000, Projects A, D, and F are selected, resulting in net savings of $66,500. Note that net savings are lower than those obtained from the joint size/allocation solution.

When there is a single budget to be allocated, it is important to make design/size increments of projects compete for funding. But when there are a series of budgets to be allocated, it may be better, as a rule-of-thumb, to predesign/size projects as though there were no budget limitation, and then let those projects compete for funding as it becomes available. This approach will tend to result in slightly oversized projects, but ignoring future budgets will result in undersized projects. The economic

ALLOCATING A BUDGET AMONG PROJECTS OF VARIABLE DESIGN/SIZE, continued:

efficiency loss will tend to be less by predesigning/sizing projects when there are a series of budgets.

Problem G-1

Allocating a Budget among Projects of Variable Size Using SIR

Allocate a budget of $6,500 among the following projects, assuming that no future funds will be available for retrofitting Buildings A, B, C and D.

Energy Conservation Projects	First Cost ($)	PV Savings ($)
Add Solar Water Heater in Building A	2,000	3,800
Replace Chillers in Building A	12,000	16,800
Add R-8 Insulation in Building B	1,000	5,000
Increase Insulation in Building B from R-8 to R-19	500	1,000
Increase Insulation in Building B from R-19 to R-30	500	600
Replace Lighting System in Building C	3,000	9,000
Replace Windows in Building D	6,000	9,600

What if the budget was $7,000?

UNCERTAINTY

MODULE H

60 MINUTES
Lecture, Discussion, Class Problem

OBJECTIVES

At the conclusion of this module, you are expected to be able to

- perform sensitivity analysis; and
- make a decision under uncertainty in accordance with Federal criteria.

MODULE H, CONTINUED

SOURCES OF UNCERTAINTY

NOTES:

CONSEQUENCES OF UNCERTAINTY

NOTES:

WHAT TO DO ABOUT UNCERTAINTY

NOTES:

SLIDE H-1

TECHNIQUES THAT ACCOUNT FOR UNCERTAINTY,

RISK, OR BOTH

1. conservative benefit and cost estimating
2. breakeven analysis
3. sensitivity analysis
4. risk-adjusted discount rate
5. certainty equivalent technique
6. input estimate using expected values
7. mean-variance criterion and coefficient of variation
8. decision analysis
9. simulation
10. mathematical/analytical technique

NOTES:

SLIDE H-2

SENSITIVITY ANALYSIS IS PERFORMED --

by repeating an economic evaluation

with one or more input values changed.

(It may be used with any of the five evaluation methods.)

NOTES:

SLIDE H-3

SENSITIVITY ANALYSIS

used to --

(1) identify critical data inputs

(2) estimate range of results

(3) answer "what if" questions

NOTES:

SLIDE H-4

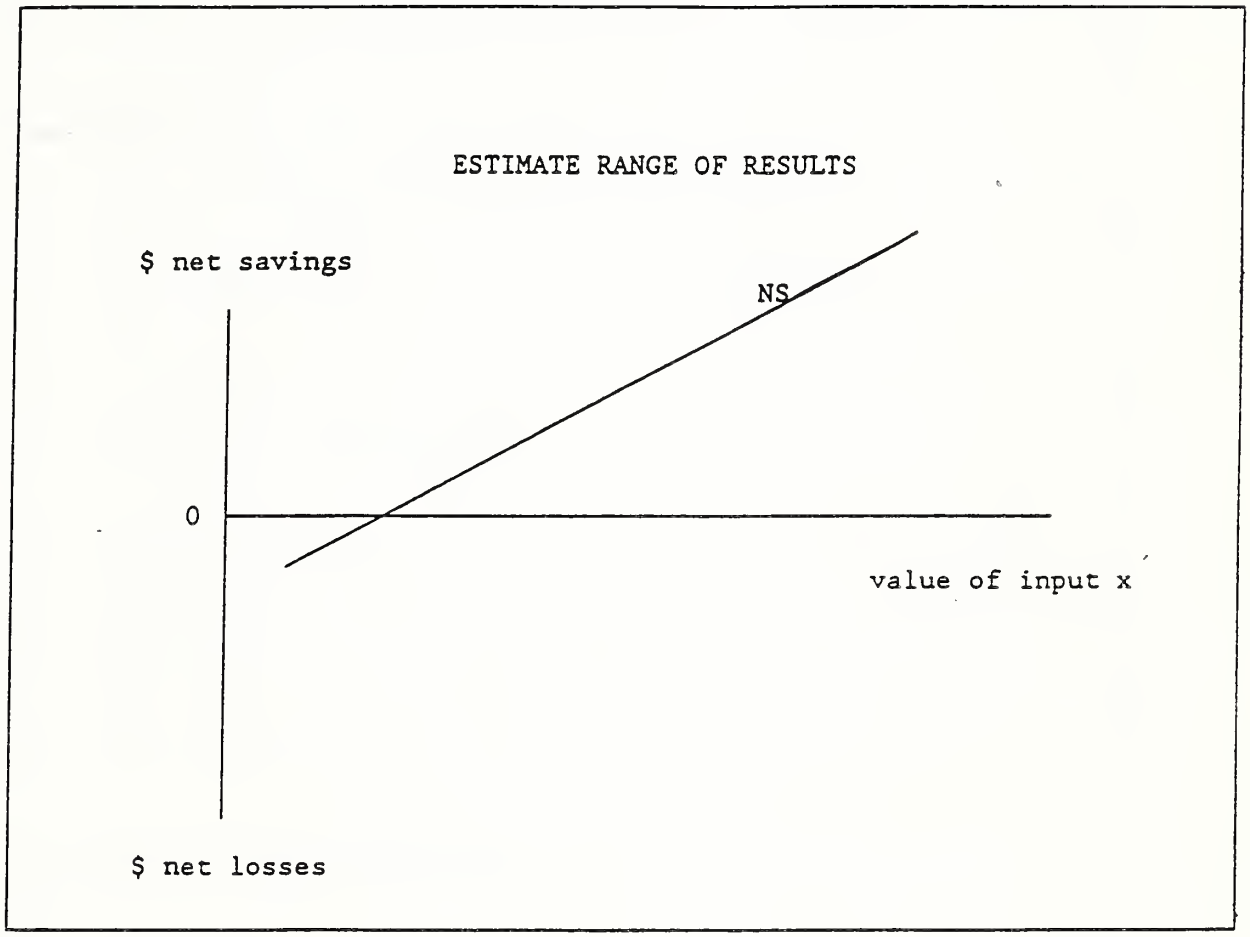
IDENTIFY CRITICAL INPUTS

10% change in input	% change in output
input 1	2
input 2	10
* input 3	20

Conclusion: devote more resources to improving data estimates for input 3 than input 1.

NOTES:

SLIDE H-5



NOTES:

SLIDE H-6

"WHAT IF?"

scenario	NS
1	$10,000
2	5,000
3	-1,000
4	3,000

NOTES:

SOURCES OF UNCERTAINTY

Economic evaluations which take a life-cycle perspective are based on projections and are, by nature, subject to uncertainty. There are usually uncertainties, for example, about the costs of constructing or purchasing and installing energy conservation systems, the quantity of energy saved, the time over which savings will continue, the future price of energy, and the costs of operating and maintaining systems over time.

CONSEQUENCES OF UNCERTAINTY

Uncertainty in input values means that actual outcomes may differ from estimated outcomes. Uncertainty may cause us to reject cost-effective projects, or accept projects that result in lower net savings than estimated or incur net losses. In short, uncertainty in input values creates risk that a decision will have a less favorable outcome than what is expected.

WHAT TO DO ABOUT UNCERTAINTY

The Presence of Uncertainty is not Cause to Abandon a Life-Cycle Approach:

Uncertainty in life-cycle cost analysis may cause you to think it is better to base decisions on first costs only, because they tend to be more certain. Consider, however, that a first-cost approach to decision making has in it the implicit assumption that future costs are zero. This is a poor assumption. Usually we can

Deterministic Approaches to Economic Evaluation Ignore Uncertainties:

Deterministic life-cycle cost analysis provides the decision maker with no information about the degree of uncertainty and associated risk. Using "best-guess estimates" as single input values to life-cycle costs and ignoring that the values are uncertain result in a single-value output.

Techniques for Treating Uncertainty and Risk:

There are a variety of techniques for treating uncertainty and risk which can improve decision making with life-cycle cost analysis. Slide H-1 lists 10 techniques. These techniques are described and their use illustrated in a 1988 report. (See H. E. Marshall, Techniques for Treating Uncertainty and Risk in the Economic Evaluation of Building Investments, National Institute of Standards and Technology, NIST Special Publication 757.)

In the limited time of the course, we will focus on one of the techniques:

Sensitivity Analysis. It is easy to perform, easy to use, is practical, and can aid in making decisions in the face of uncertainty. Sensitivity analysis requires no additional methods of computation beyond those already treated in the course. Slides H-2 through H-6 describe sensitivity analysis.

- Slide H-2 explains how to perform sensitivity analysis.

Techniques for Treating Uncertainty and Risk, continued:

- Slide H-3 lists three purposes for which sensitivity analysis is performed:

  (1) To identify critical data inputs, test the percentage change in the output value in response to a specified percentage change in each input value; e.g., the percentage change in LCC in response to a 10% increase in residual value.

  (2) To estimate the range within which an output will occur, calculate a lower bound for the output value based on pessimistic input values and an upper bound based on optimistic input values.

  (3) To answer "what if" questions, calculate output values based on different scenarios which a decision maker, or those with review responsibility, might have.

- Slide H-4 illustrates the use of sensitivity analysis to identify critical input values.

- Slide H-5 illustrates using sensitivity analysis to estimate the range within which the output will occur. Input x might, for example, be the quantity of energy saved each year and the lower and upper boundaries might be high and low construction cost, respectively.

- Slide H-6 illustrates using sensitivity anslysis to provide answers to "what if" questions.

Federal Criteria Regarding Uncertainty:

If uncertainty analysis casts substantial doubt on the results of life-cycle cost analysis, Federal agencies are advised to obtain more reliable input data, or eliminate the project.

Federal agencies are directed to use the DOE energy price projections and discount rate as published, without testing for sensitivity.

PROBLEM H-1

Taking Into Account Uncertainties

Use LCC with sensitivity analysis to evaluate the cost-effectiveness of retrofitting a computer room with a waste heat recovery system to supply part of the heating load of the building.

Data

Location:	Wyoming
Building:	Federal Building
Installed Cost of Waste Heat Recovery System:	$6,000
Yearly Maintenance and Repair Cost of Waste Heat Recovery System:	$500
Heating Load:	900 MBtu
Existing Fuel:	Natural Gas
Today's Price:	$5.15/MBtu (Commercial Pricing)
Efficiency of Existing System:	0.65
Contribution of Waste Heat Recovery System to Building's Heating Load:	25% (Best Guess) 10% (Worst Case)
Expected Period of Use:	Indefinite

REVIEW

MODULE I

60 MINUTES

Questions and Answers

OBJECTIVES

In this review, you are expected to be able to

- summarize how to perform an economic evaluation; and
- answer correctly selected questions about the evaluation process.

NOTES:

COMPUTER LAB: USING FBLCC & NBSLCC

MODULE J

150 MINUTES

Computer Lab

OBJECTIVES

By the end of this module, you are expected to be able to

- use FBLCC or NBSLCC to size a building system; and
- combine interdependent systems.

COMPUTER LAB PROBLEM J-1

Sizing Attic Insulation

Use either FBLCC or NBSLCC to determine the level of attic insulation with the lowest life-cycle cost for a single-family house with electric resistance heating, located in the suburbs of Washington, D.C. (Census Region 3). Assume a life of 25 years, and no salvage value. Use the following insulation cost and space heating load schedule:

ATTIC INSULATION LEVEL	TOTAL COST	SPACE HEATING LOAD (MBtu)
0	0	50.2
R-19	$440	35.2
R-30	$650	33.8
R-38	$800	33.3

Current electricity cost (residential rates) = $22.08/MBtu ($0.0754/kWh)

Energy conversion efficiency = 100%

Suggested Approach:

Using FBLCC or NBSLCC, create a building characteristics file (BCF) for the zero insulation case. This base case will have no investment cost (i.e., no capital component), no maintenance, and no resale value, but will have annual energy consumption based on the space heating load shown above. This base case BCF can then be modified to create BCFs for each insulation level, based on the insulation costs and corresponding space heating loads shown. Run LCCMAIN for each case and display the summary of LCCs to determine which insulation level has the lowest LCC.

COMPUTER LAB PROBLEM J-2

Combining Heating System Replacement with Attic Insulation

Use either FBLCC or NBSLCC to evaluate the cost effectiveness of replacing the electric resistance heating system described in Problem J-1, based on the data below. Determine the optimal combination of attic insulation and heat pump.

Cost of Heat Pump Installed:	$3,000
Seasonal Coefficient of Performance of Heat Pump (Heating)	2.0
Annual Maintenance Cost of Heat Pump:	$100
Annual Maintenance Cost of Electric Resistance System:	0
Expected System Lives:	25 years
Salvage:	0

APPENDIX A

ADDITIONAL PROBLEMS

Appendix Problem 1: Design Problem

Appendix Problem 2: Sizing and Ranking Problem

Appendix Problem 3: Deciding Whether a Building Investment is Subject to FEMP Guidelines and Taking into Account a Delay in Construction

APPENDIX PROBLEM 1

Building Design Problem

An energy-conserving building design (A) is being considered as an alternative to a conventional building design (B) for a Federal office building in Madison, Wisconsin (Census Region 2). The two designs are approximately equivalent in total assignable and auxiliary spaces and in functional performance with respect to the purpose of the building. Each has two underground levels for parking and seven office floors, plus a mechanical house. Each has a floor area of approximately 176,000 ft^2 (gross).

The two designs differ primarily in the envelope, building configuration, orientation, and lighting systems. The energy-conserving design is slightly elongated on the east-west axis for greater exposure of the south side to solar radiation. The window area of the energy-conserving side is 25% of the wall area and most of that is located on the south side; in the conventional building, it is 40%. More massive exterior surfaces are used and insulation is increased, reducing the wall U value from 0.16 to 0.06 and the roof U value from 0.15 to 0.06. Horizontal window fins reduce the summer cooling load of the energy-conserving design. The north wall of the first floor of the energy- conserving design is earth-bermed. It is assumed that both designs will last at least 25 years, and they are both assumed to have no salvage value remaining at the end of the 25-year study period.

Based on the data given on the following page, determine which design has the lowest life-cycle cost.

	Energy-Conserving Design (A)	Conventional Design (B)
(a) Site acquisition costs: (To ensure adequate exposure of south-facing windows, an additional acquisition cost of $100,000 is necessary for the energy-conserving design. Other site costs are assumed to be identical for the two designs, and hence, are not shown.)	$2,100,000	$2,000,000
(b) Architectural and Engineering Design Fees and Construction Costs	$9,780,000	$9,130,000
(c) Annual Energy Consumption:		
Natural Gas	2,290 MBtu	4,980 MBtu
Electricity	3,886 MBtu	7,277 MBtu
(d) Energy Prices:		
Natural Gas	$5.49/MBtu	$5.49/MBtu
Electricity	$21.21/MBtu	$21.21/MBtu
(e) Nonfuel O&M Costs:		
Recurring Annual Cost:	$70,000	$90,000
Repairs to External Surfaces Every 10 Years	$60,000	$100,000

APPENDIX PROBLEM 2

Sizing and Ranking Problem

Approximately 100 ft of hot water pipes running through the basements of each of 10 buildings of a Federal laboratory facility in Massachusetts have been found to be uninsulated. Data and assumptions are as follows:

Footage of Uninsulated Pipe: 100 ft/Bldg x 10 Bldgs = 1,000 ft
Required Water Temperature: 180°
Pipe Size: 1 1/2" Diameter
Operation: 4 hr/day x 260 days/yr = 1,040 hrs/yr
Type of Energy: Distillate Oil
Agency Base-Year Price of Distillate: $7.00/MBtu
Plant Efficiency: 0.55
Remaining Building Life: Indefinite
Insulation Life: Indefinite
Study Period: 25 years
Available Insulation Choices: 1" or 2" of Fiberglass
Heat Loss Rates[1] -- Uninsulated 1 1/2" Pipe: 150 Btu/hr/ft
1" Insulated 1 1/2" Pipe: 20 Btu/hr/ft
2" Insulated 1 1/2" Pipe: 12.5 Btu/hr/ft
Pipe Insulation Costs -- 1" Insulation: $3.60/ft installed cost
2" Insulation: $6.00/ft installed cost

The following questions are to be answered:

(1) Would it be cost-effective to insulate the pipes?
(2) How much insulation should be added, 1 or 2 inches?

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[1]Estimated from U.S. Department of Energy, Architects and Engineers Guide to Energy Conservation in Existing Buildings, Heat Loss Rate Nomogram, Figure H-1.

APPENDIX PROBLEM 2

Sizing and Ranking Problem, continued

(3) What priority should this project receive relative to the following independent projects: Project A, SIR = 5.0; Project B, SIR = 15.1; Project C, SIR = 1.7; Project D, SIR = 2.8?

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Energy Prices and Discount Factors for Life-Cycle Cost Analysis 1988 (SAMPLE)

Annual Supplement to
NBS Handbook 135 and
NBS Special Publication 709

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(Formerly National Bureau
of Standards)
Prepared for
United States Department of Energy
Federal Energy Management Program

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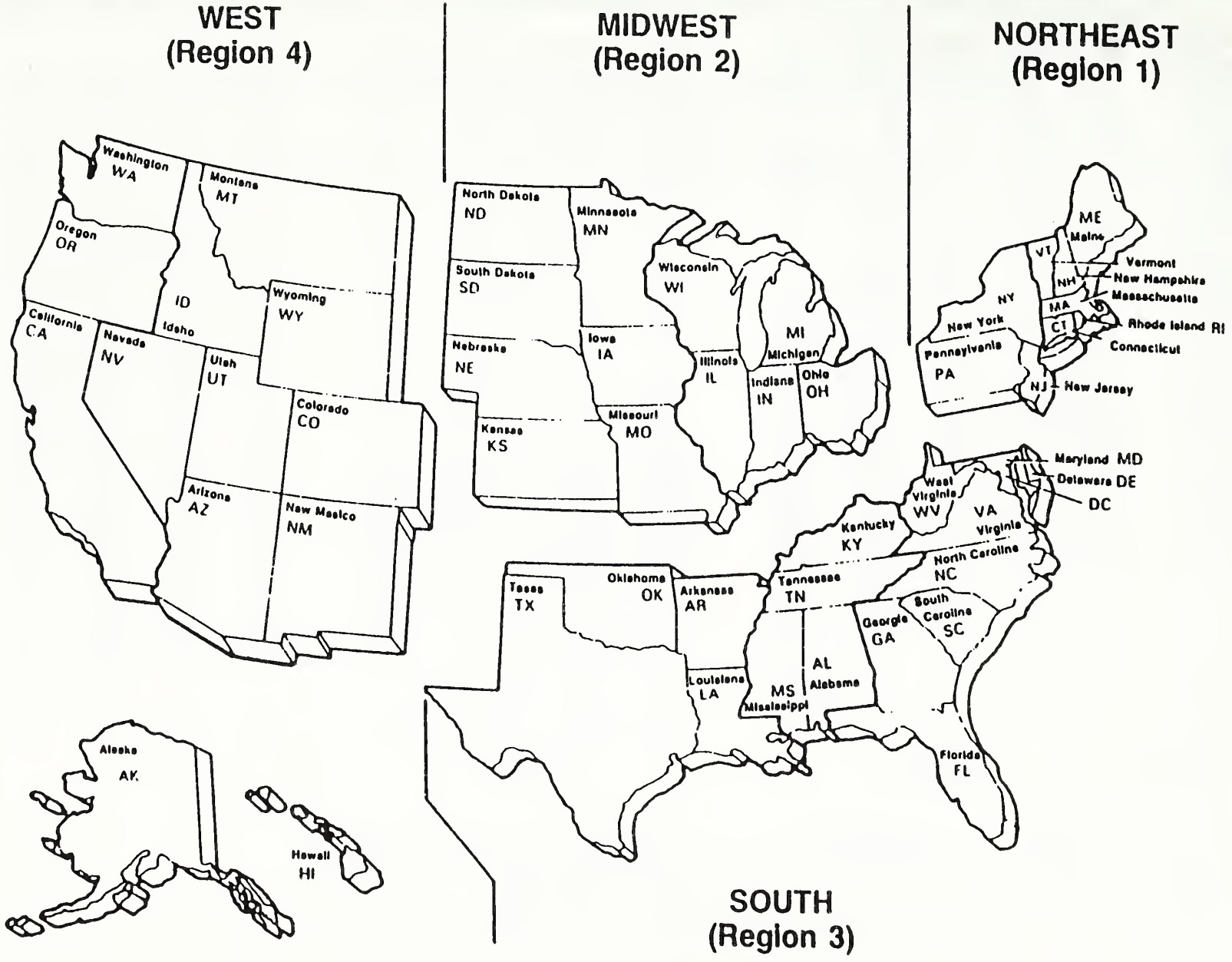
Table A-1. SPW Factors for Finding the Present Value of Future Nonfuel, Nonannually Recurring Amounts

Number of Years Until Future Amount Occurs (N)	SPW Factor (d = 0.07)	SPW Factor (d = 0.10)
1	0.93	0.91
2	0.87	0.83
3	0.82	0.75
4	0.76	0.68
5	0.71	0.62
6	0.67	0.56
7	0.62	0.51
8	0.58	0.47
9	0.54	0.42
10	0.51	0.39
11	0.48	0.35
12	0.44	0.32
13	0.41	0.29
14	0.39	0.26
15	0.36	0.24
16	0.34	0.22
17	0.32	0.20
18	0.30	0.18
19	0.28	0.16
20	0.26	0.15
21	0.24	0.14
22	0.23	0.12
23	0.21	0.11
24	0.20	0.10
25	0.18	0.09
		*** Extended Series ***
26		0.08
27		0.08
28		0.07
29		0.06
30		0.06

Table A-2. UPW Factors for Finding the Present Value of Future Nonfuel, Annually Recurring Amounts

Number of Years Over Which Amount Recurs (N)	UPW Factor (d = 0.07)	UPW Factor (d = 0.10)
1	0.93	0.91
2	1.81	1.74
3	2.62	2.49
4	3.39	3.17
5	4.10	3.79
6	4.77	4.36
7	5.39	4.87
8	5.97	5.33
9	6.52	5.76
10	7.02	6.14
11	7.50	6.50
12	7.94	6.81
13	8.36	7.10
14	8.75	7.37
15	9.11	7.61
16	9.45	7.82
17	9.76	8.02
18	10.06	8.20
19	10.34	8.36
20	10.59	8.51
21	10.84	8.65
22	11.06	8.77
23	11.27	8.88
24	11.47	8.98
25	11.65	9.08
		*** Extended Series ***
26		9.16
27		9.24
28		9.31
29		9.37
30		9.43



Source: U.S. Bureau of the Census

Figure B-1. Map of the United States Showing Census Regions.

TABLE B-1a. UPW* DISCOUNT FACTORS ADJUSTED FOR AVERAGE FUEL PRICE ESCALATION
BY END-USE SECTOR AND MAJOR FUEL[1]
DISCOUNT RATE - 7 PERCENT
Census Region 1 (Maine, New Hampshire, Vermont, Massachusetts,
Connecticut, Rhode Island, New York, New Jersey, Pennsylvania)

N	RESIDENTIAL				COMMERCIAL					INDUSTRIAL					TRANSPORTATION	
	ELEC	DIST	LPG	NATGAS	ELEC	DIST	RESID	NATGAS	COAL	ELEC	DIST	RESID	NATGAS	COAL	GASLNE	N
1	0.95	0.98	0.98	0.94	0.95	1.01	0.98	0.94	0.95	0.95	1.01	0.98	0.95	0.95	0.95	1
2	1.81	1.92	1.91	1.83	1.81	1.96	1.89	1.83	1.85	1.81	1.97	1.89	1.85	1.85	1.86	2
3	2.62	2.80	2.79	2.67	2.62	2.88	2.75	2.66	2.70	2.61	2.90	2.75	2.71	2.71	2.71	3
4	3.36	3.65	3.62	3.47	3.36	3.76	3.55	3.45	3.52	3.34	3.78	3.55	3.54	3.52	3.51	4
5	4.05	4.46	4.40	4.23	4.05	4.62	4.34	4.19	4.30	4.02	4.65	4.34	4.34	4.29	4.29	5
6	4.70	5.25	5.16	4.96	4.70	5.45	5.13	4.90	5.03	4.65	5.50	5.12	5.12	5.02	5.04	6
7	5.30	6.01	5.89	5.66	5.30	6.28	5.94	5.59	5.73	5.24	6.33	5.92	5.89	5.71	5.79	7
8	5.87	6.75	6.61	6.32	5.87	7.09	6.76	6.24	6.40	5.80	7.16	6.73	6.63	6.36	6.53	8
9	6.41	7.48	7.30	6.97	6.41	7.89	7.59	6.88	7.03	6.34	7.97	7.56	7.37	6.98	7.26	9
10	6.92	8.18	7.97	7.60	6.91	8.67	8.42	7.49	7.62	6.84	8.78	8.38	8.10	7.56	7.98	10
11	7.40	8.86	8.61	8.19	7.40	9.44	9.23	8.07	8.19	7.33	9.56	9.17	8.80	8.11	8.66	11
12	7.85	9.51	9.22	8.76	7.85	10.17	10.00	8.63	8.73	7.79	10.32	9.94	9.48	8.64	9.31	12
13	8.27	10.13	9.80	9.30	8.27	10.87	10.73	9.15	9.24	8.21	11.04	10.66	10.12	9.13	9.93	13
14	8.67	10.71	10.35	9.81	8.67	11.53	11.42	9.65	9.72	8.61	11.72	11.34	10.73	9.60	10.52	14
15	9.04	11.26	10.86	10.29	9.04	12.16	12.07	10.12	10.18	8.99	12.36	11.99	11.30	10.05	11.07	15
16	9.39	11.79	11.35	10.75	9.39	12.75	12.70	10.57	10.61	9.34	12.97	12.60	11.85	10.47	11.59	16
17	9.71	12.28	11.82	11.19	9.71	13.31	13.28	10.99	11.02	9.67	13.55	13.18	12.36	10.87	12.09	17
18	10.02	12.75	12.25	11.59	10.02	13.84	13.84	11.39	11.41	9.98	14.09	13.73	12.85	11.25	12.56	18
19	10.31	13.19	12.66	11.98	10.30	14.34	14.36	11.77	11.78	10.27	14.60	14.24	13.31	11.61	13.00	19
20	10.57	13.60	13.05	12.34	10.57	14.80	14.84	12.12	12.13	10.54	15.08	14.73	13.74	11.95	13.41	20
21	10.82	13.99	13.41	12.68	10.82	15.24	15.31	12.45	12.46	10.79	15.53	15.18	14.14	12.27	13.80	21
22	11.06	14.36	13.76	13.00	11.06	15.66	15.74	12.76	12.77	11.03	15.96	15.61	14.52	12.58	14.17	22
23	11.28	14.70	14.08	13.30	11.28	16.05	16.15	13.06	13.07	11.25	16.36	16.01	14.88	12.87	14.51	23
24	11.49	15.02	14.38	13.58	11.49	16.41	16.53	13.33	13.35	11.46	16.74	16.39	15.22	13.14	14.83	24
25	11.68	15.33	14.66	13.85	11.68	16.76	16.89	13.59	13.62	11.66	17.09	16.75	15.53	13.40	15.14	25

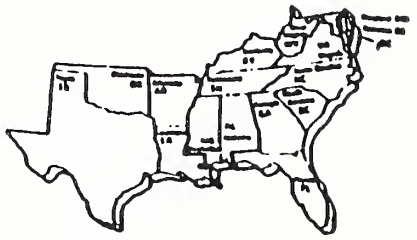
[1]ELEC - Electricity; DIST - Distillate; LPG - Liquefied Petroleum Gas; NATGAS - Natural Gas; RESID - Residual; COAL - Steam Coal; and GASLNE - Gasoline.

TABLE B-2a. UPW* DISCOUNT FACTORS ADJUSTED FOR AVERAGE FUEL PRICE ESCALATION BY END-USE SECTOR AND MAJOR FUEL[1]
DISCOUNT RATE = 7 PERCENT
Census Region 2 (Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas)

	RESIDENTIAL				COMMERCIAL					INDUSTRIAL					TRANSPORTATION	
N	ELEC	DIST	LPG	NATGAS	ELEC	DIST	RESID	NATGAS	COAL	ELEC	DIST	RESID	NATGAS	COAL	GASLNE	N
1	0.93	0.99	1.00	0.95	0.93	1.01	0.97	0.95	0.95	0.93	1.01	0.98	0.95	0.95	0.95	1
2	1.79	1.92	1.95	1.84	1.79	1.98	1.88	1.84	1.86	1.78	1.98	1.89	1.86	1.86	1.86	2
3	2.60	2.82	2.84	2.69	2.59	2.90	2.73	2.68	2.72	2.58	2.91	2.75	2.73	2.72	2.71	3
4	3.34	3.67	3.68	3.49	3.34	3.79	3.53	3.47	3.54	3.31	3.80	3.56	3.57	3.55	3.51	4
5	4.03	4.49	4.49	4.27	4.03	4.66	4.32	4.22	4.33	3.99	4.66	4.35	4.39	4.34	4.28	5
6	4.67	5.28	5.27	5.01	4.67	5.51	5.09	4.95	5.07	4.62	5.51	5.15	5.18	5.08	5.04	6
7	5.27	6.05	6.03	5.74	5.26	6.35	5.87	5.65	5.79	5.20	6.35	5.96	5.98	5.80	5.78	7
8	5.83	6.80	6.79	6.43	5.82	7.18	6.67	6.32	6.46	5.74	7.18	6.79	6.75	6.47	6.52	8
9	6.35	7.54	7.52	7.11	6.33	8.00	7.47	6.98	7.10	6.24	8.01	7.64	7.52	7.12	7.25	9
10	6.83	8.26	8.24	7.77	6.82	8.81	8.26	7.62	7.71	6.72	8.82	8.48	8.28	7.73	7.96	10
11	7.29	8.95	8.93	8.40	7.27	9.60	9.03	8.23	8.29	7.16	9.61	9.30	9.02	8.31	8.64	11
12	7.72	9.62	9.58	9.01	7.70	10.36	9.76	8.81	8.84	7.58	10.37	10.09	9.74	8.87	9.28	12
13	8.12	10.25	10.20	9.58	8.10	11.09	10.46	9.37	9.36	7.98	11.09	10.84	10.42	9.39	9.90	13
14	8.50	10.84	10.79	10.13	8.48	11.77	11.12	9.89	9.86	8.35	11.78	11.54	11.06	9.89	10.48	14
15	8.85	11.41	11.34	10.64	8.83	12.42	11.74	10.39	10.33	8.69	12.42	12.21	11.67	10.36	11.03	15
16	9.19	11.94	11.87	11.13	9.16	13.03	12.33	10.86	10.77	9.02	13.04	12.84	12.25	10.81	11.55	16
17	9.50	12.45	12.37	11.59	9.47	13.62	12.89	11.30	11.19	9.32	13.62	13.44	12.79	11.23	12.04	17
18	9.79	12.92	12.84	12.02	9.76	14.16	13.42	11.72	11.59	9.61	14.17	14.01	13.31	11.64	12.51	18
19	10.06	13.37	13.28	12.43	10.04	14.68	13.92	12.12	11.97	9.88	14.68	14.53	13.79	12.02	12.94	19
20	10.32	13.79	13.70	12.82	10.29	15.16	14.38	12.49	12.33	10.13	15.16	15.03	14.24	12.38	13.35	20
21	10.56	14.19	14.09	13.18	10.53	15.62	14.82	12.84	12.67	10.36	15.62	15.50	14.67	12.72	13.74	21
22	10.78	14.56	14.46	13.52	10.75	16.05	15.23	13.16	12.99	10.58	16.05	15.94	15.08	13.05	14.11	22
23	10.99	14.91	14.80	13.84	10.96	16.45	15.62	13.47	13.29	10.79	16.45	16.36	15.45	13.35	14.45	23
24	11.19	15.24	15.13	14.14	11.16	16.83	15.98	13.76	13.58	10.98	16.83	16.75	15.81	13.65	14.77	24
25	11.37	15.56	15.43	14.42	11.34	17.18	16.33	14.04	13.85	11.16	17.19	17.12	16.15	13.92	15.07	25

[1]ELEC = Electricity; DIST = Distillate; LPG = Liquefied Petroleum Gas; NATGAS = Natural Gas; RESID = Residual; COAL = Steam Coal; and GASLNE = Gasoline.

TABLE B-3a. UPW* DISCOUNT FACTORS ADJUSTED FOR AVERAGE FUEL PRICE ESCALATION BY END-USE SECTOR AND MAJOR FUEL[1]
DISCOUNT RATE = 7 PERCENT
Census Region 3 (Delaware, Maryland, District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Kentucky, Tennessee, Alabama, Mississippi, Arkansas, Louisiana, Oklahoma, Texas)



	RESIDENTIAL				COMMERCIAL					INDUSTRIAL					TRANSPORTATION	
N	ELEC	DIST	LPG	NATGAS	ELEC	DIST	RESID	NATGAS	COAL	ELEC	DIST	RESID	NATGAS	COAL	GASLNE	N
1	0.93	0.98	0.99	0.95	0.93	1.01	0.98	0.95	0.95	0.92	1.01	0.98	0.96	0.95	0.95	1
2	1.79	1.92	1.93	1.84	1.78	1.97	1.90	1.84	1.85	1.77	1.97	1.89	1.88	1.85	1.86	2
3	2.58	2.80	2.81	2.69	2.58	2.89	2.76	2.68	2.71	2.56	2.90	2.75	2.76	2.70	2.71	3
4	3.32	3.65	3.65	3.49	3.31	3.78	3.57	3.46	3.53	3.28	3.79	3.55	3.62	3.50	3.51	4
5	4.00	4.46	4.44	4.26	3.99	4.64	4.37	4.22	4.31	3.95	4.65	4.34	4.47	4.27	4.28	5
6	4.64	5.25	5.21	5.01	4.63	5.49	5.17	4.94	5.05	4.57	5.50	5.13	5.31	4.99	5.04	6
7	5.24	6.01	5.96	5.73	5.23	6.32	6.00	5.64	5.75	5.15	6.33	5.93	6.16	5.68	5.79	7
8	5.80	6.75	6.69	6.42	5.79	7.14	6.85	6.32	6.42	5.70	7.16	6.75	6.99	6.33	6.53	8
9	6.33	7.48	7.40	7.09	6.31	7.96	7.71	6.97	7.05	6.22	7.97	7.58	7.84	6.95	7.26	9
10	6.83	8.18	8.09	7.75	6.81	8.76	8.58	7.61	7.64	6.72	8.77	8.40	8.68	7.53	7.97	10
11	7.30	8.86	8.76	8.38	7.27	9.54	9.42	8.22	8.21	7.18	9.56	9.21	9.51	8.08	8.65	11
12	7.74	9.51	9.39	8.98	7.72	10.30	10.24	8.80	8.75	7.62	10.31	9.98	10.31	8.60	9.31	12
13	8.15	10.13	9.98	9.55	8.13	11.01	11.00	9.35	9.26	8.03	11.03	10.70	11.08	9.09	9.92	13
14	8.54	10.71	10.55	10.09	8.52	11.69	11.73	9.87	9.75	8.42	11.70	11.40	11.80	9.56	10.51	14
15	8.91	11.26	11.08	10.60	8.88	12.33	12.42	10.37	10.21	8.78	12.34	12.05	12.48	10.01	11.06	15
16	9.25	11.79	11.59	11.09	9.22	12.93	13.07	10.84	10.64	9.12	12.95	12.67	13.13	10.43	11.58	16
17	9.57	12.28	12.07	11.55	9.54	13.51	13.69	11.28	11.05	9.44	13.53	13.25	13.75	10.82	12.08	17
18	9.87	12.75	12.52	11.98	9.84	14.05	14.28	11.70	11.44	9.74	14.07	13.81	14.33	11.20	12.55	18
19	10.15	13.19	12.95	12.38	10.12	14.56	14.82	12.09	11.81	10.02	14.58	14.33	14.87	11.56	12.99	19
20	10.41	13.60	13.35	12.76	10.39	15.04	15.33	12.46	12.16	10.28	15.06	14.81	15.38	11.90	13.40	20
21	10.66	13.99	13.72	13.12	10.63	15.49	15.82	12.81	12.49	10.53	15.51	15.27	15.86	12.22	13.79	21
22	10.89	14.35	14.08	13.46	10.86	15.91	16.28	13.14	12.81	10.76	15.93	15.70	16.31	12.52	14.15	22
23	11.11	14.70	14.41	13.78	11.08	16.31	16.70	13.44	13.11	10.98	16.33	16.11	16.74	12.81	14.50	23
24	11.31	15.02	14.72	14.08	11.28	16.68	17.11	13.73	13.39	11.18	16.71	16.49	17.14	13.08	14.82	24
25	11.50	15.33	15.02	14.36	11.47	17.04	17.49	14.01	13.66	11.37	17.06	16.85	17.52	13.34	15.13	25

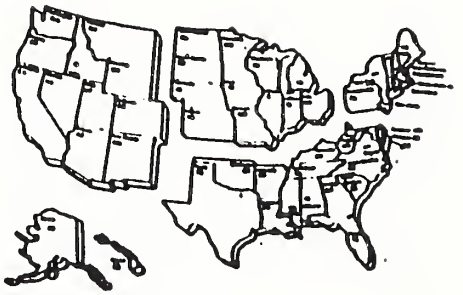
[1]ELEC = Electricity; DIST = Distillate; LPG = Liquefied Petroleum Gas; NATGAS = Natural Gas; RESID = Residual; COAL = Steam Coal; and GASLNE = Gasoline.

TABLE B-4a. UPW* DISCOUNT FACTORS ADJUSTED FOR AVERAGE FUEL PRICE ESCALATION BY END-USE SECTOR AND MAJOR FUEL[1]
DISCOUNT RATE = 7 PERCENT
Census Region 4 (Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, Utah, Nevada, Washington, Oregon, California, Alaska, Hawaii)

	RESIDENTIAL				COMMERCIAL					INDUSTRIAL					TRANSPORTATION	
N	ELEC	DIST	LPG	NATGAS	ELEC	DIST	RESID	NATGAS	COAL	ELEC	DIST	RESID	NATGAS	COAL	GASLNE	N
1	0.94	0.99	0.99	0.95	0.94	1.01	0.97	0.95	0.96	0.94	1.01	0.98	0.95	0.96	0.96	1
2	1.81	1.93	1.93	1.84	1.81	1.97	1.88	1.84	1.89	1.81	1.98	1.89	1.87	1.89	1.86	2
3	2.62	2.82	2.81	2.69	2.62	2.89	2.74	2.67	2.79	2.62	2.90	2.75	2.74	2.77	2.71	3
4	3.38	3.67	3.65	3.50	3.38	3.78	3.54	3.46	3.65	3.37	3.79	3.56	3.59	3.62	3.52	4
5	4.09	4.49	4.44	4.27	4.09	4.64	4.32	4.20	4.48	4.08	4.66	4.35	4.41	4.44	4.29	5
6	4.76	5.29	5.21	5.02	4.76	5.48	5.10	4.92	5.28	4.75	5.51	5.14	5.22	5.23	5.04	6
7	5.39	6.06	5.95	5.74	5.38	6.31	5.89	5.61	6.05	5.38	6.35	5.95	6.03	5.99	5.79	7
8	5.98	6.82	6.69	6.44	5.97	7.14	6.69	6.27	6.78	5.98	7.19	6.78	6.83	6.70	6.53	8
9	6.54	7.55	7.40	7.12	6.53	7.95	7.49	6.92	7.49	6.54	8.01	7.62	7.62	7.39	7.26	9
10	7.07	8.27	8.09	7.78	7.07	8.75	8.29	7.54	8.17	7.09	8.82	8.46	8.40	8.05	7.98	10
11	7.58	8.97	8.75	8.41	7.57	9.53	9.07	8.13	8.83	7.61	9.61	9.28	9.17	8.69	8.66	11
12	8.06	9.63	9.38	9.02	8.05	10.29	9.82	8.70	9.46	8.10	10.38	10.06	9.91	9.30	9.31	12
13	8.50	10.26	9.98	9.60	8.50	11.00	10.52	9.23	10.05	8.56	11.11	10.80	10.61	9.88	9.93	13
14	8.92	10.86	10.54	10.14	8.92	11.67	11.19	9.74	10.62	8.99	11.79	11.50	11.28	10.43	10.51	14
15	9.32	11.42	11.07	10.66	9.31	12.31	11.82	10.22	11.16	9.40	12.44	12.17	11.91	10.95	11.06	15
16	9.69	11.96	11.58	11.15	9.68	12.92	12.42	10.68	11.67	9.78	13.06	12.80	12.51	11.44	11.59	16
17	10.03	12.47	12.06	11.61	10.02	13.49	12.99	11.11	12.15	10.13	13.64	13.40	13.08	11.91	12.08	17
18	10.36	12.95	12.51	12.05	10.34	14.03	13.52	11.51	12.61	10.47	14.19	13.96	13.61	12.35	12.55	18
19	10.66	13.39	12.94	12.46	10.65	14.54	14.03	11.89	13.04	10.78	14.71	14.49	14.11	12.77	12.99	19
20	10.94	13.82	13.34	12.84	10.93	15.02	14.50	12.25	13.45	11.07	15.19	14.98	14.58	13.17	13.40	20
21	11.21	14.21	13.71	13.21	11.20	15.47	14.94	12.59	13.84	11.34	15.65	15.45	15.02	13.55	13.79	21
22	11.46	14.59	14.06	13.55	11.44	15.89	15.36	12.91	14.21	11.60	16.08	15.89	15.44	13.90	14.16	22
23	11.69	14.94	14.40	13.87	11.68	16.29	15.75	13.21	14.56	11.84	16.48	16.30	15.83	14.24	14.50	23
24	11.91	15.27	14.71	14.17	11.90	16.66	16.12	13.49	14.89	12.06	16.86	16.69	16.20	14.56	14.82	24
25	12.12	15.58	15.00	14.46	12.10	17.01	16.47	13.75	15.20	12.28	17.22	17.06	16.55	14.86	15.13	25

[1]ELEC = Electricity; DIST = Distillate; LPG = Liquefied Petroleum Gas; NATGAS = Natural Gas; RESID = Residual; COAL = Steam Coal; and GASLNE = Gasoline.

TABLE B-5a. UPW* DISCOUNT FACTORS ADJUSTED FOR AVERAGE FUEL PRICE ESCALATION
BY END-USE SECTOR AND MAJOR FUEL[1]
DISCOUNT RATE = 7 PERCENT
United States Average



	RESIDENTIAL				COMMERCIAL					INDUSTRIAL					TRANSPORTATION	
N	ELEC	DIST	LPG	NATGAS	ELEC	DIST	RESID	NATGAS	COAL	ELEC	DIST	RESID	NATGAS	COAL	GASLNE	N
1	0.93	0.99	0.99	0.94	0.93	1.01	0.97	0.95	0.95	0.93	1.01	0.98	0.96	0.95	0.95	1
2	1.80	1.92	1.93	1.84	1.79	1.97	1.88	1.83	1.86	1.79	1.98	1.89	1.87	1.86	1.86	2
3	2.60	2.81	2.82	2.69	2.59	2.89	2.74	2.67	2.72	2.58	2.90	2.75	2.75	2.72	2.71	3
4	3.34	3.66	3.66	3.49	3.34	3.77	3.54	3.45	3.54	3.31	3.79	3.55	3.59	3.54	3.51	4
5	4.03	4.47	4.45	4.26	4.02	4.63	4.33	4.20	4.33	3.99	4.66	4.34	4.42	4.32	4.28	5
6	4.67	5.26	5.23	5.00	4.67	5.47	5.12	4.92	5.07	4.62	5.51	5.13	5.25	5.06	5.04	6
7	5.27	6.03	5.98	5.72	5.27	6.30	5.92	5.61	5.78	5.22	6.34	5.93	6.06	5.77	5.79	7
8	5.84	6.78	6.72	6.41	5.83	7.12	6.74	6.28	6.46	5.77	7.17	6.75	6.87	6.44	6.53	8
9	6.37	7.50	7.43	7.09	6.36	7.93	7.58	6.93	7.10	6.29	7.99	7.59	7.68	7.07	7.26	9
10	6.87	8.21	8.13	7.74	6.86	8.73	8.41	7.55	7.71	6.79	8.80	8.41	8.48	7.68	7.97	10
11	7.34	8.90	8.80	8.36	7.33	9.50	9.22	8.15	8.29	7.26	9.58	9.22	9.27	8.25	8.65	11
12	7.79	9.55	9.44	8.96	7.78	10.25	10.00	8.73	8.84	7.71	10.34	9.99	10.03	8.79	9.30	12
13	8.20	10.17	10.04	9.53	8.20	10.96	10.73	9.27	9.36	8.12	11.06	10.73	10.76	9.31	9.92	13
14	8.59	10.76	10.61	10.07	8.59	11.63	11.43	9.78	9.86	8.51	11.74	11.42	11.44	9.80	10.50	14
15	8.96	11.32	11.15	10.58	8.95	12.26	12.09	10.27	10.33	8.88	12.39	12.07	12.09	10.27	11.05	15
16	9.30	11.85	11.66	11.06	9.30	12.87	12.71	10.73	10.77	9.22	13.00	12.70	12.70	10.70	11.58	16
17	9.63	12.34	12.15	11.52	9.62	13.44	13.30	11.16	11.19	9.54	13.58	13.29	13.28	11.12	12.07	17
18	9.93	12.81	12.61	11.95	9.92	13.97	13.86	11.57	11.59	9.85	14.12	13.84	13.83	11.52	12.54	18
19	10.21	13.26	13.04	12.35	10.20	14.48	14.38	11.96	11.97	10.13	14.63	14.36	14.34	11.89	12.98	19
20	10.47	13.67	13.44	12.73	10.47	14.95	14.87	12.32	12.33	10.39	15.11	14.85	14.83	12.24	13.39	20
21	10.72	14.06	13.82	13.09	10.71	15.40	15.34	12.67	12.66	10.64	15.57	15.31	15.28	12.58	13.78	21
22	10.95	14.43	14.18	13.43	10.95	15.82	15.77	12.99	12.99	10.87	15.99	15.74	15.71	12.90	14.14	22
23	11.17	14.78	14.51	13.75	11.16	16.21	16.18	13.29	13.29	11.09	16.39	16.15	16.11	13.20	14.49	23
24	11.37	15.10	14.83	14.04	11.37	16.59	16.57	13.57	13.58	11.29	16.77	16.53	16.49	13.48	14.81	24
25	11.56	15.41	15.13	14.33	11.56	16.94	16.93	13.84	13.85	11.48	17.13	16.90	16.85	13.75	15.11	25

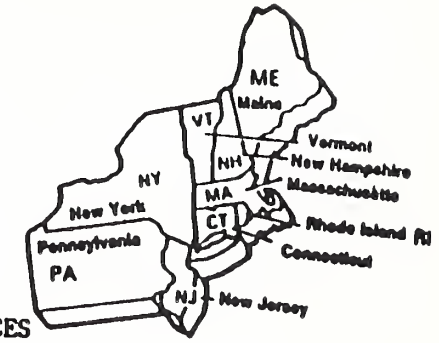
[1]ELEC = Electricity; DIST = Distillate; LPG = Liquefied Petroleum Gas; NATGAS = Natural Gas; RESID = Residual; COAL = Steam Coal; and GASLNE = Gasoline.

1988 Projected Average Fuel Prices Indices
(Tables Ca-1 through Ca-5)

and

1988 Projected Average Fuel Price Escalation Rates
(Tables Cb-1 through Cb-5)

TABLE Ca-1. PROJECTED AVERAGE FUEL PRICE INDICES TIED TO THE VALUE OF THE DOLLAR IN 1988, BY END-USE SECTOR AND MAJOR FUEL
Census Region 1 (Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania)



PROJECTED AVERAGE FUEL PRICE INDICES
(1988 = 1.00)

SECTOR/FUEL	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
RESIDENTIAL													
ELECTRICITY	1.00	1.01	0.99	0.99	0.98	0.97	0.97	0.97	0.98	0.99	1.00	1.01	1.02
DISTILLATE FUEL	1.00	1.05	1.07	1.09	1.11	1.14	1.18	1.22	1.28	1.33	1.38	1.43	1.47
LIQUEFIED PETROLEUM GAS	1.00	1.05	1.07	1.07	1.08	1.10	1.14	1.18	1.23	1.28	1.32	1.35	1.37
NATURAL GAS	1.00	1.01	1.02	1.03	1.04	1.06	1.09	1.12	1.15	1.19	1.23	1.26	1.28
COMMERCIAL													
ELECTRICITY	1.00	1.01	0.99	0.99	0.97	0.97	0.97	0.97	0.98	0.99	1.00	1.02	1.02
DISTILLATE FUEL	1.00	1.08	1.10	1.13	1.15	1.20	1.26	1.32	1.39	1.47	1.54	1.61	1.66
RESIDUAL FUEL	1.00	1.05	1.04	1.05	1.05	1.11	1.19	1.29	1.41	1.53	1.63	1.70	1.74
NATURAL GAS	1.00	1.01	1.01	1.02	1.03	1.04	1.07	1.10	1.13	1.16	1.20	1.23	1.25
STEAM COAL	1.00	1.01	1.03	1.05	1.07	1.09	1.11	1.13	1.14	1.16	1.17	1.19	1.21
INDUSTRIAL													
ELECTRICITY	1.00	1.02	0.99	0.98	0.96	0.95	0.94	0.95	0.96	0.98	1.00	1.03	1.03
DISTILLATE FUEL	1.00	1.08	1.10	1.13	1.16	1.21	1.27	1.34	1.42	1.50	1.58	1.65	1.71
RESIDUAL FUEL	1.00	1.05	1.04	1.05	1.05	1.10	1.18	1.28	1.40	1.52	1.61	1.68	1.72
NATURAL GAS	1.00	1.02	1.03	1.06	1.08	1.12	1.17	1.23	1.28	1.36	1.42	1.48	1.53
STEAM COAL	1.00	1.02	1.03	1.05	1.06	1.08	1.10	1.11	1.12	1.13	1.15	1.16	1.18
TRANSPORTATION													
MOTOR GASOLINE	1.00	1.02	1.04	1.05	1.05	1.08	1.14	1.20	1.28	1.34	1.40	1.44	1.47

PROJECTED WORLD OIL PRICE INDICES
(1988 = 1.00)

OIL PRICE ASSUMPTION	1.00	1.05	1.06	1.07	1.07	1.12	1.21	1.33	1.47	1.60	1.71	1.79	1.83

TABLE Ca-1, continued. PROJECTED AVERAGE FUEL PRICE INDICES TIED TO THE VALUE OF THE DOLLAR IN 1988, BY END-USE SECTOR AND MAJOR FUEL
Census Region 1 (Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania)

PROJECTED AVERAGE FUEL PRICE INDICES
(1988 = 1.00)

SECTOR/FUEL	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
RESIDENTIAL													
ELECTRICITY	1.02	1.02	1.02	1.03	1.03	1.03	1.03	1.04	1.04	1.04	1.04	1.05	1.05
DISTILLATE FUEL	1.49	1.51	1.52	1.55	1.57	1.58	1.59	1.60	1.61	1.62	1.63	1.64	1.65
LIQUEFIED PETROLEUM GAS	1.39	1.41	1.43	1.45	1.47	1.48	1.48	1.49	1.51	1.52	1.52	1.53	1.55
NATURAL GAS	1.30	1.32	1.33	1.35	1.37	1.38	1.39	1.39	1.41	1.42	1.42	1.43	1.45
COMMERCIAL													
ELECTRICITY	1.02	1.02	1.03	1.03	1.03	1.03	1.03	1.04	1.04	1.04	1.04	1.05	1.05
DISTILLATE FUEL	1.68	1.70	1.72	1.75	1.77	1.79	1.80	1.81	1.82	1.83	1.84	1.85	1.87
RESIDUAL FUEL	1.76	1.78	1.81	1.84	1.86	1.87	1.88	1.89	1.91	1.92	1.93	1.94	1.96
NATURAL GAS	1.27	1.29	1.30	1.32	1.34	1.35	1.35	1.36	1.37	1.38	1.39	1.40	1.41
STEAM COAL	1.23	1.25	1.26	1.28	1.30	1.31	1.33	1.35	1.37	1.39	1.41	1.43	1.45
INDUSTRIAL													
ELECTRICITY	1.03	1.03	1.04	1.04	1.04	1.04	1.05	1.05	1.05	1.05	1.05	1.06	1.06
DISTILLATE FUEL	1.73	1.75	1.77	1.80	1.82	1.83	1.85	1.86	1.87	1.88	1.90	1.91	1.92
RESIDUAL FUEL	1.74	1.76	1.79	1.81	1.84	1.85	1.86	1.87	1.89	1.90	1.91	1.92	1.94
NATURAL GAS	1.55	1.57	1.59	1.61	1.63	1.64	1.65	1.66	1.68	1.69	1.70	1.71	1.72
STEAM COAL	1.20	1.21	1.23	1.25	1.27	1.28	1.30	1.32	1.33	1.35	1.38	1.39	1.41
TRANSPORTATION													
MOTOR GASOLINE	1.49	1.51	1.53	1.55	1.57	1.58	1.59	1.60	1.61	1.62	1.63	1.64	1.66

PROJECTED WORLD OIL PRICE INDICES
(1988 = 1.00)

OIL PRICE ASSUMPTION	1.86	1.88	1.90	1.93	1.96	1.97	1.98	1.99	2.01	2.02	2.04	2.05	2.07

TABLE Ca-2. PROJECTED AVERAGE FUEL PRICE INDICES TIED TO THE VALUE OF THE DOLLAR IN 1988, BY END-USE SECTOR AND MAJOR FUEL
Census Region 2 (Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas)

PROJECTED AVERAGE FUEL PRICE INDICES
(1988 = 1.00)

SECTOR/FUEL	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
RESIDENTIAL													
ELECTRICITY	1.00	0.99	0.99	0.98	0.98	0.97	0.96	0.96	0.96	0.96	0.96	0.96	0.97
DISTILLATE FUEL	1.00	1.06	1.07	1.09	1.11	1.15	1.19	1.24	1.30	1.35	1.41	1.46	1.50
LIQUEFIED PETROLEUM GAS	1.00	1.07	1.08	1.10	1.10	1.13	1.17	1.23	1.29	1.35	1.41	1.45	1.47
NATURAL GAS	1.00	1.01	1.03	1.04	1.06	1.08	1.12	1.16	1.20	1.25	1.30	1.33	1.36
COMMERCIAL													
ELECTRICITY	1.00	0.99	0.99	0.98	0.97	0.97	0.96	0.96	0.95	0.95	0.95	0.95	0.97
DISTILLATE FUEL	1.00	1.08	1.10	1.13	1.17	1.21	1.28	1.35	1.43	1.51	1.59	1.66	1.72
RESIDUAL FUEL	1.00	1.04	1.04	1.05	1.05	1.09	1.17	1.26	1.36	1.47	1.56	1.62	1.65
NATURAL GAS	1.00	1.02	1.02	1.03	1.03	1.06	1.09	1.13	1.16	1.21	1.25	1.29	1.32
STEAM COAL	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.18	1.20	1.22	1.24
INDUSTRIAL													
ELECTRICITY	1.00	0.99	0.98	0.97	0.96	0.95	0.94	0.94	0.93	0.93	0.93	0.93	0.95
DISTILLATE FUEL	1.00	1.08	1.11	1.14	1.17	1.22	1.28	1.35	1.43	1.51	1.59	1.66	1.72
RESIDUAL FUEL	1.00	1.05	1.05	1.05	1.06	1.11	1.20	1.30	1.43	1.56	1.66	1.73	1.77
NATURAL GAS	1.00	1.02	1.04	1.07	1.10	1.14	1.20	1.27	1.33	1.42	1.50	1.56	1.61
STEAM COAL	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.18	1.20	1.23	1.25
TRANSPORTATION													
MOTOR GASOLINE	1.00	1.02	1.04	1.04	1.05	1.08	1.13	1.20	1.27	1.34	1.39	1.43	1.46

PROJECTED WORLD OIL PRICE INDICES
(1988 = 1.00)

OIL PRICE ASSUMPTION	1.00	1.05	1.06	1.07	1.07	1.12	1.21	1.33	1.47	1.60	1.71	1.79	1.83

TABLE Ca-2, continued. PROJECTED AVERAGE FUEL PRICE INDICES TIED TO THE VALUE OF THE DOLLAR IN 1988, BY END-USE SECTOR AND MAJOR FUEL
Census Region 2 (Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas)

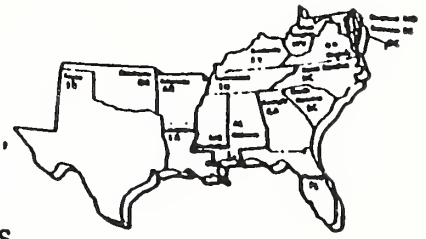
PROJECTED AVERAGE FUEL PRICE INDICES
(1988 = 1.00)

SECTOR/FUEL	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
RESIDENTIAL													
ELECTRICITY	0.97	0.97	0.98	0.98	0.98	0.98	0.99	0.99	0.99	0.99	1.00	1.00	1.00
DISTILLATE FUEL	1.52	1.54	1.56	1.58	1.60	1.61	1.62	1.63	1.64	1.65	1.66	1.67	1.69
LIQUEFIED PETROLEUM GAS	1.50	1.51	1.53	1.56	1.58	1.59	1.60	1.61	1.62	1.63	1.64	1.65	1.66
NATURAL GAS	1.38	1.40	1.42	1.44	1.46	1.47	1.48	1.49	1.50	1.51	1.52	1.53	1.54
COMMERCIAL													
ELECTRICITY	0.97	0.97	0.97	0.98	0.98	0.98	0.98	0.99	0.99	0.99	0.99	1.00	1.00
DISTILLATE FUEL	1.74	1.77	1.79	1.82	1.84	1.85	1.86	1.87	1.89	1.90	1.91	1.92	1.94
RESIDUAL FUEL	1.68	1.70	1.72	1.75	1.77	1.78	1.79	1.80	1.82	1.83	1.84	1.85	1.86
NATURAL GAS	1.34	1.35	1.37	1.39	1.41	1.42	1.43	1.43	1.45	1.45	1.46	1.47	1.48
STEAM COAL	1.26	1.28	1.29	1.31	1.33	1.35	1.37	1.38	1.41	1.42	1.45	1.46	1.49
INDUSTRIAL													
ELECTRICITY	0.95	0.96	0.96	0.96	0.96	0.97	0.97	0.97	0.97	0.97	0.98	0.98	0.98
DISTILLATE FUEL	1.74	1.76	1.79	1.81	1.84	1.85	1.86	1.87	1.89	1.90	1.91	1.92	1.94
RESIDUAL FUEL	1.80	1.82	1.84	1.87	1.89	1.90	1.92	1.93	1.95	1.96	1.97	1.98	2.00
NATURAL GAS	1.64	1.66	1.68	1.71	1.73	1.74	1.75	1.76	1.77	1.78	1.79	1.81	1.82
STEAM COAL	1.27	1.29	1.30	1.32	1.34	1.36	1.38	1.40	1.42	1.44	1.46	1.48	1.50
TRANSPORTATION													
MOTOR GASOLINE	1.48	1.50	1.52	1.54	1.56	1.57	1.58	1.59	1.60	1.61	1.62	1.63	1.65

PROJECTED WORLD OIL PRICE INDICES
(1988 = 1.00)

OIL PRICE ASSUMPTION	1.86	1.88	1.90	1.93	1.96	1.97	1.98	1.99	2.01	2.02	2.04	2.05	2.07

TABLE Ca-3. PROJECTED AVERAGE FUEL PRICE INDICES TIED TO THE VALUE OF THE DOLLAR IN 1988, BY END-USE SECTOR AND MAJOR FUEL
Census Region 3 (Delaware, Maryland, District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Kentucky, Tennessee, Alabama, Mississippi, Arkansas, Louisiana, Oklahoma, Texas)



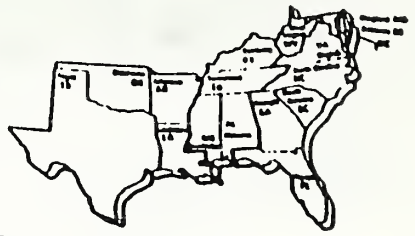
PROJECTED AVERAGE FUEL PRICE INDICES
(1988 = 1.00)

SECTOR/FUEL	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
RESIDENTIAL													
ELECTRICITY	1.00	0.99	0.98	0.97	0.97	0.96	0.96	0.96	0.97	0.97	0.98	0.98	1.00
DISTILLATE FUEL	1.00	1.05	1.07	1.09	1.11	1.14	1.18	1.22	1.28	1.33	1.38	1.43	1.47
LIQUEFIED PETROLEUM GAS	1.00	1.06	1.07	1.08	1.09	1.11	1.15	1.20	1.26	1.31	1.36	1.39	1.42
NATURAL GAS	1.00	1.01	1.02	1.04	1.05	1.08	1.12	1.16	1.19	1.24	1.29	1.32	1.36
COMMERCIAL													
ELECTRICITY	1.00	0.99	0.98	0.97	0.96	0.96	0.95	0.96	0.96	0.97	0.98	0.98	1.00
DISTILLATE FUEL	1.00	1.08	1.10	1.13	1.16	1.21	1.27	1.34	1.42	1.50	1.58	1.65	1.70
RESIDUAL FUEL	1.00	1.05	1.05	1.06	1.06	1.12	1.21	1.33	1.46	1.59	1.70	1.78	1.83
NATURAL GAS	1.00	1.02	1.02	1.03	1.03	1.06	1.09	1.13	1.16	1.21	1.25	1.28	1.31
STEAM COAL	1.00	1.02	1.03	1.06	1.07	1.09	1.11	1.13	1.15	1.15	1.18	1.20	1.21
INDUSTRIAL													
ELECTRICITY	1.00	0.99	0.97	0.96	0.95	0.94	0.93	0.94	0.94	0.95	0.97	0.97	0.99
DISTILLATE FUEL	1.00	1.08	1.10	1.13	1.16	1.21	1.27	1.34	1.42	1.50	1.58	1.65	1.70
RESIDUAL FUEL	1.00	1.04	1.04	1.05	1.05	1.10	1.19	1.29	1.41	1.53	1.62	1.69	1.73
NATURAL GAS	1.00	1.03	1.05	1.09	1.12	1.19	1.26	1.36	1.44	1.55	1.66	1.74	1.82
STEAM COAL	1.00	1.01	1.03	1.04	1.06	1.07	1.09	1.10	1.12	1.13	1.14	1.16	1.17
TRANSPORTATION													
MOTOR GASOLINE	1.00	1.02	1.03	1.04	1.05	1.08	1.14	1.20	1.27	1.34	1.40	1.44	1.47

PROJECTED WORLD OIL PRICE INDICES
(1988 = 1.00)

OIL PRICE ASSUMPTION	1.00	1.05	1.06	1.07	1.07	1.12	1.21	1.33	1.47	1.60	1.71	1.79	1.83

TABLE Ca-3, continued. PROJECTED AVERAGE FUEL PRICE INDICES TIED TO THE VALUE OF THE DOLLAR IN 1988, BY END-USE SECTOR AND MAJOR FUEL
Census Region 3 (Delaware, Maryland, District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Kentucky, Tennessee, Alabama, Mississippi, Arkansas, Louisiana, Oklahoma, Texas)



PROJECTED AVERAGE FUEL PRICE INDICES
(1988 = 1.00)

SECTOR/FUEL	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
RESIDENTIAL													
ELECTRICITY	1.00	1.00	1.00	1.01	1.01	1.01	1.02	1.02	1.02	1.02	1.02	1.03	1.03
DISTILLATE FUEL	1.49	1.50	1.52	1.55	1.57	1.58	1.59	1.60	1.61	1.62	1.63	1.64	1.65
LIQUEFIED PETROLEUM GAS	1.44	1.46	1.48	1.50	1.52	1.53	1.54	1.54	1.56	1.57	1.58	1.59	1.60
NATURAL GAS	1.38	1.39	1.41	1.43	1.45	1.46	1.47	1.48	1.49	1.50	1.51	1.52	1.53
COMMERCIAL													
ELECTRICITY	1.00	1.00	1.00	1.01	1.01	1.01	1.01	1.02	1.02	1.02	1.02	1.03	1.03
DISTILLATE FUEL	1.72	1.74	1.77	1.79	1.82	1.83	1.84	1.85	1.87	1.88	1.89	1.90	1.92
RESIDUAL FUEL	1.85	1.88	1.90	1.93	1.95	1.97	1.98	1.99	2.01	2.02	2.03	2.04	2.06
NATURAL GAS	1.33	1.35	1.37	1.39	1.40	1.41	1.42	1.43	1.44	1.45	1.46	1.47	1.48
STEAM COAL	1.23	1.25	1.27	1.28	1.30	1.32	1.33	1.36	1.37	1.39	1.41	1.43	1.46
INDUSTRIAL													
ELECTRICITY	1.00	1.00	1.00	1.01	1.01	1.01	1.01	1.02	1.02	1.02	1.02	1.02	1.03
DISTILLATE FUEL	1.72	1.75	1.77	1.80	1.82	1.83	1.84	1.85	1.87	1.88	1.89	1.90	1.92
RESIDUAL FUEL	1.76	1.78	1.80	1.83	1.85	1.86	1.88	1.89	1.90	1.92	1.93	1.94	1.95
NATURAL GAS	1.84	1.86	1.89	1.92	1.94	1.95	1.97	1.97	2.00	2.00	2.02	2.03	2.05
STEAM COAL	1.19	1.21	1.22	1.24	1.26	1.28	1.30	1.31	1.33	1.35	1.36	1.38	1.40
TRANSPORTATION													
MOTOR GASOLINE	1.49	1.51	1.53	1.55	1.57	1.58	1.59	1.60	1.61	1.62	1.63	1.64	1.65

PROJECTED WORLD OIL PRICE INDICES
(1988 = 1.00)

OIL PRICE ASSUMPTION	1.86	1.88	1.90	1.93	1.96	1.97	1.98	1.99	2.01	2.02	2.04	2.05	2.07

TABLE Ca-4. PROJECTED AVERAGE FUEL PRICE INDICES TIED TO THE VALUE OF THE DOLLAR IN 1988, BY END-USE SECTOR AND MAJOR FUEL
Census Region 4 (Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, Utah, Nevada, Washington, Oregon, California, Alaska, Hawaii)

PROJECTED AVERAGE FUEL PRICE INDICES
(1988 = 1.00)

SECTOR/FUEL	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
RESIDENTIAL													
ELECTRICITY	1.00	1.00	1.00	1.00	0.99	0.99	1.00	1.01	1.02	1.03	1.05	1.07	1.08
DISTILLATE FUEL	1.00	1.06	1.07	1.10	1.12	1.15	1.19	1.24	1.30	1.35	1.41	1.46	1.50
LIQUEFIED PETROLEUM GAS	1.00	1.06	1.07	1.08	1.09	1.11	1.15	1.20	1.26	1.31	1.36	1.39	1.42
NATURAL GAS	1.00	1.01	1.03	1.04	1.06	1.09	1.12	1.16	1.20	1.25	1.30	1.34	1.37
COMMERCIAL													
ELECTRICITY	1.00	1.00	1.00	1.00	0.99	0.99	1.00	1.01	1.02	1.03	1.05	1.07	1.07
DISTILLATE FUEL	1.00	1.08	1.10	1.13	1.16	1.21	1.27	1.33	1.42	1.49	1.57	1.64	1.70
RESIDUAL FUEL	1.00	1.04	1.04	1.05	1.05	1.09	1.17	1.27	1.37	1.48	1.58	1.64	1.68
NATURAL GAS	1.00	1.01	1.02	1.02	1.03	1.05	1.08	1.11	1.14	1.18	1.22	1.25	1.27
STEAM COAL	1.00	1.03	1.06	1.09	1.13	1.16	1.20	1.23	1.26	1.30	1.34	1.38	1.42
INDUSTRIAL													
ELECTRICITY	1.00	1.00	0.99	0.99	0.99	0.99	1.01	1.01	1.02	1.04	1.07	1.10	1.11
DISTILLATE FUEL	1.00	1.08	1.10	1.14	1.17	1.22	1.28	1.35	1.43	1.51	1.60	1.67	1.72
RESIDUAL FUEL	1.00	1.05	1.05	1.05	1.06	1.11	1.19	1.30	1.42	1.55	1.65	1.72	1.76
NATURAL GAS	1.00	1.02	1.05	1.07	1.11	1.16	1.22	1.30	1.36	1.46	1.54	1.61	1.67
STEAM COAL	1.00	1.03	1.06	1.08	1.11	1.15	1.18	1.21	1.23	1.27	1.30	1.34	1.38
TRANSPORTATION													
MOTOR GASOLINE	1.00	1.02	1.04	1.04	1.05	1.08	1.14	1.20	1.27	1.34	1.40	1.44	1.47

PROJECTED WORLD OIL PRICE INDICES
(1988 = 1.00)

OIL PRICE ASSUMPTION	1.00	1.05	1.06	1.07	1.07	1.12	1.21	1.33	1.47	1.60	1.71	1.79	1.83

TABLE Ca-4, continued. PROJECTED AVERAGE FUEL PRICE INDICES TIED TO THE VALUE OF THE DOLLAR IN 1988, BY END-USE SECTOR AND MAJOR FUEL
Census Region 4 (Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, Utah, Nevada, Washington, Oregon, California, Alaska, Hawaii)

PROJECTED AVERAGE FUEL PRICE INDICES
(1988 = 1.00)

SECTOR/FUEL	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
RESIDENTIAL													
ELECTRICITY	1.08	1.08	1.09	1.09	1.09	1.09	1.10	1.10	1.10	1.10	1.11	1.11	1.11
DISTILLATE FUEL	1.52	1.54	1.56	1.58	1.60	1.61	1.62	1.63	1.65	1.66	1.67	1.68	1.69
LIQUEFIED PETROLEUM GAS	1.44	1.46	1.47	1.50	1.52	1.52	1.53	1.54	1.56	1.57	1.58	1.58	1.60
NATURAL GAS	1.39	1.41	1.42	1.45	1.46	1.47	1.48	1.49	1.50	1.51	1.52	1.53	1.54
COMMERCIAL													
ELECTRICITY	1.08	1.08	1.08	1.09	1.09	1.09	1.09	1.10	1.10	1.10	1.10	1.11	1.11
DISTILLATE FUEL	1.72	1.74	1.76	1.79	1.81	1.82	1.84	1.85	1.86	1.87	1.88	1.90	1.91
RESIDUAL FUEL	1.70	1.72	1.74	1.77	1.79	1.80	1.81	1.82	1.84	1.85	1.86	1.88	1.89
NATURAL GAS	1.29	1.31	1.32	1.35	1.36	1.37	1.38	1.39	1.40	1.41	1.42	1.42	1.44
STEAM COAL	1.44	1.47	1.48	1.50	1.52	1.55	1.57	1.58	1.61	1.63	1.65	1.68	1.70
INDUSTRIAL													
ELECTRICITY	1.11	1.11	1.12	1.12	1.12	1.13	1.13	1.13	1.13	1.14	1.14	1.14	1.14
DISTILLATE FUEL	1.75	1.77	1.79	1.82	1.84	1.86	1.87	1.88	1.89	1.90	1.92	1.93	1.94
RESIDUAL FUEL	1.79	1.81	1.83	1.86	1.89	1.90	1.91	1.92	1.94	1.95	1.96	1.97	1.99
NATURAL GAS	1.70	1.72	1.74	1.77	1.79	1.80	1.81	1.82	1.84	1.85	1.86	1.87	1.89
STEAM COAL	1.40	1.42	1.43	1.45	1.48	1.49	1.52	1.54	1.56	1.58	1.60	1.62	1.64
TRANSPORTATION													
MOTOR GASOLINE	1.49	1.51	1.53	1.55	1.57	1.58	1.59	1.60	1.61	1.62	1.63	1.64	1.65

PROJECTED WORLD OIL PRICE INDICES
(1988 = 1.00)

OIL PRICE ASSUMPTION	1.86	1.88	1.90	1.93	1.96	1.97	1.98	1.99	2.01	2.02	2.04	2.05	2.07

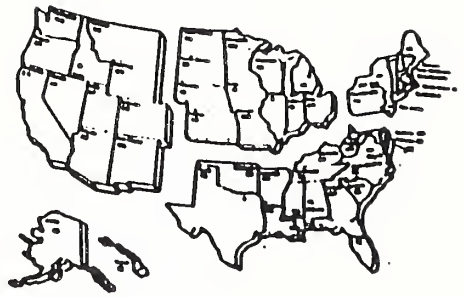
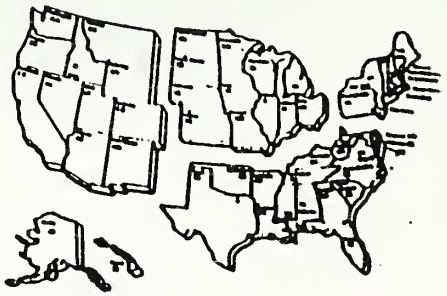


TABLE Ca-5. PROJECTED AVERAGE FUEL PRICE INDICES TIED TO THE VALUE OF THE DOLLAR IN 1988, BY END-USE SECTOR AND MAJOR FUEL
United States Average

SECTOR/FUEL	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	PROJECTED AVERAGE FUEL PRICE INDICES (1988 = 1.00)												
RESIDENTIAL													
ELECTRICITY	1.00	1.00	0.99	0.98	0.97	0.97	0.97	0.97	0.97	0.98	0.98	0.99	1.00
DISTILLATE FUEL	1.00	1.06	1.07	1.09	1.11	1.14	1.18	1.23	1.29	1.34	1.39	1.44	1.48
LIQUEFIED PETROLEUM GAS	1.00	1.06	1.08	1.09	1.09	1.12	1.16	1.21	1.27	1.32	1.37	1.41	1.43
NATURAL GAS	1.00	1.01	1.02	1.04	1.05	1.08	1.11	1.15	1.19	1.24	1.28	1.32	1.35
COMMERCIAL													
ELECTRICITY	1.00	1.00	0.99	0.98	0.97	0.96	0.96	0.97	0.97	0.97	0.98	0.99	1.00
DISTILLATE FUEL	1.00	1.08	1.10	1.13	1.16	1.21	1.26	1.33	1.41	1.49	1.57	1.63	1.68
RESIDUAL FUEL	1.00	1.04	1.04	1.05	1.05	1.10	1.18	1.29	1.41	1.54	1.64	1.71	1.75
NATURAL GAS	1.00	1.01	1.01	1.02	1.03	1.05	1.08	1.12	1.14	1.19	1.23	1.26	1.29
STEAM COAL	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.18	1.20	1.22	1.24
INDUSTRIAL													
ELECTRICITY	1.00	1.00	0.98	0.97	0.96	0.95	0.95	0.95	0.95	0.96	0.97	0.99	1.00
DISTILLATE FUEL	1.00	1.08	1.10	1.14	1.16	1.21	1.27	1.34	1.43	1.50	1.59	1.66	1.71
RESIDUAL FUEL	1.00	1.04	1.04	1.05	1.06	1.10	1.19	1.29	1.41	1.53	1.63	1.70	1.74
NATURAL GAS	1.00	1.02	1.05	1.08	1.11	1.16	1.23	1.32	1.39	1.49	1.58	1.65	1.72
STEAM COAL	1.00	1.02	1.04	1.06	1.08	1.09	1.11	1.13	1.15	1.16	1.19	1.21	1.23
TRANSPORTATION													
MOTOR GASOLINE	1.00	1.02	1.04	1.04	1.05	1.08	1.13	1.20	1.27	1.34	1.40	1.44	1.46
	PROJECTED WORLD OIL PRICE INDICES (1988 = 1.00)												
OIL PRICE ASSUMPTION	1.00	1.05	1.06	1.07	1.07	1.12	1.21	1.33	1.47	1.60	1.71	1.79	1.83

TABLE Ca-5, continued. PROJECTED AVERAGE FUEL PRICE INDICES TIED TO THE VALUE OF THE DOLLAR IN 1988, BY END-USE SECTOR AND MAJOR FUEL
United States Average



PROJECTED AVERAGE FUEL PRICE INDICES
(1988 = 1.00)

SECTOR/FUEL	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
RESIDENTIAL													
ELECTRICITY	1.01	1.01	1.01	1.01	1.02	1.02	1.02	1.02	1.03	1.03	1.03	1.03	1.04
DISTILLATE FUEL	1.50	1.52	1.54	1.56	1.58	1.59	1.60	1.61	1.62	1.63	1.64	1.65	1.66
LIQUEFIED PETROLEUM GAS	1.45	1.47	1.49	1.51	1.53	1.54	1.55	1.56	1.57	1.58	1.59	1.60	1.62
NATURAL GAS	1.37	1.39	1.41	1.43	1.44	1.45	1.46	1.47	1.48	1.49	1.50	1.51	1.52
COMMERCIAL													
ELECTRICITY	1.01	1.01	1.01	1.01	1.02	1.02	1.02	1.02	1.03	1.03	1.03	1.03	1.04
DISTILLATE FUEL	1.71	1.73	1.75	1.78	1.80	1.81	1.82	1.83	1.85	1.86	1.87	1.88	1.90
RESIDUAL FUEL	1.77	1.79	1.82	1.85	1.87	1.88	1.89	1.90	1.92	1.93	1.94	1.96	1.97
NATURAL GAS	1.31	1.32	1.34	1.36	1.38	1.39	1.40	1.40	1.42	1.42	1.43	1.44	1.45
STEAM COAL	1.26	1.28	1.30	1.31	1.33	1.35	1.37	1.39	1.41	1.42	1.44	1.46	1.49
INDUSTRIAL													
ELECTRICITY	1.01	1.01	1.01	1.01	1.02	1.02	1.02	1.02	1.03	1.03	1.03	1.03	1.04
DISTILLATE FUEL	1.73	1.76	1.78	1.81	1.83	1.84	1.85	1.86	1.88	1.89	1.90	1.91	1.93
RESIDUAL FUEL	1.76	1.79	1.81	1.84	1.86	1.87	1.88	1.89	1.91	1.92	1.93	1.94	1.96
NATURAL GAS	1.74	1.76	1.79	1.81	1.84	1.85	1.86	1.87	1.89	1.90	1.91	1.92	1.94
STEAM COAL	1.25	1.26	1.28	1.30	1.31	1.33	1.35	1.37	1.39	1.41	1.43	1.45	1.47
TRANSPORTATION													
MOTOR GASOLINE	1.48	1.50	1.52	1.55	1.57	1.58	1.58	1.59	1.61	1.62	1.63	1.64	1.65

PROJECTED WORLD OIL PRICE INDICES
(1988 = 1.00)

OIL PRICE ASSUMPTION	1.86	1.88	1.90	1.93	1.96	1.97	1.98	1.99	2.01	2.02	2.04	2.05	2.07

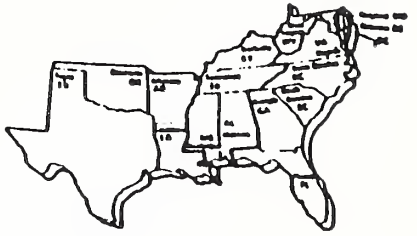
TABLE Cb-1. PROJECTED AVERAGE FUEL PRICE ESCALATION RATES
EXCLUSIVE OF GENERAL PRICE INFLATION
BY END-USE SECTOR AND MAJOR FUEL
(PERCENTAGE CHANGE COMPOUNDED ANNUALLY)
Census Region 1 (Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania)

SECTOR/FUEL	1988 to 1990	1990 to 1995	1995 to 2000	2000 to 2005	2005 to 2010	2010 to 2013
RESIDENTIAL						
ELECTRICITY	-0.40	-0.40	0.90	0.30	0.20	0.23
DISTILLATE FUEL	3.30	2.80	3.70	1.40	0.70	0.70
LIQUEFIED PETROLEUM GAS	3.30	2.00	3.10	1.40	0.70	0.69
NATURAL GAS	0.90	2.00	2.70	1.40	0.70	0.70
COMMERCIAL						
ELECTRICITY	-0.50	-0.40	0.90	0.30	0.20	0.23
DISTILLATE FUEL	4.70	3.70	4.70	1.40	0.70	0.66
RESIDUAL FUEL	2.10	4.30	6.10	1.40	0.70	0.69
NATURAL GAS	0.70	1.60	2.60	1.40	0.70	0.66
STEAM COAL	1.70	1.70	1.50	1.40	1.40	1.34
INDUSTRIAL						
ELECTRICITY	-0.70	-0.70	1.50	0.30	0.20	0.23
DISTILLATE FUEL	5.00	4.00	4.90	1.40	0.70	0.69
RESIDUAL FUEL	2.10	4.20	6.00	1.40	0.70	0.68
NATURAL GAS	1.70	3.60	4.40	1.40	0.70	0.65
STEAM COAL	1.50	1.50	1.30	1.40	1.40	1.47
TRANSPORTATION						
MOTOR GASOLINE	1.70	3.00	4.10	1.40	0.70	0.70
WORLD OIL PRICE ASSUMPTION	3.00	4.70	6.50	1.40	0.70	0.68

TABLE Cb-2. PROJECTED AVERAGE FUEL PRICE ESCALATION RATES
EXCLUSIVE OF GENERAL PRICE INFLATION
BY END-USE SECTOR AND MAJOR FUEL
(PERCENTAGE CHANGE COMPOUNDED ANNUALLY)
Census Region 2 (Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas)

SECTOR/FUEL	1988 to 1990	1990 to 1995	1995 to 2000	2000 to 2005	2005 to 2010	2010 to 2013
RESIDENTIAL						
ELECTRICITY	-0.60	-0.60	0.20	0.30	0.20	0.23
DISTILLATE FUEL	3.60	2.90	3.80	1.40	0.70	0.67
LIQUEFIED PETROLEUM GAS	4.10	2.50	3.70	1.40	0.70	0.69
NATURAL GAS	1.20	2.50	3.30	1.40	0.70	0.68
COMMERCIAL						
ELECTRICITY	-0.60	-0.60	0.20	0.30	0.20	0.24
DISTILLATE FUEL	5.10	4.00	5.00	1.40	0.70	0.69
RESIDUAL FUEL	1.90	3.90	5.60	1.40	0.70	0.65
NATURAL GAS	0.90	2.00	3.10	1.40	0.70	0.69
STEAM COAL	2.00	1.80	1.70	1.40	1.40	1.43
INDUSTRIAL						
ELECTRICITY	-0.90	-0.90	0.30	0.30	0.20	0.22
DISTILLATE FUEL	5.10	4.00	5.00	1.40	0.70	0.69
RESIDUAL FUEL	2.20	4.50	6.30	1.40	0.70	0.65
NATURAL GAS	2.00	4.10	4.90	1.40	0.70	0.66
STEAM COAL	2.00	1.90	1.80	1.40	1.40	1.35
TRANSPORTATION						
MOTOR GASOLINE	1.70	3.00	4.00	1.40	0.70	0.69
WORLD OIL PRICE ASSUMPTION	3.00	4.70	6.50	1.40	0.70	0.68

TABLE Cb-3. PROJECTED AVERAGE FUEL PRICE ESCALATION RATES
EXCLUSIVE OF GENERAL PRICE INFLATION
BY END-USE SECTOR AND MAJOR FUEL
(PERCENTAGE CHANGE COMPOUNDED ANNUALLY)
Census Region 3 (Delaware, Maryland, District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Kentucky, Tennessee, Alabama, Mississippi, Arkansas, Louisiana, Oklahoma, Texas)



SECTOR/FUEL	1988 to 1990	1990 to 1995	1995 to 2000	2000 to 2005	2005 to 2010	2010 to 2013
RESIDENTIAL						
ELECTRICITY	-0.90	-0.40	0.70	0.30	0.20	0.24
DISTILLATE FUEL	3.30	2.80	3.70	1.40	0.70	0.70
LIQUEFIED PETROLEUM GAS	3.60	2.20	3.40	1.40	0.70	0.67
NATURAL GAS	1.20	2.50	3.20	1.40	0.70	0.71
COMMERCIAL						
ELECTRICITY	-0.90	-0.40	0.80	0.30	0.20	0.24
DISTILLATE FUEL	5.00	3.90	4.90	1.40	0.70	0.68
RESIDUAL FUEL	2.40	4.80	6.60	1.40	0.70	0.67
NATURAL GAS	0.90	2.00	3.10	1.40	0.70	0.68
STEAM COAL	1.70	1.70	1.50	1.40	1.40	1.54
INDUSTRIAL						
ELECTRICITY	-1.40	-0.60	1.10	0.30	0.20	0.25
DISTILLATE FUEL	5.00	3.90	4.90	1.40	0.70	0.68
RESIDUAL FUEL	2.10	4.30	6.10	1.40	0.70	0.63
NATURAL GAS	2.70	5.20	6.00	1.40	0.70	0.71
STEAM COAL	1.40	1.40	1.30	1.40	1.40	1.36
TRANSPORTATION						
MOTOR GASOLINE	1.70	3.00	4.10	1.40	0.70	0.68
WORLD OIL PRICE ASSUMPTION	3.00	4.70	6.50	1.40	0.70	0.68

TABLE Cb-4. PROJECTED AVERAGE FUEL PRICE ESCALATION RATES
EXCLUSIVE OF GENERAL PRICE INFLATION
BY END-USE SECTOR AND MAJOR FUEL
(PERCENTAGE CHANGE COMPOUNDED ANNUALLY)
Census Region 4 (Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, Utah, Nevada, Washington, Oregon, California, Alaska, Hawaii)

SECTOR/FUEL	1988 to 1990	1990 to 1995	1995 to 2000	2000 to 2005	2005 to 2010	2010 to 2013
RESIDENTIAL						
ELECTRICITY	-0.20	0.20	1.30	0.30	0.20	0.24
DISTILLATE FUEL	3.60	2.90	3.90	1.40	0.70	0.68
LIQUEFIED PETROLEUM GAS	3.60	2.20	3.40	1.40	0.70	0.69
NATURAL GAS	1.20	2.60	3.30	1.40	0.70	0.69
COMMERCIAL						
ELECTRICITY	-0.20	0.20	1.30	0.30	0.20	0.25
DISTILLATE FUEL	5.00	3.90	4.90	1.40	0.70	0.68
RESIDUAL FUEL	2.00	4.00	5.80	1.40	0.70	0.66
NATURAL GAS	0.80	1.80	2.80	1.40	0.70	0.71
STEAM COAL	3.20	3.00	2.90	1.40	1.40	1.40
INDUSTRIAL						
ELECTRICITY	-0.30	0.30	1.80	0.30	0.20	0.24
DISTILLATE FUEL	5.20	4.10	5.00	1.40	0.70	0.70
RESIDUAL FUEL	2.20	4.50	6.30	1.40	0.70	0.71
NATURAL GAS	2.20	4.40	5.20	1.40	0.70	0.70
STEAM COAL	2.90	2.70	2.60	1.40	1.40	1.38
TRANSPORTATION						
MOTOR GASOLINE	1.70	3.00	4.10	1.40	0.70	0.67
WORLD OIL PRICE ASSUMPTION	3.00	4.70	6.50	1.40	0.70	0.68

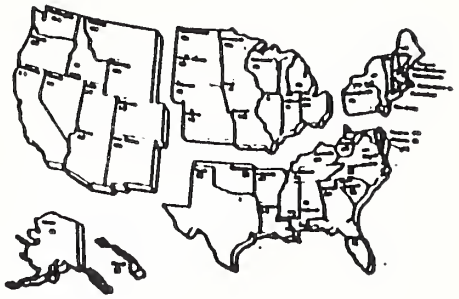


TABLE Cb-5. PROJECTED AVERAGE FUEL PRICE ESCALATION RATES
EXCLUSIVE OF GENERAL PRICE INFLATION
BY END-USE SECTOR AND MAJOR FUEL
(PERCENTAGE CHANGE COMPOUNDED ANNUALLY)
United States Average

SECTOR/FUEL	1988 to 1990	1990 to 1995	1995 to 2000	2000 to 2005	2005 to 2010	2010 to 2013
RESIDENTIAL						
ELECTRICITY	-0.60	-0.40	0.70	0.30	0.20	0.24
DISTILLATE FUEL	3.40	2.80	3.70	1.40	0.70	0.68
LIQUEFIED PETROLEUM GAS	3.80	2.30	3.50	1.40	0.70	0.67
NATURAL GAS	1.20	2.40	3.20	1.40	0.70	0.69
COMMERCIAL						
ELECTRICITY	-0.70	-0.40	0.70	0.30	0.20	0.23
DISTILLATE FUEL	4.90	3.90	4.80	1.40	0.70	0.68
RESIDUAL FUEL	2.10	4.40	6.30	1.40	0.70	0.64
NATURAL GAS	0.80	1.90	2.90	1.40	0.70	0.70
STEAM COAL	1.90	1.90	1.70	1.40	1.40	1.46
INDUSTRIAL						
ELECTRICITY	-1.00	-0.60	1.00	0.30	0.20	0.23
DISTILLATE FUEL	5.00	4.00	5.00	1.40	0.70	0.69
RESIDUAL FUEL	2.20	4.30	6.10	1.40	0.70	0.63
NATURAL GAS	2.40	4.70	5.50	1.40	0.70	0.73
STEAM COAL	1.80	1.70	1.70	1.40	1.40	1.47
TRANSPORTATION						
MOTOR GASOLINE	1.70	3.00	4.10	1.40	0.70	0.67
WORLD OIL PRICE ASSUMPTION	3.00	4.70	6.50	1.40	0.70	0.68

LIFE-CYCLE COSTING - LEARNING OBJECTIVES EVALUATION

The purpose of this evaluation is to determine if you, the student, have achieved the learning objectives for the course you have just completed. By achieved, we mean "Do you now have the knowledge and skills to perform the action or task identified in the learning objectives?" Please check whether you believe the learning objectives were achieved, were not achieved, or you don't know. Thank you for taking the time to complete this evaluation.

COURSE: _____ DATES: _____

INSTRUCTOR: _____

	Achieved	Not Achieved	Don't Know
COURSE OBJECTIVE			
Perform life-cycle cost analyses of energy-related building systems in order to make economic decisions.	_____	_____	_____
MODULE A -- ECONOMICS CAN IMPROVE DECISIONS			
Give examples of decisions affecting energy consumption which can be improved by economic evaluation, and explain the concepts of economic efficiency, cost-effectiveness, economic optimization, and marginal analysis.	_____	_____	_____
MODULE B -- WHAT YOU NEED TO GET STARTED			
Define alternatives to be evaluated, specify data requirements, and identify sources of data.	_____	_____	_____

LEARNING OBJECTIVES EVALUATION (continued)

	Achieved	Not Achieved	Don't Know
MODULE C -- ADJUSTING CASH AMOUNTS FOR TIME OF OCCURRENCE Calculate the present value of (1) a single future amount (such as a replacement cost or residual value), (2) a uniform series of future amounts (such as routine maintenance and repair costs), and (3) a series of future amounts changing over time at specified rates (such as energy costs).	_____	_____	_____
MODULE D -- CALCULATING LIFE-CYCLE COSTS, NET SAVINGS, SAVINGS-TO-INVESTMENT RATIO, ADJUSTED INTERNAL RATE OF RETURN, AND TIME TO PAYBACK Calculate life-cycle costs, net savings, savings-to-investment ratio, adjusted internal rate of return, and time to payback for a Federal energy conservation project and, on the basis of those measures, decide whether to accept or reject the project.	_____	_____	_____
MODULE E -- LCC COMPUTER PROGRAMS Run the FBLCC or NBSLCC computer program; enter data inputs for a sample problem; and read the results from a screen printout.	_____	_____	_____
MODULE F -- DESIGNING AND SIZING INDEPENDENT & INTER-DEPENDENT SYSTEMS Find the cost-effective size of an energy-related building component, such as the level of attic insulation. Find the cost-effective combination of interdependent projects, such as the level of attic insulation and heating system efficiency.	_____	_____	_____

LEARNING OBJECTIVES EVALUATION (continued)

	Achieved	Not Achieved	Don't Know
MODULE G -- DETERMINING PROJECT PRIORITY			
Use the SIR method to allocate a budget among independent projects.	_____	_____	_____
MODULE H -- UNCERTAINTY			
Perform sensitivity analysis, and make decisions under uncertainty according to Federal criteria.	_____	_____	_____
MODULE I -- REVIEW			
Summarize principal steps in performing economic evaluations, describe five methods of economic evaluation, and explain how each method is used to guide energy-related decisions.	_____	_____	_____
MODULE J -- COMPUTER LAB: USING FBLCC & NBSLCC			
Use FBLCC or NBSLCC to size a building system and establish funding priority among competing projects.	_____	_____	_____

Signature_____
(optional)

COURSE EVALUATION

PURPOSE: It is our objective to present useful and effective training courses. You are the final authority on whether that objective has been met. Your completion of this form, therefore, will play an important part in our future planning. Please do not feel bound to limit your remarks to questions on this form. Your pertinent comments on any aspect of the course will be appreciated.

TITLE OF COURSE	COURSE NO.	DATES ATTENDED FROM	TO
LOCATION			

RESPONSES (Check the response closest to your opinion)		STRONGLY DISAGREE	DISAGREE	AGREE	STRONGLY AGREE	NOT APPLICABLE
1. COURSE MATERIAL WAS:	a. WELL ORGANIZED					
	b. COMPLETE AND SUITABLE					
	c. READABLE (Printed well)					
2. AUDIO VISUAL MATERIALS WERE:	a. RELATED TO THE COURSE					
	b. GOOD QUALITY					
	c. SUFFICIENT IN NUMBER					
3. COURSE	a. WAS A REASONABLE LENGTH					
	b. WAS WORTH RECOMMENDING TO OTHERS					
	c. CONTRIBUTED TO MY KNOWLEDGE AND SKILLS					
	d. ACCOMPLISHED ANNOUNCED PURPOSE					
4. INSTRUCTION	a. SUBJECT WAS THOROUGHLY COVERED					
	b. COURSE EXPECTATIONS, REQUIREMENTS AND OBJECTIVES WERE MADE CLEAR					
	c. PARTICIPATION WAS ENCOURAGED					
	d. TIME IN CLASS WAS SPENT EFFECTIVELY					
5. CLASSROOM	a. WAS COMFORTABLE					
	b. INCLUDED A MANAGEABLE NUMBER OF STUDENTS					
	c. WAS APPROPRIATE FOR THIS COURSE					
6. INSTRUCTOR	a. WAS PREPARED FOR CLASS					
	b. STIMULATED MY INTEREST IN SUBJECT AREA					
	c. MADE COURSE A WORTHWHILE LEARNING EXPERIENCE					

REMARKS

COURSE EVALUATION (Continued)

7. OVERALL INSTRUCTOR EVALUATION (Check your opinion)

a. KNOWLEDGE OF THE SUBJECT	☐ Excellent	☐ Good	☐ Fair	☐ Poor
b. ABILITY TO TEACH	☐ Excellent	☐ Good	☐ Fair	☐ Poor

8. WOULD YOU ADD OR EMPHASIZE ANY SUBJECT MATTER AREAS IN SUBSEQUENT COURSE SESSIONS:

☐ YES ☐ NO. IF "YES" LIST THESE AREAS AND GIVE YOUR REASONS.

9. WOULD YOU DELETE OR DE-EMPHASIZE ANY SUBJECT-MATTER AREAS?

☐ YES ☐ NO. IF "YES" LIST THESE AREAS AND GIVE YOUR REASONS.

10. AS A RESULT OF YOUR PARTICIPATION IN THIS COURSE, WHAT ADDITIONAL RELATED TRAINING SHOULD BE MADE AVAILABLE TO YOU?

11. OTHER COMMENTS. PLEASE PROVIDE ANY COMMENTS, EITHER GENERAL OR SPECIFIC, THAT YOU WOULD LIKE TO MAKE RELATIVE TO THIS COURSE.

SIGNATURE AND TITLE	ORGANIZATION	DATE

FORM NBS-114A (REV. 11-84)

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5. AUTHOR(S)

Rosalie T. Ruegg and Stephen R. Petersen

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GAITHERSBURG, MD 20899

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U.S. Department of Energy, Federal Energy Management Program
1000 Independence Avenue, S.W.
Washington, D.C. 20585

10. SUPPLEMENTARY NOTES

__ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

This is the Student's Manual for an intensive two-day course on how to use life-cycle costing and related economic methods to make cost-effective decisions in designing and retrofitting Federal buildings for energy conservation. The manual is designed to serve as an in-class workbook and as a source for later reference and review. It contains 10 learning modules the mastery of which will satisfy the course's goal of enabling and encouraging building professionals to take into account long-run economic consequences of their decisions.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

building economics; capital investment; energy conservation; energy economics; engineering economics; Federal buildings; life-cycle costing; training courses

13. AVAILABILITY

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